9. Assessment of the Flathead Sole-Bering Flounder Stock Complex Stock in the Bering Sea and Aleutian Islands

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Executive Summary

Summary of Changes in Assessment Inputs

Changes in the input data:

- bottom trawl survey biomass for years 2021-2024;
- survey length composition data for years 2021-2024;
- conditional age-at-length data from the bottom trawl survey for years 2021-2023;
- marginal fishery length compositions from 2020-2023 (though only 2022 and 2023 are included in the likelihood); and
- marginal fishery age compositions from 2020 and 2021. The Age and Growth program was not able to provide marginal fishery age compositions for more recent years due to staffing shortages;
- replacement of the input sample sizes for survey compositional data with values obtained from the `surveyISS` package version 1.0.0 (previously, the number of hauls or the nominal sample size [number of otoliths] were used for marginal lengths and conditional age-at-length data, respectively).

Changes in the assessment methodology: The assessment methodology is the same as the most recent full assessment conducted in 2020 (Monnahan and Haehn 2020), with the small change that the projection model was updated to the latest version of `spm` and the recruitment time series passed to the projections now begins in 1977 for consistency with other assessment workflows. (Previously the entire time series from 1964 onwards was used).

Summary of Results

For the 2025 fishery, we recommend the maximum allowable ABC of 83,807 t. This ABC is a 22.9% increase from the ABC recommended by last year's model for 2025 of 68,203 t. The increase is attributed to several years of elevated survey biomass, and that the projection model routine has been updated to use recruitment values from 1977-present to be consistent with programmatic approaches; these recruitment estimates are on average about 14% higher than the full time series (1964-present), which was previously used.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity/Status	2024	2025	2025*	2026*
M (natural mortality)	0.2	0.2	0.2	0.2
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	609,488	608,230	801,418	832,021
Projected female spawning biomass (t)	165,629	169,452	204,323	220,515
$B_{100\%}$	203,658	203,658	243,288	243,288
$B_{40\%}$	81,463	81,463	97,315	97,315
$B_{35\%}$	71,280	71,280	85,150	85,150
F_{OFL}	0.46	0.46	0.49	0.49
maxF_{ABC}	0.37	0.37	0.40	0.40
F_{ABC}	0.37	0.37	0.40	0.40
OFL (t)	81,605	82,699	**101,621**	106,283
*max*ABC (t)	67,289	68,203	83,807	87,700
ABC (t)	67,289	68,203	**83,807**	87,700
	As determined *last* year for:		As determined *this* year for:	
Status	2023	2024	2024	2025
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Projections are based on an estimated catch of 11,125 t for 2024 and estimates of 11,148 t and 11,148 t used in place of maximum permissible ABC for 2025 and 2026.

Responses to SSC and Plan Team Comments on Assessments in General

"The SSC requests that all authors fill out the risk table in 2019…" (SSC December 2018)

We provide a risk table in the Harvest Recommendations section. After completing this exercise, we do not recommend ABC be reduced below maximum permissible ABC.

Responses to SSC and Plan Team Comments Specific to this Assessment

1. Continue exploration of environmental drivers of FHS stock distribution and behavior, as average summer bottom temperature appears inadequate (SSC, December 2018)

This is out of scope for the present assessment, but might be addressed for the next Full assessment (2028).

2. Investigate data from the NBS for Bering Flounder (SSC, December 2018)

This is out of scope for the present assessment, but might be addressed for the next Full assessment (2028).

3. Consider separately modeling the pelagic trawl fishery with its own selectivity curve (Plan Team, November 2020)

This is out of scope for the present assessment, but might be addressed for the next Full assessment (2028). The pelagic trawl fishery accounts for up to 30% of landings annually and data from that fleet are not included in fishery age nor length compositions.

Introduction

Operational Update: The reader is referred to the full operational stock assessment (Monnahan and Haehn 2020) for the description of Flathead sole-Bering flounder biology and life history.

Fishery

Operational Update: The reader is referred to the last full operational stock assessment assessment (Monnahan and Haehn 2020) for the full description of Flathead sole-Bering flounder fishery history, fishery effort and CPUE, and information regarding discarding.

Table 9.1 shows a time series of total catch, ABC, TAC, OFL and relevant management measures.

Data

Operational Update: The data description for Flathead sole-Bering flounder has been truncated to highlight relevant updates or changes made for this cycle. The reader is referred to the last full assessment (Monnahan and Haehn 2020) for the entirety of this section.

The following table summarizes the data used for this assessment.

Source	Data	Species	Years
NMFS Aleutian Islands Groundfish Trawl Survey	Survey biomass (linear regression used to combine BS shelf survey estimates with AI survey estimates for a single survey biomass index)	Flathead only; no Bering flounder were caught in the Aleutian Islands	1983, 1986, 1991-2000 (triennial), 2002-2006 (biennial), 2010-2022 (biennial)
NMFS Bering Sea Shelf Groundfish Survey (standard survey area only; excludes survey strata 70, 81, 82, 90, 140, 150, and 160)	Survey biomass (linear regression used to combine BS shelf survey estimates with AI survey estimates for a single survey biomass index)	Flathead sole and Bering flounder combined	1982-2019, 2021-2024
	Conditional age-at-length composition	Flathead sole only	1982, 1985, 1992-1995, 1999-2019, 2021-2023
	Marginal length composition	Flathead sole only	1982-2019, 2021-2024
U.S. trawl fisheries	Catch (pelagic and non-pelagic trawl in the Bering Sea and Aleutian Islands; a very small amount of catch is taken with hook and line and is included in the total catch biomass)	Flathead sole and Bering flounder combined	1963-2024 (final year is estimated)
	Marginal age composition (Bering Sea only; non-pelagic trawl only)*	Flathead sole only	2000, 2001, 2004-2007,2009-2021
	Marginal length composition (Bering Sea only; non-pelagic trawl only)*	Flathead sole only	1977-1999, 2002-2003, 2008, 2020-2023
Foreign trawl fisheries in the BSAI	Catch (Bering Sea and Aleutian Islands; trawl)	Flathead sole and Bering flounder combined	1964-1987

*To avoid double-counting data used to estimate parameters in the assessment model, the size composition data were excluded in the model optimization when the age composition data from the same year were available. Thus, only the flathead sole fishery size compositions for 1977-1999, 2002-2003, 2008, 2022 and 2023 were included.

Fishery

Catches as used in the model are shown in Table 9.1; discards are not used in the model. Fishery-dependent compositional data (catch-at-length and catch-at-age, and associated input sample sizes) are shown in Tables 9.2 through 9.5. The model uses an estimate of 2024 catch to be consistent with the projection routine.

Survey

Survey biomass estimates and associated sampling variability (annual CVs) are shown in Table 9.6. Survey length compositional data are shown in Tables 9.7 and 9.8. Survey conditional age-at-length data is prohibitively large to present in this document; readers may access these data electronically here.

This assessment updated the input sample sizes for all survey compositional datasets (marginal lengths and conditional ages-at-length [CAAL], as well as those for marginal ages which are not included in the joint likelihood). The previous approach used the number of hauls as the input sample size for marginal lengths, and the nominal number of read otoliths as the input sample size for CAAL data.

Analytical approach

Operational Update: The data description for Flathead sole-Bering flounder has been truncated to highlight relevant details and changes made for this cycle. The reader is referred to the last full assessment (Monnahan and Haehn 2020) for the entirety of this section.

General Model Structure

The model structure used for this Operational Update is unchanged from 2020. The BSAI flathead sole assessment is a two-sex, age-structured statistical catch-at-age model in Stock Synthesis (SS3, Methot and Wetzel (2013)). The assessment model was transitioned from version `3.30.16` to the latest version of SS3 available as of January 2024 (`3.30.22`). No detectable changes in derived quantities nor likelihoods occurred as a result of this software change. After all data were added to the model, we updated the Francis (2011) compositional data weights to account for the effects on effective sample size of potential time-varying processes that were not explicitly taken into account in the model structure. For more details, see externally-linked document here.

Description of Base Model

perational Update: The configuration matches the accepted model from 2020, with updated data. A full revision to the modeling framework is anticipated in the next cycle (2028). There are no alternative models presented here.

A total of 112 parameters were estimated inside the assessment model, 62 of which were annual recruitment deviations. A description of the treatment of all model parameters (fixed and estimated), their maximum likelihood estimates, and uncertainty intervals are provided in Table 9.9.

Parameters Estimated Outside the Assessment Model

The survey catchability, time- and age-invariant natural mortality for females and males, variability of recruitment (σ_r), the parameters of the maturity ogive, the ageing error matrix, and the weight-length relationship were estimated outside the assessment model.

Input Sample Sizes for Survey Compositions

Following updated research by AFSC staff, we implemented the `surveyISS` R package with 500 bootstrap samples to estimate new input sample sizes for each of these data sets, or the average estimated input sample size for nearby length bins and years when the method returned no value. Using the package resulted in values for the marginal length compositions 3-4 times higher those previously used; this is expected given that there are generally more samples than there are hauls, and length observations are less variable across hauls than they are across ages. After updating the input sample sizes, we algorithmically re-tuned the Francis data weights and compared the derived quantities and parameter estimates between models. The impact on all values was minimal; a detailed description of this bridging exercise and relevant figures are available here.

Survey Catchability

The survey catchability parameter was set to 1.0.

Natural Mortality

The natural mortality rates were set to 0.2 for both sexes, and σ_r was equal to 0.5, consistent with previous assessments.

Maturity Ogive

The maturity ogive for flathead sole followed an age-based logistic curve where age at 50% maturity was 9.7 and age at 95% maturity was 12.8 (Figure 9.19).

Ageing error matrix

The ageing error matrix was taken directly from the Stock Synthesis model used in assessments prior to 2004 (Spencer and Wilderbuer. 2004).

Length-Weight Relationship

The same length–weight relationship used in 2020, of the form $W = aL^b$ was estimated by fitting to survey data from 1982-2016 for males and females combined, with parameter estimates a = 0.00298 and b = 3.327 (weight in g, length in cm).

Parameters Estimated Inside the Assessment Model

Recruitment

The log of unfished recruitment (R_0), log-scale recruitment deviations for an early period 1964-1972 and a main period (1973-2020) were estimated. A 1:1 sex ratio is assumed. The age-0 recruitment was fixed to equal mean recruitment for the most recent four years because too few flathead sole are observed at ages 0-3 to estimate recruitment reliably.

Growth

Sex-specific growth parameters ($L_{amax=21+}$, $L_{amin=3}$, k, CV of length-at-age 3, CV of length-at-age 21+) were estimated inside the assessment model.

Selectivity and fishing mortality

Survey selectivity parameters were estimated using age-based, sex-specific, asymptotic curves that were time-invariant. The double-normal curve was used to easily allow previous and future explorations of alternative survey selectivity forms, but as in 2020 was constrained to mimic a logistic shape because there was no evidence for dome-shaped survey selectivity.

Fishery selectivity parameters for logistic, length-based, sex-specific curves were estimated (the parameters for each curve were the length at 50% selectivity to the fishery and slope of the selectivity curve). Separate fishery selectivity curves were estimated for two distinct time periods (1964-1987 and 1988-present).

Finally, annual fishing mortality rates were estimated (1964-2024).

Selected Model Results

Operational Update: This section has been condensed to follow the newest guidelines for "Operational Update Assessments" to the best of the Authors' ability. A minimal set of figures and tables are provided here; links to electronic files for supplementary data (e.g., numbers-at-age from the base model) are included in-text.

The model used in this assessment is the same as the model accepted in 2020 (Model 18.2c (2020)) with updated data and parameter priors. Model 18.2c (2020) with data updated through 2024 (presented as Model 18.2c (2024)) generally results in reasonable fits to the data (see Figures 9.3 through 9.16), estimates biologically plausible parameters (see Table 9.9), and produces consistent patterns in abundance compared to previous assessments (Figure 9.17).

Time Series Results

Definitions:

- **Spawning biomass** is the estimated weight of mature females, in t.
- **Total biomass** is the estimated weight of all fish ages 3 and greater, in t.
- **Recruitment** is measured as the number of age-zero individuals.
- **Fishing mortality** is the mortality at the age the fishery has fully selected the fish.

Key results have been summarized in Table 9.10. Model predictions generally fit the data well (Figures 9.2 through 9.3). A comma-separated electronic file containing the estimated numbers-at-age is available here.

Biomass

Spawning biomass was at a low in 1983 of 78,059.4 t, reached a peak in 1998 of 223,014 t, slowly decreased through 2020 and recently increased to a current spawning biomass of 185,493 t in 2024 (Figure 9.17). These trends correspond to a period of high recruitment from 1980-1990, a period of low recruitment occurred from 2004-2010 (Figure 9.18) and increasing survey observations since 2015 (Figure 9.3). The survey data are fit well throughout the time series.

Fishing Mortality

Historical apical fishing mortality was between 0.009 and 0.06 for the historical period of foreign fleets and the joint venture fishery. The estimates of uncertainty in fishing mortality during this period are artificially small due to the absence of a stock-recruitment relationship. Fishing mortality reached a peak in 1990 at 0.126, and remained between 0.065 and 0.104 in the 1990s and early 2000s. Fishing mortality reached another peak of approximately 0.131 in 2008 and has declined since then (Figure 9.20).

Selectivity

Figure 9.19 shows the estimated length-based fishery selectivity curves and estimated age-based survey selectivity curves for Model 18.2c (2024). The curves suggest that males are caught at smaller lengths than females for both fleets.

The time-blocked fishery survey selectivity curves Model 18.2c (2024) indicate selection of smaller fish of both sexes in the early period (1964-1987) versus the later period (1988-present). The early period is characterized by a paucity of compositional data (Figure 9.1). The survey data (beginning in 1982) do not suggest that length-at-age was distinct across these time periods. We also do not suspect that the growth curves of fish captured by the fishery vary through time, as the aggregate fits to fishery length data (Figure 9.8) are satisfactory. This is despite the fact that data from many of those years were not included in the joint likelihood; only the survey data was used to inform growth parameters and variability in growth in the model.

Recruitment

Recruitment (as measured by age-0 fish) is moderately variable (Figure 9.17). A period of high recruitments occurred from 1980-1990, and a period low recruitments occurred from 2004-2010 (Figure 9.18). The age-0 recruitment was fixed to equal mean recruitment for the most recent four years because too few flathead sole are observed at ages 0-3 to estimate recruitment reliably for recent years.

Flathead sole do not seem to exhibit a stock-recruitment relationship because large recruitment has occurred during periods of high and low biomass (Figure 9.17 and Table 9.10).Model 18.2c (2024) does not specify an explicit stock-recruitment relationship. The average annual recruitment (in numbers) spawned after 1976 is estimated to be 1.024 million.

Model Evaluation

Comparison to Previous Model

A comparison of key derived quantities from the base model and the most recent full assessment is shown in Figure 9.17. Parameter estimates, fits to the data and likelihood values have remained similar to Model 18.2c (2020).

As has resulted in the BSAI FHS models since 2012 (Monnahan and Haehn (2020), McGilliard (2016), McGilliard (2014), and Stockhausen (2012)), the estimated survey length composition often expects larger proportions of fish in the 20-30 cm range than has been observed. Several hypotheses have been explored through additional model runs about why this residual pattern occurred (McGilliard (2016)) by testing more flexible selectivity patterns, a four-parameter growth curve, more complexity in CV in length at age, alternative and data weighting schemes, yet none of these tests improved the residual pattern nor fit to the data. One last, untested hypothesis is that the data do not fully characterize the variability in length at age for this stock. In other words, the distribution of lengths for the fish with otoliths collected does not match the length distribution of all fish sampled. This hypothesis was not explored here but could be in future assessments.

Similarly, overall fits to fishery age and length composition data were reasonable, but not perfect Figures 9.4 through 9.11). The yearly distributions of ages varied from year to year, suggesting that perhaps a larger sample of ages from the fishery each year would improve our knowledge of the distribution of ages caught by the fishery. One very large Pearson residual occurred in fits to male fishery length-composition data in 1983 (Figure 9.9), which might be driven by a plus-group observation so large as to be a data entry error, and disappears upon calculation of one-step-ahead residuals (Figure 9.11). The aggregate fits to the fishery length composition data suggest that the fishery caught more 45-60cm males than were expected

(Figure 9.4), but this is mostly driven by misfits before 1989; we would not expect the fits to this data source to be as good given the low Francis weight applied to these data in the joint likelihood.

Residual Analysis and Convergence Criteria

The model achieved convergence as defined by an invertible Hessian matrix and a low maximum gradient component (less than `1e-4`) which was achieved using the `hess_step` function in ADMB. Time-series plots of observed and predicted values (e.g. Figure 9.3), and the time-series of recruitment deviations (Figure 9.18) did not suggest unusual residual patterns, or different behavior than in previous assessments. The uncertainty around parameter estimates and related derived quantities were in line with previous models (Tables 9.9 and 9.10).

Parameter Estimates and Parameter Uncertainty

Table 9.9 shows the maximum likelihood estimate (MLE) of key parameters in Model 18.2c (2024) with corresponding 95% credible intervals given by the asymptotic uncertainty. Time series of deviation parameters (fishing mortality rates F and recruitment deviations from 1964-2024 are shown in Figures 9.17 and 9.18, respectively.

Harvest recommendations

Operational Update: This section been truncated to provide minimal background and highlight relevant updates or changes made for this cycle. The reader is referred to the last full assessment (Monnahan and Haehn 2020) for the entirety of this section, including details on the projection approach.

