4. Assessment of the Yellowfin Sole Stock in the Bering Sea and Aleutian Islands

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Executive Summary

Summary of Changes in Assessment Inputs

The following substantive changes have been made to the BSAI yellowfin sole assessment relative to the 2024 Bering Sea and Aleutian Islands (BSAI) SAFE report. Note that no BSAI yellowfin sole assessment was conducted in 2025 due to the federal government shutdown.

Changes in the data

- Survey age and weight: Model-based survey age compositions were updated with data through 2025, and the mean survey weight-at-age was added for 2025.
- Catch estimates: The total catch estimate through the end of 2025 was updated. The 2026 catch was extrapolated using catch data through October 1 and the 5-year average proportion caught for the remainder of the year.
- Survey biomass: The 2026 model-based estimates for the combined EBS and NBS NMFS survey biomass and standard error (1982-2026) were incorporated.
- Index model: The model-based survey index was generated using VAST and 750 knots for the last full assessment in 2024. The 2026 index model used sdmTMB and 250 knots.

Changes in the assessment methods

- The modeling platform for the assessment has transitioned from Automatic Differentiation Model Builder (ADMB) in 2024 to Stock Synthesis 3 (SS3; Methot and Wetzel 2013) for 2026. This change follows a model bridging analysis and a Center for Independent Experts (CIE) Review in June 2026. The full peer-review reports are available on the online NOAA Fisheries CIE Report Archive (https://www.st.nmfs.noaa.gov/science-quality-assurance/cie-peer-reviews/peer-review-reports).
- Harvest Control Rules: Reference points for the 2026 assessment model will be calculated using a Tier 3 harvest control rule (HCR). In contrast, the 2024 assessment model used a Tier 1 HCR and also presented results using the Tier 3 HCR.
- Environmental Covariate: Because SS3 accommodates only a single environmental covariate per parameter, survey catchability was not modeled using 100m EBS bottom temperature and survey start date, as it was in the 2024 assessment. It was modeled either as a function of survey start date anomalies (Model 25.0 and 25.0a) or 100m EBS bottom temperature (Model 25.0b).

Models presented in this assessment

- **Model 25.0** is the same model as presented to the Plan Team in September 2025. It uses the number of hauls to weight the survey age composition sample size, and it uses survey start date as a covariate on the EBS survey catchability parameter.
- **Model 25.0a** builds on Model 25.0, uses survey age-composition weights derived using the input sample size (ISS) methodology R package sampleISS (Hulson et al. 2024).
- **Model 25.0b** is identical to Model 25.0a, except the EBS survey catchability parameter incorporates <100m EBS bottom temperature as an additive log-space environmental link.

All models were sex-structured and age-structured, in which female natural mortality was fixed at 0.12 while allowing the model to estimate male natural mortality. The model incorporates estimates of survey indices and age compositions from the combined EBS and NBS survey areas. Model 25.0b is the preferred model because the inclusion of the input sample size (ISS) for survey age composition data and temperature as a covariate on survey catchability improve the model fit to the data, particularly the survey index.

Summary Table for Model 25.0b.

	As estimated or *specified in 2024*∗ for:		As estimated or *recommended this* year for:	
Quantity	2025	2026	2027	2028
M (natural mortality rate)	0.12, 0.128	0.12, 0.128	0.12, 0.132	0.12, 0.132
Tier	1	1	3a	3a
Projected total (age 1+) biomass (t)	2,308,550	2,353,240	2,583,910	2,533,910
Projected female spawning biomass (t)	748,076	758,695	1,032,620	993,225
$B_{100\%}$	1,383,020	1,383,020	2,036,510	2,036,510
$B_{40\%}$	-	-	814,605	814,605
$B_{35\%}$	479,711	479,711	712,779	712,779
F_{OFL}	0.13	0.13	0.097	0.097
$maxF_{ABC}$	0.114	0.114	0.083	0.083
F_{ABC}	0.114	0.114	0.083	0.083
OFL	299,247	305,039	204,846	201,766
$maxABC$	262,557	267,639	175,231	172,592
ABC	262,557	267,639	175,231	172,592
	As determined in 2024 for			
Status	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Note: Projections were based on estimated catches of 96,318 t in 2026, the 2027 ABC 175,231 for 2027 and the 2028 ABC 172,592 for 2028. Summary tables for Models 25.0 and 25.0a are provided (Table 4.1 and Table 4.2). $B_{35\%}$ was considered B_{MSY} because it was calculated using a Tier 1 model; Tier 3 harvest control rules use $B_{35\%}$ as a B_{MSY} proxy. Summary table values from last year were based on the 2024 assessment, because those values were adopted in 2025 due to the government shutdown. Note that a decrease in ABC and OFL occur as a result of the shift from Tier 1 to Tier 3a.

Summary of Results

The model-based biomass estimate for EBS yellowfin sole based on the 2026 eastern Bering Sea (EBS) bottom trawl survey was 7.63% higher than the 2025 estimate, totaling 2,176,060 t. For 2027, Model 25.0b estimated the spawning biomass to be 1.27 $\times$ $B_{40\%}$, with a $B_{40\%}$ reference point of 814,605 t and a female spawning biomass of 1,032,620 t. Consequently, yellowfin sole qualifies for management under Tier 3a.

Compared to the projections made in 2025 (which were adopted from the assessment conducted in 2024), the total and spawning biomass estimates for 2027 are higher.

Catch of yellowfin sole as of October 1, 2026 in the Bering Sea and Aleutian Islands was 70,841 t. Over the past 5 years (2021 - 2025), approximately 73.5% of the catch has taken place by this date. Therefore, the full year's estimate of catch in 2026 was extrapolated to be 96,318 t. This is lower than the average catch over the past ten years, 118,192 t.

Yellowfin sole female spawning biomass continues to be above $B_{40\%}$ and the annual harvest remains below the ABC level. Management quantities are given in the results summary table for the 2024 accepted model (Model 23.0) with data through 2024. The projected estimate of total biomass for 2027 for Model 25.0b was higher by 9.8% from the 2025 assessment of 2,353,240 t, to 2,583,910 t. The model projection of spawning biomass for 2027, assuming catch for 2026 as described above, was 1,032,620 t, 36% higher than the projected 2026 spawning biomass from the 2024 assessment of 758,695 t.

This year's recommended ABC and OFL are lower than those from the 2024 assessment, matching the shift from Tier 1 to Tier 3 management; $F_{35\%}$ applied under Tier 3 is a conservative proxy for F_{MSY}. The 2027 and 2028 ABCs using F_{ABC} from this assessment model were lower than last assessment's 2026 ABC of 267,639 t: 175,231 t and 172,592 t. The 2025 and 2026 OFLs estimated by Model 23.0 were 299,247 t and 305,039 t; the 2027 and 2028 OFLs estimated by Model 25.0b were 204,846 t and 201,766 t.

Responses to SSC and Plan Team comments

General Stock Assessment Comments

Comments Specific to this Assessment

SSC December 2025

The SSC requests that an operational full assessment be prioritized for yellowfin sole in 2026.

Response

The 2026 BSAI yellowfin sole assessment is a full assessment.

SSC October 2026

Consistent with its October 2025 report, the SSC continues to support use of Tier 3 reference points for the 2026 assessment.

The SSC supports bringing forward models 25.0, 25.0a and 25.0b for consideration in December, and supports bringing forward Model 25.0b with the use of the temperature covariate.

Response

The 2026 BSAI yellowfin sole assessment uses Tier 3 reference points, and models 25.0, 25.0a and 25.0b are presented for consideration, including the use of the temperature covariate for Model 25.0b.

SSC October 2026

The Plan Team also discussed evaluating cold-pool extent as an alternative environmental covariate and the broader question of how environmental information enters both survey standardization and assessment catchability. The SSC agrees that these are useful future model-development questions rather than additional model configurations for the current assessment cycle.

Response

The authors agree to the benefits of exploring the cold-pool extent as an alternate environmental covariate in future years.

SSC October 2026

The SSC continues to support evaluation of the sampleISS approach used in Models 25.0a and 25.0b. Diagnostics for initial model runs indicate that effective and observed sample sizes differ substantially and survey age-composition residuals show some evidence of misspecification. Therefore, the SSC recommends clearly documenting the input sample sizes and effective sample sizes for the survey age compositions and providing sufficient diagnostics to determine whether the compositions are appropriately weighted or whether the low survey-index SDNR and discrepancies between observed and effective composition sample sizes indicate excessive weighting of survey information.

Response

Tables of initial and adjusted data weighting values are provided and described in the text.

SSC October 2026

The SSC supports investigation of growth as a function of temperature in the future, while recognizing that empirical annual weight-at-age may already capture much of this temporal variation.

Response

We agree; growth as a function of temperature may be a topic of future research.

SSC October 2026

The SSC requests that the assessment include standard SS3 convergence and identifiability diagnostics for the candidate models, consistent with the CIE recommendations, including maximum gradients, Hessian status and key parameter correlations.

Response

Convergence diagnostics, Hessian status, and key parameter correlations are provided in the Results section.

SSC October 2026

Finally, the SSC reiterates its October 2025 recommendation to investigate the long-term decline in yellowfin sole and persistently weak recruitment in the context of ecosystem changes in the Bristol Bay region. This work may be most appropriately developed through a future ESP, but potentially relevant environmental mechanisms could also be considered in future assessment development.

Response

We address this long-term decline in the Results section.

General Stock Assessment Comments

Comments Specific to this Assessment

Background

The BSAI yellowfin sole assessment model features a long time series of catches since 1954 and ages since 1964. It has incorporated a Tier 1 HCR through the 2024 assessment, but has shifted to a Tier 3 HCR following CIE and Plan Team Reviews indicating a poor fit to the stock recruitment curve. Empirical weight-at-age is used in the model, which allows the model to fit increasing size-at-age throughout the past several decades.

Introduction

Yellowfin sole (*Limanda aspera*) are one of the most abundant flatfish species in the eastern Bering Sea (EBS) and comprise the largest flatfish fishery off Alaska. They are distributed in North American waters from British Columbia, Canada, (approx. lat. 49°N) to the Chukchi Sea (approx. lat. 70°N) and south along the Asian coast to South Korea in the Sea of Japan (approx. lat. 35°N). Their abundance in the Aleutian Islands

region is considered low to negligible. They are managed in the combined eastern and northern Bering Sea as well as the Aleutian Islands (BSAI), and management units are presented in terms of biomass (t).

Adults exhibit a benthic lifestyle, occupying separate winter spawning areas and summer feeding grounds on the eastern Bering Sea shelf (Wakabayashi 1989). Each year in April or early May, adults begin migrating from over-wintering grounds near the shelf margins (>100 m) onto the inner shelf (15 – 75 m) to spawn and feed. They migrate back offshore in the fall and winter in response to ice cover and cold water on the inner and central shelf (Bakkala 1979). In contrast, young yellowfin sole remain in shallow, nearshore nursery areas throughout their first few years of life. They begin dispersing offshore at ages 3 – 5, and by ages 5 – 8, they follow adult migratory patterns (Bakkala 1979). The maximum observed age for yellowfin sole is 43 years for females and 38 years for males.

Year-class strength in flatfishes is thought to be determined during the first few years of life, between the pelagic egg stage and benthic settlement (van der Veer and Witte 1993). Temperature during these early life stages can affect egg size, larval duration, size at settlement, and the overall availability of suitable nursery habitat (Yeung and Cooper 2019). It has been hypothesized that colder bottom temperatures delay migration and spawning in yellowfin sole. As a result, mature individuals may still reside in nearshore nursery grounds during the months when the NMFS survey occurs, which likely decreases survey biomass estimates during cold years (Nichol et al., 2019; Yeung and Cooper 2019).

Yellowfin sole may be less sensitive to temperature variations than northern rock sole, which appear highly temperature-sensitive. Yellowfin sole settle later in the summer, when the influence of the cold pool is weaker and nearshore bottom temperatures are relatively stable and warm (Yeung and Yang, 2018). Additionally, because yellowfin sole migrate across the shelf to spawn near their nursery habitat rather than relying on currents for larval transport (Nichol and Acuna, 2001), their larvae may be less susceptible to variable ocean currents (Yeung and Cooper 2019).

There appear to be several distinct stocks, although the genetic basis remains to be determined. The stocks are referred to as the Unimak group, the Pribilof-west group, and the Pribilof-east group (Figure 4.1). However, because there is currently no direct evidence of a definitive stock structure crossing management boundaries, yellowfin sole are managed as a single stock within the BSAI management area.

Fishery and Management History

Yellowfin sole has been targeted with bottom trawls on the Bering Sea shelf since the fishery began in 1954. It was overexploited by foreign fisheries from 1959 – 1962, when catches averaged 404,000 t annually (Figure 4.2, top panel). Catch is typically taken throughout the Bering Sea shelf, as far north as 65°N, while low to negligible amounts are taken in the Aleutian Islands (Figure 4.3). Catches declined to an annual average of 117,800 t from 1963 – 1971 and further declined to an annual average of 50,700 t from 1972 – 1977. The lower yield in this latter period was partially due to the discontinuation of the Union of Soviet Socialist Republics (U.S.S.R.) fishery. In the early 1980s, after the stock condition had improved, catches again increased, reaching a peak of over 227,000 t in 1985.

During the 1980s, there was also a major transition in the characteristics of the fishery. Yellowfin sole were traditionally taken exclusively by foreign fisheries and these fisheries which continued to dominate through 1984. However, U.S. fisheries developed rapidly during the 1980s through joint ventures, and during the last half of the decade, domestic vessels began to dominate and eventually took the entirety of the catch as foreign fisheries were phased out of the Eastern Bering Sea. Since 1990, only domestic harvesting and processing has occurred.

The management of the yellowfin sole fishery changed significantly in 2008 with the implementation of Amendment 80 to the BSAI Fisheries Management Plan. The Amendment allocated fishery resources among BSAI trawl harvesters based on historic harvest patterns and future needs to improve retention and utilization of fishery resources by the non-AFA (American Fisheries Act) trawl catcher/processor fleet. This was accomplished by extending the groundfish retention standards to all H&G (headed and gutted) vessels and by allowing cooperatives to form within the newly established Amendment 80 sector. Additionally, Amendment 80 mandated enhanced monitoring requirements, which included observer coverage on all hauls,

motion-compensating scales for weighing samples, flow scales to obtain accurate catch weight estimates for the entire catch, a prohibition on mixing hauls, and a ban on on-deck sorting. The partitioning of TAC (total allowable catch) and PSC (prohibited species catch) among cooperatives significantly altered the accumulation pattern of the annual catch (Figure 4.2, lower panel) and improved the rate of target catch per bycatch ton. Consequently, the annual catch is now attained more evenly and slowly relative to the pre-Amendment 80 fishing behavior.

In 2010, following a comprehensive assessment process, the yellowfin sole fishery was certified under the Marine Stewardship Council (MSC) environmental standard for sustainable and well-managed fisheries. The certification also applies to all major flatfish fisheries in the BSAI and GOA.

In 2011, federally permitted vessels using non-pelagic trawl gear in the BSAI whose harvest resulted in a flatfish retained catch greater than any other retained fishery category were required to use modified trawl gear. The modifications required the use of elevating devices to raise the section of the trawl warps between the doors and the trawl wing tips by 2.5 inches off the seafloor. The purpose of this management action was to reduce damage to the non-target benthic animals, particularly those forming habitat structure or supporting other fisheries without substantially reducing flatfish catch rates or causing gear handling problems (Rose et al. 2010).

Yellowfin sole are typically headed and gutted, frozen at sea, and then shipped primarily to China and South Korea. Reprocessed yellowfin sole from China may also be sold as fillets to Japan, the U.S., and Europe, among other destinations (Fissel et al. 2017). The 1997 catch of 182,814 t (retained and discarded) was the largest since the fishery became completely domestic, but catches decreased from 1998 – 2010, averaging 94,004 t (Table 4.3, Table 4.4). From 2011 – 2014, catch increased, averaging 155,000 t. The 2013 catch marked the highest annual catch since 1988, accounting for 73% of the ABC (164,944). Catches have declined since 2013; the average catch over the past ten years reflects a downward trend, 118,192 t. The full year's estimate of catch for the current cycle is based on catch data downloaded October 1, 2026, and projected forward through the remainder of the year to provide an estimate relative to the prior year's ABC, 96,318 t. This estimate represents 35.99% of the 2025 ABC.

Length distributions of yellowfin sole throughout NMFS areas 509, 513, 514, 516, 521, and 524 ranged from 20 – 50 cm, with the largest individuals occurring in the northern areas 514, 521, and 524 (Figure 4.4).

Catch per unit effort (CPUE) shows a negative correlation with bottom temperature, evidenced by an increased CPUE in 2022, which was a cooler than average year in the Bering Sea. However, this relationship does not appear strong across all years; in 2023 and 2024, temperatures were lower but CPUE declined.

Bycatch of yellowfin sole takes place primarily in the directed rock sole fishery, followed by the flathead sole fishery, with minor amounts occurring in the pollock and Pacific cod fisheries (Table 4.5). Catch by month and gear indicates that trawl catches were typically distributed more inshore (Figure 4.5), while longline caught yellowfin sole as bycatch along the Bering Sea shelf (Figure 4.6). FMP species caught as bycatch in the yellowfin sole fishery include other flatfish, such as Alaska plaice and rock sole, as well as skates, Pacific cod, and pollock (Table 4.6).

Data

The data used in this assessment include estimates of total catch, bottom trawl survey biomass estimates and their 95% confidence intervals, catch-at-age from the fishery, eastern Bering Sea survey bottom temperatures <100 m, and population age composition estimates from the bottom trawl survey. Additionally, the 2025 fishery ages were not read prior to this assessment.

Data source	Year
Fishery catch	1954 – 2026
Fishery age composition	1975 – 2024
Fishery weight-at-age	1954 – 2024
Survey biomass and standard error	1982 – 2026 (not 2020)

Data source	Year
Bottom temperature	1982 – 2026
Survey age composition	1979 – 2025 (not 2020)
Annual length-at-age and weight-at-age from surveys	1979 – 2025 (not 2020)
Age at maturity	Combined 1992 and 2012 samples

Fishery Data

Age Determination

Yellowfin sole have been aged at the AFSC since 1979 using the break-and-burn method on otoliths collected from surveys and fisheries. In 2016, these age determination methods were validated using the bomb-produced radiocarbon uptake (^{14}C) method (Kastelle et al. 2016). Since 1982, an average of 706 yellowfin sole have been aged from EBS trawl surveys, and 730 yellowfin sole have been aged from fishery collections annually (Table 4.7). The number of hauls from which survey otoliths were sampled has averaged 49 per year (Table 4.7).

Fishery age trends for males and female ages from the fishery indicate that the 2010 year class was the dominant cohort through 2022 (Figure 4.7), and this is consistent in the model estimates of age composition (Figure 4.8). Survey age data show a different trend, likely due to higher survey selectivity at younger ages. The 2024 assessment indicated an extremely strong 2017 year class (defined as the cohort that was 1 year old in 2017), which continues to dominate survey age frequency distributions as a strong age-9 year class in the most recent aged collection in 2025 (Figure 4.9), but is not yet observed in the most recent aged fishery data from 2024 (Figure 4.7).

Catch

This assessment uses fishery catch data from 1954 – 2026 (Table 4.3), and estimates fishery catch-at-age (proportions) from 1975 –2024 (Table 4.8). Removals from sources other than those that are included in the Alaska Region's official estimate of catch including removals due to scientific surveys, subsistence fishing, recreational fishing, and fisheries managed under other FMPs are tabulated and presented in Table 4.9. Catch per unit effort calculated from fishery trawl data, based on the catch in kg and duration of the tow, does not indicate a consistent trend through the time series, 1996 - 2026 for vessels >125 feet (Figure 4.10), although 2022 showed an increase, and 2023 through 2024 appeared back to a relative mean value. Vessels <125 feet appear to have increased CPUE through time. CPUE has increased for both vessel size categories in the two most recent years, 2025 and 2026.

Numbers-at-age

The age composition of the yellowfin sole stock is inferred from aged fishery otoliths. Historically, the fishery age composition has consisted primarily of fish older than 9 years, including a substantial proportion of fish aged 20+. However, the proportion of fish older than age 7 declined from approximately 90% in the early 1980s to 70% between 1991 and 2018 (Table 4.8). The lowest proportions of fish older than age 7 occurred from 2019 to 2021 (mean 63%), whereas the most recent data (2022 —- 2024) indicate a subsequent increase back above 70%.

Weight-at-age

Fishery mean weights-at-age and catch-at-age for 1991 – 2024 were estimated using the catch-at-age methodology of Kimura (1989), modified by Dorn (1992), and adapted from the walleye pollock assessment (Ianelli et al. 2024). These estimates serve as direct input data for the assessment model (Figure 4.11). The estimation method uses a two-stage bootstrap resampling of the data (1,000 iterations), where observed tows are first selected with replacement, followed by the resampling of individual lengths and age specimens within those tows. This approach provides an objective way to specify the effective sample size for fitting fishery age composition data. For the most recent 2025 sdmTMB age composition estimates, 563 ages were available (Table 4.7). Additionally, weight-at-age and proportion mature-at-age schedules derived from bottom trawl survey studies were incorporated into the model. Weight-at-age has increased over the time series, and the

most recent estimates are among the highest observed (Figure 4.12). The use of empirical weight-at-age provides the changes over time directly into the model.

Maturity-at-age

The current assessment model uses a female maturity schedule derived from the combined 1992, 1993, and 2012 histological collections (Table 4.10). Originally, Nichol (1995) estimated the age at 50% maturity ($A_{50\%}$) at 10.5 years based on 639 ovaries collected during the 1992 and 1993 eastern Bering Sea trawl surveys. A subsequent histological re-evaluation of ovaries collected in 2012 yielded similar results, resulting in only a 2% difference in female spawning biomass estimates (TenBrink and Wilderbuer 2015). For yellowfin sole, sexual maturity occurs well after entry into the fishery; by age 10, females are 82% selected by the fishery but are only 40% mature.

A more recent study by TenBrink (2022) analyzed the maturity-at-age schedule of 209 female yellowfin sole sampled from the northern Bering Sea. The resulting maturity curve was highly consistent with previous studies ($A_{50\%}$ 95% confidence interval: 9.47–10.76 years). Because this study relied on NBS samples, it was not incorporated into the 2026 assessment; however it served to verify the stability of the maturity curve for yellowfin sole over space and time.

Survey Data

Eastern Bering Sea bottom temperature

The eastern Bering Sea bottom temperatures <100 m were computed within the R package coldpool (https://github.com/afsc-gap-products/coldpool; Rohan et al. 2022). Temperatures in 2026 were lower than in 2025 and approximately 1°C below the mean for the time series (Figure 4.10).

Weight-at-age

The empirical survey weight-at-age used in the model comes from the mean weight by age from survey collections. Similar to the fishery data, survey weight-at-age has increased over time for males and females (Figure 4.13).

Survey Biomass Estimates and Population Age Composition Estimates

Model-based abundance index methods for the Bering Sea

The September 2026 data release included a recalculation of the 2024, 2025, and 2026 indices to reflect the discontinuation of the Marport-to-Netmind (M2N) correction. No further changes to those indices are expected, as they are now consistent with historical data.

For Bering Sea model-based indices, we fitted observations of biomass per unit area from all sampling locations in the 83-112 bottom trawl survey. Data spanned the EBS, 1982-2026, including exploratory northern extension samples in 2001, 2005, and 2006, as well as available northern Bering Sea samples from 1982, 1985, 1988, 1991, 2010, 2017-2019, 2021-2023, and 2026.

NBS samples prior to 2010 and in 2018 did not follow the 20-nautical-mile sampling grid used in other survey years. Assimilating these unbalanced data requires extrapolating into unsampled areas. We facilitated this by including a spatially varying response to cold-pool extent (Thorson 2019. This spatially varying coefficient term was estimated for both linear predictors of a delta-model. Detailed comparisons for EBS pollock demonstrate this term has a small but notable effect on indices and subsequent stock assessment outputs for pollock and Pacific cod (O'Leary et al. 2020, 2022). Rather than using the cold-pool covariate for yellowfin sole, we used the mean bottom temperature within the inner and middle domain strata, which regulates spatial availability for this species (Nichol et al., 2019). All models were fitted in the sdmTMB R package (Anderson et al. 2025), and all environmental covariate data were computed via the coldpool R package (Rohan et al. 2022).

We applied a spatiotemporal Poisson-link delta-model (Thorson 2018), using a Bernoulli distribution (log link) for encounter probability and a gamma distribution (log link) to model positive catch rates. Population

density was predicted annually across the entire EBS and NBS using a prediction grid including 2,250-cell prediction grid at a $10nm^2$ resolution. Spatial and spatiotemporal fields were estimated using a spatial mesh including 250 "knots". Knot locations were determined via a K-means algorithm to distribute them evenly across space in proportion to the prediction grid dimensions.

Although the prior VAST index model used a 750-knot mesh, we revisited this specification for the current model year for statistical and computational reasons. The historical choice of 750 knots was somewhat arbitrary; it followed general evidence indicating that increasing mesh resolution consistently improved the likelihood (Commander et al. 2022). Thorson et al. (2021) explored knot-number sensitivity across 20 Alaska groundfish stocks but only compared meshes of 100, 250, and 500 knots. For delta models in that study, the 250 and 500 knot configurations yielded nearly identical performance based on root-mean-squared-error and agreement between model- and design-based estimates.

Our own sensitivity analyses revealed that models fitted using 250 to 750 knots (in 50-knot increments) provided similar model estimates for most species, and this included yellowfin sole (Figure 4.14). Reducing knot count dramatically improved computation time, prevented overfitting, and avoided estimation inaccuracies caused by random fields that are too flexible for the data to appropriately inform (Ward and Anderson, in preparation).

We estimated geometric anisotropy (how spatial autocorrelation declines at differing rates across cardinal directions) and included spatial and spatiotemporal terms for both linear predictors. To support density predictions in regions with unsampled years, spatiotemporal fields were structured over time as an AR(1) process, estimating the magnitude of autocorrelation as a fixed effect for each linear predictor. If the AR(1) correlation parameter ρ was estimated close to 1 for either model component, the model was simplified by specifying $\rho = 1$, i.e., effectively modeling spatiotemporal variation as a random walk. Intercepts were treated as fixed effects for each linear predictor and year without temporal correlation. Finally, we used epsilon bias-correction to correct for retransformation bias (Thorson and Kristensen 2016).

Model convergence was verified by confirming that the Hessian matrices were positive definite and that the derivative of the marginal likelihood with respect to each fixed effect was sufficiently small (<0.001), alongside additional automated checks from sdmTMB::sanity(). We evaluated goodness-of-fit by computing randomized quantile residuals (Dunn and Smyth 1996) simulated using the DHARMa R package (Hartig 2021) and inspecting quantile-quantile plots from a single draw of the random effects from the joint precision matrix (Waagepetersen, 2006). We also evaluated the spatial distribution of residuals by year to check residual spatiotemporal patterns. Bridging from the 2024 model to the current year's estimates shows no significant bias or shifts in estimates for prior years (Figure 4.15:).

Model-based age composition methods

To estimate age compositions in the Bering Sea, we fitted observations of numerical abundance-at-age per unit area at each sampling location. This was accomplished by applying a year- and region-specific (EBS and NBS) age-length key to numerical abundance and length composition records, then dividing by the area swept. For data-deficient subcategories (combinations of year, length, age, and sex), age composition was computed from length composition using a globally pooled age-length key.

We computed these estimates in the tinyVAST R package (Thorson et al. 2024) using a Poisson-link delta-model (Thorson 2018) with a Bernoulli distribution (log link) for encounter probability and a gamma distribution (log link) for positive catch rates. Density covariates were excluded from the age composition estimation due to computational constraints and to maintain consistency with previous assessments. Spatial range was estimated assuming geometric isotropy (where spatial autocorrelation declines with distance in all directions).

We used the same prediction grid as the abundance index models, but modeled spatial and spatiotemporal fields with a mesh with a coarse 50-knot spatial mesh. This lower spatial resolution was necessary to accommodate the heavy computational load of fitting multiple age categories simultaneously. Abundance-at-age estimates were bias-corrected using the same approach as the abundance index, and we applied identical diagnostics to verify model convergence and goodness-of-fit.

Both the model-based bottom trawl index and age composition estimates were calculated using code in the AFSC GAP model-based indices GitHub repository (https://github.com/afsc-gap-products/model-based-indices).

Net Spread Sensor Calibration and Biomass Index Adjustments

The Groundfish Assessment Program's (GAP) transition from Netmind to Marport net spread sensors in the Bering Sea (2009 – 2012) required developing and applying a Marport-to-Netmind (M2N) correction factor (Lauth and Kotwicki, 2014). This correction was applied in the 2013 survey and all subsequent Bering Sea surveys to maintain consistency with historical survey data. GAP subsequently upgraded to new-generation digital Marport sensors in 2024. Comparative data and field experiments since the upgrade have demonstrated that these new digital sensors align more closely with legacy Netmind data, rendering the M2N correction factor unnecessary. Continuing to apply the correction in 2024 and 2025 resulted in an underestimation of net spread relative to historical baselines.

Consequently, the M2N correction factor was discontinued for datasets from 2024 onward, prompting the recalculation of uncorrected net spread values for all hauls from the 2024 – 2026 EBS and 2025 NBS surveys. This methodological adjustment resulted in an approximate 4% increase in calculated effort causing a corresponding 3 – 4% downward adjustment in previously released biomass and abundance indices for all species. Discontinuing the M2N correction factor aligns recent survey data more accurately with historical data, and the correction will not be applied to future Bering surveys.

Variability of yellowfin sole survey biomass estimates (Figure 4.16) is in part due to the availability of yellowfin sole to the survey area (Nichol 1998, Nichol et al. 2019). Yellowfin sole are known to undergo annual migrations from wintering areas off the shelf-slope break to near shore waters where they spawn throughout the spring and summer months (Nichol 1995; Wakabayashi 1989; Wilderbuer et al. 1992). Exploratory survey sampling in coastal waters of the eastern Bering Sea during early summer indicate that yellowfin sole concentrations can be greater in these shallower areas not covered by the standard AFSC survey than in the survey proper. Commercial bottom trawlers have commonly found high concentrations of yellowfin sole in areas such as near Togiak Bay (Low and Narita 1990) and in more recent years from Kuskokwim Bay to just south of Nunivak Island.

Experiments examining the bridle efficiency of the Bering Sea survey trawl indicate that yellowfin sole are herded into the trawl path from an area between the wing tips of the net and the point where the bridles contact the seafloor (Somerton and Munro 2001). The herding experiments suggest that the survey trawl vulnerability (a component of catchability) is greater than 1.0. In a previous assessment, the likelihood profile of q from the model indicated a small variance with a narrow range of likely values with a low probability of q being equal to the value of 1.0 (Wilderbuer and Nichol 2003).

Survey biomass estimates for yellowfin sole have shown a positive correlation with shelf bottom temperatures (Nichol, 2019); estimates have generally been lower during cold years. The 1999 survey, which was conducted in exceptionally cold waters, indicated a decline in biomass that was unrealistic. The bottom temperatures during the 2000 survey were much warmer than in 1999, and the biomass increased, but still did not approach estimates from earlier years. Average bottom temperature and biomass both increased again during the period 2001 – 2003, with the 2003 value the highest temperature and biomass observed over the 22 year time series up to that time. Given that both the 1999 and 2000 surveys were conducted two weeks earlier than previous surveys, it is possible that the time difference may have also affected the availability of yellowfin sole to the survey. If, for example, the timing of peak yellowfin sole spawning in nearshore waters corresponded to the time of the survey, a greater proportion of the population would be unavailable to the standard survey area. This pattern was observed again in 2009 and 2012 when the temperatures and the bottom trawl survey point estimates were lower. Summer shelf bottom temperatures in 2012 were the 2nd coldest recorded by the survey and the time-series and resulted in a 19% decline from 2011. Temperatures in the Bering Sea have been generally higher than the mean since 2013 (Figure 4.17), and the 2016 estimate of biomass was the highest in 32 years and 48% higher than the 2015 estimate. However, 2023 and 2026 were below the long-term mean. In the current year, 2026, survey biomass estimates were up for the EBS (Table 4.11), but lower for the most recent 2025 NBS survey (Table 4.12). The combined EBS+NBS index estimate for 2026 did not result in large scale changes for the time series (Figure 4.15), and the model was relatively insensitive

to the number of knots applied to the model (Figure 4.14).

We propose several reasons why survey biomass estimates are often lower during years when bottom temperatures are low. First, catchability may be lower because yellowfin sole may be less active when cold. Less active fish may be less susceptible to herding and more likely to escape under the foot rope of survey gear. Secondly, bottom temperatures may influence the timing of the inshore spawning migrations of yellowfin sole and therefore affect their availability to the survey area (Nichol et al. 2019). Because yellowfin sole spawning grounds include nearshore areas outside the survey area, availability of fish within the survey area can vary with the timing of this migration and the timing of the survey. In the case of 2016, a very warm year in the Bering Sea, it appears that a higher portion of the adult biomass was distributed on the shelf (outside of the spawning areas) relative to the average of all previous survey years, indicating earlier spawning migration. Third, yellowfin sole growth appears to be correlated with temperature, as can be seen with greater length anomalies of 5 year old males and females in warm years and smaller lengths in cold years (Figure 4.17). Temperatures have been lower since 2022 after a decade of anomalously high temperatures, and biomass estimates have also declined from the long-term mean (Figure 4.17).

Yellowfin sole population numbers-at-age are estimated based on otolith collections from annual EBS bottom trawl surveys. The occurrence of yellowfin sole in trawl survey hauls and associated collections of lengths and age structures since 1982 have not changed significantly (Table 4.7). The number of hauls from which age structures have been collected increased in 2021 when otolith collections changed from stratified to random. The total tonnage caught in the resource assessment surveys since 1982 is listed in Table 4.9.

