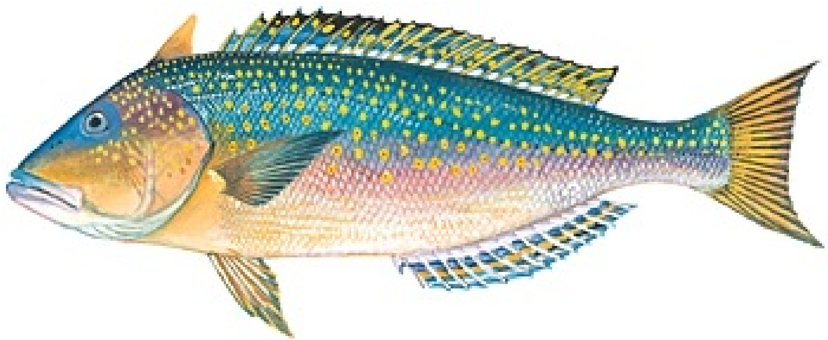
Stock Assessment of Golden Tilefish off the Southeastern United States

2016 SEDAR Update Assessment



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April 5, 2016 Original release.

April 6, 2016 Projections with 3 years to maintain current conditions before implementing management.

May 6, 2016 Table headings corrected.

Contents

List of Tables

List of Figures

2 Executive Summary

This assessment provides an update to the SEDAR-25[1] benchmark assessment of tilefish (*Lopholatilus chamaeleonticeps*) off the southeastern United States. The primary objectives were to update the benchmark assessment of tilefish with recent data and conduct new stock projections as outlined in the Terms of Reference (Appendix B). For this assessment, data compilation and modeling methods were guided by the methodology of SEDAR-25 as well as more recent SEDAR assessments.

The assessment period was 1962–2014. Available data on this stock include indices of abundance, landings, and samples of annual length and age compositions from fishery dependent and independent sources. Two indices of abundance were fitted by the model: one from the commercial longline fleet, and one from a fishery-independent survey. Data on landings were available from commercial and recreational fleets.

The primary model used in SEDAR-25—updated here—was the Beaufort Assessment Model (BAM), a statistical catch-age formulation. A base run of BAM was configured to provide estimates of key management quantities, such as stock and fishery status. Uncertainty in estimates from the base run was evaluated through a mixed Monte Carlo/Bootstrap (MCB) procedure. Median values from the uncertainty analysis were also provided. Stock status was evaluated by measuring the 2014 spawning biomass against the minimum stock size threshold (MSST). The current definition of MSST is $\mathrm{MSST} = 75\%\mathrm{SSB}_{\mathrm{MSY}}$.

Spawning stock declined in the 1980s, remained low but stable from the mid-1990s to the mid-2000s, then increased over the last decade, rising above MSST in the last seven years of the assessment. The terminal (2014) base-run estimate of spawning stock biomass was above MSST (base: $\mathrm{SSB}_{2014}/\mathrm{MSST}$ =1.13; median of MCBs: $\mathrm{SSB}_{2014}/\mathrm{MSST}$ =1.04), but below $\mathrm{SSB}_{\mathrm{MSY}}$ (base:$\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{MSY}}$ =0.85; median of MCBs: $\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{MSY}}$ =0.83).

Estimated fishing mortality rates began increasing in the early 1980s, peaked in the early 1990s, displayed another smaller peak around 2000, then declined steadily until 2012 when rates began to increase again. The base-run estimate of fishing mortality (F), represented by the geometric mean of the last three years (2012-2014), exceeded the MFMT ($F_{2012-2014}/F_{\mathrm{MSY}} = 1.22$) as did the median of the MCB estimates ($F_{2012-2014}/F_{\mathrm{MSY}} = 1.43$).

Thus, this assessment finds that the stock is experiencing overfishing, but is not overfished.

The MCB analysis indicated that estimates of stock and fishery status were robust, but also revealed some quantitative uncertainty in the results. Among all MCB runs, 53% are in qualitative agreement that the stock is not overfished ($\mathrm{SSB}_{2014}/\mathrm{MSST} > 1.0$), and 66% are in qualitative agreement that the stock is experiencing overfishing ($F_{2012-2014}/F_{\mathrm{MSY}} > 1.0$). Over 47% of MCB runs indicated that the stock was both overfished and that overfishing was occurring.

The estimated trends of this SEDAR-25-Update assessment are similar to those from the SEDAR-25 benchmark. However, the two assessments did show some differences in results, which was not surprising given several modifications made to both the data and model (described throughout the report). Of those modifications, the use of a robust multinomial likelihood function to fit age and length composition data had the greatest effect. Compared to SEDAR-25, this assessment suggests lower values of $\mathrm{SSB}_{\mathrm{MSY}}$ and MSY, and a higher value of F_{MSY}.

[1]Abbreviations and acronyms used in this report are defined in Appendix A

3 Data Review and Updates

In the SEDAR-25 benchmark, the assessment period was 1962–2010. In this update, the terminal year was extended to 2014. For some data sources, the data were simply updated with the additional four years. However, for other sources, data prior to 2011 were updated as necessary. The input data for this assessment are summarized in Tables 7.1 – 7.8 and are described below with a focus on the data that required modification from SEDAR-25.

In this update assessment, the Beaufort Assessment Model (BAM) was fitted to the same data sources as in SEDAR-25:

- Landings: commercial handline, commercial longline, and general recreational
- Indices of abundance: commercial longline fishery CPUE and MARMAP longline survey CPUE
- Length compositions of landings: commercial handline, commercial longline, and general recreational
- Age compositions of landings: commercial handline, commercial longline, and MARMAP longline survey.

3.1 Life History

Life-history inputs from SEDAR-25 remained the same in this assessment, including all growth parameters, natural mortality at age, female maturity and fecundity at age, the gutted weight to whole weight con , and other related inputs. Primary life-history information is summarized in Table 7.1.

3.2 Landings

Landings estimates were combined into three fleets: commercial handline, commercial longline, and general recreational. Estimates of commercial landings were updated for 1962-2014 using the methods outlined in SEDAR-25 (SEDAR 2011). An “other” category in the reported landings was distributed by year between handlines and longlines based on the yearly ratio of handline to longline landings as in SEDAR-25. Commercial handline and longline estimated landings were input as thousands of gutted pounds (Table 7.2) and converted to whole pounds in the model using the equation

$$Wholeweight = 1.059 * Guttedweight$$

Commercial landings in numbers for longline and handline gears were estimated using updated landed pounds and average weights by stratum following the methodology outlined in SEDAR-25 (Table 7.3). Average weight for fish caught in the “other” gear category was assumed to be the same as SEDAR-25.

Inconsistent data reporting precluded reliable characterization of trends in tilefish landings by market category. Commercial landings reported by market category are not available prior to 1988 and are inconsistently available after that year. From 1989 to 2014, landings assigned “unknown market category” ranged from 8-99% of the data by pounds in a given year, with 46.7% of all pounds in that time period having an unknown market category.

In this assessment, recreational landings included estimates of the Southeast Region Headboat Survey headboat landings and the Marine Recreational Information Program (MRIP) private and charter landings in thousands of whole pounds (Table 7.2). Landings in numbers of fish are reported in Table 7.3. Using Marine Recreational Fisheries Statistics (MRFSS) landings estimates, SEDAR-25 considered the 2005 estimate to be unrealistically high and replaced it with the average of the 2003, 2004, 2006, and 2007 estimated landings. Revised MRIP estimates for 2005 were significantly lower and on par with adjacent years; therefore, this assessment used the reported MRIP estimate of recreational landings in 2005. In years with no recreational landings estimated, a small value of 0.02 (1000 lb ww) was assumed as in SEDAR-25.

3.3 Discards

As in SEDAR-25, no discard estimates were included in the model as discards are assumed to be negligible in all sectors of the tilefish fishery.

3.4 Indices of abundance

The indices of abundance used in SEDAR-25 included the fishery–independent MARMAP horizontal longline index and the fishery dependent longline logbook index (Table 7.4). Both indices were updated for this assessment with the available data (2011-2014 for commercial logbook; 2011 for MARMAP given suspension of this data collection program). MARMAP CPUE from 2011 was pooled with 2009 and 2010 to generate the "2010" point estimate.

3.5 Length Composition

Length compositions were developed from the commercial handline, commercial longline, and recreational sampling data. Sample sizes (number of trips) are reported in Table 7.5. Following the methodology of SEDAR-25, the contribution of each length was weighted by the landings associated by state, gear, and year. In this assessment, length composition data for the commercial fishery was recalculated in some years because of small corrections in historical landings used as weights (Table 7.6). These corrections resulted in only slight changes in length compositions from SEDAR-25.

Recreational samples included a combination of headboat and MRIP samples. In SEDAR-25, the recreational headboat data query mistakenly included commercial and research samples. In this assessment, only recreational samples from the headboat survey were selected for use. As a result, a more appropriate set of samples were used to characterize the fishery in this assessment. However, the total number of recreational length samples was reduced. The number of trips (used to characterize effective sample size) fell from 85 to 75, and the number of fish sampled fell from 578 to 382. Proportions at length were re-calculated and included in this assessment if the number of trips in a given year was greater than two and the number of fish sampled was greater than ten (Table 7.6). The number of trips associated with recreational data are either vessel trips or angler trips depending on the year (Table 7.5).

3.6 Age Composition

Age data were available from the commercial handline, commercial longline, and MARMAP longline sampling programs. Ages greater than 25 were pooled to age 25 creating a plus group. The annual commercial age compositions developed for tilefish were updated with data from 2011 to 2014 for both fleets (Table 7.7). Sample sizes are reported in Tables 7.5 and 7.7.

All years of MARMAP age composition data were recalculated given an error identified in data treatment from SEDAR-25. Limited samples were available from the MARMAP longline index (Table 7.8); therefore, data were pooled across years as in SEDAR-25. Following the benchmark's methodology, 2011 samples were pooled with samples collected in 2009-2011 to generate an updated "2010" age composition. As in SEDAR-25, MARMAP longline standard deviation estimates provided were converted to CV (CPUE/SD) for input to the model.

4 Stock Assessment Model and Results

4.1 Model Methods

4.1.1 Overview

The Beaufort assessment model (BAM) developed for tilefish in SEDAR-25 was updated in this assessment. The BAM applies a statistical catch-age formulation (Williams and Shertzer 2015) and was implemented with the AD Model Builder software (ADMB Foundation 2011).

4.1.2 Data Sources

The catch-age model included data from a fishery dependent survey, a fishery independent survey, and three fleets that caught southeastern U.S. tilefish: commercial longline, commercial handline, and the recreational fishery. The model was fitted to annual landings, annual length compositions of landings, annual age compositions of landings, and two indices of abundance (MARMAP longline and the commercial longline logbook).

Data used in the model are described and tabulated in Section 3 of this report. One exception is that longline age composition data from 1996, 1998, and 1999 were removed from model inputs after data compilation in response to concerns raised in the SEDAR-25 DW report about how age samples appeared to be collected from the largest fish in the catch in those years (as opposed to random sample collection across all lengths of fish encountered by the port agents). This method of data collection generated biased age composition data. In this update assessment, 1996, 1998, and 1999 longline age composition data were removed from the model inputs.

4.1.3 Base Model Configuration

Model configuration was identical to SEDAR-25 with the following three exceptions discussed in detail below:

- Use of a robust multinomial likelihood
- Estimation of recreational fleet selectivity
- Removal of biased commercial longline age composition data from 1996, 1998, and 1999.

A general description of the base run configuration follows.

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 $1 - 25^{+}$, where the oldest age class 25^{+} allowed for the accumulation of fish (i.e., plus group).

Initialization Initial (1962) abundance at age was assumed equal to the equilibrium age structure and computed as follows. First, the equilibrium age structure was computed for ages 1–25 based on natural and fishing mortality (F), where F was set equal to a value that resulted in the 1962 biomass level equaling 90% of the unfished level. This was based on the assumption by the SEDAR-25 workshop panel that the stock was lightly exploited prior to the 1960's.

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 Lorenzen (1996). The Lorenzen estimates of M_a were rescaled to provide the same fraction of fish surviving from age-1 through the oldest observed age (40 yr) as would occur with constant $M = 0.10$. This approach using cumulative mortality is consistent with the findings of Hoenig (1983) and Hewitt and Hoenig (2005).

Growth Mean size at age of the population (total length, TL) was modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of total length (Figure 8.1, Table 7.1). Parameters of growth and conversions (TL-WW) were estimated during SEDAR-25 and were treated as input to the assessment model. The von Bertalanffy parameter estimates from the DW were $L_\infty = 825.1$, $k = 0.189$, and $t_0 = -0.47$. For fitting length composition data, the distribution of size at age was assumed normal with coefficient of variation (CV) estimated by the assessment model. A constant CV, rather than constant standard deviation, was suggested by the size at age data.

Female maturity Females were modeled to be fully mature at age 4 and the proportion mature at ages 1, 2, and 3 were estimated to be 0.1, 0.25, and 0.5 respectively (Table 7.1).

Spawning Stock Spawning stock was modeled using mature female gonad weight measured at the time of peak spawning. For tilefish, peak spawning was considered to occur in May. In cases when reliable estimates of fecundity are unavailable, spawning biomass, and in this case, female gonad weight, is commonly used as a proxy for population fecundity.

Recruitment Expected recruitment of age-1 fish was predicted from spawning stock using the Beverton–Holt spawner-recruit model. Annual variation in recruitment was assumed to occur with lognormal deviations for years 1976–2007 only. The start of recruitment residuals in 1976 was based on examination of a series of different starting years and the start of the age and length composition data that have information on year class strength. The ending year of estimated recruitment residuals (2007) is based on the age at full selection in the fisheries and the last year of age composition data. Because the age at full selection for the tilefish fisheries generally occurs at age 7 and the last year of composition data in the model is 2014, recruitment deviations during 2007–2014 could not be reliably estimated. Autocorrelation of the recruitment deviations was assumed to be zero.

Landings The model included time series of landings from three fleets: commercial longlines (1962-2014), commercial handlines (1962-2014), and general recreational (1981-2014). Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in units of weight (1000 lb whole weight). A correction was made to the BAM code such that predicted recreational landings in whole pounds (vs. numbers in previous assessment) are now fit to observed landings in whole pounds.

Fishing Mortality For each time series of landings, 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. Apical F was computed as the maximum of F at age summed across fleets.

Selectivities Selectivity curves applied to landings and CPUE series 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. As in SEDAR-25, selectivity of landings from all fleets were modeled as flat-topped, using a two parameter logistic function. Selectivity of the fishery-dependent longline logbook index was the same as that of the longline fleet. The MARMAP index was also modeled as a flat-topped, two parameter logistic function.

In SEDAR-25, a selectivity curve was not estimated for the recreational fleet due to concerns about low sample sizes and noisy composition data. Instead, the recreational selectivity was assumed to be equal to the commercial handline fishery because both sectors use vertical hook and line and their length compositions appeared to cover a similar range. However, once commercial and research SRHS samples were removed from the recreational data considered in this update assessment, it was determined that the recreational fleet selected for smaller fish than the handline fishery. Therefore, a separate selectivity curve was estimated for the recreational fishery in this update.

Indices of Abundance The model was fit to two indices of relative abundance: MARMAP longline (binned years between 1985 and 2011) and commercial longline (1993–2014). Predicted indices were conditional on selectivity of the corresponding fleet or survey and were computed from abundance or biomass (as appropriate) at the midpoint of the year.

In this assessment, commercial CPUE units within the model code were converted from gutted to whole weight to better match the population units of whole weight. This correction affected only the relative value of the index's catchability coefficient between assessments, but does not affect model results in any other way because catchability is a scaling parameter.

Catchability In the BAM, catchability scales indices of relative abundance to estimated exploitable abundance at large. Following the methodology used to generate the SEDAR-25 base run, this update assessment assumed time-invariant catchability.

Fitting Criterion The fitting criterion was a penalized likelihood approach in which observed landings were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Landings and index data were fitted using lognormal likelihoods. Length and age composition data were fitted using multinomial likelihoods. In this update, the multinomial likelihood was upgraded from the function described in SEDAR-25 to the robust multinomial likelihood (Francis 2011) to ensure best practices were used and to emulate other recent SEDAR assessments including the 2014 gag update assessment (SEDAR 2014). For multinomial likelihoods, the number of trips sampled was used as the measure of effective sample size.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values (for instance, to give more influence to stronger data sources). For data components, these weights were applied by either adjusting CVs (lognormal components) or adjusting effective sample sizes (multinomial components). In this application to tilefish, CVs of landings (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allowing some imprecision. Weights on other data components (indices, age and length compositions) were adjusted iteratively, starting from initial weights as follows. The CVs of indices were set equal to the estimated values. 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 (SEDAR25-RW04, SEDAR25-RW06). The weight on the commercial longline index was then adjusted upward to a value of 3 (SEDAR25-RW06), in accordance with the principle that abundance data should be given primacy (Francis 2011), and consistent with SEDAR-25 procedures.

In addition, the compound objective function included several prior distributions, applied to the CV of growth (based on the empirical estimate), slope parameters for each selectivity function, and recruitment standard deviation based on Beddington and Cooke (1983) and Mertz and Myers (1996). 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 which can result in a non-positive definite Hessian matrix.

Parameters Estimated The model estimated annual fishing mortality rates of each fishery, selectivity parameters, catchability coefficients associated with indices, parameters of the spawner-recruit model, annual recruitment deviations, and CV of size at age. Estimated parameters are described mathematically in the document (Williams and Shertzer 2015).

4.1.4 Per Recruit and Equilibrium Analyses

Static spawning potential ratio (static SPR) of each year was computed as the asymptotic spawners per recruit given that year's fishery-specific Fs and selectivities, divided by spawners per recruit that would be obtained in an unexploited stock. In this form, static SPR ranges between zero and one, and it represents SPR that would be achieved under an equilibrium age structure given the year-specific F.

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

4.1.5 Biological Reference Points

Biological reference points (benchmarks) were calculated based on maximum sustainable yield (MSY) estimates in gutted pounds from the Beverton–Holt spawner-recruit model with bias correction (expected values in arithmetic space). In this assessment of tilefish, the quantities F_{MSY}, $\mathrm{SSB}_{\mathrm{MSY}}$, B_{MSY}, and MSY were estimated by the method of Shepherd (1982). Here, spawning stock measures total gonad weight of mature females. 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 fishery estimated as the full F averaged over the last three years of the assessment (2012-2014).

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) as $\mathrm{MSST} = 0.75 * \mathrm{SSB}_{\mathrm{MSY}}$ (Restrepo et al. 1998). Overfishing is defined as $F > \mathrm{MFMT}$ and overfished as $\mathrm{SSB} < \mathrm{MSST}$. 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).

4.1.6 Sensitivity and Retrospective Analyses

In order to portray uncertainty in point estimates produced by the base run described above, sensitivity analyses and a Monte-Carlo/bootstrap procedure were conducted. Steepness was not estimated for tilefish, but rather the parameter was fixed at 0.84, the mode of the prior from the meta–analysis described in Shertzer and Conn (2012).

Sensitivity of results to the three changes made in this update were explored through sensitivity analyses. These model runs, as well as retrospective analyses, vary from the base run as follows:

- S1: multinomial likelihood as parameterized in SEDAR-25
- S2: recreational selectivity set equal to commercial handline selectivity
- S3: biased commercial longline age composition data from 1996, 1998, and 1999 included
- S4: Retrospective run with data through 2013
- S5: Retrospective run with data through 2012
- S6: Retrospective run with data through 2011
- S7: Retrospective run with data through 2010
- S8: Retrospective run with data through 2009
- S9: Retrospective run with data through 2008
- S10: Retrospective run with data through 2007
- S11: Retrospective run with data through 2006.

Retrospective analyses should be interpreted with caution because several data sources appear only near the end of the full time series. Also, some data are not continuous across years which removes information in larger intervals than a single year. Commercial handline age composition data and MARMAP index age composition data are not continuous by year from 2006 to 2011. The final year of recruitment deviations in each retrospective run was set to the terminal year minus seven years to mirror the base run model configuration.

4.1.7 **Uncertainty and Measures of Precision**

Uncertainty was in part examined through sensitivity runs. For the base run, uncertainty in results and precision of estimates was computed more thoroughly through a mixed Monte Carlo and bootstrap (MCB) approach (Efron and Tibshirani 1993; Restrepo et al. 1992; Legault et al. 2001; Manly 1997; SEDAR 2004; 2009; 2010). This approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010).

In this assessment, the BAM was successively re-fit to n=5000 trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. Runs with $F > 6$ were trimmed from the final uncertainty characterization. Runs with a maximum gradient > 1000 and a recruitment standard deviation > 1.0 were considered unrealistic and trimmed as well.

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.

Bootstrap of Observed Data To include uncertainty in time series of observed landings and 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 ($\hat{O}_{s,y}$),

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y}) - \sigma^2_{s,y}/2] \quad (1)$$

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 landings and discards were assumed to be 0.05, and CVs of indices of abundance were those listed in Table 7.4.

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 individuals sampled was the same as in the original data (number of fish), and the effective sample sizes used for fitting (number of trips) was unmodified.

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 as in SEDAR-25.

Steepness: The steepness stock–recruit parameter was fixed at 0.84 in the base run based on a meta–analysis (Shertzer and Conn 2012). Uncertainty in this parameter was characterized by drawing random values from a truncated beta distribution [0.32, 0.99] with parameters $\alpha = 5.94$ and $\beta = 1.97$ estimated by Shertzer and Conn (2012).

Natural Mortality Point estimates of natural mortality ($M = 0.10$) were provided by the SEDAR-25 data workshop, but with some uncertainty. To carry forward this source of uncertainty, Monte Carlo sampling was used to generate deviations from the point estimate. A new M value was drawn for each MCB trial from a truncated normal distribution (range [0.03, 0.21]) with mean equal to the point estimate ($M = 0.10$) and standard deviation set to provide a lower 95% confidence limit at 0.03 (the low end of the DW range). Each realized value of M was used to scale the age-specific Lorenzen M, as in the base run.

Weighting of Indices In the base run, external weights applied to the commercial longline index was adjusted upward to a value of $\omega = 3.0$. In MCB trials, that weight was drawn from a uniform distribution with bounds at $\pm 25\%$ of 3.0.

4.1.8 **Projection Methods**

Projections were run to predict stock status in years after the assessment, 2015–2024. The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Fully selected F was apportioned between landings according to the selectivity curves averaged across fisheries, using geometric mean F from the last three years of the assessment period (2012-2014).

Central tendencies of SSB (time of peak spawning), F, recruits, abundance, biomass, and landings were represented by deterministic projections using parameter estimates from the base run. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at $\mathrm{SSB}_{\mathrm{MSY}}$. Uncertainty in future time series was quantified through projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

Initialization of projections Point estimates of initial abundance at age in the projection (start of 2015), other than at age 1, were taken to be the 2014 estimates from the assessment, discounted by 2014 natural and fishing mortalities. The initial abundance at age 1 was computed using the estimated spawner-recruit model and a 2014 estimate of SSB.

Because the assessment period ended in 2014, the projections required an initialization period. Fishing mortality in 2015 was assumed equal to the geometric mean F from the last three years of the assessment period. Current conditions (fishing rates or catch levels) were maintained for two years before implementing management. As requested in the TORs, three constant-F projection scenarios were considered:

- Scenario 1: $F = Fcurrent$
- Scenario 2: $F = F_{\mathrm{MSY}}$
- Scenario 3: $F = 75\% F_{\mathrm{MSY}}$.

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, as well as in estimated quantities such as spawner-recruit parameters, 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 of each MCB fit was used to compute median unbiased annual recruitment values ($\bar{R}_y$). Variability was added to the median values by choosing multiplicative deviations at random from the recruitment deviations estimated for that chosen MCB run. Because the base run model assumed no recruitment deviation for years 2007–2014, the initial projection year (start of 2015) ages 2–7 included additional variability in recruitment following the same method for subsequent years at age–1.

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. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

Rebuilding time frame Based on results from previous SEDAR assessments, tilefish was not overfished and no rebuilding plan is necessary.

4.1.9 Acceptable Biological Catch

Acceptable biological catch (ABC) was computed using the probability-based approach of Shertzer et al. (2008). In short, this approach solves for annual levels of projected landings that are consistent with a preset, acceptable probability of overfishing ($P^\star$) in each year. The method considers uncertainty in $F_{\rm MSY}$, computed as in Section 4.1.7, and described by the probability density function, $\phi_{F_{\rm MSY}}$. It also considers uncertainty in annual fishing mortality, described by the probability density function, ϕ_{F_t}. Here, ϕ_{F_t} is computed by scaling $\phi_{F_{\rm MSY}}$ toward smaller values of F using a scalar multiplier $\lambda \leq 1.0$. Given the distributions $\phi_{F_{\rm MSY}}$ and ϕ_{F_t}, the probability of overfishing associated with catch C can be computed as,

$$\Pr(F_t > F_{\rm MSY}) = \int_0^\infty \left[\int_F^\infty \phi_{F_t}(\theta) d\theta \right] \phi_{F_{\rm MSY}}(F) dF \tag{2}$$

where θ is a dummy integration variable. This equation was solved for λ and the value of λ was used in the projections such that in each iteration, the applied fishing rate was $F = \lambda F_{\rm MSY}$, where $F_{\rm MSY}$ was specific to that particular run (i.e., MCB draw). The ABC at the desired $P^\star$ was defined as the median catch from the projections.

In this application, projections were run for 10 years past the end of the assessment. The first year of the projection was 2015 and management was expected to begin in 2017. Given recent landings were greater than the ACL, interim landings were assumed to be the average of the last three years. No implementation uncertainty was included. The following projections (continued from list above) were conducted as requested in the Terms of Reference:

- Scenario 4: $P^\star = 0.35$
- Scenario 5: $P^\star = 0.50$.

4.2 Model Results

4.2.1 Base Run Results

Measures of Overall Model Fit Generally, the Beaufort Assessment Model (BAM) fit the available data well. The model was configured to fit observed commercial and recreational landings and the commerical longline index closely (Figures 8.2–8.5). Since the mid-2000s, the general trend in the commercial longline index had been increasing; however, CPUE declined in the last two years of this update assessment. As in SEDAR-25, fits to the fishery-independent MARMAP index of abundance captured recent, but not early, trends in relative abundance (Figure 8.6).

Predicted length compositions from each fishery were reasonably close to observed data in most years, as were predicted age compositions (Figure 8.7). As in SEDAR-25, fit of length composition data for the commercial longline fishery was poor, but could not be remedied during this assessment update.

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

Stock Abundance and Recruitment Estimated abundance declined in the early 1980s, exhibited a smaller peak in the 1990s, then stabilized at moderate levels in the 2000s (Figure 8.8). Older ages appear to have been significantly truncated by the late 1980s (Table 7.9). Moderate expansion of population age structure began again in the mid-2000s; however fish ages 17+ are still relatively rare in the population.

Annual estimated number of recruits is shown in Table 7.9 (age-1 column) and in Figure 8.9. The model had identified the 2001 year class (age-1 fish) as being exceptionally strong in SEDAR-25; however, with the inclusion of additional years of age compositions data to the updated model, the 2001 year class shows no evidence of having been particularly strong.

Total and Spawning Biomass Estimated biomass and biomass at age exhibited a largely similar pattern to that of abundance (Figure 8.10; Table 7.10). Total biomass declined in the early 1980s, remained relatively low until the early 2000s when biomass climbed again and stabilized at moderate levels. Total and spawning biomass showed similar trends (Figure 8.11; Table 7.11).

Selectivity Selectivity estimates among all fisheries and surveys were similar with the exception of the recreational fleet which appeared to target smaller fish than the commercial fisheries or the MARMAP longline survey (Figures 8.12 – 8.13). Fish were estimated to be near fully selected by age 4 for the recreational fleet, age 8 for MARMAP, and by age 9 for the commercial fleets.

Average selectivities of landings were computed from F-weighted selectivities in the most recent period (Figure 8.14). These average selectivities were used to compute benchmarks and central-tendency projections. All selectivities from the most recent period, including average selectivities, are tabulated in Table 7.12.

Fishing Mortality Estimated fishing mortality rates (F) began increasing in the early 1980s, peaked in the early 1990s, displayed another smaller peak around 2000, then declined steadily until 2012 when rates began to increase again (Figure 8.15, Table 7.13). The commercial longline fleet dominates total F (Table 7.14). 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 full selection occuring at different ages among gears in the estimated selectivities.

Table 7.15 shows total predicted landings in weight and Table 7.16 shows total predicted landings in numbers by fleet. Estimated landings at age in weight and numbers are provided in Tables 7.17, 7.18. Commercial harvest has increased in both fleets since the last assessment. In general, the majority of estimated landings were from the commercial longline sector (Figures 8.17, 8.16; Tables 7.15). During the same time period, recreational harvest increased for two years and then declined.

Spawner-Recruitment Parameters The estimated Beverton–Holt spawner-recruit curve is shown in Figure 8.18, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawners. Values of recruitment-related parameters were as follows: assumed steepness $h = 0.84$, unfished age-1 recruitment $\widehat{R_0} = 362,411$, unfished spawning biomass per recruit $\phi_0 = 0.00028$, and assumed standard deviation of recruitment residuals in log space $\sigma = 0.4$ (which resulted in bias correction $\varsigma = 1.06$). The empirical standard deviation of recruitment residuals in log space was $\widehat{\sigma} = 0.34$. Uncertainty in these quantities was estimated through the Monte Carlo/bootstrap (MCB) analysis (Figure 8.19).

4.2.2 **Per Recruit and Equilibrium Analyses**

Static spawning potential ratio (static SPR) shows a general trend of decline during the 1970s and early 1980s, followed by a relatively stable period, an increasing trend between 2000 and 2011, then a decline in the last three years of the assessment (Figure 8.20, Table 7.11). Values lower than the MSY level, such as those seen in recent years, imply that population equilibria would be lower than desirable (as defined by MSY) given estimated fishing rates.

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 8.21). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2012–2014). The Fs that provide 30%, 40%, and 50% SPR are 0.17, 0.11, and 0.08, respectively (Table 7.19).

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figures 8.22). By definition, the F that maximizes equilibrium landings is F_{MSY}, and the corresponding landings and spawning biomass are MSY and $\mathrm{SSB}_{\mathrm{MSY}}$. Equilibrium landings and discards could also be viewed as functions of biomass B, which itself is a function of F (Figure 8.23).

4.2.3 Benchmarks/Reference Points

Biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the expected spawner-recruit curve (Figure 8.18). Reference points estimated were F_{MSY}, MSY, F/F_{MSY},B_{MSY}, $\mathrm{SSB}_{\mathrm{MSY}}$, and $\mathrm{SSB/MSST}$. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered—$F_{\mathrm{OY}} = 65\%F_{\mathrm{MSY}}$, $F_{\mathrm{OY}} = 75\%F_{\mathrm{MSY}}$, and $F_{\mathrm{OY}} = 85\%F_{\mathrm{MSY}}$—and for each, the corresponding yield was computed. Standard errors of benchmarks were approximated as those from Monte Carlo/bootstrap analysis (Section 4.1.7).

Estimates of benchmarks are summarized in Table 7.19. Point estimates of MSY-related quantities were $F_{\mathrm{MSY}} = 0.24\ \mathrm{y}^{-1}$, $\mathrm{MSY} = 560$ klb, $B_{\mathrm{MSY}} = 2574$ mt, $\mathrm{SSB}_{\mathrm{MSY}} = 21.93$ mt, and $\mathrm{SSB/MSST} = 1.13$. Distributions of these benchmarks are shown in Figure 8.24.

4.2.4 Status of the Stock and Fishery

Estimated time series of stock status $(\mathrm{SSB/MSST})$ shows decline in the early 1980s, and then increase since the mid-2000s, (Figure 8.25, Table 7.11). Base-run estimates of spawning biomass remained below MSST throughout the 1990s and most of the 2000s, then rose above MSST during 2009 to 2014. Current stock status in the base run was estimated to be $\mathrm{SSB}_{2014}/\mathrm{MSST} = 1.13$ (Table 7.19). MCB analysis suggests that the stock status determination of being not overfished (i.e., $\mathrm{SSB} > \mathrm{MSST}$) has a high degree of uncertainty (Figures 8.26, 8.27). Over 47% of MCB runs were below MSST in the terminal year.

The estimated time series of F/F_{MSY} suggests that overfishing has occurred throughout a large potion of the assessment period (Figure 8.25, Table 7.11). Spikes in the early 1980s through 2004 are due primarily to the longline fleet (Figure 8.15). Current fishery status in the terminal year, with current F represented by the geometric mean from 2012–2014, is estimated in the base run to be $F_{2012-2014}/F_{\mathrm{MSY}} = 1.22$ (Table 7.19). This estimate indicates that overfishing is occurring and appears robust across MCB trials (Figures 8.26, 8.27). Across all MCB runs, 66% were above MFMT.

4.2.5 Sensitivity and Retrospective Analyses

Sensitivity runs, described in Section 4.1.6, may be useful for evaluating implications of changes made to the base assessment model between this update and SEDAR-25. The effect of each change on stock status determinations is provided in Figure 8.28 and Table 7.20. The estimation of recreational selectivity (not set equal to commerical handline selectivity) and the removal of biased age composition data in the 1990s had little to no effect on stock status estimates. The adoption of a robust multinomial likelihood allowed the model to place less emphasis on outlier data points which resulted in higher F and lower SSB relative to benchmarks.

Retrospective analyses revealed no apparent pattern in F, B, SSB, recruits, F/F_{MSY}, or $\mathrm{SSB/MSST}$ and seemed to indicate little retrospective error (Figures 8.29 – 8.34).

4.2.6 Comparison with Previous Assessment

To place this update assessment in context with SEDAR-25, the base run from this update assessment was compared with results from two other model configurations similar to that used in SEDAR-25. The first comparison run, called "SEDAR25 rev," was the run resulting from implementation of the SEDAR-25 code after an error in the likelihood evaluation function was corrected. The second comparison run, called "Continuity," was simply the "SEDAR25 rev" run implemented using data updated through 2014.

Stock and fishery status estimated by this assessment show trends similar to those from SEDAR-25 (Figure 8.35; Table 7.20). This update assessment estimates higher F and lower SSB in recent years than runs configured similarly to SEDAR-25. The main cause of this difference is improvements in fitting procedures through the adoption of a robust multinomial likelihood function as described in Section 4.1.6. Given the advances in BAM and the additional years of data, estimates of stock and fishery status from this assessment are expected to be improvements over those from SEDAR-25.

4.2.7 Projections

There are only slight differences in the F_{current}, F_{MSY}, and $75\%F_{MSY}$ projection scenarios (Tables 7.21 – 7.23 and Figures 8.37 – 8.41). Under the F_{current}projection, SSB_{MSY} could not be achieved nor could overfishing be prevented (Table 7.21 and Figure 8.37). Under the F_{MSY} projection, SSB approached SSB_{MSY} and F remained steady near or at F_{MSY} (Table 7.22 and Figure 8.39). Under the $75\%F_{MSY}$ projection, SSB exceeded SSB_{MSY} and overfishing was prevented (Table 7.23 and Figure 8.41).

The $P* = 0.35$ and $P* = 0.5$ projections demonstrated similar trends to the $75\%F_{MSY}$ and F_{MSY} projections, respectively (Figures 8.43 – 8.45). Annual landings (in numbers and 1000 lb gutted weight) associated with each $P*$ are listed in Tables 7.24 – 7.25.

5 Discussion

5.1 Comments on Projections

Projections should be interpreted in light of 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 projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals 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 trajectories may be affected.

- Recruitment in the last 7 years is not informed by data and could be higher or lower than expected recruitment which would affect projection results.
- Projections were based on the calendar year, because they are extensions of the assessment model. A shift in the fishing year relative to calendar year may introduce some unquantified disconnect between projection results and management implementation. However, if quotas are reached each year prior to December 31, as might be expected, all fishing mortality within a fishing year would also occur within the same calendar year.

5.2 Recommendations for the Next Benchmark Assessment

The following recommendations are offered for consideration during the next benchmark assessment:

- Re-examine the quantity and quality of biological samples collected by "Other" commercial gears. If adequate, consider methods for inclusion.
- Monitor the quantity of commercial and recreational discards and consider methods for inclusion if deemed necessary.
- More closely examine historical length composition data used in the assessment and consider alternate methods for incorporating this information in the model.

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7 Tables

Table 7.1. Life-history characteristics at age of tilefish, including average body size in total length (TL) and weight (mid-year), gonad weight (GW), proportion females mature (F.mat), and natural mortality (M).

Age	TL (mm)	TL (in)	CV length	Whole weight (kg)	Whole weight (lb)	GW (kg)	F.mat	M
1	256.5	10.1	0.15	0.16	0.36	0.00	0.10	0.2968
2	354.4	14.0	0.15	0.45	0.99	0.00	0.25	0.2174
3	435.5	17.1	0.15	0.86	1.89	0.01	0.50	0.1783
4	502.6	19.8	0.15	1.34	2.96	0.01	1.00	0.1554
5	558.1	22.0	0.15	1.87	4.13	0.02	1.00	0.1405
6	604.1	23.8	0.15	2.40	5.30	0.04	1.00	0.1302
7	642.2	25.3	0.15	2.91	6.42	0.05	1.00	0.1227
8	673.7	26.5	0.15	3.39	7.47	0.07	1.00	0.1172
9	699.7	27.5	0.15	3.82	8.42	0.09	1.00	0.1130
10	721.3	28.4	0.15	4.21	9.27	0.11	1.00	0.1097
11	739.2	29.1	0.15	4.54	10.02	0.13	1.00	0.1072
12	754.0	29.7	0.15	4.84	10.66	0.15	1.00	0.1052
13	766.2	30.2	0.15	5.09	11.22	0.17	1.00	0.1035
14	776.4	30.6	0.15	5.30	11.69	0.18	1.00	0.1022
15	784.8	30.9	0.15	5.49	12.10	0.19	1.00	0.1012
16	791.7	31.2	0.15	5.64	12.44	0.21	1.00	0.1003
17	797.5	31.4	0.15	5.77	12.72	0.22	1.00	0.0996
18	802.2	31.6	0.15	5.88	12.96	0.23	1.00	0.0991
19	806.2	31.7	0.15	5.97	13.17	0.24	1.00	0.0986
20	809.4	31.9	0.15	6.05	13.34	0.24	1.00	0.0982
21	812.1	32.0	0.15	6.11	13.48	0.25	1.00	0.0979
22	814.4	32.1	0.15	6.17	13.59	0.25	1.00	0.0976
23	816.2	32.1	0.15	6.21	13.69	0.26	1.00	0.0974
24	817.7	32.2	0.15	6.25	13.77	0.26	1.00	0.0973
25	819.0	32.2	0.15	6.28	13.84	0.27	1.00	0.0971

Table 7.2. Time series of estimated landings in weight for commercial handline, commercial longline, and recreational fleets. Confidential data indicated by an asterisk (*).

	Thousand Pounds		
Year	Handline (Gutted)	Longline (Gutted)	Recreational (Whole)
1962	0.468	2.93	.
1963	0.443	2.78	.
1964	0.138	0.86	.
1965	3.208	20.10	.
1966	0.602	3.77	.
1967	1.426	8.93	.
1968	0.873	5.47	.
1969	0.713	4.47	.
1970	1.413	8.85	.
1971	2.618	16.40	.
1972	1.561	9.78	.
1973	5.469	34.26	.
1974	12.425	77.84	.
1975	21.571	133.97	.
1976	21.928	129.79	.
1977	25.734	62.76	.
1978	91.554	92.14	.
1979	55.857	114.23	.
1980	148.605	177.80	.
1981	334.407	783.69	0.412
1982	596.732	2774.40	0.018
1983	263.259	1630.17	0.592
1984	202.687	1108.28	4.445
1985	142.764	985.93	58.259
1986	120.538	981.22	0.167
1987	23.827	233.46	0.228
1988	50.123	452.68	2.427
1989	92.569	743.82	0.014
1990	86.011	757.83	0.350
1991	82.231	821.40	0.407
1992	81.444	878.69	5.004
1993	170.882	864.03	0.020
1994	105.336	701.69	7.564
1995	82.706	591.46	0.020
1996	*	*	3.205
1997	33.830	328.21	20.354
1998	28.527	334.57	0.746
1999	37.705	473.60	5.781
2000	54.117	666.86	9.789
2001	38.459	389.57	11.488
2002	*	*	10.110
2003	18.408	222.24	29.438
2004	29.051	231.88	61.915
2005	*	*	97.346
2006	26.498	379.48	58.926
2007	49.660	260.57	16.665
2008	*	*	0.020
2009	*	*	18.206

Table 7.2. (Continued) Time series of estimated landings in weight for commercial handline, commercial longline, and recreational fleets. Confidential data indicated by an asterisk (*).