Amendment 56 Reference Points

This stock complex is managed under Tier 3a of Amendment 56. The following table shows the reference points calculated for the 2024 assessment.

Reference Point	Description	Value
$B_{100\%}$	The equilibrium spawning biomass that would be obtained in the absence of fishing	243,288 t
$B_{40\%}$	40% of the equilibrium spawning biomass that would be obtained in the absence of fishing	97,315 t
$B_{35\%}$	35% of the equilibrium spawning biomass that would be obtained in the absence of fishing	85,150.5 t
$F_{40\%}$	The fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing	0.4
ABC	Yield at $F_{40\%}$ in 2025	83,807 t
$F_{35\%}$	The fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing	0.49
OFL	Yield at $F_{35\%}$ in 2025	101,621 t

Specification of OFL and Maximum Permissible ABC

<u>Standard Harvest Scenarios (Harvest Projections)</u>

We used the `spm` projection software, downloaded and compiled on 04 April 2024.

A standard set of projections is required for each stock managed under Tier 3 of Amendment 56. Five of the seven standard scenarios support the alternative harvest strategies analyzed in the Alaska Groundfish Harvest Specifications Final Environmental Impact Statement. They are as follows ("maxF_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

- *Scenario 1*: In all future years, F is set equal to maxF_{ABC} (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
- *Scenario 2*: The exact calculation of these values is shown below.
- *Scenario 3*: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)
- *Scenario 4*: In all future years, F is set equal to the 2018-2022 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of FTAC than F_{ABC}.)
- *Scenario 5*: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

- *Scenario 6*: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above 1) above its MSY level in 2024 or 2) above ½ of its MSY level in 2024 and above its MSY level in 2034 under this scenario, then the stock is not overfished.) While Scenario 6 gives the best estimate of OFL for 2024, it does not provide the best estimate of OFL for 2025, because the mean 2024 catch under Scenario 6 is predicated on the 2024 catch being equal to the 2024 OFL, whereas the actual 2024 catch will likely be less than the 2024 OFL. The executive summary contains the appropriate one- and two-year ahead projections for both ABC and OFL.
- *Scenario 7*: In 2025 and 2026, F is set equal to maxF_{ABC}, and in all subsequent years F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its MSY level in 2026 or 2) above 1/2 of its *MSY* level in 2026 and expected to be above its MSY level in 2036 under this scenario, then the stock is not approaching an overfished condition.)

<u>How Future Catches are Specified for Scenario 2 (Author's F)</u>

The method for specifying catches in years 2024 to 2026 has not changed from the 2020 assessment.

For Scenario 2 (*Author's F*); we use pre-specified catches to increase accuracy of short-term projections in fisheries where the catch is usually less than the ABC. We specify 2024 catches as the most current observed catches plus the typical (5-year average) landings through the present date through the end of the calendar year, and the catches for years 2025 and 2026 as the average catch from 2019 to 2023, which is 11,148 t.

Projected catches, spawning biomass, and fishing mortality rates corresponding to the alternative harvest scenarios over a 13-year period are shown in Tables 9-11 through 9-13.

Risk Table and ABC recommendation

The risk table scoring for BSAI FHS has not changed since 2020.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: No concern	Level 1: No concern	Level 1: No concern	Level 1: No concern

An abridged summary of the considerations that led to this determination for each category follows.

Assessment considerations

Overall, the model fits all the data sets very well. Both the survey index, and survey and fishery composition data show no concerning patterns. All parameters were well estimated, without any convergence issues. Adding the new data had a minimal impact on estimated parameters and management quantities, corroborating the general stability of the model found in previous assessments. *We therefore conclude there are no increased concerns and set this consideration at level 1.*

Population dynamics considerations

The spawning stock biomass has been above target for the entire time period for which there are data. It is projected to increase into the near future (based on the Scenario 4 projection above) as there was a series of above-average recruitments from 2015-2020 that continue to mature. This increase is already borne out in the estimated age 3+ biomass (Figure 9-17) and observed index (Figure 9-3), both of which show a general increase since 2015. *Since we have no increased concerns we set the concern level to 1.*

Environmental/Ecosystem considerations

Summary for Environmental/Ecosystem considerations: This is a summary of details provided by the

Environment: The EBS shelf experienced oceanographic conditions that were largely average based on historical time series of multiple metrics over the past year (August 2023 - August 2024). The cold pool was average in extent over the shelf. Winds favored offshore Ekman transport from March through May that may have hindered transport to suitable nearshore nursery habitat. **Prey**: Indicators of prey availability suggest sufficient prey may have been available for FHS-Bering flounder. Competition: Trends in potential competitors indicate competition for prey resources remains low in 2024. **Predation**: Trends in competitors indicate potentially increased predation pressure for FHS-Bering flounder.

Together, the most recent data available suggest an ecosystem risk Level 1 – Normal: "No apparent ecosystem concerns related to biological status (e.g., environment, prey, competition, predation), or minor concerns with uncertain impacts on the stock."

Fishery performance

There is no ESP for this stock complex, but we note that the fishery has consistently caught only a small fraction of the ABC (averaging less than 20% over the last five years). We did not examine CPUE trends nor spatial patterns of fishing. There are no changes in the duration of fishing openings. *Altogether, we see no cause for concern and give this consideration a level 1 as well.*

Risk Table Summary and ABC recommendation

Since we rated all four considerations at level 1, we do not believe a reduction from max_{ABC} *is warranted.*

Status Determination

The status definitions under the MSFCMA have been truncated from this report.

Overfishing

The official catch estimate for the most recent complete year (2023) is 8,988 t. This is less than the 2023 OFL of 48,161 t. *The stock is not subject to overfishing.*

Overfished (Harvest Scenario 6)

The minimum stock size threshold (MSST) for BSAI FHS is given by $B_{35\%}$ which is 85,150 in 2024. The estimated stock spawning biomass in 2024 is more than double the MSST at 204,323. *The stock is not overfished*.

Approaching Overfished (Harvest Scenario 7)

The mean estimated stock spawning biomass in 2037 under Harvest Scenario 7 is greater than $B_{35\%}$ (Table 9-12). *The stock is not approaching an overfished state*.

The F using Model 18.2c (2024) that would have produced a catch for 2023 equal to the OFL specified in 2023 for 2023 (48,161) was 0.333.

Ecosystem Considerations

Operational Update: The Ecosystem Considerations for BSAI FHS are unchanged. The reader is referred to the last full assessment (Monnahan and Haehn 2020) for the entirety of this section. The Ecosystem component of the Risk Table provides the most updated information for this stock.

Data Gaps and Research Priorities

Operational Update: The reader is referred to the last full stock assessment (Monnahan and Haehn 2020) for the entirety of the BSAI FHS Data Gaps and Research Priorities section. The sole update to this section concerns the genetic distinction between Bering flounder and Flathead sole:

A collection of flathead sole from the Aleutian Islands (n=24) was analyzed using low coverage whole genome sequencing along with collections of yellowfin sole (*Limanda aspera*) and Bering flounder (*Hippoglossoides robustus*) (Figure 9.21). Results confirmed that flathead sole is genetically distinct from Bering flounder, which is significant given that they are identical at cytochrome b (Kartavtsev YP (2008)). A principal components analysis (Figure 9.22) shows clear separation among flathead sole, Bering flounder, and yellowfin sole, and the differences are all relatively similar; no two species appear more similar than others. This is significant because previous analyses based on cytochrome b, morphometric, and protein data have suggested synonymization of Hippoglossoides robustus under H. elassodon. (Hardy and Mah (2011)). Further analysis is needed to examine whether there is genetic diversity among flathead sole from the Aleutian Islands vs. eastern Bering Sea. We recommend that a collection of flathead sole (n=25) from the eastern Bering Sea survey be sequenced in 2025.

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Auxiliary Files

A script to reproduce the analyses presented in this assessment is available here.

Survey conditional age-at-length data are prohibitively large to present in this document; readers may access these data electronically here.

A comma-separated electronic file containing the estimated numbers-at-age is available here.

A document describing the bridging exercises (software, data, and input sample sizes) from 2020 to the present assessment is provided here.

A document describing the ecosystem considerations for 2024 is provided here.

Tables

Table 9.1. Total catch, ABC, Final TAC, OFL, and associated management measures for BSAI FHS since 2007. The Total column are the catches used in the assessment and projection model. Catch at age and length are provided in separate tables. Catch Accounting System via AKFIN database.

Year	Total Catch (t)	ABC	TAC	OFL	Management Measures
1986	5,208				
1987	3,595				
1988	6,783				
1989	3,604				
1990	20,245				
1991	14,197				
1992	14,407				
1993	13,574				
1994	17,006				
1995	14,715	138,000	30,000	167,000	
1996	17,346	116,000	30,000	140,000	
1997	20,683	101,000	43,500	145,000	
1998	24,387	132,000	100,000	190,000	
1999	18,573	77,300	77,300	118,000	
2000	20,441	73,500	52,652	90,000	
2001	17,811	84,000	40,000	102,000	
2002	15,575	82,600	25,000	101,000	Red King crab and halibut caps
2003	13,785	66,000	20,000	81,000	Halibut caps
2004	17,398	61,900	19,000	75,200	Halibut caps, bycatch status, protected species status
2005	16,108	58,500	19,500	70,200	Halibut caps
2006	17,981	59,800	19,500	71,800	"
2007	18,958	79,200	30,000	95,300	"
2008	24,540	71,700	50,000	86,000	Amendment 80 closures; bycatch limited access; incidental catch allowance
2009	19,558	71,400	60,000	83,800	"
2010	20,127	69,200	60,000	83,100	"
2011	13,557	69,300	41,548	83,300	"
2012	11,365	70,400	34,134	84,500	"
2013	17,353	67,900	22,699	81,500	Amendment 80 closures
2014	16,511	66,293	24,500	79,633	"
2015	11,306	66,130	24,250	79,419	"
2016	10,313	66,250	21,000	79,562	"
2017	9,111	68,278	14,500	81,654	"
2018	11,007	66,773	14,500	79,862	"
2019	15,880	66,625	14,500	80,918	"
2020	9,392	68,134	19,500	82,810	"
2021	10,260	62,567	25,000	75,863	"
2022	14,690	64,288	35,500	77,967	"
2023	8,988	65,344	35,500	79,256	"
2024	11,148	67,289	35,500	81,605	"

Table 9.2. Fishery length frequency data for female BSAI FHS since 2000 used in the model. Input sample sizes are in parentheses.

Length (cm)	2002 (1124)	2003 (1002)	2008 (4164)	2022 (2254)	2023 (1260)
6	0.0000	0.0000	0.0001	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0001	0.0002	0.0001	0.0001	0.0000
16	0.0000	0.0001	0.0000	0.0002	0.0001
18	0.0005	0.0001	0.0001	0.0006	0.0002
20	0.0006	0.0006	0.0002	0.0012	0.0018
22	0.0014	0.0008	0.0006	0.0033	0.0042
24	0.0006	0.0027	0.0020	0.0078	0.0092
26	0.0021	0.0065	0.0057	0.0137	0.0190
28	0.0064	0.0084	0.0089	0.0264	0.0253
30	0.0101	0.0158	0.0189	0.0409	0.0320
32	0.0183	0.0232	0.0332	0.0501	0.0396
34	0.0396	0.0407	0.0546	0.0502	0.0485
36	0.0617	0.0615	0.0685	0.0569	0.0488
38	0.0750	0.0757	0.0609	0.0420	0.0438
40	0.1178	0.1333	0.0788	0.0496	0.0481
43	0.0804	0.0913	0.0713	0.0500	0.0474
46	0.0458	0.0382	0.0535	0.0498	0.0542
49	0.0157	0.0095	0.0191	0.0322	0.0265
52	0.0037	0.0022	0.0023	0.0050	0.0056
55	0.0012	0.0000	0.0002	0.0002	0.0002
58+	0.0009	0.0003	0.0001	0.0001	0.0001

Table 9.3. Fishery length frequency data for male BSAI FHS since 2000 used in the model. Input sample sizes are in parentheses.

Length (cm)	2002 (1124)	2003 (1002)	2008 (4164)	2022 (2254)	2023 (1260)
6	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0002	0.0000	0.0001	0.0000	0.0000
14	0.0001	0.0003	0.0000	0.0001	0.0000
16	0.0005	0.0003	0.0000	0.0001	0.0004
18	0.0005	0.0001	0.0001	0.0006	0.0011
20	0.0017	0.0007	0.0008	0.0020	0.0024
22	0.0054	0.0030	0.0020	0.0057	0.0041
24	0.0074	0.0071	0.0057	0.0089	0.0146
26	0.0113	0.0209	0.0128	0.0279	0.0247
28	0.0236	0.0262	0.0266	0.0493	0.0439
30	0.0408	0.0359	0.0551	0.0729	0.0772
32	0.0710	0.0551	0.0984	0.0981	0.0923
34	0.1074	0.1054	0.1096	0.0769	0.0809
36	0.1194	0.1137	0.0954	0.0604	0.0551
38	0.0761	0.0763	0.0654	0.0479	0.0563
40	0.0406	0.0356	0.0381	0.0526	0.0656
43	0.0081	0.0054	0.0069	0.0122	0.0219
46	0.0030	0.0019	0.0027	0.0022	0.0035
49	0.0008	0.0006	0.0012	0.0013	0.0010
52	0.0001	0.0002	0.0001	0.0002	0.0004
55	0.0000	0.0000	0.0000	0.0001	0.0000
58+	0.0000	0.0000	0.0000	0.0001	0.0000

Table 9.4. Fishery age frequency data for female BSAI FHS in last ten years used in the model. Input sample sizes are in parentheses.

Age	2014 (347)	2015 (310)	2016 (585)	2017 (379)	2018 (435)	2019 (530)	2020 (439)	2021 (487)
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0000	0.0041
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0060	0.0225	0.0000
5	0.0017	0.0022	0.0072	0.0031	0.0014	0.0132	0.0464	0.0108
6	0.0017	0.0087	0.0103	0.0062	0.0123	0.0132	0.0267	0.0270
7	0.0120	0.0261	0.0383	0.0201	0.0192	0.0120	0.0267	0.0458
8	0.0206	0.0326	0.0507	0.0370	0.0233	0.0216	0.0394	0.0391
9	0.0309	0.0370	0.0507	0.0509	0.0369	0.0276	0.0801	0.0566
10	0.0498	0.0652	0.0775	0.0386	0.0342	0.0324	0.0225	0.0552
11	0.0498	0.0630	0.0786	0.0509	0.0588	0.0228	0.0394	0.0364
12	0.0550	0.0869	0.0848	0.0771	0.0602	0.0348	0.0295	0.0350
13	0.0533	0.0522	0.0465	0.0602	0.0602	0.0348	0.0408	0.0270
14	0.0481	0.0261	0.0372	0.0478	0.0697	0.0432	0.0394	0.0323
15	0.0550	0.0370	0.0321	0.0370	0.0533	0.0432	0.0323	0.0391
16	0.0292	0.0326	0.0207	0.0247	0.0315	0.0480	0.0295	0.0485
17	0.0275	0.0239	0.0124	0.0201	0.0438	0.0324	0.0295	0.0283
18	0.0292	0.0196	0.0145	0.0278	0.0246	0.0324	0.0169	0.0270
19	0.0223	0.0087	0.0072	0.0124	0.0096	0.0156	0.0183	0.0148
20	0.0120	0.0130	0.0052	0.0124	0.0096	0.0240	0.0155	0.0175
21+	0.0447	0.0326	0.0352	0.0478	0.0424	0.0623	0.0366	0.0229

Table 9.5. Fishery age frequency data for male BSAI FHS in last ten years used in the model. Input sample sizes are in parentheses.

Age	2015 (310)	2016 (585)	2017 (379)	2018 (435)	2019 (530)	2020 (439)	2021 (487)
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0010	0.0000	0.0000	0.0000	0.0028	0.0000
3	0.0000	0.0000	0.0016	0.0000	0.0024	0.0014	0.0014
4	0.0044	0.0052	0.0046	0.0055	0.0132	0.0225	0.0041
5	0.0022	0.0103	0.0093	0.0068	0.0192	0.0464	0.0445
6	0.0130	0.0176	0.0247	0.0164	0.0120	0.0281	0.0714
7	0.0456	0.0248	0.0185	0.0260	0.0324	0.0309	0.0431
8	0.0283	0.0476	0.0478	0.0164	0.0348	0.0309	0.0256
9	0.0391	0.0341	0.0417	0.0233	0.0240	0.0394	0.0216
10	0.0435	0.0290	0.0555	0.0492	0.0300	0.0169	0.0283
11	0.0565	0.0393	0.0309	0.0424	0.0204	0.0141	0.0094
12	0.0435	0.0362	0.0432	0.0328	0.0240	0.0141	0.0121
13	0.0304	0.0321	0.0339	0.0410	0.0204	0.0183	0.0256
14	0.0283	0.0269	0.0216	0.0315	0.0360	0.0323	0.0189
15	0.0109	0.0155	0.0154	0.0274	0.0420	0.0253	0.0283
16	0.0174	0.0155	0.0108	0.0178	0.0456	0.0169	0.0243
17	0.0065	0.0062	0.0077	0.0109	0.0264	0.0211	0.0189
18	0.0130	0.0114	0.0108	0.0137	0.0168	0.0070	0.0135
19	0.0065	0.0083	0.0108	0.0137	0.0096	0.0028	0.0067
20	0.0022	0.0000	0.0077	0.0109	0.0120	0.0099	0.0054
21+	0.0413	0.0300	0.0293	0.0233	0.0587	0.0253	0.0296

Table 9.6. Survey biomass estimates (t) with standard error (SE) for BSAI FHS.