The center of gravity for yellowfin sole moved west in the late 2010s before moving eastward during the past several years, while a northward trend in the center of gravity occurred between 2014 and 2023. The most recent center of gravity is north of the historical distribution (Figure 4.18). Analysis using sdmTMB indicates that the total effective area occupied by yellowfin sole has decreased since a peak in 2018. The effective area occupied in the eastern Bering Sea has declined slightly since 2024, and the area occupied in the northern Bering Sea has decreased for the past two years (Figure 4.19).

Northern Bering Sea survey

Trawl survey sampling was extended to the northern Bering Sea in 2010, 2017, 2018, 2019, 2021, 2022, 2023, and 2025. The 2018 survey was a reduced effort and only sampled a subset of the northern Bering Sea. Stations in 2018 were 30 nautical miles apart (instead of 20 nm) and excluded Norton Sound and inshore areas north of Nunivak Island. For comparison among years, 2018 biomass estimates were derived by truncating the areal coverage of the 2010 and 2017 surveys to include only the area covered in 2018 that was common to all three surveys, and this was treated as a single stratum. This truncated area was 158,286 square kilometers (compared to 200,207 square kilometers in 2010 and 2017). There has been an increase in the biomass estimate of yellowfin sole in the northern Bering Sea since 2010, but it decreased from 2022 to 2023, and again in 2025. Large shifts in the abundance of yellowfin sole into the Bering Sea have not been observed. The center distribution of yellowfin sole may be related to temperature, as northward shifts were concurrent with anomalously warm temperatures 2014-2021, followed by shifts southward during recent years of cooler temperatures (Figure 4.18). The spatial distribution of the yellowfin sole stock in the eastern and northern Bering Sea appears continuous.

Norton Sound survey

A time series based on an ADF&G survey in Norton Sound confirmed that the biomass of yellowfin sole has increased over time. The mean CPUE of yellowfin sole in Norton Sound increased from a mean CPUE of 278 kg/hectare over the first five survey years (1996 through 2018) to a mean CPUE of 605 kg/hectare over the last four survey years (2019, 2020, 2021, and 2023) (Figure 4.20). There has been no Norton Sound survey since that time.

Data weighting

Data weighting and model tuning

In Model 25.0, the survey age composition data was weighted by the number of hauls from which otoliths

were collected. Fishery age composition data was weighted by the mean of the survey age composition weights. For Models 25.0a and 25.0b, survey age input sample sizes were generated by bootstrapping the number of hauls from which age data were taken using the methodology of Hulson et al. (2024). Fishery age composition input sample sizes were set equal to the mean of the survey age composition weights. Next, age composition data from survey and fishery were tuned over three iterations using the Francis weighting methodology (Francis 2011; Table 4.13). Initial and adjusted sample sizes show that survey weights were generally downweighted and fishery sample sizes were weighted higher than survey (Table 4.14, Table 4.15).

Analytic Approach

General Model Structure

The abundance, mortality, recruitment and selectivity of yellowfin sole were assessed using Stock Synthesis 3 (SS3; Methot and Wetzel 2013). The assessment model is structured as a separable catch-at-age analysis that integrates survey estimates of biomass and age composition. The model simulates the dynamics of the population and compares expected values to those observed from surveys and fishery sampling programs. This was accomplished by simultaneously estimating model parameters using a maximum likelihood estimation (MLE) procedure, where the fit of simulated values to observable characteristics was optimized by maximizing a log-likelihood function based on the distributional assumptions of the observed data.

The model trajectory begins in 1954 and tracks ages 0 through a 20+ group, which accumulates all individuals aged 20 and older. Because the sex-specific weight-at-age for yellowfin sole diverges after the age of maturity (approximately age 10 for 40% of the stock), with females growing larger than males, the model is structured to accommodate sex-specific population dynamics. Specifically it incorporates sex-specific estimates of weight-at-age along with fishery and survey age compositions. Consequently, the model outputs sex-specific estimates of population abundance, fishing mortality, and age compositions, while allowing for the independent estimation of sex-specific natural mortality and catchability. However, the model retains the utility to fit combined-sex data inputs, and neither fishery nor survey selectivity is split by sex.

The data components used to fit the model and estimate parameters are classified by three primary likelihood components:

Data component	Distributional assumption
Trawl fishery catch-at-age	Multinomial
Trawl survey population age composition	Multinomial
Trawl survey biomass estimates and S.E.	Log-normal

Sharp increases in trawl survey abundance estimates for most species of Bering Sea flatfish between 1981 and 1982 indicate that the 83-112 trawl was more efficient for capturing these species than the 400-mesh eastern trawl used in 1975 and from 1979 to 1981. Allowing the model to tune to these early survey estimates would underestimate the true pre-1982 biomass, thereby exaggerating the magnitude of the biomass increase during that period. While this underestimate would have a negligible effect on the current yellowfin sole biomass estimate, it would distort the historical spawner and recruitment estimates across the time series. Consequently, the pre-1982 survey biomass estimates were omitted from the analysis.

The model incorporates sex-specific parameters for length-weight relationships, fishery and survey weights-at-age, and fishery and survey proportions-at-age. The sex-specific proportions-at-age are structured so that the male and female fractions sum to 1 over all ages for each year, and the proportions by sex align with the estimated sex ratio of the population based on extrapolated numbers from the EBS survey. Since 2022, the combined Northern Bering Sea and Eastern Bering Sea (NBS+EBS) survey proportions-at-age have been derived using model-based estimation. Mean fishery weights-at-age were estimated using the catch-at-age methodology of Kimura (1989). Beginning in 2023, selectivity curves were combined across sexes; males and females share the same selectivity parameter, as this configuration was found to improve the overall model fit

to the data. Fishery selectivity is estimated annually, whereas survey selectivity is assumed to be constant over time.

Initial population proportions-at-age are based on an estimated mean initial proportion (a single value) that is adjusted for each age by a vector of sex-specific initial deviations. To calculate the initial numbers-at-age, sex-specific natural mortality is applied for the 20 years prior to the model's start year. In subsequent years, male and female recruitment does not differ. Total biomass and other derived population quantities are calculated as the sum of male and female numbers-at-age. Several likelihood components incorporate sex-specific parameterizations. The recruitment likelihood includes both the initial sex-specific deviations and the combined recruitment deviations throughout the modeled time series. Additionally, the age likelihood incorporates the fit to fishery and survey age compositions, which are split by sex.

Although the modeling platform was transitioned to SS3 from ADMB, the fundamental aspects of the underlying population dynamics model remain unchanged.

A Center for Independent Experts (CIE) review confirmed that utilizing bottom temperature both in the model-based index calculations and as a covariate for survey catchability (q) does not constitute 'double counting'. Its inclusion in the model-based index estimation is appropriate because it is not used to account for annual variations in fish availability. Because catchability transitions in SS3 are constrained to a single environmental covariate, the model could not accommodate the combination of survey start date, bottom temperature, and their interaction as previously configured. To resolve this, survey start date was incorporated into catchability for Models 25.0 and 25.0a, and bottom temperature was incorporated into catchability for Model 25.0b. Model fits were then evaluated to determine which single covariate provided the best performance.

Model 23.0 presented in 2024 (Spies et al. 2024) incorporated time-varying catchability (q) that varied over time (t) as a function of annual temperature (T), annual survey start date (S) and their interaction ($T : S$):

$$q_t = e^{-\alpha+\beta T+\gamma S+\mu T:S}$$

where α is time-invariant q, β is a time-varying covariate based on temperature, γ is a time-varying covariate based on survey start date, and μ is time-varying based on the interaction between temperature and survey start date.

Model 25.0 catchability (q) estimates vary over time (t) as a function of the annual survey start date anomaly (S).

$$q_t = e^{-\alpha+\beta S}$$

where α is time-invariant and β is based on the start date anomaly.

In SS3, the environmental link is coded as additive in log-space (201), with a flat, uninformative prior estimated in phase 4.

Model 25.0b catchability (q) estimates also vary over time (t), but they vary as a function of the annual bottom temperature anomaly (T) rather than survey start date:

$$q_t = e^{-\alpha+\beta T}$$

where α is time-invariant and β is based on the bottom temperature anomaly.

Recruitment was assumed to follow mean recruitment, and recruits are defined as individuals of age 1. Recruitment was estimated within the model as the unfished recruitment level, or average number of age 1 fish entering the population annually in the absence of fishing pressure. Steepness was fixed to 1 and recruitment variation fixed to 0.6. Main recruitment deviations were estimated between 1954 and 2020. The value 2020 was selected because yellowfin sole do not exceed 50% selection until age 5. SS3 initializes the population assuming equilibrium and includes a plus group:

$$N_{0,a,s} = \begin{cases} cR_0 e^{-aM_s} & a = 0 \text{ to } 3A-1 \\ \left(\sum_{a=A}^{3A-1} N_{0,a,s}\right) + \frac{N_{0,3A-1,s}e^{-M_s}}{1-e^{-M_s}} & a > A \end{cases}$$

where $N_{0,a,s}$ is the sex-specific initial numbers-at-age, c is the assumed sex-ratio at recruitment and fixed at 0.5, R_0 is mean recruitment, and M_s is sex-specific natural mortality. The numbers in 1954 are then derived as:

$$N_{1954,a,s} = N_{0,a,s} e^{dev_a}$$

Model 25.0 initializes the population in 1954 as:

$$n_{1954,a,s} = \begin{cases} 0.5e^{\bar{R}} & a = 1 \\ e^{\bar{I}} + \epsilon_{a,s} & a > 1 \end{cases}$$

where $\bar{R}$ is mean recruitment, $\bar{I}$ represents the mean number of age 2+ in 1954, and $\epsilon_{a,s}$ is the sex and age specific deviation.

Spawning biomass is calculated using:

$$SSB = \sum_a N_{fa} e^{-(M+F)t} W_a M_a$$

where N_{fa} is the female numbers-at-age, M = natural mortality, F = fishing mortality, t is the fraction of the year prior to spawning, W_a is weight-at-age, and M_a = maturity-at-age.

Description of Alternative Models

- **Model 25.0** is the same model as presented to the Plan Team in September 2025. It uses the number of hauls to weight the survey age composition sample size, and it uses survey start date as a covariate on the EBS survey catchability parameter.
- **Model 25.0a** builds on Model 25.0, with data weighting for survey age composition is based on the input sample size (ISS) methodology R package sampleISS (Hulson et al. 2024).
- **Model 25.0b** is identical to Model 25.0a, except the EBS survey catchability parameter incorporates 100m EBS bottom temperature as an additive log-space environmental link.

As described below, Model 25.0b provides the closest match to the observed proportions at age, due to improved survey input sample sizes and incorporation of temperature into the catchability index.

Parameters Estimated Outside the Assessment Model

Weight-at-age

Parameters of the von Bertalanffy growth curve were estimated for yellowfin sole using the trawl survey database:

Sex	L_{inf}	K	t_0	n
Males	34.03	0.161	0.515	656
Females	38.03	0.137	0.297	709

Survey weight-at-age data were evaluated for all individuals from age 1 through 19, as well as a 20+ group (comprising all ages 20 and over). The historical time series spans from 1984 through 2025; however, because

the 2026 age structures have not been processed, the mean survey weight-at-age from 2025 was used as a proxy for 2026.

To resolve gaps caused by years in which no fish of a given age were collected, survey length-at-age data were converted into weight-at-age values. This was particularly necessary between 1975 and 1991, a period when lengths were recorded for aged yellowfin sole in greater abundance than weights. Conversions were executed using a sex-specific length-weight power function derived from all available data:

$Weight(g) = a * Length(cm)^b$.

The parameters a and b were estimated to maximize model fit to the data. The resulting parameter estimates and sample sizes (n) are shown below:

Sex	a	b	n
Males	0.0091	3.068	10,663
Females	0.0059	3.205	13,702

Natural mortality

Natural mortality (M) was initially estimated by a least squares analysis where catch-at-age data were fitted to Japanese pair trawl effort data while varying the catchability coefficient (q) and M simultaneously. The best fit to the data (the point where the residual variance was minimized) occurred at a value of M=0.12 (Bakkala and Wespestad 1984). This was also the value which provided the best fit to the observable population characteristics when M was profiled over a range of values in the stock assessment model using data up to 1992. Since then, natural mortality has been estimated as a free parameter in some of the stock assessment model runs which have been evaluated the past five years. A fixed female natural mortality at M=0.12 and male natural mortality estimated by the model is used in all models.

Maturity

Yellowfin sole maturity schedules were estimated from in-situ observations from two studies as discussed in the "Data" section (Table 4.10).

Parameter Estimates

A list of selected parameters estimated inside the model are shown for Model 23.0 from the 2024 assessment in Table 4.16 and for Models 25.0, 25.0a, and 25.0b with Table 4.17. The three models (25.0, 25.0a, and 25.0b) all estimated a total of 258 parameters, which included 22 parameters for biology, 5 for spawner-recruitment, 20 for early recruitment deviations (recdevs), 21 forecast recruitments, 2 for catchability, 8 for selectivity, and two sets of 71 (142 total) annual deviation vectors from 1954 – 2024. There were also 30 parameters held static, including fixed minimum size limits and forecast recruitment placeholders.

Selectivity

Survey selectivity was constant over time, and a single logistic curve was estimated for males and females combined (Figure 4.21). Conversely, time-varying fishing selectivity curves were estimated because there have been annual changes in management, vessel participation, and likely gear selectivity (Figure 4.22). For both the fishery and the survey, the selectivity pattern follows an increasing logistic form, and the oldest year-classes were truncated at age 20+.

The logistic equation models fishery selectivity as a function of the time-varying parameters specifying the age at 50% selection (ϕ_t) and the slope (eta_t), respectively. The fishing selectivity ($S_{f,a,t}$) for age a and year t is modeled as

$$S_{f,a,t} = \left[1 + e^{\eta_t(a-\phi_t)}\right]^{-1},$$

where ϕ_t and eta_t are time-varying and partitioned into parameters representing the mean and a vector of log-scale deviations conditioned to sum to zero. The deviations are constrained by a log-normal prior with a variance that was iteratively estimated.

Fishing Mortality

The fishing mortality rates (F) for each age and year are calculated to approximate the catch weight by solving for F while allowing for observation error in catch measurement.

Results

All models fit the data acceptably. Below, we compare their diagnostics to evaluate and justify the preferred model.

Convergence

The three models (Model 25.0, 25.0a, and 25.0b) achieved the convergence criterion of <0.001. However, after incorporating the ISS age composition survey weighting (Hulson et al. 2024), the maximum gradient component was lower for Models 25.0a (8.345×10^{-5}) and 25.0b (9.702×10^{-5}) than for Model 25.0 (1.760×10^{-4}). A lower maximum gradient demonstrates stability in the estimated parameter space.

Objective function values were 673, 723, and 734 for the three models, respectively. Because Models 25.0a and 25.0b utilize the revised ISS age composition weighting method, their total likelihoods are on a different scale and cannot be directly compared to Model 25.0. However, likelihoods between Models 25.0a and 25.0b are directly comparable because they have the same ISS age compositions and the same Francis weighting methodology.

The Hessian matrix at the final convergence point was positive-definite (invertible) for all three models. Additionally, catchability and initial recruitment were negatively correlated for all models (Table 4.18, Table 4.19, and Table 4.20).

Residual Patterns

One step ahead (OSA) residuals and Pearson residuals were calculated for all three models. OSA residuals are preferred because they are independent and identically distributed (iid), and were calculated by removing the last age bin. For the fishery age composition data, males and females showed similar residual patterns, with magnitudes generally remaining within two standard deviations (Figure 4.23, Figure 4.24, and Figure 4.25). Survey residuals for both sexes displayed comparable, low-magnitude patterns that rarely exceeded one standard deviation (Figure 4.26, Figure 4.27, and Figure 4.28). The standard deviation of normalized residuals (SDNR) for the fishery was just over 1.0 for females and slightly higher for males, for all models. The SDNR for the survey was somewhat lower, approximately 0.8 for males and females, for all models. The quantile-quantile (Q-Q) plots for the fishery were skewed high for older ages, particularly for females. However, Q-Q plots for the survey exhibited a reverse S-shaped curve, indicating a heavy-tailed but symmetric distribution. In general, an SDNR significantly greater than 1.0 implies a poor fit to the data. Conversely, a value less than 1.0 implies that the data were fitted better than expected (Francis 2011).

A trend of positive OSA residuals has emerged since 2020 for the intermediate age classes of yellowfin sole in the survey, although these deviations remain below two standard deviations. This cohort-specific trend is less apparent in the fishery OSA residuals.

Fishing Mortality and Selectivity

The highest full-selection fishing mortality, F, occurred early in the time series, prior to 1966 (Figure 4.29, upper panel). Note that the estimated year of peak fishing mortality differed following ISS weighting; Model 25.0 estimates the highest year of fishing at 1962 while Models 25.0a and 25.0b indicate this occurred in 1963. Since 1978, F has remained <1, and has fluctuated between 0.025 and 0.075 since 1990. Current-year F has increased slightly over the past two years, and is estimated at 0.042, 0.042, 0.049 for Models 25.0 and 25.0a, and for Model 25.0b.

Survey selectivity was similar for the three models (Figure 4.21), but Model 25.0a estimated the lowest age inflection (Table 4.17) for the survey and fishery selectivities.

Retrospective Analysis

A within-model retrospective analysis was included for all three models. In this analysis, retrospective female spawning biomass was calculated by sequentially dropping data one year at a time and then comparing the peeled estimate to the reference stock assessment model used in the assessment (Figure 4.30, Figure 4.31, Figure 4.32). The same series of model-based survey estimates was used for each retrospective peel (rather than replacing the series with previous years' estimates). The three models provided consistent retrospective patterns, with higher biomass estimates for each successive peel except the last two peels, which were lower. As new data were added in recent years, the model consistently revised its past biomass estimates downward, indicating a slight positive retrospective bias. In other words, the past 7 years of assessments were slightly more optimistic and were corrected downwards with the addition of new data. Mohn's rho was 0.084, 0.058, and 0.099 for Models 25.0, 25.0a, and 25.0b, respectively, which are all within the range of acceptable values. The rule of thumb guideline for long-lived stocks proposed by Hurtado-Ferro et al. (2015), which includes flatfish, states that Mohn's rho higher than 0.20 or lower than -0.15 may be an indication of a retrospective pattern.

Model Evaluation

Model 25.0b produced the lowest biomass estimates, while Model 25.0a estimated consistently higher total and spawning biomass, and Model 25.0 most closely matched Model 25.0a (Figure 4.16). The lower biomass in Model 25.0b is likely due to the temperature covariate on catchability, which provides a closer fit to the survey index (Figure 4.33, Table 4.21). Catchability (q) was generally higher for Model 25.0b and is consistent with the model's lower biomass estimates (Figure 4.34).

All models estimated male natural mortality to be slightly higher than female natural mortality (Table 4.17), which is consistent with the skewed sex ratios observed in the data (Table 4.8) and known life history parameters of other Alaska flatfish. For example, male arrowtooth flounder are assumed to have higher natural mortality to reflect their skewed sex ratio (Wilderbuer and Turnock 2009). Higher natural mortality for male flatfish has also been assumed for species in other regions (Maunder and Wong 2011).

Notable improvements occurred when incorporating the input sample size methodology of Hulson et al. (2024) in Model 25.0a and when adding the bottom temperature covariate on catchability in Model 25.0b. Model 25.0b introduced some trade-offs: it improved both the fit to the survey index (Figure 4.33), and the survey likelihood component, but it did not improve the age composition likelihood (Table 4.21) or the overall likelihood. Changes in input sample size and catchability affected the estimates of total and spawning stock biomass (Figure 4.16). Fits to the fishery and survey age compositions all provide a good fit to the data (Figure 4.35, Figure 4.36, Figure 4.37, Figure 4.38, Figure 4.39), but Model 25.0b provides a slightly better fit to survey age composition for younger ages.

Estimates of total and spawning biomass were similar among models, tracking the survey indices, with a peak in the early 1980s, followed by a slow decline (Table 4.22 and Table 4.23). The models also tracked estimates of fishing mortality rate, with Model 25.0b estimating slightly higher overall rates (Table 4.24).

Of the three models evaluated, Models 25.0a and 25.0b are both good candidates that incorporate improved survey weighting, fit the data well, and exhibit acceptable diagnostics. Model 25.0b is slightly advantageous because the temperature covariate on catchability improves the fit to the survey index, resulting in a better survey likelihood score (Table 4.21). For these reasons, we recommend Model 25.0b, subject to the caveats noted above. Further diagnostics are limited to Model 25.0b, the preferred model for this assessment.

Time Series Results

The data were updated in 2026 to include current values of catch, survey biomass estimates, and survey age compositions from 2025. The latest year of fishery weight-at-age data was included (2024), as no new fishery ages were available for 2025 (Figure 4.11). The 2026 bottom temperature anomaly was below the mean,

which results in reduced catchablity (Figure 4.17). The temperature-dependent q adjustment for 2026 based on Model 25.0b was 0.91.

Indices of relative abundance available from AFSC surveys showed high NMFS surveys biomass estimates in the 1980s (Table 4.11. High levels of biomass in the late 1970s have been documented through Japanese commercial pair trawl data and catch-at-age modeling in past assessments (Bakkala and Wilderbuer 1990). Average survey CPUE for yellowfin sole has fluctuated from approximately 2,500-7,500 kg/km^2 over the eastern Bering Sea time survey from 1982-2026 (Figure 4.40). The CPUE for 2023 was the second lowest in the time series, at 2,733 kg/km^2. The lowest CPUE occurred in 1999, at 2,525 kg/km^2, which corresponded with the lowest survey biomass estimate for yellowfin sole in the eastern Bering Sea. This year's CPUE estimate represents an increase from 2023 and 2024, at 3,403 kg/km^2.

Biomass estimates for yellowfin sole from the annual eastern Bering Sea shelf bottom trawl survey showed a doubling of survey biomass between 1975 and 1979 with a further increase to over 3.3 million t in 1981 (Figure 4.16). Total survey abundance estimates fluctuated from 1983 to 1990 with biomass ranging from as high as 3.5 million t in 1983 to as low as 1.9 million t in 1986. Biomass estimates since 1990 indicate consistently high levels of abundance for yellowfin sole, with the exception of the 1999 and 2000 summer surveys, which fell to lower levels. Surveys from 2001-2005 estimated an annual increase, but estimates since 2006 indicate a stable level with some annual variability. However, the 2012 estimate decreased by 19% from 2011, while the 2013 and 2014 surveys estimated a 17% increase over 2012. Given that weight-at-age has increased, numbers-at-age may provide a more accurate way to track population size. The total number declined from a high of 35 billion in 1984 to below 20 billion in 2010 and has not recovered (Figure 4.41). Similarly, there was a 24% decrease from 2014 to 2015 followed by a 48% increase from 2015 to 2016, which was the highest biomass estimate since 1984 (Table 4.11).

Model-based estimates of survey biomass have increased following a low in 2024 of 1,899,833 t, rising to 2,010,033 t in 2025 and 2,176,060 t in 2026. Whether this increasing trend will continue remains to be seen, but a general decline has occurred since 2005 (Table 4.11, Figure 4.16). In the northern Bering Sea, yellowfin sole biomass estimates decreased based on the most recent survey in 2025 at 300,639 t (Table 4.12).

While the assessment model is based on biomass, examining numbers-at-age can be informative, particularly in a population that is declining while growing faster. Estimated numbers of yellowfin sole in the Bering Sea have declined steadily from a peak of over 30 billion in the late 1980s to approximately half that value today (Figure 4.41). Unfished population size (Model 25.0b) is estimated at 23 billion individuals, with a corresponding unfished biomass of 2,036,510 t.

Figure 4.9 and Figure 4.7 suggest that this long-term population decline in yellowfin sole is linked to changes in longevity. While a high proportion (up to 10%) of the 1980s year classes survived to age 16, survival rates have dropped in subsequent cohorts, as has the mean age in the population (Figure 4.42). Similarly, the proportion of individuals reaching the plus group peaked at 10% between 2000 and 2020 but has declined since. Collection protocols for yellowfin sole otoliths were stratified until 2020, after which they were randomized. While this methodological shift may explain the apparent decline in older fish within the survey data, a matching downward trend is also present in the fishery data.

A phase plane plot for Model 25.0b from 1975 – 2026 including projections for 2027 and 2028 indicates that the population has increased since the 1970s following a period of high fishing mortality rates. Fishing mortality has remained below $F_{35\%}$ in recent years, and the projected 2027 and 2028 spawning biomass estimates remain above $B_{40\%}$ (Figure 4.43).

Abundance Trends

Model results indicate that yellowfin sole total biomass was at low levels during most of the 1960s and early 1970s (700,000-1,000,000 t) after a period of high exploitation (Figure 4.16). Sustained above-average recruitment from 1967-1976 combined with light exploitation resulted in a biomass increase to a peak of approximately 3.6 million t by 1985. The population biomass has since been in a slow decline as the strong 1981 and 1983 year-classes have passed through the population, with only the 1991, 1995 and 2003 year-classes at levels observed during the 1970s. The present spawning biomass is estimated at 66% of the peak 1995 level (Table 4.25).

Recruitment Trends

Recruitment in 2011 (2012 year class) is emerging as a record low for the time series (Figure 4.44). While strong recruitment events have occurred at approximately 4-year intervals since the 1980s (Figure 4.44), the missing 2012 year class and the poor recruitment between 2004 and 2010 have resulted in longer intervals between years of high yellowfin sole recruitment. The mechanism driving this poor recruitment remains unknown; however, the cold pool index was anomalously low from 2013 to 2015, which may have negatively impacted the survival and recruitment of the 2012 year class (Figure 4.17).

Other Diagnostics

Likelihood profiles were performed over male and female natural mortality (M). In the base model configuration, Female M is fixed at 0.12 while male M is freely estimated. The likelihood profile for male M was conducted using this configuration. Conversely, the profile over female M required first fixing male M at its maximum likelihood estimate of 0.132. Age composition data informed the female M maximum likelihood estimate of female natural mortality of 0.12; and a Piner plot, showed that both fishery and survey age data supported this value (Figure 4.45). Similarly, age data served as the primary driver for male M estimates, and there was no conflict between survey and fishery data sources (Figure 4.46).

A likelihood profile was also performed over initial recruitment ($\ln(R_0)$). Some conflict is evident among the data sources, with survey indices pointing to a lower $\ln(R_0)$ and age composition data a higher value. The overall model estimate represented a compromise between these competing signals. The Piner plot further illustrated this conflict with fishery data providing higher and survey data indicating lower estimates (Figure 4.47).

Age Structured Model Results

Harvest Recommendations and Projection Methodology

Results presented in this section pertain to Model 25.0b only; however, results for Models 25.0 and 25.0a are noted.

Amendment 56 Reference Points

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines the "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (F_{ABC}) may be less than this maximum permissible level, but not greater. Because reliable estimates of reference points related to maximum sustainable yield (MSY) are currently not available but reliable estimates of reference points related to spawning per recruit are available, Tier 3 uses the following reference points: $B_{40\%}$, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; $F_{35\%}$, equal to 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; and $F_{40\%}$, equal to 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. The following formulas are used under the Tier 3 harvest control rule.

3a) Stock status: $B/B_{40\%} > 1$

- $F_{OFL} = F_{35\%}$
- $F_{ABC} < F_{40\%}$

3b) Stock status: $0.05 < B/B_{40\%} < 1$

- $F_{OFL} = F_{35\%} \times \left(\frac{B}{B_{40\%}} - 0.05\right) \times \frac{1}{0.95}$
- $F_{ABC} < F_{40\%} \times \left(\frac{B}{B_{40\%}} - 0.05\right) \times \frac{1}{0.95}$

3c) Stock status: $B/B_{40\%} < 0.05$

- $F_{OFL} = 0$
- $F_{ABC} = 0$

For Model 25.0b the estimate of $F_{35\%}$ is 0.097, and the estimate of $F_{40\%}$ is 0.083 (Summary Table). The estimate of $B_{100\%}$ from Model 25.0b is 2,036,510 t. The estimate of $B_{40\%}$ from Model 25.0b is 814,605 t; and $B_{35\%}$ is 712,779 t.

Corresponding values for Models 25.0 and 25.0a are shown in Table 4.1 and Table 4.2.

Means and standard deviations of the ABC and OFL distributions for 2027 and 2028 are shown for Model 25.0b in the following table.

Specification of OFL and Maximum Permissible ABC

For Model 25.0b female spawning biomass for 2027 is estimated to be 1,032,620 t; and female spawning biomass for 2028 is estimated to drop to 993,225 t (Summary Table). For Model 25.0b, female spawning biomass for 2027 and 2028 is projected to be above B40%, placing yellowfin sole in Tier 3a for both 2027 and 2028. Given this, the estimates of OFL, maximum permissible ABC, associated fishing mortality rates for 2027 and 2028 and standard deviations for ABC and OFL are as follows:

Year	Catch	Spawning Biomass	Total 1+ Biomass	ABC	OFL
2027	175,231	1,032,620	2,583,910	175,231 (13,199)	204,846 (14,858)
2028	172,592	993,225	2,533,910	172,592 (14,848)	201,766 (15,310)

A complete record of catch, ABC, and OFL is available in Table 4.3.

Status Determination

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3, of Amendment 56. This set of projections encompasses harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Act (MSA). Prior to the 2026 assessment, the standard harvest scenarios were made using the AFSC's "Proj" program. In 2026, projections were made in Stock Synthesis. Point estimates of all time-varying parameters used in the projections are set at their respective time series means, except for annual deviations governing length at age of year classes currently in the population, as these propagate into the future. Year-end catch for 2026 was estimated to be 96,318 t, as described above. In the event that catch is likely to be less than the recommended ABC in either of the first two projection years, Scenario 2 must be conducted, using the best estimates of catch in those two years (otherwise, Scenario 2 can be omitted if the author's recommended ABCs for the next two years are equal to the maximum permissible ABCs). Projections were performed under Scenario 1; catch for 2026 was the year's projected catch and catch for 2027 was the recommended ABC (Table 4.26, Table 4.27, Table 4.28, and Figure 4.48).

Under the MSFCMA, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions:

1) Is the stock subjected to overfishing?

The official catch estimate for the most recent complete year (2025) is 91,887 t. This is less than the 2025 OFL of 299,247 t and also the ABC of 262,557. Therefore, the BSAI yellowfin sole stock is not subjected to overfishing.

2) Is the stock currently overfished?

The estimate of spawning biomass for 2026 is estimated to be above $B_{35\%}$. Therefore, the stock is not currently overfished.

3) Is the stock approaching an overfished condition?

The estimate of spawning biomass for 2027 is above $B_{35\%}$. Therefore, the stock is not approaching an overfished condition.

Standard Projection Alternatives

- **Scenario 1 (Maximum Permissible Harvest):** In all future years, F is set equal to max F_{ABC}. This scenario was used for projections; catch for 2026 was the estimate for the full year, and catches for 2027 and 2028 were the ABC for those years.
  - *Rationale:* Historically, TAC has been constrained by the Acceptable Biological Catch (ABC), so this scenario provides a likely upper limit on future TACs.
- **Scenario 2:** If catch is likely to be less than the recommended ABC in either of the first two projection years, Scenario 2 must be conducted using the best estimates of catch in those two years. (This scenario can be omitted if the author's recommended ABCs for the next two years are equal to the maximum permissible ABCs). In all subsequent years, F is set equal to a constant fraction ("author's F") of max F_{ABC}, where this fraction is equal to the ratio of the recommended F_{ABC} to the max F_{ABC} in $yr + 1$. Catches for $yr + 1$ and $yr + 2$ are estimated at their most likely values given the recommended ABCs under this scenario.
  - *Rationale:* When F_{ABC} is set below max F_{ABC}, it typically aligns with the stock assessment recommendation; additionally, actual catch rarely matches the ABC exactly.
- **Scenario 3 (Recent Average Harvesting Pressure):** In all future years, F is set equal to the 5-year historical average fishing mortality ($yr - 5$ to $yr - 1$).
  - *Rationale:* For some stocks, TAC and catch remain well below the ABC. The recent average F may provide a more realistic indicator of future catches than target rates like F_{TAC} or F_{ABC}.
- **Scenario 4 (Optional Reduced Harvest Lower Bound):** In all future years, the upper bound on F_{ABC} is set at 75% of F_{ABC}.
  - *Rationale:* The rationale for this adjustment is that catch has typically been lower than the ABC, 53% over the time series, and 75% is a conservative upper bound.
- **Scenario 5 (No Fishing):** In all future years, F is set equal to zero.
  - *Rationale:* In extreme conservation cases, the TAC may be set at or near zero.

Magnuson-Stevens Act Overfishing Determinations

Two additional scenarios are required to satisfy the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) requirements to determine whether a stock is currently overfished or approaching an overfished condition. For Tier 3 stocks, the Maximum Sustainable Yield (MSY) level is defined as $B_{35\%}$.

- **Scenario 6 (Overfished Determination):** In all future years, F is set equal to F_{OFL}.
  - *Rationale:* This scenario determines whether a stock is currently overfished. The stock is **not overfished** if it is:
    1. Above its MSY level ($B_{35\%}$) in year $yr + 1$, or
    2. Above $1/2 \times B_{35\%}$ in year $yr + 1$ and expected to rebuild above $B_{35\%}$ by year $yr + 10$ under this strategy.
- **Scenario 7 (Approaching Overfished Condition):** In years $yr + 1$ and $yr + 2$, F is set equal to max F_{ABC}. In all subsequent years, F is set equal to F_{OFL}.
  - *Rationale:* This scenario determines whether a stock is approaching an overfished condition. The stock is **not approaching an overfished condition** if it is:
    1. Above its MSY level ($B_{35\%}$) in year $yr + 2$, or
    2. Above $1/2 \times B_{35\%}$ in year $yr + 1$ and expected to rebuild above $B_{35\%}$ by year $yr + 12$ under this strategy.