	Thousand Pounds		
Year	Handline (Gutted)	Longline (Gutted)	Recreational (Whole)
2010	*	*	13.935
2011	22.897	350.68	25.470
2012	*	*	28.382
2013	*	*	16.039
2014	175.722	523.99	7.013

Table 7.3. Time series of estimated recreational landings and commerical landings in numbers (1000 fish) by gear since sampling began. Confidential data indicated by an asterisk (*).

Year	Longline	Handline	Other	Recreational
1981	.	.	.	0.094
1982	.	.	.	0.012
1983	152.237	23.862	3.144	0.134
1984	81.664	18.442	1.827	1.004
1985	76.315	11.404	2.133	13.153
1986	86.233	10.929	1.751	0.038
1987	18.799	1.936	0.369	0.044
1988	43.842	4.555	0.851	0.548
1989	62.729	8.373	1.790	0.010
1990	60.164	7.816	1.442	0.092
1991	79.847	6.501	4.322	0.092
1992	75.837	6.925	7.426	1.144
1993	83.636	8.612	3.382	.
1994	90.347	15.437	0.166	1.713
1995	68.081	9.319	0.034	.
1996	*	*	*	0.724
1997	33.268	3.255	0.448	4.567
1998	41.905	2.343	0.096	0.168
1999	49.906	1.962	0.552	1.308
2000	73.078	6.138	0.460	2.210
2001	40.876	2.165	0.122	2.594
2002	*	*	*	2.283
2003	31.404	1.702	0.001	8.050
2004	17.116	2.684	0.022	13.979
2005	*	*	*	27.706
2006	30.249	3.029	0.022	13.304
2007	23.365	4.592	0.001	3.763
2008	*	*	*	.
2009	*	*	*	4.110
2010	*	*	*	3.146
2011	25.574	1.788	1.565	5.750
2012	*	*	*	6.408
2013	*	*	*	3.533
2014	30.977	12.754	0.025	1.132

Table 7.4. Observed indices of abundance and coefficient of variation (CV) from commercial longline logbooks and the MARMAP horizontal longline survey. MARMAP values are combined across years: 1983-1986 for 1985, 1996-1999 for 1998, 2000-2003 for 2002, 2004-2007 for 2006, and 2009-2011 for 2010.

Year	C.Logbook	C.Logbook CV	MARMAP	MARMAP CV
1985	.	.	1.03	1.63
1986	.	.	.	.
1987	.	.	.	.
1988	.	.	.	.
1989	.	.	.	.
1990	.	.	.	.
1991	.	.	.	.
1992	.	.	.	.
1993	0.62	0.21	.	.
1994	0.60	0.20	.	.
1995	0.74	0.22	.	.
1996	0.45	0.26	.	.
1997	0.62	0.22	.	.
1998	0.69	0.27	2.43	1.60
1999	0.70	0.28	.	.
2000	0.66	0.28	.	.
2001	0.62	0.24	.	.
2002	0.52	0.27	0.95	1.81
2003	0.68	0.24	.	.
2004	0.63	0.25	.	.
2005	0.96	0.33	.	.
2006	1.31	0.22	0.89	1.92
2007	1.94	0.23	.	.
2008	2.03	0.28	.	.
2009	1.84	0.30	.	.
2010	2.39	0.19	2.60	1.49
2011	2.82	0.21	.	.
2012	2.96	0.18	.	.
2013	2.27	0.19	.	.
2014	2.42	0.19	.	.

Table 7.5. Sample sizes (number of trips or sets) for length (len) and age (age) compositions by fleet and survey. Data sources are commercial handlines (cH), commercial longlines (cL), general recreational (rA), and the MARMAP horizontal longline survey (mm).

Year	len.cH	age.cH	len.cL	age.cL	len.rA	age.mm
1984	2	.	.	.	.	.
1985	7	.	.	.	.	155
1986	3	.	.	.	.	.
1987	2	.	.	7	.	.
1988	.	.	8	.	.	.
1989	.	.	7	.	10	.
1990	.	.	7	.	7	.
1991	8	.	51	.	.	.
1992	.	.	.	100	.	.
1993	3	.	.	141	.	.
1994	3	.	77	.	.	.
1995	6	.	.	64	.	.
1996	3	.	.	.	.	.
1997	.	5	.	19	3	.
1998	.	2	.	.	.	74
1999	.	8	.	.	.	.
2000	.	8	.	13	.	.
2001	.	7	.	23	7	.
2002	.	13	.	19	6	59
2003	.	.	.	10	7	.
2004	.	.	.	15	4	.
2005	.	5	.	16	9	.
2006	.	2	.	36	4	52
2007	.	.	.	35	.	.
2008	.	.	.	20	.	.
2009	.	.	.	25	5	.
2010	.	2	.	24	5	93
2011	.	3	.	22	.	.
2012	.	21	.	48	.	.
2013	.	19	.	29	8	.
2014	.	38	.	18	.	.

Table 7.6. Annual proportion at length input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured.

Year	n.fish	n.trips	340	370	400	430	460	490	520	550	580	610	640	670
Commercial Handline														
1984	13	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0598	0.0000	0.0000	0.0000	0.1340	0.1794	0.4186
1985	32	7	0.0000	0.0000	0.0000	0.0070	0.0000	0.0070	0.0000	0.0018	0.0007	0.0470	0.1176	0.3115
1986	40	3	0.0000	0.0128	0.0256	0.0000	0.0897	0.0897	0.0641	0.0384	0.0897	0.0513	0.0769	0.1031
1987	17	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0345	0.0690	0.0690	0.0000	0.0000	0.0345
1991	55	8	0.0000	0.0000	0.0089	0.0268	0.0268	0.0537	0.0268	0.0805	0.0716	0.0805	0.0537	0.0910
1993	37	3	0.0000	0.0186	0.0186	0.0186	0.0186	0.0186	0.0929	0.0372	0.0372	0.1487	0.0929	0.0743
1994	30	3	0.0000	0.0000	0.0000	0.0121	0.0284	0.2195	0.0774	0.2038	0.1264	0.0732	0.1094	0.0526
1995	43	6	0.0000	0.0000	0.0000	0.0119	0.0460	0.0657	0.0642	0.1465	0.1216	0.1426	0.0753	0.0763
1996	13	3	0.0000	0.0215	0.0000	0.0108	0.0108	0.0108	0.0000	0.0000	0.1541	0.0108	0.1541	0.0000
Commercial Longline														
1988	163	8	0.0019	0.0045	0.0108	0.0347	0.0596	0.0671	0.1192	0.1492	0.1074	0.0910	0.0625	0.0590
1989	62	7	0.0074	0.0037	0.0323	0.0414	0.0635	0.0561	0.1488	0.1207	0.1062	0.0799	0.0541	0.0494
1990	129	7	0.0000	0.0021	0.0045	0.0046	0.0288	0.0499	0.0396	0.0879	0.1231	0.1191	0.0798	0.0804
1991	225	51	0.0066	0.0110	0.0362	0.1062	0.1144	0.0850	0.0478	0.0727	0.0783	0.0945	0.0739	0.0591
1994	183	77	0.0011	0.0013	0.0068	0.0601	0.1496	0.1764	0.1131	0.1263	0.0970	0.0628	0.0352	0.0476
Recreational														
1989	17	10	0.3529	0.1765	0.1176	0.1176	0.0000	0.0588	0.0000	0.0000	0.1176	0.0000	0.0000	0.0588
1990	14	7	0.8571	0.0714	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	14	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.1429	0.2143	0.1429	0.0714	0.0714	0.2857
2001	20	7	0.1000	0.0000	0.0500	0.0500	0.0000	0.0000	0.4500	0.0500	0.1000	0.0500	0.0500	0.0000
2002	28	6	0.0000	0.0000	0.0000	0.0000	0.0357	0.1071	0.1071	0.0357	0.1786	0.1429	0.1071	0.1071
2003	64	7	0.0000	0.0000	0.0000	0.0000	0.0938	0.2656	0.2344	0.0781	0.1094	0.0938	0.0938	0.0312
2004	28	4	0.0714	0.2857	0.2143	0.0357	0.0000	0.0000	0.1786	0.1786	0.0000	0.0000	0.0357	0.0000
2005	130	9	0.0000	0.0000	0.0000	0.0077	0.0692	0.1538	0.3154	0.1692	0.1308	0.0692	0.0462	0.0231
2006	17	4	0.0588	0.0588	0.2353	0.0000	0.1176	0.0588	0.1176	0.1765	0.0000	0.0000	0.0588	0.0000
2009	12	5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0833	0.0833	0.0833	0.1667	0.1667	0.1667	0.0000
2010	11	5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0909	0.0000	0.1818	0.0000	0.0909
2013	27	8	0.0000	0.0000	0.0741	0.0000	0.0370	0.0370	0.1481	0.0741	0.0370	0.0370	0.1111	0.1111

Table 7.6. (Continued) Annual proportion at length input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured.

Year	n.fish	n.trips	700	770	760	790	820	850	880	910	940	970	1000
Commercial Handline													
1984	13	2	0.0598	0.0598	0.0598	0.0000	0.0144	0.0000	0.0000	0.0000	0.0000	0.0000	0.0144
1985	32	7	0.1176	0.0710	0.0660	0.0235	0.0882	0.1176	0.0000	0.0235	0.0000	0.0000	0.0000
1986	40	3	0.1025	0.0513	0.0769	0.0256	0.0128	0.0384	0.0384	0.0128	0.0000	0.0000	0.0000
1987	17	2	0.1035	0.2414	0.3104	0.0690	0.0000	0.0000	0.0345	0.0345	0.0000	0.0000	0.0000
1991	55	8	0.1081	0.0753	0.0447	0.0455	0.0805	0.0805	0.0358	0.0000	0.0089	0.0000	0.0000
1993	37	3	0.0372	0.0000	0.0743	0.0186	0.0106	0.0186	0.0558	0.0186	0.0417	0.0558	0.0929
1994	30	3	0.0405	0.0163	0.0121	0.0121	0.0000	0.0163	0.0000	0.0000	0.0000	0.0000	0.0000
1995	43	6	0.0557	0.0542	0.0573	0.0411	0.0152	0.0191	0.0073	0.0000	0.0000	0.0000	0.0000
1996	13	3	0.1649	0.0000	0.1541	0.0000	0.0000	0.1541	0.0000	0.0000	0.0000	0.1541	0.0000
Commercial Longline													
1988	163	8	0.0509	0.0458	0.0362	0.0248	0.0119	0.0143	0.0162	0.0187	0.0075	0.0053	0.0013
1989	62	7	0.0366	0.0332	0.0410	0.0154	0.0095	0.0210	0.0191	0.0369	0.0185	0.0022	0.0030
1990	129	7	0.0937	0.0652	0.0602	0.0324	0.0362	0.0145	0.0193	0.0140	0.0242	0.0137	0.0068
1991	225	51	0.0506	0.0440	0.0348	0.0234	0.0206	0.0140	0.0110	0.0063	0.0031	0.0024	0.0044
1994	183	77	0.0394	0.0243	0.0164	0.0087	0.0109	0.0077	0.0062	0.0033	0.0031	0.0022	0.0006
Recreational													
1989	17	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
1990	14	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
1997	14	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
2001	20	7	0.0000	0.0000	0.0000	0.0500	0.0000	0.0000	0.0000	0.0000	0.050	0.000	0.000
2002	28	6	0.0714	0.0357	0.0000	0.0000	0.0357	0.0357	0.0000	0.0000	0.000	0.000	0.000
2003	64	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
2004	28	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
2005	130	9	0.0154	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000
2006	17	4	0.0000	0.0588	0.0000	0.0000	0.0000	0.0588	0.0000	0.0000	0.000	0.000	0.000
2009	12	5	0.0000	0.0833	0.0833	0.0000	0.0000	0.0000	0.0000	0.0833	0.000	0.000	0.000
2010	11	5	0.0909	0.0000	0.0909	0.0909	0.1818	0.0909	0.0909	0.0000	0.000	0.000	0.000
2013	27	8	0.1111	0.0000	0.0000	0.0000	0.0370	0.0000	0.0000	0.1111	0.037	0.037	0.000

Table 7.7. Annual proportion at age from commercial samples input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured.

Year	n.fish	n.trips	1	2	3	4	5	6	7	8	9	10	11	12	13
Commercial Handline															
1997	84	5	0.0000	0.0000	0.0000	0.0083	0.0880	0.1334	0.1586	0.1231	0.2620	0.1549	0.0261	0.0118	0.0233
1998	43	2	0.0000	0.0000	0.0000	0.0175	0.0700	0.1581	0.0530	0.1751	0.2106	0.1406	0.1401	0.0175	0.0175
1999	35	8	0.0000	0.0000	0.0000	0.0167	0.0000	0.3357	0.2188	0.0772	0.1032	0.2185	0.0225	0.0000	0.0000
2000	222	8	0.0000	0.0000	0.0000	0.0000	0.0407	0.1354	0.3657	0.2680	0.0541	0.0379	0.0460	0.0249	0.0139
2001	46	7	0.0000	0.0000	0.0000	0.0000	0.0016	0.0013	0.1082	0.4005	0.2144	0.1132	0.0032	0.0000	0.1037
2002	160	13	0.0000	0.0000	0.0012	0.0298	0.1292	0.1598	0.0908	0.1033	0.1258	0.1111	0.0412	0.0476	0.0704
2005	103	5	0.0000	0.0000	0.0000	0.0037	0.0460	0.0934	0.1922	0.2220	0.0770	0.0503	0.0947	0.0658	0.0204
2006	59	2	0.0000	0.0000	0.0000	0.0058	0.1081	0.3178	0.2682	0.1807	0.0640	0.0291	0.0029	0.0058	0.0087
2010	13	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.1808	0.2417	0.0591	0.0627	0.0627	0.1495	0.1513	0.0313
2011	71	3	0.0000	0.0000	0.0141	0.0282	0.0563	0.2817	0.2817	0.1972	0.0704	0.0423	0.0141	0.0000	0.0141
2012	454	21	0.0000	0.0000	0.0220	0.1454	0.2599	0.0815	0.0727	0.1211	0.1035	0.0815	0.0441	0.0352	0.0176
2013	293	19	0.0000	0.0034	0.0273	0.0819	0.1297	0.0717	0.1024	0.0819	0.1229	0.1024	0.0648	0.0819	0.0375
2014	478	38	0.0000	0.0000	0.0021	0.0335	0.0941	0.0858	0.0649	0.0900	0.1360	0.0983	0.0795	0.1025	0.0586
Commercial Longline															
1987	28	7	0.0000	0.0000	0.1993	0.1313	0.3979	0.2715	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	124	100	0.0000	0.0000	0.0000	0.0045	0.0754	0.2587	0.1848	0.1208	0.1536	0.0426	0.0445	0.0157	0.0334
1993	209	141	0.0000	0.0000	0.0029	0.1446	0.2937	0.2695	0.1373	0.0795	0.0097	0.0078	0.0148	0.0085	0.0038
1995	373	64	0.0000	0.0000	0.0000	0.0137	0.1159	0.2277	0.2885	0.2057	0.1044	0.0149	0.0078	0.0026	0.0075
1997	782	19	0.0000	0.0000	0.0021	0.0266	0.0714	0.1371	0.2186	0.1904	0.1533	0.0883	0.0367	0.0287	0.0146
2000	312	13	0.0000	0.0000	0.0026	0.0043	0.0864	0.1708	0.3229	0.1264	0.0730	0.0383	0.0432	0.0523	0.0396
2001	234	23	0.0000	0.0000	0.0000	0.0180	0.0696	0.1177	0.2461	0.1965	0.0990	0.0664	0.0593	0.0360	0.0299
2002	32	19	0.0000	0.0000	0.0000	0.0232	0.0596	0.0585	0.2390	0.1820	0.1160	0.0000	0.0216	0.0689	0.0952
2003	167	10	0.0000	0.0000	0.0002	0.0006	0.0800	0.1507	0.3706	0.1719	0.1158	0.0577	0.0136	0.0110	0.0111
2004	264	15	0.0000	0.0000	0.0065	0.0141	0.0387	0.0969	0.2925	0.1724	0.1415	0.0613	0.0452	0.0470	0.0133
2005	368	16	0.0000	0.0000	0.0000	0.0000	0.0036	0.0387	0.1377	0.2071	0.1496	0.1137	0.1110	0.0763	0.0187
2006	820	36	0.0000	0.0000	0.0001	0.0124	0.0474	0.1204	0.1510	0.2279	0.1648	0.0904	0.0744	0.0255	0.0282
2007	945	35	0.0000	0.0000	0.0000	0.0047	0.0386	0.1516	0.1229	0.1844	0.2009	0.0939	0.0667	0.0442	0.0319
2008	554	20	0.0000	0.0000	0.0000	0.0013	0.0224	0.0810	0.1732	0.1862	0.1871	0.1641	0.0627	0.0342	0.0229
2009	880	25	0.0000	0.0000	0.0000	0.0000	0.0114	0.0679	0.1407	0.1580	0.1336	0.1423	0.1148	0.0753	0.0450
2010	703	24	0.0000	0.0000	0.0000	0.0000	0.0089	0.0564	0.1087	0.1745	0.1705	0.1407	0.1014	0.0744	0.0532
2011	528	22	0.0000	0.0000	0.0000	0.0019	0.0246	0.0758	0.1761	0.2386	0.1477	0.1193	0.0606	0.0606	0.0492
2012	1264	48	0.0000	0.0000	0.0063	0.0229	0.0372	0.0728	0.1187	0.1598	0.1709	0.1646	0.0910	0.0601	0.0467
2013	694	29	0.0000	0.0000	0.0000	0.0202	0.0303	0.0346	0.0865	0.1081	0.1398	0.1657	0.1124	0.0821	0.0648
2014	427	18	0.0000	0.0000	0.0000	0.0117	0.0398	0.0211	0.0632	0.0984	0.1101	0.1522	0.1382	0.0867	0.0562

Table 7.7. (Continued) Annual proportion at age from commercial samples input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured.

Year	n.fish	n.trips	14	15	16	17	18	19	20	21	22	23	24	25
Commercial Handline														
1997	84	5	0.0039	0.0052	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	43	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	35	8	0.0000	0.0000	0.0074	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	222	8	0.0069	0.0000	0.0060	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	46	7	0.0539	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	160	13	0.0304	0.0003	0.0086	0.0202	0.0000	0.0000	0.0202	0.0000	0.0000	0.0099	0.0000	0.0000
2005	103	5	0.0638	0.0354	0.0068	0.0136	0.0000	0.0000	0.0000	0.0000	0.0149	0.0000	0.0000	0.0000
2006	59	2	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0000	0.0000	0.0000	0.0000
2010	13	2	0.0295	0.0000	0.0000	0.0313	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	71	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	454	21	0.0044	0.0022	0.0022	0.0022	0.0000	0.0022	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000
2013	293	19	0.0171	0.0307	0.0137	0.0068	0.0102	0.0034	0.0000	0.0034	0.0000	0.0000	0.0000	0.0068
2014	478	38	0.0397	0.0272	0.0272	0.0084	0.0042	0.0084	0.0105	0.0084	0.0000	0.0021	0.0105	0.0084
Commercial Longline														
1987	28	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	124	100	0.0135	0.0257	0.0194	0.0000	0.0000	0.0073	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	209	141	0.0075	0.0085	0.0082	0.0001	0.0000	0.0000	0.0000	0.0035	0.0000	0.0000	0.0000	0.0000
1995	373	64	0.0024	0.0051	0.0006	0.0015	0.0003	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0011
1997	782	19	0.0082	0.0016	0.0045	0.0006	0.0045	0.0031	0.0019	0.0029	0.0025	0.0006	0.0006	0.0012
2000	312	13	0.0144	0.0042	0.0024	0.0000	0.0032	0.0044	0.0045	0.0028	0.0023	0.0006	0.0000	0.0013
2001	234	23	0.0051	0.0041	0.0091	0.0098	0.0057	0.0015	0.0009	0.0005	0.0042	0.0053	0.0032	0.0121
2002	32	19	0.0476	0.0000	0.0000	0.0241	0.0381	0.0000	0.0000	0.0260	0.0000	0.0000	0.0000	0.0000
2003	167	10	0.0016	0.0132	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016
2004	264	15	0.0103	0.0000	0.0033	0.0063	0.0086	0.0011	0.0017	0.0000	0.0104	0.0197	0.0032	0.0060
2005	368	16	0.0179	0.0344	0.0055	0.0281	0.0097	0.0111	0.0064	0.0000	0.0017	0.0026	0.0069	0.0191
2006	820	36	0.0107	0.0071	0.0099	0.0091	0.0000	0.0020	0.0077	0.0030	0.0000	0.0011	0.0015	0.0056
2007	945	35	0.0128	0.0141	0.0034	0.0046	0.0072	0.0036	0.0030	0.0004	0.0019	0.0016	0.0014	0.0062
2008	554	20	0.0205	0.0132	0.0096	0.0029	0.0041	0.0022	0.0041	0.0025	0.0014	0.0006	0.0016	0.0022
2009	880	25	0.0253	0.0200	0.0090	0.0100	0.0171	0.0094	0.0013	0.0040	0.0055	0.0044	0.0010	0.0040
2010	703	24	0.0341	0.0226	0.0129	0.0163	0.0057	0.0025	0.0020	0.0036	0.0016	0.0039	0.0009	0.0053
2011	528	22	0.0170	0.0114	0.0057	0.0019	0.0000	0.0000	0.0000	0.0038	0.0000	0.0000	0.0000	0.0057
2012	1264	48	0.0111	0.0142	0.0040	0.0079	0.0040	0.0008	0.0032	0.0000	0.0008	0.0008	0.0000	0.0024
2013	694	29	0.0490	0.0331	0.0245	0.0159	0.0058	0.0029	0.0058	0.0058	0.0014	0.0029	0.0014	0.0072
2014	427	18	0.0515	0.0398	0.0398	0.0141	0.0234	0.0141	0.0187	0.0023	0.0070	0.0000	0.0000	0.0117

Table 7.8. Annual proportion at age from the MARMAP survey input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.sets–number of sets from which fish were measured. MARMAP values are combined across years: 1983-1986 for 1985, 1996-1999 for 1998, 2000-2003 for 2002, 2004-2007 for 2006, and 2009-2011 for 2010.

							MARMAP longline survey								
Year	n.fish	n.sets	1	2	3	4	5	6	7	8	9	10	11	12	13
1985	269	155	0.0000	0.0223	0.0892	0.0818	0.1041	0.1190	0.1413	0.1375	0.1190	0.0446	0.0260	0.0186	0.0074
1998	344	74	0.0000	0.0029	0.0087	0.0494	0.1134	0.1715	0.2064	0.1831	0.1134	0.0552	0.0640	0.0203	0.0116
2002	94	59	0.0000	0.0000	0.0000	0.0000	0.0213	0.0213	0.1277	0.2447	0.1596	0.1809	0.1170	0.0745	0.0426
2006	80	52	0.0000	0.0000	0.0000	0.0125	0.0625	0.1250	0.1750	0.1375	0.2250	0.1000	0.1000	0.0375	0.0125
2010	461	93	0.0000	0.0000	0.0000	0.0000	0.0260	0.0889	0.1302	0.1952	0.1562	0.1605	0.0803	0.0607	0.0325

Table 7.8. (Continued) Annual proportion at age from the MARMAP survey input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.sets–number of sets from which fish were measured. MARMAP values are combined across years: 1983-1986 for 1985, 1996-1999 for 1998, 2000-2003 for 2002, 2004-2007 for 2006, and 2009-2011 for 2010.

			MARMAP longline survey											
Year	n.fish	n.trips	14	15	16	17	18	19	20	21	22	23	24	25
1985	269	155	0.0112	0.0000	0.0223	0.0074	0.0074	0.0112	0.0000	0.0000	0.0000	0.0037	0.0074	0.0186
1998	344	74	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	94	59	0.0000	0.0000	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	80	52	0.0000	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	461	93	0.0239	0.0130	0.0174	0.0087	0.0022	0.0043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 7.9. 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
1962	381.45	283.49	228.09	190.83	163.34	141.86	124.32	109.47	96.63	85.51	75.88	67.50	60.15
1963	381.45	283.49	228.09	190.83	163.37	141.93	124.54	109.95	97.34	86.28	76.60	68.15	60.74
1964	381.69	283.49	228.09	190.84	163.37	141.96	124.61	110.14	97.77	86.91	77.29	68.80	61.33
1965	381.84	283.67	228.09	190.84	163.38	141.96	124.63	110.21	97.95	87.31	77.87	69.43	61.92
1966	381.97	283.78	228.23	190.84	163.37	141.95	124.59	110.13	97.86	87.31	78.07	69.81	62.36
1967	382.09	283.88	228.33	190.95	163.37	141.96	124.62	110.18	97.92	87.37	78.21	70.11	62.81
1968	382.21	283.97	228.41	191.03	163.47	141.96	124.61	110.18	97.92	87.38	78.22	70.19	63.05
1969	382.32	284.06	228.48	191.10	163.54	142.05	124.62	110.19	97.95	87.41	78.25	70.23	63.15
1970	382.43	284.14	228.55	191.16	163.60	142.11	124.70	110.20	97.97	87.44	78.29	70.27	63.19
1971	382.52	284.22	228.61	191.22	163.65	142.15	124.74	110.25	97.95	87.43	78.29	70.27	63.19
1972	382.60	284.29	228.68	191.27	163.70	142.19	124.76	110.25	97.93	87.34	78.21	70.21	63.15
1973	382.67	284.35	228.74	191.32	163.74	142.24	124.81	110.30	97.98	87.38	78.19	70.19	63.14
1974	382.72	284.40	228.78	191.37	163.78	142.26	124.80	110.22	97.84	87.22	78.03	69.99	62.96
1975	382.71	284.44	228.82	191.41	163.81	142.26	124.71	109.97	97.42	86.73	77.54	69.54	62.50
1976	300.14	284.43	228.85	191.43	163.83	142.23	124.57	109.60	96.77	85.89	76.66	68.69	61.72
1977	310.16	223.06	228.84	191.46	163.85	142.25	124.56	109.49	96.45	85.33	75.93	67.92	60.98
1978	303.46	230.51	179.47	191.46	163.89	142.31	124.70	109.76	96.78	85.50	75.86	67.66	60.65
1979	260.03	225.53	185.46	150.15	163.86	142.27	124.54	109.41	96.34	85.09	75.36	67.01	59.89
1980	233.15	193.25	181.45	155.16	128.51	142.26	124.54	109.34	96.13	84.80	75.07	66.64	59.38
1981	238.26	173.27	155.48	151.79	132.76	111.47	124.17	108.55	94.95	83.43	73.72	65.40	58.17
1982	307.12	177.07	139.40	130.02	129.72	114.62	95.82	104.19	88.52	76.38	66.93	59.19	52.59
1983	262.68	228.22	142.40	116.41	110.56	109.96	92.80	69.18	66.18	52.60	44.45	38.79	34.31
1984	250.94	195.20	183.55	118.96	99.12	94.19	90.51	69.83	47.05	42.69	33.39	28.13	24.56
1985	193.41	186.48	157.00	153.33	101.27	84.54	77.93	69.08	48.65	31.26	27.97	21.82	18.40
1986	256.15	143.72	149.93	130.62	129.10	85.22	68.72	57.91	46.38	30.98	19.58	17.47	13.63
1987	339.96	190.34	115.58	125.20	111.04	109.36	68.85	49.35	36.42	27.20	17.77	11.18	9.98
1988	653.82	252.65	153.13	96.65	106.98	95.83	93.92	57.62	40.03	29.08	21.64	14.15	8.92
1989	425.09	485.88	203.22	127.96	82.39	91.68	80.53	74.50	42.77	28.71	20.65	15.35	10.05
1990	219.92	315.88	390.75	169.72	108.81	69.85	74.26	58.20	47.34	25.40	16.69	11.95	8.89
1991	222.31	163.42	254.00	326.16	144.04	91.64	55.39	50.90	33.85	25.25	13.18	8.60	6.16
1992	232.62	165.18	131.37	211.78	275.69	119.55	69.27	33.66	24.22	14.15	10.11	5.22	3.40
1993	250.94	172.82	132.71	109.26	177.43	222.41	82.65	33.73	11.08	6.47	3.52	2.47	1.27
1994	388.64	186.40	138.76	110.18	90.89	138.95	138.88	31.14	7.28	1.78	0.94	0.50	0.35
1995	241.68	288.71	149.71	115.24	91.87	72.41	92.57	61.87	8.88	1.64	0.37	0.19	0.10
1996	165.36	179.54	231.95	124.57	96.64	74.07	49.73	44.25	19.77	2.29	0.39	0.09	0.04
1997	199.31	122.87	144.34	193.37	105.29	80.54	56.96	31.65	22.77	9.09	1.01	0.17	0.04
1998	234.72	148.09	98.75	119.99	162.23	87.13	61.74	36.44	16.53	10.68	4.11	0.46	0.08
1999	394.38	174.41	119.07	82.40	101.71	136.12	68.27	41.07	20.16	8.29	5.19	1.98	0.22
2000	395.65	293.03	140.19	99.19	69.49	84.25	102.87	41.64	19.69	8.50	3.35	2.08	0.79
2001	358.35	293.94	235.42	116.48	82.92	56.10	58.91	51.84	14.55	5.66	2.29	0.89	0.55
2002	328.14	266.26	236.24	195.83	97.84	68.34	42.11	35.54	24.49	6.03	2.25	0.90	0.35
2003	318.04	243.81	213.98	196.56	164.54	80.46	50.73	24.66	15.99	9.58	2.26	0.83	0.33
2004	343.65	236.33	195.99	177.86	164.98	137.34	63.92	35.66	15.09	9.10	5.33	1.25	0.46
2005	318.30	255.36	189.93	162.36	147.98	136.79	109.45	46.06	22.93	9.14	5.41	3.15	0.74
2006	245.14	236.52	205.18	156.83	133.94	121.78	108.87	79.85	30.45	14.40	5.65	3.33	1.95
2007	226.56	182.17	190.12	170.28	131.14	111.83	98.19	80.16	53.01	19.14	8.90	3.48	2.05
2008	294.87	168.36	146.51	158.64	144.57	111.92	93.66	77.80	59.60	38.15	13.65	6.34	2.48
2009	303.65	219.13	135.43	122.47	135.38	124.17	94.59	75.30	59.02	43.89	27.86	9.96	4.63
2010	310.25	225.66	176.25	113.03	104.08	115.88	104.99	76.71	58.15	44.45	32.83	20.83	7.46
2011	315.08	230.56	181.51	147.17	96.17	89.21	98.11	85.27	59.33	43.87	33.31	24.59	15.63
2012	318.74	234.15	185.44	151.41	124.90	82.23	75.44	79.80	66.24	45.02	33.08	25.11	18.57
2013	320.10	236.87	188.31	154.61	128.28	106.29	68.56	59.30	58.66	47.06	31.67	23.25	17.67
2014	319.03	237.88	190.50	157.15	131.31	109.35	88.49	53.43	42.85	40.77	32.33	21.73	15.96
2015	316.15	237.08	191.31	159.05	133.56	111.60	89.66	66.17	36.06	27.43	25.69	20.31	13.66

Table 7.9. (Continued) Estimated total abundance at age (1000 fish) at start of year.

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	53.70	48.00	42.95	38.46	34.47	30.90	27.72	24.88	22.34	20.06	18.01	159.30	2529.32
1963	54.22	48.46	43.36	38.83	34.80	31.21	27.99	25.12	22.55	20.25	18.19	160.85	2538.62
1964	54.75	48.94	43.79	39.21	35.14	31.51	28.27	25.37	22.77	20.45	18.37	162.42	2547.25
1965	55.29	49.42	44.22	39.60	35.49	31.82	28.55	25.62	23.00	20.65	18.55	164.04	2555.36
1966	55.71	49.81	44.57	39.91	35.77	32.07	28.77	25.82	23.18	20.81	18.69	165.32	2560.72
1967	56.21	50.28	45.00	40.30	36.11	32.38	29.05	26.07	23.40	21.02	18.87	166.92	2567.40
1968	56.58	50.69	45.39	40.66	36.44	32.68	29.31	26.31	23.62	21.21	19.05	168.44	2572.97
1969	56.82	51.05	45.79	41.04	36.78	32.99	29.59	26.56	23.84	21.41	19.23	170.03	2578.46
1970	56.91	51.27	46.12	41.40	37.13	33.30	29.87	26.81	24.07	21.61	19.41	171.66	2583.60
1971	56.92	51.33	46.29	41.68	37.44	33.60	30.14	27.05	24.29	21.81	19.59	173.22	2587.84
1972	56.88	51.30	46.31	41.80	37.66	33.85	30.39	27.28	24.49	21.99	19.75	174.66	2590.93
1973	56.88	51.30	46.32	41.85	37.80	34.07	30.64	27.52	24.71	22.19	19.93	176.24	2594.48
1974	56.72	51.17	46.20	41.74	37.74	34.11	30.76	27.67	24.86	22.33	20.06	177.37	2595.12
1975	56.31	50.80	45.87	41.45	37.48	33.91	30.66	27.66	24.89	22.37	20.09	177.71	2591.05
1976	55.56	50.12	45.27	40.91	36.99	33.47	30.29	27.40	24.73	22.26	20.01	176.98	2498.82
1977	54.88	49.47	44.68	40.38	36.52	33.04	29.91	27.08	24.51	22.12	19.91	176.30	2439.11
1978	54.54	49.15	44.35	40.09	36.26	32.81	29.70	26.89	24.36	22.05	19.91	176.61	2388.71
1979	53.77	48.42	43.68	39.44	35.68	32.29	29.23	26.47	23.98	21.72	19.66	175.34	2294.61
1980	53.15	47.78	43.07	38.89	35.14	31.80	28.80	26.08	23.62	21.40	19.40	174.17	2192.98
1981	51.91	46.53	41.87	37.77	34.13	30.86	27.94	25.31	22.93	20.78	18.83	170.32	2100.61
1982	46.85	41.86	37.56	33.83	30.54	27.61	24.98	22.62	20.50	18.58	16.83	153.31	2016.63
1983	30.52	27.21	24.34	21.86	19.70	17.80	16.10	14.57	13.20	11.96	10.84	99.34	1675.98
1984	21.75	19.37	17.29	15.48	13.91	12.54	11.34	10.26	9.29	8.42	7.63	70.29	1495.69
1985	16.08	14.26	12.71	11.36	10.17	9.15	8.25	7.46	6.75	6.12	5.54	51.34	1330.33
1986	11.51	10.07	8.94	7.98	7.13	6.39	5.75	5.19	4.69	4.25	3.85	35.81	1260.98
1987	7.79	6.59	5.77	5.13	4.58	4.09	3.67	3.30	2.98	2.70	2.44	22.82	1284.11
1988	7.97	6.23	5.27	4.62	4.11	3.67	3.29	2.95	2.65	2.40	2.17	20.30	1690.05
1989	6.34	5.67	4.44	3.76	3.30	2.93	2.62	2.35	2.11	1.90	1.71	16.07	1741.98
1990	5.82	3.68	3.29	2.58	2.19	1.92	1.71	1.53	1.37	1.23	1.11	10.37	1554.45
1991	4.58	3.01	1.90	1.70	1.34	1.13	1.00	0.89	0.79	0.71	0.64	5.96	1418.55
1992	2.44	1.82	1.19	0.75	0.68	0.53	0.45	0.40	0.35	0.32	0.28	2.63	1308.06
1993	0.83	0.60	0.44	0.29	0.18	0.17	0.13	0.11	0.10	0.09	0.08	0.71	1210.48
1994	0.18	0.12	0.08	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.11	1235.40
1995	0.07	0.04	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.03	1125.45
1996	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	988.76
1997	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	967.46
1998	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	980.99
1999	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1153.32
2000	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1260.83
2001	0.21	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1278.12
2002	0.22	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1304.62
2003	0.13	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1322.02
2004	0.18	0.07	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1387.26
2005	0.27	0.11	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1408.06
2006	0.46	0.17	0.07	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1344.62
2007	1.20	0.28	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1278.67
2008	1.47	0.86	0.20	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	1319.20
2009	1.82	1.07	0.63	0.15	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	1359.25
2010	3.47	1.36	0.81	0.47	0.11	0.04	0.02	0.01	0.00	0.00	0.00	0.00	1396.87
2011	5.60	2.61	1.03	0.61	0.36	0.08	0.03	0.01	0.00	0.00	0.00	0.00	1430.15
2012	11.81	4.24	1.98	0.78	0.46	0.27	0.06	0.02	0.01	0.00	0.00	0.00	1459.80
2013	13.08	8.33	2.99	1.40	0.55	0.33	0.19	0.05	0.02	0.01	0.00	0.00	1467.58
2014	12.14	9.00	5.74	2.06	0.96	0.38	0.23	0.13	0.03	0.01	0.00	0.00	1471.49
2015	10.04	7.65	5.68	3.62	1.30	0.61	0.24	0.14	0.08	0.02	0.01	0.01	1457.14

Table 7.10. Estimated biomass at age (1000 lb) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	135.4	279.3	430.3	565.7	674.2	751.6	798.7	817.9	813.9	792.8	759.9	719.6	674.8
1963	135.4	279.3	430.3	565.7	674.2	752.0	800.1	821.7	819.9	799.8	767.2	726.6	681.2
1964	135.6	279.3	430.3	565.7	674.2	752.0	800.5	823.0	823.6	805.8	774.0	733.5	687.8
1965	135.6	279.3	430.3	565.7	674.2	752.2	800.7	823.4	825.2	809.5	780.0	740.1	694.7
1966	135.6	279.5	430.6	565.7	674.2	752.0	800.3	823.0	824.3	809.5	782.0	744.3	699.5
1967	135.6	279.5	430.8	566.1	674.2	752.0	800.5	823.2	824.7	810.0	783.3	747.4	704.6
1968	135.8	279.8	430.8	566.4	674.6	752.0	800.5	823.2	824.7	810.0	783.3	748.2	707.2
1969	135.8	279.8	431.0	566.6	674.8	752.7	800.5	823.4	825.0	810.4	783.7	748.7	708.3
1970	135.8	280.0	431.2	566.8	675.3	752.9	801.2	823.4	825.2	810.6	784.2	749.1	708.8
1971	135.8	280.0	431.2	567.0	675.3	753.1	801.4	823.9	825.0	810.6	784.0	749.1	708.8
1972	135.8	280.0	431.4	567.0	675.5	753.3	801.6	823.9	825.0	809.8	783.3	748.5	708.3
1973	135.8	280.0	431.4	567.2	675.7	753.5	801.8	824.3	825.4	810.2	783.1	748.2	708.1
1974	136.0	280.2	431.7	567.5	675.9	753.8	801.8	823.6	824.1	808.7	781.5	746.3	706.1
1975	135.8	280.2	431.7	567.5	676.2	753.8	801.2	821.7	820.6	804.0	776.7	741.4	701.1
1976	106.5	280.2	431.7	567.7	676.2	753.5	800.3	819.0	815.0	796.3	767.6	732.4	692.3
1977	110.2	219.8	431.7	567.7	676.2	753.5	800.3	818.1	812.4	791.0	760.4	724.2	684.1
1978	107.8	227.1	338.6	567.7	676.4	754.0	801.2	820.1	815.3	792.8	759.7	721.4	680.3
1979	92.4	222.2	349.9	445.1	676.4	753.8	800.1	817.5	811.5	788.8	754.6	714.5	671.7
1980	82.9	190.3	342.4	460.1	530.4	753.8	800.1	817.0	809.8	786.2	751.8	710.5	666.0
1981	84.7	170.6	293.2	450.0	547.8	590.6	797.6	811.1	799.8	773.6	738.3	697.3	652.6
1982	109.1	174.4	263.0	385.6	535.3	607.4	615.5	778.5	745.6	708.1	670.4	631.0	590.0
1983	93.3	224.9	268.7	345.2	456.4	582.7	596.1	517.0	557.5	487.7	445.1	413.6	384.9
1984	89.1	192.2	346.3	352.7	409.0	498.9	581.4	521.8	396.4	395.7	334.4	299.8	275.6
1985	68.8	183.6	296.1	454.6	418.0	447.8	500.7	516.1	409.8	289.9	280.2	232.6	206.4
1986	91.1	141.5	282.9	387.4	532.9	451.5	441.4	432.8	390.7	287.3	196.2	186.3	153.0
1987	120.8	187.4	218.0	371.3	458.3	579.4	442.2	368.8	306.9	252.2	177.9	119.3	112.0
1988	232.1	248.9	288.8	286.6	441.6	507.7	603.4	430.6	337.1	269.6	216.7	150.8	100.1
1989	151.0	478.6	383.4	379.4	340.0	485.7	517.4	556.7	360.2	266.1	206.8	163.6	112.7
1990	78.0	311.1	737.2	503.1	449.1	370.2	477.1	435.0	398.8	235.5	167.1	127.4	99.6
1991	78.9	160.9	479.1	966.9	594.4	485.5	355.8	380.3	285.3	234.1	132.1	91.7	69.0
1992	82.7	162.7	247.8	627.9	1137.8	633.4	445.1	251.5	203.9	131.2	101.2	55.6	38.1
1993	89.1	170.2	250.4	323.9	732.2	1178.4	530.9	252.0	93.3	60.0	35.3	26.5	14.3
1994	138.0	183.6	261.7	326.7	375.2	736.1	892.2	232.8	61.3	16.5	9.5	5.3	4.0
1995	85.8	284.4	282.4	341.7	379.2	383.6	594.8	462.3	74.7	15.2	3.7	2.0	1.1
1996	58.6	176.8	437.6	369.3	398.8	392.4	319.4	330.7	166.4	21.2	4.0	0.9	0.4
1997	70.8	121.0	272.3	573.4	434.5	426.6	366.0	236.6	191.8	84.2	10.1	1.8	0.4
1998	83.3	145.9	186.3	355.8	669.5	461.6	396.6	272.3	139.1	99.0	41.2	4.9	0.9
1999	140.0	171.7	224.7	244.3	419.8	721.1	438.5	306.9	169.8	76.9	52.0	21.2	2.4
2000	140.4	288.6	264.6	294.1	286.8	446.4	660.9	311.1	165.8	78.7	33.5	22.0	8.8
2001	127.2	289.5	444.0	345.5	342.2	297.2	378.5	387.4	122.6	52.5	22.9	9.5	6.2
2002	116.6	262.3	445.6	580.7	403.9	362.0	270.5	265.7	206.4	56.0	22.5	9.7	4.0
2003	112.9	240.1	403.7	582.7	679.0	426.2	325.8	184.3	134.7	88.8	22.5	8.8	3.7
2004	122.1	232.8	369.7	527.3	680.8	727.7	410.7	266.5	127.2	84.4	53.4	13.2	5.1
2005	113.1	251.5	358.3	481.3	610.7	724.7	703.1	344.1	193.1	84.7	54.2	33.7	8.4
2006	87.1	233.0	387.1	465.0	552.7	645.3	699.3	596.6	256.4	133.4	56.7	35.5	21.8
2007	80.5	179.5	358.7	504.9	541.2	592.4	630.7	599.0	446.4	177.5	89.1	37.0	23.1
2008	104.7	165.8	276.5	470.2	596.6	593.0	601.6	581.4	502.0	353.6	136.7	67.7	27.8
2009	107.8	215.8	255.5	363.1	558.7	657.9	607.6	562.6	497.1	407.0	279.1	106.3	52.0
2010	110.2	222.2	332.5	335.1	429.5	614.0	674.4	573.2	489.9	412.0	328.7	222.0	83.6
2011	112.0	227.1	342.4	436.3	396.8	472.7	630.3	637.1	499.8	406.8	333.6	262.1	175.3
2012	113.1	230.6	349.9	448.9	515.4	435.6	484.6	596.3	558.0	417.3	331.4	267.6	208.3
2013	113.8	233.2	355.2	458.3	529.3	563.1	440.5	443.1	494.1	436.3	317.2	247.8	198.2
2014	113.3	234.4	359.4	465.8	541.9	579.4	568.6	399.3	360.9	378.1	323.9	231.7	179.0
2015	112.2	233.5	360.9	471.6	551.2	591.3	576.1	494.5	303.8	254.4	257.3	216.5	153.2