Year	Biomass (t)	SE
1982	197,759	0.09
1983	277,331	0.10
1984	291,972	0.08
1985	271,890	0.07
1986	364,713	0.09
1987	400,742	0.09
1988	569,867	0.09
1989	528,806	0.08
1990	601,534	0.09
1991	552,288	0.08
1992	626,382	0.10
1993	616,911	0.07
1994	699,446	0.07
1995	603,642	0.09
1996	625,889	0.09
1997	794,426	0.21
1998	692,722	0.20
1999	408,611	0.09
2000	401,106	0.09
2001	523,303	0.10
2002	562,073	0.17
2003	523,393	0.10
2004	624,805	0.08
2005	621,858	0.08
2006	643,731	0.09
2007	571,325	0.09
2008	553,787	0.14
2009	426,509	0.12
2010	506,197	0.14
2011	593,207	0.18
2012	386,892	0.11
2013	499,449	0.17
2014	532,889	0.13
2015	400,761	0.11
2016	452,785	0.07
2017	549,526	0.08
2018	494,579	0.08
2019	603,874	0.14
2021	669,293	0.11
2022	710,804	0.18
2023	604,283	0.16
2024	730,523	0.13

Table 9.7. Survey length frequency data for female BSAI FHS for last ten years used in the model. Input sample sizes are in parentheses.

Length (cm)	2015 (1273.8)	2016 (2226.9)	2017 (2321.1)	2018 (2094.5)	2019 (1672.8)	2021 (1887.6)	2022 (1101.8)	2023 (983.2)	2024 (1128.1)
6	0.0002	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0006	0.0002	0.0008	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
10	0.0023	0.0020	0.0038	0.0024	0.0005	0.0006	0.0003	0.0005	0.0006
12	0.0050	0.0092	0.0103	0.0143	0.0041	0.0036	0.0016	0.0012	0.0018
14	0.0155	0.0187	0.0197	0.0273	0.0125	0.0147	0.0074	0.0072	0.0059
16	0.0328	0.0240	0.0292	0.0316	0.0257	0.0202	0.0221	0.0126	0.0099
18	0.0314	0.0294	0.0308	0.0333	0.0410	0.0225	0.0233	0.0185	0.0208
20	0.0315	0.0364	0.0373	0.0336	0.0361	0.0308	0.0276	0.0241	0.0213
22	0.0330	0.0361	0.0404	0.0405	0.0302	0.0431	0.0327	0.0270	0.0260
24	0.0331	0.0445	0.0389	0.0389	0.0289	0.0386	0.0381	0.0389	0.0245
26	0.0248	0.0420	0.0369	0.0418	0.0321	0.0380	0.0436	0.0431	0.0287
28	0.0270	0.0347	0.0376	0.0371	0.0349	0.0336	0.0393	0.0444	0.0339
30	0.0271	0.0316	0.0319	0.0413	0.0392	0.0339	0.0398	0.0449	0.0397
32	0.0285	0.0290	0.0287	0.0343	0.0446	0.0430	0.0392	0.0446	0.0464
34	0.0387	0.0303	0.0286	0.0288	0.0389	0.0435	0.0372	0.0402	0.0532
36	0.0424	0.0305	0.0263	0.0252	0.0265	0.0292	0.0319	0.0383	0.0566
38	0.0336	0.0282	0.0182	0.0176	0.0200	0.0240	0.0235	0.0299	0.0427
40	0.0386	0.0328	0.0231	0.0168	0.0258	0.0203	0.0194	0.0204	0.0401
43	0.0223	0.0271	0.0216	0.0134	0.0279	0.0162	0.0180	0.0129	0.0106
46	0.0114	0.0117	0.0139	0.0103	0.0169	0.0128	0.0172	0.0199	0.0069
49	0.0047	0.0058	0.0059	0.0039	0.0066	0.0045	0.0067	0.0097	0.0021
52	0.0006	0.0008	0.0012	0.0010	0.0011	0.0005	0.0018	0.0034	0.0007
55	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58+	0.0001	0.0000	0.0003	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000

Table 9.8. Survey length frequency data for male BSAI FHS for last ten years used in the model. Input sample sizes are in parentheses.

Length (cm)	2015 (1273.8)	2016 (2226.9)	2017 (2321.1)	2018 (2094.5)	2019 (1672.8)	2021 (1887.6)	2022 (1101.8)	2023 (983.2)	2024 (1128.1)
6	0.0002	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0011	0.0007	0.0018	0.0002	0.0001	0.0001	0.0000	0.0000	0.0003
10	0.0025	0.0028	0.0062	0.0040	0.0007	0.0017	0.0006	0.0006	0.0013
12	0.0054	0.0098	0.0108	0.0133	0.0049	0.0064	0.0031	0.0023	0.0024
14	0.0169	0.0206	0.0162	0.0336	0.0145	0.0235	0.0104	0.0083	0.0055
16	0.0332	0.0245	0.0328	0.0323	0.0354	0.0284	0.0291	0.0146	0.0130
18	0.0344	0.0342	0.0367	0.0380	0.0481	0.0297	0.0302	0.0303	0.0238
20	0.0297	0.0399	0.0385	0.0393	0.0396	0.0432	0.0340	0.0340	0.0265
22	0.0321	0.0411	0.0427	0.0463	0.0333	0.0514	0.0458	0.0380	0.0336
24	0.0338	0.0435	0.0439	0.0480	0.0364	0.0523	0.0507	0.0483	0.0330
26	0.0424	0.0435	0.0503	0.0458	0.0396	0.0469	0.0483	0.0618	0.0427
28	0.0393	0.0395	0.0475	0.0437	0.0480	0.0461	0.0502	0.0563	0.0604
30	0.0450	0.0344	0.0449	0.0487	0.0546	0.0538	0.0558	0.0588	0.0744
32	0.0533	0.0440	0.0422	0.0381	0.0469	0.0525	0.0521	0.0591	0.0745
34	0.0613	0.0496	0.0389	0.0348	0.0349	0.0323	0.0369	0.0443	0.0730
36	0.0439	0.0360	0.0283	0.0196	0.0290	0.0244	0.0254	0.0251	0.0364
38	0.0254	0.0199	0.0183	0.0115	0.0216	0.0178	0.0274	0.0180	0.0168
40	0.0130	0.0094	0.0120	0.0077	0.0163	0.0127	0.0260	0.0148	0.0084
43	0.0016	0.0012	0.0018	0.0012	0.0023	0.0023	0.0024	0.0031	0.0013
46	0.0002	0.0002	0.0003	0.0001	0.0001	0.0002	0.0003	0.0001	0.0000
49	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
52	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
58+	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 9.9. All parameters from the base model, with 95% credible intervals.

Purpose	Estimated parameter	Treatment	MLE	95% Interval
Growth, Mortality and Maturity	NatM_uniform_Fem_GP_1	Fixed	0.2	
Growth, Mortality and Maturity	L_at_Amin_Fem_GP_1	Estimated	14.1	13.7-14.5
Growth, Mortality and Maturity	L_at_Amax_Fem_GP_1	Estimated	44.9	44.3-45.5
Growth, Mortality and Maturity	VonBert_K_Fem_GP_1	Estimated	0.145	0.135-0.154
Growth, Mortality and Maturity	CV_young_Fem_GP_1	Estimated	0.115	0.103-0.126
Growth, Mortality and Maturity	CV_old_Fem_GP_1	Estimated	0.0856	0.0788-0.0925
Growth, Mortality and Maturity	Wtlen_1_Fem_GP_1	Fixed	2.98e-06	
Growth, Mortality and Maturity	Wtlen_2_Fem_GP_1	Fixed	3.33	
Growth, Mortality and Maturity	Mat50%_Fem_GP_1	Fixed	9.7	
Growth, Mortality and Maturity	Mat_slope_Fem_GP_1	Fixed	-0.943	
Growth, Mortality and Maturity	Eggs/kg_inter_Fem_GP_1	Fixed	1	
Growth, Mortality and Maturity	Eggs/kg_slope_wt_Fem_GP_1	Fixed	0	
Growth, Mortality and Maturity	NatM_uniform_Mal_GP_1	Fixed	0.2	
Growth, Mortality and Maturity	L_at_Amin_Mal_GP_1	Estimated	13.8	13.4-14.2
Growth, Mortality and Maturity	L_at_Amax_Mal_GP_1	Estimated	37.6	37.2-38
Growth, Mortality and Maturity	VonBert_K_Mal_GP_1	Estimated	0.222	0.21-0.235
Growth, Mortality and Maturity	CV_young_Mal_GP_1	Estimated	0.122	0.11-0.134
Growth, Mortality and Maturity	CV_old_Mal_GP_1	Estimated	0.0705	0.0649-0.076
Growth, Mortality and Maturity	Wtlen_1_Mal_GP_1	Fixed	2.98e-06	
Growth, Mortality and Maturity	Wtlen_2_Mal_GP_1	Fixed	3.33	
Recruitment	CohortGrowDev	Fixed	1	
Recruitment	FracFemale_GP_1	Fixed	0.5	
Recruitment	SR_LN(R0)	Estimated	13.8	13.7-13.8
Recruitment	SR_BH_steep	Fixed	1	
Recruitment	SR_sigmaR	Fixed	0.5	
Recruitment	SR_regime	Fixed	0	
Recruitment	SR_autocorr	Fixed	0	
Initial Conditions and Scale	Early_InitAge_1	Estimated	-0.85	-1.57--0.131

Purpose	Estimated parameter	Treatment	MLE	95% Interval
Initial Conditions and Scale	ForeRecr_2025		0	
Initial Conditions and Scale	InitF_seas_1_flt_1Fishery	Estimated	0.0228	0.0204-0.0251
Initial Conditions and Scale	LnQ_base_Survey(2)	Fixed	0	
Fishery Size Selectivity	Size_inflection_Fishery(1)	Estimated	39.2	37.4-41.1
Fishery Size Selectivity	Size_95%width_Fishery(1)	Estimated	9.61	8.32-10.9
Fishery Size Selectivity	SzSel_Male_Infl_Fishery(1)	Estimated	-2.77	-3.76--1.78
Fishery Size Selectivity	SzSel_Male_Slope_Fishery(1)	Estimated	-0.656	-1.94-0.629
Fishery Size Selectivity	SzSel_Male_Scale_Fishery(1)	Fixed	1	
Survey Age Selectivity	Age_DblN_peak_Survey(2)	Estimated	6.45	5.98-6.92
Survey Age Selectivity	Age_DblN_top_logit_Survey(2)	Fixed	12	
Survey Age Selectivity	Age_DblN_ascend_se_Survey(2)	Estimated	1.88	1.64-2.13
Survey Age Selectivity	Age_DblN_descend_se_Survey(2)	Fixed	3	
Survey Age Selectivity	Age_DblN_start_logit_Survey(2)	Fixed	-1,000	
Survey Age Selectivity	Age_DblN_end_logit_Survey(2)	Fixed	20	
Survey Age Selectivity (Male Offset)	AgeSel_2Male_Peak_Survey	Estimated	-0.718	-1.22--0.219
Survey Age Selectivity (Male Offset)	AgeSel_2Male_Ascend_Survey	Estimated	-0.306	-0.603--0.00827
Survey Age Selectivity (Male Offset)	AgeSel_2Male_Descend_Survey	Fixed	0	
Survey Age Selectivity (Male Offset)	AgeSel_2Male_Final_Survey	Fixed	0	
Survey Age Selectivity (Male Offset)	AgeSel_2Male_Scale_Survey	Fixed	1	
Fishery Size Selectivity (Time Blocking)	Size_inflection_Fishery(1)_BLK1repl_1964	Estimated	23.5	19.8-27.1
Fishery Size Selectivity (Time Blocking)	Size_95%width_Fishery(1)_BLK1repl_1964	Estimated	6.74	2.77-10.7
Fishery Size Selectivity (Time Blocking)	SzSel_Male_Infl_Fishery(1)_BLK1repl_1964	Estimated	0.735	-3.44-4.91
Fishery Size Selectivity (Time Blocking)	SzSel_Male_Slope_Fishery(1)_BLK1repl_1964	Estimated	0.657	-4.62-5.94

Table 9.10. Estimated time series of female spawning biomass, total biomass, fully-selected fishing mortality rate, age 0 Recruitment, for BSAI FHS. Values shown are the median and standard deviation in parentheses; these are not available for total biomass. The average number of recruits from 1977-present is 1.03 million.

Year	Spawning Biomss (kt)	Total (3+) Biomass (kt)	Stock Depletion	Fully Selected F	Age 0 Recruits (millions)
1964	192,255 (6173)	589,464	0.799 (0.01)	0.024 (0)	369,235 (147,164)
1965	192,011 (6168)	588,845	0.798 (0.01)	0.00668 (0)	350,577 (132,850)
1966	195,068 (6176)	590,080	0.811 (0.01)	0.00974 (0)	337,529 (123,315)
1967	197,513 (6177)	581,732	0.821 (0.01)	0.0216 (0)	333,251 (120,375)
1968	197,513 (6160)	559,335	0.821 (0.01)	0.025 (0)	341,720 (126,746)
1969	196,494 (6131)	529,114	0.817 (0.01)	0.02 (0)	364,104 (144,093)
1970	195,618 (6087)	497,498	0.813 (0.01)	0.0473 (0)	386,698 (162,755)
1971	187,841 (6010)	452,995	0.781 (0.01)	0.0652 (0)	379,928 (157,324)
1972	174,369 (5985)	404,832	0.725 (0.01)	0.0287 (0)	366,335 (146,469)
1973	164,355 (6102)	374,766	0.683 (0.01)	0.0538 (0)	331,348 (119,994)
1974	148,357 (6319)	340,551	0.617 (0.02)	0.0442 (0)	458,014 (229,587)
1975	133,823 (6489)	314,210	0.556 (0.02)	0.018 (0)	715,178 (560,552)
1976	123,571 (6540)	298,338	0.514 (0.02)	0.0289 (0)	695,920 (531,503)
1977	113,240 (6465)	283,294	0.471 (0.02)	0.032 (0)	618,291 (420,119)
1978	104,227 (6298)	274,135	0.433 (0.02)	0.0596 (0)	727,961 (583,179)
1979	94,300 (6053)	265,504	0.392 (0.02)	0.0269 (0)	947,894 (990,158)
1980	89,125 (5809)	269,473	0.37 (0.02)	0.0382 (0)	1,049,470 (1,215,413)
1981	84,254 (5523)	275,595	0.35 (0.02)	0.0462 (0)	2,057,190 (4,676,631)
1982	80,114 (5205)	285,664	0.333 (0.02)	0.0354 (0)	936,430 (970,360)
1983	78,596 (4884)	304,022	0.327 (0.02)	0.0219 (0)	827,272 (758,366)
1984	80,303 (4583)	341,522	0.334 (0.02)	0.0162 (0)	1,222,630 (1,658,713)
1985	84,899 (4328)	383,552	0.353 (0.02)	0.0182 (0)	2,036,430 (4,608,080)
1986	91,251 (4134)	423,742	0.379 (0.02)	0.0147 (0)	850,417 (804,717)
1987	99,601 (4028)	463,801	0.414 (0.02)	0.00905 (0)	2,218,490 (5,483,951)
1988	110,892 (4040)	512,417	0.461 (0.02)	0.0499 (0.01)	529,306 (312,602)
1989	123,855 (4199)	553,214	0.515 (0.02)	0.0237 (0)	1,033,020 (1,192,328)
1990	141,852 (4551)	605,347	0.59 (0.02)	0.122 (0.01)	1,067,130 (1,274,124)
1991	154,501 (5000)	632,212	0.642 (0.02)	0.0793 (0.01)	1,081,840 (1,311,299)
1992	168,045 (5396)	657,805	0.699 (0.02)	0.0745 (0.01)	1,068,060 (1,279,872)
1993	179,803 (5612)	675,160	0.747 (0.03)	0.0653 (0.01)	723,915 (588,776)
1994	192,533 (5770)	686,515	0.8 (0.03)	0.0769 (0.01)	683,649 (525,824)
1995	204,700 (5967)	689,774	0.851 (0.03)	0.0633 (0.01)	7e+05 (552,144)
1996	216,629 (6150)	687,682	0.9 (0.03)	0.0721 (0.01)	1,059,590 (1,266,620)
1997	223,723 (6296)	676,245	0.93 (0.03)	0.0848 (0.01)	1,077,880 (1,312,541)
1998	224,201 (6393)	656,203	0.932 (0.03)	0.1 (0.01)	1,010,390 (1,154,907)
1999	219,162 (6393)	633,205	0.911 (0.03)	0.0774 (0.01)	730,988 (605,327)
2000	215,507 (6359)	617,953	0.896 (0.03)	0.0868 (0.01)	801,998 (729,450)
2001	209,986 (6308)	604,188	0.873 (0.03)	0.0776 (0.01)	939,871 (1e+06)