Risk Table and ABC Recommendation

Assessment related considerations

The current Stock Synthesis (SS3) model performs as well as the previous ADMB model (Model 23.0 used in 2024), and successfully retains the benefits of the past framework. We have thoroughly evaluated the structural choices made during this transition. The CIE review process was conducted in 2026 to resolve

outstanding questions and clarify remaining uncertainties. The outcome of that review was support for the models presented in this assessment.

The data time series used in this assessment is extensive, particularly for the Alaska region. Transitioning to a Tier 3 assessment optimizes the use of this dataset, providing a more robust and balanced framework than the potentially over-extended Tier 1 approach. Finally, convergence statistics and related diagnostics confirm that the models presented are stable and provide reliable parameter estimates.

For these reasons, we retain a 'Level 1: Normal' risk level rating for assessment related considerations.

Population dynamics considerations

As described in this document, the population remains healthy, with biomass well over $B_{40\%}$ and total population numbers at approximately 60% of their unfished abundance. However, the stock has declined steadily over the past few decades, with lower overall numbers, lower survival rates, and a lower mean age.

This may be balanced somewhat by faster growth, larger weight-at-age, and a recent uptick in population biomass and steady population sizes since 2024. Because of recent improvements and steady population sizes, we retain a 'Level 1: Normal' risk level rating for population dynamics.

Ecosystem considerations

Based on ecosystem information provided in the 2026 Eastern Bering Sea Ecosystem Status Report, the overall ecosystem-related risk for BSAI yellowfin sole is evaluated as 'Level 1 – Normal'. Following a prolonged warm period (2014-2021), then four years of near-average thermal conditions (2022-2025), 2026 marked a sharp transition to cool oceanographic conditions across the eastern Bering Sea shelf, driven by a weak winter Aleutian Low and a six-week period of sea ice expansion in March-April. For early life stages, cooler spring and summer temperatures may result in lower metabolic demands combined with high quantity and quality pelagic prey resources for pre-settlement stages. Spring winds favored Ekman transport off-shelf and toward the northwest, influencing larval dispersal trajectories. For adult fishable biomass, standard bottom trawl survey biomass increased from 2025, adult morphometric condition (based on L/W residuals) in the SEBS remained above the long-term mean, and indicators of benthic prey availability were strong. Furthermore, apex predator biomass remains below historical time-series means, resulting in low predation pressure.

References below refer to individual contributions within the 2026 Eastern Bering Sea Ecosystem Status Report (Siddon, 2026).

Distribution

- Survey Biomass: In 2026, standard bottom trawl survey biomass for yellowfin sole increased relative to 2025 (though remaining below the long-term survey mean).
- Spatial Habitat Distribution: High CPUE concentrations remain across the inner and middle shelf domains (e.g., Bristol Bay and inner domain).

Environmental Processes

- Cool Thermal Conditions: Bottom temperatures in 2026 were comparable to historical cool years (1986, 1992, 2006, 2010) (Kearney, 2026).
- Below-average SSTs across most of the year (Lemagie and Callahan, 2026) resulted in reduced thermal stress for adult fishable biomass.
- Ocean Acidification: Bottom water pH continued its multidecadal decline, but the inner/middle shelf domains and Bristol Bay remained well buffered (pH $>$ 7.8) (Pilcher et al., 2026).

Habitat

- Structural epifauna showed sponges well below average, while sea anemones and sea pens were above average (Buser, 2026).

Prey

- Benthic Prey Productivity: Adult yellowfin sole consume benthic infaunal invertebrates (polychaetes, miscellaneous worms, clams, and benthic amphipods). Indirect measures of benthic productivity were strongly positive: motile epifauna biomass remained >+1 SD above the long-term mean (Whitehouse, 2026), and miscellaneous benthic fauna (eelpouts, poachers, sea stars) were all >+1 SD above average (Buser, 2026).
- Adult Condition: Morphometric condition (L/W residuals) for yellowfin sole in the SEBS remained above the long-term time-series mean in 2026 (though slightly lower than 2025). In the NBS (2025 data), condition was below the long-term mean but higher than 2025 (Prohaska and Rohan, 2026).

Competitors

- Benthic Forager Guild: Biomass of benthic foragers increased from 2025 to 2026 back to its time-series mean, driven by increases in Alaska plaice, flathead sole, northern rock sole, and yellowfin sole (Whitehouse, 2026). While an increase in guild biomass indicates slightly increased competition for benthic space and prey, high overall benthic productivity mitigates competition concerns.

Predators

- Apex Predators: Primary predators of adult yellowfin sole include apex groundfish like Pacific cod and Pacific halibut. Apex predator guild biomass increased from 2025, but remains below the long-term time-series mean (Whitehouse, 2026). Additionally, yellowfin sole distribution in the inner domain provides spatial refuge from Pacific cod, maintaining low overall predation pressure.

Fishery performance considerations

The 2026 fishery CPUE has increased slightly since 2024, but overall CPUE is within the range observed over the past several decades (Figure 4.10). There are no specific concerns regarding stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, or changes in the duration of fishery openings.

The Amendment 80 flatfish fishery remains one of the most operationally complex sectors due to year-round fishing and management of multiple bycatch limits (including Opilio crab, red king crab, and halibut). In addition high abundance of Pacific cod has introduced challenges, such as relocating to preserve bycatch allowances for the full calendar year.

Flatfish effort is dynamic and influenced by other opportunities in other regions, such as Atka mackerel in the Aleutian Islands or Pacific ocean perch in the Gulf of Alaska.

While overall flatfish performance was strong and fishing activity continues as of October 2026, early season sea ice disrupted fishing early in the year. The Togiak and Kuskokwim areas typically provide a clean catch of large spawning yellowfin sole. However, in this year, sea ice restricted access and shortened available fishing windows. Specifically, the regulatory window is open from April 15 – June 15, but sea ice compressed the fishable window to just 20 days.

Another prominent trend this year was heavy intermixing of yellowfin sole and rock sole, even in areas that typically yield 90% YFS. Whether the unexpected high abundance of rock sole is related to environmental factors or high abundance is unknown.

We propose a 'Level 1: Normal' designation for the fishery performance category in the risk table.

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: Normal	Level 1: Normal	Level 1: Normal	Level 1: Normal

The Risk Table does not warrant a reduction from the maximum permissible ABC under the Tier 3 harvest control rule. We recommend no reduction in ABC based on this risk table assessment.

F_{limit}

The F (based on this year's preferred Model 25.0b) that would have produced a catch for last year equal to the 2025 OFL (299,247 t) is 0.173. This value is reported in the SARA files as the F_LIMIT and included in the species information system (SIS) output.

Data Gaps and Research Priorities

To understand how climate change and environmental variability influence the recruitment, movement, and stock productivity of yellowfin sole (YFS) in the Bering Sea, Aleutian Islands, and southern Chukchi Sea, research must address early life history bottlenecks, juvenile nursery dynamics, and adult population structure through four integrated priorities:

1. Define adult stock structure through expanded genetic sampling: While initial genetic analyses have been conducted on a limited number of samples, a comprehensive genetic study is necessary to define the precise spatial limits and population structure that comprise the YFS stock across the Bering Sea, Aleutian Islands, and northward expansion zones.
2. Evaluate spawning phenology, larval match-mismatch, and northern YOY survival: Rapid ocean warming and earlier sea ice retreat are altering YFS early life history and expanding larval distributions into the Northern Bering Sea (NBS) and southern Chukchi Sea. Research must first determine if earlier ice loss and warming temperatures are shifting adult spawning migrations earlier in the season and further offshore, potentially creating a trophic match-mismatch between first-feeding larvae and their zooplankton prey. Additionally, defining young-of-the-year (YOY) habitat and energetic thresholds is critical to assess whether larvae advected northward during warm summers find sufficient prey to survive late summer and fall, and how this boreal flatfish influx impacts native Arctic food webs.
3. Assess climate impacts on diverse juvenile nurseries: Bottom-trawl survey data identify three primary shallow nursery areas spanning a wide latitudinal range: Bristol Bay, Nunivak Island, and Norton Sound. Because these regions differ substantially in environmental conditions and habitat quality, accelerating warming—particularly in Norton Sound—presents an uncertain future where rising temperatures could either boost production by expanding suitable habitat and accelerating growth, or decrease it by exceeding physiological thermal optima. Long-term monitoring and comparative assessments are required to track nursery usage (spatial distribution and density), environmental quality (seasonal temperature, salinity, and dissolved oxygen), and juvenile fitness (growth and physiological condition) across all three areas.
4. Determine natal origins, ontogenetic fate, and connectivity: To link juvenile nursery function directly to adult stock productivity, research should trace the natal origins of juveniles and their subsequent recruitment into adult populations. This includes clarifying the ontogenetic fate of northern-distributed juveniles in the NBS and Chukchi Sea to determine whether they settle and overwinter locally, grow large enough to migrate back to warmer southern or offshore waters, or suffer mass mortality. Addressing these questions requires an integrated approach combining hydrodynamic larval transport modelling, adult spawning distribution mapping, cohort tracking, and biochemical analyses (e.g., elemental and stable isotope signatures in otoliths and eye lenses).

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Tables

Table 4.1: Summary table for Model 25.0.

	As estimated or *specified in 2024∗* for:		As estimated or *recommended this* year for:	
Quantity	2025	2026	2027	2028
M (natural mortality rate)	0.12, 0.128	0.12, 0.128	0.12, 0.132	0.12, 0.132
Tier	1	1	3a	3a
Projected total (age 1+) biomass (t)	2,308,550	2,353,240	3,006,350	2,870,560
Projected female spawning biomass (t)	748,076	758,695	1,206,920	1,164,970
$B_{100\%}$	1,383,020	1,383,020	2,139,500	2,139,500
$B_{40\%}$	-	-	855,801	855,801
$B_{35\%}$	479,711	479,711	748,826	748,826
F_{OFL}	0.13	0.13	0.099	0.099
$maxF_{ABC}$	0.114	0.114	0.084	0.084
F_{ABC}	0.114	0.114	0.084	0.084
OFL	299,247	305,039	243,338	235,789
$maxABC$	262,557	267,639	208,046	201,597
ABC	262,557	267,639	208,046	201,597
	As determined in 2024 for			
Status	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Table 4.2: Summary table for Model 25.0a.

Quantity	As estimated or *specified in 2024*∗ for: 2025	2026	As estimated or *recommended this* year for: 2027	2028
M (natural mortality rate)	0.12, 0.128	0.12, 0.128	0.12, 0.132	0.12, 0.132
Tier	1	1	3a	3a
Projected total (age 1+) biomass (t)	2,308,550	2,353,240	2,944,530	2,853,780
Projected female spawning biomass (t)	748,076	758,695	1,243,340	1,180,670
$B_{100\%}$	1,383,020	1,383,020	2,149,880	2,149,880
$B_{40\%}$	-	-	859,953	859,953
$B_{35\%}$	479,711	479,711	752,459	752,459
F_{OFL}	0.13	0.13	0.096	0.096
$maxF_{ABC}$	0.114	0.114	0.081	0.081
F_{ABC}	0.114	0.114	0.081	0.081
OFL	299,247	305,039	233,407	227,070
$maxABC$	262,557	267,639	199,803	194,370
ABC	262,557	267,639	199,803	194,370
	As determined in 2024 for			
Status	2023	2024	2025	2026
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Table 4.3: Foreign and domestic catch (t) of yellowfin sole 1954 - 2026, overfishing limit (OFL), acceptable biological catch (ABC), and total allowable catch (TAC). Foreign catches are designated as joint venture processing (JVP), and non-foreign catches as domestic annual processing (DAP). Domestic catch since 1991 is subdivided into catch from the Aleutian Islands and the Bering Sea. Catch for 2026 was downloaded October 1, 2026. The extrapolated catch for the full year was 96,318 t.

		Domestic					Harvest Specifications		
Year	Foreign	JVP	DAP	Aleutian Islands	Bering Sea	Total Catch	OFL	ABC	TAC
1954	12,562					12,562			
1955	14,690					14,690			
1956	24,697					24,697			
1957	24,145					24,145			
1958	44,153					44,153			
1959	185,321					185,321			
1960	456,103					456,103			
1961	553,742					553,742			
1962	420,703					420,703			
1963	85,810					85,810			
1964	111,777					111,777			
1965	53,810					53,810			
1966	102,353					102,353			
1967	162,228					162,228			
1968	84,189					84,189			
1969	167,134					167,134			
1970	133,079					133,079			
1971	160,399					160,399			
1972	47,856					47,856			
1973	78,240					78,240			
1974	42,235					42,235			
1975	64,690					64,690			
1976	56,221					56,221			
1977	58,373					58,373			106,000
1978	138,433					138,433			106,000
1979	99,019					99,019			106,000
1980	77,768	9,623				87,391			117,000
1981	81,255	16,046				97,301			117,000
1982	78,331	17,381				95,712			117,000
1983	85,874	22,511				108,385		214,500	214,500
1984	126,762	32,764				159,526			230,000
1985	100,706	126,401				227,107			229,700
1986	57,197	151,400				208,597			209,500
1987	1,811	179,613	4			181,428			187,000
1988		213,323	9,833			223,156		254,000	254,000
1989		151,501	1,664			153,165		241,000	182,675
1990		69,677	14,293			83,970		278,900	207,650
1991			117,303		117,303	117,303		250,600	135,000
1992			145,386	3.6	145,382	145,386	452,000	372,000	235,000
1993			105,810		105,810	105,810	275,000	238,000	220,000
1994			140,050	0.2	140,050	140,050	269,000	230,000	150,325
1995			124,752	5.6	124,746	124,752	319,000	277,000	190,000
1996			129,659	0.4	129,659	129,659	342,000	278,000	200,000
1997			182,814	1.2	182,813	182,814	339,000	233,000	230,000
1998			101,155	4.7	101,150	101,155	314,000	220,000	220,000

1999	69,234	12.8	69,221	69,234	308,000	212,000	207,980
2000	84,071	12.5	84,058	84,071	226,000	191,000	123,262
2001	63,579	14.5	63,564	63,579	209,000	176,000	113,000
2002	74,986	28.5	74,957	74,986	136,000	115,000	86,000
2003	79,806	0.4	79,806	79,806	136,000	114,000	83,750
2004	75,511	8.8	75,502	75,511	135,000	114,000	86,075
2005	94,385	1.8	94,383	94,385	148,000	124,000	90,686
2006	99,160	3.8	99,156	99,160	144,000	121,000	95,701
2007	120,964	2.4	120,962	120,964	240,000	225,000	136,000
2008	148,894	0.5	148,893	148,894	265,000	248,000	225,000
2009	107,513	1.1	107,512	107,513	224,000	210,000	210,000
2010	118,624	0.2	118,624	118,624	234,000	219,000	219,000
2011	151,158	1.1	151,157	151,158	262,000	239,000	196,000
2012	147,187	1.1	147,186	147,187	222,000	203,000	202,000
2013	164,944	0.3	164,944	164,944	220,000	206,000	198,000
2014	156,772	0.3	156,772	156,772	259,700	239,800	184,000
2015	126,937	0.0	126,937	126,937	266,400	248,800	149,000
2016	135,324	0.2	135,324	135,324	228,100	211,700	144,000
2017	132,220	0.6	132,219	132,220	287,000	260,800	154,000
2018	131,496	4.5	131,491	131,496	306,700	277,500	154,000
2019	128,051	4.6	129,061	128,051	290,000	263,200	154,000
2020	133,799	11.1	133,788	133,799	287,307	260,918	150,700
2021	108,788	53.9	108,734	108,788	341,571	313,477	200,000
2022	154,253	8.7	154,245	154,253	377,071	354,014	250,000
2023	112,889	1.3	112,888	112,889	404,882	378,499	230,000
2024	74,289	0.0	74,289	74,289	305,298	265,913	195,000
2025	91,887	0.0	91,887	91,887	299,247	262,557	169,000
2026	70,840	1.0	70,840	70,841	305,039	267,639	145,000

Table 4.4: Estimates of retained and discarded (t) yellowfin sole caught in Bering Sea fisheries from 1991 through October 1, 2026, and the proportion discarded. The 2026 estimate is preliminary and may differ from the total represented elsewhere.

Year	Retained (t)	Discarded (t)	Proportion discarded
1991	88,967	28,337	0.24
1992	102,542	42,843	0.29
1993	76,798	29,012	0.27
1994	104,918	35,132	0.25
1995	96,770	27,982	0.22
1996	101,324	28,335	0.22
1997	150,745	32,069	0.18
1998	80,267	20,888	0.21
1999	56,604	12,629	0.18
2000	69,971	14,100	0.17
2001	54,918	8,661	0.14
2002	63,625	11,361	0.15
2003	68,832	10,974	0.14
2004	62,746	12,765	0.17
2005	85,311	9,074	0.1
2006	90,592	8,568	0.09
2007	109,004	11,960	0.1
2008	141,235	7,659	0.05
2009	100,642	6,871	0.06
2010	113,244	5,380	0.05
2011	146,418	4,738	0.03
2012	142,132	5,055	0.03
2013	158,781	6,162	0.04
2014	152,167	4,605	0.03
2015	123,065	3,872	0.03
2016	131,203	4,121	0.03
2017	128,665	3,554	0.03
2018	127,331	4,164	0.03
2019	126,111	2,955	0.02
2020	131,774	2,025	0.02
2021	106,801	2,003	0.02
2022	151,493	2,760	0.02
2023	111,154	1,735	0.02
2024	89,569	1,623	0.02
2025	90,316	1,572	0.02
2026	69,186	1,655	0.02

Table 4.5: Discarded and retained catch of non-CDQ yellowfin sole, by fishery, in 2025. Gear types include longline (HAL), bottom trawl (NPT), pot (POT), and pelagic trawl (PTR). Catch was non-zero for all target-gear combinations shown, but may appear as zero as results were rounded to the nearest metric ton (t). Source: NMFS AKRO BLEND/Catch Accounting System.

Trip.target.name	Gear.type	Discarded..t.	Retained..t.
Other.Species	HAL	2	0
Other.Species.1	NPT	0	0
Alaska.Plaice...BSAI	NPT	0	1
Arrowtooth.Flounder	NPT	0	0
Flathead.Sole	NPT	9	838
Other.Flatfish...BSAI	NPT	0	0
Pacific.Cod	HAL	726	0
Pacific.Cod.1	NPT	8	26
Pacific.Cod.2	POT	56	1
Pollock...bottom	HAL	1	0
Pollock...bottom.1	NPT	5	205
Pollock...bottom.2	PTR	0	0
Pollock...midwater	PTR	2	16
Rock.Sole...BSAI	NPT	269	30,539
Yellowfin.Sole...BSAI	NPT	493	58,685

Table 4.6: Incidental trawl catch of FMP species in the Bering Sea and Aleutian Is. yellowfin sole target fishery, 2016 – 2026 (2026 current through November 1).

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Arrowtooth Flounder	3250	1263	3076	3219	2016	1541	1335	1014	1841	963	313
Atka Mackerel	0	0	0	0	0	0	0	0	0	0	2
BSAI Alaska Plaice	8164	12782	15340	12954	16595	11799	9732	11871	5963	4310	2049
BSAI Kamchatka Flounder	284	165	218	230	129	93	77	83	87	24	19
BSAI Other Flatfish	1136	1734	3283	1476	2176	1029	552	540	526	739	793
BSAI Shortraker Rockfish	0	0	0	0	2	0	0	0	0	0	0
BSAI Skate and GOA Skate, Other	1295	1932	2562	3508	2481	3474	3362	2234	1399	349	356
Flathead Sole	4104	3106	3967	4133	3499	3005	6003	2629	3006	1876	1807
Greenland Turbot	8	8	26	6	13	5	4	11	4	0	0
Northern Rockfish	0	0	0	0	0	0	0	0	0	0	0
Octopus	1	0	0	0	0	0	1	1	0	0	0
Other Rockfish	0	0	1	1	0	0	1	1	1	0	0
Pacific Cod	11985	14648	12582	11770	12062	8934	10034	7481	6216	2575	2079
Pacific Ocean Perch	3	0	1	1	63	2	1	1	0	0	0
Pollock	22306	23414	28235	23153	31651	24845	26515	22348	18895	8710	5898
Rock Sole	7949	12196	9362	9204	11240	8121	8957	10126	7425	6067	3084
Sablefish	0	1	7	0	4	0	0	0	0	1	0
Sculpin	949	1308	1247	1535	1452	0	0	0	0	0	0
Shark	4	2	4	3	3	1	7	1	1	0	0
Squid	0	0	0	0	0	0	0	0	0	0	0
Yellowfin Sole	107496	110445	109832	111504	120541	100147	144486	96290	75267	59179	54130

Table 4.7: Occurrence of yellowfin sole in the eastern Bering Sea trawl survey and collections of length and age structures and the number of otoliths aged from the survey. The final column represents the number of otoliths read in each year from the fishery.

Year	Total hauls	Hauls w length	N. lengths	Hauls w otoliths	N. otoliths	N. ages (survey)	N. ages (fishery)
1982	329	246	37,023	35	744	744	2432
1983	353	256	33,924	37	709	709	1178
1984	355	271	33,894	56	821	796	338
1985	353	261	33,824	44	810	802	840
1986	354	249	30,470	34	739	739	1503
1987	357	224	31,241	16	798	798	1071
1988	373	254	27,138	14	543	543	1361
1989	374	236	29,672	24	740	740	1462
1990	371	251	30,257	28	792	792	1220
1991	372	248	27,986	26	742	742	935
1992	356	229	23,628	16	606	606	1203
1993	375	242	26,651	20	549	549	1020
1994	375	269	24,448	14	526	522	573
1995	376	254	22,116	20	654	647	554
1996	375	247	27,505	16	729	721	314
1997	376	262	26,034	11	470	466	397
1998	375	310	34,509	15	575	570	426
1999	373	276	28,431	31	777	770	487
2000	372	255	24,880	20	517	511	583
2001	375	251	26,558	25	604	593	491
2002	375	246	26,309	32	738	723	486
2003	376	241	27,135	37	699	695	590
2004	375	251	26,103	26	725	712	483
2005	373	251	24,658	35	663	653	494
2006	376	246	28,470	39	428	426	490
2007	376	247	24,790	66	779	772	496
2008	375	238	25,848	65	858	830	542
2009	376	235	22,018	70	783	751	515
2010	376	228	20,619	77	841	827	535
2011	376	228	21,665	65	784	753	525
2012	376	242	23,519	72	992	973	504
2013	376	232	23,261	70	821	803	670
2014	376	219	20,229	52	799	790	502
2015	376	223	20,830	73	878	875	622
2016	376	242	92,368	69	884	876	495
2017	376	258	25,767	78	896	886	595
2018	376	262	27,285	68	724	720	608
2019	376	270	25,669	67	836	832	589
2020	-	-	-	-	-	-	660
2021	376	234	18,757	201	1030	983	692
2022	376	238	16,765	195	619	581	624
2023	376	233	15,501	172	514	508	642
2024	350	212	15,673	160	479	479	638
2025	350	214	16,068	189	563	563	-
2026	350	218	15,676	175	521	-	-

Table 4.8: Yellowfin sole fishery catch-at-age (proportions) estimated by the model and informed by bootstrapped fishery age composition data, 1977-2024 female first then male, ages 7-17+.

Year	7	8	9	10	11	12	13	14	15	16	17+	Total female proportion over age 7
1977	34130	52297	44971	28441	23088	11236	3523	1695	795	632	963	0.87
1978	11334	21862	33285	31810	22575	19951	10242	3312	1621	767	613	0.86
1979	19359	18970	29568	35894	28263	17428	14069	6843	2146	1032	484	0.85
1980	30919	27816	20059	24966	26411	19290	11446	9065	4369	1364	655	0.86
1981	22534	36687	27564	18430	22302	23357	16999	10074	7976	3843	1200	0.84
1982	31604	29851	47934	35914	24003	29043	30417	22138	13120	10387	5005	0.93
1983	27981	51348	39611	59516	43799	29141	35221	36877	26837	15905	12592	0.92
1984	21276	34267	46226	31856	46285	33747	22396	27051	28318	20607	12212	0.87
1985	21648	16609	26158	35921	25003	36459	26613	17668	21341	22341	16258	0.87
1986	19361	43425	22758	29580	38063	25999	37714	27491	18243	22034	23066	0.82
1987	21132	16242	31007	14576	18236	23217	15814	22925	16707	11087	13390	0.83
1988	5210	39889	12317	14502	5901	7144	9034	6145	8905	6489	4306	0.80
1989	25064	7543	39704	11420	13681	5694	6995	8914	6087	8840	6448	0.78
1990	13737	48200	12344	55825	14480	16334	6582	7951	10048	6833	9902	0.82
1991	4589	9263	29422	7692	36634	9915	11491	4702	5728	7270	4956	0.75
1992	9196	9829	17815	48155	10925	47215	12057	13528	5441	6568	8298	0.78
1993	20772	18501	12352	16436	38105	8100	34115	8626	9643	3873	4673	0.77
1994	20690	23334	16703	10427	13646	31515	6693	28184	7126	7966	3200	0.81
1995	15000	42396	35373	22979	14003	18224	42035	8924	37579	9502	10621	0.81
1996	7411	10260	24092	19500	12693	7759	10112	23335	4955	20866	5276	0.78
1997	4570	4205	5438	13069	11007	7347	4546	5956	13774	2927	12330	0.77
1998	4637	15166	10092	8913	16520	12232	7736	4687	6092	14048	2982	0.73
1999	3395	7191	15019	7549	5983	10749	7898	4986	3020	3925	9051	0.73
2000	3242	6077	10864	18696	8379	6320	11143	8133	5122	3100	4028	0.69
2001	11654	8551	9005	10752	15551	6589	4890	8584	6257	3940	2384	0.73
2002	4221	16364	8710	7611	8460	11970	5041	3735	6554	4777	3008	0.74
2003	6684	10278	25782	10548	8221	8775	12254	5140	3804	6673	4863	0.73
2004	11993	11784	12887	26287	9732	7266	7620	10567	4420	3268	5729	0.73
2005	16762	14382	12976	14178	29171	10855	8122	8525	11825	4947	3657	0.73
2006	16214	31088	20396	15948	16417	33037	12196	9101	9543	13233	5535	0.74
2007	12171	13382	20218	11789	8817	8941	17905	6600	4922	5161	7156	0.76
2008	15818	20335	15485	20612	11617	8616	8720	17453	6432	4797	5029	0.72
2009	28042	22471	24102	17394	22855	12844	9521	9634	19283	7107	5300	0.76
2010	15548	35978	21468	20552	14311	18607	10426	7721	7811	15633	5762	0.76
2011	12668	17112	36930	21811	20885	14553	18929	10607	7856	7948	15907	0.77
2012	12880	18346	17712	32837	18460	17427	12096	15716	8804	6520	6596	0.74
2013	6795	11370	13319	12517	23387	13227	12519	8697	11303	6333	4690	0.72
2014	12101	17066	17542	15014	12376	22125	12343	11633	8072	10487	5875	0.74
2015	19296	19150	17338	14800	12016	9782	17439	9723	9164	6358	8260	0.76
2016	8485	27015	20401	15974	12893	10273	8313	14792	8243	7767	5389	0.76
2017	4490	12285	28285	18569	13939	11139	8861	7170	12760	7111	6701	0.74
2018	11545	8229	15001	27587	16364	11789	9273	7332	5919	10526	5864	0.70
2019	8488	9398	5945	10496	19151	11338	8165	6422	5077	4099	7289	0.64
2020	18748	10657	10730	6604	11574	21077	12472	8980	7063	5584	4508	0.60
2021	17080	12749	6549	6415	3921	6859	12486	7388	5319	4183	3308	0.62
2022	23572	12929	8830	4465	4361	2664	4661	8484	5020	3614	2842	0.68
2023	5783	19950	12217	8670	4434	4345	2657	4649	8463	5007	3605	0.73
2024	8372	8227	20833	11244	7678	3885	3797	2320	4058	7388	4371	0.72

Year	7	8	9	10	11	12	13	14	15	16	17+	Total male proportion over age 7
1977	31121	47103	40008	24993	20040	9634	2983	1417	657	516	776	0.87
1978	10334	19690	29612	27953	19594	17105	8674	2771	1339	626	494	0.85
1979	17652	17086	26304	31542	24532	14942	11914	5724	1773	843	390	0.85
1980	28193	25053	17845	21939	22924	16538	9693	7583	3609	1113	528	0.85
1981	20547	33043	24522	16196	19357	20025	14395	8427	6590	3136	967	0.84
1982	28818	26886	42645	31559	20834	24900	25759	18518	10840	8477	4034	0.93
1983	25514	46249	35241	52301	38018	24984	29827	30847	22174	12980	10150	0.92
1984	19401	30864	41126	27994	40175	28934	18967	22628	23397	16818	9845	0.87
1985	19739	14959	23272	31566	21702	31258	22537	14779	17633	18233	13106	0.87
1986	17654	39112	20247	25994	33039	22291	31940	22996	15074	17983	18595	0.82
1987	19268	14628	27586	12809	15829	19905	13392	19176	13804	9048	10794	0.84
1988	4751	35927	10958	12743	5121	6125	7650	5140	7357	5296	3471	0.81
1989	22854	6794	35321	10035	11875	4882	5923	7456	5030	7214	5198	0.79
1990	12526	43412	10982	49056	12569	14004	5574	6651	8302	5577	7982	0.83
1991	4184	8343	26175	6759	31797	8501	9731	3933	4733	5933	3995	0.76
1992	8385	8853	15849	42316	9483	40480	10210	11316	4495	5361	6689	0.79
1993	18940	16664	10989	14443	33074	6944	28890	7216	7967	3161	3767	0.79
1994	18865	21016	14860	9163	11844	27019	5668	23575	5888	6501	2579	0.82
1995	13678	38186	31470	20193	12155	15625	35598	7465	31049	7755	8562	0.82
1996	6758	9240	21433	17136	11017	6652	8563	19519	4094	17029	4253	0.79
1997	4167	3787	4837	11484	9554	6299	3850	4982	11380	2389	9939	0.79
1998	4228	13660	8978	7832	14339	10487	6551	3920	5033	11464	2404	0.75
1999	3096	6477	13361	6634	5193	9215	6688	4171	2495	3203	7296	0.75
2000	2956	5473	9665	16429	7273	5418	9436	6803	4232	2530	3247	0.71
2001	10626	7702	8011	9448	13498	5649	4141	7180	5170	3215	1922	0.75
2002	3849	14739	7749	6688	7343	10262	4269	3124	5415	3898	2424	0.77
2003	6095	9257	22937	9269	7136	7523	10377	4300	3143	5446	3920	0.74
2004	10935	10614	11465	23100	8447	6229	6453	8839	3652	2667	4618	0.74
2005	15284	12953	11544	12459	25320	9306	6878	7131	9770	4037	2948	0.75
2006	14785	28000	18146	14014	14250	28324	10328	7612	7884	10800	4462	0.75
2007	11098	12053	17987	10359	7653	7666	15163	5521	4067	4212	5768	0.78
2008	14423	18315	13776	18113	10083	7387	7384	14599	5315	3915	4054	0.74
2009	25570	20239	21442	15285	19838	11012	8063	8059	15932	5800	4273	0.78
2010	14178	32405	19099	18060	12421	15953	8829	6459	6454	12758	4644	0.78
2011	11551	15412	32855	19166	18128	12477	16030	8873	6491	6486	12822	0.79
2012	11744	16524	15758	28856	16023	14941	10243	13146	7274	5321	5317	0.76
2013	6196	10241	11849	10999	20300	11340	10602	7275	9339	5168	3781	0.75
2014	11034	15370	15606	13194	10743	18969	10452	9731	6669	8558	4736	0.76
2015	17594	17248	15425	13005	10430	8386	14768	8133	7571	5189	6659	0.78
2016	7737	24332	18150	14037	11191	8808	7040	12373	6810	6338	4344	0.79
2017	4094	11065	25164	16317	12099	9550	7504	5997	10543	5803	5402	0.76
2018	10527	7412	13346	24242	14204	10107	7853	6133	4891	8590	4727	0.72
2019	7740	8464	5289	9223	16622	9721	6914	5371	4195	3345	5876	0.65
2020	17096	9599	9546	5803	10046	18070	10562	7512	5835	4557	3634	0.61
2021	15575	11483	5827	5637	3403	5881	10574	6180	4395	3414	2666	0.63
2022	21494	11645	7855	3923	3785	2284	3947	7096	4147	2950	2291	0.70
2023	5273	17969	10869	7619	3849	3725	2250	3889	6992	4086	2906	0.75
2024	7634	7410	18534	9881	6664	3331	3215	1940	3353	6029	3524	0.74

Table 4.9: Total tonnage of yellowfin sole caught in resource assessment surveys in the eastern Bering Sea reported through October, 2026, by the Alaska Department of Fish & Game (ADFG), International Pacific Fisheries Commission (IPHC), and the National Marine Fisheries Service (NMFS).

Year	NMFS	ADFG	IPHC	Total
2006	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0
2010	118.6	0.0	0.0	118.6
2011	100.9	0.1	0.0	101.0
2012	83.4	0.0	0.0	83.4
2013	75.0	0.0	0.0	75.0
2014	82.6	0.0	0.0	82.6
2015	64.8	0.0	0.1	64.9
2016	97.8	0.1	0.0	97.9
2017	112.1	0.0	0.0	112.1
2018	72.5	0.1	0.0	72.6
2019	84.5	0.1	0.0	84.6
2020	0.0	0.0	0.0	0.0
2021	71.6	0.0	0.0	71.6
2022	87.4	0.1	0.0	87.5
2023	47.9	0.0	0.0	47.9
2024	48.4	0.0	0.0	48.4
2025	58.3	0.0	0.0	58.3

Table 4.10: Female yellowfin sole proportion mature-at-age from Nichol (1995) and TenBrink and Wilderbuer (2015).