Table 7.10. (Continued) Estimated biomass at age (1000 lb) at start of year

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	627.9	580.5	534.2	489.4	446.9	407.0	369.7	335.3	303.6	274.7	248.0	2204.8	15035.9
1963	634.0	586.2	539.3	494.1	451.3	410.9	373.2	338.6	306.7	277.3	250.4	2226.2	15141.6
1964	640.0	591.9	544.5	498.9	455.7	414.9	377.0	341.9	309.5	280.0	252.9	2247.8	15240.5
1965	646.4	597.7	550.1	504.0	460.1	419.1	380.7	345.2	312.6	282.9	255.5	2270.3	15335.3
1966	651.5	602.5	554.2	507.9	463.6	422.4	383.6	347.9	315.0	285.1	257.5	2288.2	15399.9
1967	657.2	608.0	559.5	512.8	468.3	426.4	387.4	351.4	318.1	287.7	259.9	2310.2	15479.5
1968	661.6	613.1	564.6	517.4	472.5	430.3	390.9	354.5	321.0	290.3	262.3	2331.2	15546.8
1969	664.3	617.5	569.5	522.1	476.9	434.3	394.6	357.8	324.1	293.0	264.8	2353.2	15613.1
1970	665.4	620.2	573.6	526.7	481.3	438.5	398.4	361.3	327.2	295.9	267.4	2375.7	15675.7
1971	665.6	620.8	575.6	530.2	485.5	442.2	401.9	364.6	330.3	298.5	269.8	2397.3	15728.0
1972	665.1	620.6	575.8	532.0	488.3	445.8	405.2	367.5	332.9	301.2	272.1	2417.4	15766.8
1973	665.1	620.6	576.1	532.4	490.1	448.6	408.5	370.8	336.0	303.8	274.5	2439.2	15810.4
1974	663.1	618.8	574.5	531.1	489.4	449.1	410.3	373.0	338.0	305.8	276.2	2454.8	15821.0
1975	658.3	614.4	570.6	527.3	485.9	446.4	409.0	372.8	338.4	306.2	276.7	2459.5	15777.1
1976	649.7	606.3	563.1	520.5	479.7	440.7	404.1	369.3	336.2	304.7	275.6	2449.6	15637.8
1977	641.8	598.3	555.6	513.9	473.6	435.2	398.8	365.1	333.1	302.9	274.3	2440.1	15481.9
1978	637.8	594.6	551.6	509.9	470.0	432.1	396.2	362.4	331.1	301.8	274.3	2444.3	15367.7
1979	628.8	585.5	543.2	501.8	462.5	425.1	389.8	356.7	325.8	297.4	270.7	2426.6	15112.9
1980	621.5	577.8	535.7	494.7	455.7	418.7	384.0	351.4	321.2	293.0	267.2	2410.5	14832.5
1981	606.9	562.8	520.7	480.6	442.5	406.3	372.6	341.1	311.7	284.4	259.3	2357.2	14353.6
1982	547.8	506.4	467.2	430.3	395.9	363.5	333.1	304.9	278.7	254.4	231.9	2121.7	13049.4
1983	356.7	329.1	302.7	278.2	255.5	234.4	214.7	196.2	179.5	163.8	149.3	1374.8	9407.6
1984	254.2	234.4	215.0	196.9	180.3	165.1	151.2	138.2	126.3	115.3	105.2	972.9	7548.6
1985	188.1	172.4	158.1	144.4	131.8	120.4	110.0	100.5	91.7	83.8	76.3	710.5	6393.0
1986	134.5	121.9	111.1	101.4	92.4	84.2	76.7	69.9	63.7	58.2	52.9	495.6	5437.3
1987	91.1	79.6	71.9	65.3	59.3	54.0	48.9	44.5	40.6	37.0	33.7	315.7	4655.7
1988	93.0	75.4	65.5	58.9	53.4	48.3	43.9	39.7	36.2	32.8	29.8	280.9	4971.9
1989	74.1	68.6	55.3	47.8	42.8	38.6	35.1	31.7	28.7	26.0	23.6	222.4	5096.2
1990	68.1	44.5	41.0	32.8	28.4	25.4	22.7	20.5	18.5	16.8	15.2	143.5	4866.9
1991	53.6	36.4	23.6	21.6	17.4	15.0	13.2	11.9	10.8	9.7	8.8	82.5	4618.9
1992	28.4	22.0	14.8	9.7	8.8	7.1	6.0	5.3	4.9	4.4	4.0	36.4	4270.3
1993	9.7	7.3	5.5	3.7	2.4	2.2	1.8	1.5	1.3	1.1	1.1	9.9	3803.9
1994	2.2	1.3	1.1	0.9	0.4	0.4	0.2	0.2	0.2	0.2	0.2	1.5	3251.6
1995	0.9	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2913.6
1996	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2678.0
1997	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2790.2
1998	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2857.0
1999	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2989.9
2000	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3003.4
2001	2.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2827.9
2002	2.4	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3008.9
2003	1.5	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3216.8
2004	2.2	0.9	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3624.6
2005	3.1	1.3	0.4	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3966.6
2006	5.3	2.0	0.9	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4178.9
2007	14.1	3.3	1.3	0.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	4279.8
2008	17.2	10.4	2.4	0.9	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	4509.3
2009	21.2	13.0	7.9	2.0	0.7	0.2	0.2	0.0	0.0	0.0	0.0	0.0	4715.7
2010	40.6	16.5	10.1	6.0	1.5	0.4	0.2	0.0	0.0	0.0	0.0	0.0	4903.3
2011	65.5	31.5	12.8	7.7	4.6	1.1	0.4	0.2	0.0	0.0	0.0	0.0	5056.3
2012	138.0	51.4	24.7	9.9	6.0	3.5	0.9	0.2	0.2	0.0	0.0	0.0	5192.3
2013	153.0	100.8	37.3	17.9	7.1	4.4	2.6	0.7	0.2	0.0	0.0	0.0	5154.2
2014	142.0	108.9	71.4	26.2	12.6	5.1	3.1	1.8	0.4	0.2	0.0	0.0	5106.8
2015	117.5	92.6	70.5	46.1	17.0	7.9	3.3	2.0	1.1	0.2	0.0	0.0	4934.6

Table 7.11. Estimated time series of status indicators, fishing mortality, biomass, and static SPR. Fishing mortality rate is apical F. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, female gonad weight mt) at the end of May (time of peak spawning). The $MSST$ is defined by $MSST = 0.75 * SSB_{MSY}$ with constant $M = 0.1$. SPR is the static spawning potential ratio.

Year	F	F/F_{MSY}	B	B/B_{MSY}	SSB	SSB/SSB_{MSY}	$SSB/MSST$	SPR
1962	0.000	0.001	6820	0.914	95	4.314	5.752	0.996
1963	0.000	0.001	6868	0.920	96	4.367	5.822	0.996
1964	0.000	0.000	6913	0.926	97	4.403	5.870	0.999
1965	0.002	0.009	6956	0.932	97	4.434	5.911	0.974
1966	0.000	0.002	6985	0.936	98	4.461	5.948	0.995
1967	0.001	0.004	7021	0.941	98	4.490	5.987	0.988
1968	0.001	0.002	7052	0.945	99	4.517	6.022	0.993
1969	0.000	0.002	7082	0.949	100	4.543	6.057	0.994
1970	0.001	0.004	7110	0.953	100	4.566	6.089	0.989
1971	0.002	0.007	7134	0.956	101	4.586	6.115	0.979
1972	0.001	0.004	7152	0.958	101	4.603	6.138	0.988
1973	0.004	0.015	7172	0.961	101	4.616	6.155	0.958
1974	0.008	0.034	7176	0.962	101	4.614	6.152	0.908
1975	0.014	0.060	7156	0.959	101	4.590	6.120	0.850
1976	0.014	0.059	7093	0.951	100	4.553	6.071	0.852
1977	0.008	0.034	7022	0.941	99	4.528	6.037	0.908
1978	0.017	0.072	6971	0.934	99	4.499	5.999	0.824
1979	0.016	0.067	6855	0.919	97	4.445	5.927	0.834
1980	0.031	0.131	6728	0.902	96	4.365	5.821	0.717
1981	0.113	0.479	6511	0.872	90	4.116	5.487	0.400
1982	0.441	1.870	5919	0.793	72	3.277	4.369	0.157
1983	0.352	1.494	4267	0.572	51	2.313	3.085	0.183
1984	0.320	1.357	3424	0.459	39	1.774	2.365	0.195
1985	0.366	1.550	2900	0.389	31	1.400	1.866	0.172
1986	0.456	1.933	2466	0.331	24	1.086	1.448	0.153
1987	0.121	0.515	2112	0.283	21	0.948	1.265	0.383
1988	0.238	1.008	2255	0.302	20	0.933	1.244	0.242
1989	0.442	1.875	2312	0.310	18	0.837	1.116	0.157
1990	0.559	2.369	2208	0.296	16	0.709	0.946	0.134
1991	0.823	3.492	2095	0.281	13	0.610	0.813	0.106
1992	1.308	5.549	1937	0.260	11	0.512	0.683	0.082
1993	1.858	7.879	1725	0.231	9	0.423	0.563	0.068
1994	1.494	6.337	1475	0.198	8	0.359	0.478	0.076
1995	1.346	5.708	1322	0.177	7	0.308	0.411	0.081
1996	0.720	3.052	1215	0.163	7	0.301	0.402	0.114
1997	0.698	2.959	1266	0.170	7	0.334	0.446	0.114
1998	0.626	2.654	1296	0.174	8	0.362	0.483	0.125
1999	0.813	3.450	1356	0.182	8	0.369	0.492	0.106
2000	1.230	5.214	1362	0.183	7	0.328	0.437	0.084
2001	0.831	3.525	1283	0.172	7	0.298	0.397	0.103
2002	0.893	3.788	1365	0.183	7	0.312	0.416	0.099
2003	0.488	2.070	1459	0.196	8	0.361	0.482	0.141
2004	0.419	1.777	1644	0.220	10	0.439	0.585	0.151
2005	0.379	1.606	1799	0.241	11	0.512	0.683	0.156
2006	0.379	1.608	1895	0.254	13	0.571	0.761	0.164
2007	0.233	0.990	1941	0.260	14	0.635	0.847	0.241
2008	0.209	0.887	2045	0.274	16	0.713	0.950	0.266
2009	0.184	0.782	2139	0.287	17	0.781	1.041	0.285
2010	0.183	0.775	2224	0.298	18	0.837	1.116	0.288
2011	0.176	0.747	2294	0.307	19	0.884	1.179	0.293
2012	0.247	1.047	2355	0.316	20	0.903	1.204	0.230
2013	0.271	1.151	2338	0.313	19	0.888	1.184	0.217
2014	0.360	1.525	2316	0.310	19	0.850	1.134	0.179
2015	.	.	2238	0.300	20	0.933	1.244	.

Table 7.12. Selectivity at age for commercial handline (cH) landings, commerical longlines (cL) landings, recreational (rA) landings, and the MARMAP longline survey (mm). TL is total length.

Age	TL(mm)	TL(in)	cH	cL	rA	mm
1	256.5	10.1	0.000	0.000	0.002	0.000
2	354.4	14.0	0.001	0.001	0.028	0.000
3	435.5	17.1	0.004	0.004	0.330	0.000
4	502.6	19.8	0.016	0.015	0.895	0.002
5	558.1	22.0	0.062	0.055	0.993	0.023
6	604.1	23.8	0.205	0.180	1.000	0.235
7	642.2	25.3	0.503	0.451	1.000	0.804
8	673.7	26.5	0.799	0.756	1.000	0.982
9	699.7	27.5	0.940	0.921	1.000	0.999
10	721.3	28.4	0.984	0.978	1.000	1.000
11	739.2	29.1	0.996	0.994	1.000	1.000
12	754.0	29.7	0.999	0.998	1.000	1.000
13	766.2	30.2	1.000	1.000	1.000	1.000
14	776.4	30.6	1.000	1.000	1.000	1.000
15	784.8	30.9	1.000	1.000	1.000	1.000
16	791.7	31.2	1.000	1.000	1.000	1.000
17	797.5	31.4	1.000	1.000	1.000	1.000
18	802.2	31.6	1.000	1.000	1.000	1.000
19	806.2	31.7	1.000	1.000	1.000	1.000
20	809.4	31.9	1.000	1.000	1.000	1.000
21	812.1	32.0	1.000	1.000	1.000	1.000
22	814.4	32.1	1.000	1.000	1.000	1.000
23	816.2	32.1	1.000	1.000	1.000	1.000
24	817.7	32.2	1.000	1.000	1.000	1.000
25	819.0	32.2	1.000	1.000	1.000	1.000

Table 7.13. Estimated instantaneous fishing mortality rate (per yr) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.002	0.002	0.002	0.002
1966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
1968	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001
1969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
1971	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.002	0.002
1972	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
1973	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.003	0.004	0.004	0.004
1974	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.006	0.007	0.008	0.008	0.008	0.008
1975	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.011	0.013	0.014	0.014	0.014	0.014
1976	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.011	0.013	0.014	0.014	0.014	0.014
1977	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.008	0.008	0.008	0.008	0.008
1978	0.000	0.000	0.000	0.000	0.001	0.003	0.008	0.013	0.016	0.017	0.017	0.017	0.017
1979	0.000	0.000	0.000	0.000	0.001	0.003	0.007	0.012	0.015	0.016	0.016	0.016	0.016
1980	0.000	0.000	0.000	0.000	0.002	0.006	0.015	0.024	0.029	0.030	0.031	0.031	0.031
1981	0.000	0.000	0.000	0.002	0.006	0.021	0.053	0.087	0.105	0.111	0.112	0.113	0.113
1982	0.000	0.000	0.002	0.007	0.025	0.081	0.203	0.337	0.408	0.432	0.438	0.440	0.441
1983	0.000	0.000	0.001	0.005	0.020	0.065	0.162	0.268	0.325	0.345	0.350	0.352	0.352
1984	0.000	0.000	0.002	0.006	0.019	0.059	0.147	0.244	0.296	0.313	0.318	0.320	0.320
1985	0.000	0.001	0.006	0.017	0.032	0.077	0.174	0.281	0.338	0.358	0.364	0.365	0.365
1986	0.000	0.000	0.002	0.007	0.025	0.083	0.208	0.347	0.421	0.446	0.453	0.455	0.456
1987	0.000	0.000	0.001	0.002	0.007	0.022	0.055	0.092	0.112	0.119	0.121	0.121	0.121
1988	0.000	0.000	0.001	0.004	0.014	0.044	0.109	0.181	0.219	0.233	0.236	0.237	0.238
1989	0.000	0.000	0.002	0.007	0.025	0.081	0.202	0.336	0.408	0.433	0.440	0.441	0.442
1990	0.000	0.001	0.002	0.009	0.031	0.102	0.255	0.425	0.515	0.547	0.555	0.558	0.558
1991	0.000	0.001	0.003	0.013	0.046	0.150	0.375	0.625	0.760	0.805	0.819	0.822	0.823
1992	0.000	0.001	0.006	0.022	0.074	0.239	0.597	0.994	1.207	1.280	1.301	1.306	1.308
1993	0.001	0.002	0.008	0.029	0.104	0.341	0.853	1.416	1.716	1.818	1.847	1.855	1.857
1994	0.000	0.002	0.007	0.026	0.087	0.276	0.686	1.138	1.380	1.462	1.486	1.492	1.494
1995	0.000	0.001	0.006	0.021	0.075	0.245	0.615	1.024	1.242	1.317	1.338	1.344	1.345
1996	0.000	0.001	0.004	0.013	0.042	0.132	0.329	0.547	0.664	0.704	0.716	0.719	0.719
1997	0.000	0.001	0.006	0.020	0.049	0.136	0.324	0.533	0.645	0.683	0.694	0.697	0.697
1998	0.000	0.001	0.003	0.010	0.035	0.114	0.285	0.475	0.577	0.612	0.622	0.625	0.625
1999	0.000	0.001	0.004	0.015	0.048	0.150	0.372	0.618	0.750	0.796	0.809	0.812	0.813
2000	0.000	0.001	0.007	0.024	0.074	0.228	0.563	0.934	1.134	1.203	1.222	1.228	1.229
2001	0.000	0.001	0.006	0.019	0.053	0.157	0.383	0.633	0.767	0.813	0.826	0.830	0.831
2002	0.000	0.001	0.006	0.019	0.055	0.168	0.412	0.681	0.825	0.874	0.888	0.892	0.893
2003	0.000	0.001	0.007	0.020	0.040	0.100	0.230	0.374	0.451	0.478	0.485	0.487	0.488
2004	0.000	0.001	0.010	0.029	0.047	0.097	0.205	0.325	0.389	0.410	0.417	0.418	0.419
2005	0.000	0.001	0.013	0.037	0.054	0.098	0.193	0.297	0.352	0.371	0.377	0.378	0.378
2006	0.000	0.001	0.008	0.024	0.040	0.085	0.183	0.293	0.351	0.371	0.377	0.379	0.379
2007	0.000	0.000	0.003	0.008	0.018	0.047	0.110	0.179	0.216	0.228	0.232	0.233	0.233
2008	0.000	0.000	0.001	0.003	0.012	0.038	0.095	0.159	0.193	0.205	0.208	0.209	0.209
2009	0.000	0.000	0.002	0.007	0.015	0.038	0.087	0.141	0.171	0.181	0.183	0.184	0.184
2010	0.000	0.000	0.002	0.006	0.014	0.036	0.085	0.140	0.169	0.179	0.182	0.182	0.183
2011	0.000	0.000	0.003	0.009	0.016	0.037	0.084	0.135	0.163	0.173	0.175	0.176	0.176
2012	0.000	0.000	0.003	0.010	0.021	0.052	0.118	0.191	0.229	0.242	0.246	0.247	0.247
2013	0.000	0.000	0.003	0.008	0.019	0.053	0.127	0.208	0.251	0.266	0.270	0.271	0.271
2014	0.000	0.000	0.002	0.007	0.022	0.068	0.168	0.276	0.333	0.352	0.358	0.359	0.360

Table 7.13. (Continued) Estimated instantaneous fishing mortality rate (per yr) at age.

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1968	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1971	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1972	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1973	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1974	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1975	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1976	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1977	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1978	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
1979	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
1980	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
1981	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
1982	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441	0.441
1983	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352
1984	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
1985	0.366	0.366	0.366	0.366	0.366	0.366	0.366	0.366	0.366	0.366	0.366	0.366
1986	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456	0.456
1987	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
1988	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
1989	0.442	0.442	0.442	0.442	0.442	0.442	0.442	0.442	0.442	0.442	0.442	0.442
1990	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559
1991	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823	0.823
1992	1.308	1.308	1.308	1.308	1.308	1.308	1.308	1.308	1.308	1.308	1.308	1.308
1993	1.858	1.858	1.858	1.858	1.858	1.858	1.858	1.858	1.858	1.858	1.858	1.858
1994	1.494	1.494	1.494	1.494	1.494	1.494	1.494	1.494	1.494	1.494	1.494	1.494
1995	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346	1.346
1996	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720
1997	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698
1998	0.626	0.626	0.626	0.626	0.626	0.626	0.626	0.626	0.626	0.626	0.626	0.626
1999	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813
2000	1.229	1.229	1.229	1.230	1.230	1.230	1.230	1.230	1.230	1.230	1.230	1.230
2001	0.831	0.831	0.831	0.831	0.831	0.831	0.831	0.831	0.831	0.831	0.831	0.831
2002	0.893	0.893	0.893	0.893	0.893	0.893	0.893	0.893	0.893	0.893	0.893	0.893
2003	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488	0.488
2004	0.419	0.419	0.419	0.419	0.419	0.419	0.419	0.419	0.419	0.419	0.419	0.419
2005	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379
2006	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379
2007	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
2008	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209
2009	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184
2010	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
2011	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
2012	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247
2013	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
2014	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360

Table 7.14. Estimated time series of fully selected fishing mortality rates for commercial handlines (F.cH), commercial longline (F.cL), recreational (F.rA) landings (L). Also shown is apical F, the maximum F at age summed across fleets.

Year	F.cH	F.cL	F.rA	Apical F
1962	0.00004	0.00028	0.00000	0.00032
1963	0.00004	0.00026	0.00000	0.00031
1964	0.00001	0.00008	0.00000	0.00009
1965	0.00030	0.00188	0.00000	0.00217
1966	0.00006	0.00035	0.00000	0.00041
1967	0.00013	0.00082	0.00000	0.00095
1968	0.00008	0.00050	0.00000	0.00058
1969	0.00006	0.00041	0.00000	0.00047
1970	0.00013	0.00080	0.00000	0.00093
1971	0.00023	0.00148	0.00000	0.00172
1972	0.00014	0.00088	0.00000	0.00102
1973	0.00049	0.00308	0.00000	0.00357
1974	0.00111	0.00701	0.00000	0.00812
1975	0.00194	0.01214	0.00000	0.01408
1976	0.00198	0.01187	0.00000	0.01385
1977	0.00234	0.00577	0.00000	0.00811
1978	0.00839	0.00852	0.00000	0.01691
1979	0.00516	0.01067	0.00000	0.01584
1980	0.01397	0.01688	0.00000	0.03085
1981	0.03347	0.07943	0.00003	0.11294
1982	0.07663	0.36432	0.00000	0.44096
1983	0.04815	0.30411	0.00009	0.35234
1984	0.04855	0.27075	0.00080	0.32010
1985	0.04380	0.30921	0.01255	0.36556
1986	0.04876	0.40703	0.00004	0.45583
1987	0.01096	0.11034	0.00006	0.12137
1988	0.02297	0.21414	0.00068	0.23780
1989	0.04739	0.39476	0.00000	0.44216
1990	0.05499	0.50355	0.00011	0.55866
1991	0.07195	0.75134	0.00014	0.82343
1992	0.10465	1.20202	0.00178	1.30845
1993	0.28602	1.57184	0.00001	1.85787
1994	0.18077	1.30958	0.00384	1.49419
1995	0.15230	1.19361	0.00001	1.34592
1996	0.06513	0.65269	0.00191	0.71973
1997	0.06062	0.62632	0.01081	0.69775
1998	0.04624	0.57910	0.00037	0.62572
1999	0.05615	0.75434	0.00297	0.81347
2000	0.08660	1.13717	0.00574	1.22951
2001	0.06980	0.75421	0.00714	0.83115
2002	0.11372	0.77380	0.00569	0.89320
2003	0.03404	0.44005	0.01402	0.48812
2004	0.04121	0.35259	0.02513	0.41892
2005	0.04376	0.29936	0.03551	0.37863
2006	0.02248	0.33661	0.02017	0.37926
2007	0.03509	0.19296	0.00531	0.23335
2008	0.02035	0.18879	0.00001	0.20915
2009	0.01444	0.16487	0.00514	0.18445
2010	0.01435	0.16458	0.00382	0.18275
2011	0.01012	0.15934	0.00679	0.17625
2012	0.04755	0.19188	0.00751	0.24694
2013	0.03463	0.23243	0.00431	0.27137
2014	0.08792	0.26978	0.00194	0.35964

Table 7.15. Estimated time series of landings in gutted weight (1000 lb) for commercial handlines (cH), loglines (cL), and recreational (rA).

Year	cH	cL	rA	Total
1962	0.47	2.93	0.00	3.40
1963	0.44	2.78	0.00	3.22
1964	0.14	0.86	0.00	1.00
1965	3.21	20.10	0.00	23.31
1966	0.60	3.77	0.00	4.37
1967	1.43	8.93	0.00	10.36
1968	0.87	5.47	0.00	6.34
1969	0.71	4.47	0.00	5.18
1970	1.41	8.85	0.00	10.26
1971	2.62	16.40	0.00	19.02
1972	1.56	9.78	0.00	11.34
1973	5.47	34.26	0.00	39.73
1974	12.43	77.86	0.00	90.29
1975	21.57	134.04	0.00	155.61
1976	21.93	129.86	0.00	151.79
1977	25.74	62.78	0.00	88.51
1978	91.59	92.18	0.00	183.77
1979	55.87	114.29	0.00	170.16
1980	148.71	177.96	0.00	326.67
1981	334.99	786.89	0.41	1122.29
1982	598.61	2816.02	0.02	3414.65
1983	263.61	1644.04	0.59	1908.25
1984	202.87	1113.91	4.45	1321.23
1985	142.86	990.30	58.28	1191.43
1986	120.61	985.51	0.17	1106.28
1987	23.83	233.82	0.23	257.88
1988	50.14	454.29	2.43	506.86
1989	92.64	748.45	0.01	841.10
1990	86.07	762.77	0.35	849.20
1991	82.28	826.60	0.41	909.29
1992	81.48	883.42	5.00	969.91
1993	170.74	860.80	0.02	1031.56
1994	105.14	693.00	7.56	805.71
1995	82.85	598.72	0.02	681.59
1996	33.83	316.01	3.21	353.05
1997	33.81	326.81	20.35	380.97
1998	28.52	333.86	0.75	363.12
1999	37.70	472.05	5.78	515.53
2000	54.07	660.28	9.79	724.14
2001	38.45	388.61	11.49	438.54
2002	57.41	367.04	10.11	434.56
2003	18.41	222.56	29.43	270.40
2004	29.05	231.66	61.83	322.53
2005	41.14	262.50	96.98	400.61
2006	26.46	372.44	58.79	457.70
2007	49.59	258.71	16.66	324.97
2008	33.87	300.36	0.02	334.24
2009	27.36	299.97	18.20	345.53
2010	30.16	333.31	13.93	377.40
2011	22.89	348.40	25.46	396.75
2012	108.36	424.72	28.38	561.47
2013	75.04	489.61	16.04	580.69
2014	175.52	522.17	7.01	704.70

Table 7.16. Estimated time series of landings in numbers (1000 fish) for commercial handlines (cH), headboat (cL), and recreational (rA).

Year	cH	cL	rA	Total
1962	0.05	0.29	0.00	0.33
1963	0.04	0.27	0.00	0.31
1964	0.01	0.08	0.00	0.10
1965	0.31	1.95	0.00	2.27
1966	0.06	0.37	0.00	0.43
1967	0.14	0.87	0.00	1.01
1968	0.09	0.53	0.00	0.62
1969	0.07	0.43	0.00	0.50
1970	0.14	0.86	0.00	0.99
1971	0.25	1.59	0.00	1.84
1972	0.15	0.95	0.00	1.10
1973	0.53	3.31	0.00	3.84
1974	1.21	7.52	0.00	8.73
1975	2.10	12.95	0.00	15.05
1976	2.13	12.55	0.00	14.68
1977	2.50	6.07	0.00	8.57
1978	8.92	8.92	0.00	17.83
1979	5.44	11.06	0.00	16.50
1980	14.49	17.22	0.00	31.71
1981	32.65	76.20	0.05	108.90
1982	58.76	274.57	0.00	333.33
1983	26.45	163.63	0.08	190.16
1984	20.92	113.83	0.63	135.39
1985	15.20	104.30	9.00	128.50
1986	13.35	107.87	0.03	121.24
1987	2.75	26.65	0.04	29.44
1988	5.93	53.10	0.41	59.45
1989	11.23	89.72	0.00	100.95
1990	10.78	94.50	0.07	105.35
1991	10.96	108.74	0.10	119.79
1992	12.27	131.16	1.19	144.62
1993	28.91	144.45	0.00	173.37
1994	17.82	116.95	1.73	136.50
1995	13.46	96.83	0.00	110.29
1996	5.38	49.91	0.80	56.09
1997	5.32	51.00	5.01	61.33
1998	4.48	51.96	0.17	56.61
1999	5.91	73.31	1.27	80.48
2000	8.44	102.35	2.20	113.00
2001	5.96	59.81	2.83	68.60
2002	8.96	56.85	2.65	68.46
2003	2.94	35.28	7.54	45.76
2004	4.63	36.60	14.85	56.08
2005	6.40	40.47	21.90	68.77
2006	3.96	55.31	12.75	72.02
2007	7.14	36.94	3.49	47.57
2008	4.70	41.35	0.00	46.05
2009	3.69	40.08	3.43	47.21
2010	3.96	43.40	2.54	49.91
2011	2.93	44.24	4.62	51.79
2012	13.58	52.77	5.17	71.52
2013	9.32	60.25	2.96	72.54
2014	21.99	64.73	1.32	88.05

Table 7.17. Estimated landings at age in gutted weight (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	0.00	0.00	0.00	0.00	0.01	0.04	0.11	0.18	0.22	0.23	0.22	0.21	0.20
1963	0.00	0.00	0.00	0.00	0.01	0.04	0.10	0.17	0.21	0.21	0.21	0.20	0.19
1964	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.06	0.07	0.06	0.06	0.06
1965	0.00	0.00	0.00	0.02	0.07	0.26	0.71	1.21	1.48	1.54	1.51	1.44	1.35
1966	0.00	0.00	0.00	0.00	0.01	0.05	0.13	0.23	0.28	0.29	0.28	0.27	0.25
1967	0.00	0.00	0.00	0.01	0.03	0.12	0.31	0.53	0.65	0.68	0.66	0.64	0.60
1968	0.00	0.00	0.00	0.00	0.02	0.07	0.19	0.32	0.39	0.41	0.40	0.39	0.37
1969	0.00	0.00	0.00	0.00	0.02	0.06	0.15	0.26	0.32	0.33	0.33	0.32	0.30
1970	0.00	0.00	0.00	0.01	0.03	0.11	0.30	0.52	0.63	0.66	0.65	0.62	0.59
1971	0.00	0.00	0.00	0.01	0.06	0.21	0.56	0.96	1.17	1.22	1.20	1.15	1.09
1972	0.00	0.00	0.00	0.01	0.03	0.12	0.33	0.57	0.69	0.72	0.71	0.68	0.65
1973	0.00	0.00	0.01	0.03	0.12	0.44	1.16	1.99	2.42	2.53	2.48	2.39	2.26
1974	0.00	0.00	0.01	0.06	0.27	0.99	2.65	4.52	5.50	5.72	5.63	5.40	5.12
1975	0.00	0.00	0.02	0.11	0.47	1.72	4.58	7.81	9.47	9.84	9.67	9.28	8.79
1976	0.00	0.00	0.02	0.11	0.46	1.69	4.51	7.66	9.25	9.59	9.40	9.02	8.54
1977	0.00	0.00	0.01	0.06	0.27	1.01	2.68	4.53	5.43	5.60	5.47	5.24	4.95
1978	0.00	0.00	0.02	0.13	0.59	2.16	5.72	9.54	11.36	11.66	11.35	10.83	10.23
1979	0.00	0.00	0.02	0.10	0.54	1.98	5.25	8.83	10.56	10.86	10.56	10.05	9.47
1980	0.00	0.01	0.04	0.20	0.83	3.92	10.34	17.21	20.45	20.96	20.36	19.33	18.15
1981	0.00	0.02	0.12	0.70	3.11	10.94	36.42	60.15	71.02	72.52	70.31	66.72	62.55
1982	0.01	0.07	0.41	2.29	11.53	41.92	100.70	198.90	223.70	222.88	213.91	202.24	189.38
1983	0.01	0.07	0.34	1.66	7.87	32.26	79.17	108.71	138.69	127.59	118.19	110.27	102.79
1984	0.01	0.06	0.47	1.73	6.67	25.47	70.94	100.99	90.85	95.48	81.86	73.76	67.86
1985	0.01	0.11	1.43	6.57	11.66	29.42	71.24	113.07	105.41	78.25	76.69	63.97	56.84
1986	0.01	0.06	0.46	2.38	11.79	31.90	73.92	113.34	120.28	92.79	64.26	61.28	50.41
1987	0.00	0.02	0.10	0.62	2.74	11.22	21.19	28.97	29.05	25.28	18.14	12.21	11.48
1988	0.01	0.06	0.30	1.06	5.36	19.29	55.38	63.59	59.45	50.16	40.96	28.64	19.02
1989	0.02	0.20	0.60	2.25	7.29	33.32	84.28	142.10	108.20	83.92	66.14	52.56	36.25
1990	0.01	0.16	1.49	3.80	12.15	31.74	95.70	134.63	144.12	89.12	64.10	49.08	38.45
1991	0.02	0.12	1.42	10.72	23.49	59.89	99.38	158.54	136.48	116.66	66.53	46.42	35.02
1992	0.03	0.20	1.27	11.75	71.83	119.53	178.86	142.51	129.11	85.65	66.74	36.79	25.27
1993	0.04	0.29	1.65	8.01	63.82	302.38	273.19	172.38	69.43	45.65	27.04	20.25	10.97
1994	0.05	0.27	1.67	7.43	27.55	157.65	396.30	142.45	41.48	11.48	6.61	3.74	2.75
1995	0.03	0.35	1.35	6.12	24.16	74.13	244.41	266.57	48.03	10.04	2.47	1.37	0.76
1996	0.01	0.13	1.35	4.08	14.39	43.15	79.93	124.84	72.61	9.65	1.81	0.43	0.23
1997	0.01	0.11	1.50	10.03	18.28	48.00	90.30	87.46	81.86	37.52	4.58	0.83	0.19
1998	0.01	0.09	0.43	3.07	20.33	44.02	87.67	92.17	54.80	40.75	17.18	2.03	0.36
1999	0.03	0.14	0.84	3.20	17.30	89.02	121.46	126.80	80.58	37.98	25.98	10.62	1.24
2000	0.04	0.37	1.58	6.07	17.93	80.65	254.15	169.85	101.51	49.84	21.43	14.17	5.70
2001	0.03	0.27	2.20	5.69	15.53	38.26	107.36	162.87	59.04	26.29	11.62	4.81	3.13
2002	0.03	0.25	2.13	9.43	19.11	49.64	81.54	117.69	104.27	29.38	11.96	5.11	2.08
2003	0.01	0.18	2.29	10.00	23.59	35.95	59.59	51.40	43.87	30.31	7.81	3.08	1.30
2004	0.02	0.22	3.15	12.98	27.49	59.54	67.78	66.01	36.69	25.48	16.33	4.09	1.59
2005	0.01	0.29	4.04	15.32	28.52	60.08	109.71	78.96	51.37	23.59	15.27	9.52	2.35
2006	0.01	0.19	2.71	9.47	19.07	46.70	104.35	135.23	68.06	37.16	15.98	10.08	6.20
2007	0.00	0.06	0.83	3.63	8.53	24.16	58.48	87.70	77.60	32.48	16.56	6.93	4.31
2008	0.01	0.03	0.21	1.32	6.08	19.62	48.73	76.24	78.82	58.64	23.02	11.44	4.72
2009	0.01	0.06	0.54	2.32	7.36	21.56	44.95	66.15	69.72	60.21	41.93	16.03	7.86
2010	0.01	0.06	0.57	1.80	5.16	19.39	49.07	66.67	68.07	60.46	49.00	33.26	12.55
2011	0.01	0.07	0.87	3.29	5.59	15.39	45.06	71.94	67.24	57.73	48.10	37.99	25.44
2012	0.01	0.09	1.05	4.07	9.41	19.45	48.01	92.34	102.15	80.38	64.75	52.56	40.95
2013	0.01	0.08	0.77	3.18	8.87	25.81	46.62	74.18	98.14	91.25	67.34	52.86	42.34
2014	0.01	0.09	0.66	2.96	10.47	33.93	78.22	86.05	91.58	100.68	87.47	62.84	48.65

Table 7.17. (Continued) Estimated landings at age in gutted weight (1000 lb)