2002	204,448 (6219)	593,163	0.85 (0.03)	0.0696 (0.01)	1,124,420 (1,433,860)
2003	197,996 (6059)	583,824	0.823 (0.03)	0.0631 (0.01)	1,481,720 (2,489,903)
2004	191,855 (5853)	576,983	0.797 (0.03)	0.0815 (0.01)	362,386 (148,933)
2005	185,326 (5659)	570,333	0.77 (0.02)	0.0772 (0.01)	921,139 (962,276)
2006	181,996 (5540)	572,911	0.757 (0.02)	0.0878 (0.01)	739,983 (621,002)
2007	179,111 (5466)	569,274	0.745 (0.02)	0.0946 (0.01)	427,192 (206,964)
2008	176,251 (5430)	565,452	0.733 (0.02)	0.126 (0.01)	683,191 (529,338)
2009	170,102 (5372)	553,664	0.707 (0.02)	0.102 (0.01)	532,228 (321,251)
2010	167,419 (5340)	540,904	0.696 (0.02)	0.106 (0.01)	448,635 (228,263)
2011	166,325 (5363)	524,782	0.691 (0.02)	0.0715 (0.01)	1,413,750 (2,266,708)
2012	169,672 (5454)	510,604	0.705 (0.02)	0.0595 (0.01)	588,451 (392,708)
2013	173,024 (5560)	494,451	0.719 (0.02)	0.0916 (0.01)	1,303,840 (1,927,957)
2014	170,345 (5585)	481,019	0.708 (0.02)	0.0893 (0.01)	1,134,580 (1,459,882)
2015	165,285 (5518)	469,594	0.687 (0.02)	0.0628 (0.01)	2,731,090 (8,459,083)
2016	160,882 (5398)	471,988	0.669 (0.02)	0.0587 (0.01)	1,410,560 (2,228,988)
2017	155,743 (5244)	481,586	0.647 (0.02)	0.0529 (0.01)	822,548 (748,723)
2018	151,174 (5086)	515,496	0.628 (0.02)	0.0648 (0.01)	1,500,460 (2,461,071)
2019	147,205 (4984)	556,157	0.612 (0.02)	0.0944 (0.01)	890,580 (856,436)
2020	144,307 (5022)	591,530	0.6 (0.02)	0.055 (0.01)	851,674 (773,697)
2021	149,114 (5315)	633,314	0.62 (0.02)	0.0572 (0.01)	982,226 (982,226)
2022	157,878 (5897)	665,184	0.656 (0.02)	0.0767 (0.01)	982,226 (982,226)
2023	169,661 (6824)	682,979	0.705 (0.02)	0.0434 (0)	982,226 (982,226)
2024	189,013 (8163)	696,889	0.786 (0.03)	0.0496 (0.01)	982,226 (982,226)
2025	209,206 (9816)	701,041	0.87 (0.03)	0.0587 (0.01)	982,226 (982,226)

Table 9.11. Table of 13-year projected catches corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios). This set of projections encompasses six harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see Projections and Harvest Alternatives. All units in t.

Year	Maximum permissible F	Author's F* (pre-specified catch)	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished
2024	11,125	11,125	11,125	11,125	11,125	11,125	11,125
2025	11,148	11,148	11,148	11,148	11,148	101,621	83,807
2026	11,148	11,148	11,148	11,148	11,148	84,214	74,696
2027	90,501	90,501	14,375	21,320	0	68,090	76,684
2028	80,256	80,256	14,672	21,494	0	57,781	62,366
2029	65,554	65,554	15,007	21,746	0	52,340	54,866
2030	57,840	57,840	15,490	22,246	0	51,692	53,098
2031	57,158	57,158	16,178	23,077	0	55,995	56,740
2032	60,880	60,880	17,065	24,225	0	63,517	63,860
2033	66,222	66,222	18,055	25,541	0	71,649	71,768
2034	71,392	71,392	19,096	26,936	0	78,416	78,427
2035	75,439	75,439	20,094	28,271	0	83,078	83,047
2036	78,197	78,197	21,021	29,497	0	85,884	85,846
2037	79,834	79,834	21,799	30,511	0	87,154	87,120
2038	80,646	80,646	22,444	31,336	0	87,430	87,406

Table 9.12. Table of 13-year projected spawning biomass corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios). This set of projections encompasses six harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see Projections and Harvest Alternatives. All units in t.

Year	Maximum permissible F	Author's F* (pre-specified catch)	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished
2024	185,492	185,492	185,492	185,492	185,492	185,492	185,492
2025	204,323	204,323	204,323	204,323	204,323	204,323	204,323
2026	220,515	220,515	220,515	220,515	220,515	181,938	189,373
2027	230,746	230,746	230,746	230,746	230,746	162,918	173,754
2028	199,890	199,890	234,491	231,282	241,165	148,484	154,709
2029	174,100	174,100	235,323	229,179	248,409	138,491	142,048
2030	158,951	158,951	236,266	227,581	255,210	133,940	135,904
2031	154,949	154,949	241,552	230,724	265,715	136,586	137,591
2032	160,369	160,369	253,774	241,067	282,733	145,869	146,306
2033	170,748	170,748	271,070	256,642	304,556	157,980	158,100
2034	181,882	181,882	290,649	274,522	328,659	169,155	169,126
2035	191,171	191,171	309,640	291,833	352,150	177,470	177,389
2036	197,816	197,816	326,901	307,387	374,003	182,681	182,599
2037	201,743	201,743	341,029	319,917	392,473	185,161	185,095
2038	203,530	203,530	352,236	329,630	407,798	185,748	185,703

Table 9.13. Table of 13-year projected fishing mortality rates corresponding to the alternative harvest scenarios, using stochastic methods if possible (mean values or other statistics may be shown in the case of stochastic recruitment scenarios). This set of projections encompasses six harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see Projections and Harvest Alternatives. All units in t.

Year	Maximum permissible F	Author's F* (pre-specified catch)	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished
2024	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2025	0.050	0.050	0.050	0.050	0.050	0.490	0.400
2026	0.050	0.050	0.050	0.050	0.050	0.460	0.390
2027	0.400	0.400	0.060	0.090	0.000	0.410	0.440
2028	0.400	0.400	0.060	0.090	0.000	0.370	0.390
2029	0.350	0.350	0.060	0.090	0.000	0.340	0.350
2030	0.320	0.320	0.060	0.090	0.000	0.330	0.340
2031	0.310	0.310	0.060	0.090	0.000	0.340	0.340
2032	0.310	0.310	0.060	0.090	0.000	0.350	0.360
2033	0.320	0.320	0.060	0.090	0.000	0.380	0.380
2034	0.340	0.340	0.060	0.090	0.000	0.390	0.390
2035	0.340	0.340	0.060	0.090	0.000	0.410	0.410
2036	0.350	0.350	0.060	0.090	0.000	0.410	0.410
2037	0.350	0.350	0.060	0.090	0.000	0.420	0.420
2038	0.350	0.350	0.060	0.090	0.000	0.420	0.420

Figures

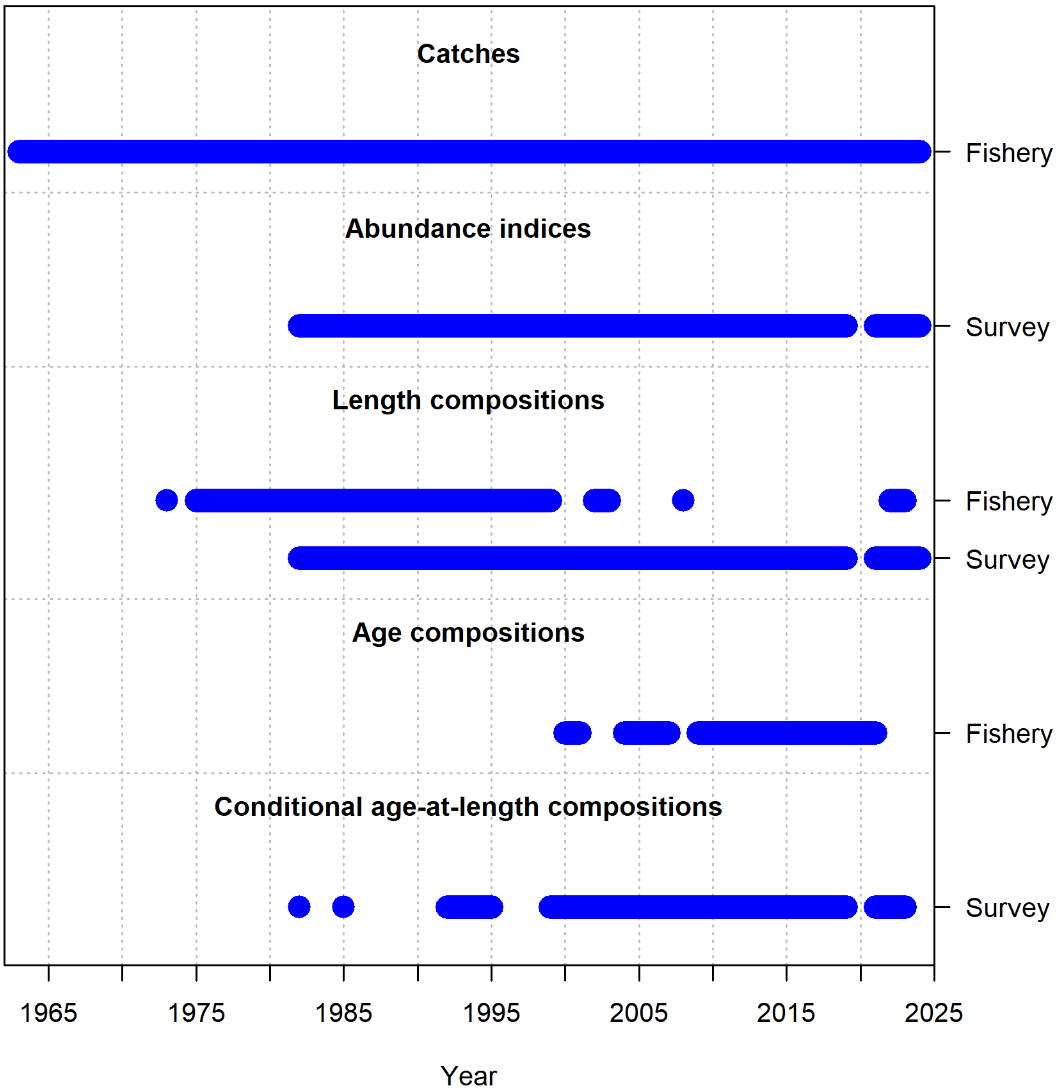

Figure 9.1. Data included in the update assessment, Model 18.2c (2024).

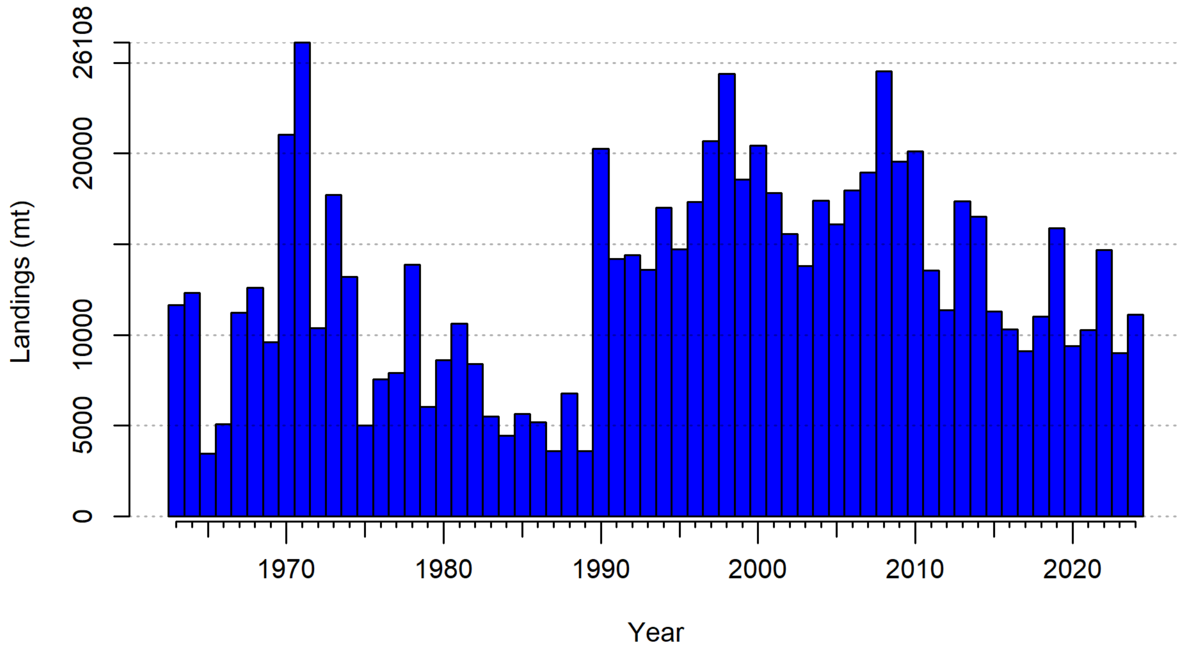

Figure 9.2. Catches for BSAI FHS used in the model; the 2024 value is extrapolated.

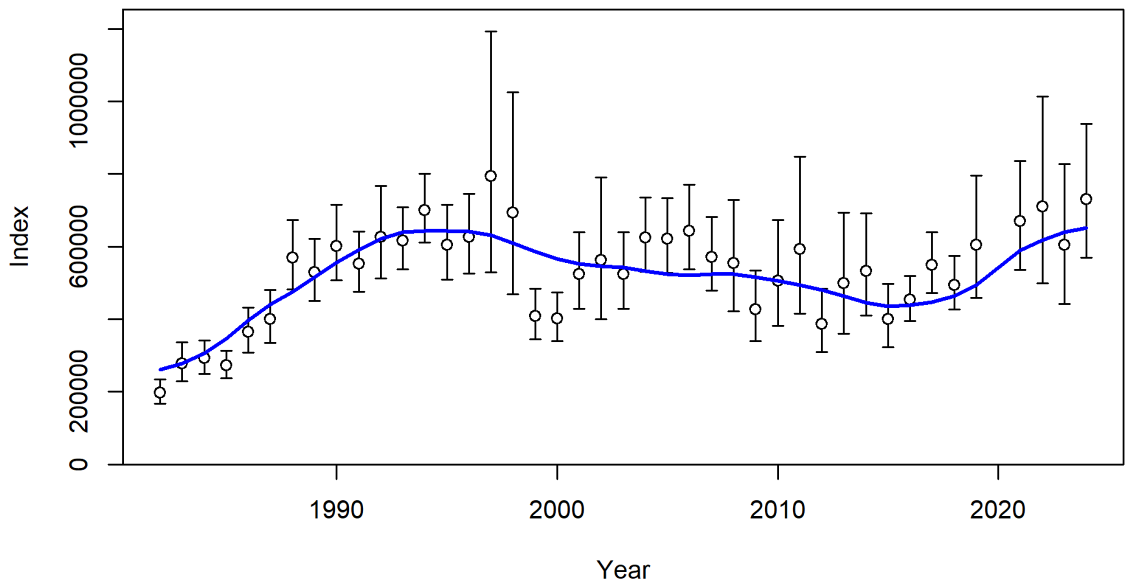

Figure 9.3. BS/AI Combined Trawl Survey observed biomass estimates with 95% sampling error confidence intervals for BSAI FHS (black points and vertical bars). Model expectations are shown in blue.

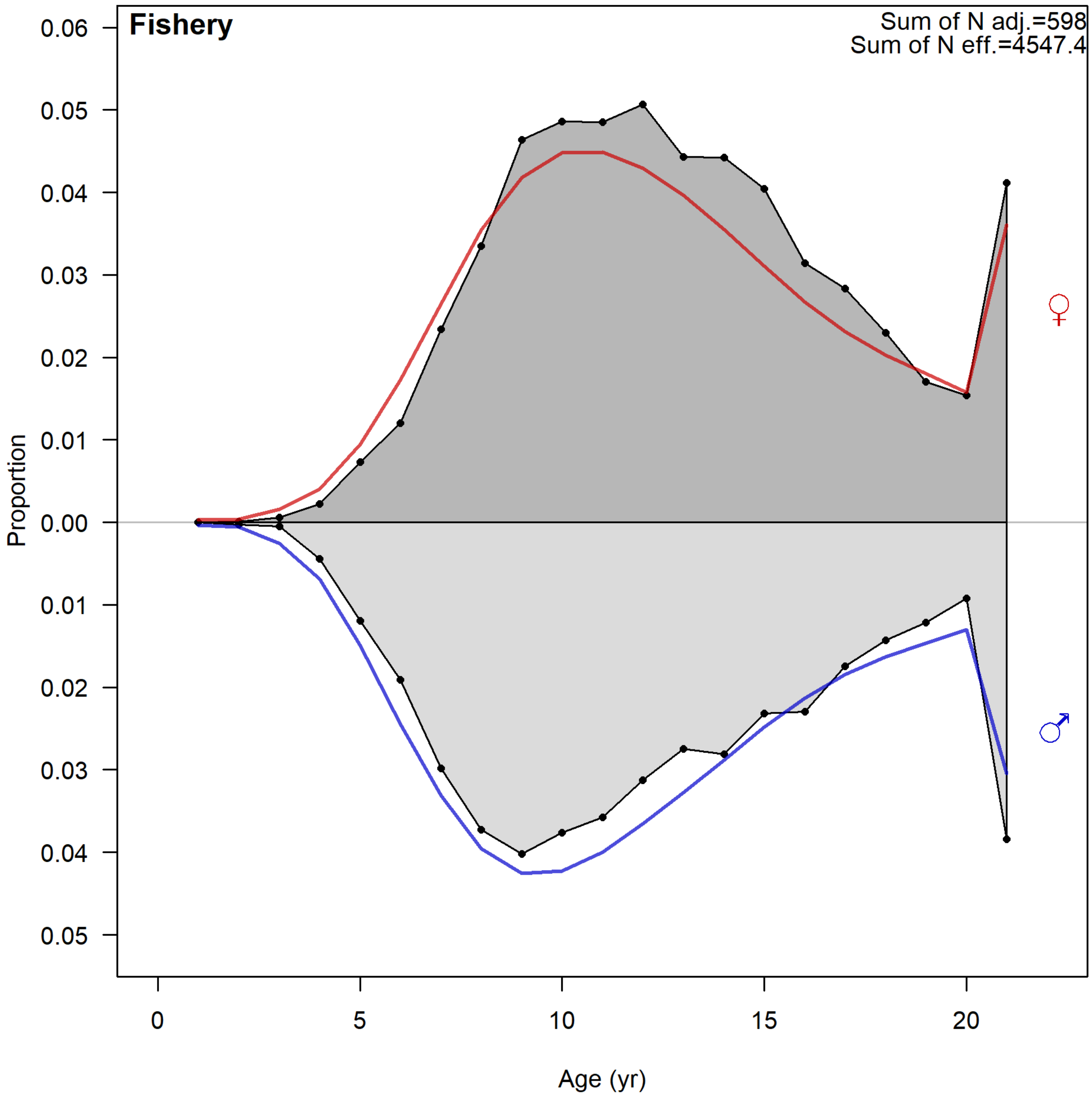

Figure 9.4. Observed (grey polygons) and predicted (colored lines) fishery age compositions for BSAI FHS, aggregated through time.