	Nichol (1995)	TenBrink and Wilderbuer (2015)	Total
Age	1992, 1993 samples	2012 samples	Combined
1	0.000	0.00	0.00
2	0.000	0.00	0.00
3	0.001	0.00	0.00
4	0.004	0.00	0.00
5	0.008	0.00	0.00
6	0.020	0.01	0.01
7	0.046	0.03	0.04
8	0.104	0.09	0.10
9	0.217	0.21	0.21
10	0.397	0.43	0.41
11	0.612	0.68	0.65
12	0.790	0.86	0.83
13	0.899	0.94	0.92
14	0.955	0.98	0.97
15	0.981	0.99	0.99
16	0.992	1.00	1.00
17	0.997	1.00	1.00
18	1.000	1.00	1.00
19	1.000	1.00	1.00
20	1.000	1.00	1.00

Table 4.11: Yellowfin sole model-based biomass estimates (t) for the combined northern and eastern Bering Sea survey areas (EBS+NBS), with upper (UCI) and lower (LCI) 95% confidence intervals, 1982 – 2026. Note that surveys were not conducted in 2020.

Year	Model-based estimate (2024)			Model-based estimate (2026)		
	EBS+NBS	LCI	UCI	EBS+NBS	LCI	UCI
1982	4,012,970	4,012,486	4,013,453	4,137,097	3,521,217	4,860,696
1983	4,645,390	4,644,776	4,646,003	4,743,822	3,965,569	5,674,811
1984	4,246,000	4,245,458	4,246,541	4,348,777	3,660,508	5,166,458
1985	3,105,250	3,104,928	3,105,571	3,124,313	2,733,018	3,571,631
1986	2,352,470	2,352,216	2,352,723	2,344,000	2,035,817	2,698,835
1987	3,087,340	3,087,009	3,087,670	3,095,931	2,696,751	3,554,198
1988	2,631,620	2,631,383	2,631,856	2,716,143	2,428,689	3,037,620
1989	2,804,980	2,804,683	2,805,276	2,848,808	2,487,008	3,263,241
1990	2,633,570	2,633,304	2,633,835	2,668,897	2,345,276	3,037,174
1991	3,166,840	3,166,556	3,167,123	3,203,408	2,854,467	3,595,004
1992	2,724,190	2,723,808	2,724,571	2,898,049	2,406,175	3,490,472
1993	3,130,010	3,129,645	3,130,374	3,175,160	2,718,983	3,707,872
1994	3,431,940	3,431,482	3,432,397	3,520,346	2,960,215	4,186,464
1995	2,475,100	2,474,807	2,475,392	2,485,331	2,137,510	2,889,751
1996	2,735,080	2,734,758	2,735,401	2,717,201	2,344,809	3,148,733
1997	2,821,510	2,821,134	2,821,885	2,784,240	2,360,314	3,284,306
1998	3,496,900	3,496,186	3,497,613	3,462,964	2,715,856	4,415,596
1999	1,817,780	1,817,424	1,818,135	1,792,132	1,427,744	2,249,517
2000	2,073,620	2,073,335	2,073,904	2,023,568	1,719,828	2,380,952
2001	2,249,590	2,249,282	2,249,897	2,193,945	1,868,216	2,576,465
2002	2,521,940	2,521,567	2,522,312	2,518,725	2,115,481	2,998,834
2003	2,846,410	2,846,003	2,846,816	2,843,343	2,407,519	3,358,062
2004	3,433,310	3,432,805	3,433,814	3,369,723	2,846,811	3,988,686
2005	3,504,700	3,504,242	3,505,157	3,511,963	3,024,558	4,077,913
2006	2,794,580	2,794,248	2,794,911	2,766,575	2,399,656	3,189,598
2007	2,758,160	2,757,813	2,758,506	2,680,170	2,307,954	3,112,417
2008	2,842,390	2,841,970	2,842,809	2,808,553	2,358,174	3,344,948
2009	2,316,830	2,316,516	2,317,143	2,238,531	1,903,704	2,632,247
2010	2,985,410	2,985,112	2,985,707	3,034,834	2,681,993	3,434,094
2011	2,812,180	2,811,847	2,812,512	2,822,648	2,439,029	3,266,604
2012	2,746,000	2,745,636	2,746,363	2,644,512	2,252,470	3,104,788
2013	2,763,400	2,763,092	2,763,707	2,710,038	2,364,818	3,105,655
2014	2,981,080	2,980,755	2,981,404	2,986,113	2,609,363	3,417,259
2015	2,335,960	2,335,710	2,336,209	2,289,959	2,003,468	2,617,417
2016	3,727,530	3,727,150	3,727,909	3,632,779	3,199,605	4,124,596
2017	3,502,670	3,502,384	3,502,955	3,464,448	3,130,984	3,833,428
2018	2,794,610	2,794,381	2,794,838	2,782,095	2,507,808	3,086,382
2019	2,743,450	2,743,241	2,743,658	2,777,918	2,519,634	3,062,677
2021	2,372,550	2,372,361	2,372,738	2,336,798	2,114,976	2,581,885
2022	2,785,320	2,785,094	2,785,545	2,739,225	2,476,282	3,030,088
2023	1,889,620	1,889,460	1,889,779	1,903,848	1,714,129	2,114,565
2024	2,022,780	2,022,500	2,023,059	1,899,833	1,634,583	2,208,125
2025	-	-	-	2,010,033	1,806,263	2,236,792
2026	-	-	-	2,176,060	1,831,621	2,585,271

Table 4.12: Yellowfin sole design-based biomass estimates (t) from the northern Bering Sea survey, with upper and lower 95% confidence intervals, as well as number of hauls, hauls with yellowfin sole, and hauls in which length data was obtained. There was no NBS survey in 2024 or 2026.

Year	Biomass (t)	LCI	HCI	Haul count	Hauls with catch	Hauls with length	Otoliths read	Hauls with otoliths
2010	427,374	291,231	563,518	141	121	121	351	46
2017	434,088	281,972	586,203	143	131	130	536	50
2019	520,031	326,389	713,674	144	141	140	0	53
2021	496,045	339,918	652,173	144	138	138	0	122
2022	548,027	286,945	809,108	144	135	135	362	123
2023	393,305	276,321	510,288	116	108	108	316	107
2025	300,639	235,460	365,819	137	133	134	374	-

Table 4.13: Iterative Francis reweighting values for the fishery and survey age composition data for Models 25.0, 25.0a, 25.0b.

Iteration	Model 25.0		Model 25.0a		Model 25.0b	
	Fishery	Survey	Fishery	Survey	Fishery	Survey
1	1.703737	0.327496	1.041923	0.165561	1.016508	0.175408
2	2.287648	0.322269	1.007138	0.165270	1.024927	0.176640
3	2.599925	0.320573	0.995017	0.165315	1.027910	0.176747

Table 4.14: Data weights for age compositions for fishery (fleet = 1), raw and adjusted after Francis reweighting for Models 25.0, 25.0a, 25.0b. All years of fishery data used the same weights.

Fleet	Year	Model 25.0		Model 25.0a		Model 25.0b	
		Initial N	Adjusted N	Initial N	Adjusted N	Initial N	Adjusted N
1	1964	56.9302	148.014	157.419	156.634	157.419	161.812

Table 4.15: Data weighs for age compositions for survey (fleet = 2), raw and adjusted after Francis reweighting for Models 25.0, 25.0a, 25.0b.

Fleet	Year	Model 25.0		Model 25.0a		Model 25.0b	
		Initial N	Adjusted N	Initial N	Adjusted N	Initial N	Adjusted N
2	1979	56.9302	18.25030	157.419	26.02370	157.419	27.8233
2	1980	56.9302	18.25030	157.419	26.02370	157.419	27.8233
2	1981	56.9302	18.25030	157.419	26.02370	157.419	27.8233
2	1982	35.0000	11.22010	175.000	28.93010	175.000	30.9307
2	1983	37.0000	11.86120	149.000	24.63190	149.000	26.3353
2	1984	56.0000	17.95210	172.000	28.43420	172.000	30.4005
2	1985	43.0000	13.78460	190.000	31.40980	190.000	33.5819
2	1986	34.0000	10.89950	192.000	31.74050	192.000	33.9354
2	1987	16.0000	5.12917	148.000	24.46660	148.000	26.1586
2	1988	14.0000	4.48802	106.000	17.52340	106.000	18.7352
2	1989	24.0000	7.69375	111.000	18.35000	111.000	19.6189
2	1990	28.0000	8.97604	117.000	19.34190	117.000	20.6794
2	1991	26.0000	8.33490	76.000	12.56390	76.000	13.4328
2	1992	16.0000	5.12917	92.000	15.20900	92.000	16.2607
2	1993	20.0000	6.41146	57.000	9.42295	57.000	10.0746
2	1994	14.0000	4.48802	72.000	11.90270	72.000	12.7258
2	1995	20.0000	6.41146	83.000	13.72110	83.000	14.6700
2	1996	16.0000	5.12917	109.000	18.01930	109.000	19.2654
2	1997	11.0000	3.52630	100.000	16.53150	100.000	17.6747
2	1998	15.0000	4.80860	151.000	24.96260	151.000	26.6888
2	1999	31.0000	9.93776	151.000	24.96260	151.000	26.6888
2	2000	20.0000	6.41146	142.000	23.47470	142.000	25.0981
2	2001	25.0000	8.01432	150.000	24.79720	150.000	26.5120
2	2002	32.0000	10.25830	191.000	31.57520	191.000	33.7587
2	2003	37.0000	11.86120	120.000	19.83780	120.000	21.2096
2	2004	26.0000	8.33490	162.000	26.78100	162.000	28.6330
2	2005	35.0000	11.22010	132.000	21.82160	132.000	23.3306
2	2006	39.0000	12.50230	121.000	20.00310	121.000	21.3864
2	2007	66.0000	21.15780	224.000	37.03060	224.000	39.5913
2	2008	65.0000	20.83720	249.000	41.16340	249.000	44.0100
2	2009	70.0000	22.44010	179.000	29.59140	179.000	31.6377
2	2010	77.0000	24.68410	264.000	43.64320	264.000	46.6612
2	2011	64.0000	20.51670	207.000	34.22020	207.000	36.5866
2	2012	72.0000	23.08130	298.000	49.26390	298.000	52.6706
2	2013	70.0000	22.44010	242.000	40.00620	242.000	42.7728
2	2014	52.0000	16.66980	193.000	31.90580	193.000	34.1122
2	2015	73.0000	23.40180	228.000	37.69180	228.000	40.2983
2	2016	69.0000	22.11950	248.000	40.99810	248.000	43.8333
2	2017	78.0000	25.00470	211.000	34.88150	211.000	37.2936
2	2018	68.0000	21.79900	180.000	29.75670	180.000	31.8145
2	2019	67.0000	21.47840	192.000	31.74050	192.000	33.9354
2	2021	200.0000	64.11460	108.000	17.85400	108.000	19.0887
2	2022	195.0000	62.51170	122.000	20.16840	122.000	21.5631
2	2023	172.0000	55.13860	152.000	25.12790	152.000	26.8655
2	2024	160.0000	51.29170	100.000	16.53150	100.000	17.6747
2	2025	160.0000	51.29170	103.000	17.02740	103.000	18.2049

Table 4.16: Parameter values and standard deviation (SD) for the 2024 accepted Model 23.0.

Name	Value	Standard Deviation	Name	Value	SD
male natural mortality	0.128	0.004	sel_slope_srv	1.650	0.193
alpha (q-temp model)	0.159	0.067	sel50_srv	4.294	0.146
beta (q-temp model)	0.074	0.010	R_logalpha	-4.542	0.611
beta (survey start date)	0.008	0.003	R_logbeta	-6.416	0.401
beta (start date/temp interaction)	-0.004	0.003	msy	453.730	179.900
mean log recruitment	0.804	0.099	Fmsy	0.184	0.090
log_avg_fmort	-0.560	0.131	logFmsy	-1.695	0.491
log_avg_fmort	-2.451	0.100	Fmsyr	0.121	0.044
sel_slope_fsh_f	1.192	0.116	logFmsyr	-2.108	0.362
sel50_fsh_f	8.217	0.276		NA	NA

Table 4.17: Selected parameter estimates and standard deviation (SD) for 2026 Models 25.0, 25.0a, 25.0b.

Description	Label	M25.0a	SD	M25.0	SD	M25.0b	SD
M (Natural Mortality) - Male	MGparm[13]	0.132	0.002	0.132	0.002	0.132	0.002
ln(R0) - Base Recruitment	SRparm[1]	14.966	0.035	14.961	0.036	14.912	0.032
Steepness (h)	SRparm[2]	1.000	—	1.000	—	1.000	—
Sigma_R (Recruitment Variability)	SRparm[3]	0.600	—	0.600	—	0.600	—
Autocorrelation_Rho	SRparm[5]	0.000	—	0.000	—	0.000	—
Base ln(q) - Survey Fleet 2	Q_parm[1]	-0.168	0.054	-0.151	0.054	-0.091	0.050
Survey ln(q) - Environmental Link	Q_parm[2]	0.050	0.013	0.049	0.013	0.080	0.012
Fishery Age Inflection	selparm[1]	8.016	0.211	7.984	0.212	8.029	0.212
Fishery Age 95% Width	selparm[2]	2.201	0.132	2.198	0.132	2.206	0.132
Survey Age Inflection	selparm[3]	4.559	0.125	4.167	0.141	4.556	0.121
Survey Age 95% Width	selparm[4]	1.872	0.172	1.699	0.187	1.871	0.166

Table 4.18: Highly correlated parameter pairs for Model 25.0.

label.i	label.j	corr
LnQ_base_SHELF(2)	SR_LN(R0)	-0.905953
Age_inflection_Fsh(1)_DEVmult_1961	Early_InitAge_1	-0.796914
Age_95%width_Fsh(1)_DEVmult_1980	Age_inflection_Fsh(1)_DEVmult_1980	0.784842
Age_inflection_Fsh(1)_DEVmult_1971	Age_inflection_Fsh(1)	-0.777593
Age_inflection_Fsh(1)_DEVmult_1961	Main_RecrDev_1954	-0.757232
Age_95%width_Fsh(1)_DEVmult_2005	Age_inflection_Fsh(1)_DEVmult_2005	0.741151
Age_95%width_Fsh(1)_DEVmult_1981	Age_inflection_Fsh(1)_DEVmult_1981	0.718664
Age_95%width_Fsh(1)_DEVmult_2020	Age_inflection_Fsh(1)_DEVmult_2020	0.711091
Age_95%width_Fsh(1)_DEVmult_2021	Age_inflection_Fsh(1)_DEVmult_2021	0.699594
Age_95%width_Fsh(1)_DEVmult_2015	Age_inflection_Fsh(1)_DEVmult_2015	0.690657
Main_RecrDev_1954	Early_InitAge_1	0.681400
Age_inflection_Fsh(1)_DEVmult_1969	Age_inflection_Fsh(1)	-0.674015
Age_95%width_Fsh(1)_DEVmult_1968	Age_inflection_Fsh(1)_DEVmult_1968	0.668709
Age_inflection_Fsh(1)_DEVmult_1973	Age_inflection_Fsh(1)	-0.666277
Age_95%width_Fsh(1)_DEVmult_1993	Age_inflection_Fsh(1)_DEVmult_1993	0.663660
Age_95%width_Fsh(1)_DEVmult_2010	Age_inflection_Fsh(1)_DEVmult_2010	0.662550
Age_95%width_Fsh(1)_DEVmult_1998	Age_inflection_Fsh(1)_DEVmult_1998	0.660749
Age_95%width_Fsh(1)_DEVmult_1967	Age_inflection_Fsh(1)_DEVmult_1967	0.642036
Age_95%width_Fsh(1)_DEVmult_1996	Age_inflection_Fsh(1)_DEVmult_1996	0.642030
Age_95%width_Fsh(1)_DEVmult_1974	Age_inflection_Fsh(1)_DEVmult_1974	0.637753
Age_inflection_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)	-0.634304
Age_95%width_Fsh(1)_DEVmult_1978	Age_inflection_Fsh(1)_DEVmult_1978	0.631157
Age_inflection_Fsh(1)_DEVmult_1962	Age_inflection_Fsh(1)	-0.631023
Age_inflection_Fsh(1)_DEVmult_1975	Age_inflection_Fsh(1)	-0.630955
Age_95%width_Fsh(1)_DEVmult_2002	Age_inflection_Fsh(1)_DEVmult_2002	0.627009
Age_95%width_Fsh(1)_DEVmult_2001	Age_inflection_Fsh(1)_DEVmult_2001	0.624509
Age_95%width_Fsh(1)_DEVmult_2019	Age_inflection_Fsh(1)_DEVmult_2019	0.622349
Age_95%width_Fsh(1)_DEVmult_2012	Age_inflection_Fsh(1)_DEVmult_2012	0.620861
Age_95%width_Fsh(1)_DEVmult_1979	Age_inflection_Fsh(1)_DEVmult_1979	0.619145
Age_95%width_Fsh(1)_DEVmult_1982	Age_inflection_Fsh(1)_DEVmult_1982	0.616019
Age_95%width_Fsh(1)_DEVmult_1970	Age_inflection_Fsh(1)_DEVmult_1970	0.615262
Age_95%width_Fsh(1)_DEVmult_2008	Age_inflection_Fsh(1)_DEVmult_2008	0.615134
Age_95%width_Fsh(1)_DEVmult_1994	Age_inflection_Fsh(1)_DEVmult_1994	0.614812
Age_95%width_Fsh(1)_DEVmult_1999	Age_inflection_Fsh(1)_DEVmult_1999	0.613286
Age_95%width_Fsh(1)_DEVmult_2007	Age_inflection_Fsh(1)_DEVmult_2007	0.613186
Age_95%width_Fsh(1)_DEVmult_2016	Age_inflection_Fsh(1)_DEVmult_2016	0.612511
Age_inflection_Fsh(1)_DEVmult_1988	Age_inflection_Fsh(1)	-0.611959
Age_inflection_Fsh(1)_DEVmult_1965	Age_inflection_Fsh(1)	-0.610886
Age_95%width_SHELF(2)	Age_inflection_SHELF(2)	0.609673
Age_95%width_Fsh(1)_DEVmult_1977	Age_inflection_Fsh(1)_DEVmult_1977	0.606766
Age_95%width_Fsh(1)_DEVmult_2014	Age_inflection_Fsh(1)_DEVmult_2014	0.605486
Age_inflection_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)	-0.605264
Age_95%width_Fsh(1)_DEVmult_2006	Age_inflection_Fsh(1)_DEVmult_2006	0.604989
Age_95%width_Fsh(1)_DEVmult_1995	Age_inflection_Fsh(1)_DEVmult_1995	0.603520
Age_95%width_Fsh(1)_DEVmult_2003	Age_inflection_Fsh(1)_DEVmult_2003	0.595142
Age_95%width_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)_DEVmult_1989	0.587614
Age_95%width_Fsh(1)_DEVmult_1987	Age_inflection_Fsh(1)_DEVmult_1987	0.587391
Age_95%width_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)_DEVmult_1972	0.584284
Age_95%width_Fsh(1)_DEVmult_2011	Age_inflection_Fsh(1)_DEVmult_2011	0.582647
Age_95%width_Fsh(1)_DEVmult_1985	Age_inflection_Fsh(1)_DEVmult_1985	0.582144

Table 4.19: Highly correlated parameter pairs for Model 25.0a.

label.i	label.j	corr
LnQ_base_SHELF(2)	SR_LN(R0)	-0.896123
Age_inflection_Fsh(1)_DEVmult_1961	Main_RecrDev_1954	-0.792653
Age_inflection_Fsh(1)_DEVmult_1971	Age_inflection_Fsh(1)	-0.783953
Age_95%width_Fsh(1)_DEVmult_1980	Age_inflection_Fsh(1)_DEVmult_1980	0.782824
Age_95%width_Fsh(1)_DEVmult_2005	Age_inflection_Fsh(1)_DEVmult_2005	0.732235
Age_95%width_Fsh(1)_DEVmult_1981	Age_inflection_Fsh(1)_DEVmult_1981	0.719610
Age_95%width_Fsh(1)_DEVmult_2020	Age_inflection_Fsh(1)_DEVmult_2020	0.716411
Age_95%width_Fsh(1)_DEVmult_2021	Age_inflection_Fsh(1)_DEVmult_2021	0.709249
Age_95%width_Fsh(1)_DEVmult_2015	Age_inflection_Fsh(1)_DEVmult_2015	0.696724
Age_inflection_Fsh(1)_DEVmult_1969	Age_inflection_Fsh(1)	-0.681999
Age_inflection_Fsh(1)_DEVmult_1973	Age_inflection_Fsh(1)	-0.675614
Age_95%width_Fsh(1)_DEVmult_1968	Age_inflection_Fsh(1)_DEVmult_1968	0.667709
Age_95%width_Fsh(1)_DEVmult_1993	Age_inflection_Fsh(1)_DEVmult_1993	0.663932
Age_95%width_Fsh(1)_DEVmult_2010	Age_inflection_Fsh(1)_DEVmult_2010	0.661035
Age_95%width_Fsh(1)_DEVmult_1998	Age_inflection_Fsh(1)_DEVmult_1998	0.659102
Age_95%width_SHELF(2)	Age_inflection_SHELF(2)	0.645333
Age_inflection_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)	-0.644281
Age_inflection_Fsh(1)_DEVmult_1975	Age_inflection_Fsh(1)	-0.641490
Age_95%width_Fsh(1)_DEVmult_1967	Age_inflection_Fsh(1)_DEVmult_1967	0.640342
Age_95%width_Fsh(1)_DEVmult_1996	Age_inflection_Fsh(1)_DEVmult_1996	0.639713
Age_95%width_Fsh(1)_DEVmult_2012	Age_inflection_Fsh(1)_DEVmult_2012	0.633090
Age_95%width_Fsh(1)_DEVmult_1974	Age_inflection_Fsh(1)_DEVmult_1974	0.633067
Age_inflection_Fsh(1)_DEVmult_1961	Main_RecrDev_1955	-0.632085
Age_95%width_Fsh(1)_DEVmult_1978	Age_inflection_Fsh(1)_DEVmult_1978	0.631301
Age_95%width_Fsh(1)_DEVmult_2002	Age_inflection_Fsh(1)_DEVmult_2002	0.626396
Age_95%width_Fsh(1)_DEVmult_2019	Age_inflection_Fsh(1)_DEVmult_2019	0.621653
Age_95%width_Fsh(1)_DEVmult_2016	Age_inflection_Fsh(1)_DEVmult_2016	0.618133
Age_inflection_Fsh(1)_DEVmult_1965	Age_inflection_Fsh(1)	-0.617843
Age_95%width_Fsh(1)_DEVmult_2001	Age_inflection_Fsh(1)_DEVmult_2001	0.617732
Age_inflection_Fsh(1)_DEVmult_1988	Age_inflection_Fsh(1)	-0.617382
Age_95%width_Fsh(1)_DEVmult_1979	Age_inflection_Fsh(1)_DEVmult_1979	0.617110
Age_inflection_Fsh(1)_DEVmult_1962	Early_InitAge_2	-0.616109
Age_95%width_Fsh(1)_DEVmult_1982	Age_inflection_Fsh(1)_DEVmult_1982	0.613629
Age_95%width_Fsh(1)_DEVmult_2014	Age_inflection_Fsh(1)_DEVmult_2014	0.609597
Age_95%width_Fsh(1)_DEVmult_1999	Age_inflection_Fsh(1)_DEVmult_1999	0.609254
Age_95%width_Fsh(1)_DEVmult_2008	Age_inflection_Fsh(1)_DEVmult_2008	0.609176
Age_95%width_Fsh(1)_DEVmult_2007	Age_inflection_Fsh(1)_DEVmult_2007	0.607280
Age_95%width_Fsh(1)_DEVmult_1970	Age_inflection_Fsh(1)_DEVmult_1970	0.607252
Age_95%width_Fsh(1)_DEVmult_1977	Age_inflection_Fsh(1)_DEVmult_1977	0.607154
Age_inflection_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)	-0.606733
Age_95%width_Fsh(1)_DEVmult_1994	Age_inflection_Fsh(1)_DEVmult_1994	0.605527
Age_95%width_Fsh(1)_DEVmult_1995	Age_inflection_Fsh(1)_DEVmult_1995	0.603005
Age_95%width_Fsh(1)_DEVmult_2006	Age_inflection_Fsh(1)_DEVmult_2006	0.593803
Age_95%width_Fsh(1)_DEVmult_1987	Age_inflection_Fsh(1)_DEVmult_1987	0.590547
Age_95%width_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)_DEVmult_1989	0.589425
Age_inflection_Fsh(1)_DEVmult_1970	Age_inflection_Fsh(1)	-0.588343
Age_inflection_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)_DEVmult_1971	0.586719
Age_95%width_Fsh(1)_DEVmult_2003	Age_inflection_Fsh(1)_DEVmult_2003	0.586634
Age_95%width_Fsh(1)_DEVmult_2011	Age_inflection_Fsh(1)_DEVmult_2011	0.586294
Age_inflection_Fsh(1)_DEVmult_1963	Age_inflection_Fsh(1)	-0.582538

Table 4.20: Highly correlated parameter pairs for Model 25.0b.

label.i	label.j	corr
LnQ_base_SHELF(2)	SR_LN(R0)	-0.880896
Age_inflection_Fsh(1)_DEVmult_1961	Main_RecrDev_1954	-0.795305
Age_inflection_Fsh(1)_DEVmult_1971	Age_inflection_Fsh(1)	-0.788172
Age_95%width_Fsh(1)_DEVmult_1980	Age_inflection_Fsh(1)_DEVmult_1980	0.781954
Age_95%width_Fsh(1)_DEVmult_2005	Age_inflection_Fsh(1)_DEVmult_2005	0.735582
Age_95%width_Fsh(1)_DEVmult_1981	Age_inflection_Fsh(1)_DEVmult_1981	0.720550
Age_95%width_Fsh(1)_DEVmult_2021	Age_inflection_Fsh(1)_DEVmult_2021	0.718439
Age_95%width_Fsh(1)_DEVmult_2020	Age_inflection_Fsh(1)_DEVmult_2020	0.715157
Age_inflection_Fsh(1)_DEVmult_1969	Age_inflection_Fsh(1)	-0.687134
Age_inflection_Fsh(1)_DEVmult_1973	Age_inflection_Fsh(1)	-0.681690
Age_95%width_Fsh(1)_DEVmult_2015	Age_inflection_Fsh(1)_DEVmult_2015	0.680216
Age_95%width_Fsh(1)_DEVmult_1968	Age_inflection_Fsh(1)_DEVmult_1968	0.667177
Age_95%width_Fsh(1)_DEVmult_1998	Age_inflection_Fsh(1)_DEVmult_1998	0.663410
Age_95%width_Fsh(1)_DEVmult_2010	Age_inflection_Fsh(1)_DEVmult_2010	0.661484
Age_95%width_Fsh(1)_DEVmult_1993	Age_inflection_Fsh(1)_DEVmult_1993	0.659910
Age_95%width_Fsh(1)_DEVmult_1996	Age_inflection_Fsh(1)_DEVmult_1996	0.650922
Age_inflection_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)	-0.650396
Age_inflection_Fsh(1)_DEVmult_1975	Age_inflection_Fsh(1)	-0.647163
Age_95%width_SHELF(2)	Age_inflection_SHELF(2)	0.645700
Age_95%width_Fsh(1)_DEVmult_1967	Age_inflection_Fsh(1)_DEVmult_1967	0.639068
Age_inflection_Fsh(1)_DEVmult_1962	Early_InitAge_2	-0.638494
Age_inflection_Fsh(1)_DEVmult_1961	Main_RecrDev_1955	-0.634265
Age_95%width_Fsh(1)_DEVmult_1978	Age_inflection_Fsh(1)_DEVmult_1978	0.631167
Age_95%width_Fsh(1)_DEVmult_1974	Age_inflection_Fsh(1)_DEVmult_1974	0.631153
Age_95%width_Fsh(1)_DEVmult_2002	Age_inflection_Fsh(1)_DEVmult_2002	0.628989
Age_inflection_Fsh(1)_DEVmult_1965	Age_inflection_Fsh(1)	-0.623093
Age_inflection_Fsh(1)_DEVmult_1988	Age_inflection_Fsh(1)	-0.621612
Age_95%width_Fsh(1)_DEVmult_1979	Age_inflection_Fsh(1)_DEVmult_1979	0.616541
Age_95%width_Fsh(1)_DEVmult_2001	Age_inflection_Fsh(1)_DEVmult_2001	0.615054
Age_95%width_Fsh(1)_DEVmult_2007	Age_inflection_Fsh(1)_DEVmult_2007	0.614920
Age_95%width_Fsh(1)_DEVmult_1995	Age_inflection_Fsh(1)_DEVmult_1995	0.613458
Age_95%width_Fsh(1)_DEVmult_1982	Age_inflection_Fsh(1)_DEVmult_1982	0.612991
Age_95%width_Fsh(1)_DEVmult_2008	Age_inflection_Fsh(1)_DEVmult_2008	0.612933
Age_95%width_Fsh(1)_DEVmult_2012	Age_inflection_Fsh(1)_DEVmult_2012	0.612178
Age_95%width_Fsh(1)_DEVmult_1999	Age_inflection_Fsh(1)_DEVmult_1999	0.611227
Age_95%width_Fsh(1)_DEVmult_2019	Age_inflection_Fsh(1)_DEVmult_2019	0.611185
Age_95%width_Fsh(1)_DEVmult_1994	Age_inflection_Fsh(1)_DEVmult_1994	0.610782
Age_95%width_Fsh(1)_DEVmult_2006	Age_inflection_Fsh(1)_DEVmult_2006	0.607568
Age_95%width_Fsh(1)_DEVmult_1977	Age_inflection_Fsh(1)_DEVmult_1977	0.607353
Age_inflection_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)	-0.606548
Age_95%width_Fsh(1)_DEVmult_1970	Age_inflection_Fsh(1)_DEVmult_1970	0.603796
Age_95%width_Fsh(1)_DEVmult_2003	Age_inflection_Fsh(1)_DEVmult_2003	0.600378
Age_95%width_Fsh(1)_DEVmult_2016	Age_inflection_Fsh(1)_DEVmult_2016	0.596107
Age_95%width_Fsh(1)_DEVmult_1989	Age_inflection_Fsh(1)_DEVmult_1989	0.595226
Age_inflection_Fsh(1)_DEVmult_1970	Age_inflection_Fsh(1)	-0.594602
Age_inflection_Fsh(1)_DEVmult_1972	Age_inflection_Fsh(1)_DEVmult_1971	0.592113
Age_95%width_Fsh(1)_DEVmult_1987	Age_inflection_Fsh(1)_DEVmult_1987	0.591592
Age_95%width_Fsh(1)_DEVmult_2014	Age_inflection_Fsh(1)_DEVmult_2014	0.589027
Age_inflection_Fsh(1)_DEVmult_1964	Age_inflection_Fsh(1)	-0.587635
Age_inflection_Fsh(1)_DEVmult_1963	Age_inflection_Fsh(1)	-0.586616

Table 4.21: Likelihood components and selected parameter values for Model 25.0 (with data through 2025) and 2026 Models 25.0, 25.0a, 25.0b.

Label	M25.0_CIE	M25_0	M25_0a	M25_0b
TOTAL_like	207.658	673.316	723.459	733.857
Survey_like	4.555	9.108	0.512	-9.417
Age_comp_like	197.967	631.987	686.652	707.678
Recruitment_like	-8.741	-1.178	-0.692	-1.306
Forecast_Recruitment_like	0.000	0.558	0.165	0.147
Parm_priors_like	0.089	0.004	0.006	0.000
Recr_Virgin_billions	2.386	3.144	3.160	2.993
SR_BH_steep	1.000	1.000	1.000	1.000
NatM_uniform_Fem_GP_1	0.120	0.120	0.120	0.120
NatM_uniform_Mal_GP_1	0.123	0.132	0.132	0.132
LnQ_base_SHELF(2)	0.308	-0.151	-0.168	-0.091
LnQ_base_SHELF(2)_ENV_add	0.040	0.049	0.050	0.080
SmryBio_unfished	3,729,530	4,676,070	4,699,120	4,453,770
SSB_Virgin	1,372,200	1,808,500	1,817,270	1,721,440
SSB_2026	—	1,204,630	1,263,830	1,040,200
Bratio_2026	—	0.563	0.588	0.511
SPRratio_2026	—	0.356	0.355	0.397
Ret_Catch_MSY	147,958	170,605	170,037	161,906
Dead_Catch_MSY	147,958	170,605	170,037	161,906
SR_LN(R0)	14.685	14.961	14.966	14.912
LnQ_base_SHELF(2)	0.308	-0.151	-0.168	-0.091
LnQ_base_SHELF(2)_ENV_add	0.040	0.049	0.050	0.080

Table 4.22: Spawning biomass (SSB, metric tons) estimates and standard errors from 2026 Models 25.0, 25.0a, and 25.0b.