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.18	0.17	0.16	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.64
1963	0.17	0.16	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.61
1964	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.19
1965	1.26	1.17	1.07	0.98	0.90	0.82	0.74	0.67	0.61	0.55	0.50	4.44
1966	0.24	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.11	0.10	0.09	0.83
1967	0.56	0.52	0.48	0.44	0.40	0.37	0.33	0.30	0.27	0.25	0.22	1.98
1968	0.34	0.32	0.29	0.27	0.25	0.22	0.20	0.19	0.17	0.15	0.14	1.22
1969	0.28	0.26	0.24	0.22	0.20	0.18	0.17	0.15	0.14	0.12	0.11	1.00
1970	0.56	0.52	0.48	0.44	0.40	0.37	0.33	0.30	0.27	0.25	0.22	1.99
1971	1.03	0.96	0.89	0.82	0.75	0.68	0.62	0.56	0.51	0.46	0.42	3.70
1972	0.61	0.57	0.53	0.49	0.45	0.41	0.37	0.34	0.31	0.28	0.25	2.22
1973	2.13	1.98	1.84	1.70	1.57	1.44	1.31	1.19	1.08	0.97	0.88	7.82
1974	4.81	4.49	4.17	3.86	3.56	3.27	2.98	2.71	2.46	2.22	2.01	17.86
1975	8.26	7.72	7.17	6.63	6.11	5.61	5.14	4.69	4.26	3.85	3.48	30.95
1976	8.02	7.49	6.96	6.44	5.93	5.45	5.00	4.57	4.16	3.77	3.41	30.33
1977	4.65	4.34	4.03	3.73	3.44	3.16	2.90	2.65	2.42	2.20	1.99	17.74
1978	9.60	8.95	8.31	7.69	7.09	6.51	5.97	5.47	5.00	4.55	4.14	36.89
1979	8.87	8.26	7.67	7.09	6.53	6.01	5.51	5.04	4.61	4.21	3.83	34.32
1980	16.95	15.77	14.63	13.51	12.45	11.44	10.50	9.61	8.78	8.01	7.31	65.93
1981	58.23	54.03	50.01	46.18	42.52	39.06	35.83	32.80	29.98	27.36	24.94	226.75
1982	175.98	162.75	150.21	138.45	127.40	116.99	107.21	98.15	89.71	81.89	74.66	683.30
1983	95.39	88.05	81.01	74.45	68.39	62.76	57.50	52.59	48.07	43.89	40.02	368.48
1984	62.69	57.80	53.07	48.62	44.53	40.79	37.35	34.15	31.19	28.47	25.97	240.44
1985	51.83	47.57	43.62	39.89	36.42	33.26	30.40	27.78	25.36	23.14	21.10	196.37
1986	44.39	40.21	36.71	33.52	30.55	27.81	25.35	23.12	21.09	19.24	17.53	163.89
1987	9.36	8.19	7.38	6.71	6.10	5.55	5.04	4.58	4.17	3.80	3.46	32.51
1988	17.73	14.36	12.50	11.21	10.16	9.22	8.36	7.58	6.88	6.26	5.70	53.62
1989	23.87	22.09	17.80	15.42	13.79	12.46	11.28	10.21	9.24	8.38	7.62	71.80
1990	26.28	17.18	15.82	12.69	10.96	9.78	8.81	7.96	7.20	6.51	5.89	55.55
1991	27.18	18.45	12.00	11.01	8.80	7.58	6.74	6.07	5.47	4.94	4.46	41.92
1992	18.88	14.56	9.83	6.37	5.82	4.64	3.99	3.54	3.18	2.87	2.58	24.13
1993	7.46	5.54	4.25	2.86	1.84	1.68	1.34	1.15	1.02	0.91	0.82	7.61
1994	1.48	1.00	0.74	0.56	0.38	0.24	0.22	0.18	0.15	0.13	0.12	1.09
1995	0.55	0.29	0.20	0.15	0.11	0.07	0.05	0.04	0.03	0.03	0.03	0.24
1996	0.13	0.09	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.04
1997	0.10	0.06	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.02
1998	0.08	0.05	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01
1999	0.22	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01
2000	0.66	0.12	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2001	1.25	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	1.34	0.53	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.52	0.33	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.66	0.27	0.17	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.90	0.37	0.15	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	1.52	0.58	0.24	0.09	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2007	2.63	0.64	0.24	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2008	2.91	1.76	0.43	0.16	0.07	0.03	0.02	0.01	0.00	0.00	0.00	0.00
2009	3.22	1.97	1.19	0.29	0.11	0.04	0.02	0.01	0.00	0.00	0.00	0.00
2010	6.10	2.48	1.51	0.91	0.22	0.08	0.03	0.01	0.01	0.00	0.00	0.00
2011	9.51	4.59	1.86	1.13	0.67	0.16	0.06	0.02	0.01	0.01	0.00	0.00
2012	27.18	10.10	4.85	1.95	1.18	0.70	0.17	0.06	0.03	0.01	0.01	0.00
2013	32.70	21.56	7.97	3.81	1.53	0.92	0.55	0.13	0.05	0.02	0.01	0.01
2014	38.62	29.63	19.43	7.15	3.41	1.36	0.82	0.49	0.12	0.04	0.02	0.01

Table 7.18. Estimated total landings at age in numbers (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.02
1963	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.02	0.02	0.02	0.02
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1965	0.00	0.00	0.00	0.01	0.02	0.05	0.12	0.17	0.19	0.18	0.16	0.14	0.13
1966	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.02
1967	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.08	0.08	0.08	0.07	0.06	0.06
1968	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.05	0.05	0.04	0.04	0.03
1969	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.04	0.03	0.03	0.03
1970	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.07	0.08	0.08	0.07	0.06	0.06
1971	0.00	0.00	0.00	0.00	0.01	0.04	0.09	0.14	0.15	0.14	0.13	0.11	0.10
1972	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.08	0.09	0.08	0.08	0.07	0.06
1973	0.00	0.00	0.00	0.01	0.03	0.09	0.19	0.28	0.30	0.29	0.26	0.24	0.21
1974	0.00	0.00	0.01	0.02	0.07	0.20	0.44	0.64	0.69	0.65	0.59	0.54	0.48
1975	0.00	0.00	0.01	0.04	0.12	0.34	0.76	1.11	1.19	1.12	1.02	0.92	0.83
1976	0.00	0.00	0.01	0.04	0.12	0.34	0.74	1.09	1.16	1.10	0.99	0.90	0.81
1977	0.00	0.00	0.01	0.02	0.07	0.20	0.44	0.64	0.68	0.64	0.58	0.52	0.47
1978	0.00	0.00	0.01	0.05	0.15	0.43	0.94	1.35	1.43	1.33	1.20	1.08	0.97
1979	0.00	0.00	0.01	0.03	0.14	0.40	0.87	1.25	1.33	1.24	1.12	1.00	0.89
1980	0.00	0.01	0.02	0.07	0.21	0.78	1.70	2.44	2.57	2.39	2.15	1.92	1.71
1981	0.01	0.02	0.07	0.25	0.80	2.19	6.00	8.52	8.93	8.28	7.43	6.63	5.90
1982	0.03	0.08	0.23	0.82	2.96	8.38	16.60	28.19	28.12	25.46	22.62	20.09	17.88
1983	0.02	0.08	0.19	0.59	2.02	6.45	13.05	15.41	17.43	14.57	12.50	10.95	9.70
1984	0.02	0.06	0.27	0.62	1.71	5.09	11.69	14.31	11.42	10.91	8.66	7.33	6.41
1985	0.02	0.12	0.80	2.35	2.99	5.88	11.74	16.02	13.25	8.94	8.11	6.35	5.37
1986	0.03	0.06	0.26	0.85	3.02	6.38	12.18	16.06	15.12	10.60	6.79	6.09	4.76
1987	0.01	0.02	0.05	0.22	0.70	2.24	3.49	4.11	3.65	2.89	1.92	1.21	1.08
1988	0.04	0.06	0.17	0.38	1.37	3.86	9.13	9.01	7.47	5.73	4.33	2.84	1.80
1989	0.05	0.21	0.34	0.80	1.87	6.66	13.89	20.14	13.60	9.58	6.99	5.22	3.42
1990	0.03	0.17	0.83	1.36	3.12	6.34	15.77	19.08	18.12	10.18	6.78	4.87	3.63
1991	0.05	0.13	0.80	3.83	6.03	11.97	16.38	22.47	17.16	13.32	7.03	4.61	3.31
1992	0.08	0.22	0.71	4.20	18.43	23.89	29.48	20.20	16.23	9.78	7.06	3.65	2.39
1993	0.12	0.31	0.93	2.86	16.37	60.44	45.03	24.43	8.73	5.21	2.86	2.01	1.04
1994	0.15	0.29	0.94	2.66	7.07	31.51	65.32	20.19	5.21	1.31	0.70	0.37	0.26
1995	0.08	0.38	0.76	2.19	6.20	14.82	40.29	37.78	6.04	1.15	0.26	0.14	0.07
1996	0.03	0.13	0.76	1.46	3.69	8.63	13.17	17.69	9.13	1.10	0.19	0.04	0.02
1997	0.04	0.12	0.84	3.58	4.69	9.59	14.88	12.39	10.29	4.29	0.48	0.08	0.02
1998	0.04	0.09	0.24	1.10	5.22	8.80	14.45	13.06	6.89	4.65	1.82	0.20	0.03
1999	0.08	0.15	0.47	1.14	4.44	17.79	20.02	17.97	10.13	4.34	2.75	1.05	0.12
2000	0.12	0.39	0.89	2.17	4.60	16.12	41.89	24.07	12.76	5.69	2.27	1.41	0.54
2001	0.08	0.29	1.23	2.03	3.98	7.65	17.70	23.08	7.42	3.00	1.23	0.48	0.30
2002	0.08	0.27	1.19	3.37	4.90	9.92	13.44	16.68	13.11	3.36	1.26	0.51	0.20
2003	0.04	0.20	1.28	3.57	6.05	7.19	9.82	7.28	5.51	3.46	0.83	0.31	0.12
2004	0.05	0.24	1.77	4.63	7.05	11.90	11.17	9.35	4.61	2.91	1.73	0.41	0.15
2005	0.04	0.31	2.27	5.47	7.32	12.01	18.08	11.19	6.46	2.69	1.61	0.95	0.22
2006	0.03	0.20	1.52	3.38	4.89	9.33	17.20	19.16	8.56	4.24	1.69	1.00	0.58
2007	0.01	0.06	0.47	1.30	2.19	4.83	9.64	12.43	9.76	3.71	1.75	0.69	0.41
2008	0.02	0.03	0.12	0.47	1.56	3.92	8.03	10.80	9.91	6.70	2.43	1.14	0.45
2009	0.02	0.07	0.30	0.83	1.89	4.31	7.41	9.37	8.76	6.88	4.43	1.59	0.74
2010	0.02	0.06	0.32	0.64	1.32	3.88	8.09	9.45	8.56	6.91	5.18	3.30	1.18
2011	0.02	0.08	0.49	1.18	1.44	3.08	7.43	10.20	8.45	6.59	5.09	3.77	2.40
2012	0.02	0.10	0.59	1.45	2.42	3.89	7.91	13.09	12.84	9.18	6.85	5.22	3.87
2013	0.02	0.09	0.43	1.14	2.27	5.16	7.68	10.51	12.34	10.42	7.12	5.25	4.00
2014	0.03	0.09	0.37	1.06	2.69	6.78	12.89	12.19	11.51	11.50	9.25	6.24	4.59

Table 7.18. (Continued) Estimated total landings at age in numbers (1000 fish)

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
1963	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1965	0.11	0.10	0.09	0.08	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.34
1966	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06
1967	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.15
1968	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.09
1969	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.08
1970	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.15
1971	0.09	0.08	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.28
1972	0.06	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.17
1973	0.19	0.17	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.60
1974	0.44	0.39	0.36	0.32	0.29	0.26	0.24	0.21	0.19	0.17	0.15	1.37
1975	0.75	0.68	0.61	0.55	0.50	0.45	0.41	0.37	0.33	0.30	0.27	2.37
1976	0.73	0.66	0.59	0.54	0.48	0.44	0.40	0.36	0.32	0.29	0.26	2.32
1977	0.42	0.38	0.34	0.31	0.28	0.25	0.23	0.21	0.19	0.17	0.15	1.36
1978	0.87	0.78	0.71	0.64	0.58	0.52	0.47	0.43	0.39	0.35	0.32	2.82
1979	0.80	0.72	0.65	0.59	0.53	0.48	0.44	0.40	0.36	0.33	0.29	2.63
1980	1.54	1.38	1.25	1.12	1.02	0.92	0.83	0.76	0.68	0.62	0.56	5.04
1981	5.27	4.73	4.26	3.84	3.47	3.14	2.84	2.58	2.34	2.12	1.92	17.35
1982	15.94	14.25	12.79	11.52	10.41	9.41	8.51	7.71	6.99	6.33	5.74	52.28
1983	8.64	7.71	6.90	6.20	5.59	5.05	4.57	4.13	3.74	3.39	3.08	28.19
1984	5.68	5.06	4.52	4.05	3.64	3.28	2.97	2.68	2.43	2.20	2.00	18.40
1985	4.69	4.16	3.71	3.32	2.97	2.68	2.41	2.18	1.98	1.79	1.62	15.02
1986	4.02	3.52	3.13	2.79	2.50	2.24	2.01	1.82	1.64	1.49	1.35	12.54
1987	0.85	0.72	0.63	0.56	0.50	0.45	0.40	0.36	0.33	0.29	0.27	2.49
1988	1.61	1.26	1.06	0.93	0.83	0.74	0.66	0.60	0.54	0.48	0.44	4.10
1989	2.16	1.93	1.52	1.28	1.13	1.00	0.90	0.80	0.72	0.65	0.59	5.49
1990	2.38	1.50	1.35	1.06	0.90	0.79	0.70	0.63	0.56	0.50	0.45	4.25
1991	2.46	1.62	1.02	0.92	0.72	0.61	0.54	0.48	0.43	0.38	0.34	3.21
1992	1.71	1.27	0.84	0.53	0.48	0.37	0.32	0.28	0.25	0.22	0.20	1.85
1993	0.68	0.48	0.36	0.24	0.15	0.14	0.11	0.09	0.08	0.07	0.06	0.58
1994	0.13	0.09	0.06	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.08
1995	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02
1996	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.12	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.06	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.08	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.14	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.24	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.26	0.15	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	0.29	0.17	0.10	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.55	0.22	0.13	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.86	0.40	0.16	0.09	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2012	2.46	0.88	0.41	0.16	0.10	0.06	0.01	0.00	0.00	0.00	0.00	0.00
2013	2.96	1.89	0.68	0.32	0.12	0.07	0.04	0.01	0.00	0.00	0.00	0.00
2014	3.50	2.59	1.65	0.60	0.28	0.11	0.07	0.04	0.01	0.00	0.00	0.00

Table 7.19. Estimated status indicators, benchmarks, and related quantities from the Beaufort catch-age model, conditional on estimated current selectivities averaged across fisheries. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of metric tons or gutted pounds, as indicated. Spawning stock biomass (SSB) and minimum stock size threshold (MSST) are measured by total gonad weight of mature females. Symbols, abbreviations, and acronyms are listed in Appendix A.*

Quantity	Units	Estimate
MSST	mt	16.45
F_{MSY}	y^{-1}	0.24
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.20
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.18
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.15
MSY	1000 lb	560
$Yat85\%F_{MSY}$	1000 lb	557
$Yat75\%F_{MSY}$	1000 lb	551
$Yat65\%F_{MSY}$	1000 lb	540
B_{MSY}	mt	2574
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	21.93
R_{MSY}	1000 age-1 fish	327
$F_{30\%}$	y^{-1}	0.17
$F_{40\%}$	y^{-1}	0.11
$F_{50\%}$	y^{-1}	0.08
$F_{2012-2014}$	—	0.29
$F_{2012-2014}/F_{\mathrm{MSY}}$	—	1.22
F_{2014}	y^{-1}	0.36
$F_{2014}/F_{\mathrm{MSY}}$	—	1.53
SSB_{2014}	mt	18.65
SSB_{2014}/MSST	—	1.13
$SSB_{2014}/\mathrm{SSB}_{\mathrm{MSY}}$	—	0.85

Table 7.20. Results from sensitivity runs of the Beaufort catch-at-age model. Current F represented by geometric mean of last three assessment years. See text for full description of sensitivity runs. Fleet abbreviations include rA for recreational, cH for commercial handline, and cL for commercial longline.

Run	Description	F_{MSY}	SSB_{MSY} (mt)	MSY(1000 lb gutted)	$F_{2012-2014}/F_{\text{MSY}}$	SSB/MSST
Base	Base Run	0.24	21.93	560	1.22	1.13
Run1	SEDAR-25 multinomial likelihood	0.19	23.79	587	0.70	1.94
Run2	rA=cH selectivity	0.23	22.28	578	1.05	1.29
Run3	’96, ’98, and ’99 cL age comps included	0.24	21.99	561	1.18	1.18
Run4	Retrospective 2013	0.25	21.67	552	1.22	1.00
Run5	Retrospective 2012	0.24	22.09	562	0.90	1.18
Run6	Retrospective 2011	0.23	22.02	560	0.76	1.20
Run7	Retrospective 2010	0.22	21.90	562	0.67	1.24
Run8	Retrospective 2009	0.21	21.82	557	0.70	1.15
Run9	Retrospective 2008	0.23	21.40	550	0.98	0.96
Run10	Retrospective 2007	0.21	21.54	530	1.33	0.80
Run11	Retrospective 2006	0.17	21.82	512	1.27	0.79

Table 7.21. Projection results with fishing mortality rate fixed at F = Fcurrent starting in 2017. R = number of age-1 recruits (in 1000s), N = total stock abundance (1000 fish), F = fishing mortality rate (per year), S = spawning stock (mt), B = total stock biomass (mt),L = landings expressed in numbers (1000 fish) and gutted weight (w, in 1000 lb*), and pr.75=proportion of stochastic projection replicates with* SSB ≥ MSST *using the 75% definition of MSST. 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	N.b	N.med	F.b	F.med	S.b(mt)	S.med(mt)	B.b(mt)	B.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	pr.75
2015	316	313	1457	1517	0.2889	0.2632	18	18	2238	2294	69	66	537	524	0.5012
2016	314	307	1460	1514	0.2889	0.2632	18	18	2248	2290	69	66	534	509	0.4988
2017	313	309	1462	1512	0.2889	0.2632	18	18	2259	2283	70	66	537	506	0.4976
2018	314	305	1464	1509	0.2889	0.2632	18	18	2270	2282	71	66	543	508	0.4956
2019	314	309	1465	1513	0.2889	0.2632	18	18	2277	2278	72	67	548	511	0.4938
2020	314	305	1466	1502	0.2889	0.2632	18	18	2281	2274	72	67	552	513	0.4939
2021	314	306	1466	1500	0.2889	0.2632	18	18	2283	2268	72	67	554	512	0.4927
2022	314	303	1466	1496	0.2889	0.2632	18	18	2284	2261	72	67	555	511	0.4918
2023	314	305	1466	1500	0.2889	0.2632	18	18	2284	2255	72	67	555	509	0.4898
2024	314	301	1467	1490	0.2889	0.2632	18	18	2284	2248	72	66	555	506	0.4877

Table 7.22. Projection results with fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$ starting in 2017. R = number of age-1 recruits (in 1000s), N = total stock abundance (1000 fish), F = fishing mortality rate (per year), S = spawning stock (mt), B = total stock biomass (mt),L = landings expressed in numbers (1000 fish) and gutted weight (w, in 1000 lb*), and pr.75=proportion of stochastic projection replicates with* SSB $\geq$ MSST *using the 75% definition of MSST. 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	N.b	N.med	F.b	F.med	S.b(mt)	S.med(mt)	B.b(mt)	B.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	pr.75
2015	316	314	1457	1519	0.2889	0.2652	18	18	2238	2313	69	66	537	522	0.5012
2016	314	309	1460	1520	0.2889	0.2652	18	18	2248	2303	69	65	534	510	0.4964
2017	313	308	1462	1524	0.2358	0.2157	18	18	2259	2302	58	48	448	376	0.5138
2018	315	313	1476	1525	0.2358	0.2157	19	18	2315	2303	61	52	469	404	0.5471
2019	317	315	1488	1537	0.2358	0.2157	19	18	2359	2309	63	55	487	427	0.5816
2020	319	319	1499	1547	0.2358	0.2157	20	18	2392	2322	65	57	502	444	0.6154
2021	320	317	1507	1555	0.2358	0.2157	20	18	2418	2330	66	59	513	459	0.6446
2022	321	323	1515	1564	0.2358	0.2157	20	19	2439	2338	66	59	520	468	0.6702
2023	322	324	1522	1568	0.2358	0.2157	21	19	2455	2351	67	60	525	473	0.6923
2024	323	325	1527	1579	0.2358	0.2157	21	19	2470	2361	67	60	529	477	0.7127

Table 7.23. Projection results with fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$ starting in 2017. R = number of age-1 recruits (in 1000s), N = total stock abundance (1000 fish), F = fishing mortality rate (per year), S = spawning stock (mt), B = total stock biomass (mt),L = landings expressed in numbers (1000 fish) and gutted weight (w, in 1000 lb*), and pr.75=proportion of stochastic projection replicates with* SSB $\geq$ MSST *using the 75% definition of MSST. 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	N.b	N.med	F.b	F.med	S.b(mt)	S.med(mt)	B.b(mt)	B.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	pr.75
2015	316	311	1457	1507	0.2889	0.2644	18	18	2238	2285	69	66	537	522	0.5016
2016	314	303	1460	1506	0.2889	0.2644	18	18	2248	2286	69	66	534	511	0.4976
2017	313	306	1462	1505	0.1768	0.1611	19	18	2259	2283	45	37	344	286	0.5204
2018	316	310	1490	1530	0.1768	0.1611	20	19	2367	2353	48	41	374	323	0.5741
2019	320	315	1516	1551	0.1768	0.1611	21	19	2457	2392	51	45	402	356	0.6300
2020	324	320	1538	1574	0.1768	0.1611	22	20	2532	2428	54	48	426	380	0.6798
2021	326	324	1558	1590	0.1768	0.1611	23	21	2593	2464	56	49	445	398	0.7208
2022	329	328	1576	1606	0.1768	0.1611	23	21	2645	2500	57	51	460	411	0.7573
2023	330	326	1592	1621	0.1768	0.1611	24	22	2689	2537	58	52	471	420	0.7911
2024	332	332	1605	1634	0.1768	0.1611	24	22	2728	2569	59	52	480	428	0.8219

Table 7.24. Projection results with fishing mortality rate fixed at $P = 0.35$ starting in 2017. R = number of age-1 recruits (in 1000s), N = total stock abundance (1000 fish), F = fishing mortality rate (per year), S = spawning stock (mt), B = total stock biomass (mt),L = landings expressed in numbers (1000 fish) and gutted weight (w, in 1000 lb), and pr.75=proportion of stochastic projection replicates with SSB $\geq$ MSST using the 75% definition of MSST. All values except year and probabilities are medians from the stochastic projections.*

Year	R	N	F	S(mt)	B(mt)	L(n)	L(w)	pr.75
2015	316	1517	0.2642	19	2302	66	524	0.5058
2016	307	1514	0.2642	18	2301	66	511	0.5040
2017	307	1509	0.1507	19	2293	35	273	0.5266
2018	311	1535	0.1507	19	2367	39	304	0.5740
2019	320	1561	0.1507	20	2423	43	334	0.6329
2020	322	1583	0.1507	20	2472	45	359	0.6911
2021	326	1605	0.1507	21	2515	47	380	0.7398
2022	329	1622	0.1507	22	2553	48	394	0.7808
2023	330	1648	0.1507	23	2587	50	405	0.8172
2024	337	1663	0.1507	23	2625	50	415	0.8460

Table 7.25. Projection results with fishing mortality rate fixed at $P* = 0.5$ *starting in 2017. R = number of age-1 recruits (in 1000s), N = total stock abundance (1000 fish), F = fishing mortality rate (per year), S = spawning stock (mt), B = total stock biomass (mt),L = landings expressed in numbers (1000 fish) and gutted weight (w, in 1000* lb*), and pr.75=proportion of stochastic projection replicates with* SSB $\geq$ MSST *using the 75% definition of MSST. All values except year and probabilities are medians from the stochastic projections.*

Year	R	N	F	S(mt)	B(mt)	L(n)	L(w)	pr.75
2015	311	1514	0.2651	18	2301	67	523	0.4986
2016	310	1516	0.2651	18	2294	66	510	0.4926
2017	307	1516	0.2162	18	2288	48	377	0.5055
2018	309	1519	0.2162	18	2297	52	402	0.5385
2019	314	1530	0.2162	18	2295	55	426	0.5740
2020	321	1545	0.2162	18	2301	57	441	0.6076
2021	320	1555	0.2162	18	2313	58	455	0.6387
2022	322	1561	0.2162	19	2324	59	466	0.6670
2023	321	1566	0.2162	19	2337	59	471	0.6899
2024	324	1580	0.2162	19	2345	60	476	0.7118

8 Figures

Figure 8.1. Mean length at age (mm) and estimated 95% confidence interval of the population.

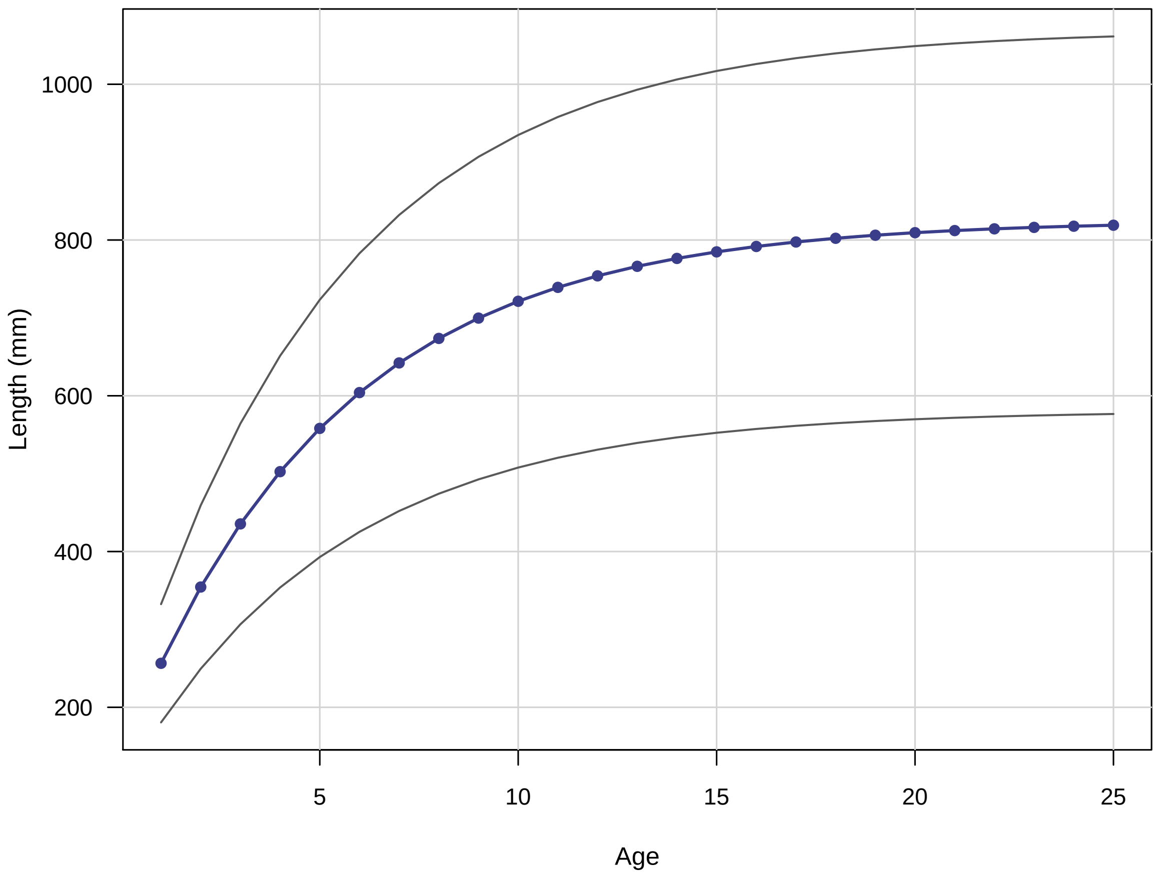


Figure 8.2. Observed (open circles) and estimated (line, solid circles) commercial handline landings (1000 lb gutted weight).

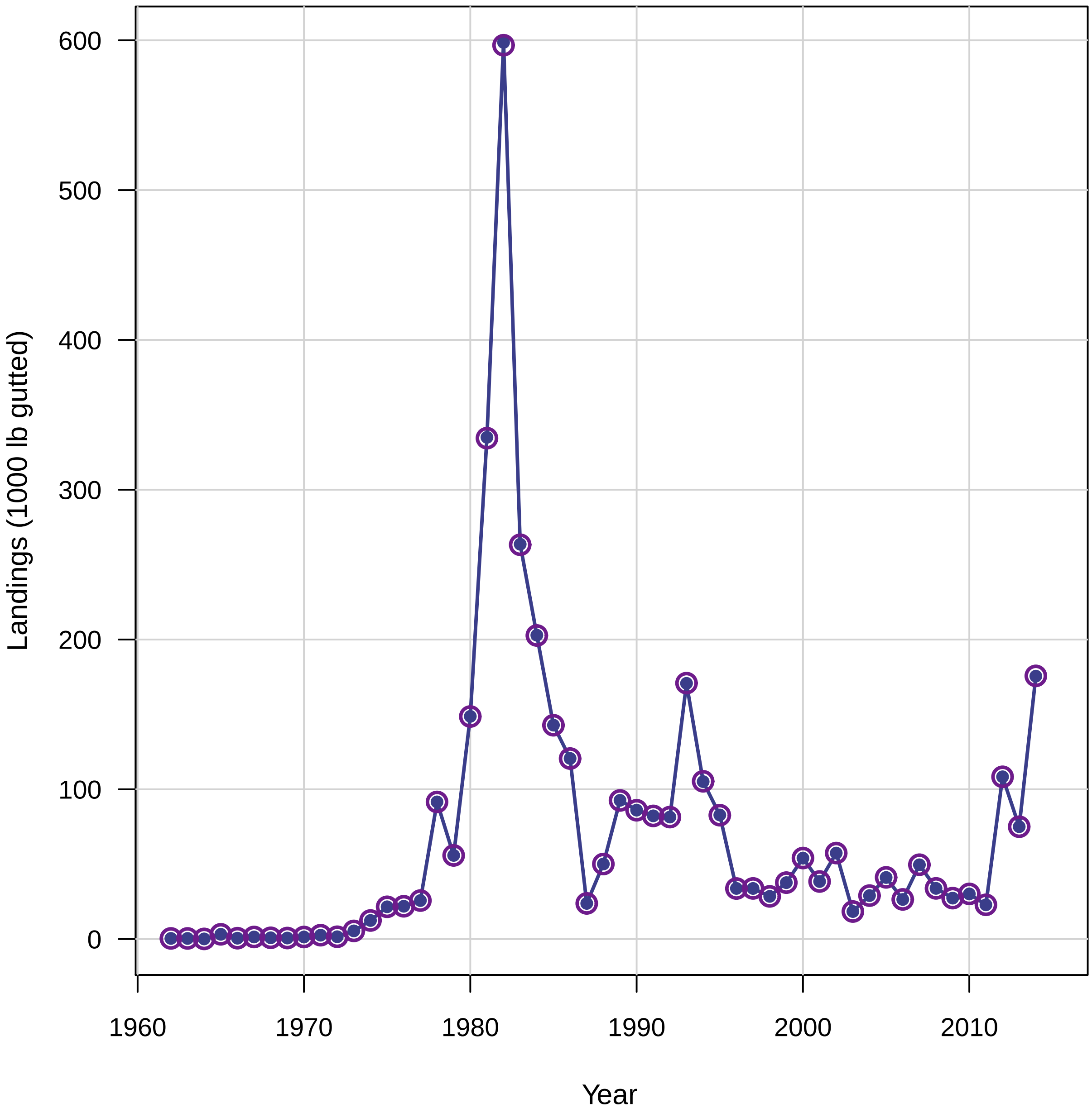


Figure 8.3. Observed (open circles) and estimated (line, solid circles) commercial longline landings (1000 lb gutted weight).

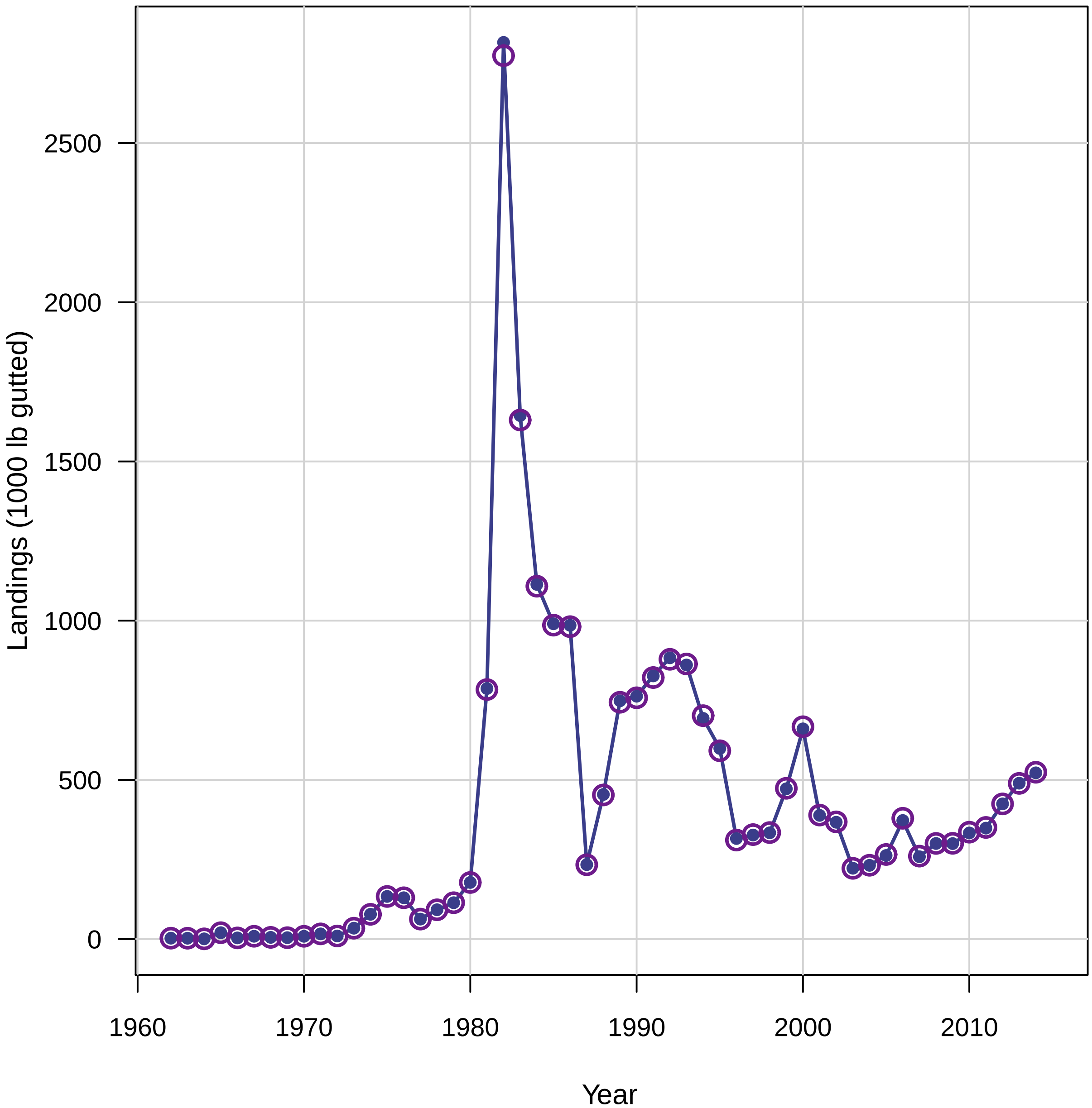


Figure 8.4. Observed (open circles) and estimated (line, solid circles) recreational landings (1000 whole lbs).

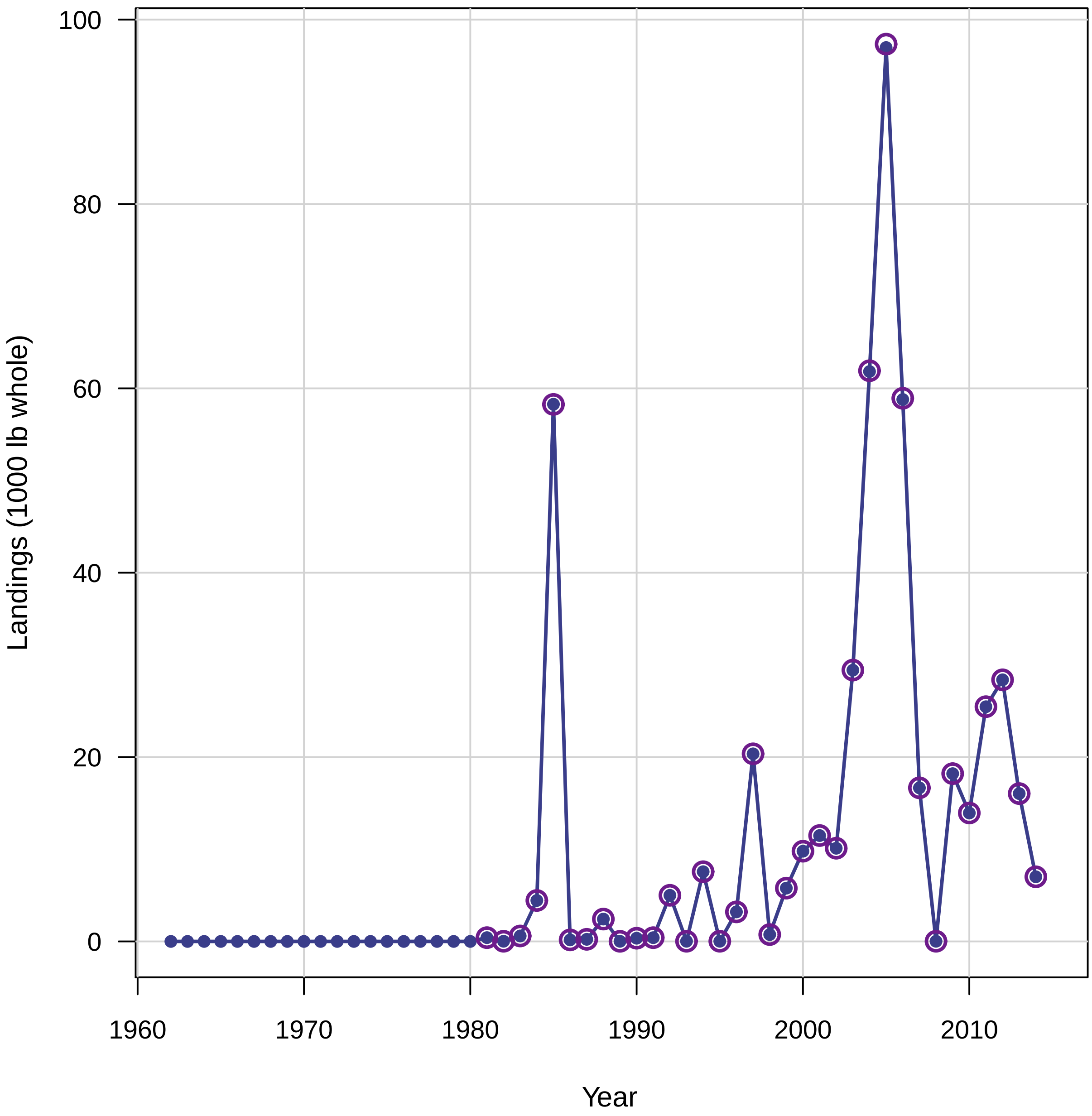


Figure 8.5. Observed (open circles) and estimated (line, solid circles) index of abundance from the commercial longline fishery.

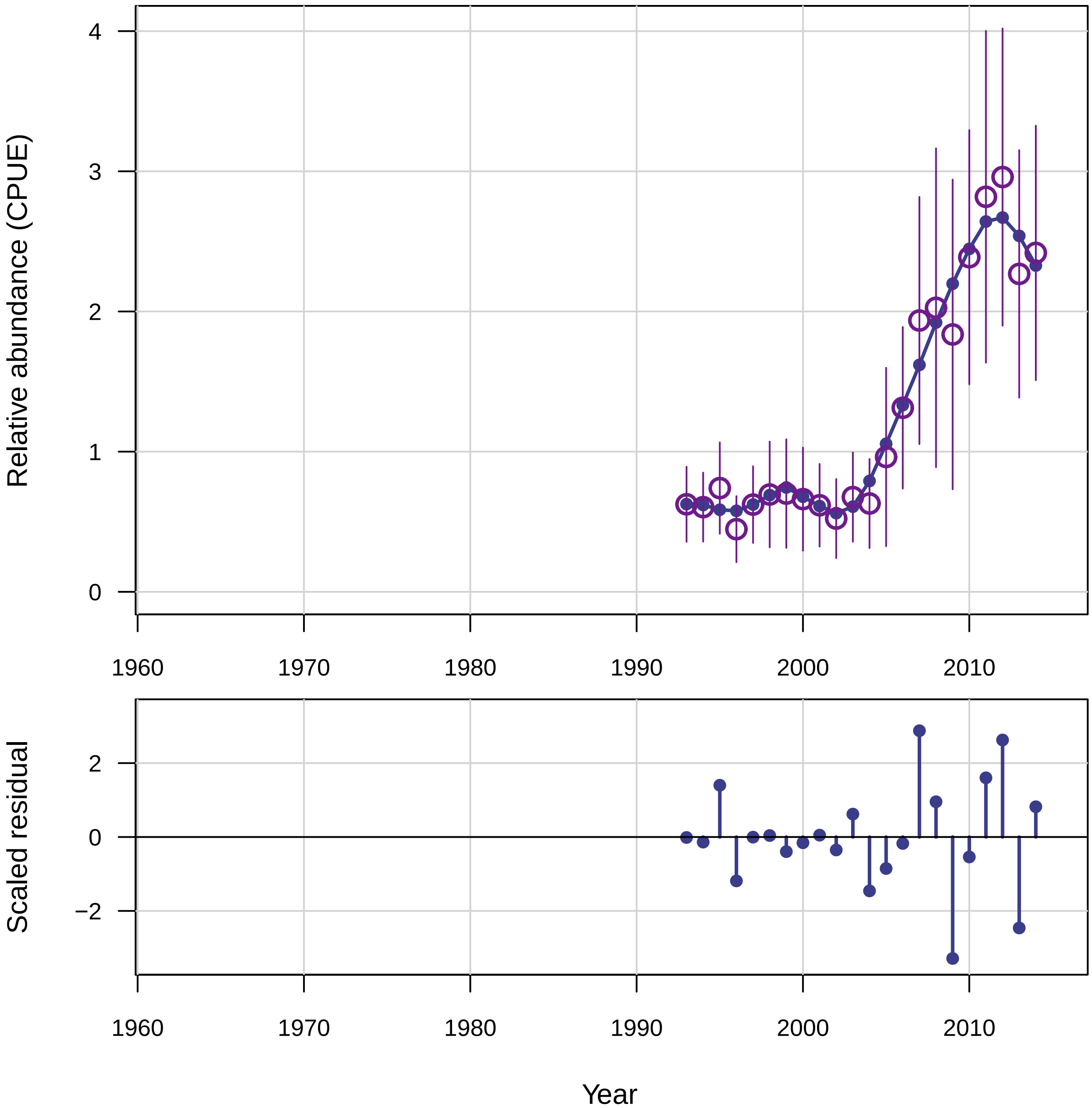


Figure 8.6. Observed (open circles) and estimated (solid circles) index of abundance from the MARMAP horizontal longline survey.