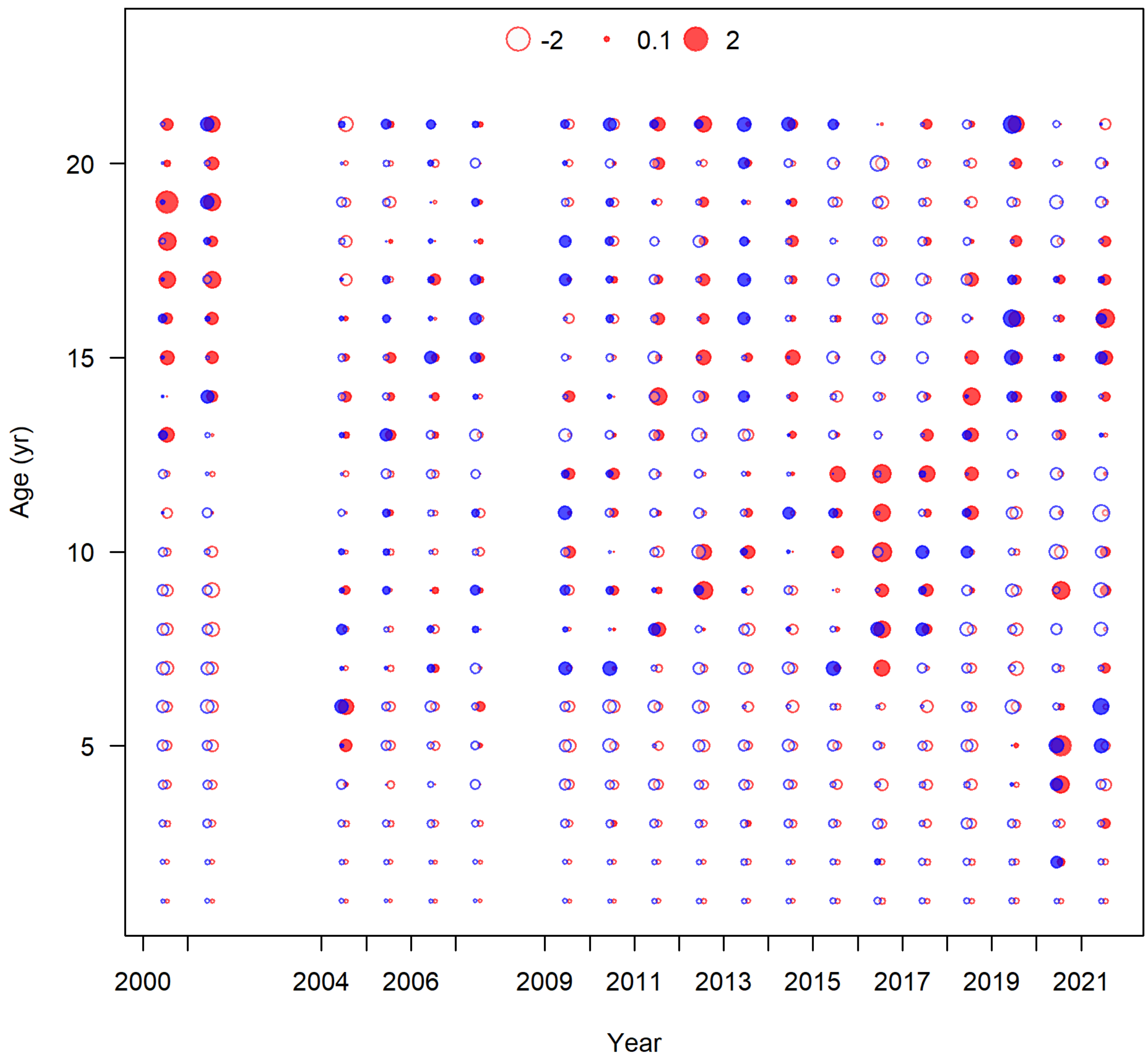

Figure 9.5. Pearson residuals for fishery and survey length compositions. Blue points are males, red points are females.

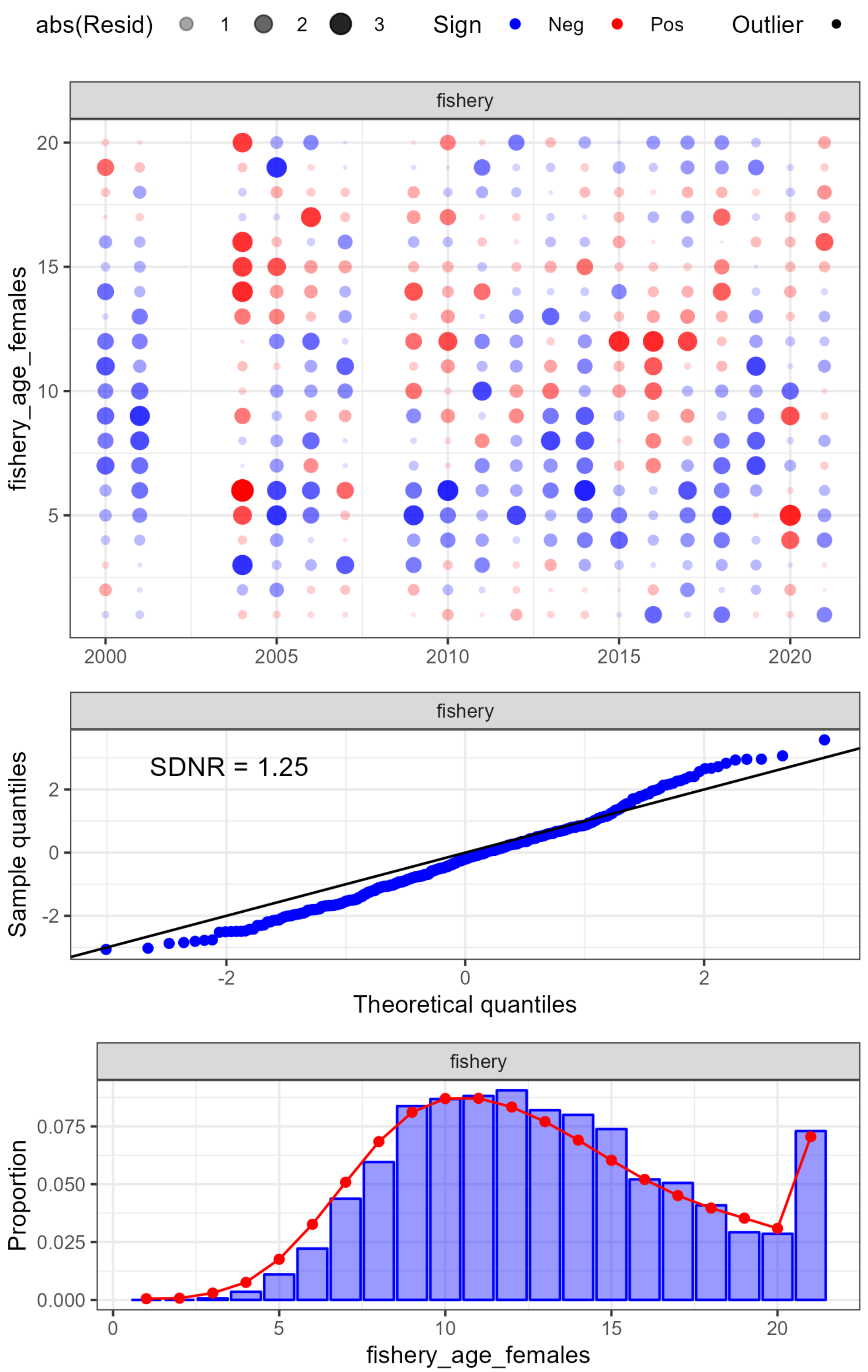

Figure 9.6. One-Step-Ahead residuals and diagnostics for female fishery age composition data.

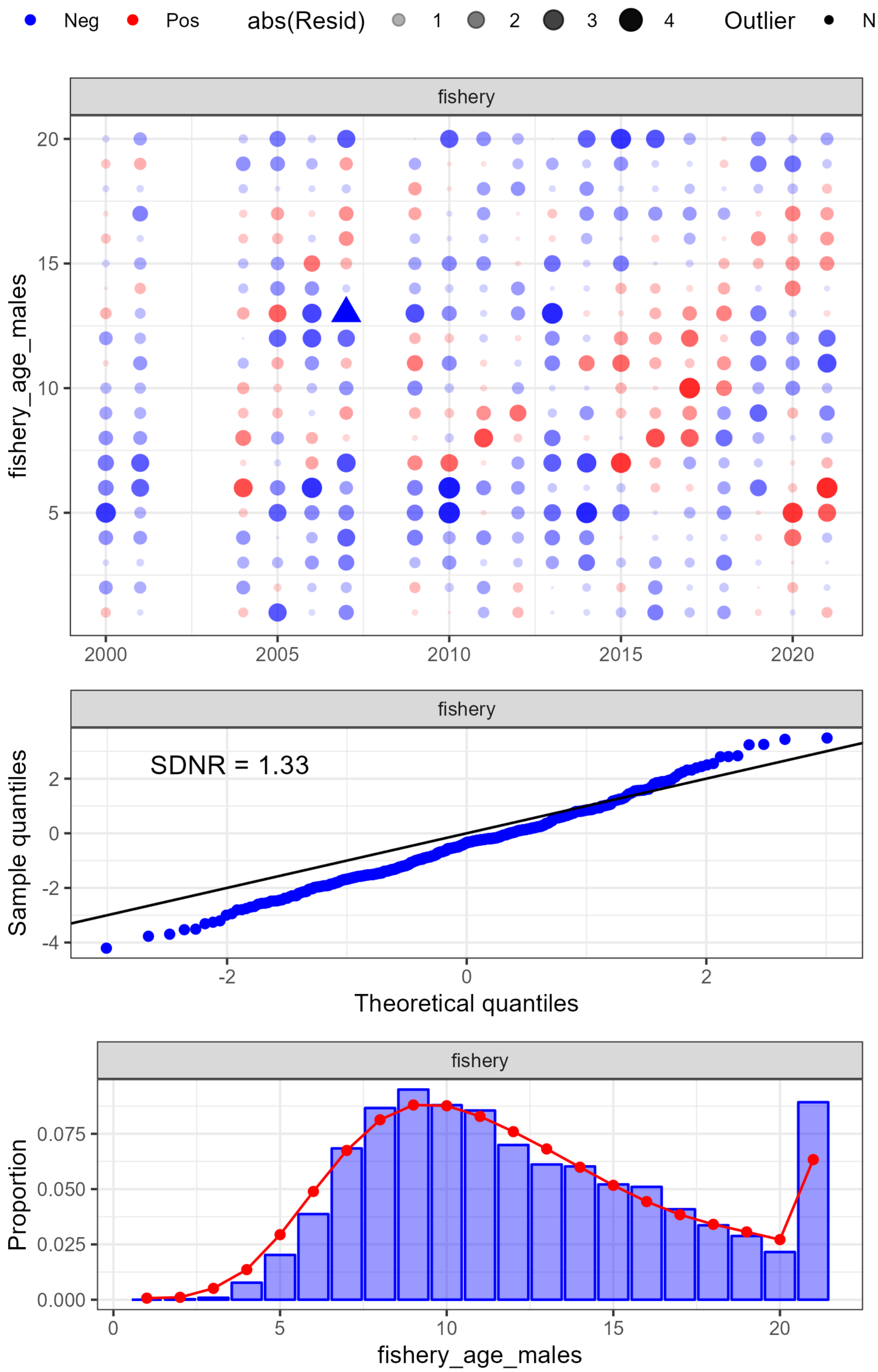

Figure 9.7. One-Step-Ahead residuals and diagnostics for male fishery age composition data.

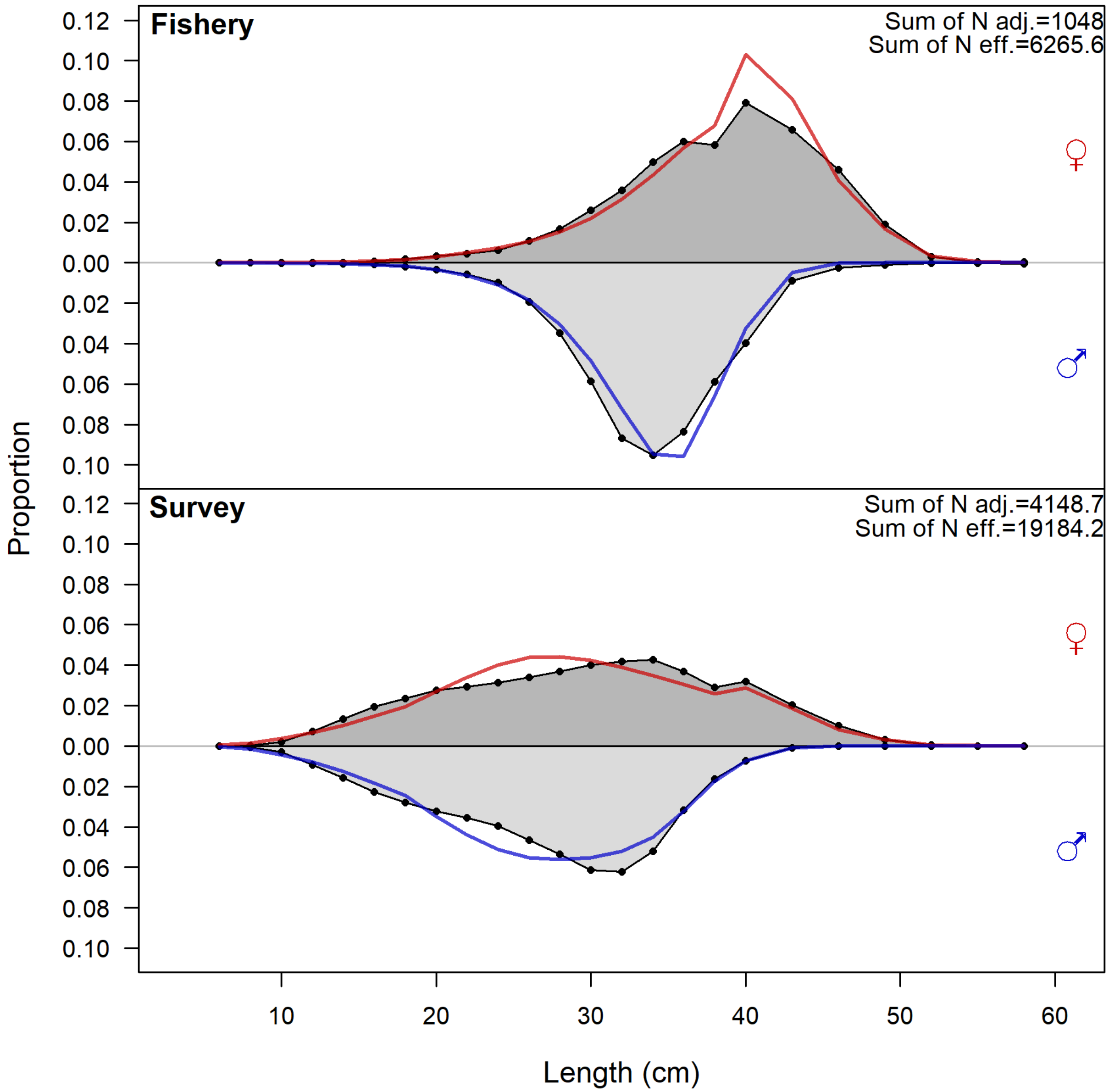

Figure 9.8. Observed (grey polygons) and predicted (colored lines) fishery and survey length (cm) compositions for BSAI FHS, aggregated through time. Note that many years of the Fishery length composition data are not included in the joint likelihood (in lieu of age compositions).