Year	2026					
	M25.0 SSB	M25.0 SE	M25.0a SSB	M25.0a SE	M25.0b SSB	M25.0b SE
1979	654,526	44,330	657,079	42,735	629,390	39,119
1980	840,523	53,363	845,113	51,631	808,519	47,030
1981	1,021,310	61,580	1,028,310	59,825	982,683	54,249
1982	1,126,970	65,836	1,136,160	64,193	1,084,540	57,995
1983	1,271,510	72,162	1,283,840	70,626	1,224,300	63,574
1984	1,383,520	77,091	1,399,740	75,746	1,332,990	67,929
1985	1,453,620	82,230	1,474,670	81,068	1,400,900	72,482
1986	1,442,310	84,461	1,468,400	83,553	1,390,520	74,510
1987	1,437,940	87,227	1,469,670	86,578	1,387,540	77,061
1988	1,362,120	85,905	1,397,960	85,541	1,315,650	76,022
1989	1,330,800	86,906	1,371,450	86,812	1,286,810	77,044
1990	1,342,690	87,777	1,387,030	87,902	1,300,220	77,920
1991	1,443,260	91,823	1,491,620	92,120	1,399,520	81,578
1992	1,560,480	96,720	1,610,780	97,076	1,512,740	85,883
1993	1,627,250	100,338	1,678,050	100,676	1,575,930	89,026
1994	1,637,500	100,750	1,686,930	101,037	1,584,160	89,306
1995	1,639,470	101,775	1,688,070	101,993	1,584,270	90,133
1996	1,552,970	97,873	1,599,900	98,089	1,499,720	86,643
1997	1,508,150	96,436	1,554,610	96,637	1,455,250	85,300
1998	1,419,810	93,121	1,465,360	93,344	1,368,430	82,305
1999	1,402,190	92,386	1,447,810	92,605	1,350,660	81,608
2000	1,321,220	87,858	1,364,900	88,083	1,271,670	77,563
2001	1,397,810	93,169	1,444,900	93,432	1,344,990	82,222
2002	1,349,580	88,833	1,395,470	89,138	1,299,370	78,412
2003	1,411,630	91,408	1,459,590	91,783	1,359,870	80,686
2004	1,458,150	92,565	1,506,040	92,962	1,404,800	81,695
2005	1,507,760	94,290	1,554,180	94,723	1,451,340	83,185
2006	1,566,090	97,023	1,611,670	97,480	1,506,810	85,568
2007	1,516,750	93,406	1,556,860	93,805	1,457,230	82,272
2008	1,430,720	87,443	1,465,280	87,770	1,373,870	76,966
2009	1,500,090	92,041	1,534,340	92,419	1,439,650	80,965
2010	1,587,430	97,598	1,621,440	98,041	1,521,420	85,761
2011	1,472,150	89,461	1,501,000	89,895	1,409,380	78,542
2012	1,464,290	90,019	1,494,950	90,677	1,399,830	79,027
2013	1,390,680	85,932	1,422,530	86,834	1,325,840	75,438
2014	1,344,440	85,001	1,378,700	86,148	1,276,000	74,628
2015	1,379,940	88,485	1,418,410	89,951	1,301,200	77,679
2016	1,347,490	87,164	1,390,220	88,974	1,260,340	76,525
2017	1,399,440	92,879	1,448,040	95,021	1,297,870	81,475
2018	1,266,370	83,581	1,317,420	85,951	1,160,900	73,301
2019	1,346,750	89,883	1,408,760	92,804	1,220,750	78,714
2020	1,314,540	89,340	1,382,800	92,559	1,178,590	78,032
2021	1,224,830	84,548	1,295,550	87,853	1,086,450	73,512
2022	1,252,000	89,135	1,330,070	92,704	1,103,490	77,218
2023	1,258,860	93,236	1,342,090	96,907	1,104,680	80,369
2024	1,207,780	90,474	1,288,560	93,884	1,056,090	77,224
2025	1,194,260	89,647	1,268,330	92,622	1,039,900	75,396
2026	1,204,630	90,620	1,263,830	92,736	1,040,200	74,700

Table 4.23: Total biomass (metric tons) estimates from 2026 Models 25.0, 25.0a, and 25.0b.

Year	2026		
	M25.0	M25.0a	M25.0b
1979	3,580,490	3,618,060	3,474,060
1980	3,805,650	3,852,050	3,694,430
1981	3,997,850	4,054,540	3,885,310
1982	4,102,440	4,172,960	3,995,560
1983	4,066,860	4,142,490	3,963,070
1984	4,340,510	4,429,310	4,234,130
1985	4,362,560	4,459,960	4,257,520
1986	4,057,170	4,153,430	3,955,470
1987	4,052,750	4,155,830	3,950,210
1988	3,957,160	4,061,380	3,854,810
1989	4,078,970	4,188,160	3,969,190
1990	3,933,410	4,040,230	3,824,350
1991	4,076,840	4,186,410	3,963,420
1992	4,340,860	4,454,020	4,218,770
1993	4,420,890	4,537,400	4,294,570
1994	4,464,890	4,584,140	4,337,150
1995	4,190,270	4,303,180	4,065,500
1996	4,074,960	4,186,600	3,951,730
1997	4,103,090	4,215,310	3,977,400
1998	3,756,780	3,863,250	3,637,440
1999	3,506,210	3,608,540	3,393,150
2000	3,311,970	3,406,060	3,203,920
2001	3,313,890	3,406,820	3,202,340
2002	3,378,730	3,465,860	3,264,500
2003	3,729,770	3,817,240	3,602,940
2004	3,885,620	3,969,050	3,752,340
2005	3,979,780	4,057,450	3,841,870
2006	3,993,590	4,073,550	3,854,310
2007	3,900,640	3,976,260	3,759,200
2008	3,719,980	3,793,060	3,579,400
2009	3,742,850	3,818,560	3,594,320
2010	3,898,690	3,982,740	3,732,930
2011	3,803,760	3,891,790	3,628,520
2012	3,604,460	3,696,930	3,421,390
2013	3,455,310	3,553,310	3,260,410
2014	3,425,730	3,535,420	3,206,170
2015	3,411,110	3,530,560	3,171,010
2016	3,444,930	3,583,440	3,175,340
2017	3,480,850	3,626,930	3,190,870
2018	3,184,320	3,331,090	2,895,180
2019	3,280,030	3,436,520	2,964,060
2020	3,194,940	3,341,170	2,866,960
2021	3,251,890	3,378,930	2,894,090
2022	3,373,570	3,484,300	2,984,890
2023	3,224,280	3,278,330	2,817,970
2024	3,304,800	3,329,660	2,884,770
2025	3,248,330	3,254,830	2,838,780
2026	3,290,070	3,275,670	2,878,110

Table 4.24: Annual fishing mortality (F) estimates and standard errors from 2026 Models 25.0, 25.0a, and 25.0b.

Year	2026					
	M25.0 F	M25.0 SE	M25.0a F	M25.0a SE	M25.0b F	M25.0b SE
1979	0.052	0.005	0.052	0.005	0.055	0.005
1980	0.059	0.014	0.060	0.014	0.064	0.015
1981	0.045	0.006	0.045	0.006	0.047	0.006
1982	0.034	0.002	0.034	0.002	0.035	0.002
1983	0.035	0.002	0.035	0.002	0.036	0.002
1984	0.054	0.003	0.053	0.003	0.056	0.003
1985	0.079	0.005	0.078	0.005	0.082	0.005
1986	0.074	0.004	0.072	0.004	0.076	0.004
1987	0.071	0.005	0.069	0.004	0.073	0.004
1988	0.090	0.006	0.087	0.006	0.093	0.006
1989	0.067	0.005	0.065	0.005	0.069	0.005
1990	0.031	0.002	0.030	0.002	0.032	0.002
1991	0.036	0.003	0.034	0.003	0.037	0.003
1992	0.047	0.003	0.046	0.003	0.048	0.003
1993	0.040	0.004	0.039	0.004	0.042	0.004
1994	0.054	0.004	0.052	0.004	0.056	0.004
1995	0.046	0.003	0.044	0.003	0.047	0.003
1996	0.045	0.003	0.043	0.003	0.046	0.003
1997	0.071	0.005	0.069	0.004	0.073	0.004
1998	0.047	0.003	0.046	0.003	0.049	0.003
1999	0.033	0.003	0.032	0.002	0.034	0.003
2000	0.039	0.003	0.038	0.003	0.040	0.003
2001	0.029	0.002	0.028	0.002	0.030	0.002
2002	0.035	0.003	0.034	0.002	0.036	0.003
2003	0.032	0.002	0.030	0.002	0.033	0.002
2004	0.028	0.002	0.027	0.002	0.029	0.002
2005	0.033	0.003	0.032	0.003	0.034	0.003
2006	0.033	0.002	0.032	0.002	0.034	0.002
2007	0.044	0.003	0.043	0.003	0.045	0.003
2008	0.058	0.004	0.057	0.004	0.060	0.004
2009	0.037	0.002	0.036	0.002	0.039	0.002
2010	0.042	0.003	0.042	0.003	0.044	0.003
2011	0.056	0.004	0.055	0.004	0.058	0.004
2012	0.054	0.003	0.053	0.003	0.056	0.003
2013	0.065	0.004	0.064	0.004	0.068	0.004
2014	0.065	0.004	0.063	0.004	0.068	0.004
2015	0.056	0.004	0.055	0.004	0.059	0.004
2016	0.061	0.004	0.060	0.004	0.066	0.004
2017	0.057	0.004	0.056	0.004	0.062	0.004
2018	0.058	0.004	0.055	0.004	0.063	0.004
2019	0.059	0.005	0.057	0.005	0.066	0.005
2020	0.058	0.004	0.055	0.004	0.065	0.004
2021	0.048	0.003	0.045	0.003	0.054	0.004
2022	0.063	0.005	0.059	0.004	0.071	0.005
2023	0.045	0.003	0.042	0.003	0.051	0.004
2024	0.036	0.003	0.034	0.002	0.041	0.003
2025	0.041	0.003	0.040	0.003	0.048	0.003
2026	0.042	0.003	0.042	0.003	0.049	0.003

Table 4.25: Age-1 recruitment estimates (billions, $\times 10^9$ from the 2024 accepted model and from 2026 Models 25.0, 25.0a, and 25.0b.

Year	2024	2026					
	M23.0	M25.0 rec.	M25.0 std.	M25.0a rec.	M25.0a std.	M25.0b rec.	M25. 0b std.
1979	1.535	4.005	0.365	4.163	0.358	3.997	0.333
1980	2.499	2.827	0.300	2.985	0.295	2.856	0.275
1981	2.079	9.608	0.647	9.741	0.628	9.313	0.576
1982	5.774	1.942	0.245	1.954	0.234	1.874	0.219
1983	1.437	7.783	0.557	7.843	0.538	7.542	0.497
1984	5.104	2.895	0.301	2.912	0.289	2.794	0.270
1985	2.07	1.860	0.230	1.912	0.224	1.835	0.209
1986	1.607	2.632	0.276	2.707	0.268	2.595	0.250
1987	2.17	3.592	0.329	3.676	0.319	3.513	0.296
1988	2.886	4.174	0.366	4.243	0.352	4.042	0.325
1989	3.228	1.971	0.235	2.003	0.225	1.902	0.208
1990	1.717	2.205	0.254	2.246	0.243	2.129	0.224
1991	1.913	4.320	0.389	4.514	0.378	4.292	0.347
1992	3.553	2.688	0.291	2.775	0.279	2.640	0.258
1993	2.242	2.206	0.260	2.265	0.247	2.159	0.229
1994	1.982	2.616	0.287	2.600	0.267	2.490	0.249
1995	2.099	6.069	0.473	6.038	0.445	5.830	0.413
1996	4.615	2.598	0.277	2.593	0.260	2.522	0.245
1997	2.165	2.222	0.246	2.216	0.231	2.162	0.219
1998	1.917	2.563	0.261	2.576	0.248	2.517	0.234
1999	2.189	3.970	0.334	3.945	0.317	3.833	0.295
2000	3.024	2.602	0.256	2.593	0.243	2.506	0.227
2001	2.109	3.156	0.284	3.213	0.274	3.064	0.252
2002	2.753	2.827	0.263	2.933	0.258	2.758	0.234
2003	2.654	4.365	0.339	4.548	0.336	4.181	0.297
2004	3.874	2.142	0.221	2.184	0.215	1.968	0.189
2005	1.779	2.208	0.228	2.283	0.225	2.006	0.192
2006	1.876	2.299	0.240	2.418	0.240	2.068	0.201
2007	2.07	2.475	0.253	2.589	0.254	2.165	0.208
2008	1.925	2.826	0.276	3.014	0.283	2.506	0.230
2009	2.138	3.997	0.348	4.270	0.362	3.544	0.293
2010	2.615	1.867	0.219	1.962	0.226	1.636	0.184
2011	1.113	0.906	0.144	0.944	0.149	0.793	0.122
2012	0.728	1.202	0.166	1.303	0.179	1.112	0.148
2013	0.978	1.002	0.149	1.122	0.166	0.971	0.140
2014	0.86	1.722	0.209	1.836	0.230	1.627	0.196
2015	1.295	2.171	0.251	2.229	0.274	2.026	0.238
2016	1.664	3.868	0.395	3.505	0.408	3.287	0.365
2017	3.066	1.609	0.255	1.330	0.257	1.284	0.243
2018	1.506	2.347	0.378	1.783	0.391	1.765	0.375
2019	2.155	2.965	0.535	2.505	0.630	2.454	0.595
2020	2.58	1.867	0.503	1.817	0.663	1.763	0.629
2021	2.052	1.852	0.676	2.231	1.010	2.136	0.963
2022	2.191	1.949	0.951	2.492	1.354	2.341	1.272
2023	2.196	2.708	1.522	2.892	1.695	2.722	1.597
2024	2.235	2.894	1.721	2.963	1.775	2.776	1.662
2025	-	2.958	1.779	2.986	1.795	2.798	1.682
2026	-	2.958	1.779	2.986	1.795	2.798	1.682

Table 4.26: Projections of BSAI yellowfin sole future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 25.0. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.04 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2026	96318	96318	96318	96318	96318	96318	96318
2027	208046	208046	117590	208046	0	243338	208046
2028	201597	201597	117761	201597	0	232719	201597
2029	193807	193807	116644	193807	0	221098	226689
2030	190665	190665	117717	190665	0	215365	220199
2031	188115	188115	118514	188115	0	210867	214892
2032	188798	188798	120888	188798	0	210382	213710
2033	192459	192459	124908	192459	0	213438	216197
2034	194364	194364	127482	194364	0	214781	217007
2035	198410	198410	131474	198410	0	218498	220339
2036	200762	200762	134154	200762	0	220489	221987
2037	202859	202859	136532	202859	0	222290	223500
2038	205009	205009	138921	205009	0	224172	225161
2039	206609	206609	140813	206609	0	225533	226335
2040	207975	207975	142459	207975	0	226690	227338

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2026	1204630	1204630	1204630	1204630	1204630	1204630	1204630
2027	1206920	1206920	1221900	1206920	1240890	1200990	1206920
2028	1164970	1164970	1223330	1164970	1300510	1142440	1164970
2029	1131710	1131710	1231670	1131710	1369370	1094100	1126150
2030	1087700	1087700	1225070	1087700	1422070	1037280	1066660
2031	1041020	1041020	1210570	1041020	1463330	980287	1006520
2032	1007590	1007590	1205570	1007590	1511860	938286	961286
2033	988698	988698	1211950	988698	1569440	912191	931973
2034	983880	983880	1229910	983880	1636370	901151	917846
2035	995982	995982	1265950	995982	1725010	906752	920895
2036	1008770	1008770	1300130	1008770	1808760	913945	925771
2037	1019740	1019740	1329760	1019740	1884160	920220	930008
2038	1032370	1032370	1360370	1032370	1960300	928396	936503
2039	1042500	1042500	1386020	1042500	2027470	934833	941482
2040	1051840	1051840	1409220	1051840	2089270	940953	946359

Year	Scenarios						
F	1	2	3	4	5	6	7
2026	0.042	0.042	0.0420	0.042	0.042	0.0420	0.0420
2027	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0840
2028	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0840
2029	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2030	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2031	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2032	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2033	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2034	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2035	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2036	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2037	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2038	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2039	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989
2040	0.084	0.084	0.0467	0.084	0.000	0.0989	0.0989

Table 4.27: Projections of BSAI yellowfin sole future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 25.0a. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.04 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2026	96318	96318	96318	96318	96318	96318	96318
2027	199803	199803	110225	199803	0	233407	199803
2028	194370	194370	110757	194370	0	224262	194370
2029	189954	189954	111394	189954	0	216792	221925
2030	189622	189622	113961	189622	0	214437	218897
2031	189611	189611	116267	189611	0	212858	216608
2032	191444	191444	119372	191444	0	213643	216760
2033	195140	195140	123442	195140	0	216683	219276
2034	196943	196943	126036	196943	0	217839	219942
2035	200437	200437	129696	200437	0	220901	222645
2036	202613	202613	132311	202613	0	222652	224076
2037	204287	204287	134436	204287	0	223961	225114
2038	206131	206131	136630	206131	0	225493	226436
2039	207472	207472	138357	207472	0	226560	227326
2040	208638	208638	139880	208638	0	227489	228110

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2026	1263830	1263830	1263830	1263830	1263830	1263830	1263830
2027	1243340	1243340	1258760	1243340	1277280	1237470	1243340
2028	1180670	1180670	1239850	1180670	1313880	1158700	1180670
2029	1129160	1129160	1228920	1129160	1358780	1093050	1123830
2030	1077990	1077990	1214010	1077990	1398080	1029960	1057990
2031	1036540	1036540	1204820	1036540	1441230	978518	1003600
2032	1015980	1015980	1214540	1015980	1503460	949024	971166
2033	1009590	1009590	1236350	1009590	1577260	934684	953860
2034	1011830	1011830	1264360	1011830	1655530	929946	946224
2035	1025740	1025740	1304370	1025740	1748190	936921	950735
2036	1037790	1037790	1339460	1037790	1832470	943107	954675
2037	1047430	1047430	1369120	1047430	1907440	947864	957453
2038	1059330	1059330	1400410	1059330	1984030	955123	963084
2039	1069350	1069350	1427510	1069350	2053090	961202	967757
2040	1078780	1078780	1452410	1078780	2117510	967150	972512

Year	Scenarios						
F	1	2	3	4	5	6	7
2026	0.0420	0.0420	0.0420	0.0420	0.042	0.0420	0.0420
2027	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0813
2028	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0813
2029	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2030	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2031	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2032	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2033	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2034	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2035	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2036	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2037	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2038	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2039	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956
2040	0.0813	0.0813	0.0441	0.0813	0.000	0.0956	0.0956

Table 4.28: Projections of BSAI yellowfin sole future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 25.0b. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.04 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2026	96318	96318	96318	96318	96318	96318	96318
2027	175231	175232	113692	175231	0	204846	175231
2028	172592	172592	114879	172592	0	199250	172592
2029	170345	170346	115971	170345	0	194514	199152
2030	171594	171594	119081	171594	0	194149	198190
2031	172853	172853	121831	172853	0	194154	197550
2032	175627	175627	125388	175627	0	196110	198931
2033	180000	180000	129942	180000	0	199997	202343
2034	182365	182365	132821	182365	0	201845	203744
2035	186242	186242	136805	186242	0	205383	206957
2036	188732	188732	139615	188732	0	207518	208803
2037	190700	190700	141909	190700	0	209177	210215
2038	192752	192752	144239	192752	0	210956	211805
2039	194260	194260	146051	194260	0	212219	212908
2040	195560	195560	147637	195560	0	213305	213863

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2026	1040200	1040200	1040200	1040200	1040200	1040200	1040200
2027	1032620	1032620	1042830	1032620	1061240	1027650	1032620
2028	993225	993225	1032690	993225	1106860	974407	993225
2029	964278	964278	1031410	964278	1162780	932951	959638
2030	934324	934324	1026620	934324	1214500	892151	916672
2031	910212	910212	1025110	910212	1268020	858759	880813
2032	902798	902798	1039050	902798	1337570	842916	862436
2033	905979	905979	1062150	905979	1415790	838515	855433
2034	915543	915543	1089960	915543	1497060	841351	855713
2035	934507	934507	1127490	934507	1590800	853582	865780
2036	950753	950753	1160150	950753	1676130	864066	874285
2037	963844	963843	1187520	963844	1752080	872313	880786
2038	978254	978253	1215740	978254	1828920	882109	889144
2039	990137	990137	1239710	990137	1897730	890073	895862
2040	1000940	1000930	1261410	1000940	1961570	897412	902140

Year	Scenarios						
F	1	2	3	4	5	6	7
2026	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494	0.0494
2027	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0827
2028	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0827
2029	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2030	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2031	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2032	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2033	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2034	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2035	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2036	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2037	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2038	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2039	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973
2040	0.0827	0.0827	0.0530	0.0827	0.0000	0.0973	0.0973

Figures

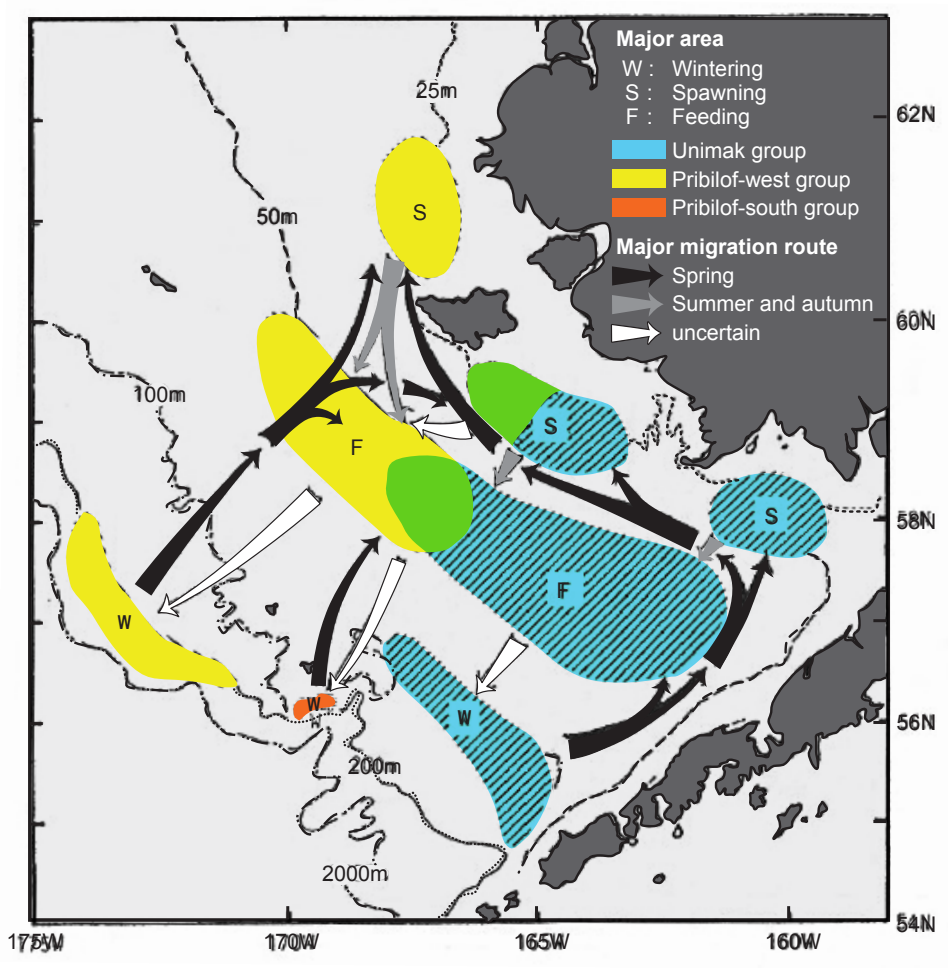


Figure 4.1: Distribution of wintering, spawning, and feeding areas for yellowfin sole in the Bering Sea, and observed regional grouping. Migration routes from wintering to feeding take place in spring, and the dates that yellowfin sole return to their wintering areas are unknown, adapted from Wakabayashi (1989).

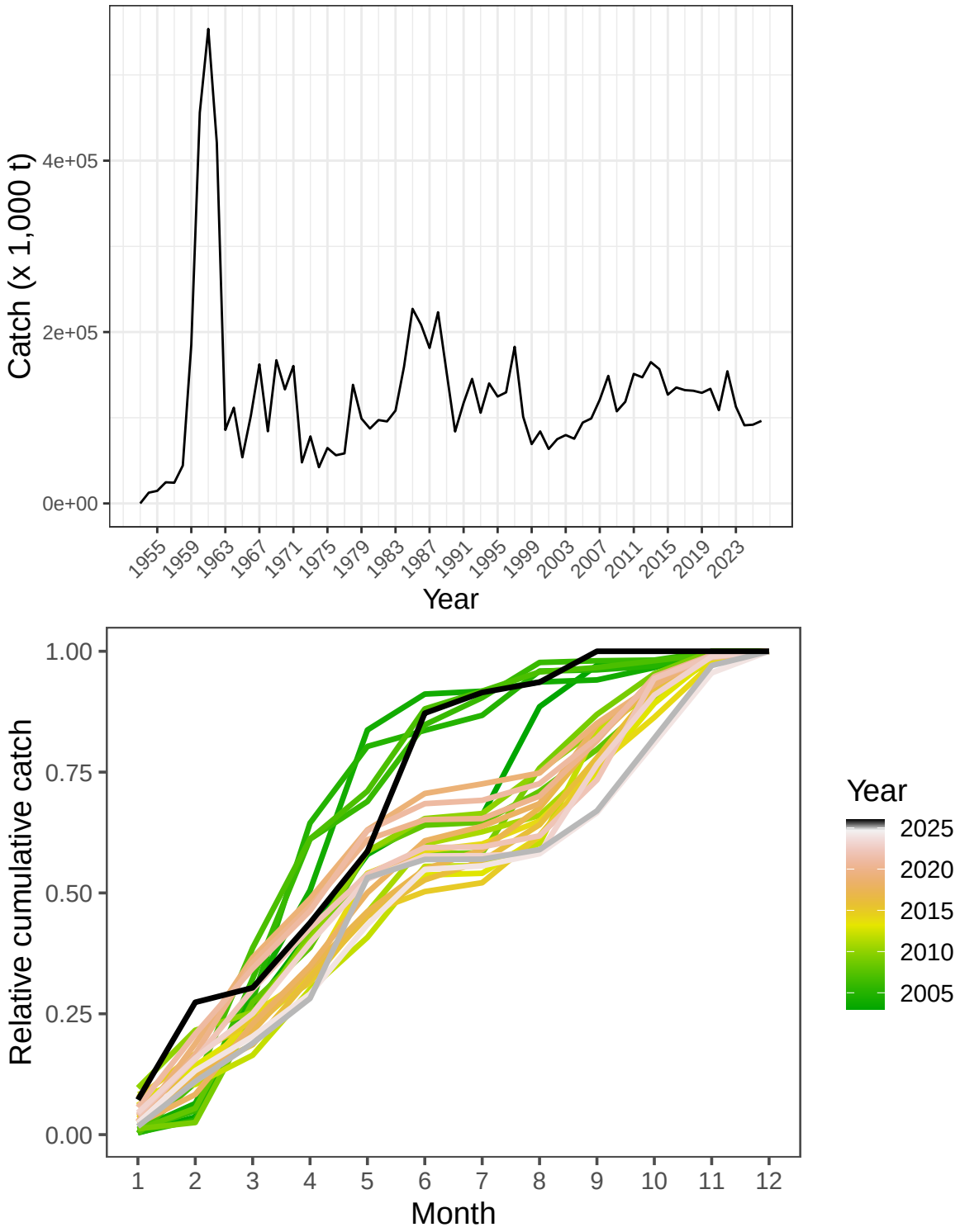


Figure 4.2: Yellowfin sole annual total catch (1,000 t) in the eastern Bering Sea from 2003-2026 (upper panel). Yellowfin sole annual cumulative catch by month and year (non CDQ) 2003-October 1, 2024 (lower panel).

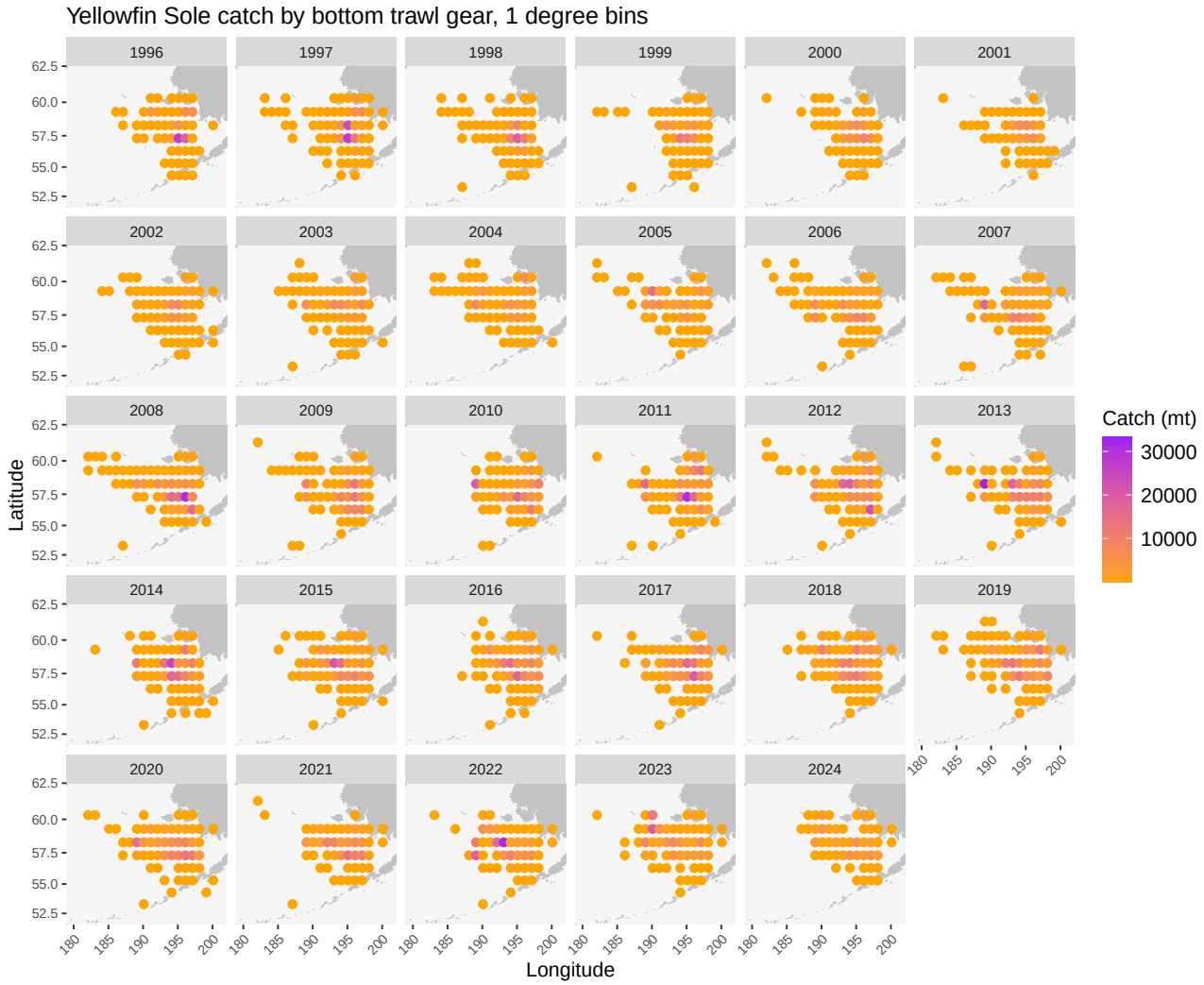


Figure 4.3: Catch of yellowfin sole by non-pelagic trawl gear in the eastern Bering Sea, 2008-2024, by year, reported by observers. Colored circles represent catch of yellowfin sole, with darker shades representing higher catch.

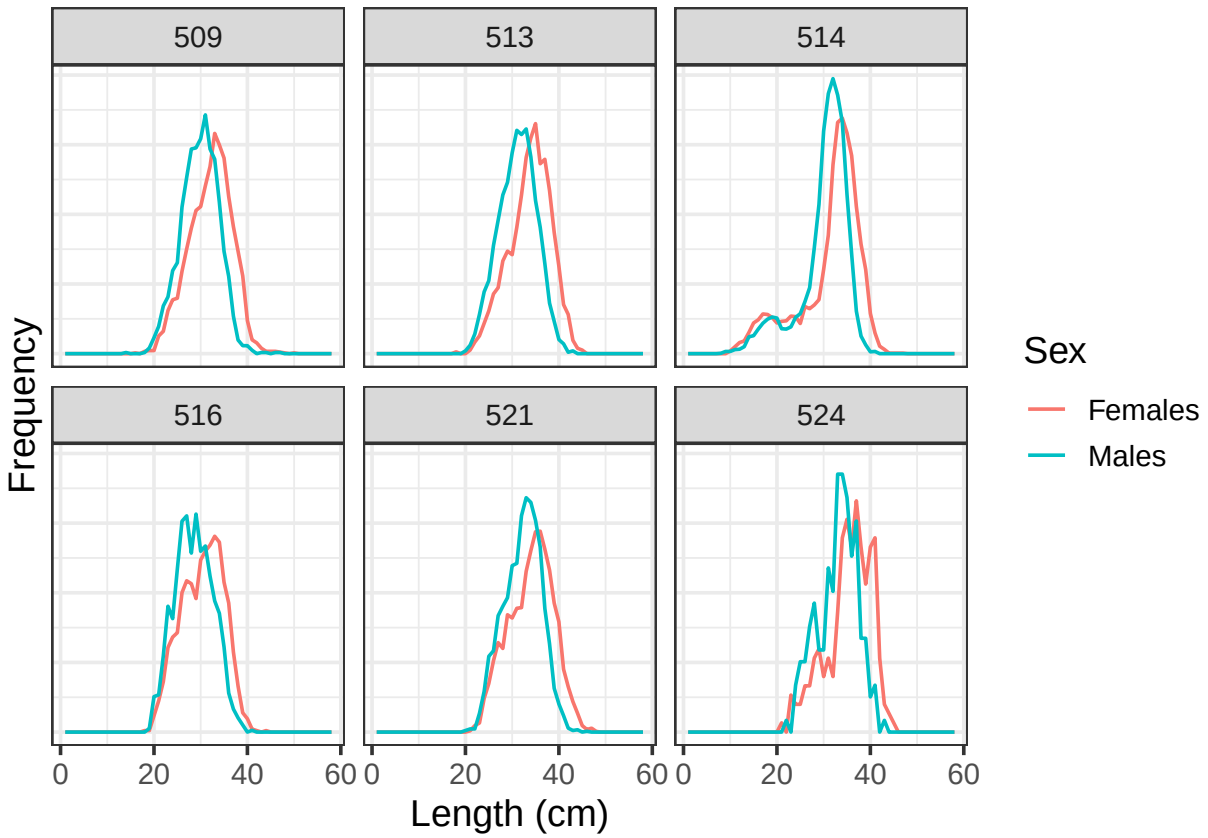


Figure 4.4: Size composition of the yellowfin sole catch in 2026 (through November 1) caught by trawl gear, by subarea, for the primary areas where yellowfin sole are caught, 509, 513, 514, 516, 521, and 524.