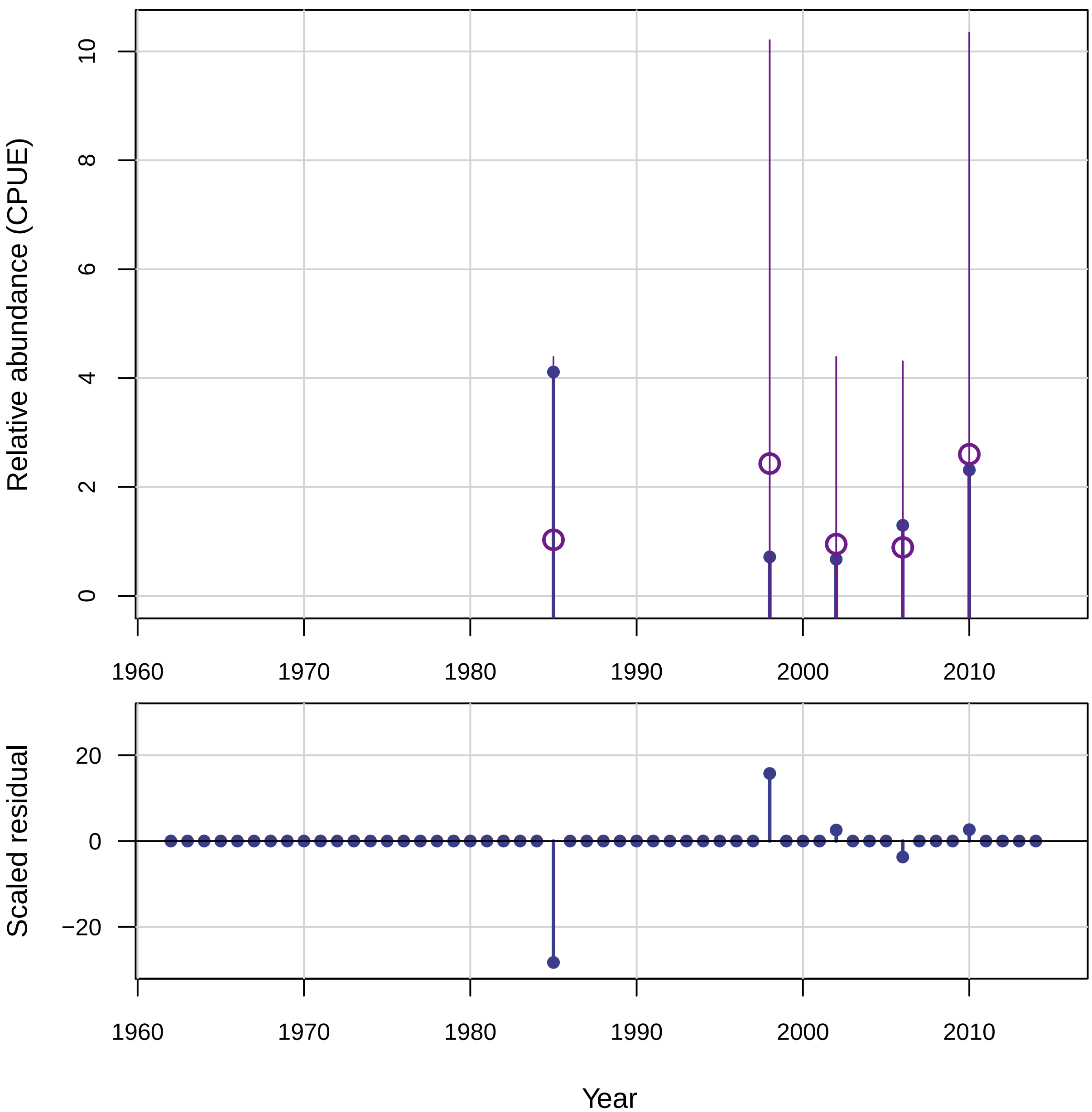


Figure 8.7. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cH to commercial handline, cL to commercial longline, rA to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

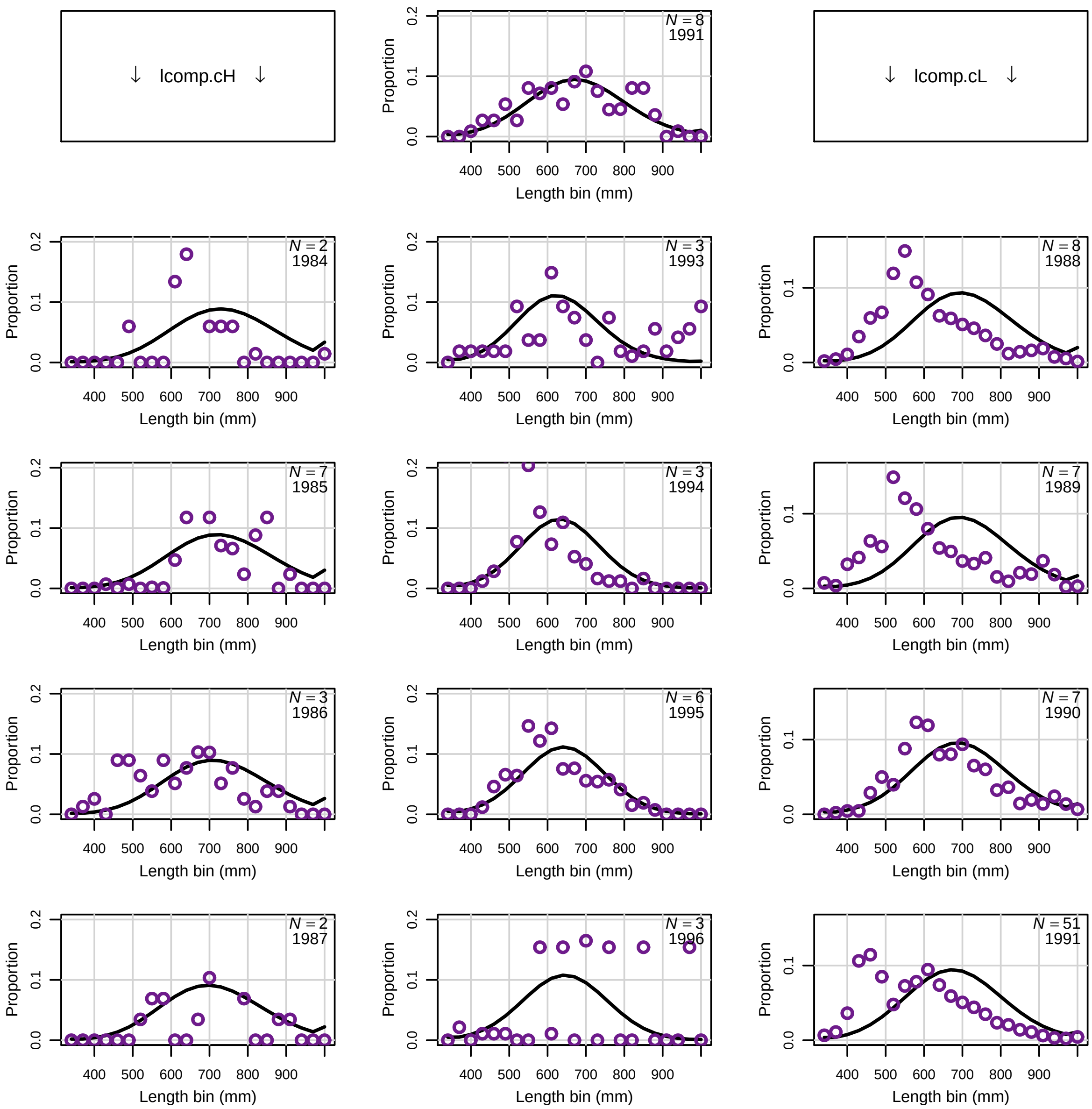


Figure 8.7. (Continued) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cH to commercial handline, cL to commercial longline, rA to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

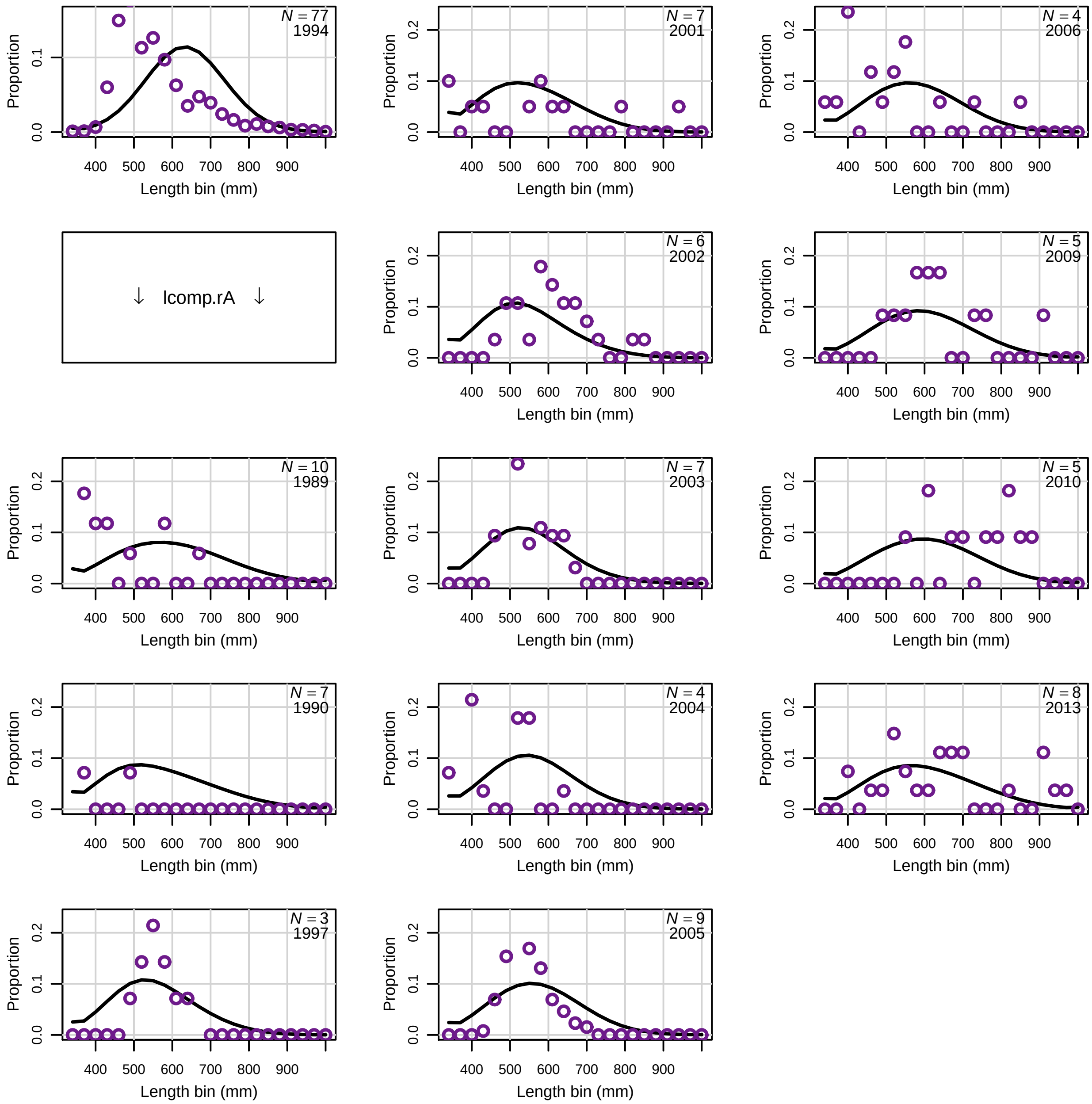


Figure 8.7. (Continued) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cH to commercial handline, cL to commercial longline, rA to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

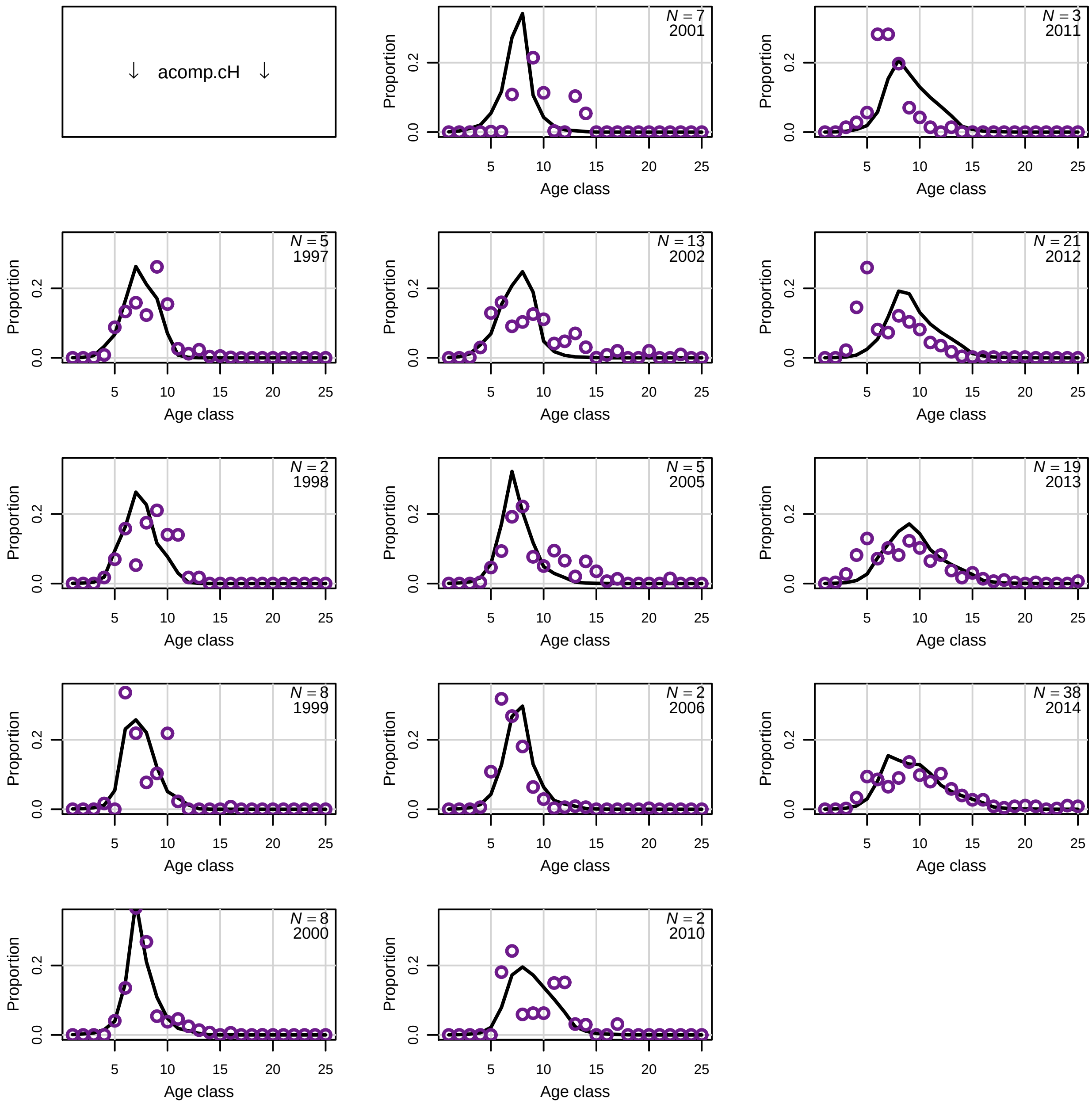


Figure 8.7. (Continued) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cH to commercial handline, cL to commercial longline, rA to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

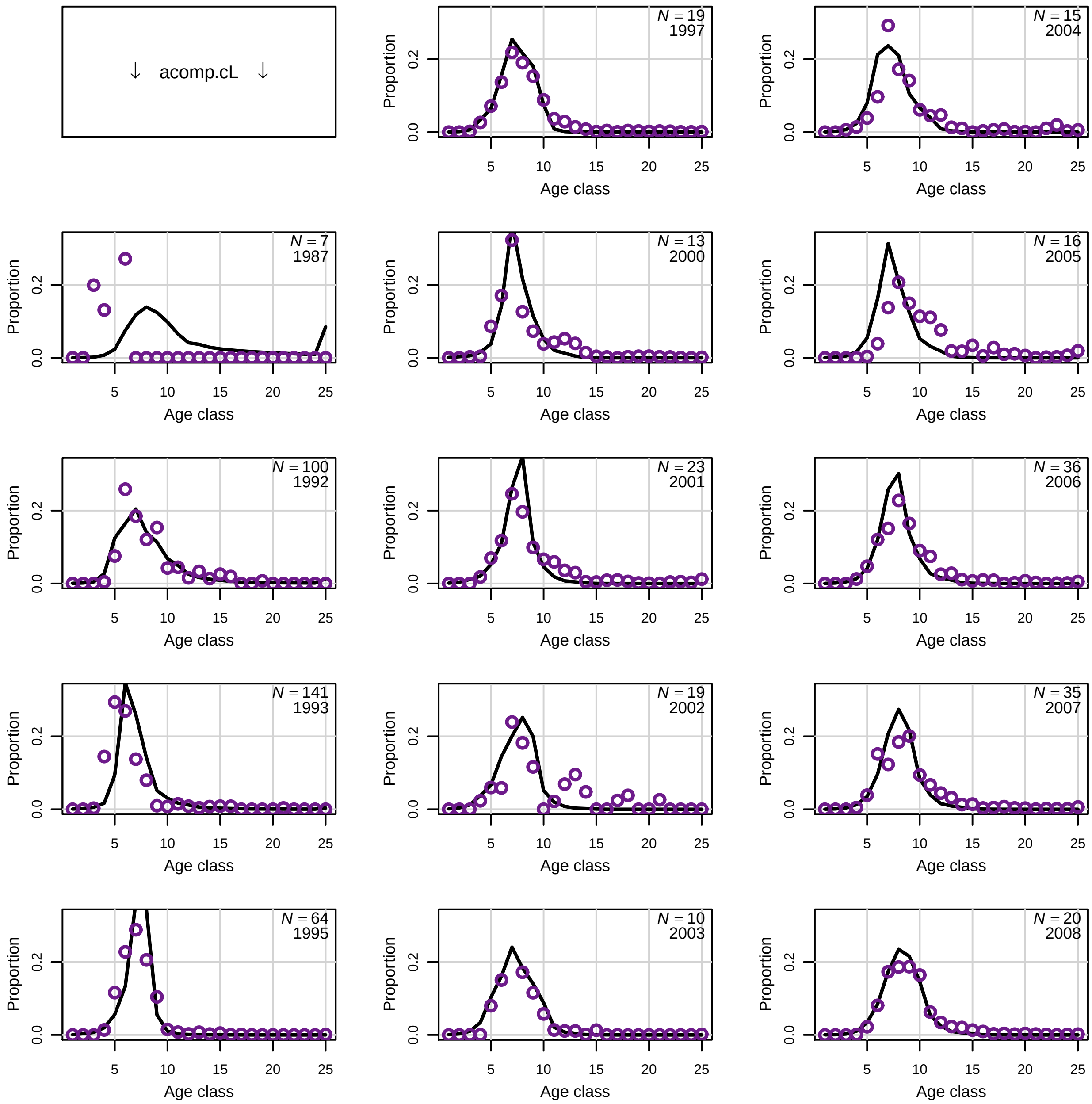


Figure 8.7. (Continued) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cH to commercial handline, cL to commercial longline, rA to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

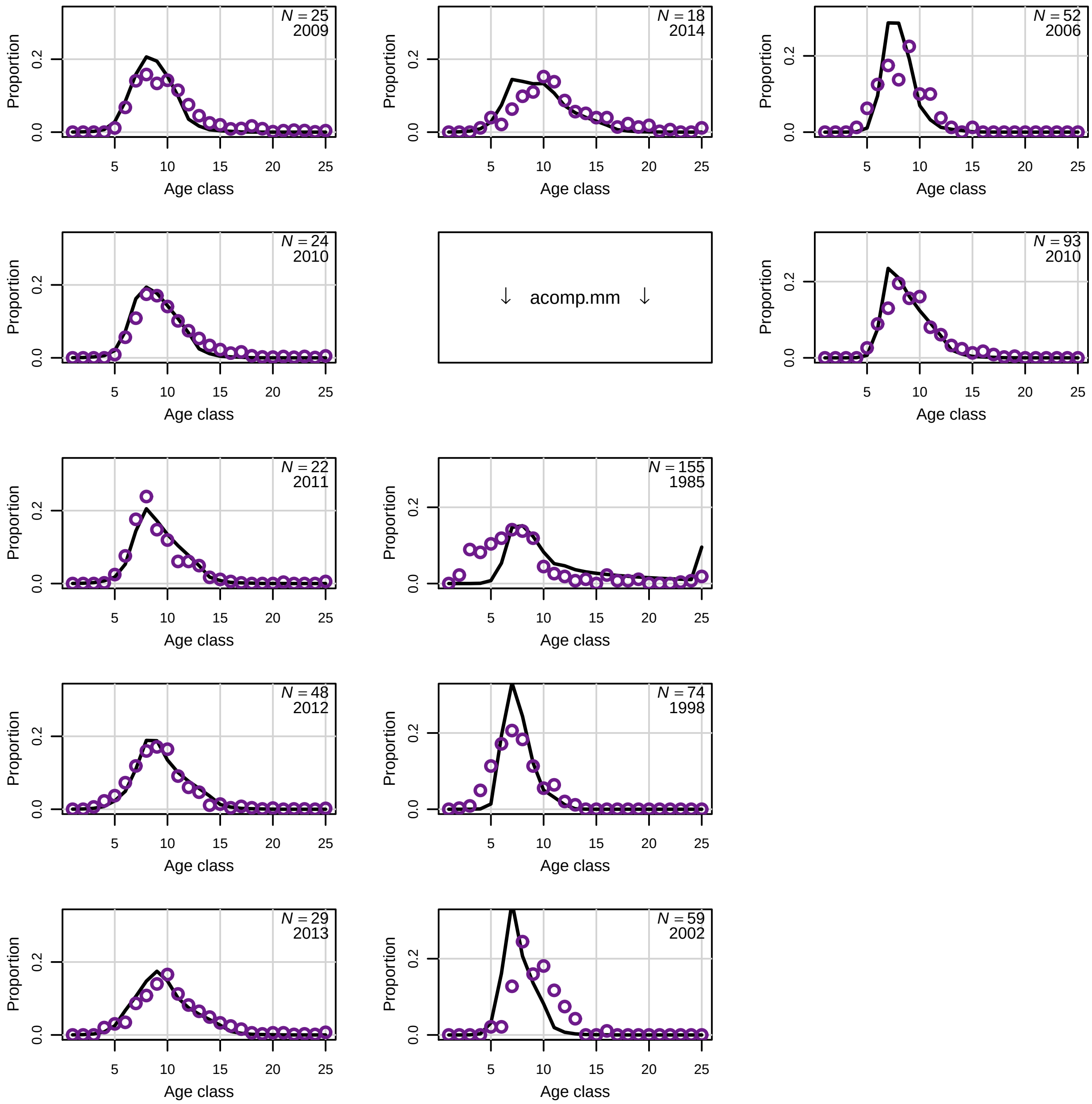


Figure 8.8. Estimated abundance at age at start of year.

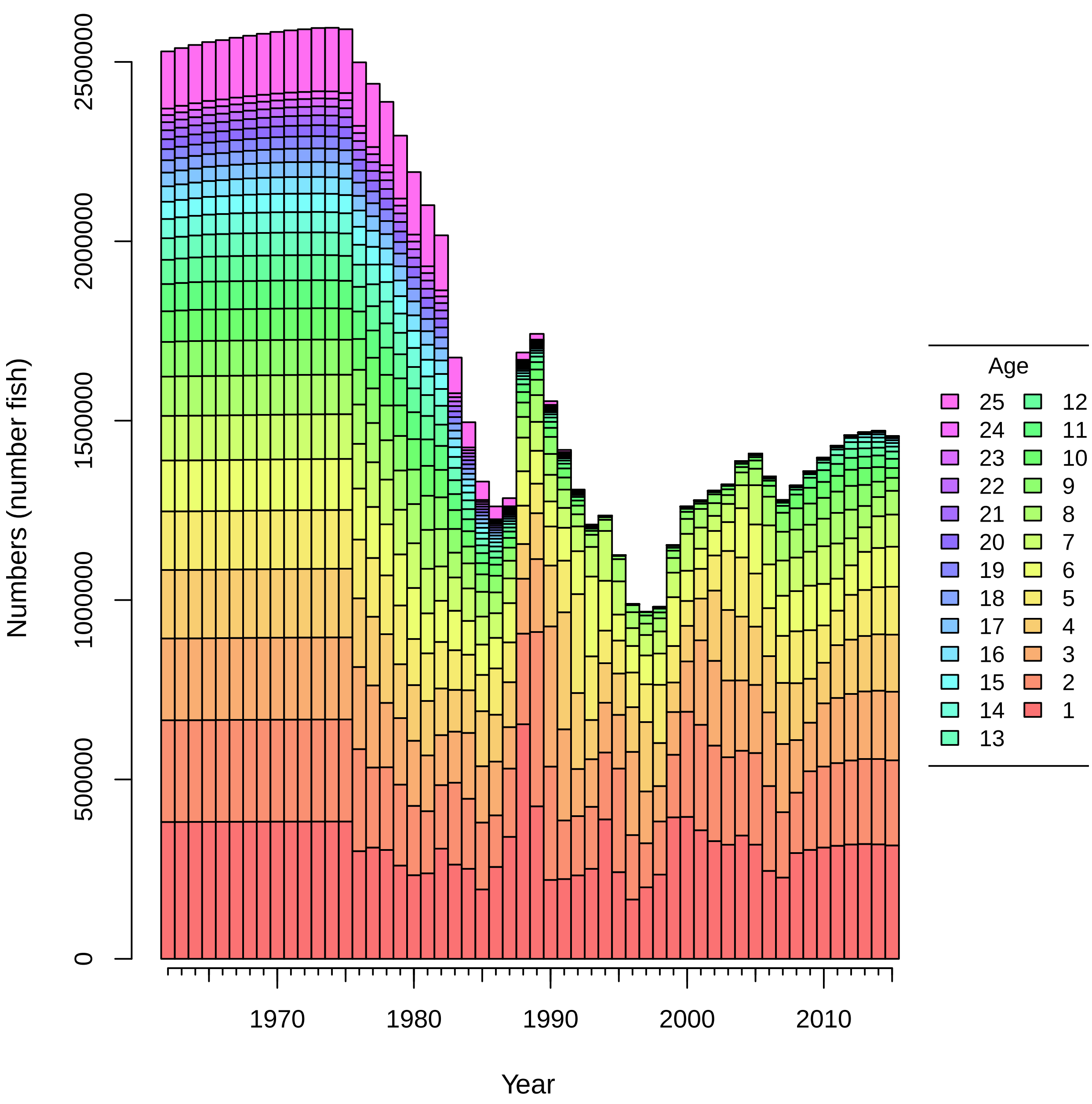


Figure 8.9. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

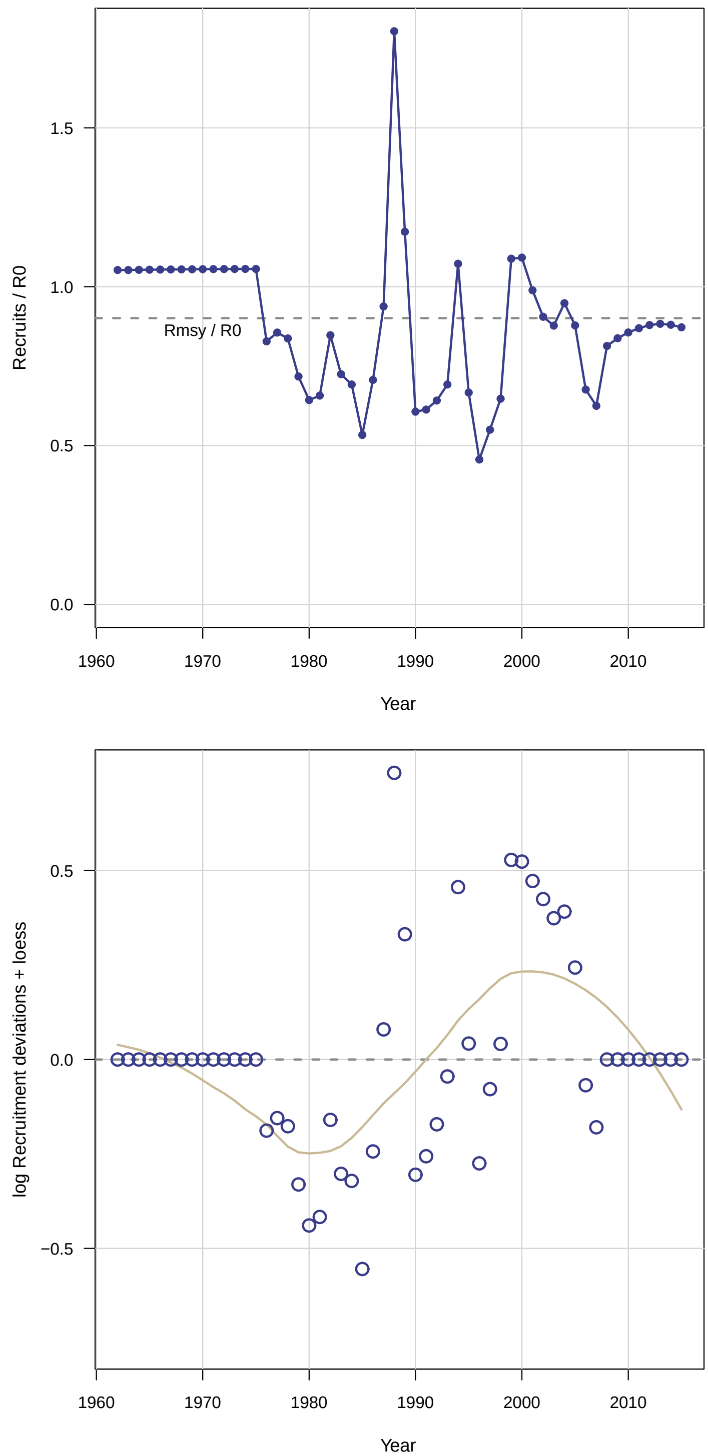


Figure 8.10. Estimated biomass at age at start of year.

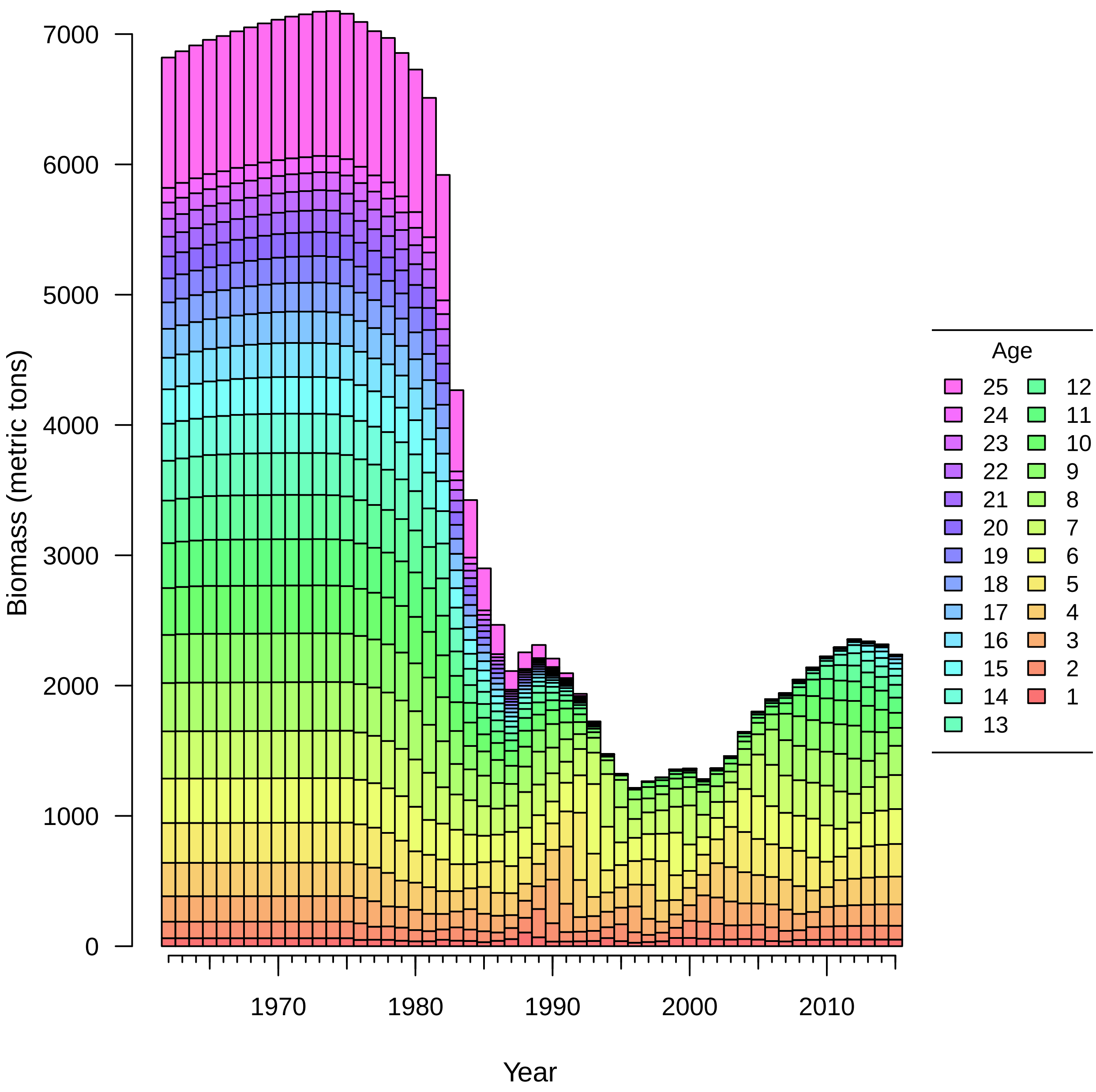


Figure 8.11. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}*. Bottom panel: Estimated spawning stock (gonad biomass of mature females) at time of peak spawning.*

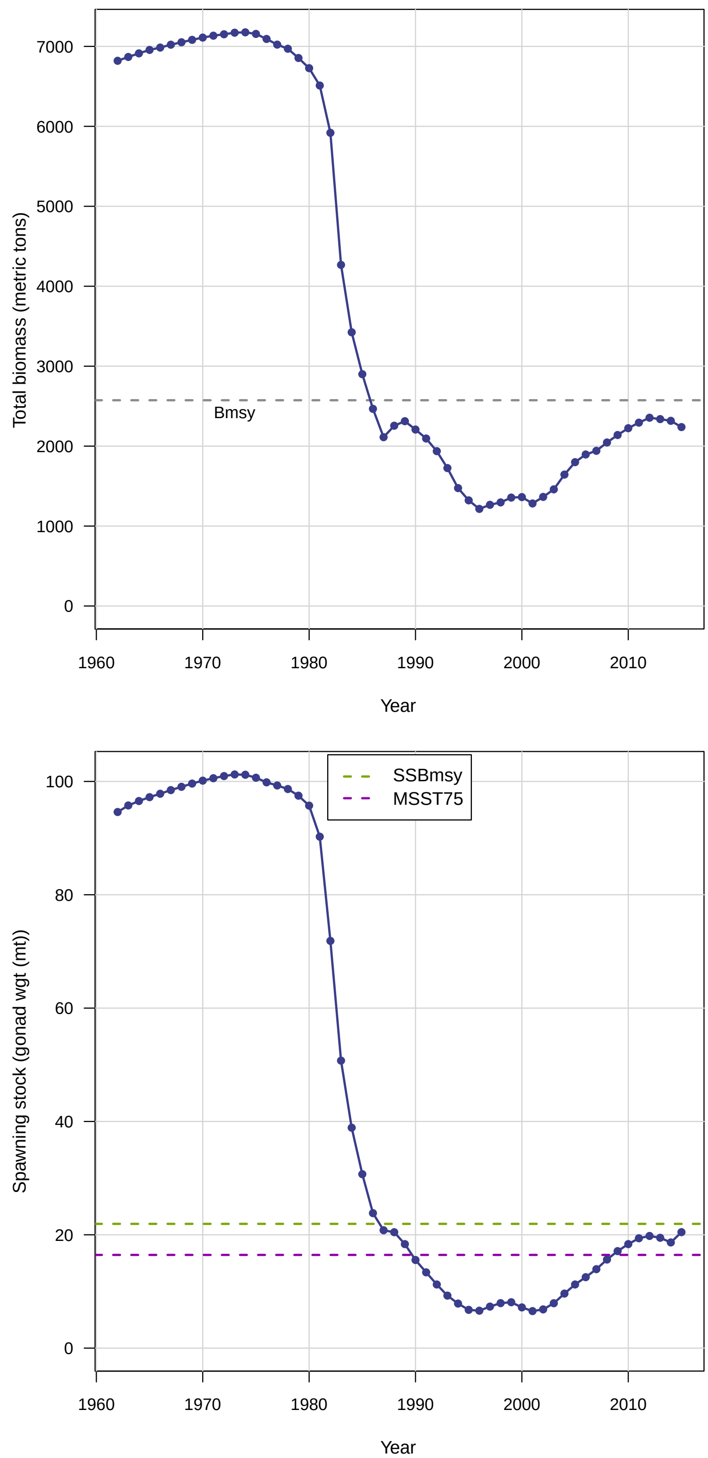


Figure 8.12. Selectivities of commercial fleets, 1962–2014. Top panel: commercial handline, Bottom panel: commercial longline.

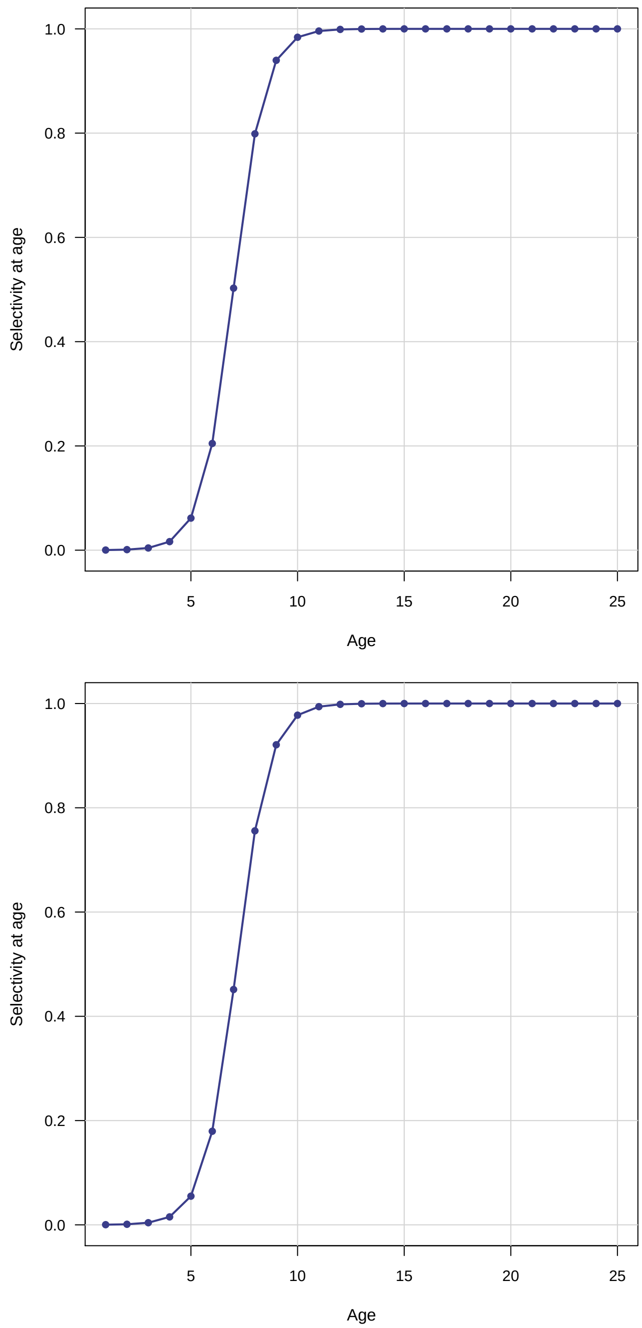


Figure 8.13. Selectivities of the recreational fleet and MARMAP survey 1962–2014. Top panel: recreational, Bottom panel: MARMAP longline survey.