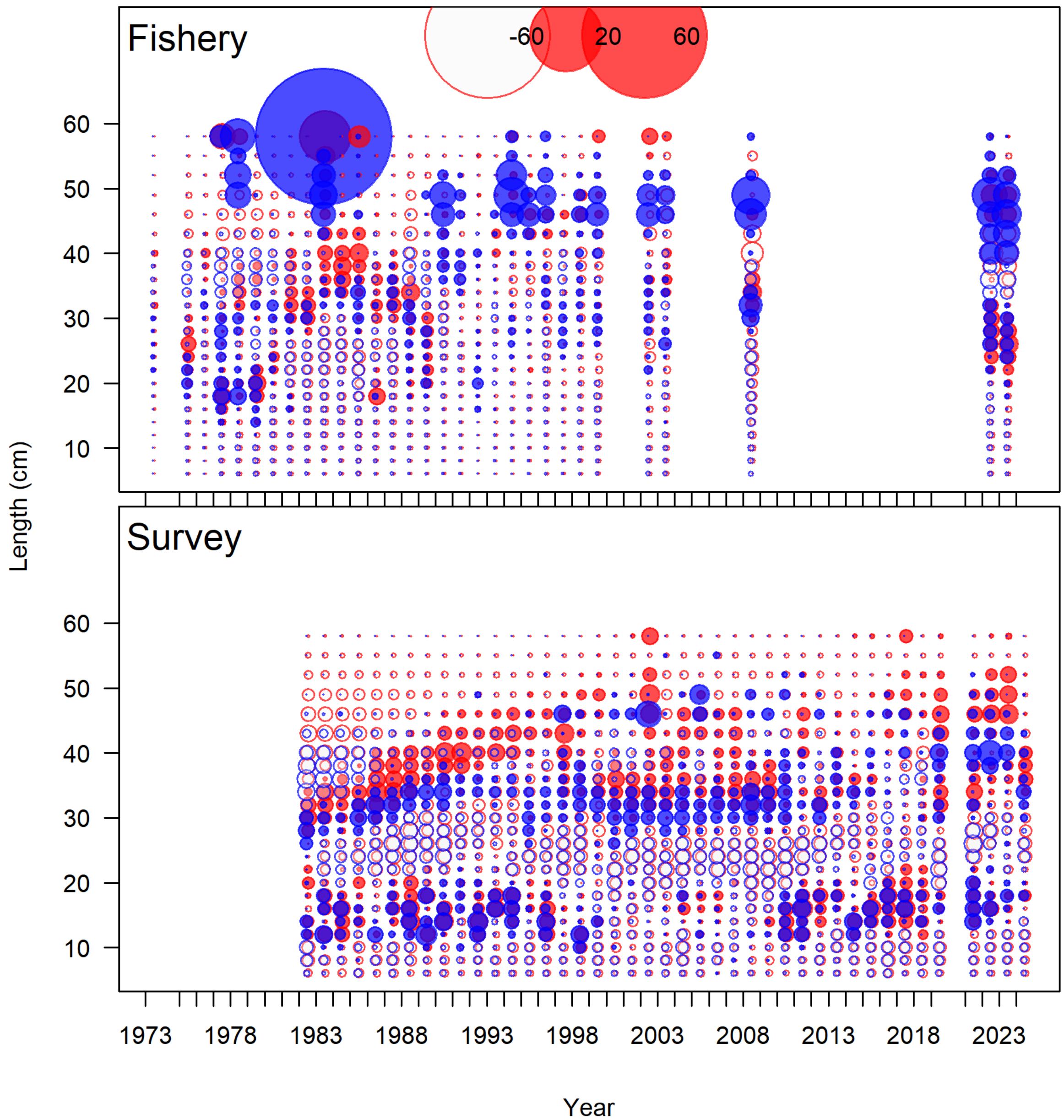

Figure 9.9. Observed (grey polygons) and predicted (colored lines) fishery age compositions for BSAI FHS, aggregated through time.

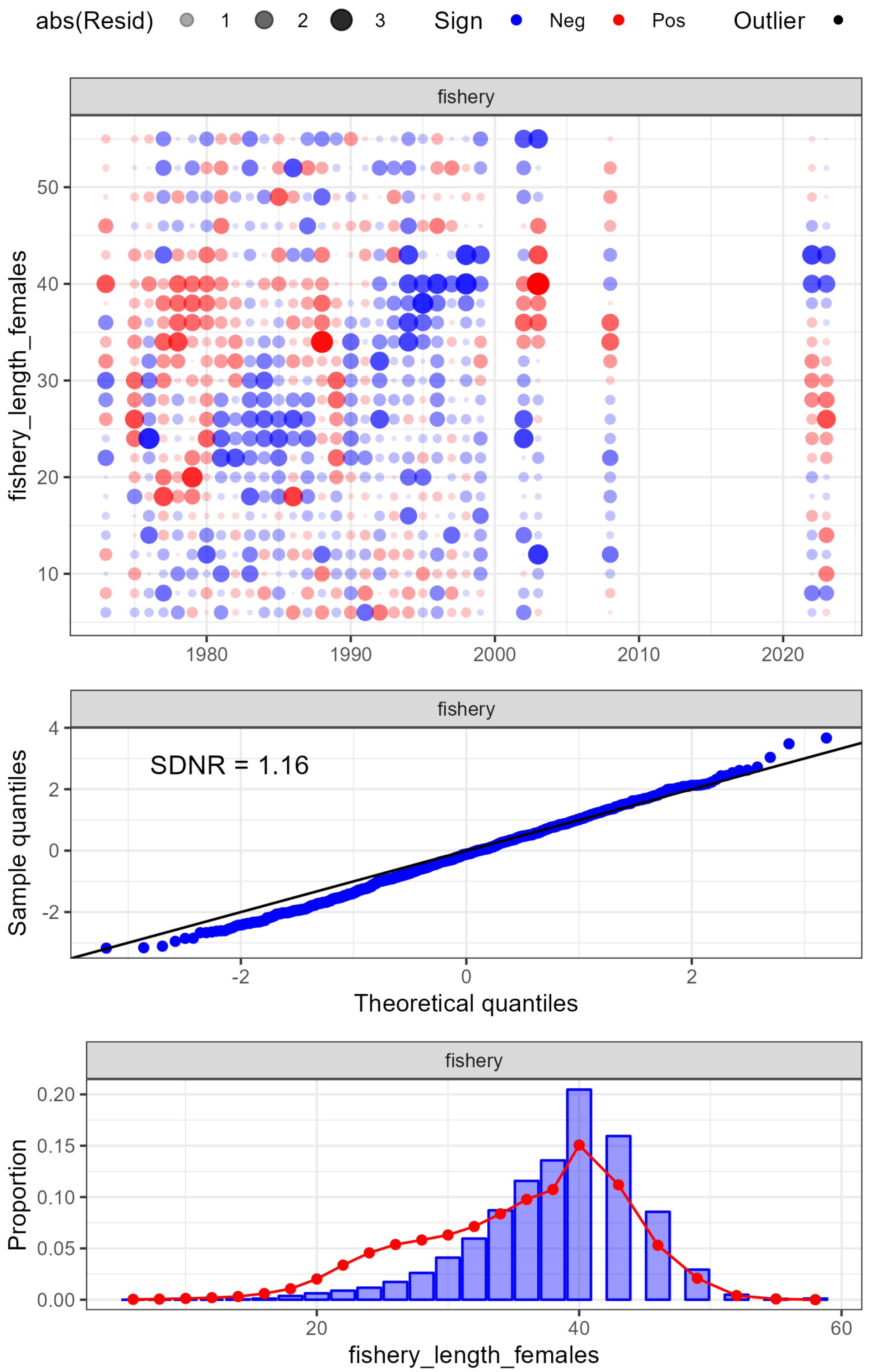

Figure 9.10. One-Step-Ahead residuals and diagnostics for female fishery length composition data.

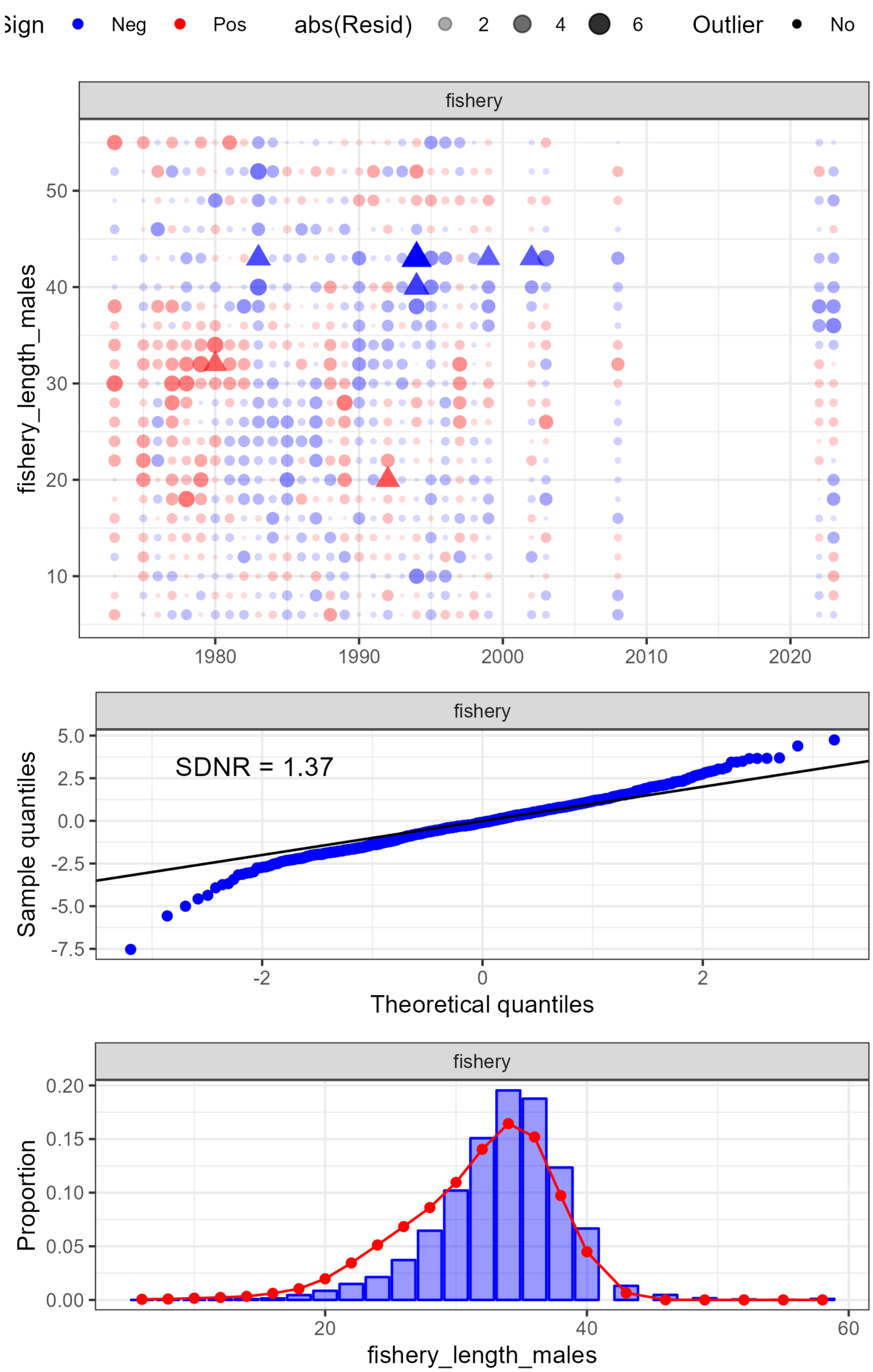

Figure 9.11. One-Step-Ahead residuals and diagnostics for male fishery length composition data.

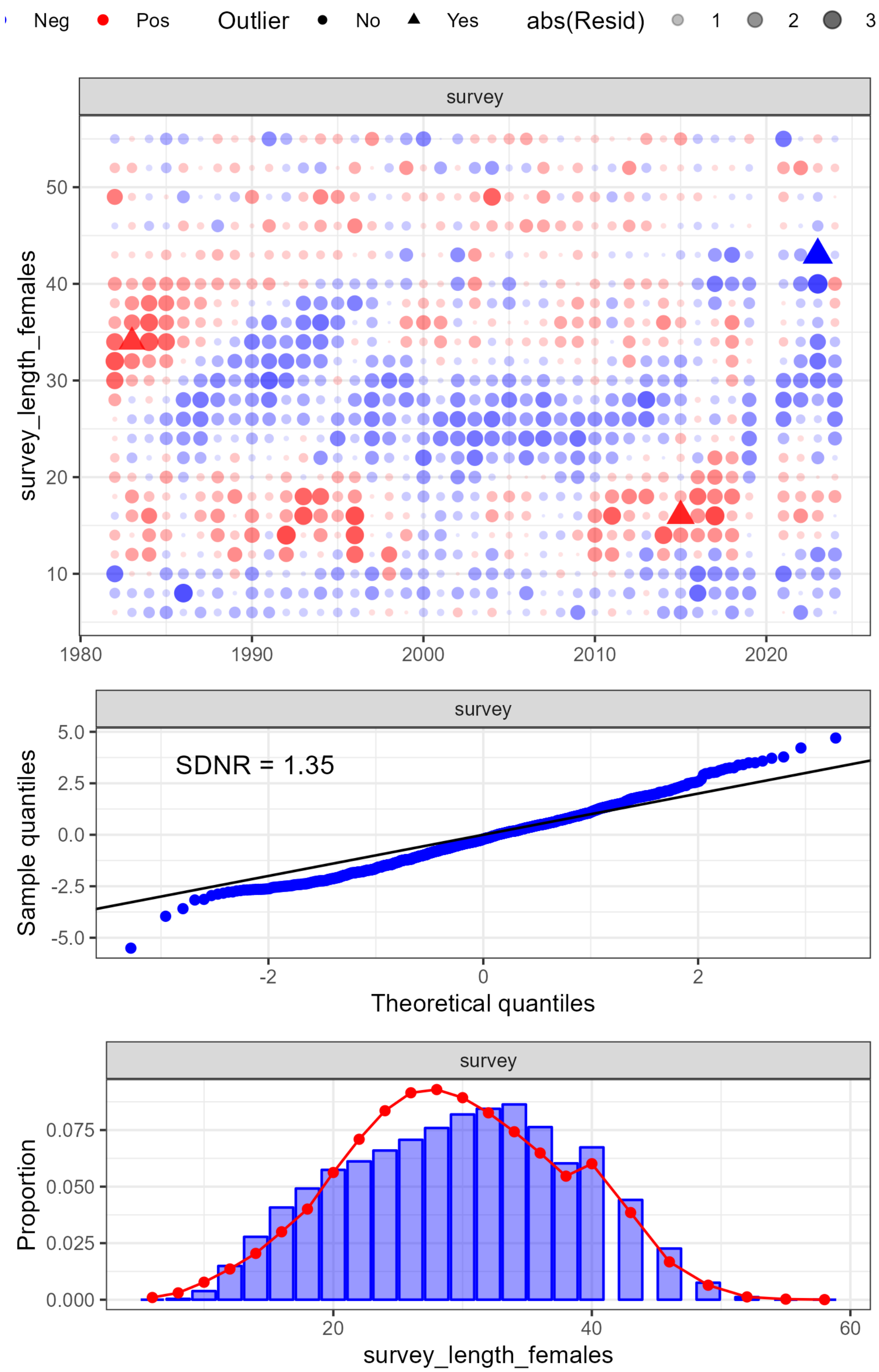

Figure 9.12. One-Step-Ahead residuals and diagnostics for female survey length composition data.