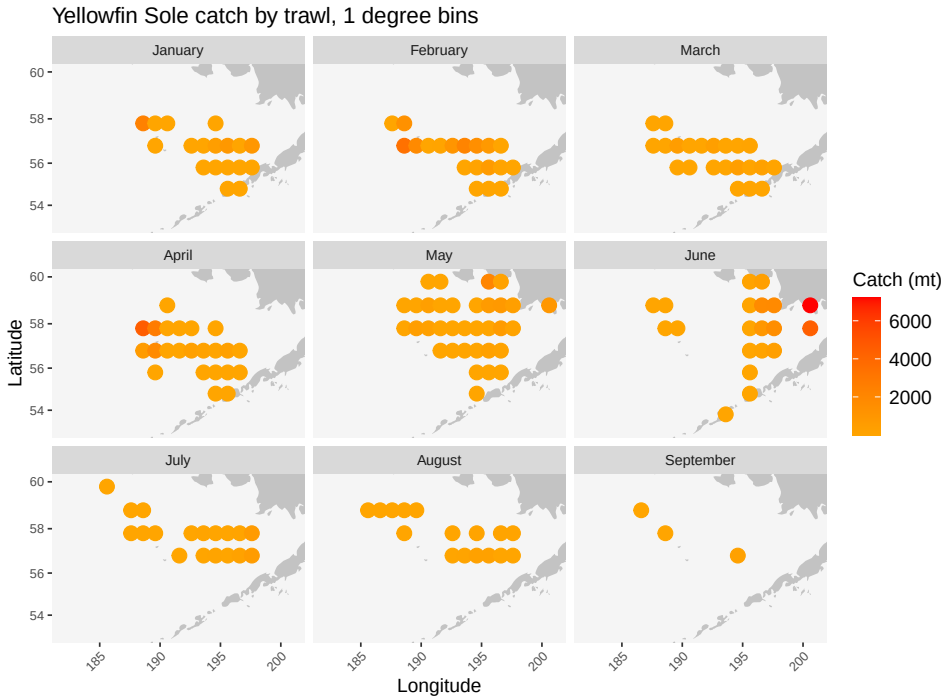


Figure 4.5: Catch of yellowfin sole in the BSAI in 2026 using trawl gear by month (through October 1), reported by observers.

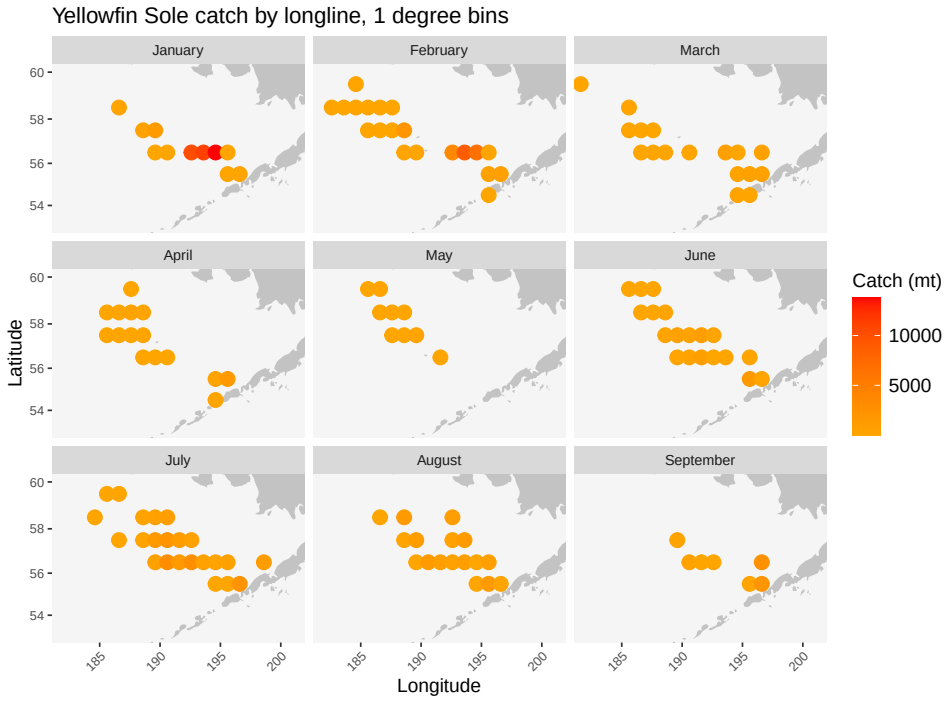


Figure 4.6: Bycatch of yellowfin sole in the BSAI in 2026 by longline gear by month (through October 1), reported by observers.

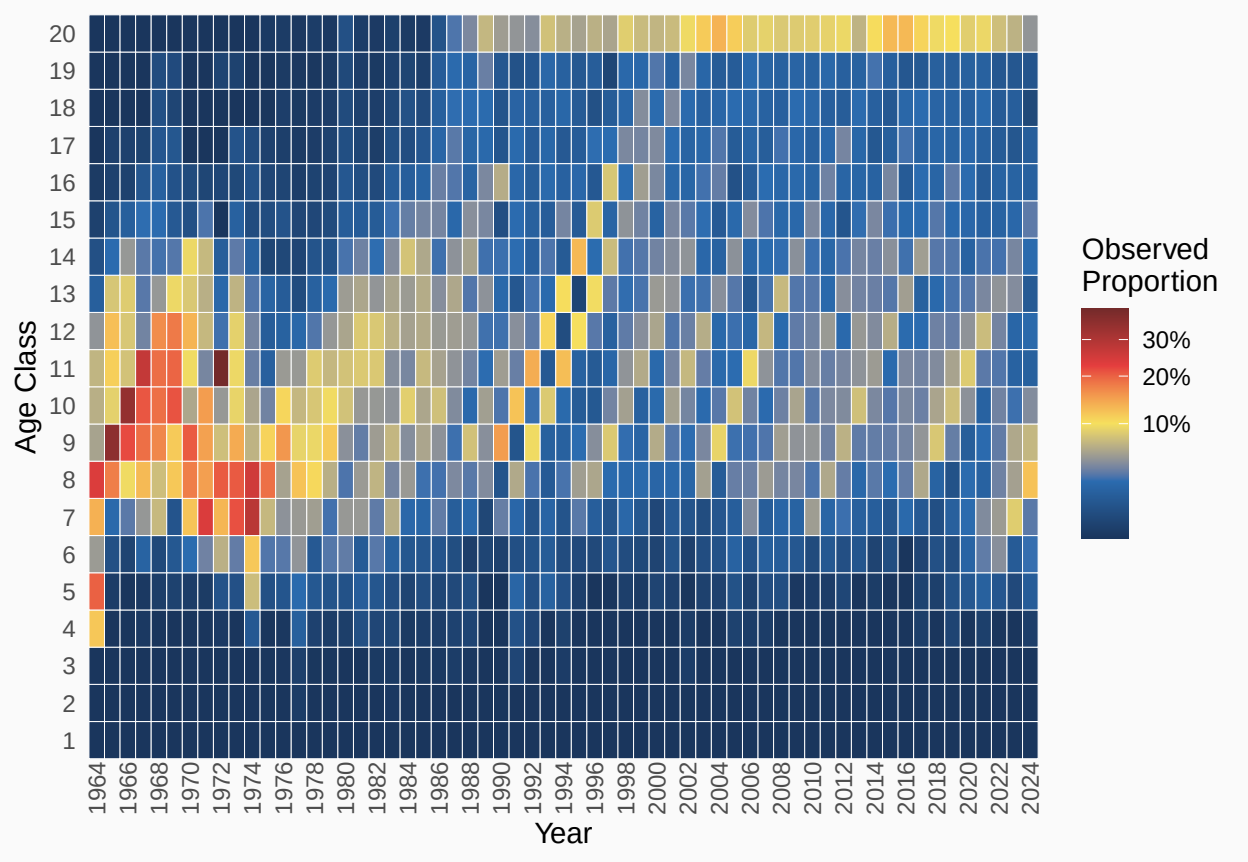


Figure 4.7: Raw age composition data for the yellowfin sole fishery, 1964 - 2024. Data shown are scaled proportions tracking age classes 1-20 over time.

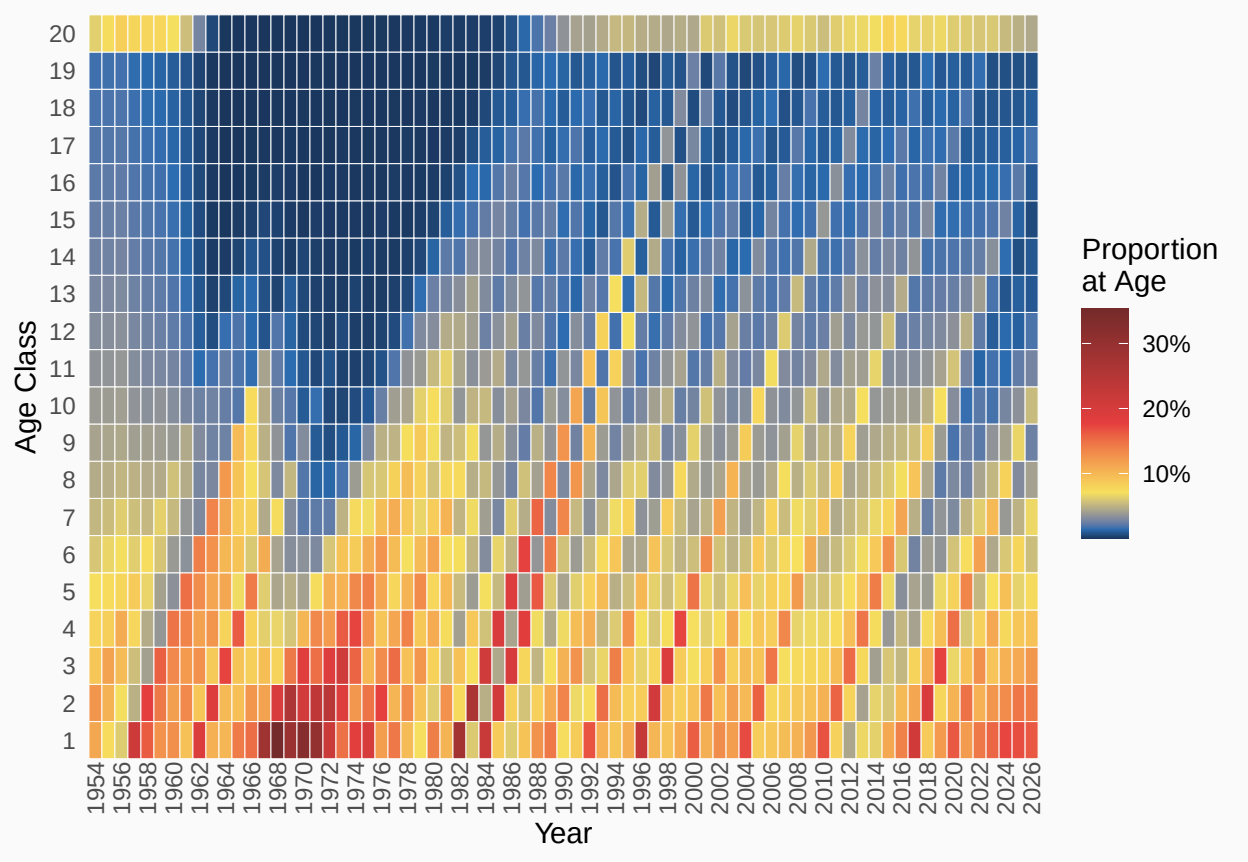


Figure 4.8: Modeled age composition data for yellowfin sole from 1964 - 2026. Data shown are scaled proportions tracking age classes 1-20 over time.

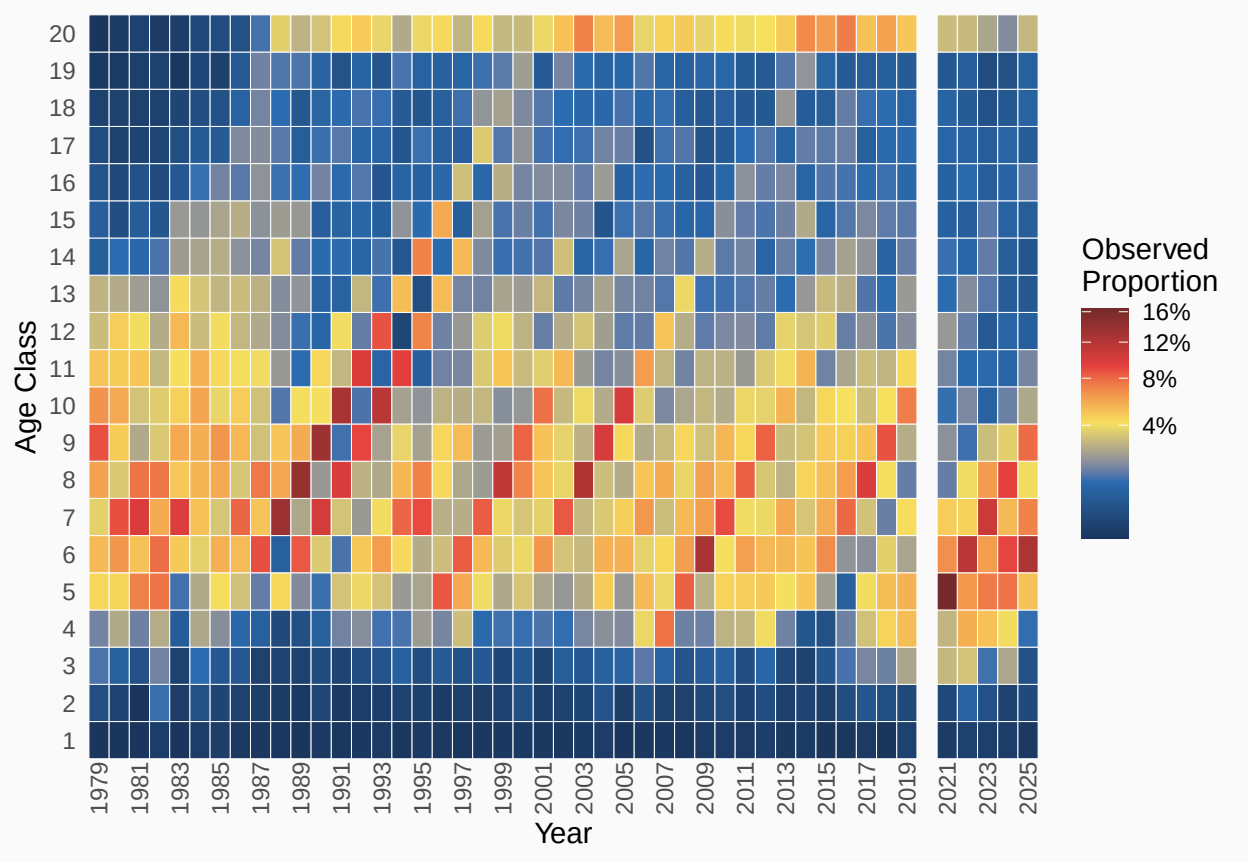


Figure 4.9: Raw age composition data for the yellowfin sole survey, 1982 - 2025. Data shown are scaled proportions tracking age classes 1-20 over time.

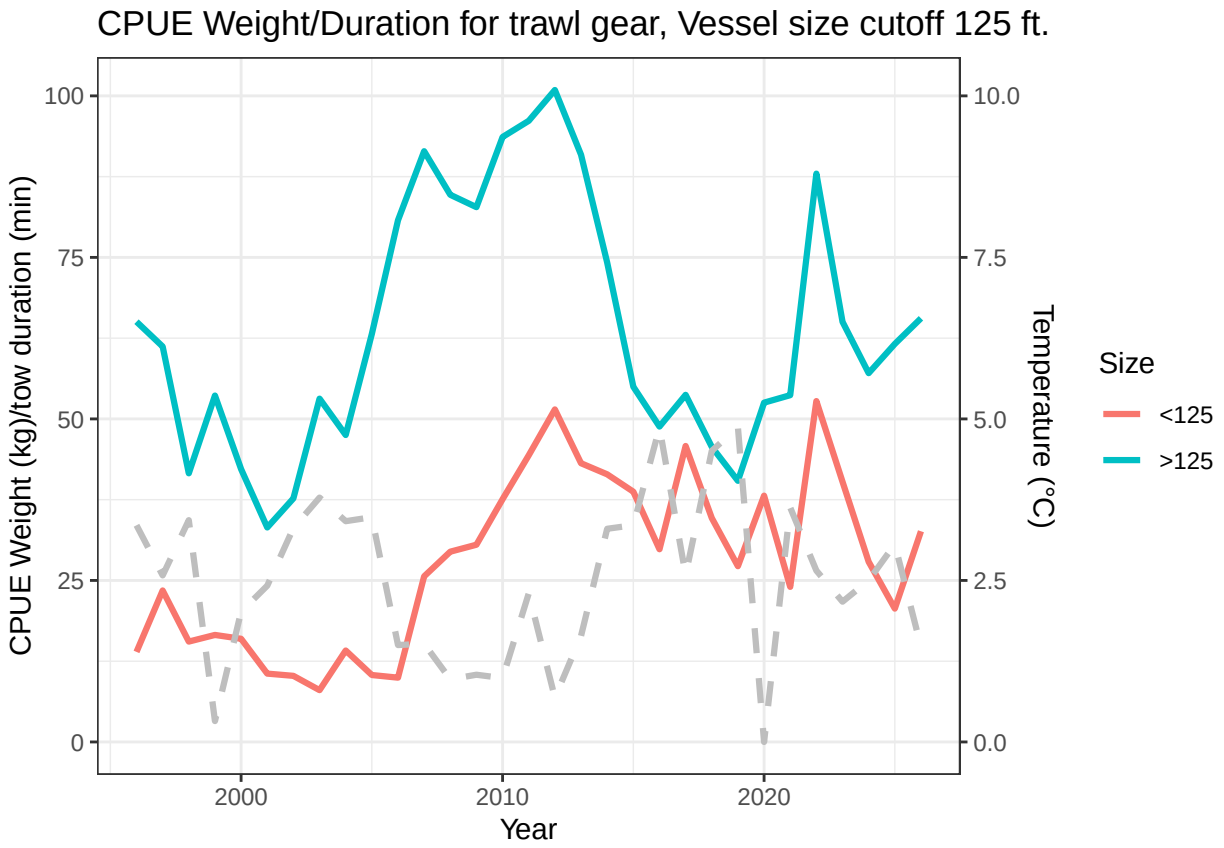


Figure 4.10: Catch per unit effort based on yellowfin sole fishery data, 1996-2026. CPUE weight (kg)/trawl duration (min) is shown for vessels greater and less than 125 ft, and only including self-made tows. Estimates of relative CPUE are complete through October 1, 2026. Results are limited to Catcher/Processor and Catcher vessels and tow duration >0 and <the 90% percentile of all the data (974 minutes). Source: NMFS/AKRO Catch Accounting System. The EBS bottom temperature anomalies from 1996-2026 (x10 for visualization) are shown as a dashed line.

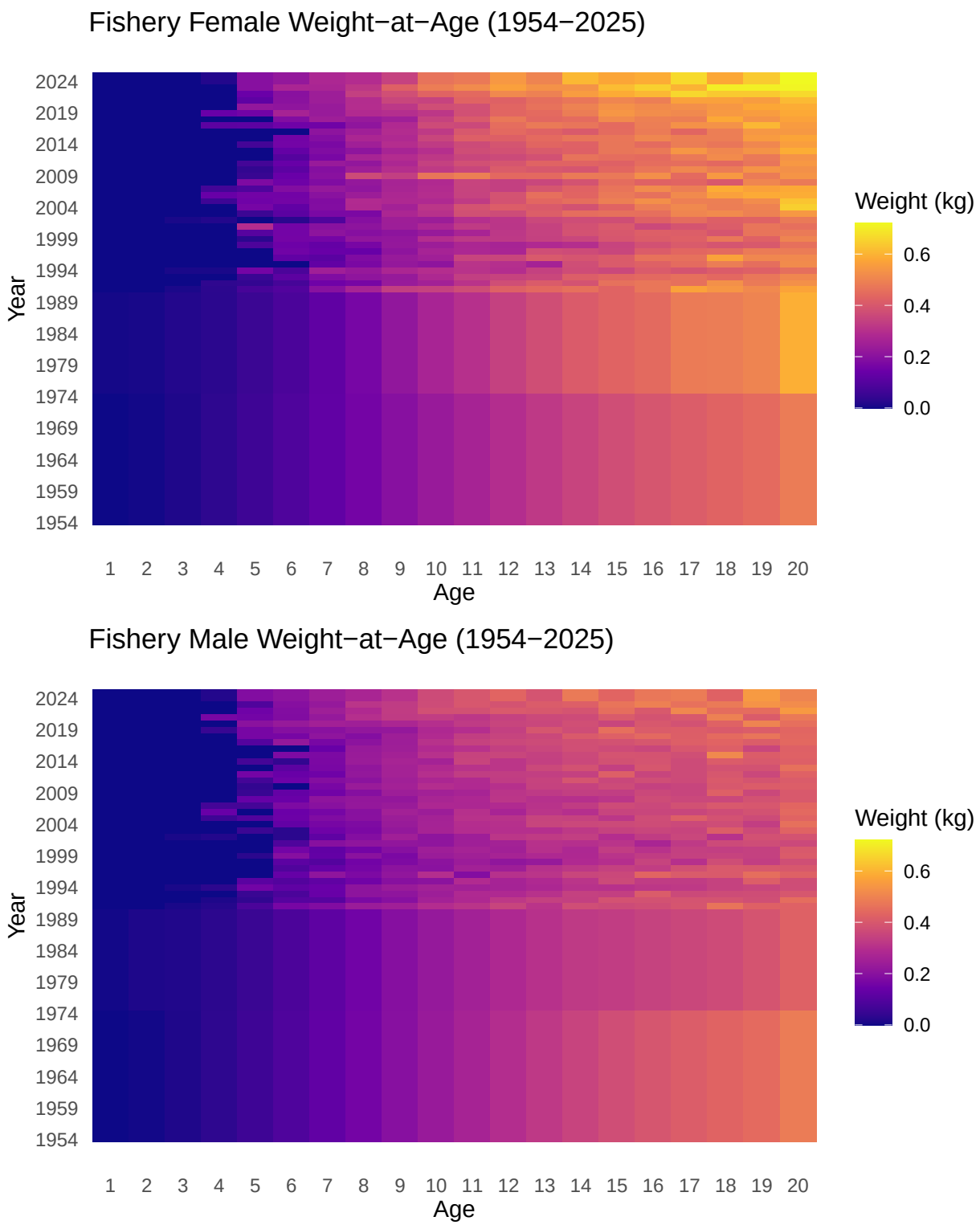
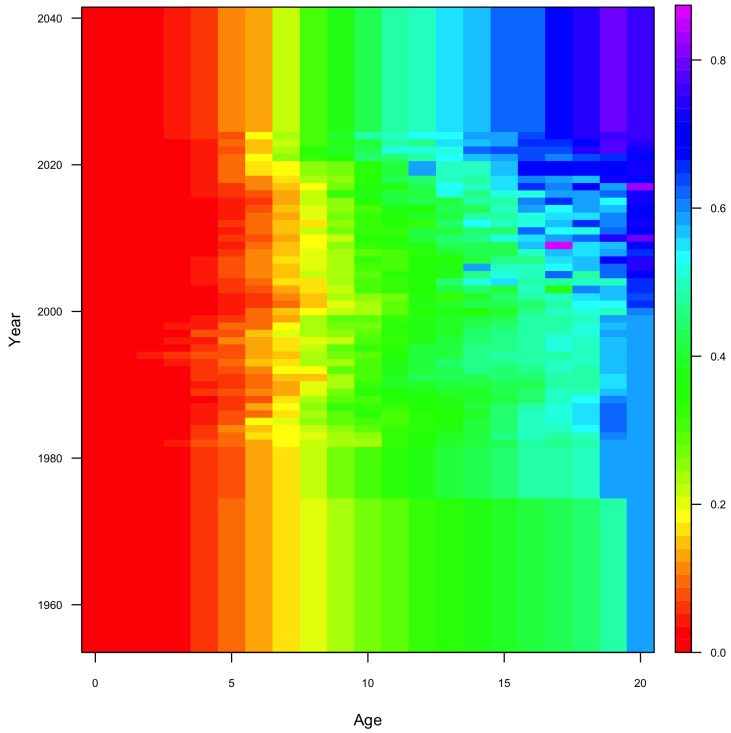


Figure 4.11: Mean weight-at-age based on catch-at-age methodology from the yellowfin sole fishery otoliths, females above, males below.

Females



Males

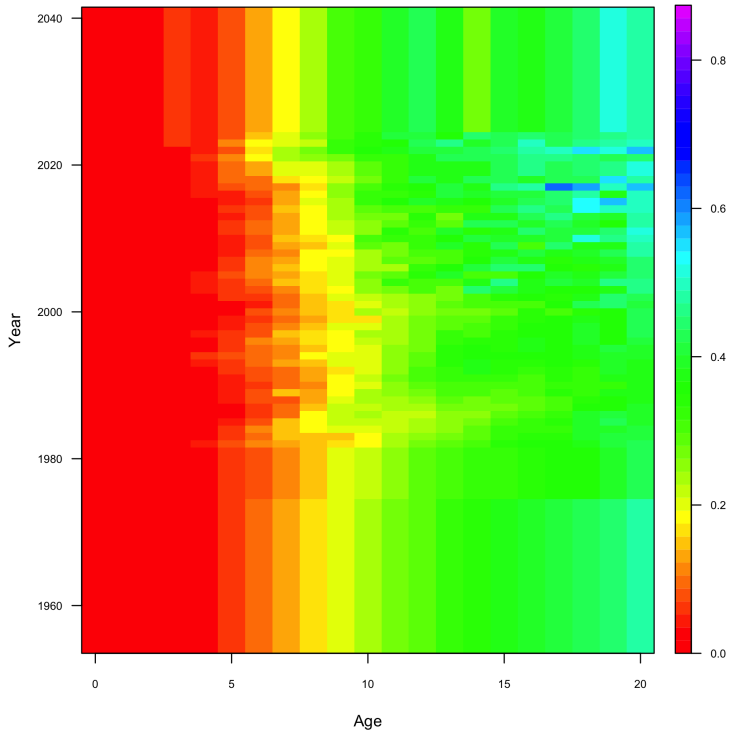


Figure 4.12: Model derived estimates of weight (kg) at age by year for yellowfin sole females (above) and males (below), for the modeled time period, 1954 – 2026, and extended into the forecast years through 2040. Estimates do not vary by model; therefore only one set of figures is presented.



Figure 4.13: Mean weight-at-age based on catch-at-age methodology from the yellowfin sole survey, females above, males below.

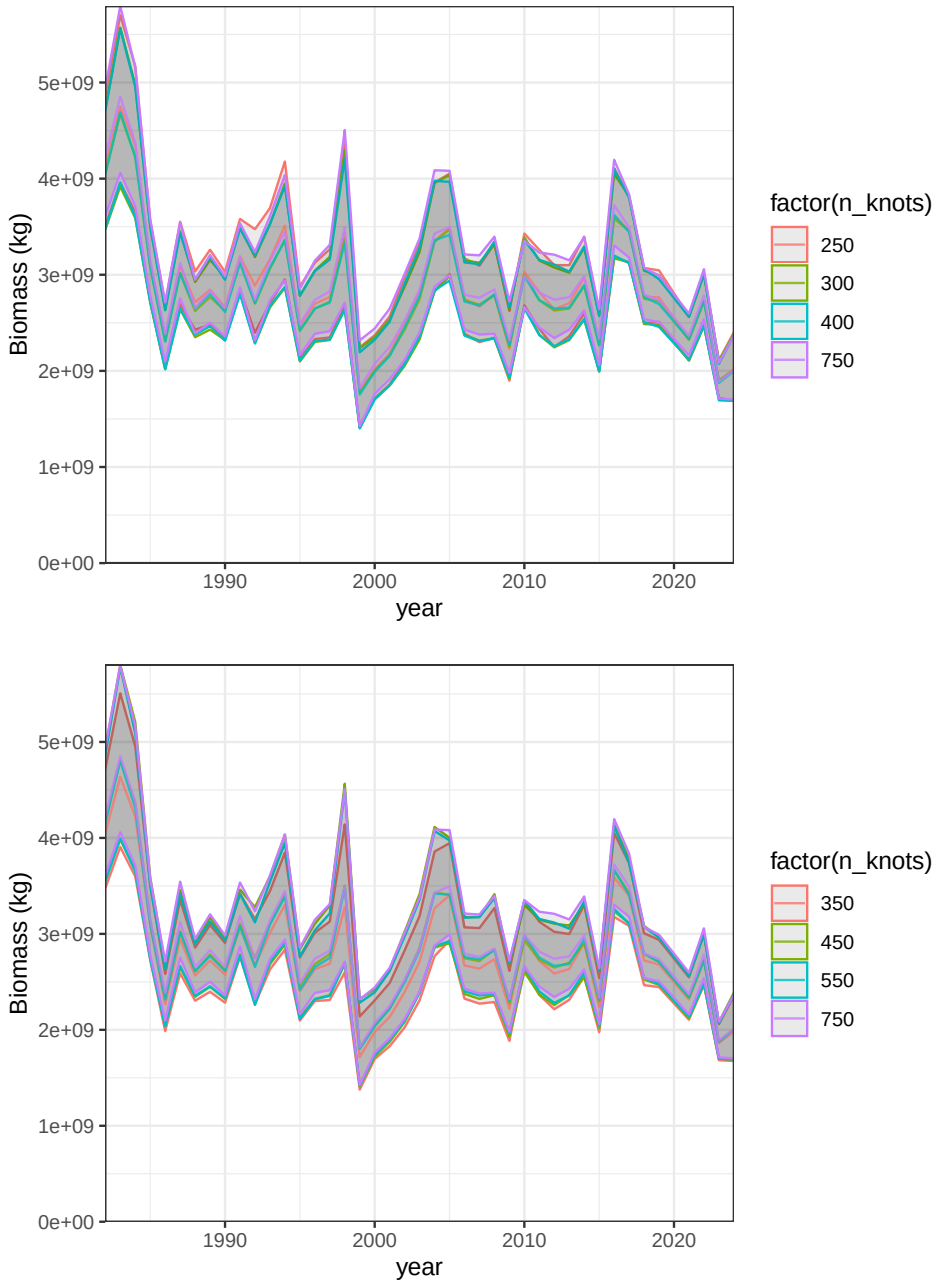


Figure 4.14: sdmTMB modeling of the bottom trawl survey index, based on 2025 hindcast modeling. Indices were bridged across knots from 250-750.

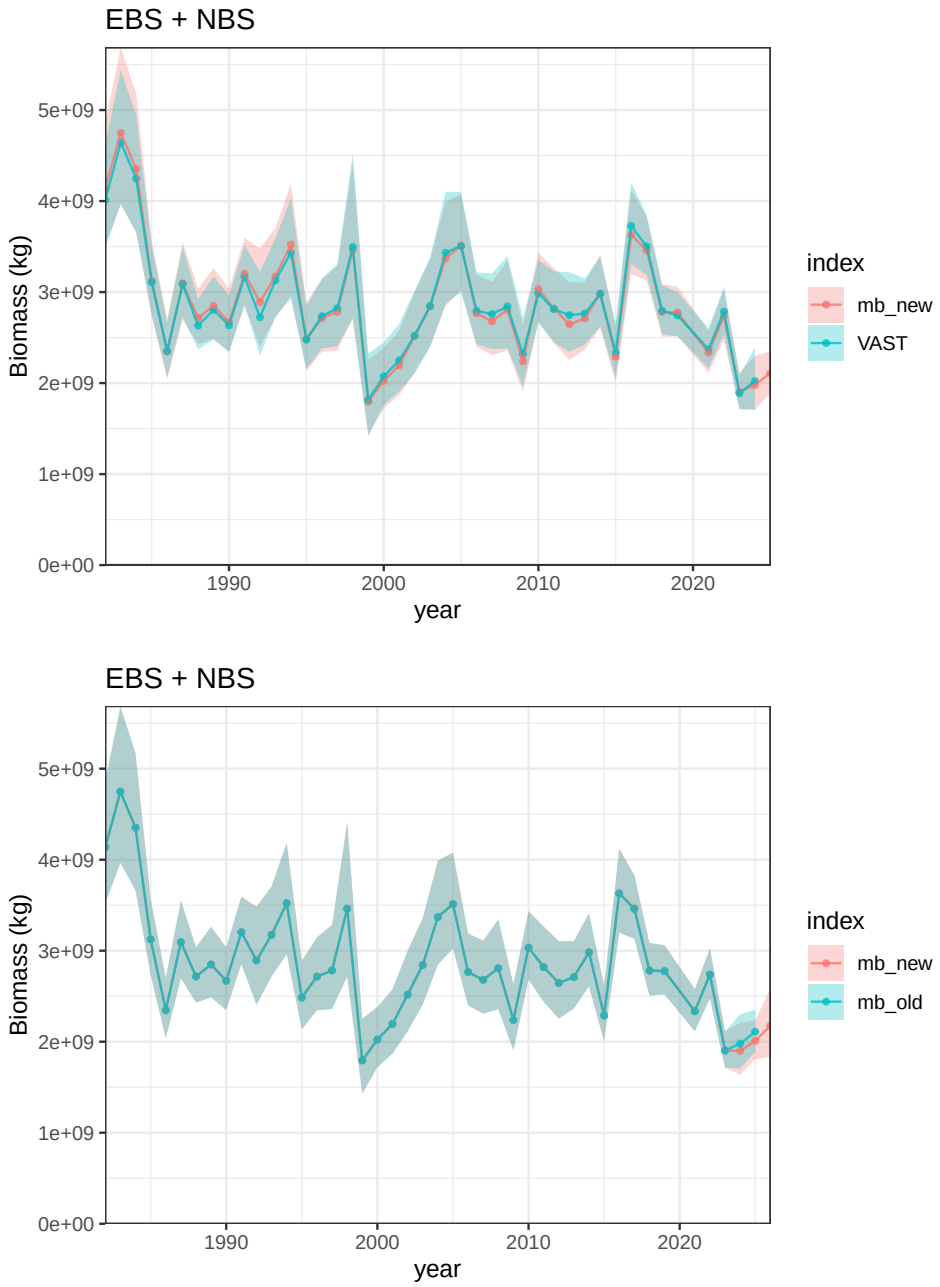


Figure 4.15: Estimated combined eastern and northern Bering Sea survey indices for yellowfin sole: bridging from VAST with 750 knots through 2024 to sdmTMB with 250 knots through 2025 (above) and bridging from 2025 to 2026, both sdmTMB with 250 knots (below). The lower plot includes a net measurement correction, the Marport-to-Netmind (M2N).