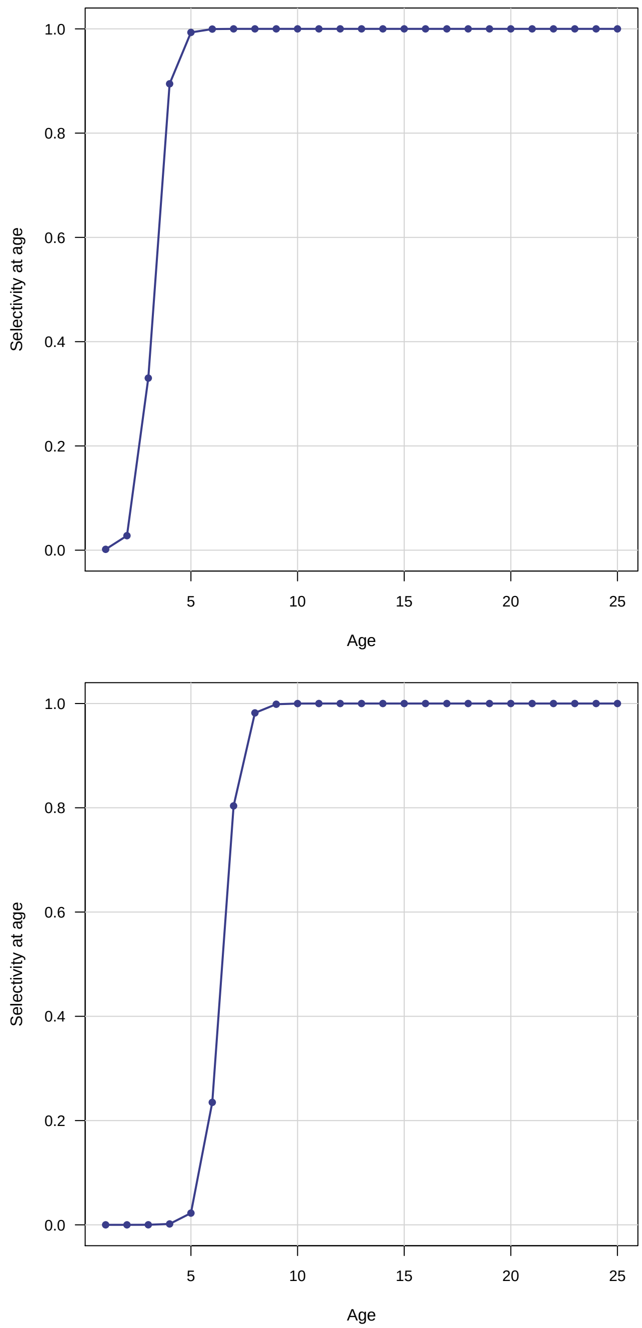


Figure 8.14. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and central-tendency projections.

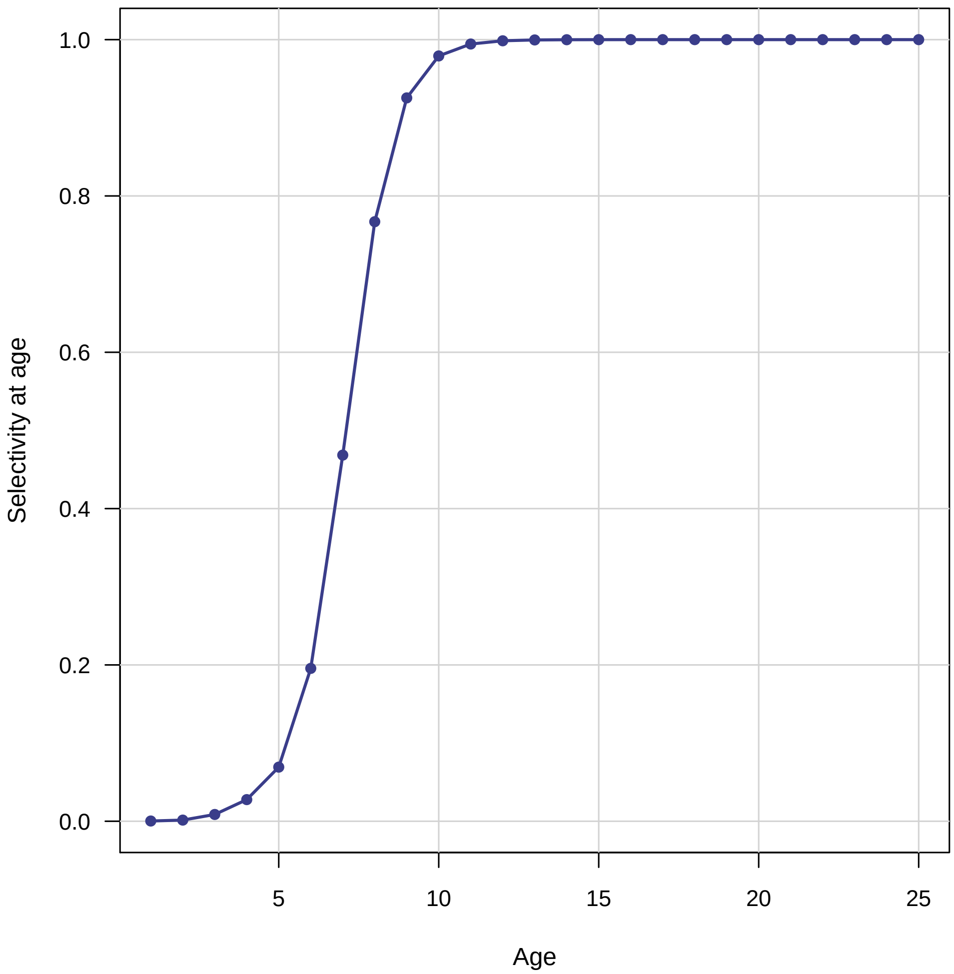


Figure 8.15. Estimated fully selected fishing mortality rate (per year) by fishery. cL refers to commercial longline, cH to commercial handline, and rA to recreational.

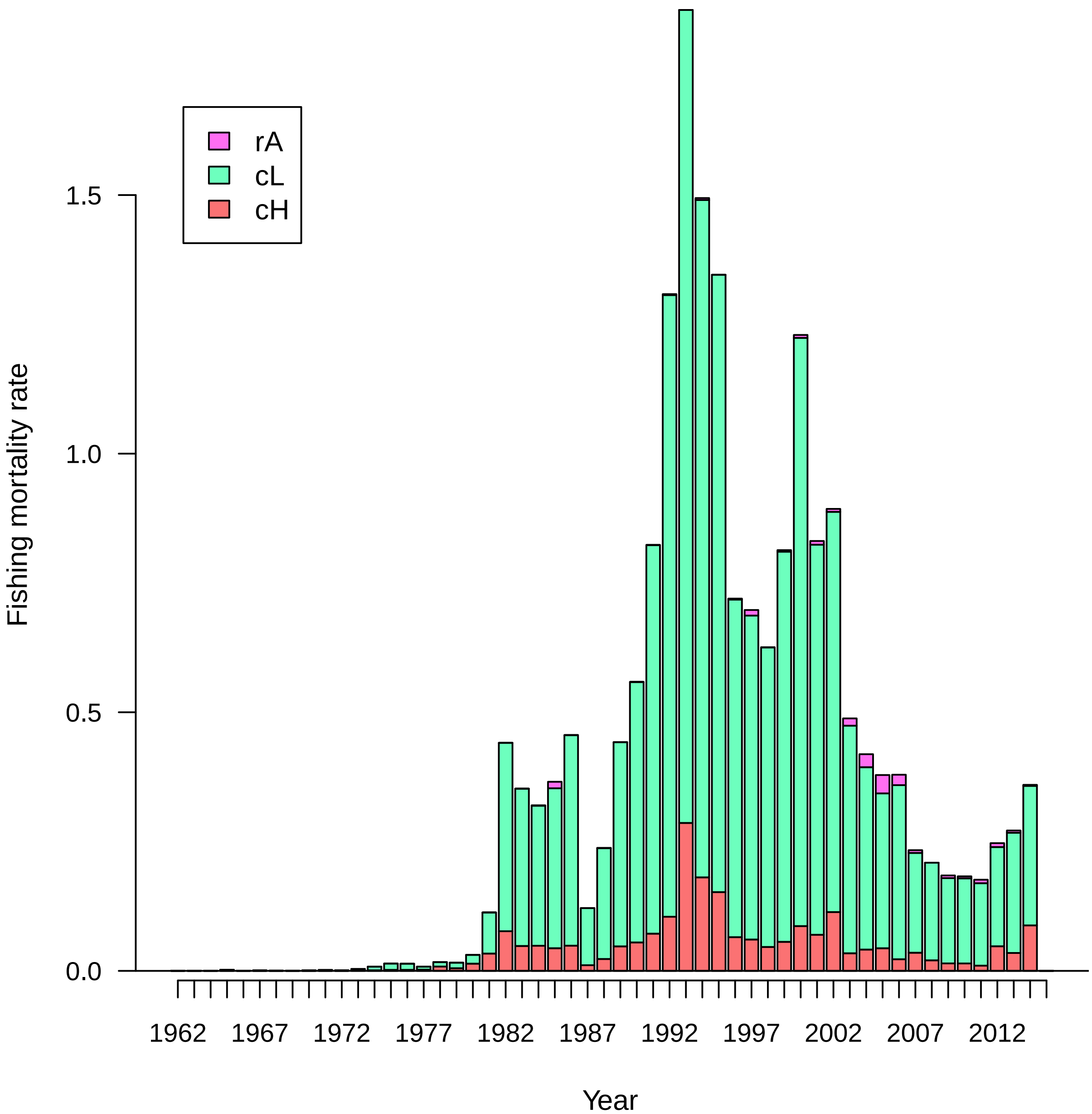


Figure 8.16. Estimated landings in gutted weight by fishery from the catch-age model. cL refers to commercial longline, cH to commercial handline, and rA to recreational. Horizontal dashed line in the top panel corresponds to the point estimate of MSY.

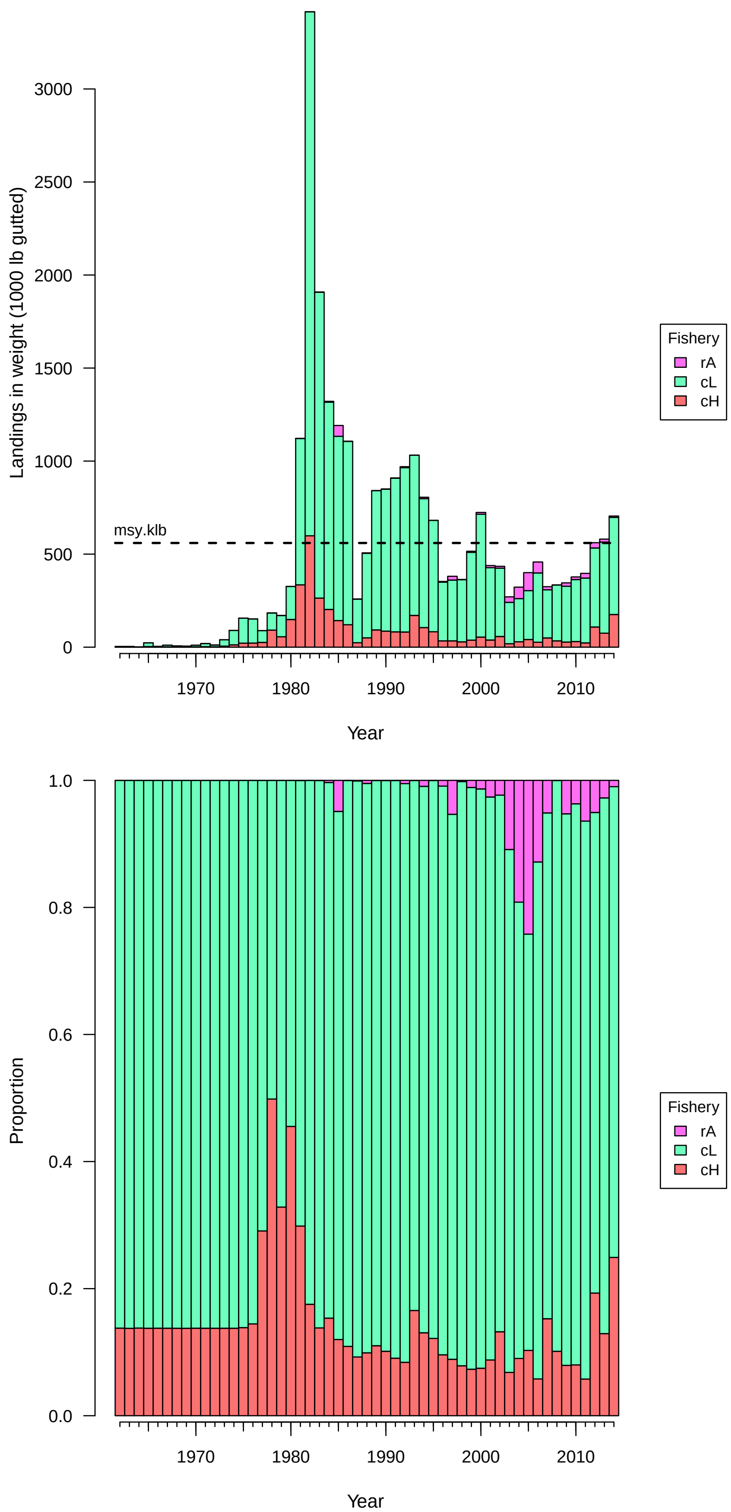


Figure 8.17. Estimated landings in numbers by fishery from the catch-age model. cL refers to commercial longline, cH to commercial handline, and rA ro recreational.

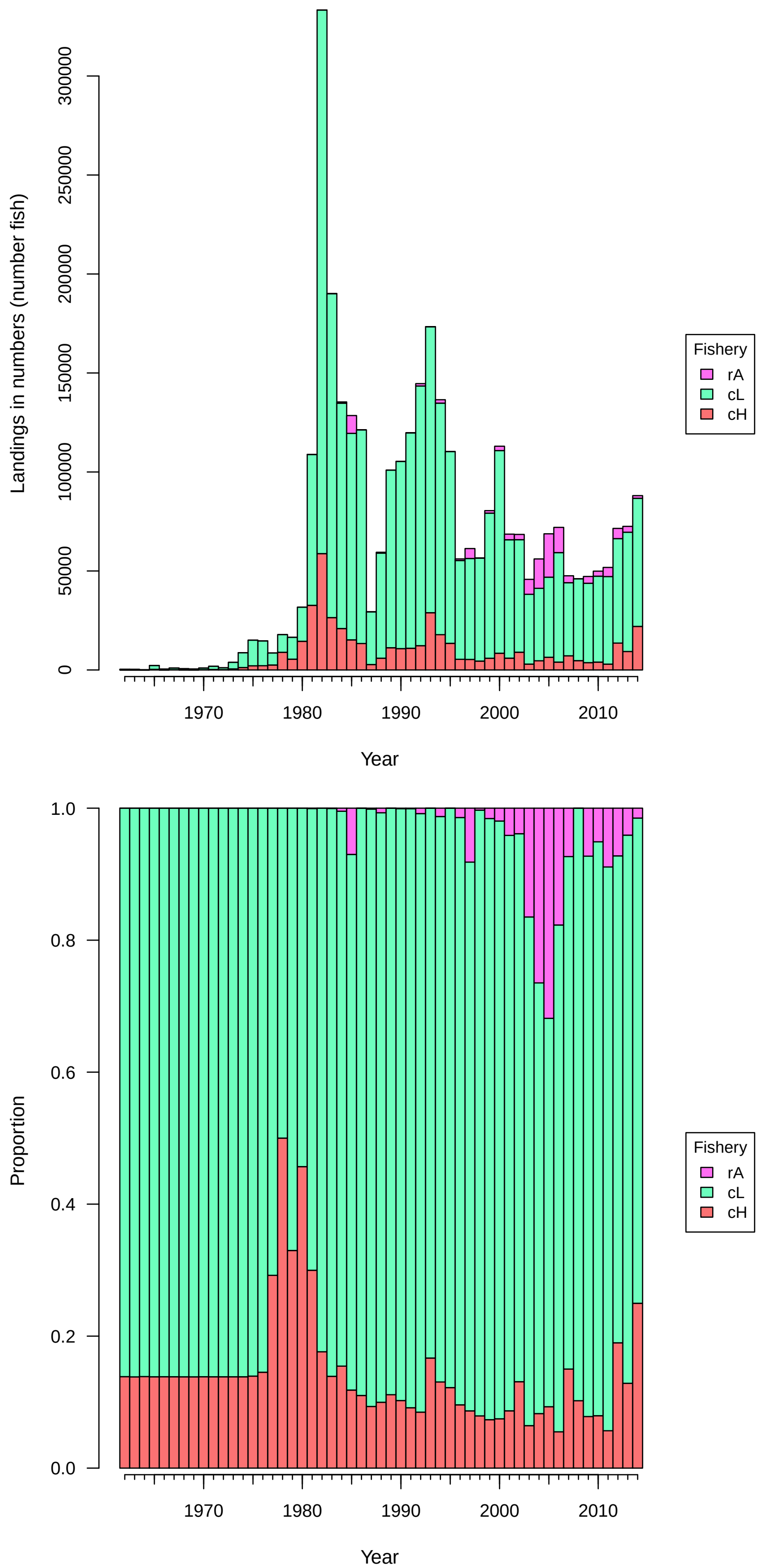


Figure 8.18. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. Bottom panel: log of recruits (number age-1 fish) per spawner (mature female gonad weight) as a function of spawners.

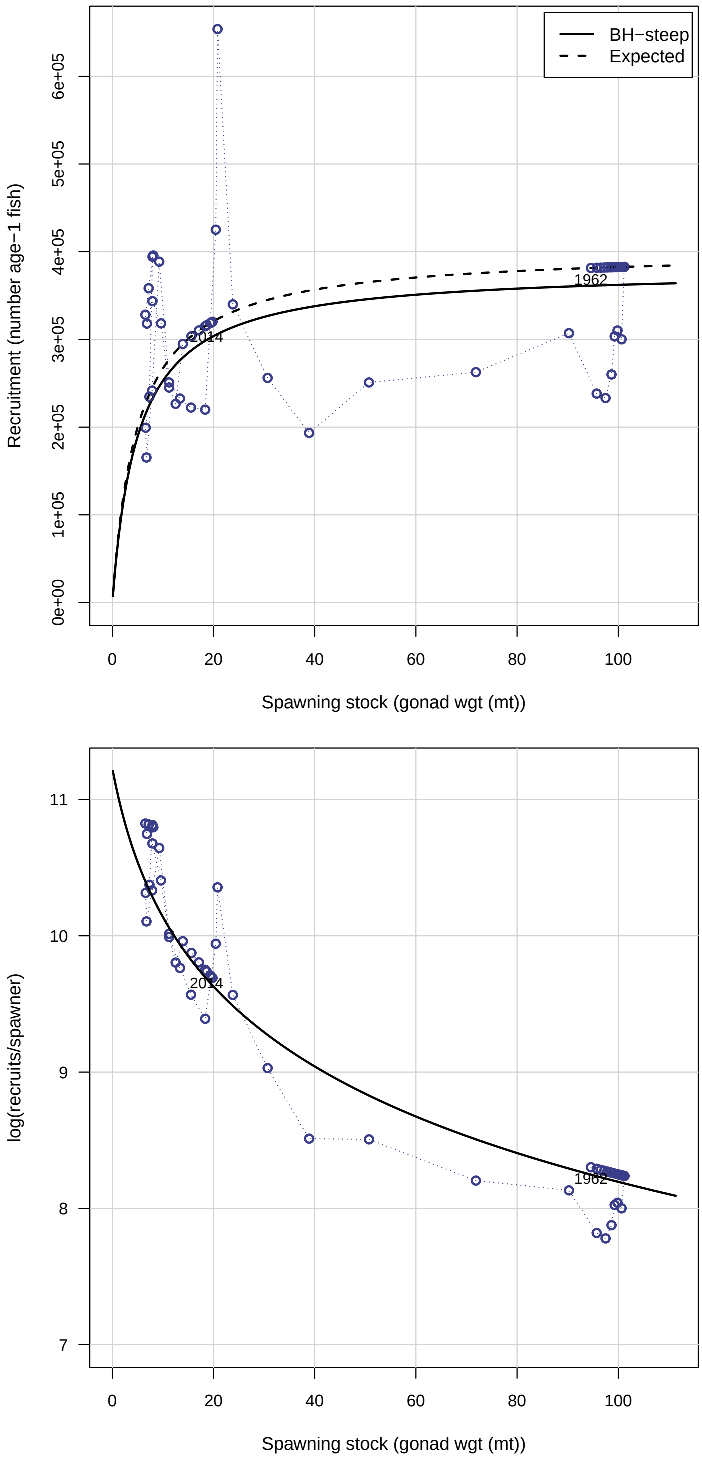


Figure 8.19. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness, unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Solid vertical lines represent point estimates or values from the base run; dashed vertical lines represent medians from the MCB runs.

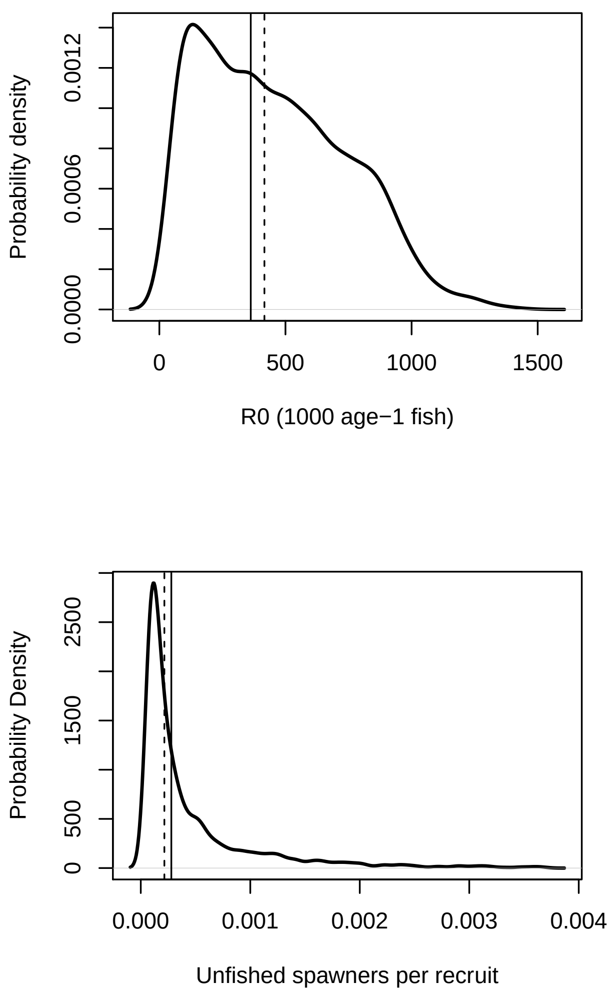
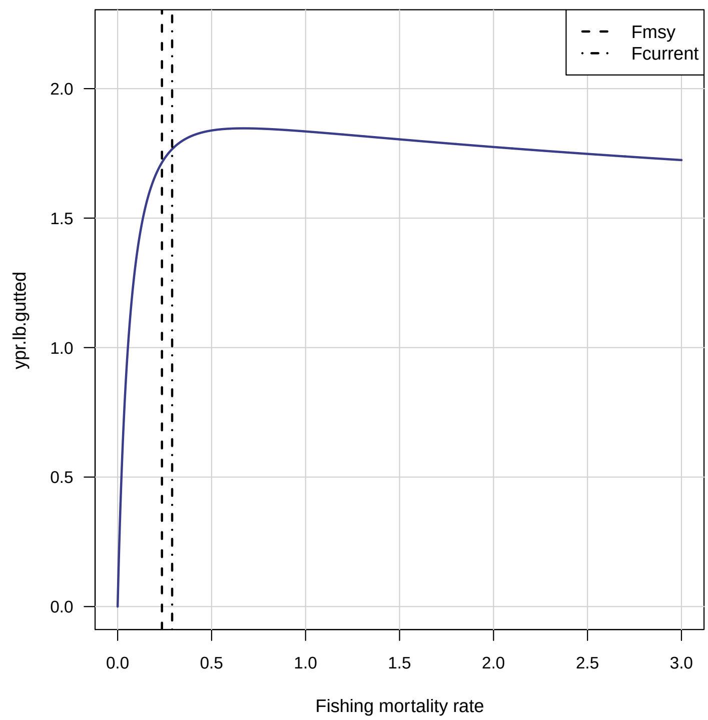


Figure 8.20. Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level. Horizontal dashed line indicates the equilibrium MSY level.

Figure 8.21. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the y% levels provide $F_{y\%}$. Both curves are based on average selectivity from the end of the assessment period.



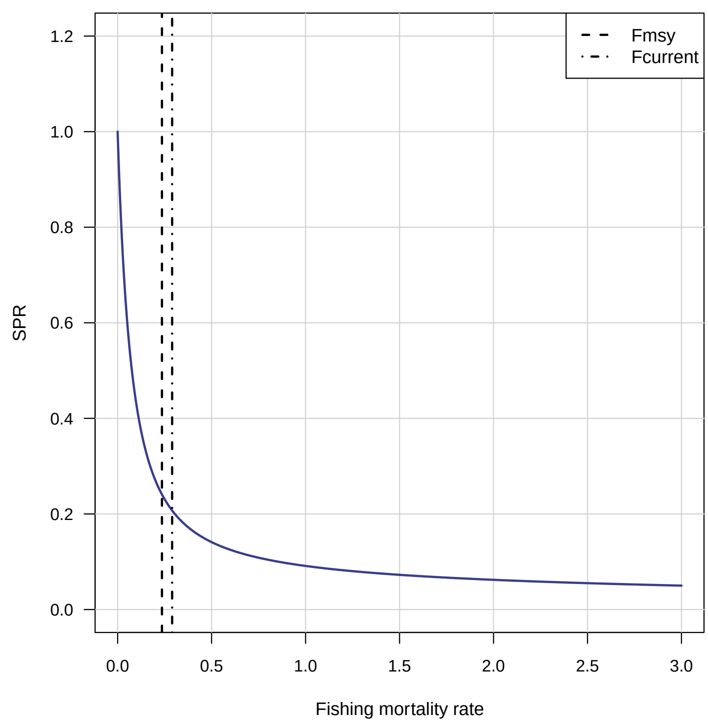


Figure 8.22. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.24$ *and equilibrium landings are* MSY = 560 *(1000 lb gutted weight). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

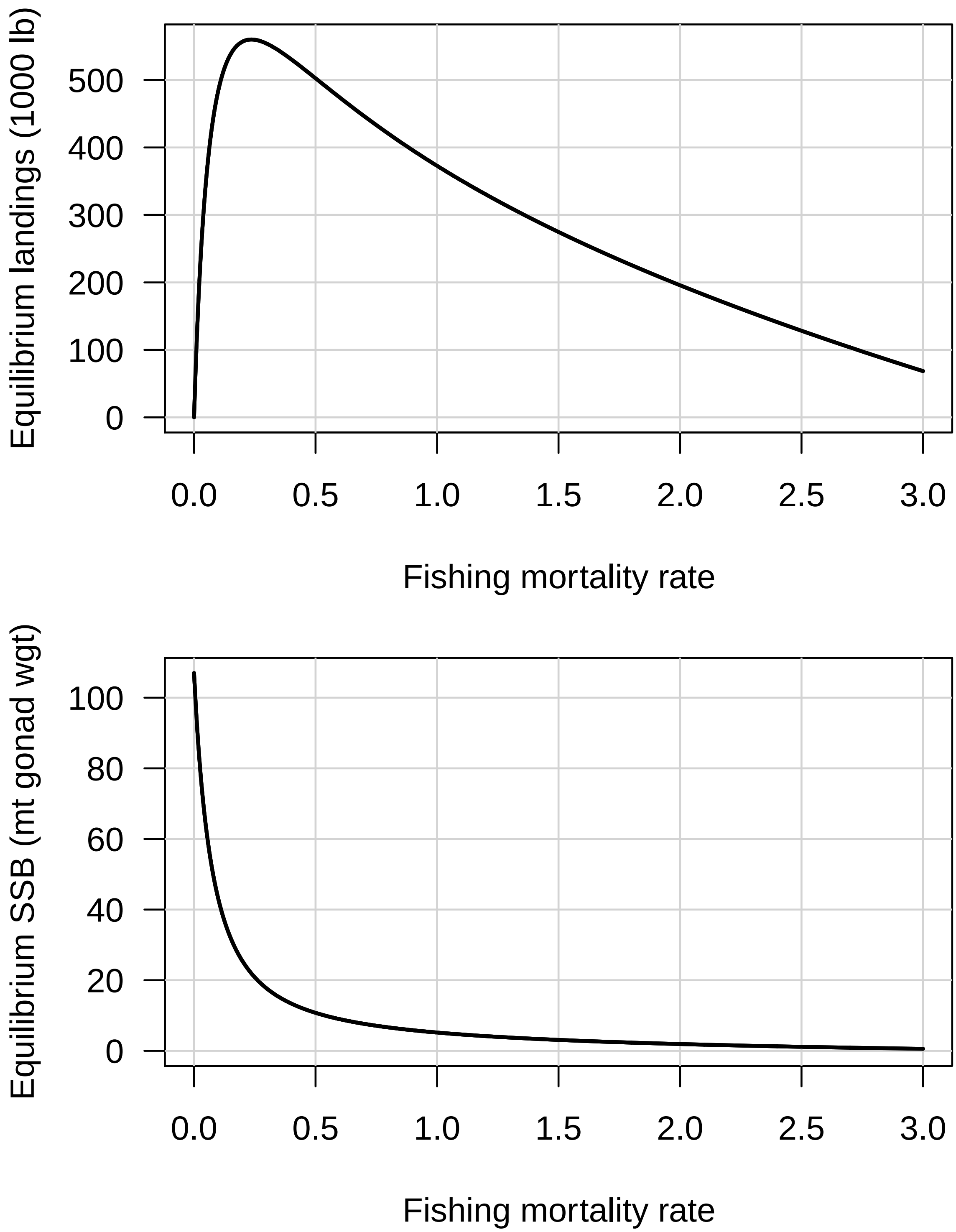


Figure 8.23. Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 2574$ *mt and equilibrium landings are* $\mathrm{MSY} = 560$ *(1000 lb gutted weight).*

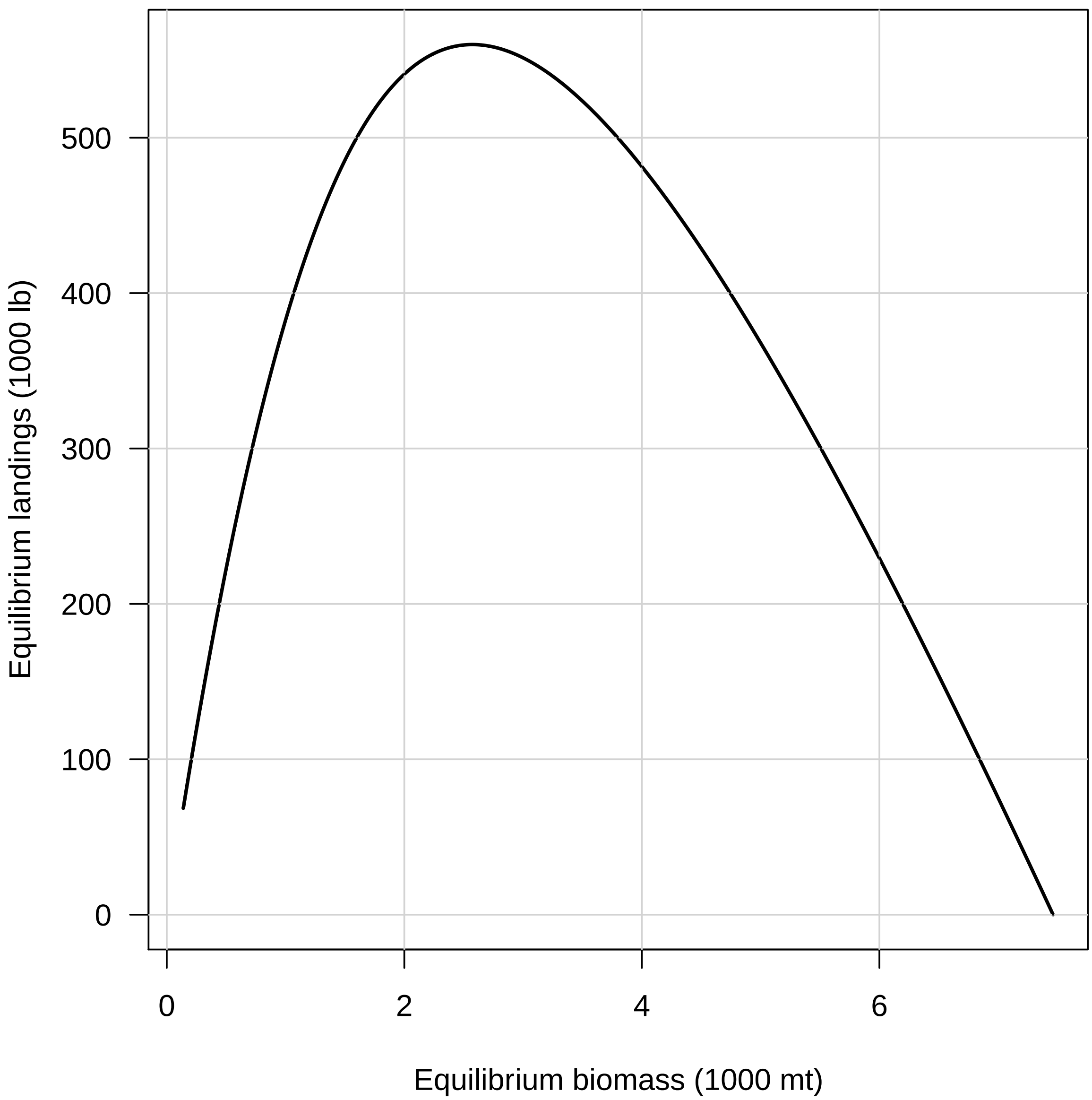


Figure 8.24. Probability densities of MSY*-related benchmarks from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.*

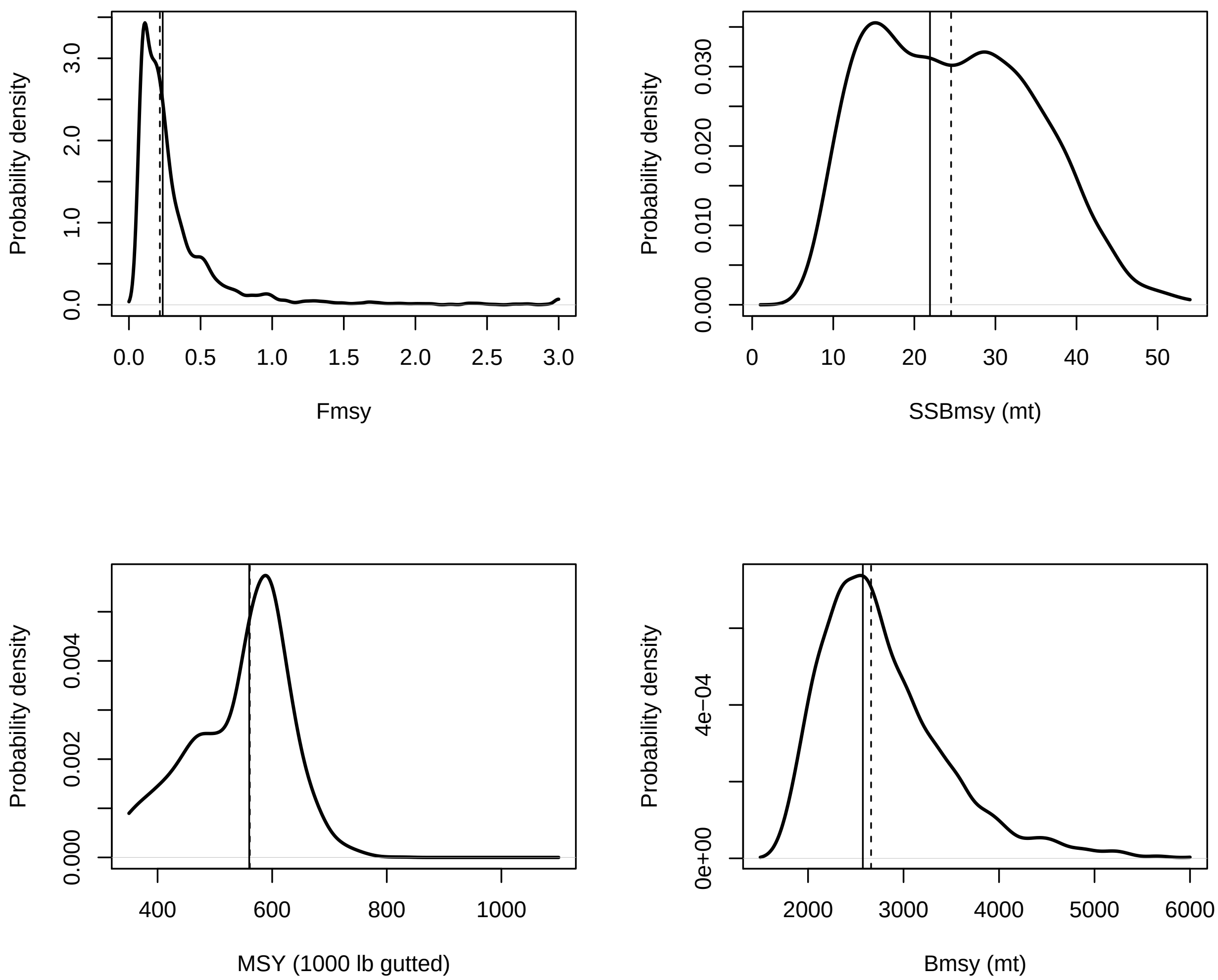


*Figure 8.25. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (*MSST*). Bottom panel: F relative to* F_{MSY}.