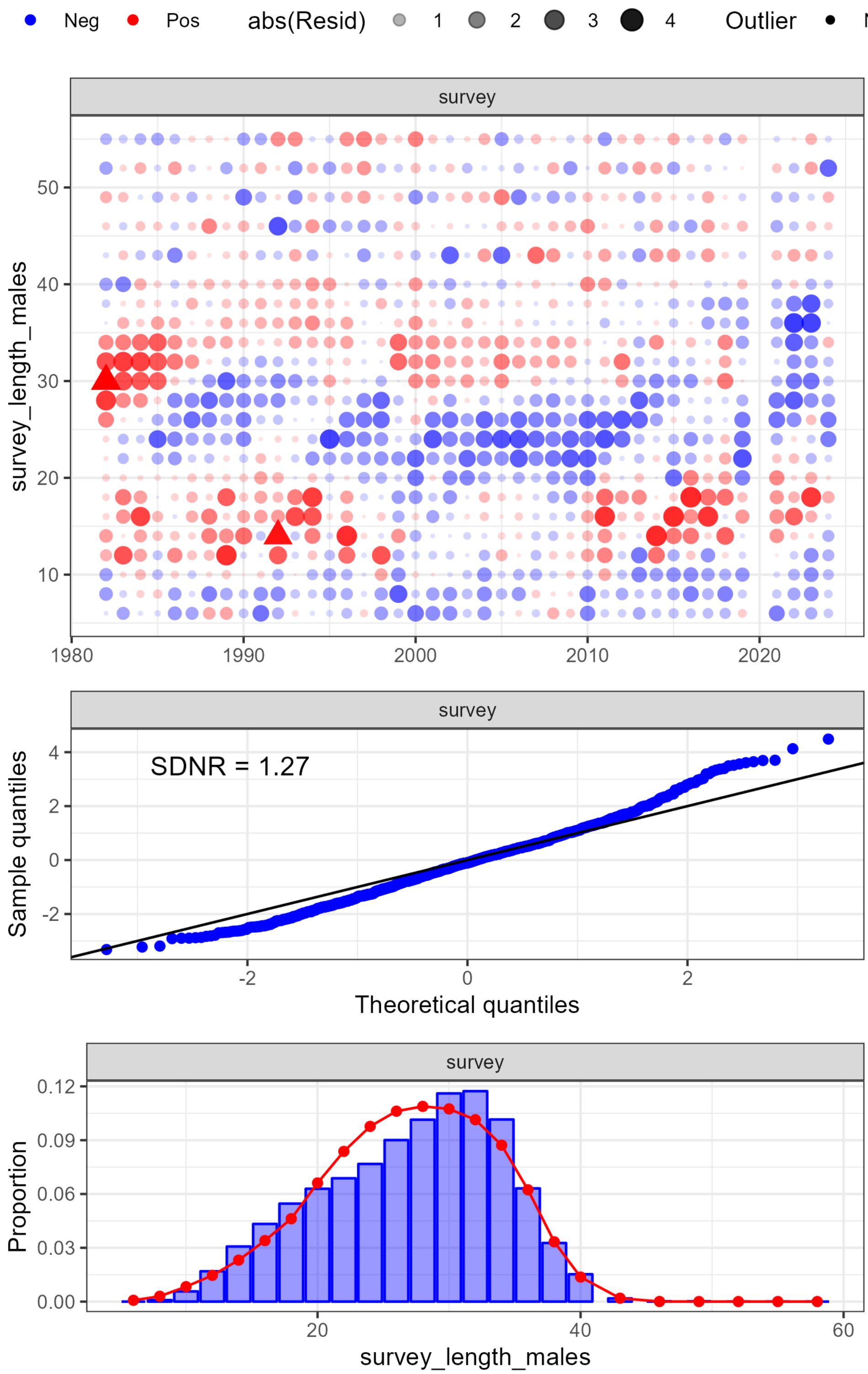

Figure 9.13. One-Step-Ahead residuals and diagnostics for male survey length composition data.

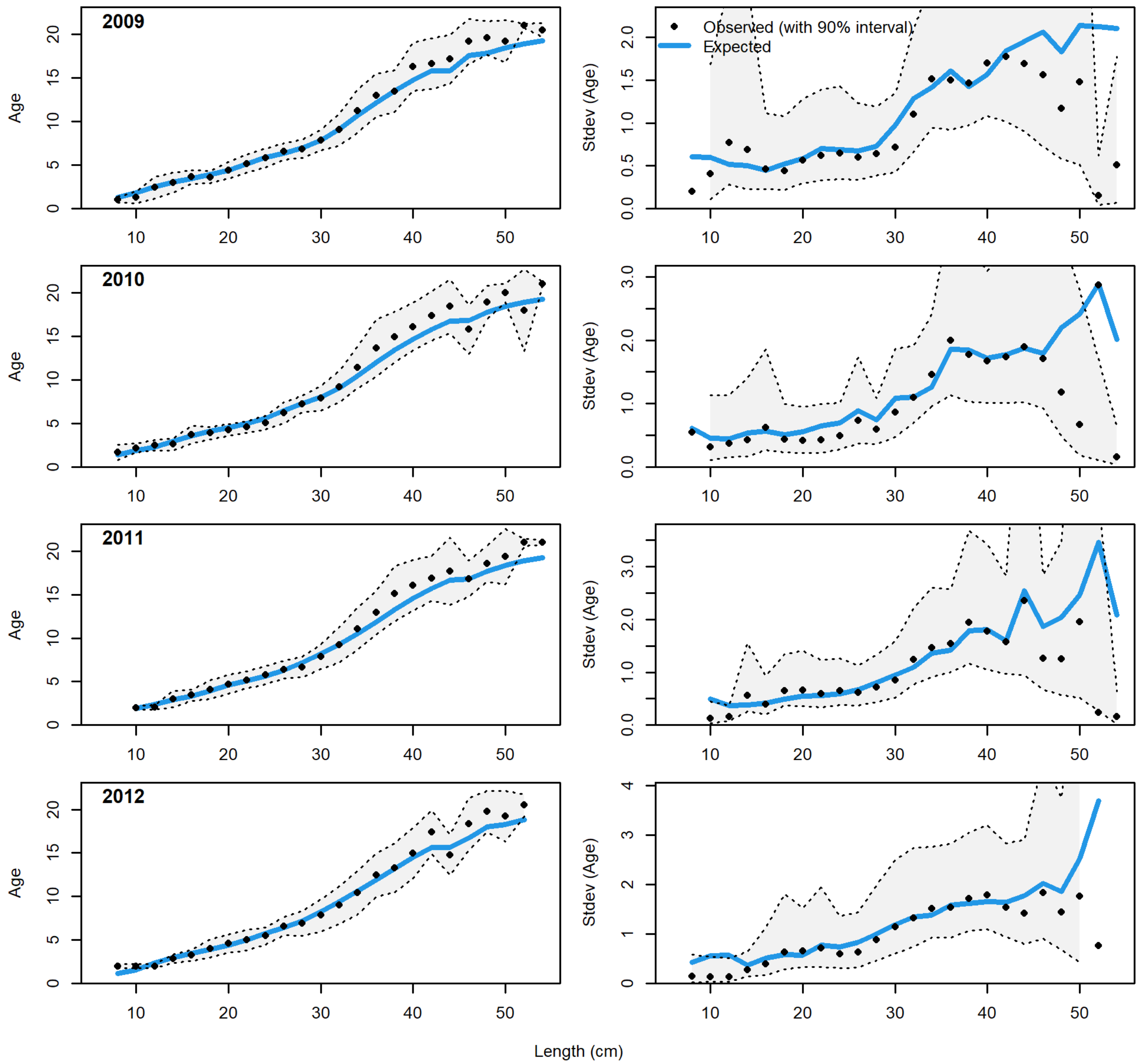

Figure 9.14. Observed and expected mean age-at-length for both females and males with 90% intervals about observed age-at-length (left panels) and observed and expected standard deviation in age-at-length (right panels) for Model 18.2c (2024) for years 2009-2012 (1 of 3).

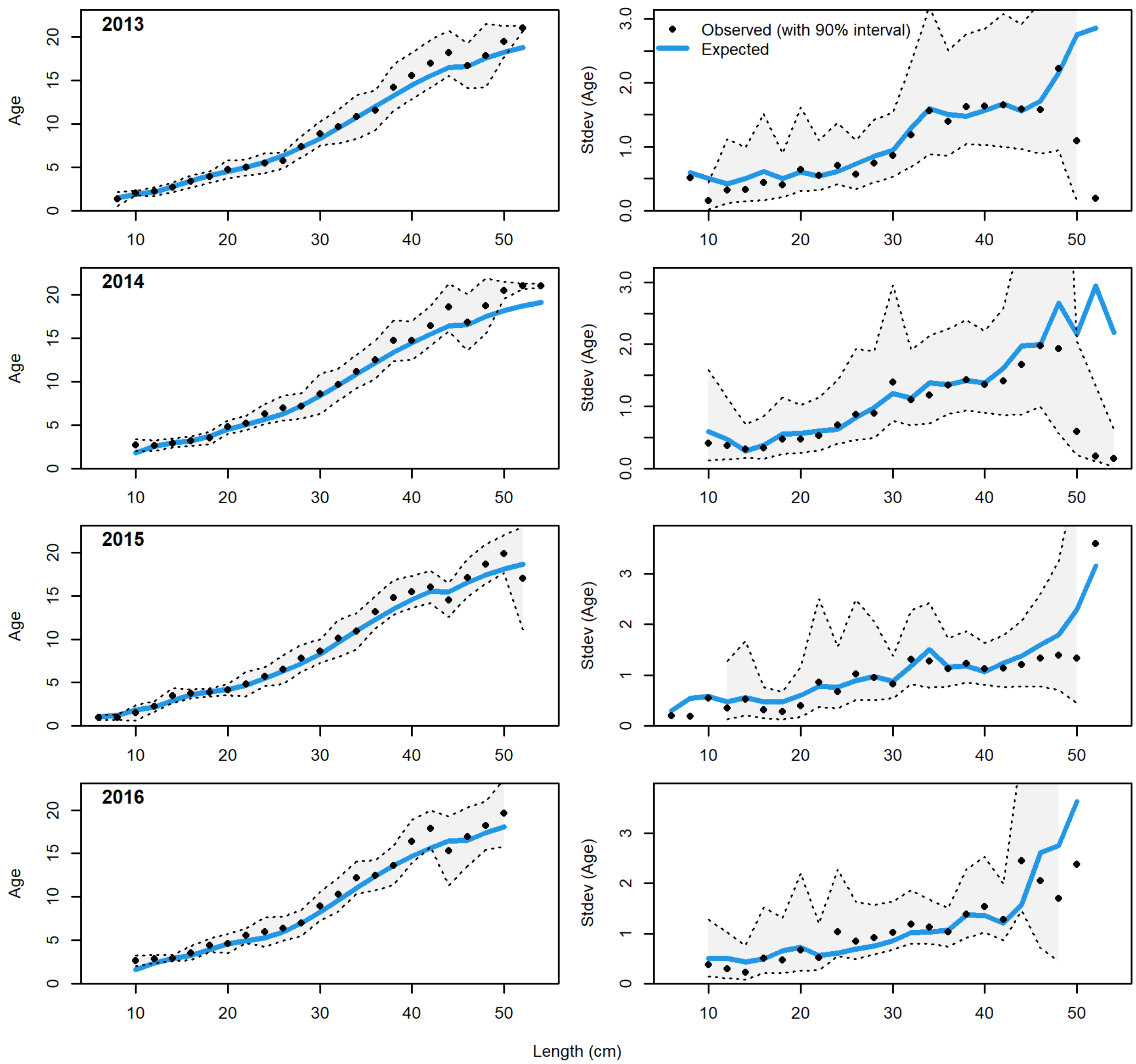

Figure 9.15. Observed and expected mean age-at-length for both females and males with 90% intervals about observed age-at-length (left panels) and observed and expected standard deviation in age-at-length (right panels) for Model 18.2c (2024) for years 2013-2016 (2 of 3).

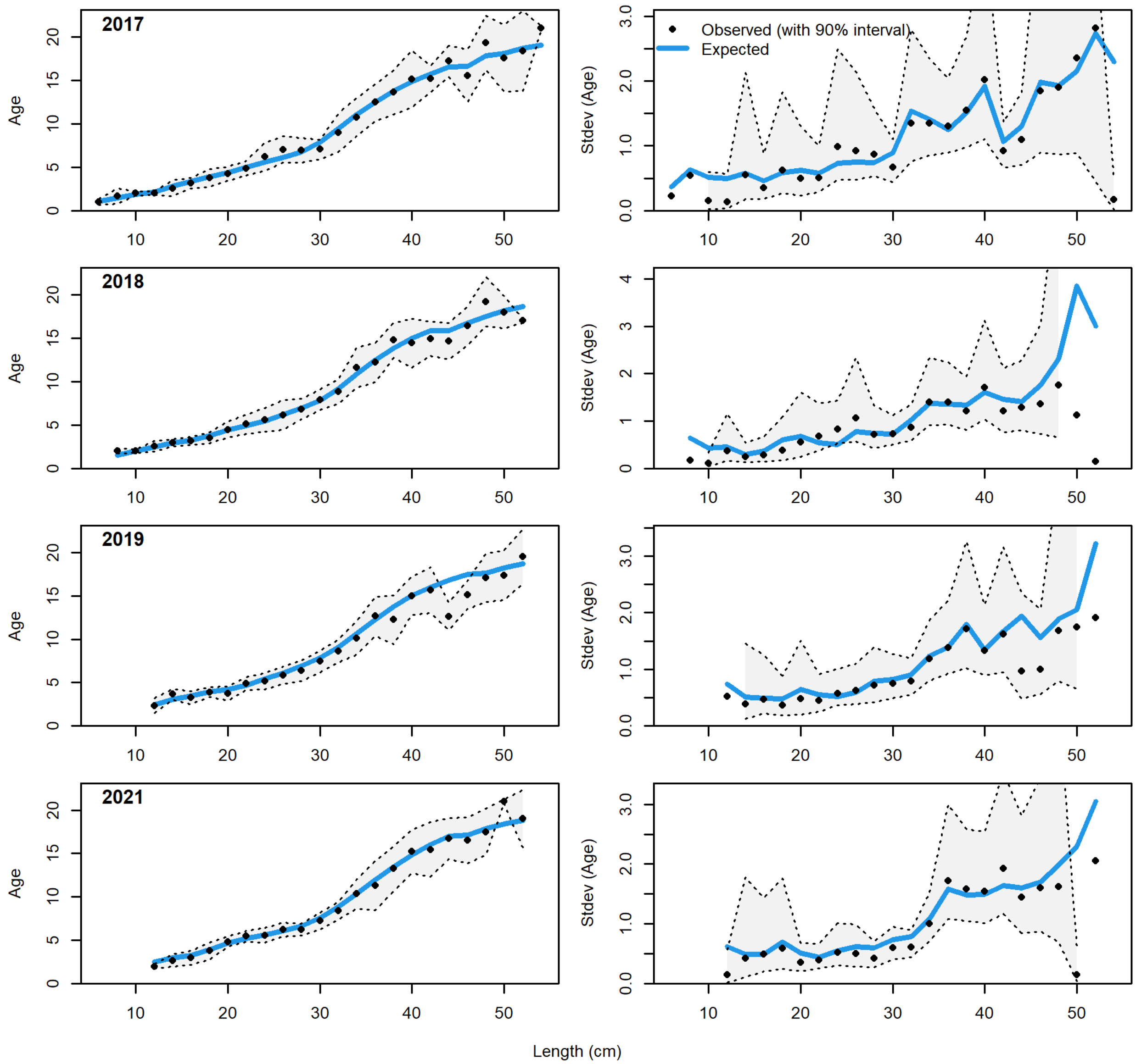

Figure 9.16. Observed and expected mean age-at-length for both females and males with 90% intervals about observed age-at-length (left panels) and observed and expected standard deviation in age-at-length (right panels) for Model 18.2c (2024) for years 2017-2021 (3 of 3).

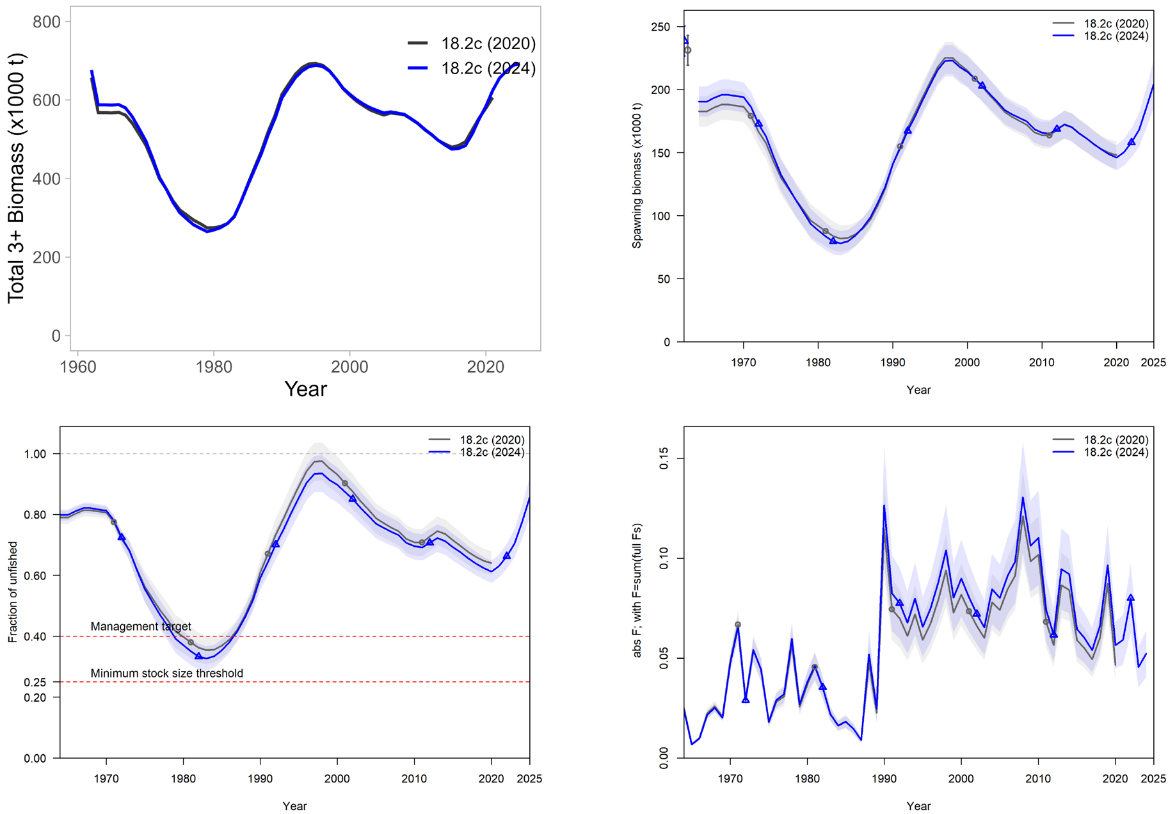

Figure 9.17. Comparison of spawning biomass, fishing mortality rates, and recruitment for the 2024 Update model (blue) and 2020 Full model (grey). The shaded ribbon represents the 95% quantile. Uncertainty intervals not available for total biomass.