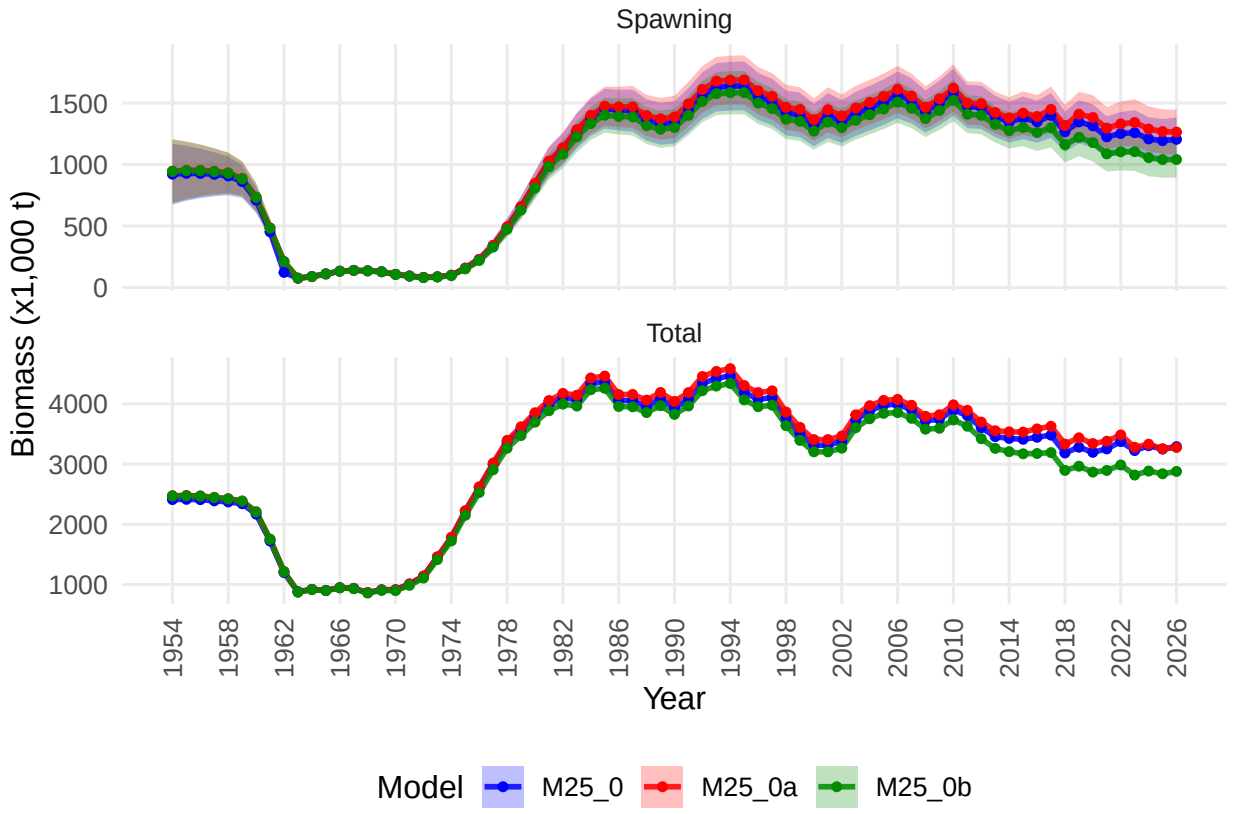


Figure 4.16: Total and spawning biomass estimates for the three models. Estimated 95% confidence intervals are shown for spawning biomass.

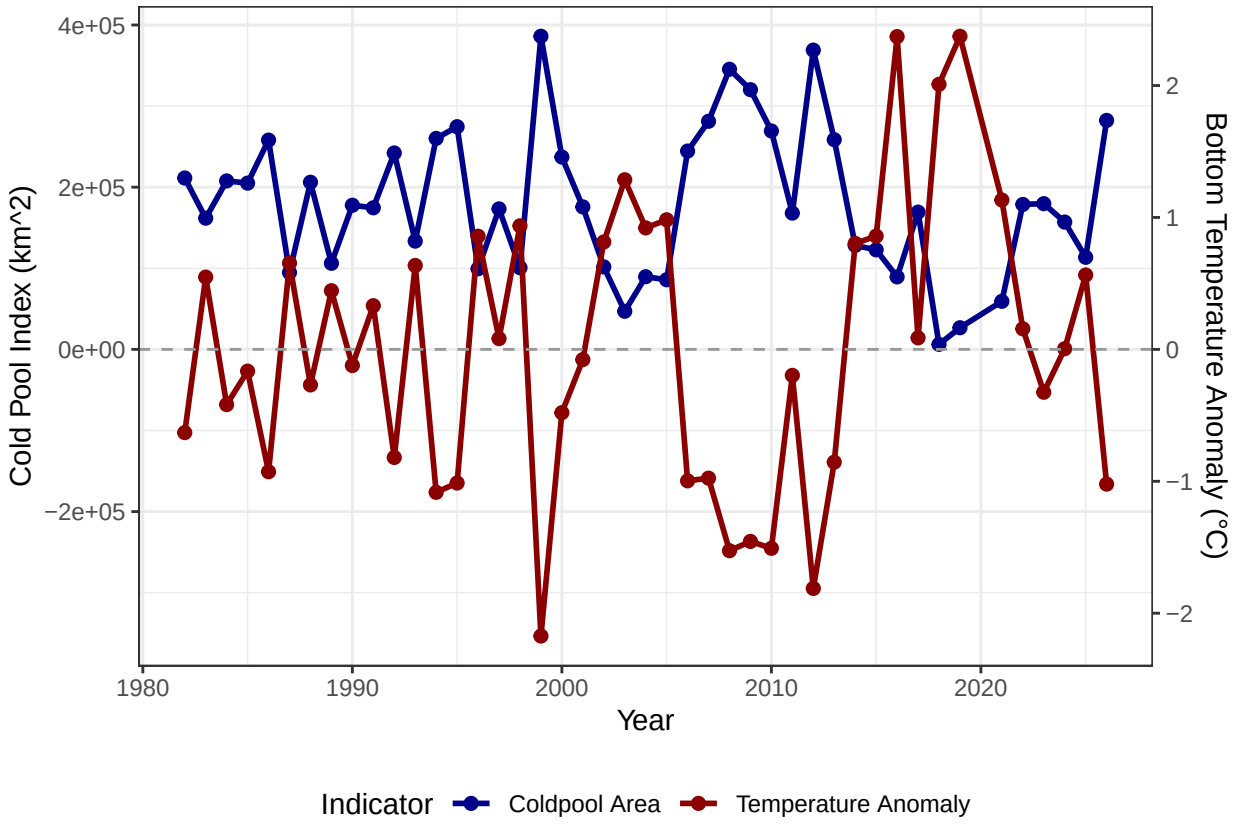


Figure 4.17: Cold pool 1982 - 2025 for the eastern Bering Sea (EBS), northern Bering Sea (NBS), and both regions combined, overlaid with the mean Bering Sea bottom temperature <100 m, 1982 - 2026.

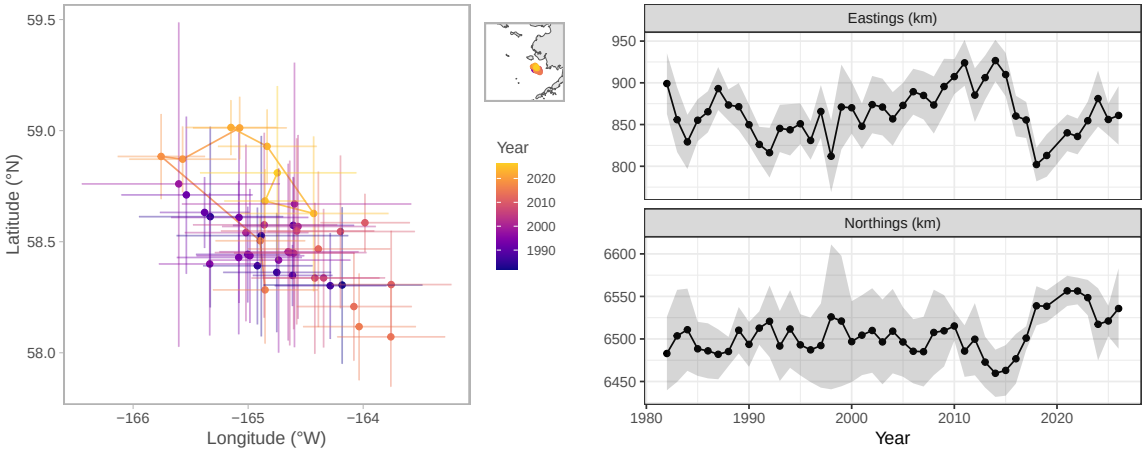


Figure 4.18: Estimated yellowfin sole center of gravity (COG) from EBS and NBS surveys from 1982 through 2026. Annual COG is mapped in the left panel (see inset center), Eastings (Longitude, km) in the upper right panel and northings (Latitude, km) in the lower right panel.

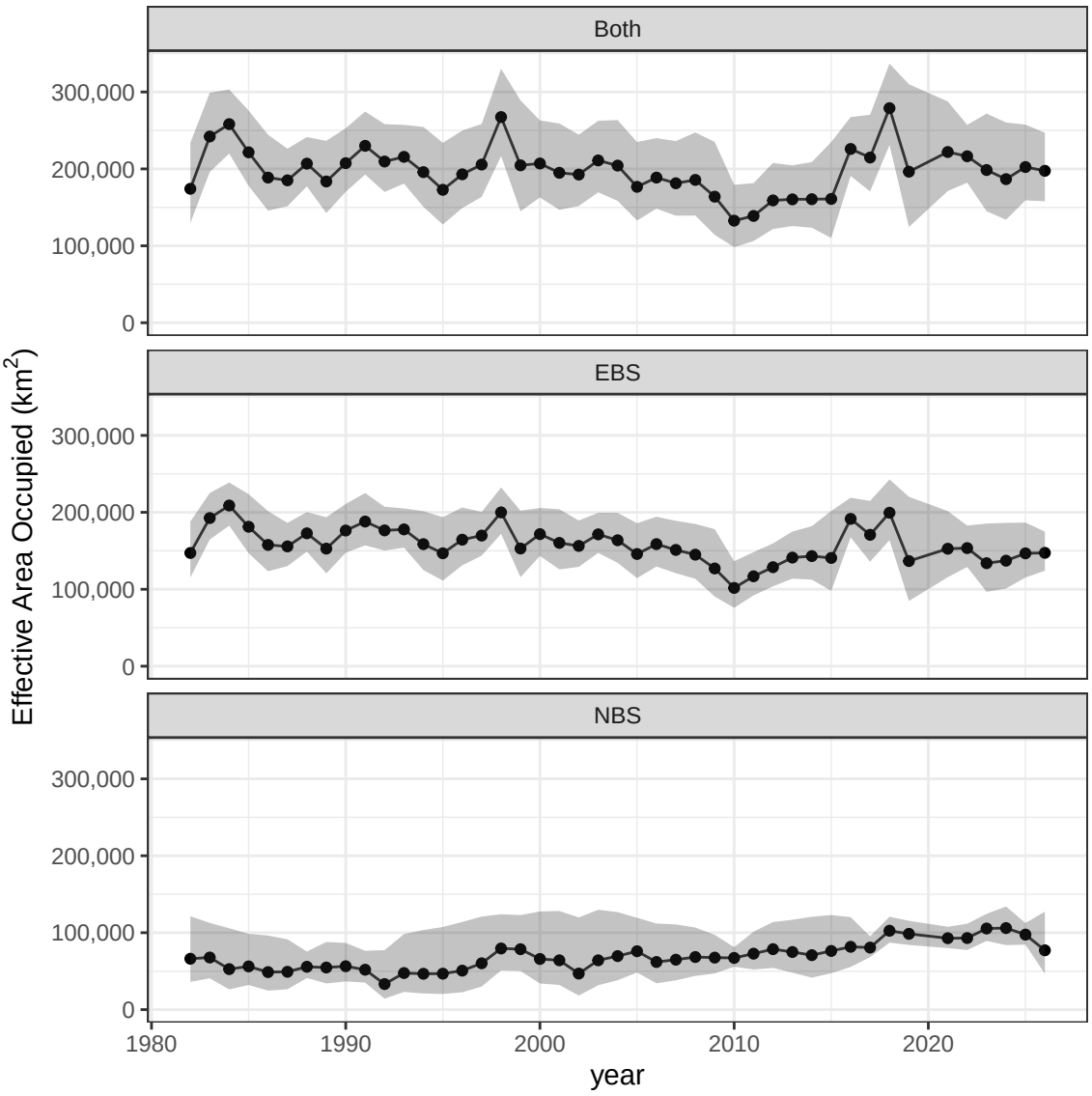


Figure 4.19: The effective area occupied by yellowfin sole, estimated using sdmTMB, in the eastern Bering Sea (middle), northern Bering Sea (bottom) and the combined region (upper).

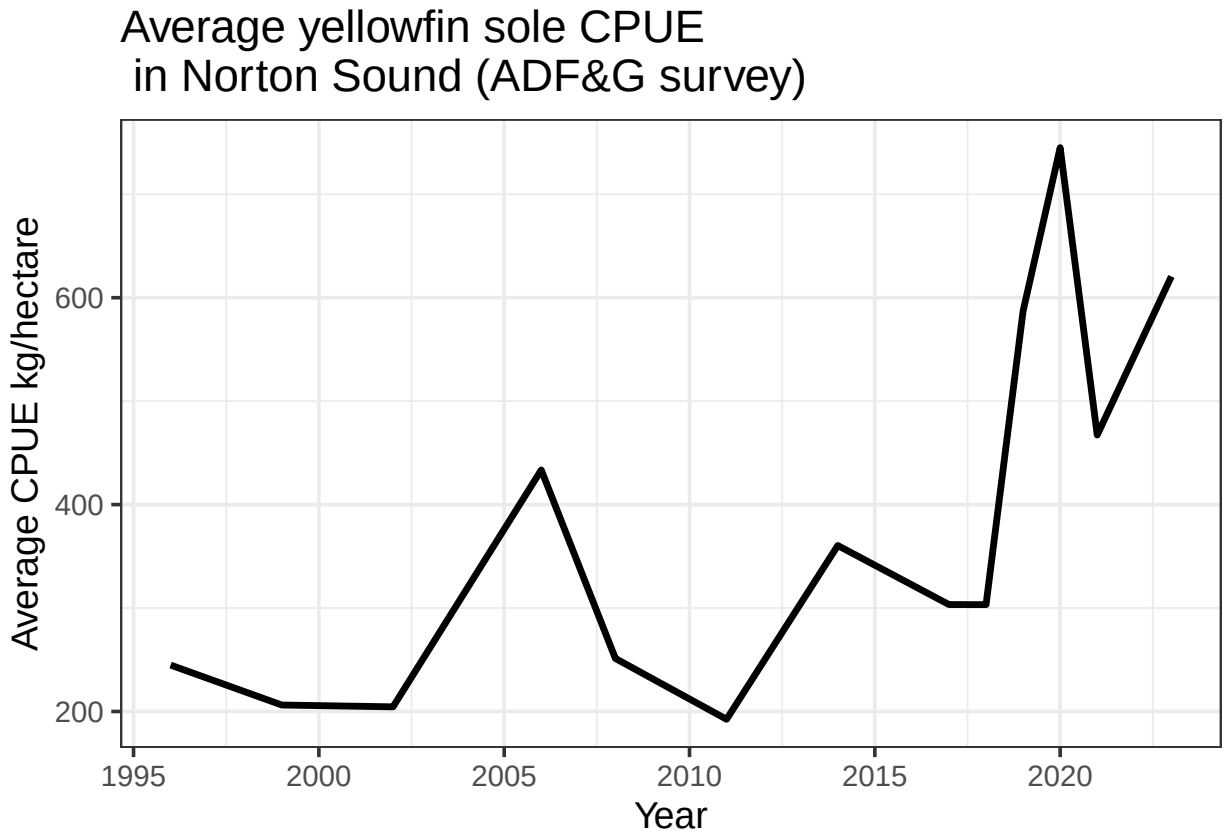
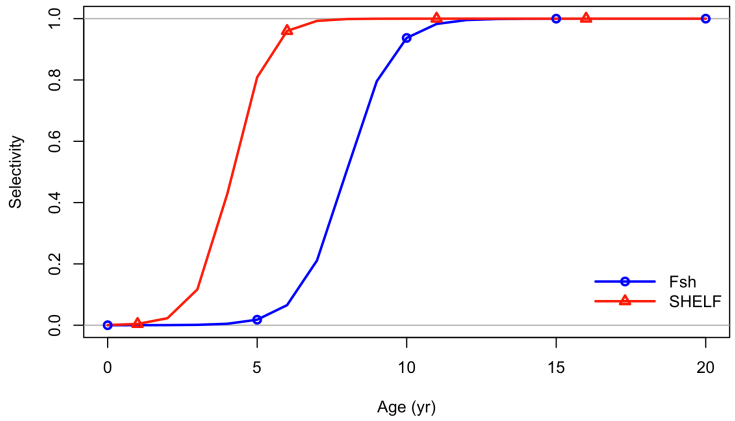
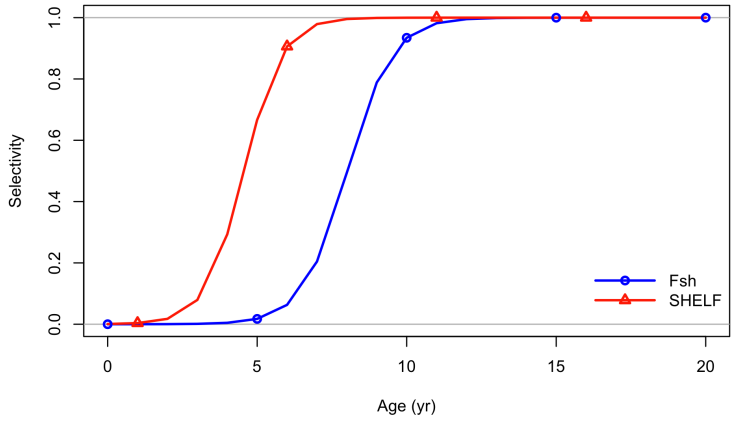


Figure 4.20: Average catch per unit effort (CPUE) of yellowfin sole in Norton Sound, based on ADF&G survey time series, 1996 - 2023.

Model 25.0



Model 25.0a



Model 25.0b

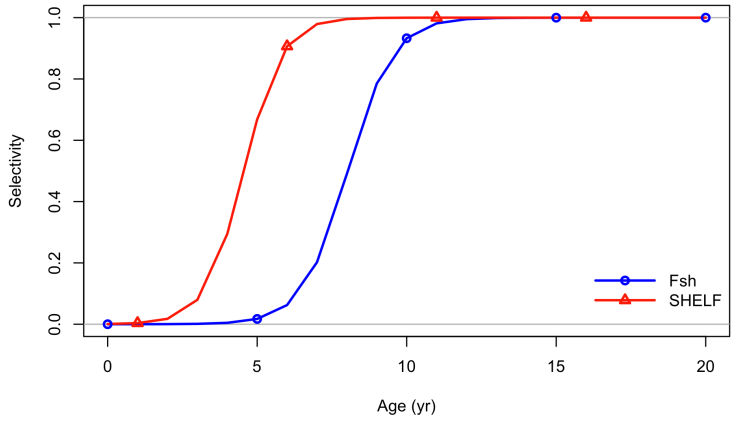


Figure 4.21: Estimate of yellowfin sole survey selectivity, and fishery selectivity in the final year (2026), Models 25.0, 25.0a, 25.0b. Estimates are very close; parameters can be found in Table 4.17.

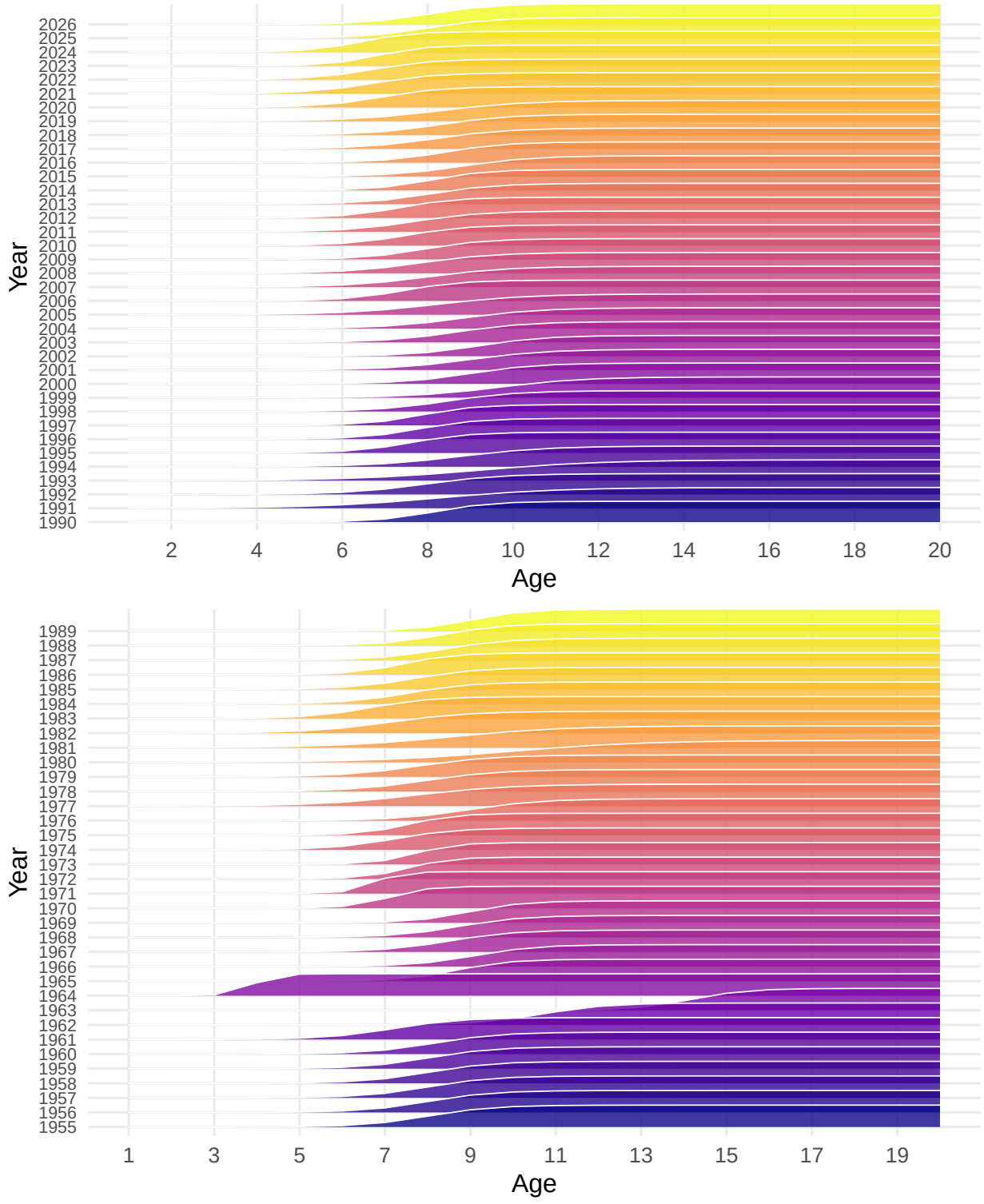


Figure 4.22: Annually varying fishery selectivity, Model 25.0b.

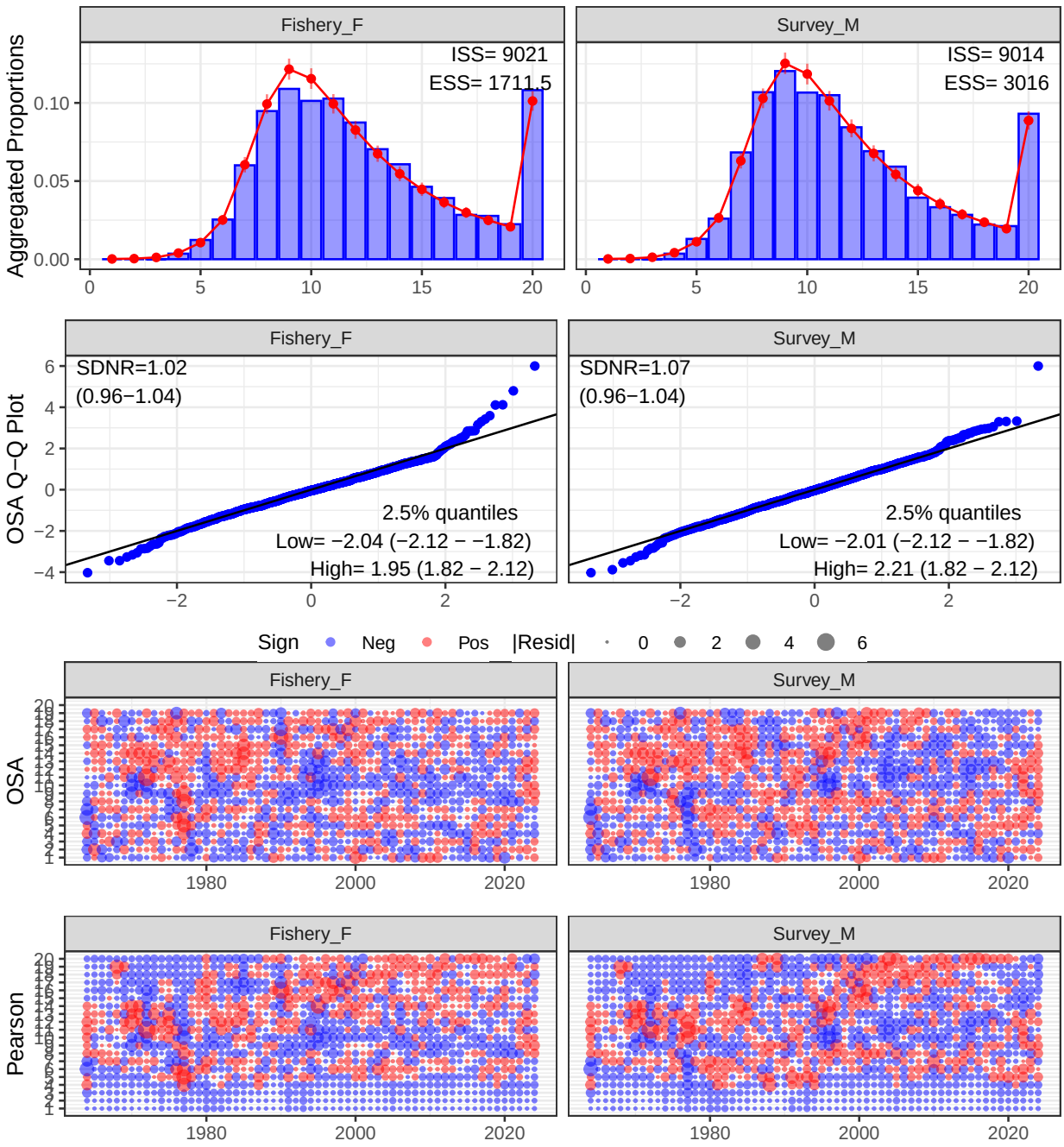


Figure 4.23: EBS fishery age composition OSA residuals for Model 25.0, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

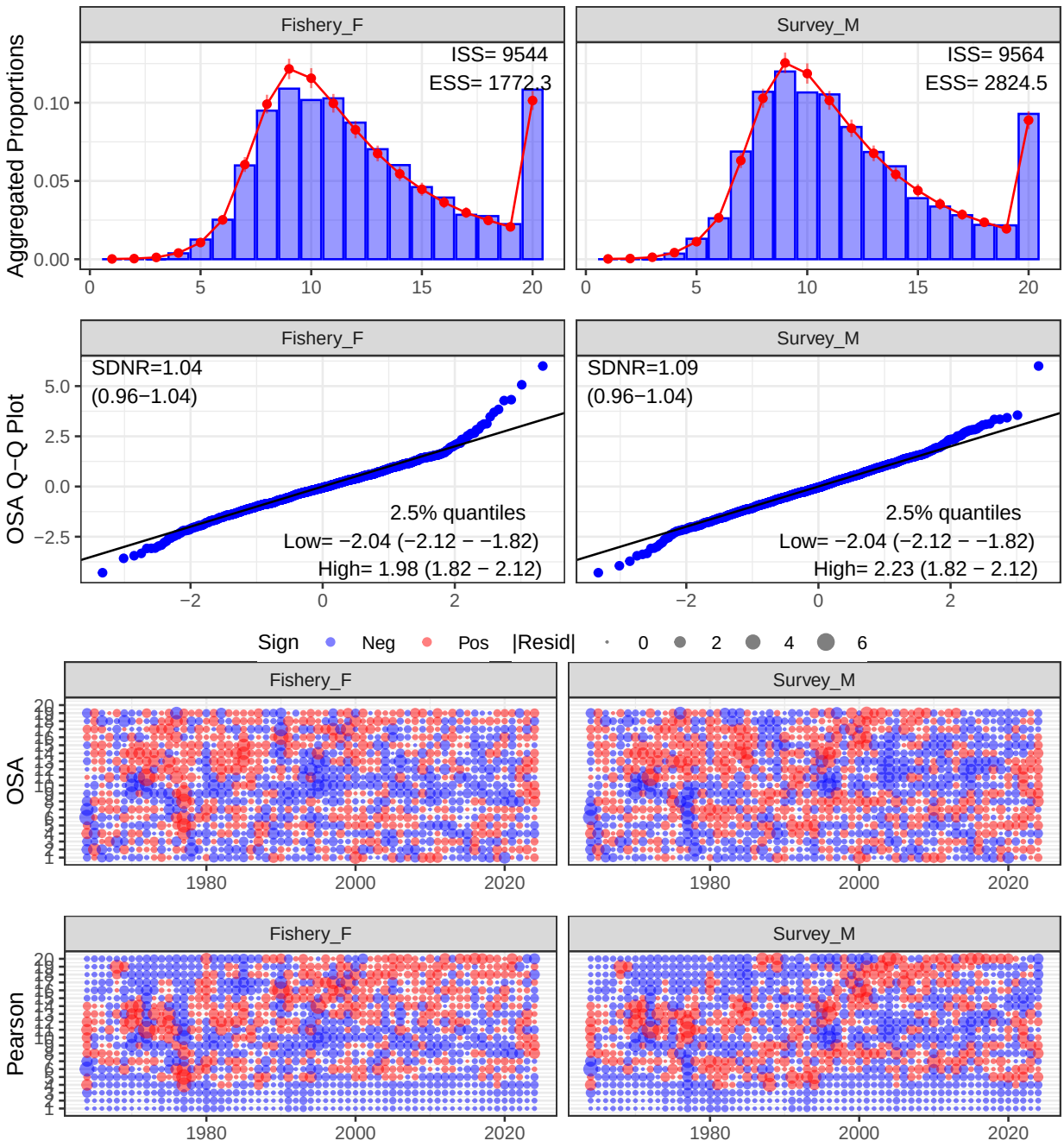


Figure 4.24: EBS fishery age composition OSA residuals for Model 25.0a, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