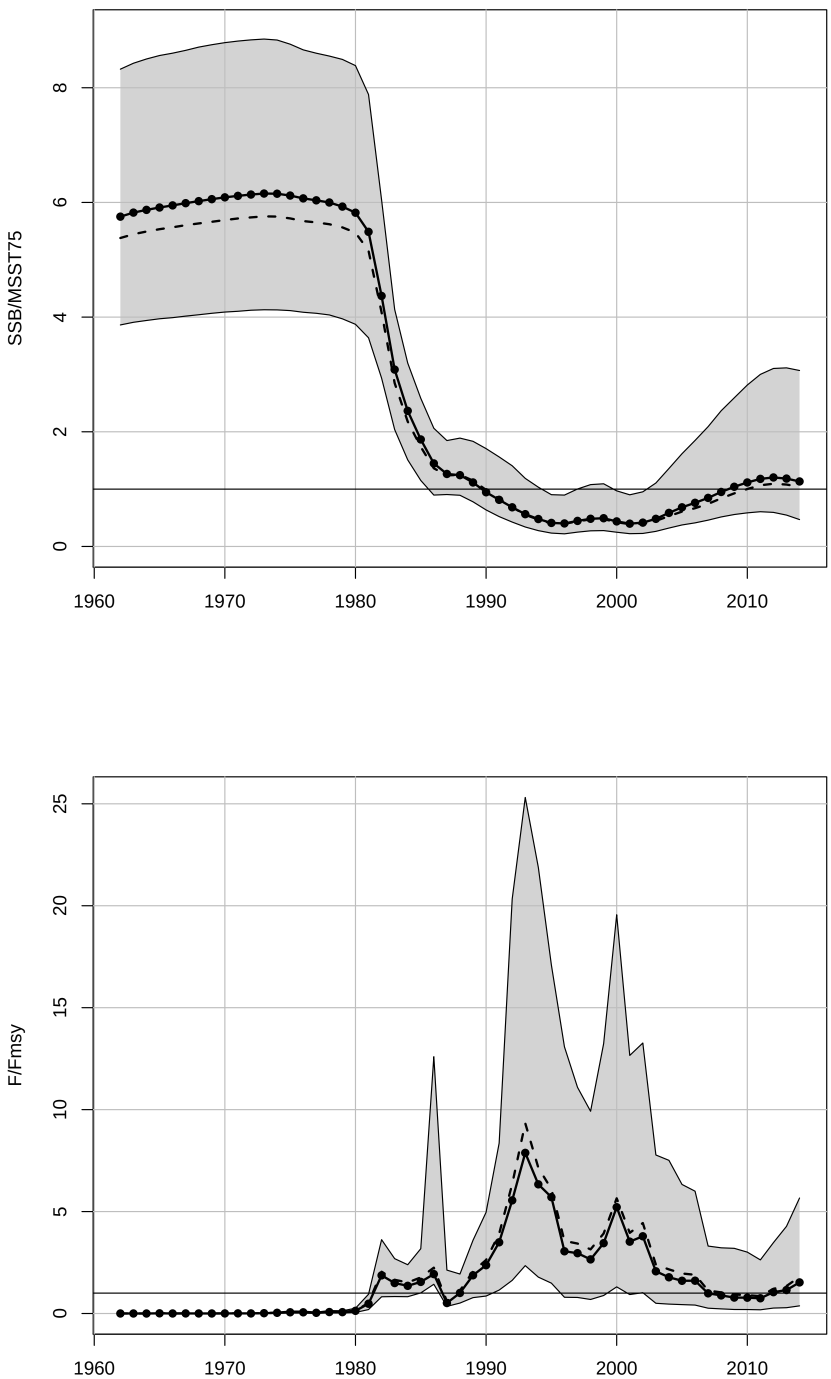


Figure 8.26. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.

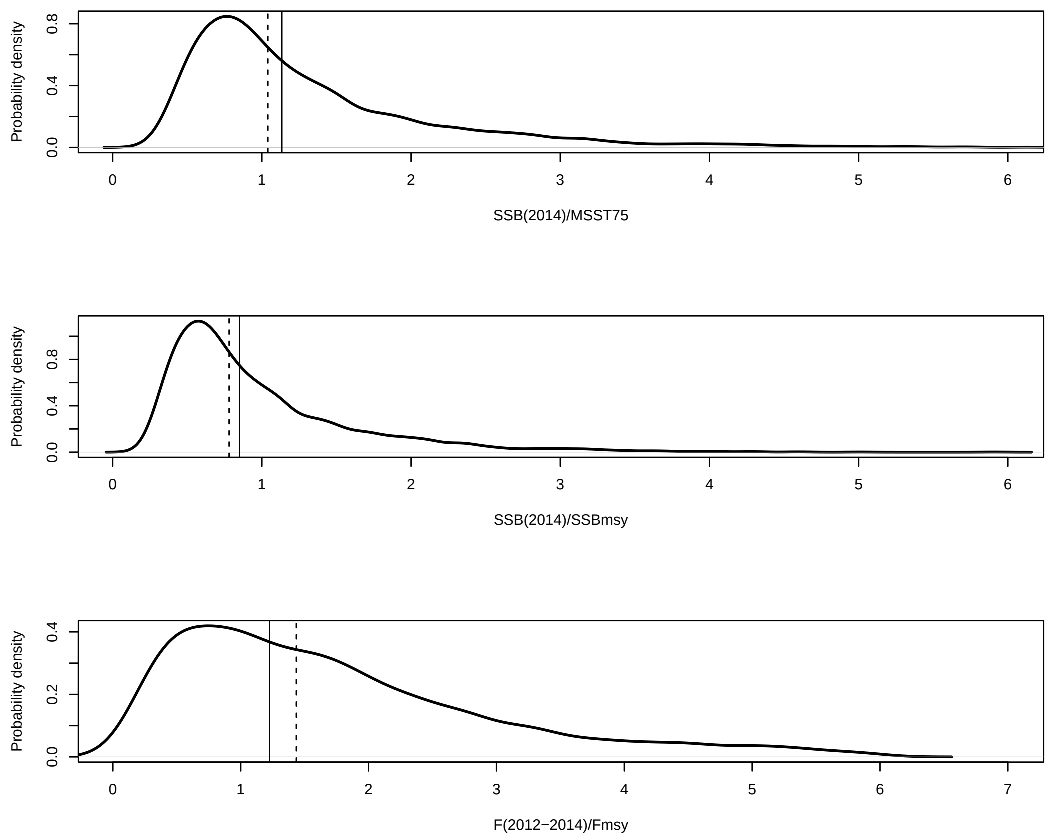


Figure 8.27. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles.

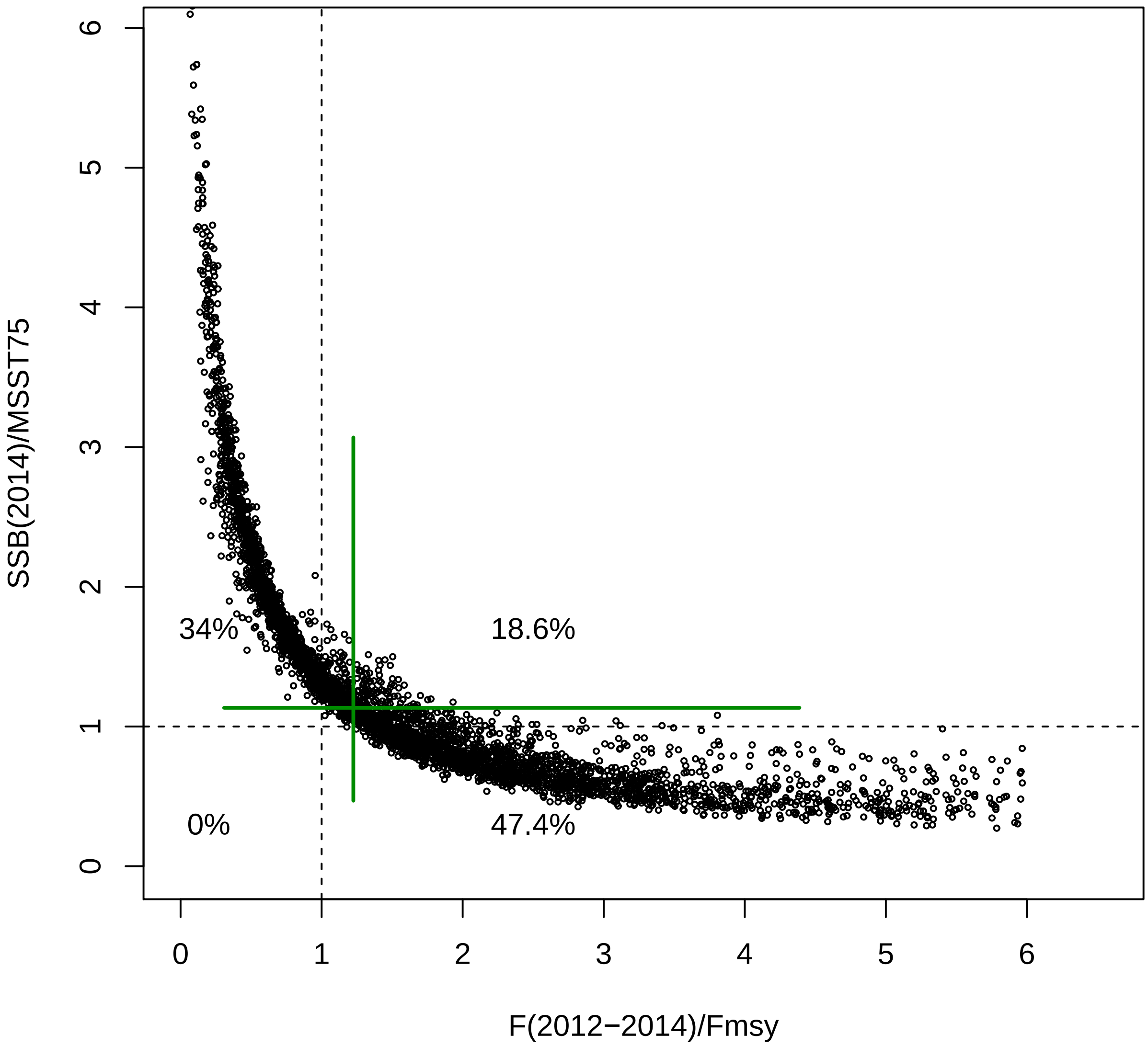


Figure 8.28. Top panel: Sensitivity of F/Fmsy to model configuration changes made during this update. Bottom panel: Sensitivity of SSB/MSST to model configuration changes made during this update. The solid line indicates sensitivity run S1 (effect of using SEDAR-25 multinomial likelihood), S2 (setting recreational selectivity equal to commercial handline), and S3 (inclusion of biased age compositions from 1990s longline samples) as described in 4.1.6.

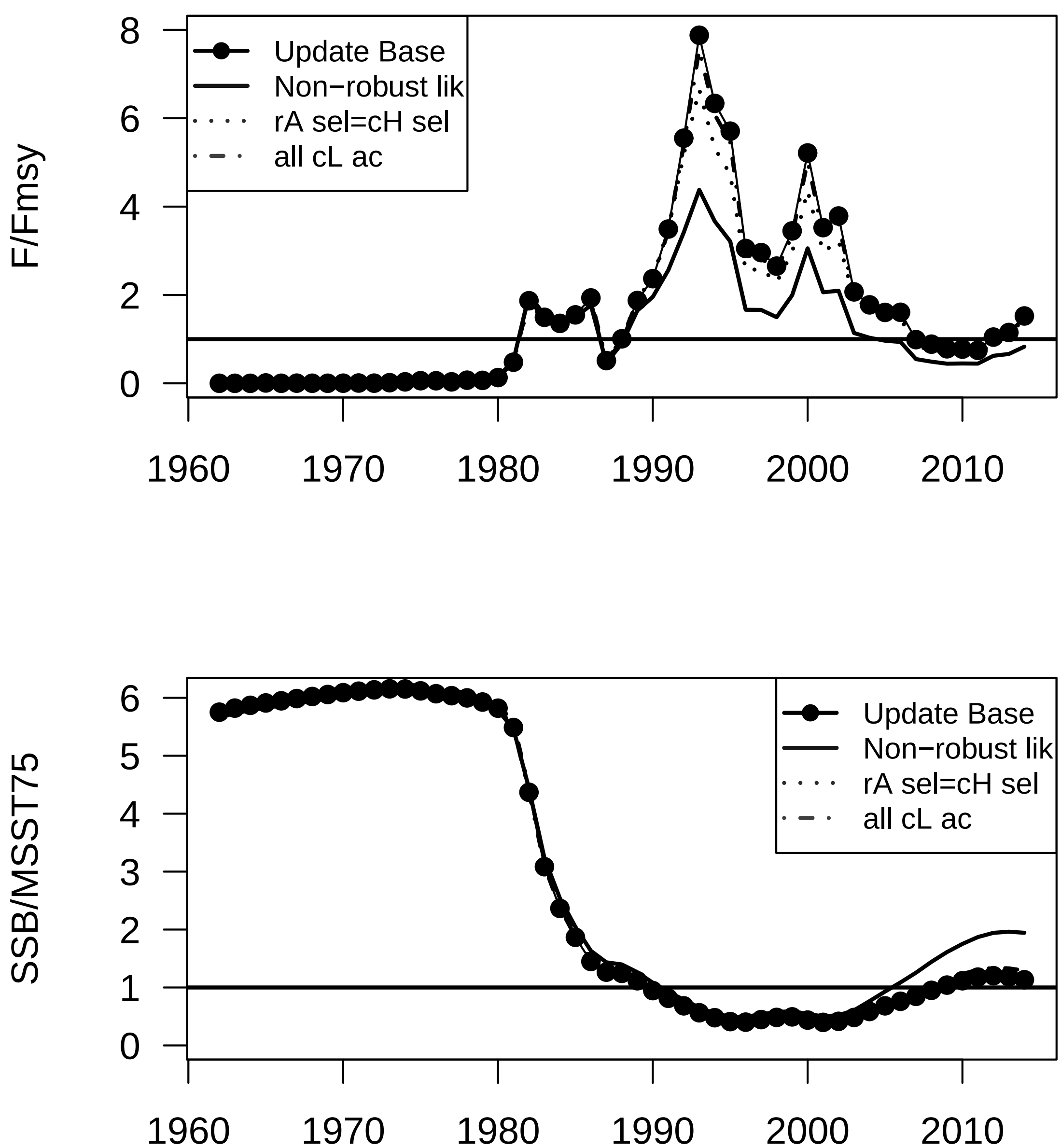


Figure 8.29. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Fishing mortality rate, where solid circles show geometric mean of terminal three years, as used to compute fishing status.

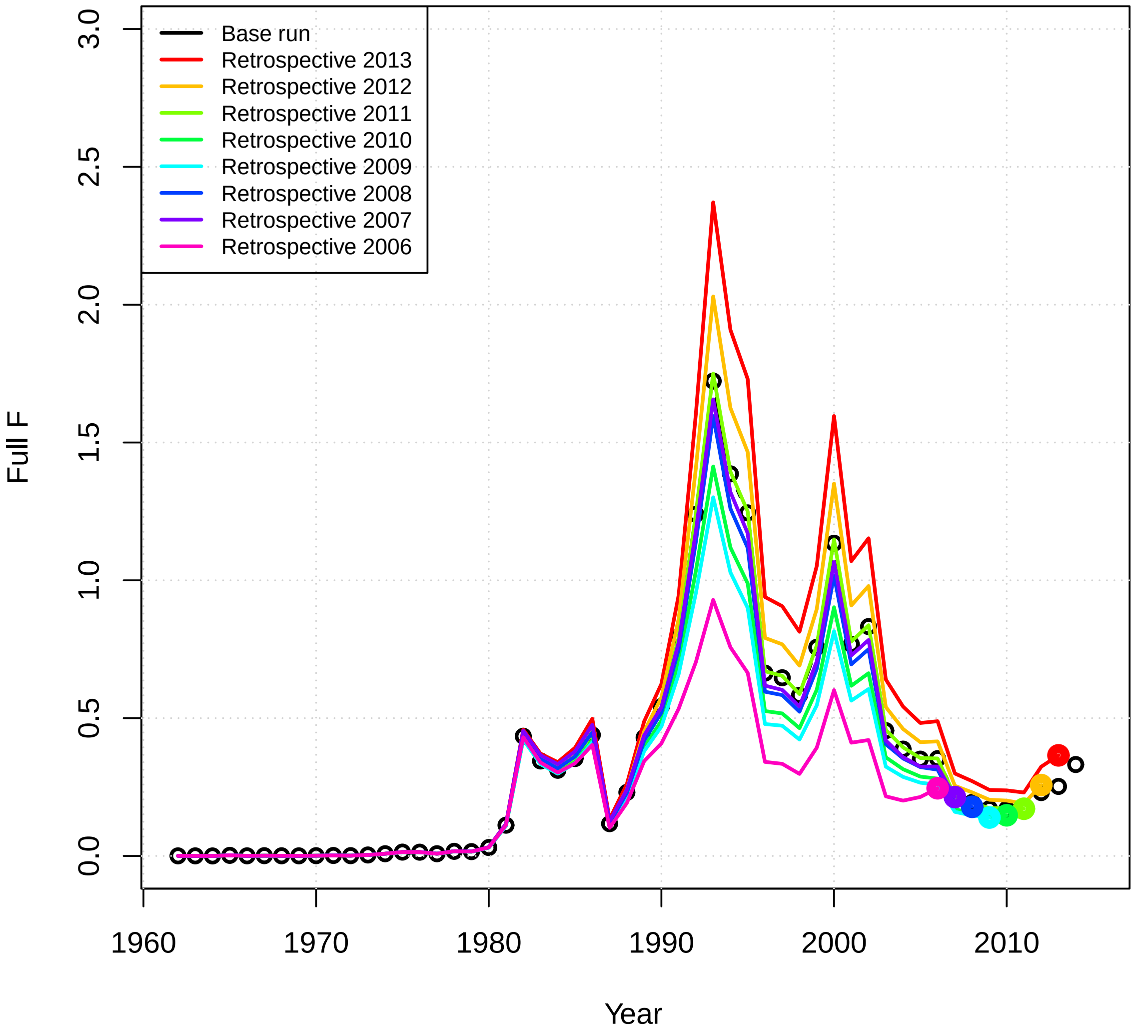


Figure 8.30. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Biomass time series.

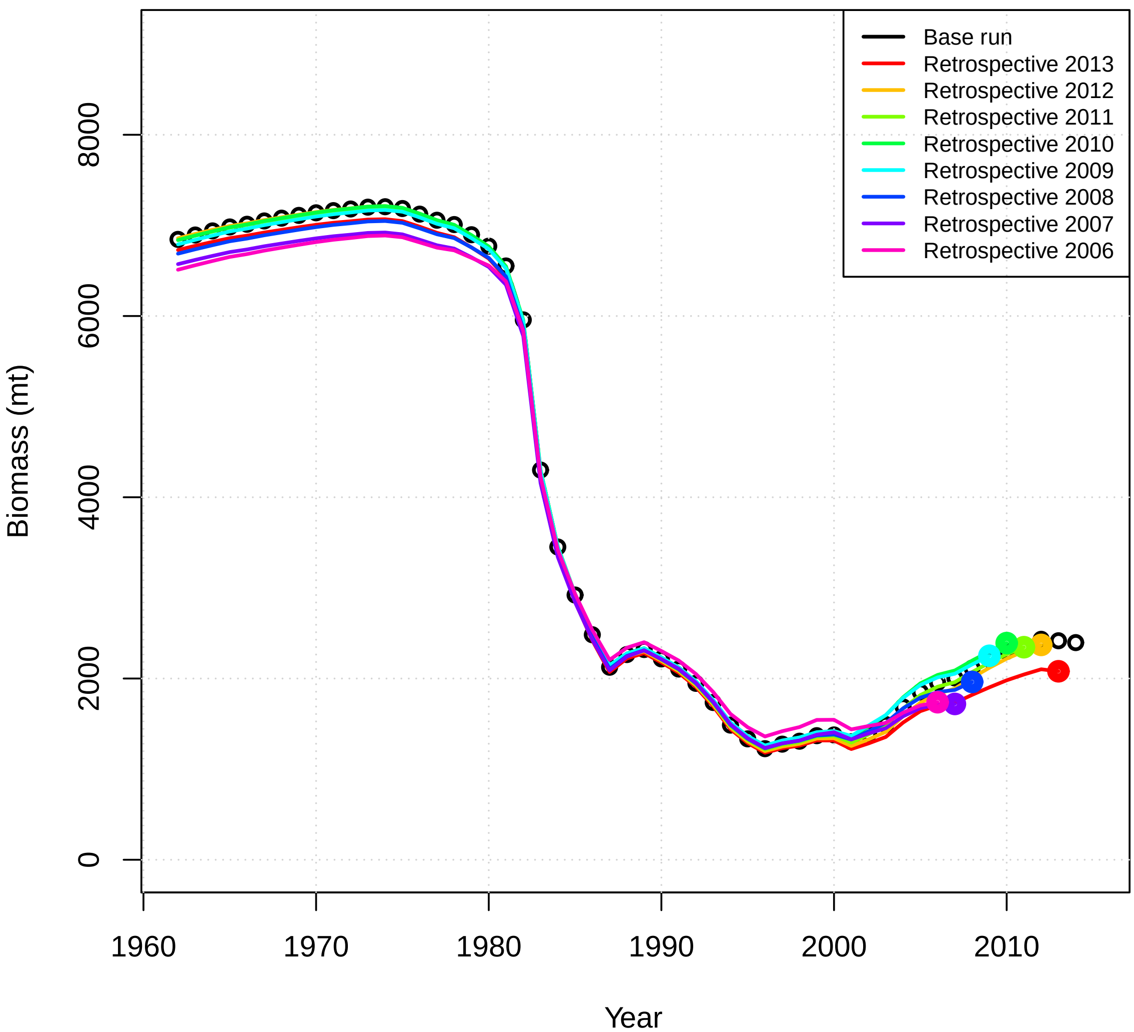


Figure 8.31. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Spawning stock biomass time series.

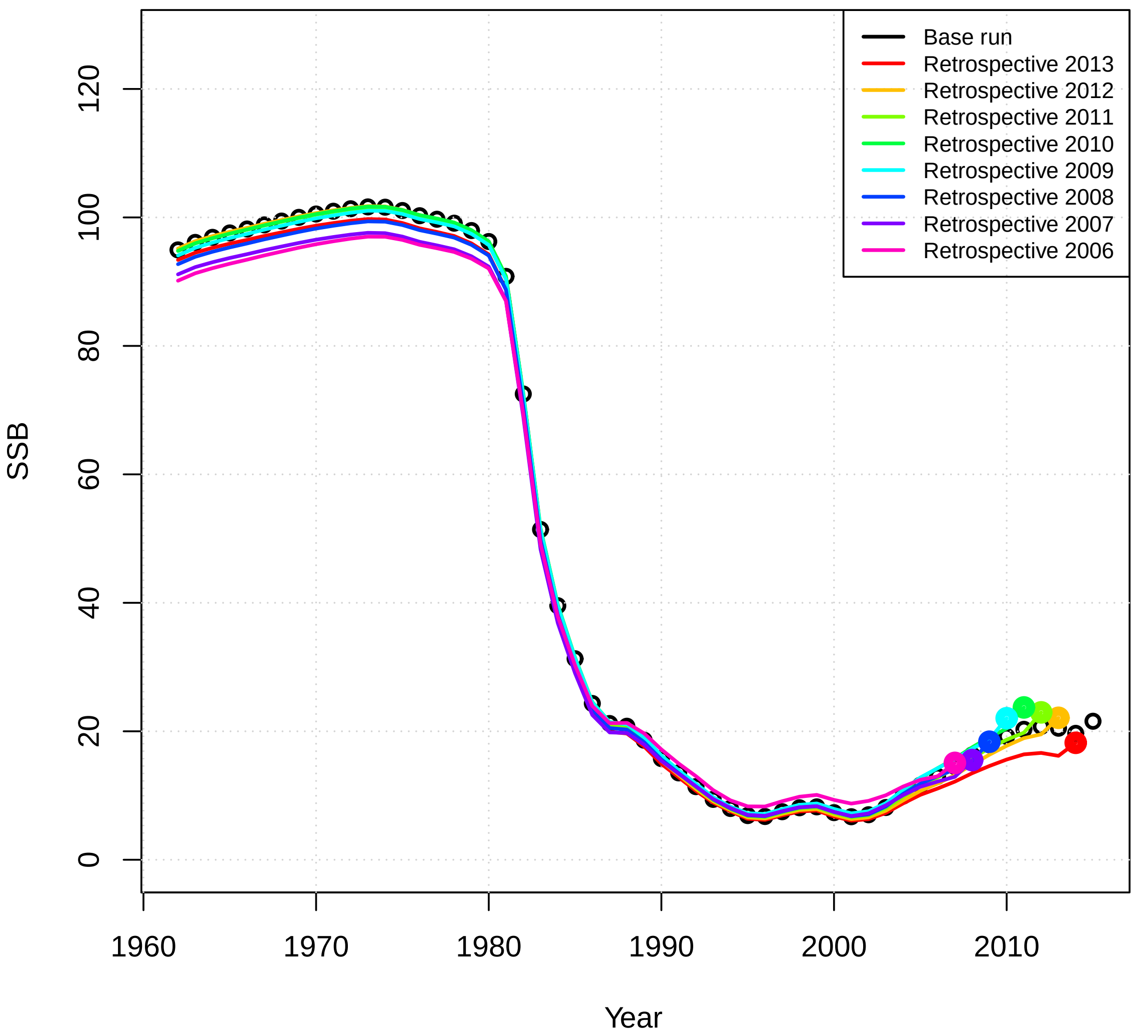


Figure 8.32. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Recruitment time series.

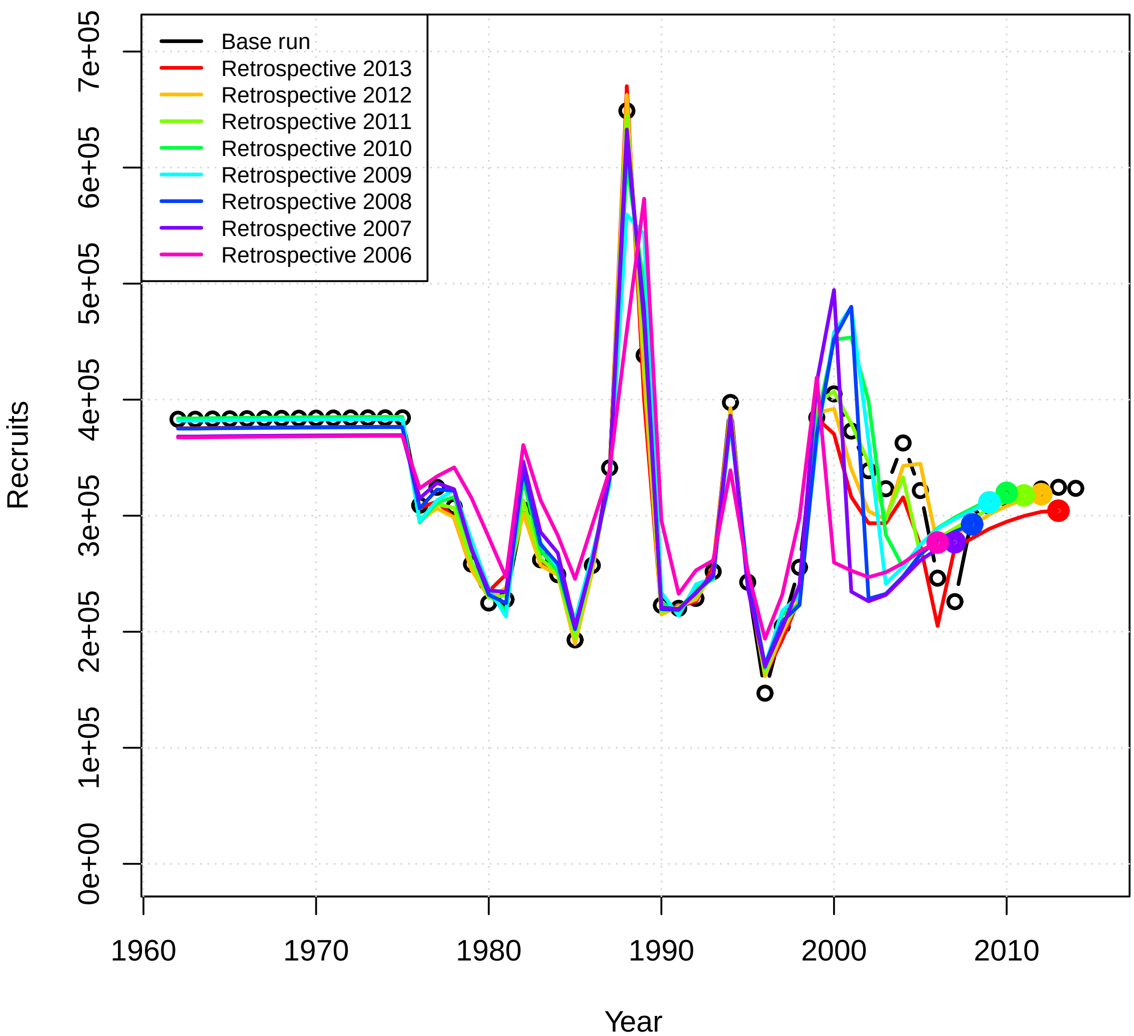


Figure 8.33. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Relative fishing mortality rate time series.

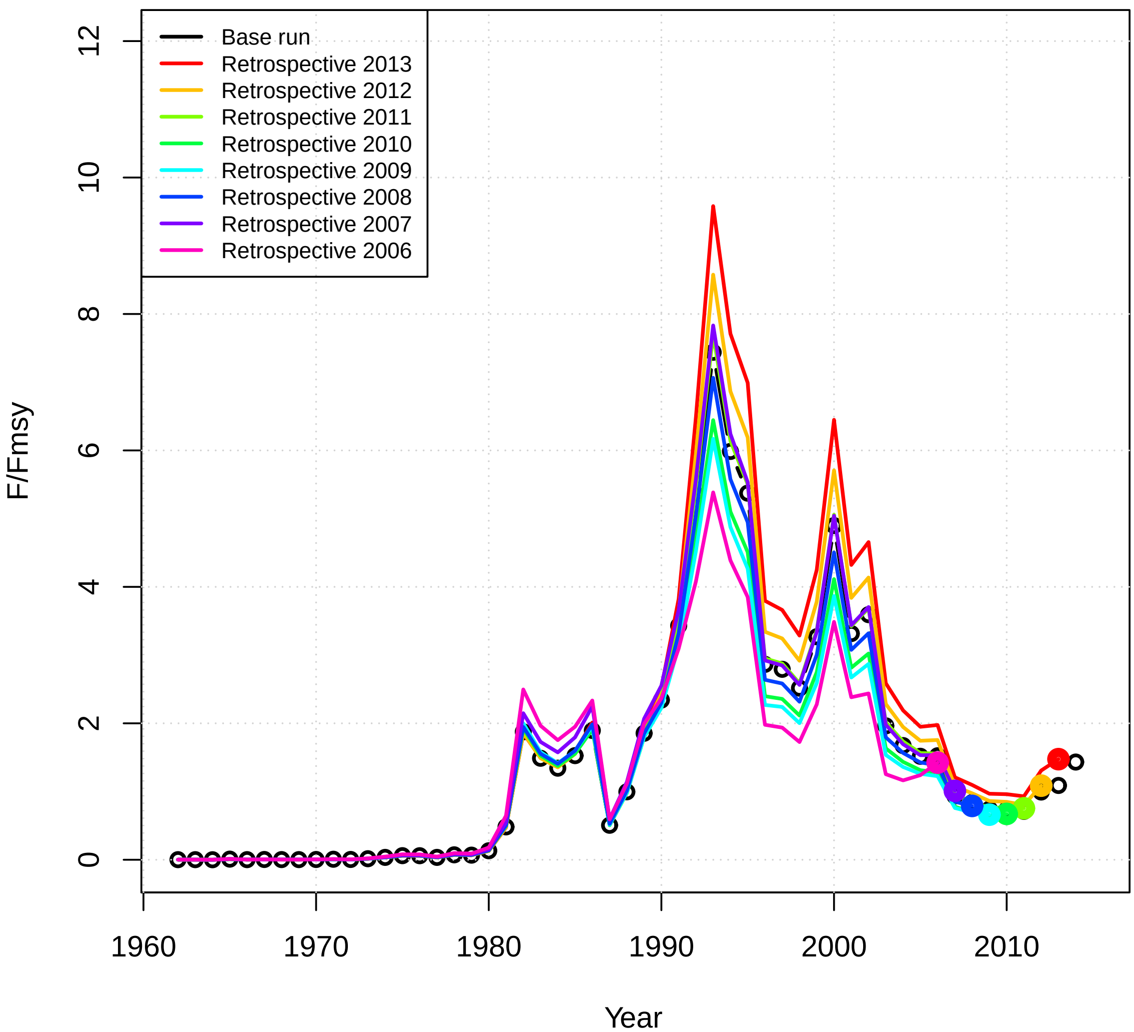


Figure 8.34. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S4–S11 as described in 4.1.6). Relative spawning stock biomass time series

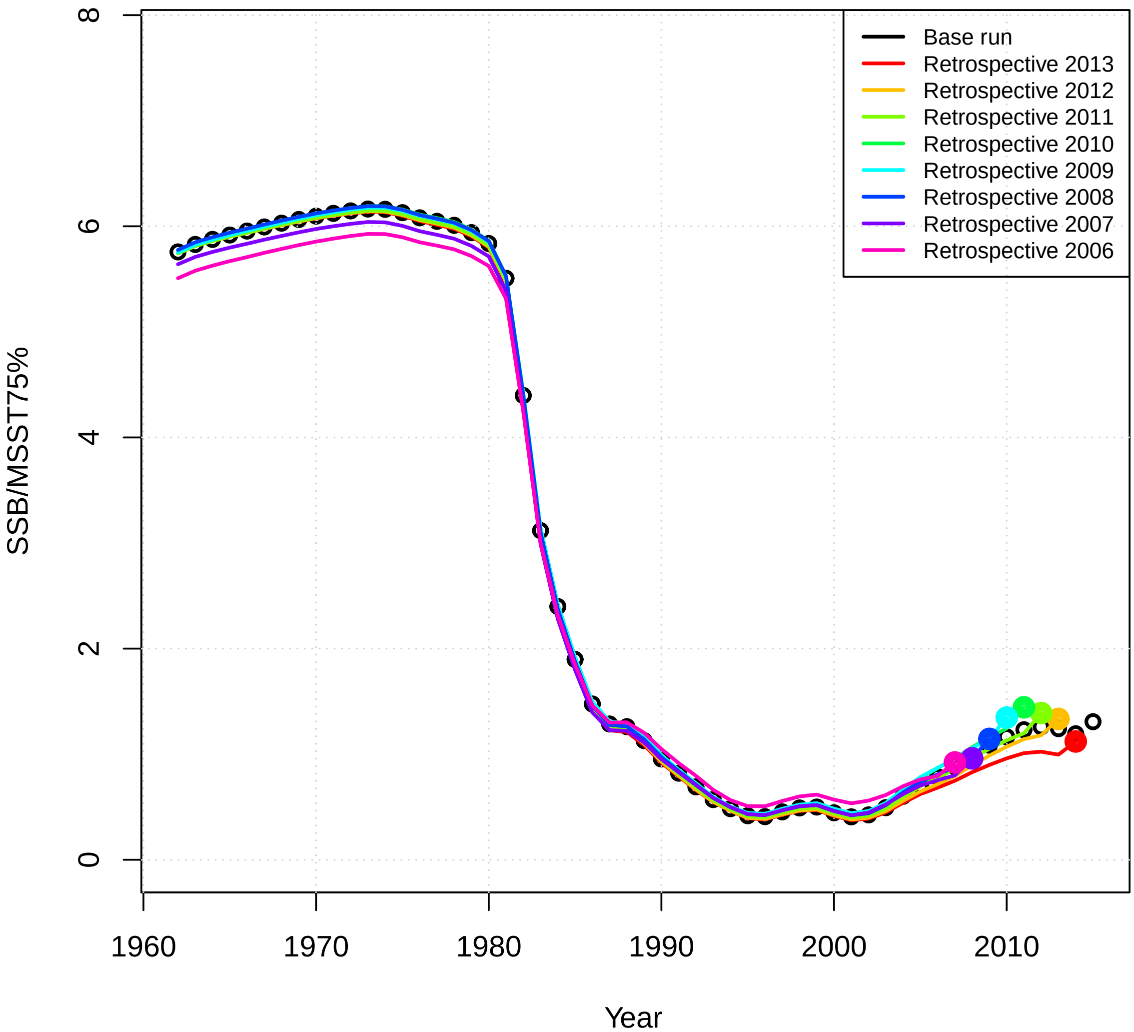
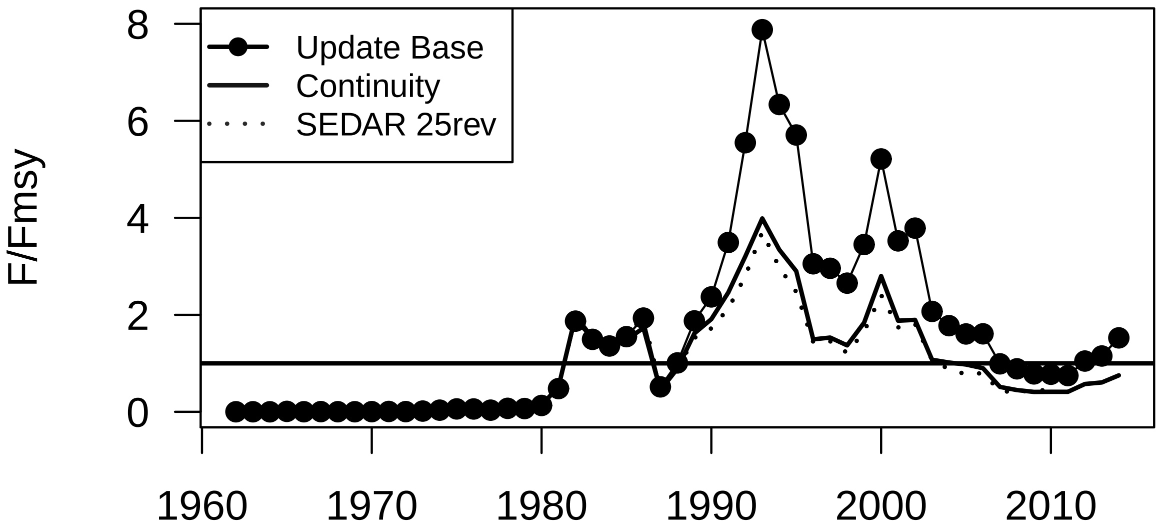


Figure 8.35. Comparison of stock status indicators among base and continuity runs described in Section 4.2.6.



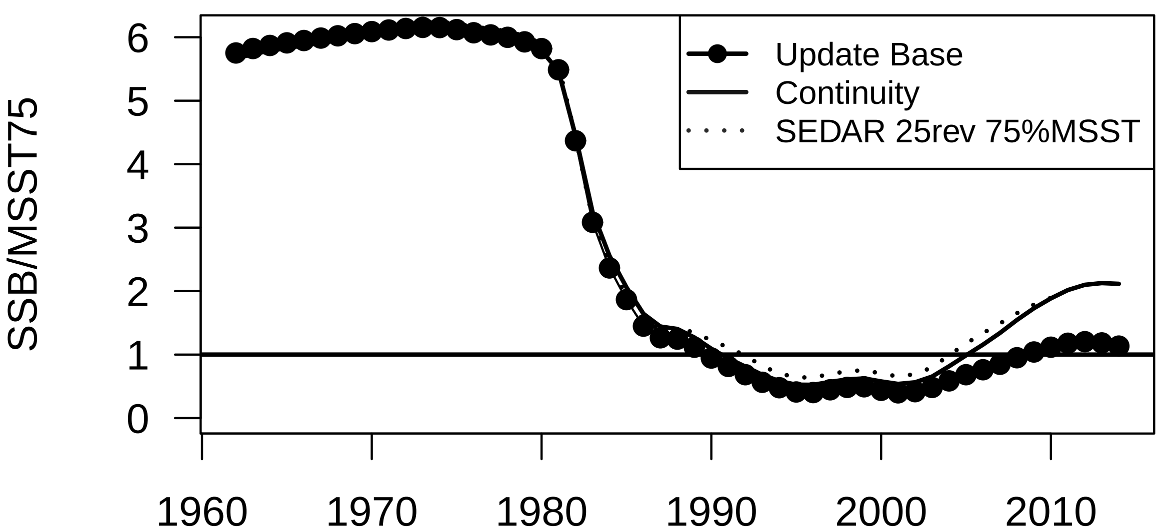


Figure 8.36. Projection results under scenario 1—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians.