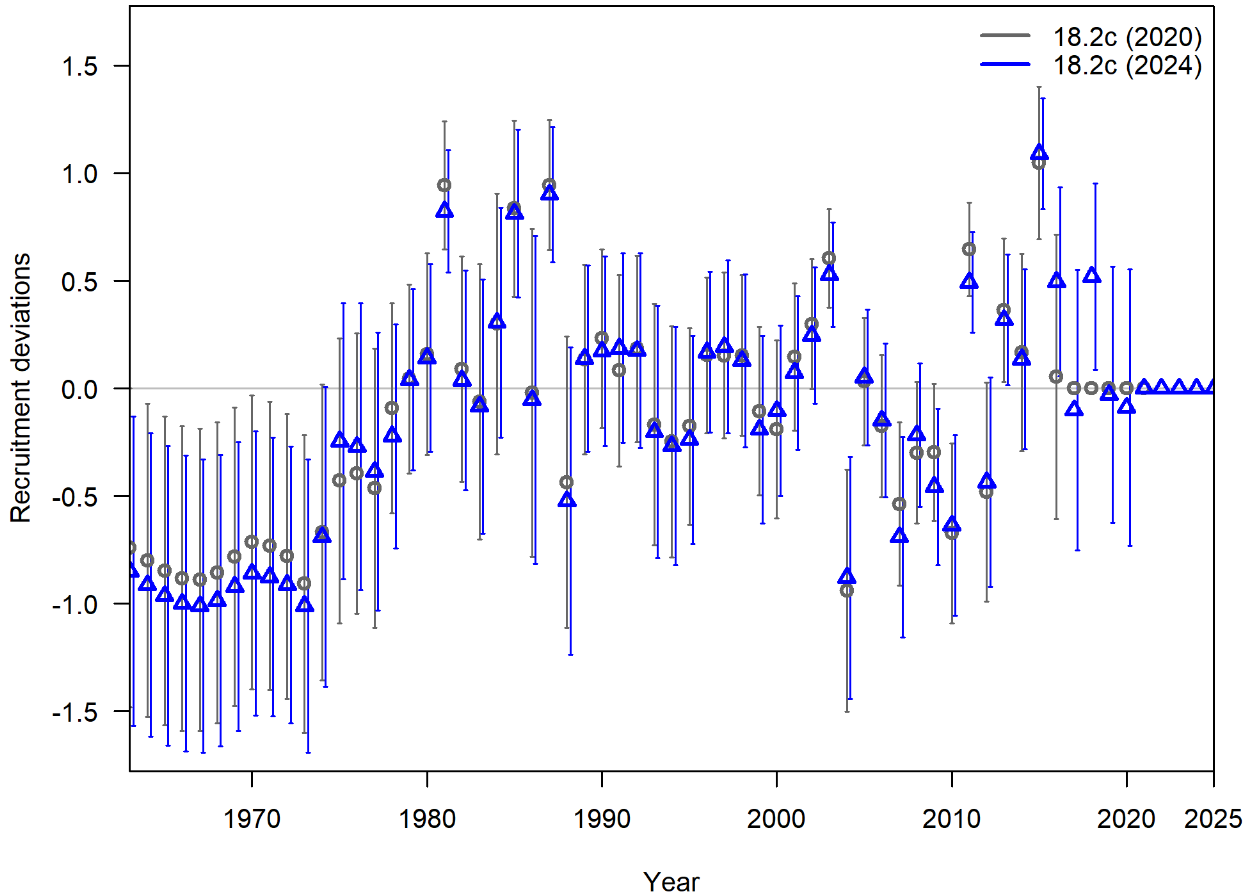

Figure 9.18. Time series of recruitment deviations, from the 2024 base model (blue) and 2021 base model (grey), with 95% intervals.

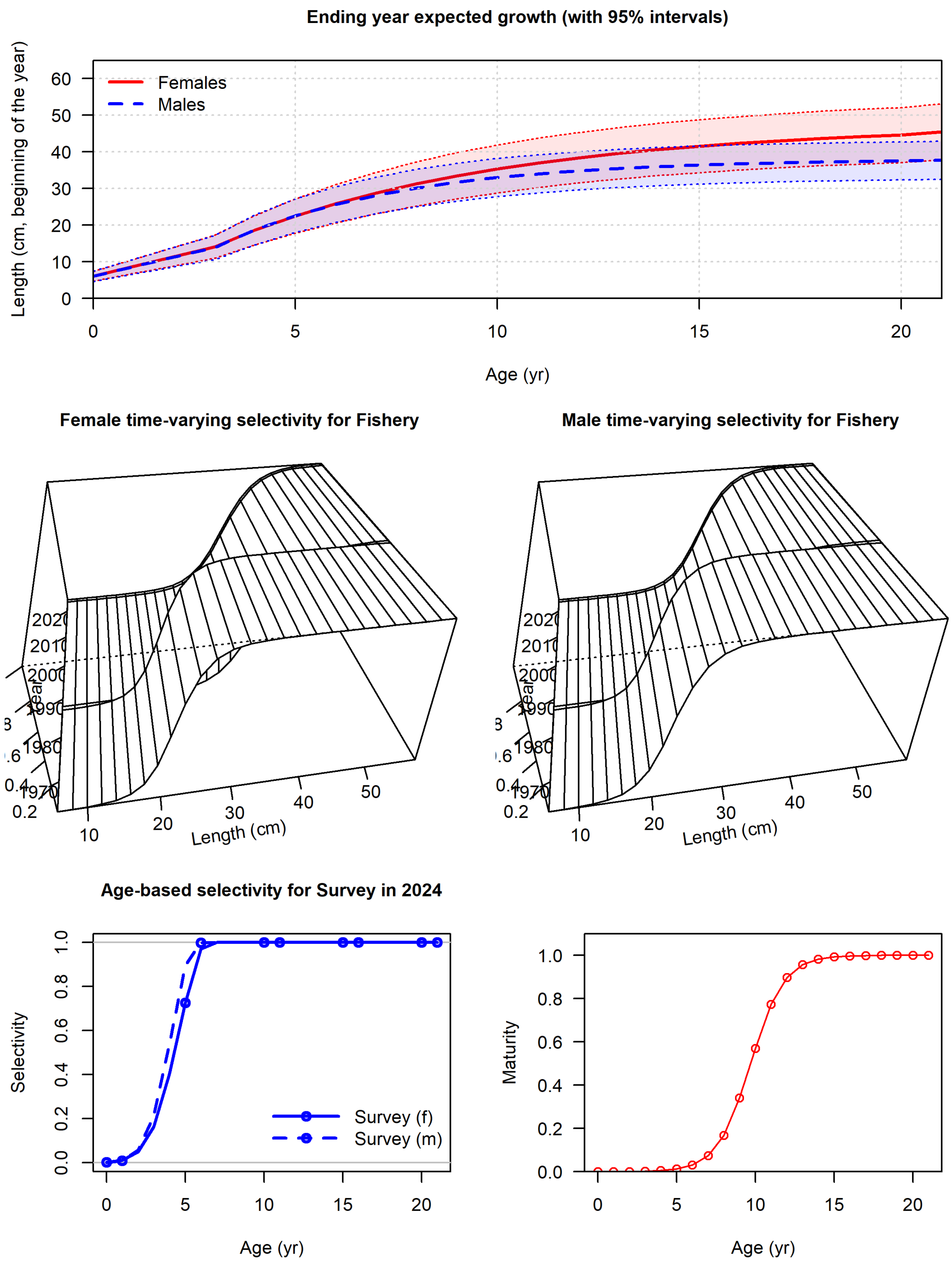

Figure 9.19. Estimated growth curves; time-varying, length-based fishery selectivity; age-based survey selectivity; and female maturity-at-age.

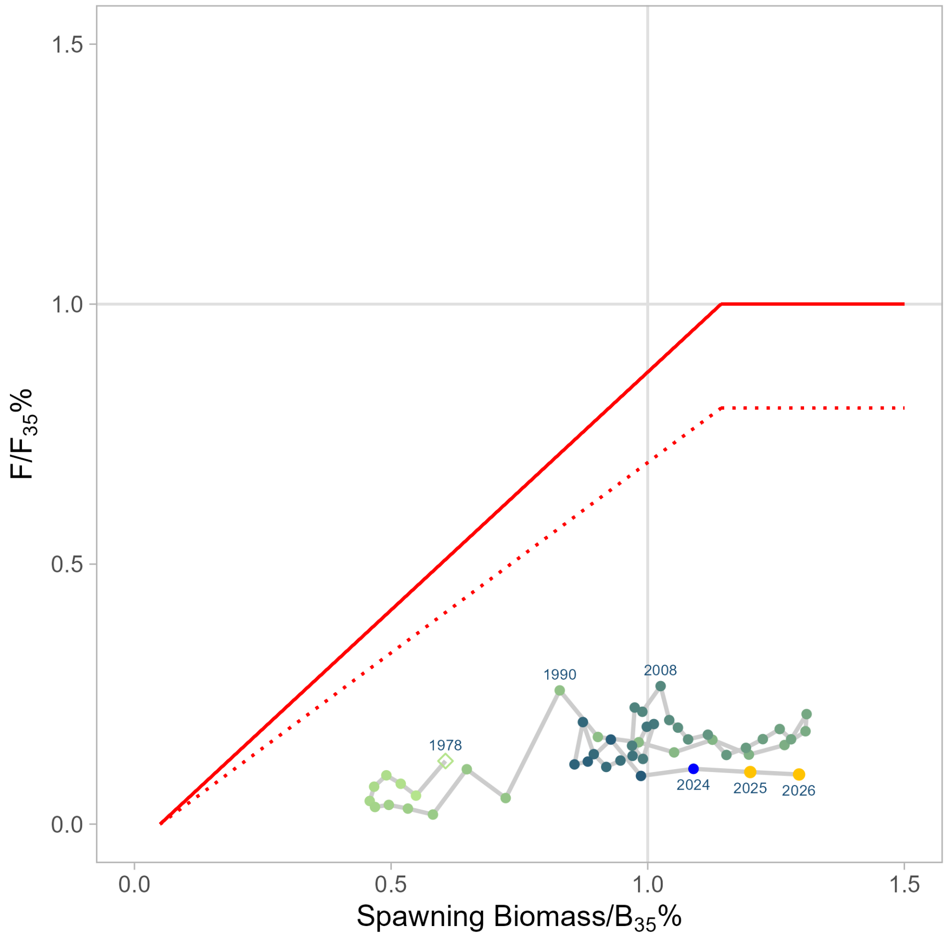

Figure 9.20. Time series of estimated fishing mortality versus estimated spawning stock biomass (phase-plane plot) for 1978-2026, including applicable OFL and maximum FABC definitions for the stock, including 2 years of projected values. Target levels correspond to B35% and F35% for author recommended model.

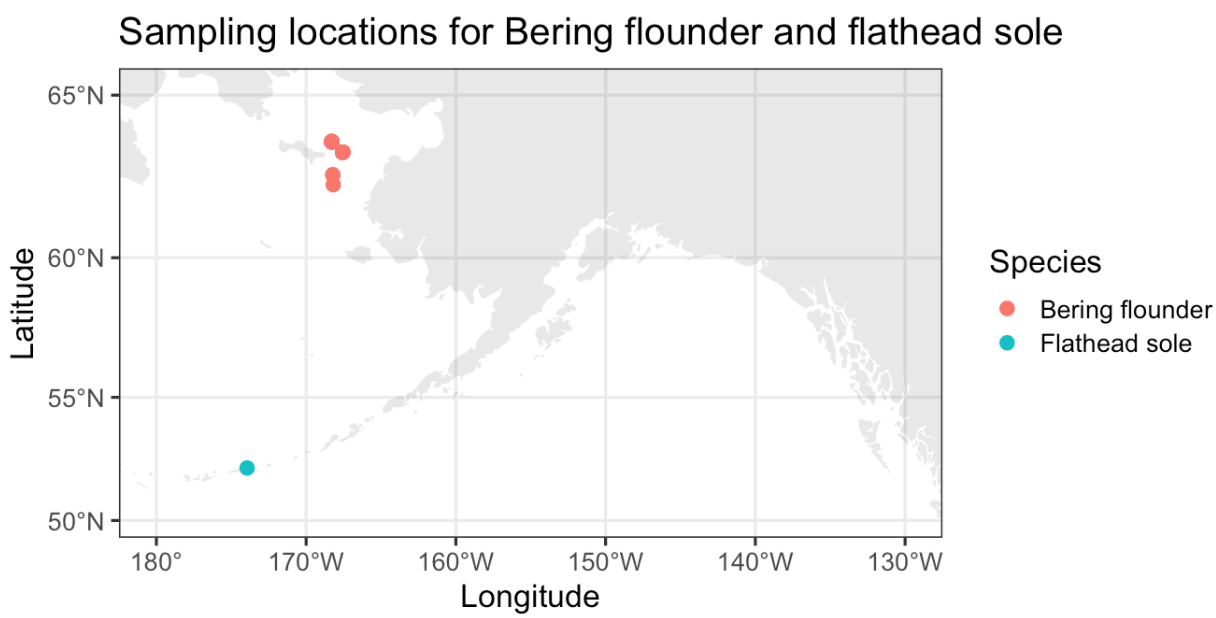

Figure 9.21. Collection locations of Bering flounder (n=23) and flathead sole (n=24) sequenced using low coverage whole genome sequencing.

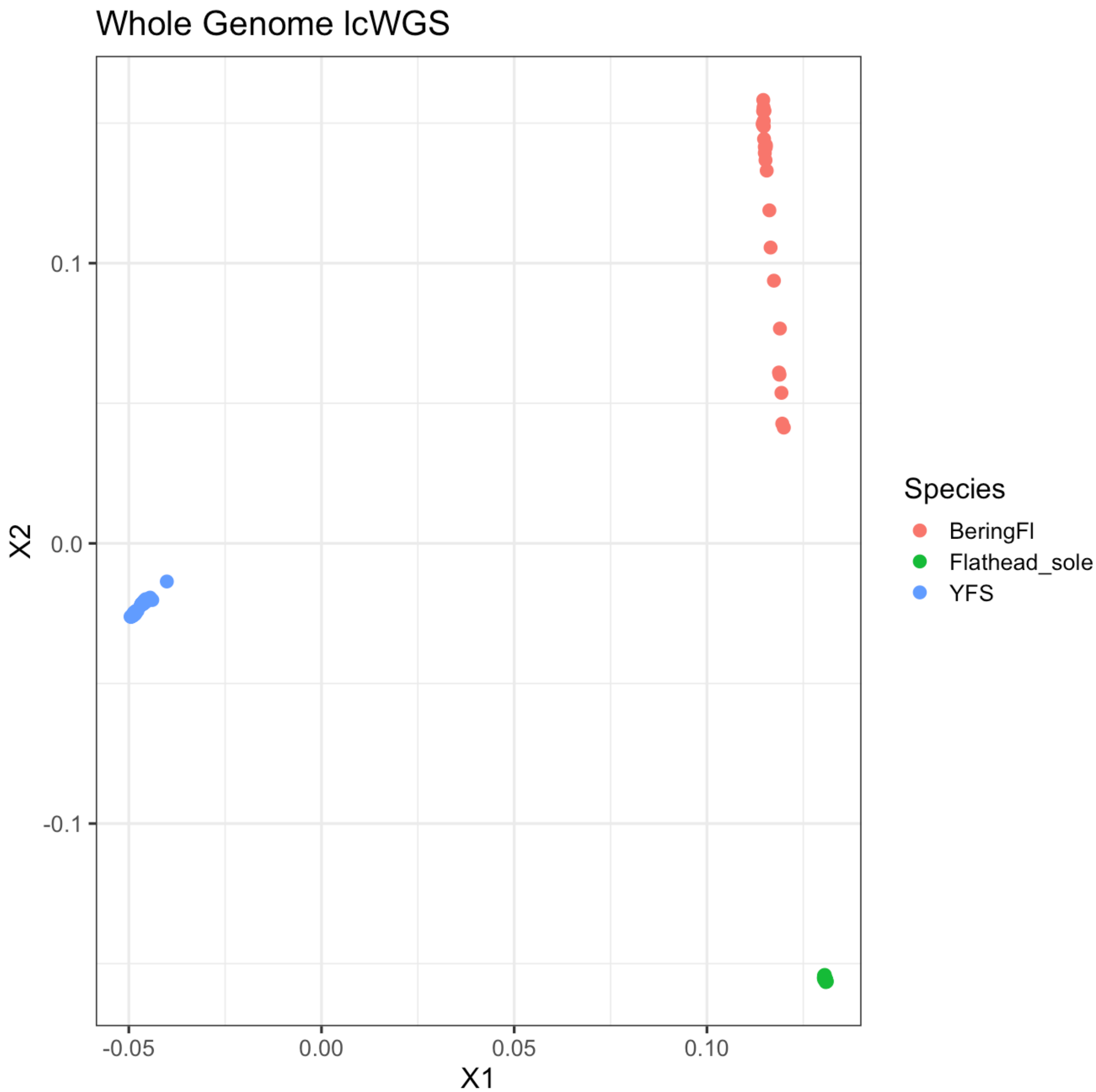

Figure 9.22. . Principal components analysis of yellowfin sole (YFS), Bering flounder, and flathead sole, first and second principal components axes. .