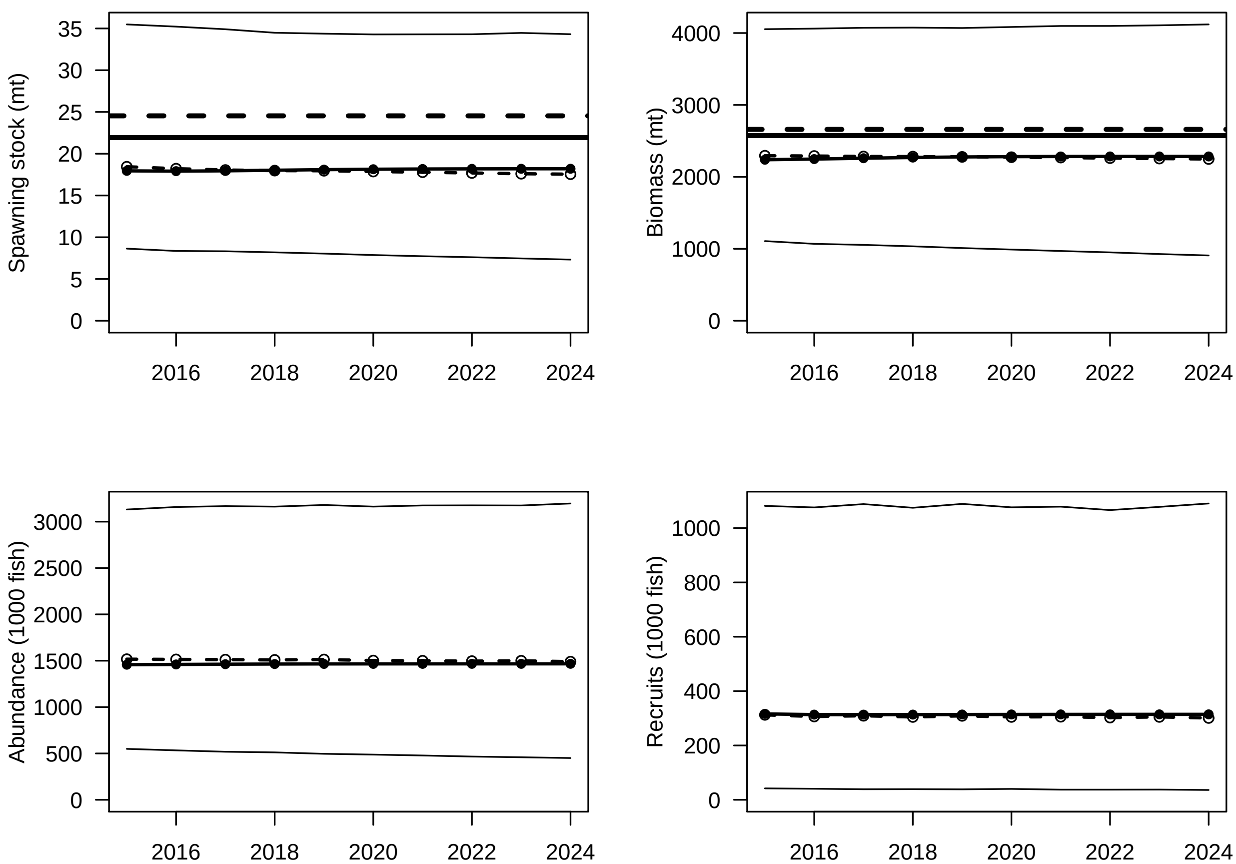


Figure 8.37. Projection results under scenario 1—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians. In the bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific $MSST$. Horizontal lines drawn at 0.5 and 0.7 for reference.

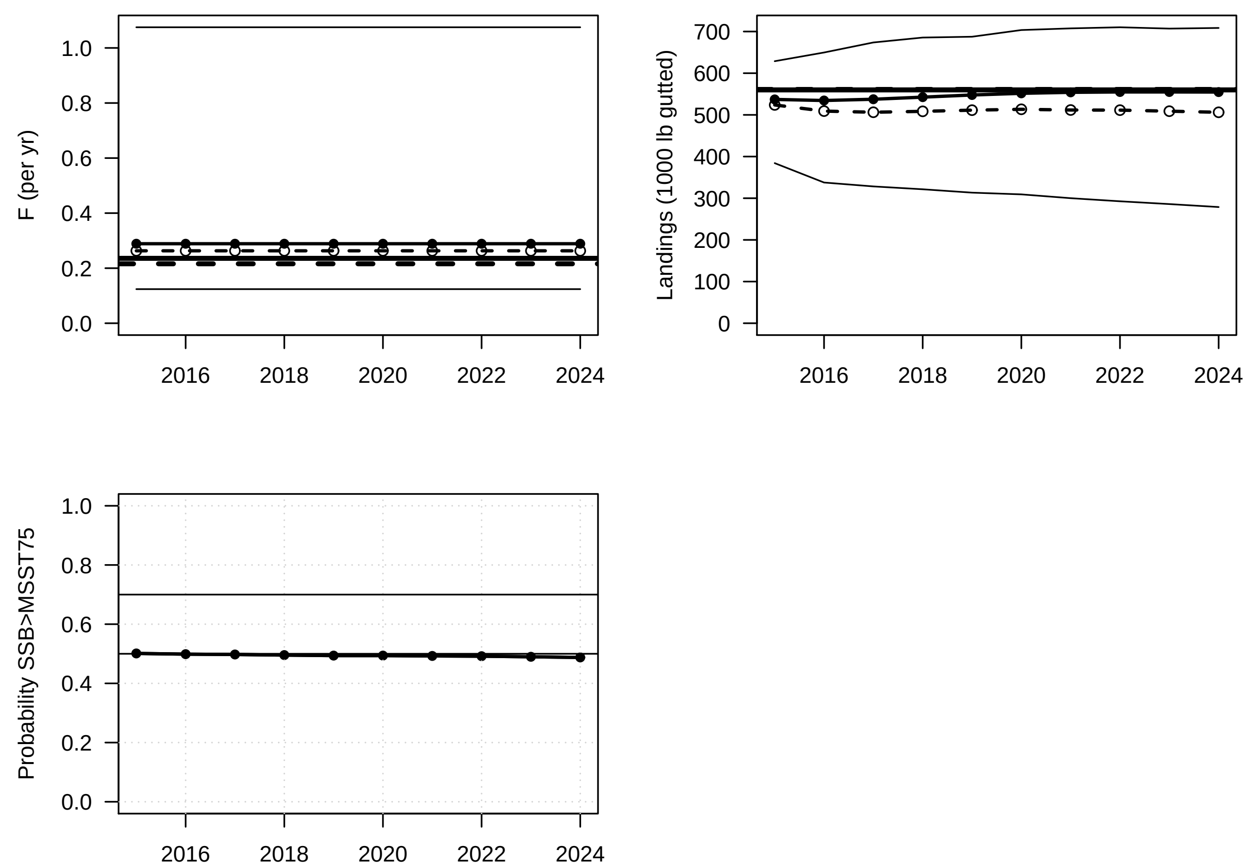


Figure 8.38. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians.

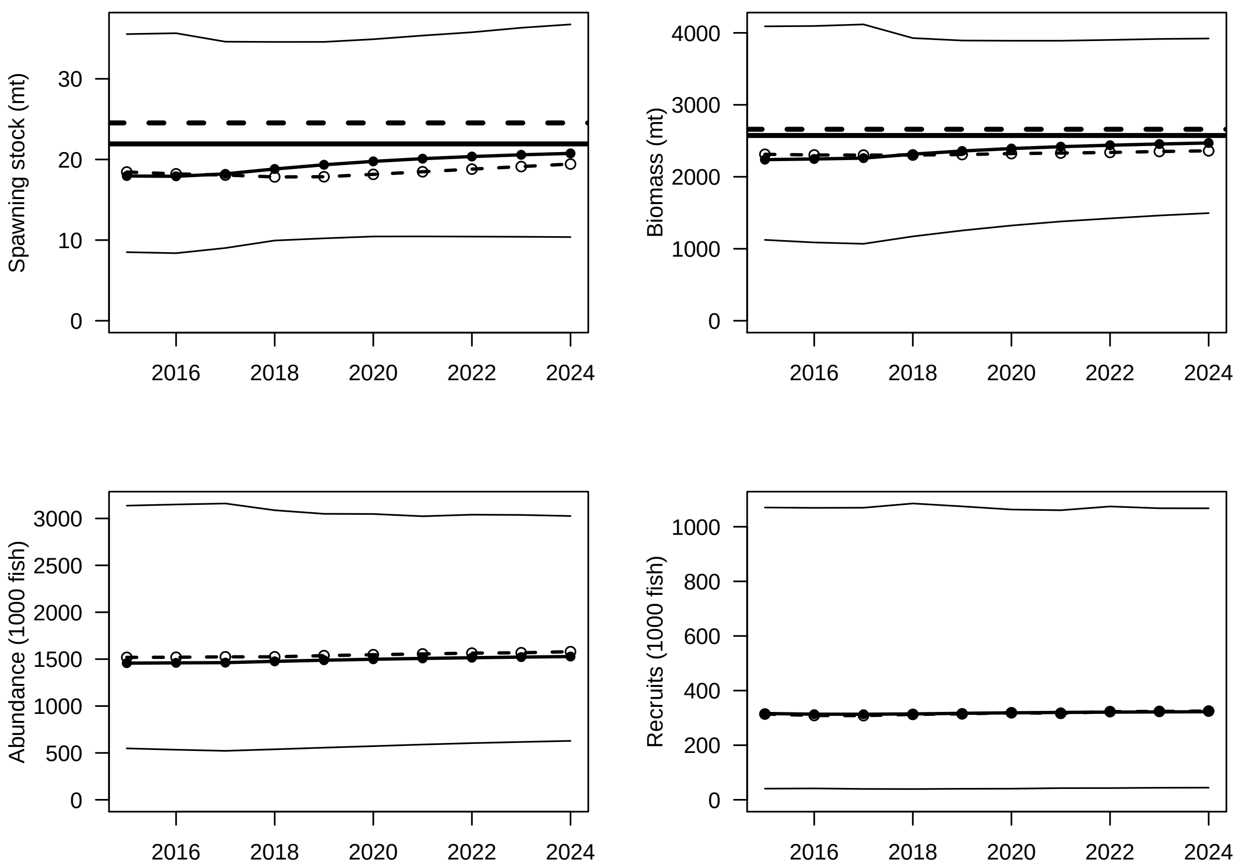


Figure 8.39. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians. In the bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific $MSST$. Horizontal lines drawn at 0.5 and 0.7 for reference.

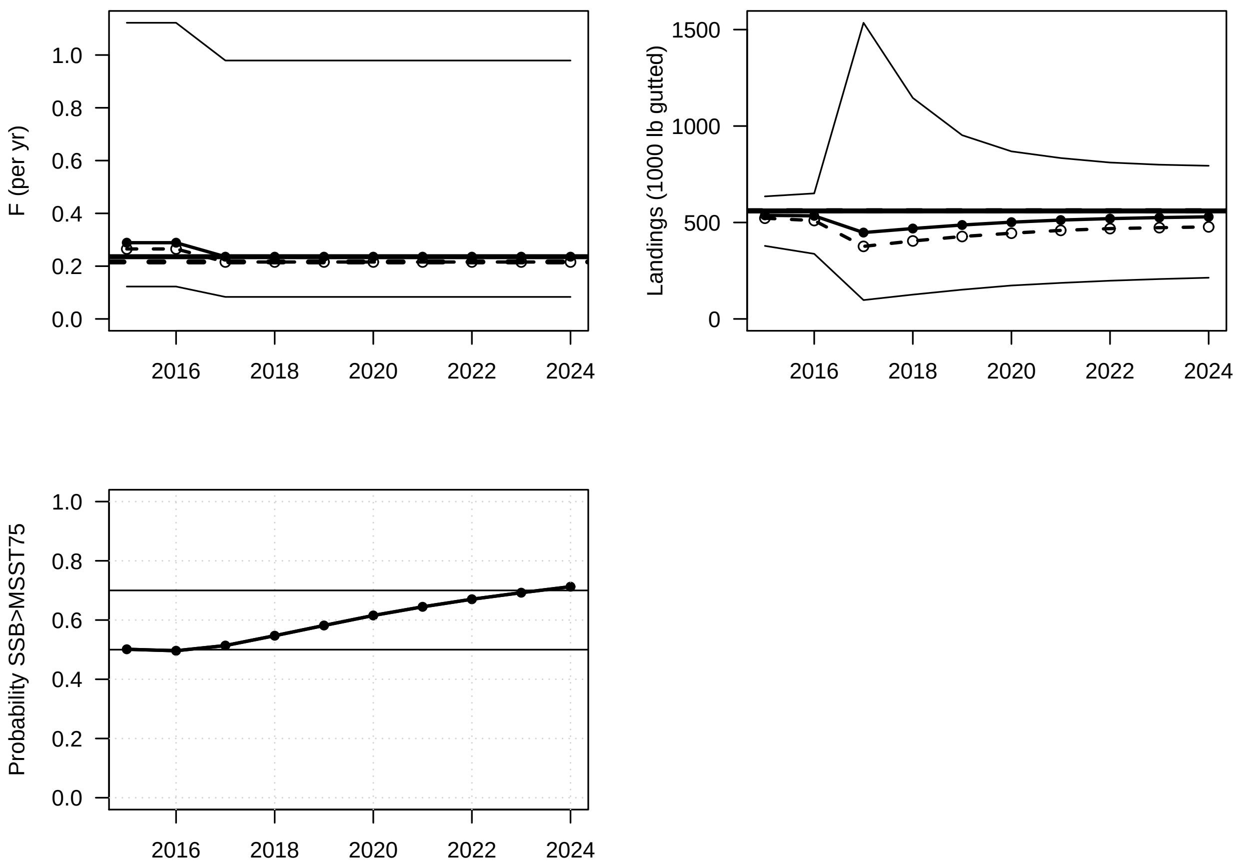


Figure 8.40. Projection results under scenario 3—fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$*. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians.*

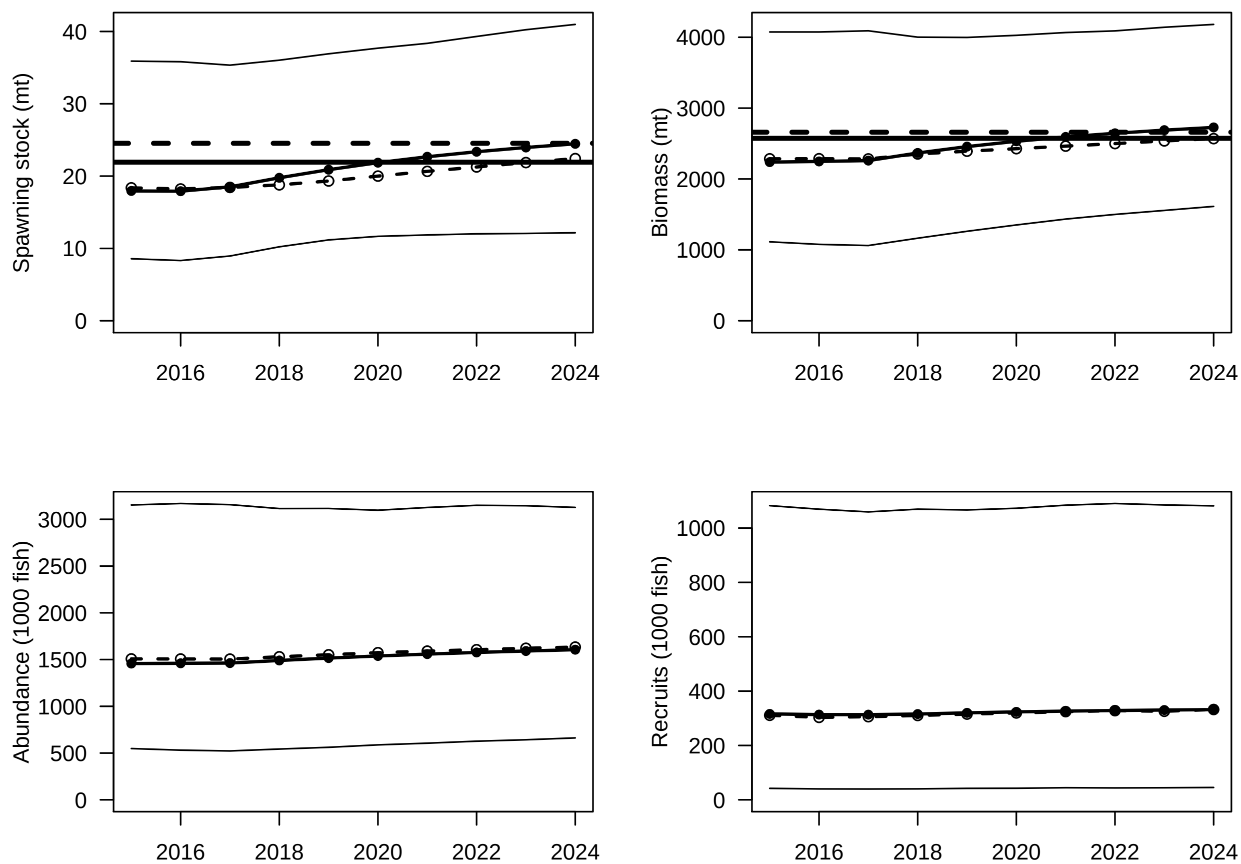


Figure 8.41. Projection results under scenario 3—fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$*. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians. In the bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific* $MSST$*. Horizontal lines drawn at 0.5 and 0.7 for reference.*

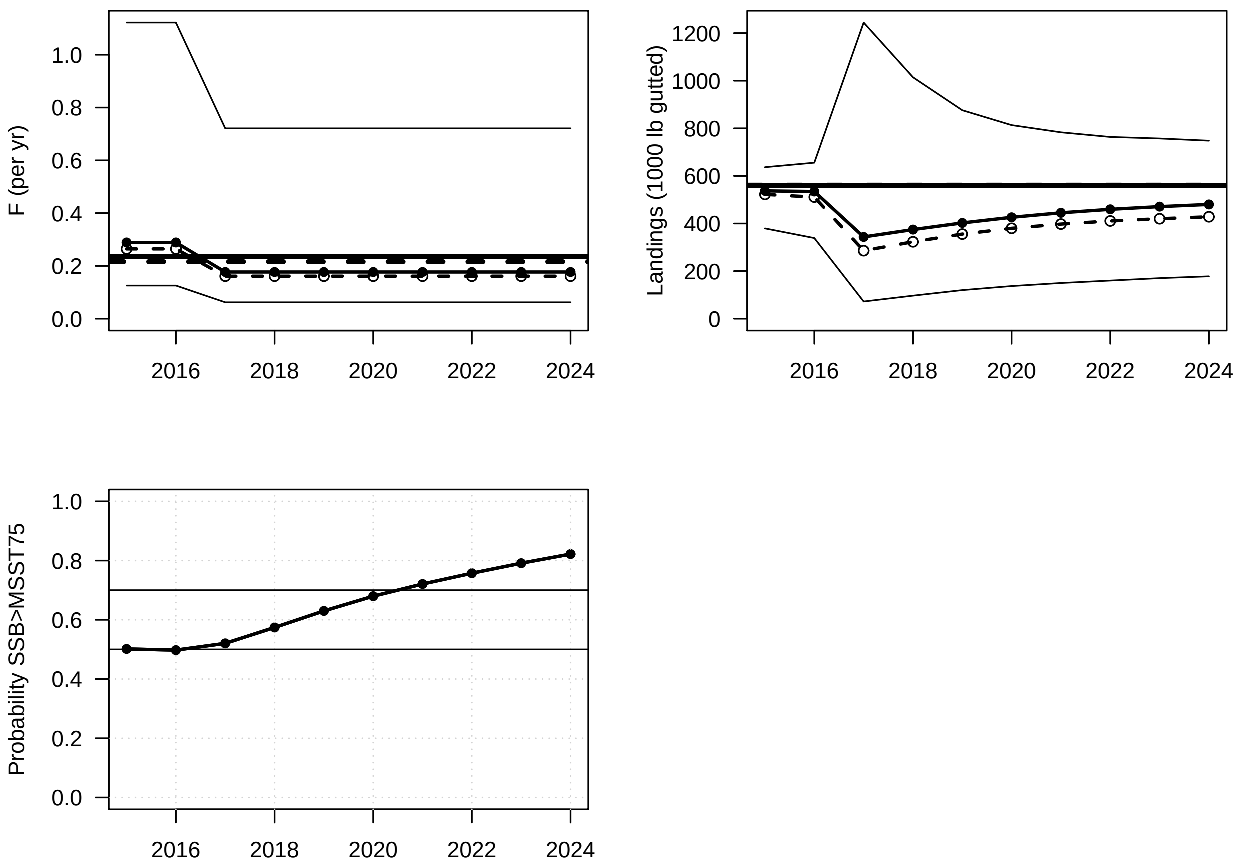


Figure 8.42. Projection results under scenario 4—fishing mortality rate fixed at $P = 0.35$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians.*

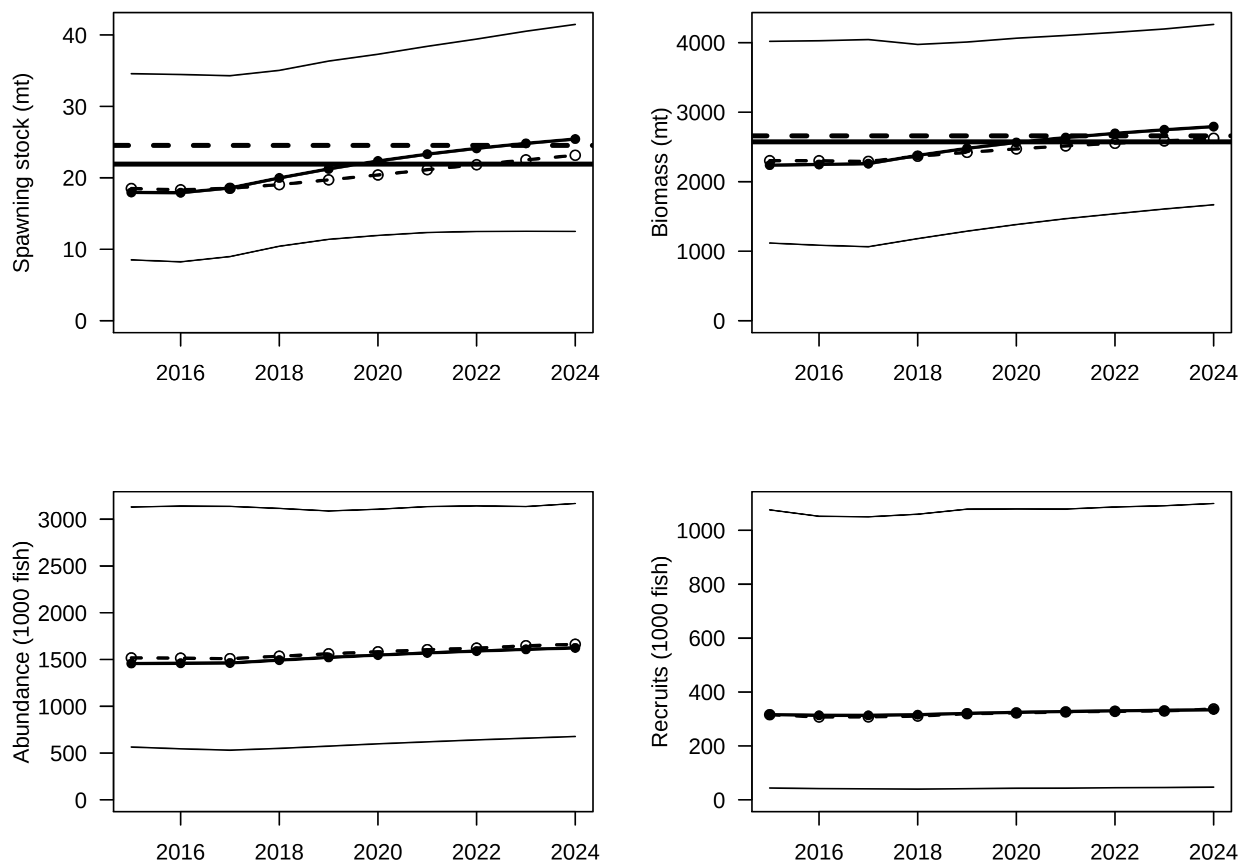


Figure 8.43. Projection results under scenario 4—fishing mortality rate fixed at $P* = 0.35$*. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians. In the bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific* $MSST$*. Horizontal lines drawn at 0.5 and 0.7 for reference.*

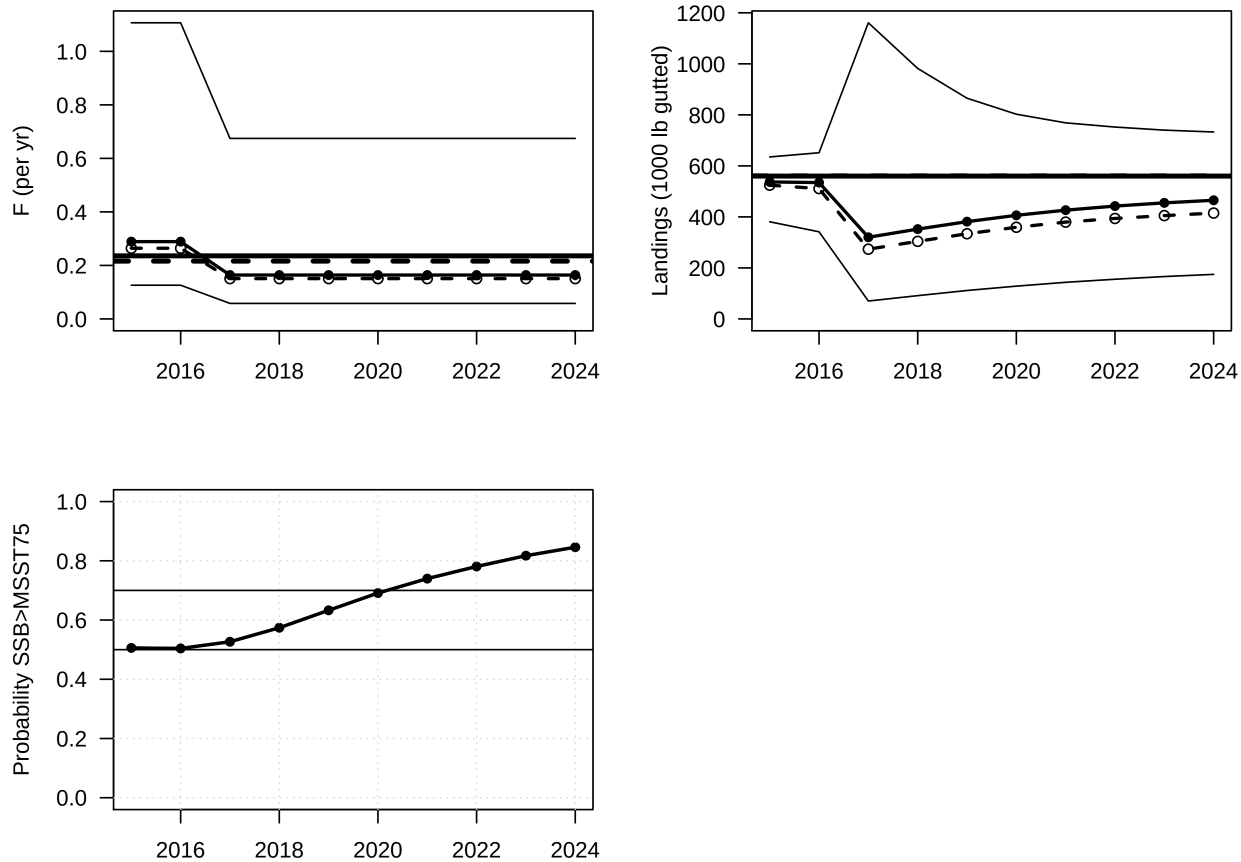


Figure 8.44. Projection results under scenario 5—fishing mortality rate fixed at $P = 0.5$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians.*

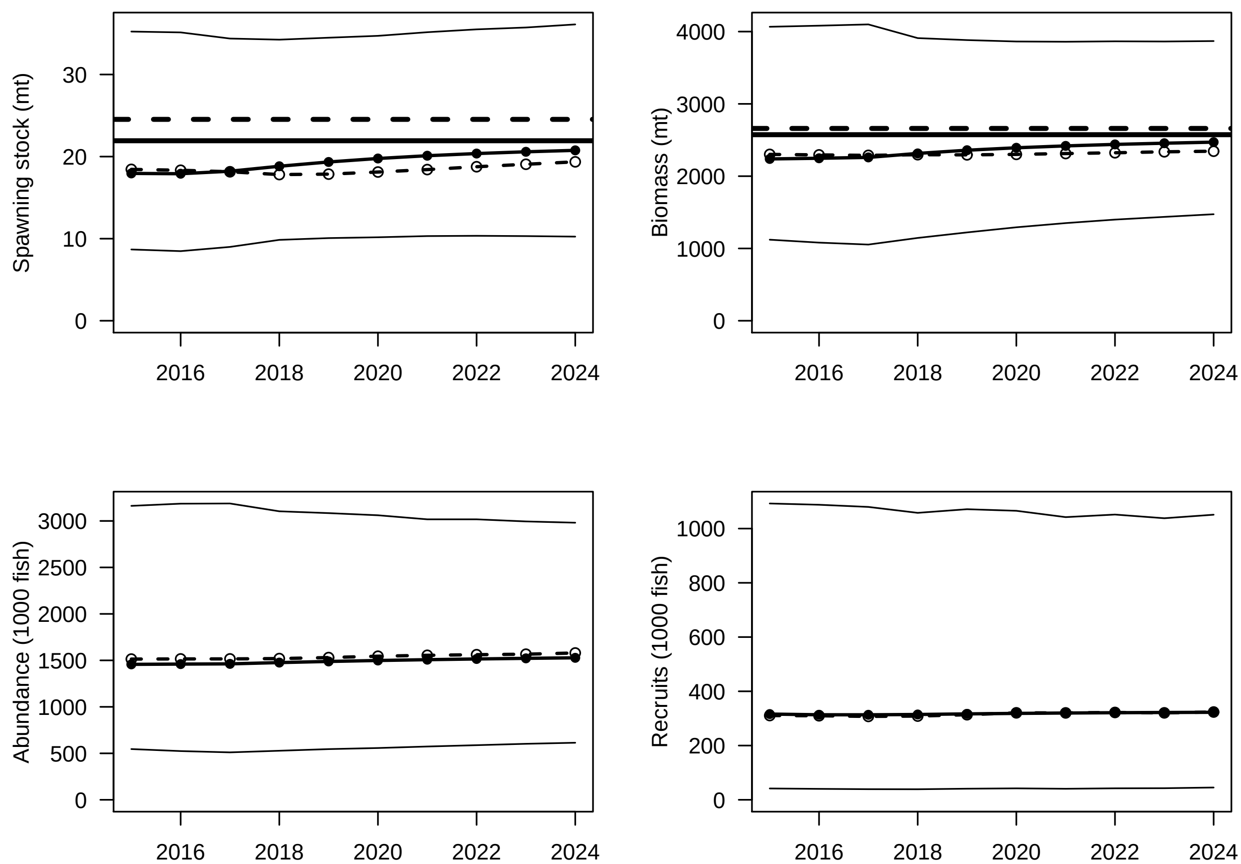
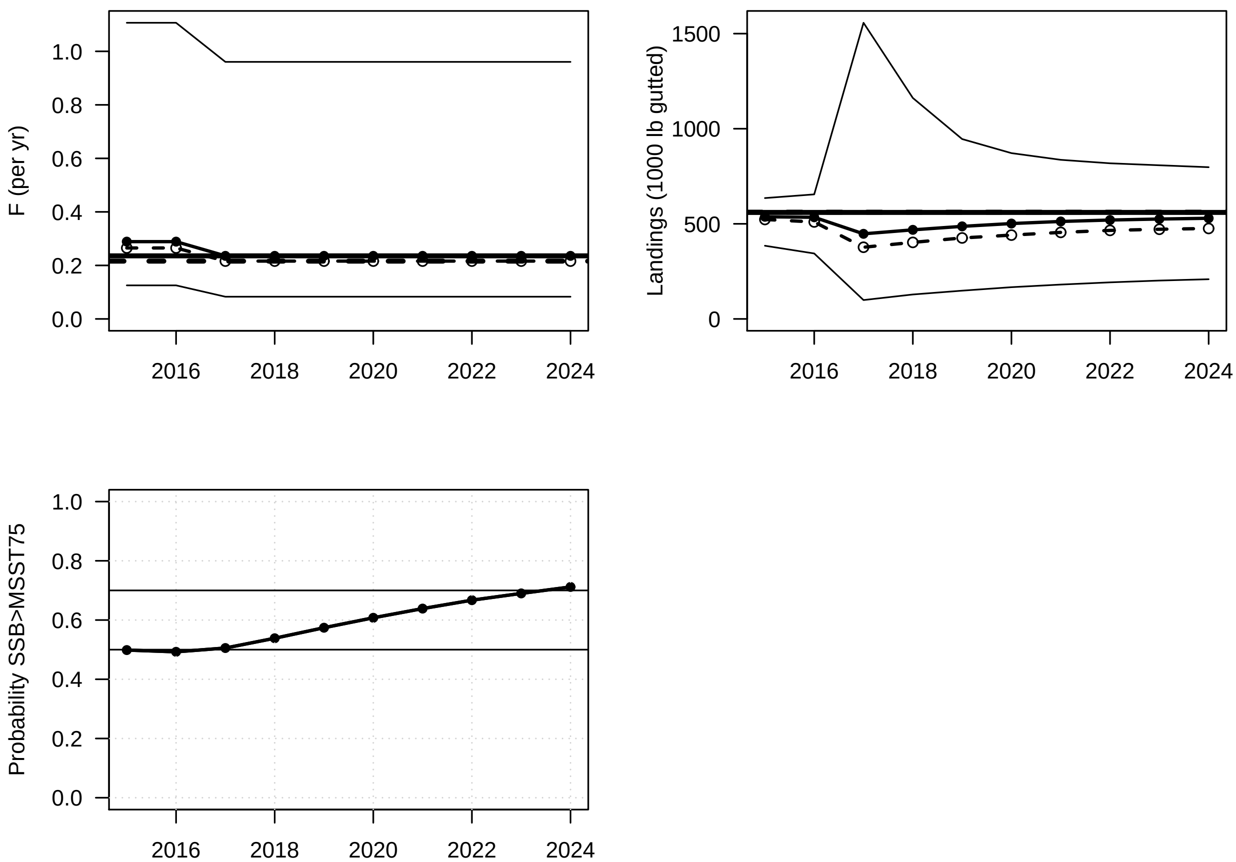


Figure 8.45. Projection results under scenario 5—fishing mortality rate fixed at $P = 0.5$. Expected values (base run) represented by dotted solid lines, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark MSY-related quantities; dashed horizontal lines represent corresponding medians. In the bottom panel, the curve represents the proportion of projection replicates for which SSB exceeds the replicate-specific $MSST$. Horizontal lines drawn at 0.5 and 0.7 for reference.*



Appendix A Abbreviations and symbols

Table A.1. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for tilefish)
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
DW	Data Workshop (here, for tilefish)
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
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 tilefish 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
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
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 Final SEDAR South Atlantic Tilefish Assessment Terms of Reference Approved 9-28-2015

SEDAR

SouthEast Data, Assessment, and Review

4055 Faber Place Drive #201
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Phone (843) 571-4366
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SEDAR South Atlantic Tilefish Assessment*

Terms of Reference

1. Update the approved SEDAR 25 South Atlantic Tilefish ("*Golden Tilefish*") base model with data through 2014.
2. Document any changes or corrections made to the model and input datasets and provide updated input data tables. Provide commercial and recreational landings and discards in pounds and numbers.
3. Update model parameter estimates and their variances, model uncertainties, and estimates of stock status and management benchmarks. Identify other sources of scientific uncertainty that are not already included in the model uncertainties.
4. Provide stock projections, including a pdf for biological reference point estimates and yield separated for landings and discards reported in pounds and numbers. Projection outputs shall include relevant population parameters including recruitment, spawning and stock biomass, population abundance, exploitation rates and the probability that biomass and exploitation exceed reference values for MFMT and MSST. Projection criteria:
   - Probability of overfishing (P*) = 50% and 35%.
   - If the stock is determined to be overfished, provide the probability of rebuilding within mandated time periods based on F=0, F=Fcurrent, F=Frebuild, and F=Fmsy. For this analysis, Frebuild is defined as the maximum exploitation that rebuilds the stock in the maximum time allowed; evaluate at Prebuild = 50% and 65%. In addition to reporting yield and stock status as described above, for this projection also report the probability of SSB>SSBmsy.
5. Develop a stock assessment update report to address these TORS and fully document the input data and results of the stock assessment update.

NOTE: The intent of the assessment update approach is to expedite appraisals of stock status by using only the methods and data sets used in the base model and approved during the preceding SEDAR assessment of that stock. Accordingly, it is not the intent of this update to resolve any outstanding issues identified in the previous SEDAR 25 assessment.

*This assessment is following the update assessment approach.

Appendix C Parameter estimates from the Beaufort Assessment Model

%

```
# Number of parameters = 188  Objective function value = -3030.83  Maximum gradient component = 8.39261e-005
# Linf:
825.100000000
# K:
0.189000000000
# t0:
-0.470000000000
# Linf_f:
806.300000000
# K_f:
0.167000000000
# t0_f:
-0.470000000000
# len_cv_val:
0.150819142821
# 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 0.00000000000
 0.00000000000 0.00000000000
 0.00000000000 0.00000000000
 0.00000000000 0.00000000000
 0.00000000000 0.00000000000
# log_R0:
12.8005344427
# steep:
0.840000000000
# rec_sigma:
0.330013121980
# R_autocorr:
0.00000000000
# log_rec_dev:
 -0.188330436602 -0.155115349017
 -0.176686408015 -0.330819241480
 -0.439357031221 -0.416747816119
 -0.159855627911 -0.302683327635
 -0.321406902021 -0.554602748140
 -0.243403244666 0.0796627275268
 0.758767149479 0.331513078878
 -0.305076606272 -0.256129115945
 -0.171617546922 -0.0448728410623
 0.456362914022 0.0422065542115
 -0.274948972357 -0.0784469698168
 0.0412636949189 0.528290177897
 0.523848934528 0.472448874850
 0.424599061416 0.373935776134
 0.391462969155 0.243396511634
 -0.0681572688094 -0.179500970636
# selpar_L50_cH:
6.99231613396
# selpar_slope_cH:
1.36760587934
# selpar_L50_cL:
7.14721289359
# selpar_slope_cL:
1.32462982627
# selpar_L50_rA:
3.24863183885
# selpar_slope_rA:
2.84629573669
# selpar_L50_mm:
6.45592314032
# selpar_slope_mm:
2.58969298498
# log_q_cL:
-6.77307997818
# log_q_mm:
-6.94553772716
# M_constant:
0.108300000000
# log_avg_F_cH:
-4.79993246435
# log_F_dev_cH:
 -5.22354117794 -5.28781207116
 -6.46558020569 -3.32348039021
 -5.00237262903 -4.14675499552
 -4.64331155471 -4.85094852090
 -4.17114406915 -3.55857409447
 -4.07910454532 -2.82740467323
 -2.00545231549 -1.44759156619
 -1.42251535014 -1.25713600316
 0.0186593537473 -0.465985138499
 0.528986451848 1.40296122646
```

```
 2.23118714370 1.76641098029
 1.77480445966 1.67192458804
 1.77901840644 0.286353286001
 1.02619426128 1.75061922533
 1.89937447585 2.16818840735
 2.54283072139 3.54824145130
 3.08942420536 2.91801227791
 2.06861051982 1.99674689904
 1.72610072715 1.92022229115
 2.35345263136 2.13785400201
 2.62591351789 1.41984243524
 1.61087025174 1.67095338711
 1.00474145577 1.45004164958
 0.905258633744 0.562296757630
 0.556022008378 0.207157954238
 1.75385410713 1.43700294164
 2.36857620822
# log_avg_F_cL:
-2.89682218885
# log_F_dev_cL:
 -5.28285905990 -5.34420997566
 -6.52587728437 -3.38123290566
 -5.06113552861 -4.20505619352
 -4.70086996392 -4.90817296906
 -4.22992642144 -3.61684626065
 -4.13722815339 -2.88576057485
 -2.06362169918 -1.51417769570
 -1.53718787106 -2.25864996323
 -1.86808399836 -1.64335095243
 -1.18451934583 0.363928289889
 1.88711185899 1.70646586941
 1.59025902964 1.72307396662
 1.99794728979 0.692673100832
 1.35571996257 1.96735699170
 2.21074893406 2.61092870165
 3.08082835307 3.34906792735
 3.16653172076 3.07380769629
 2.47017526670 2.42893340127
 2.35054337970 2.61491335020
 3.02536457002 2.61473272054
 2.64037555402 2.07596152737
 1.85436515196 1.69070470652
 1.80798080482 1.25153613795
 1.22970614604 1.09420074963
 1.09243807570 1.06011027149
 1.24594121564 1.43765586024
 1.58667823441
# log_avg_F_rA:
-7.09511523176
# log_F_dev_rA:
 -3.17059795603 -6.07494736049
 -2.27512113437 -0.0385896390333
 2.71698654487 -2.95388448022
 -2.56511523758 -0.191306200127
 -5.26955263330 -1.97551142004
 -1.81308656676 0.763117260887
 -4.59185259874 1.53220254089
 -4.24484902766 0.832369028904
 2.56744293945 -0.795132784843
 1.27673282519 1.93497616059
 2.15263688160 1.92564896479
 2.82772386848 3.41126812859
 3.75721111066 3.19161281460
 1.85611069710 -4.94362853672
 1.82418444423 1.52810492474
 2.10222541161 2.20410090518
 1.64738121530 0.851138908252
# F_init:
0.0100000000000
```