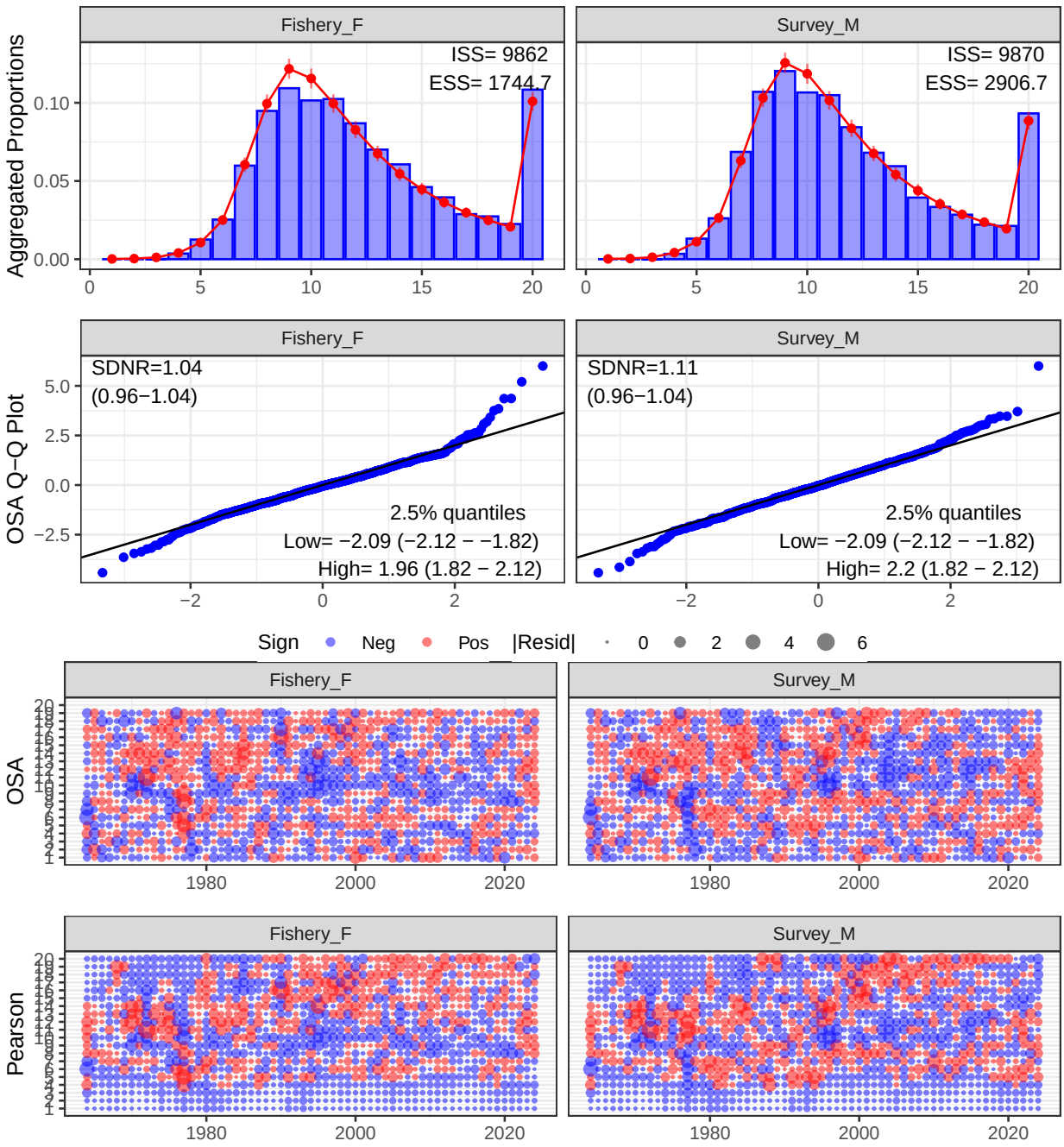


Figure 4.25: EBS fishery age composition OSA residuals for Model 25.0b, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

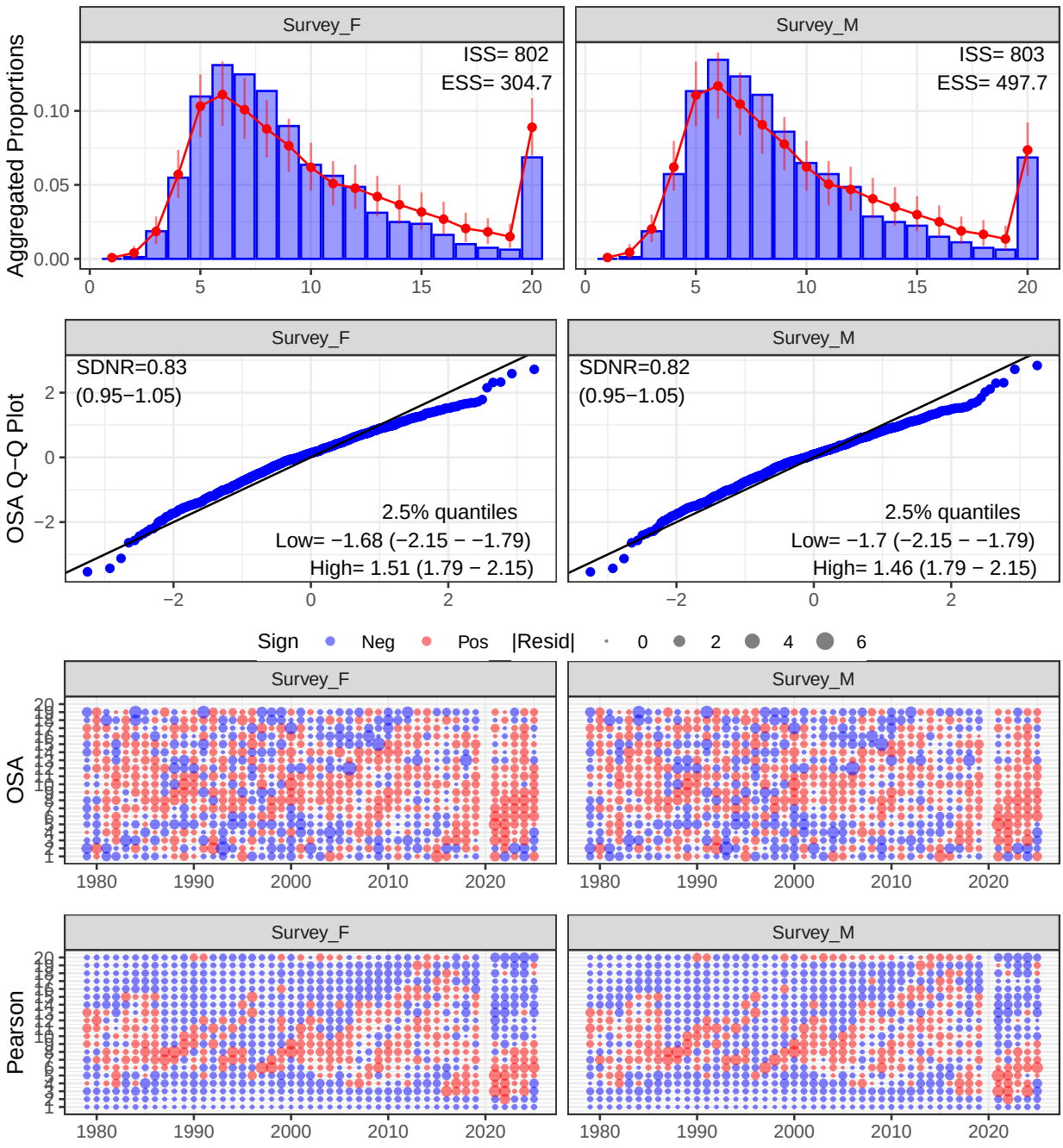


Figure 4.26: EBS survey age composition OSA residuals for Model 25.0, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

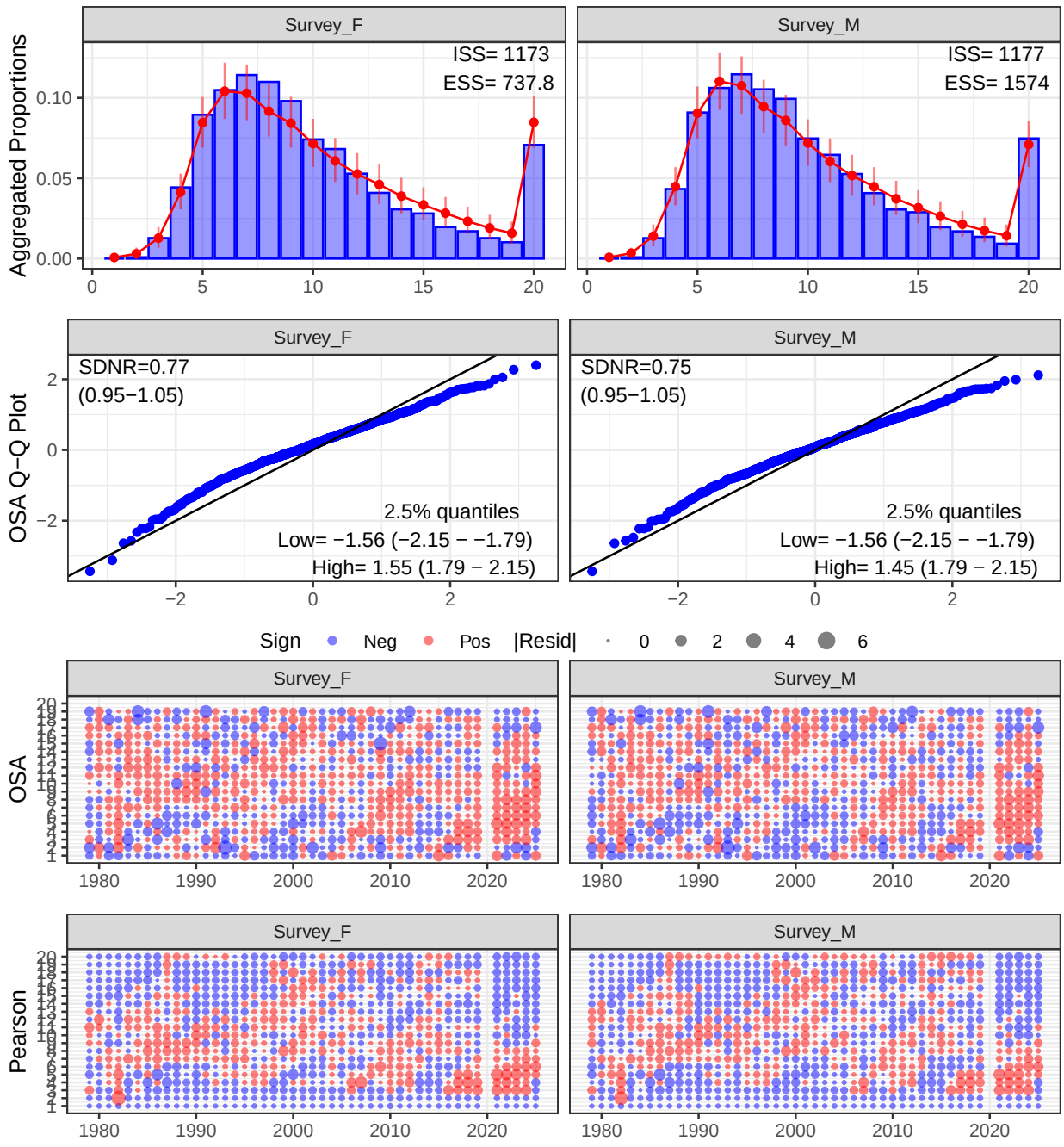


Figure 4.27: EBS survey age composition OSA residuals for Model 25.0a, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

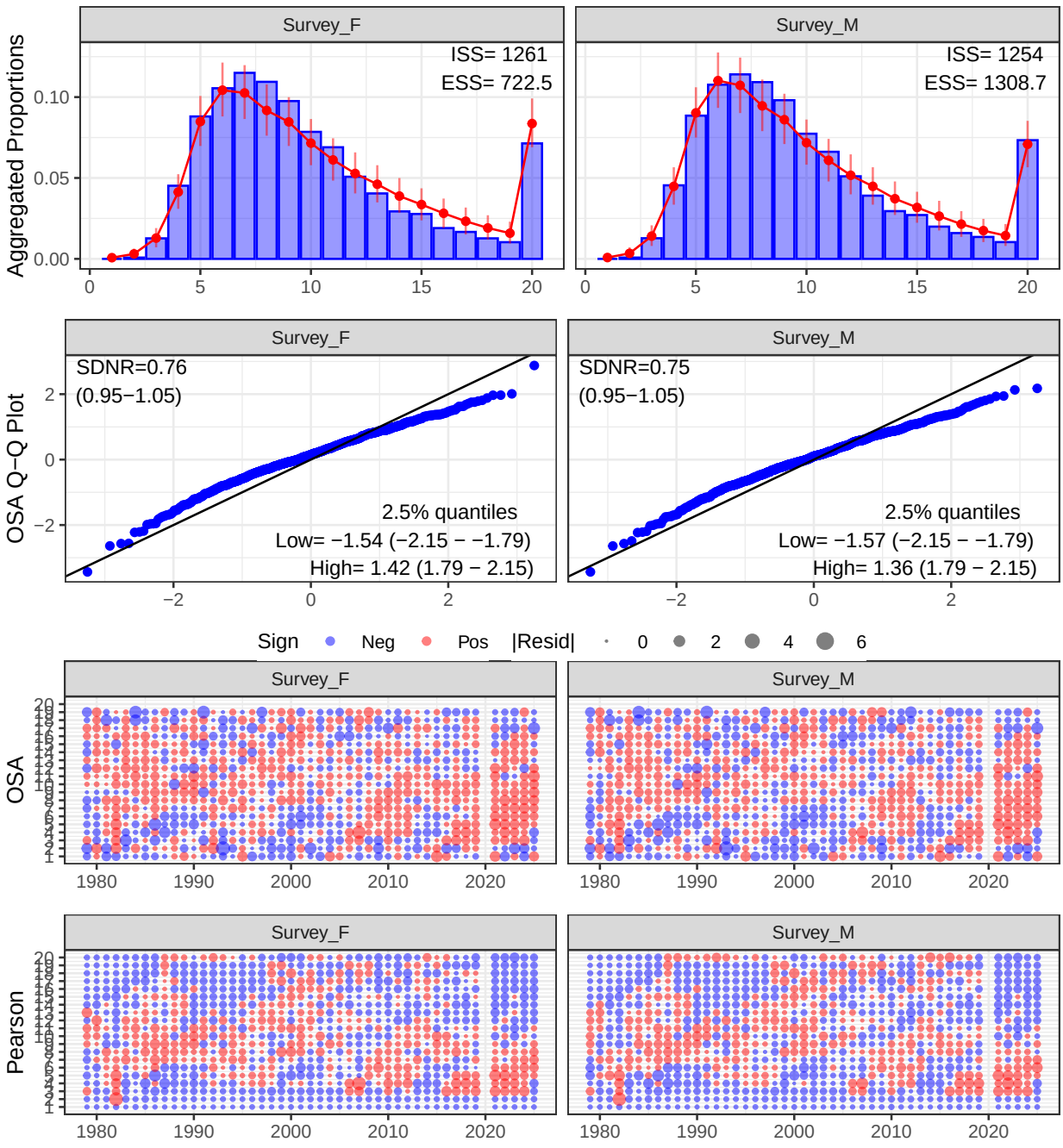


Figure 4.28: EBS survey age composition OSA residuals for Model 25.0b, females left and males right. Positive residual (red dots): observed > expected, negative residual (blue dots): observed < expected.

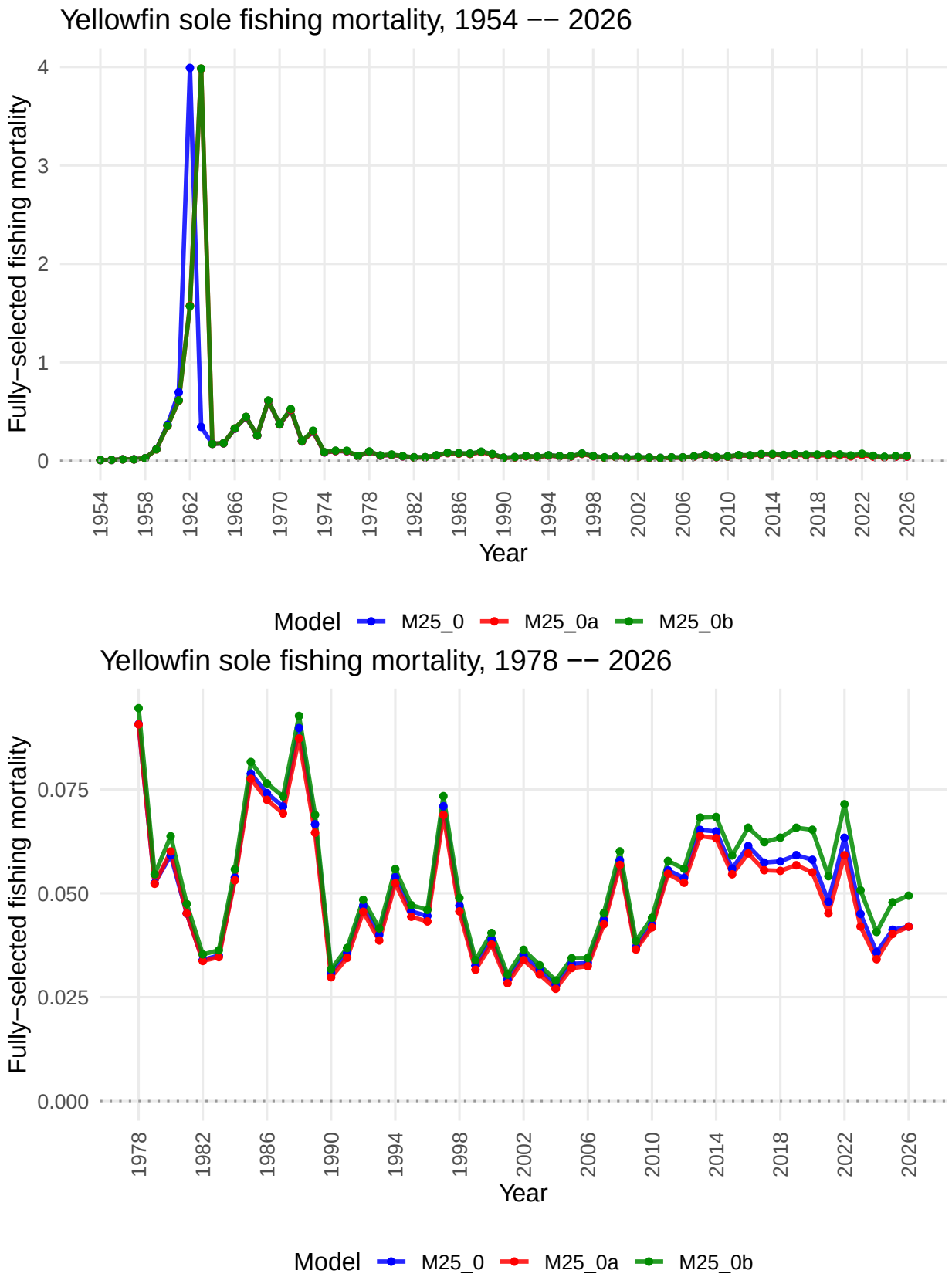


Figure 4.29: Comparison of annual full-selection fishing mortality for yellowfin sole, models 25.0, 25.0a, and 25.0b from 1954 – 2026 (above), and 1978 – 2026 (below).

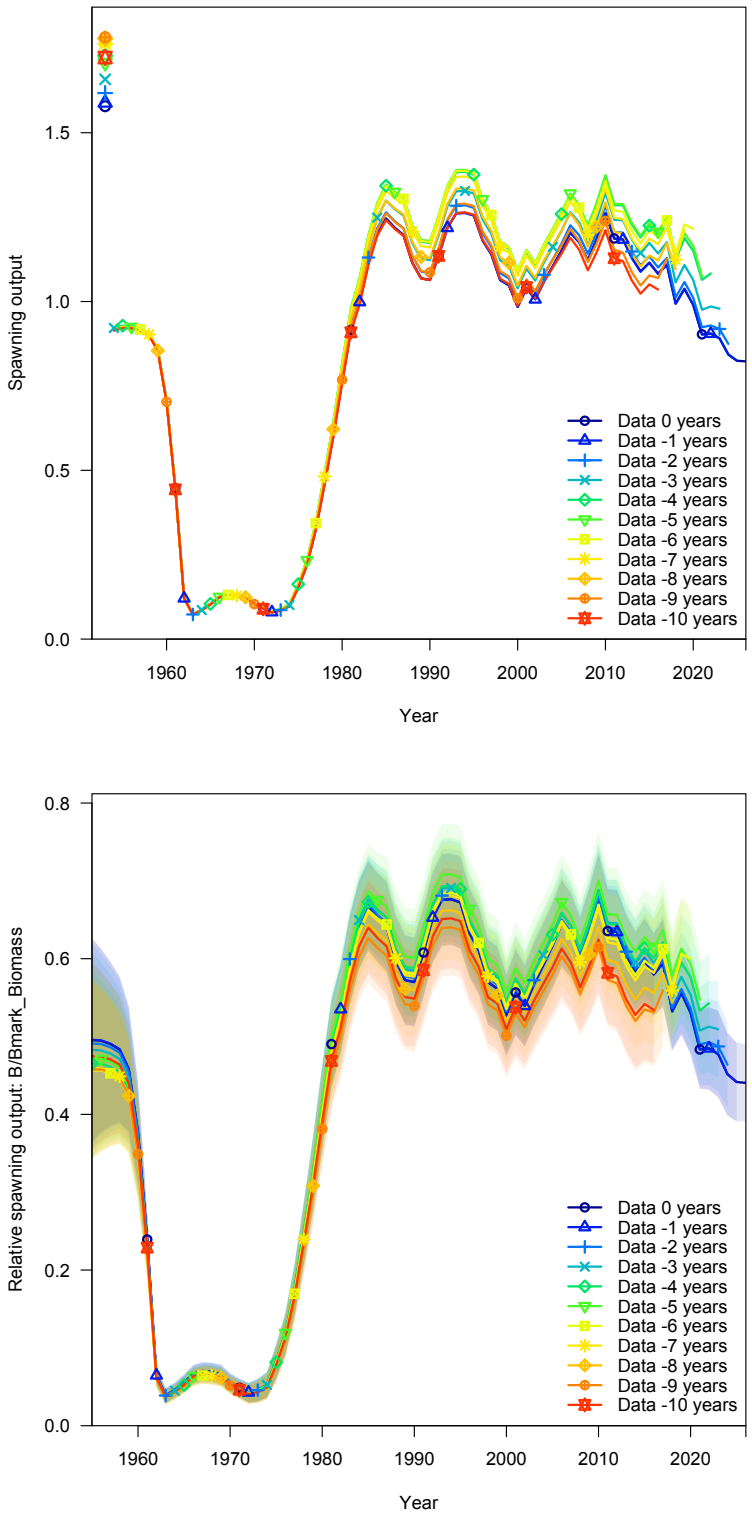


Figure 4.30: Retrospective plots of female spawning biomass incorporating a 10-year time period (2016–2026) for yellowfin sole Model 25.0: spawning biomass relative to $B_{40\%}$ above, and spawning biomass with 95% confidence intervals, below. Mohn's rho was 0.084.

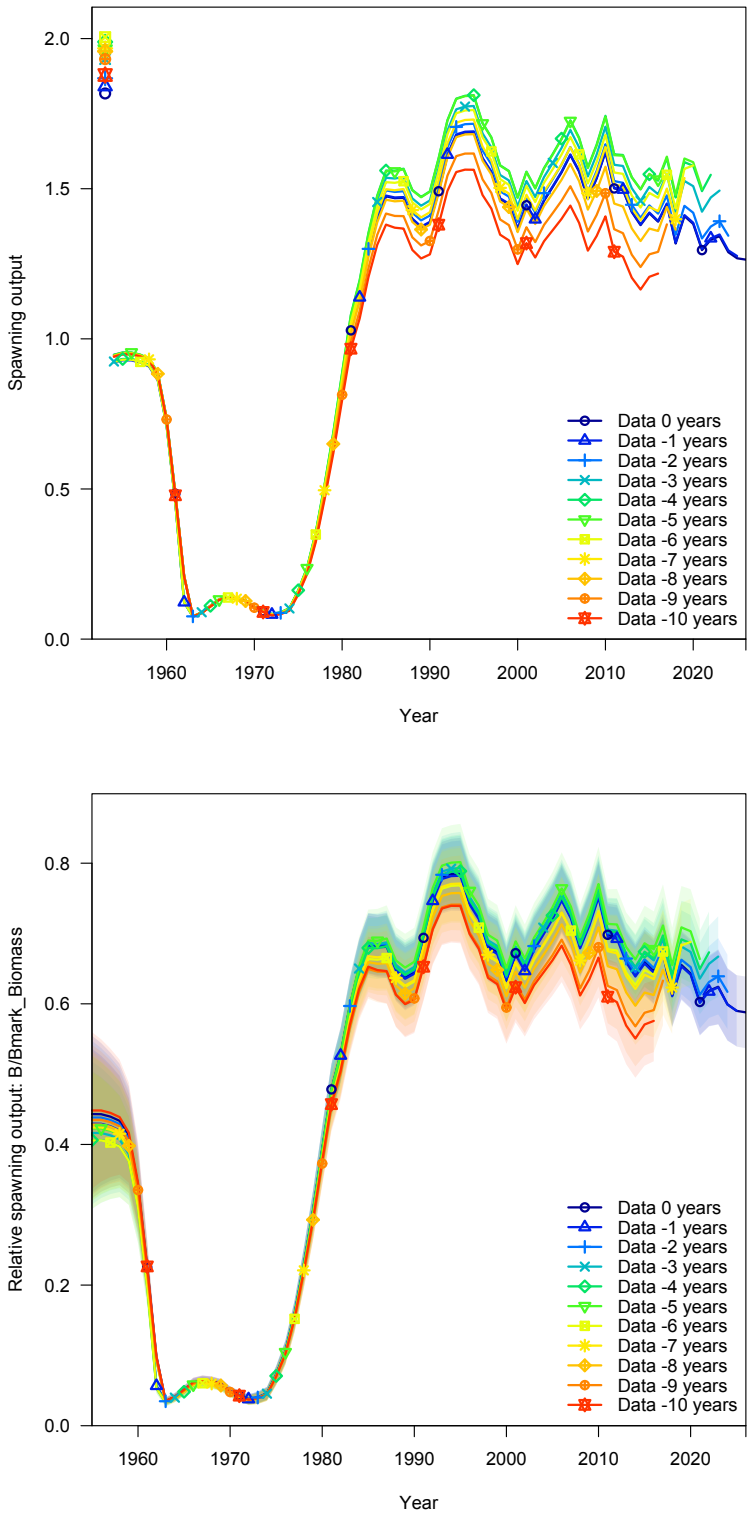


Figure 4.31: Retrospective plots of female spawning biomass incorporating a 10-year time period (2016–2026) for yellowfin sole Model 25.0a: spawning biomass relative to $B_{40\%}$ above, and spawning biomass with 95% confidence intervals, below. Mohn's rho was 0.058.

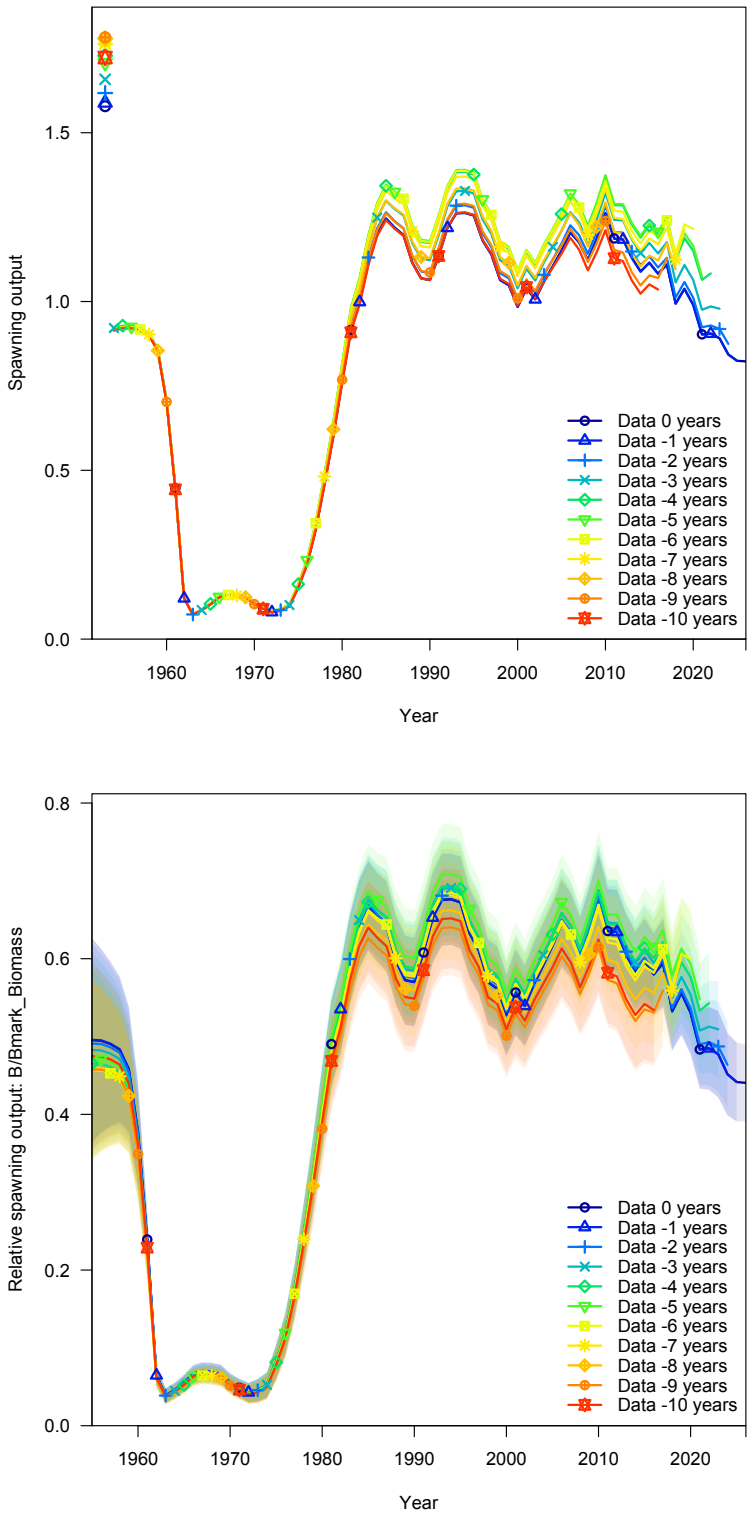


Figure 4.32: Retrospective plots of female spawning biomass incorporating a 10-year time period (2016–2026) for yellowfin sole Model 25.0b: spawning biomass relative to $B_{40\%}$ above, and spawning biomass with 95% confidence intervals, below. Mohn's rho was 0.099.

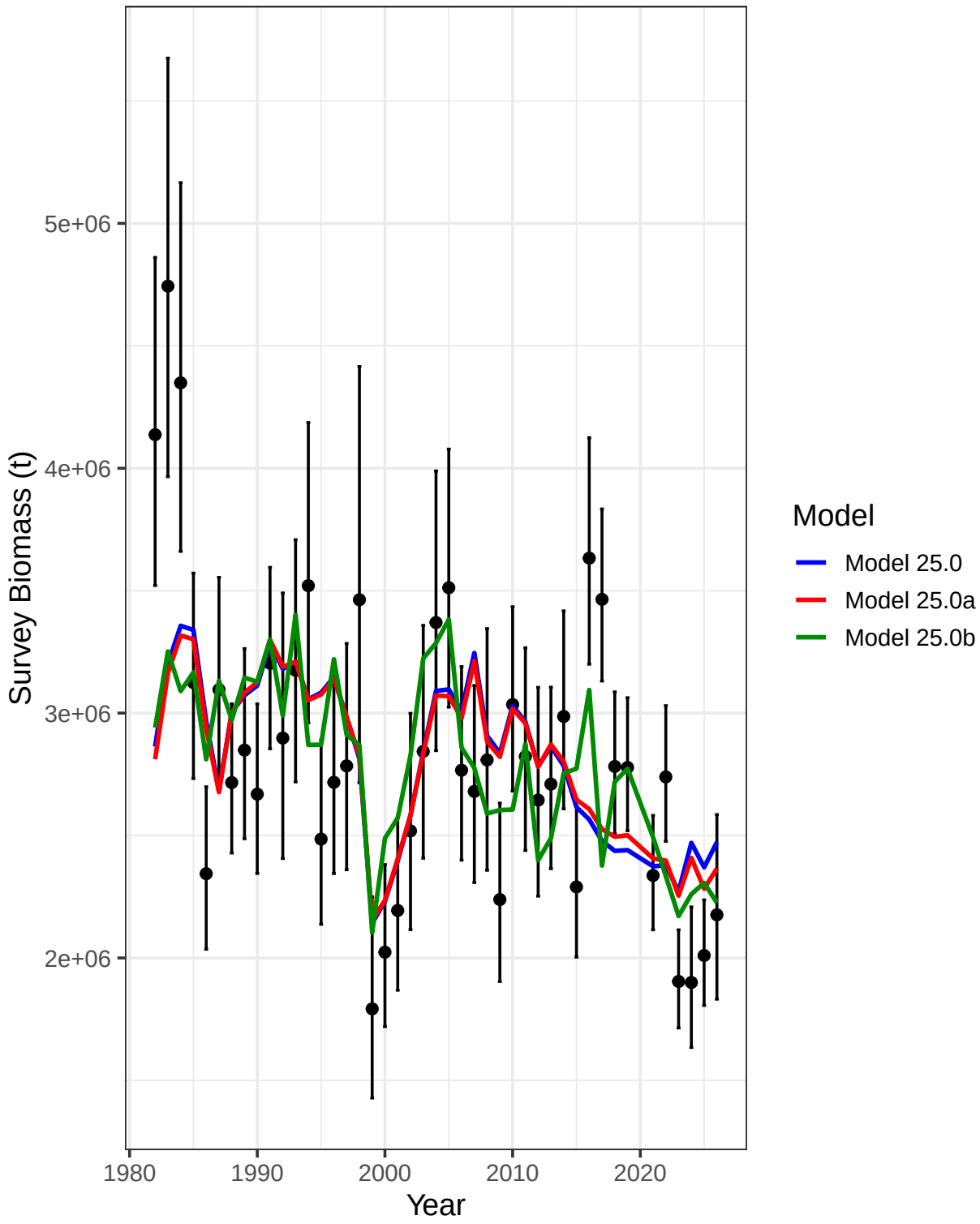


Figure 4.33: Model fit to survey index, with 95% confidence intervals, for Models 25.0, 25.0a, and 25.0b.

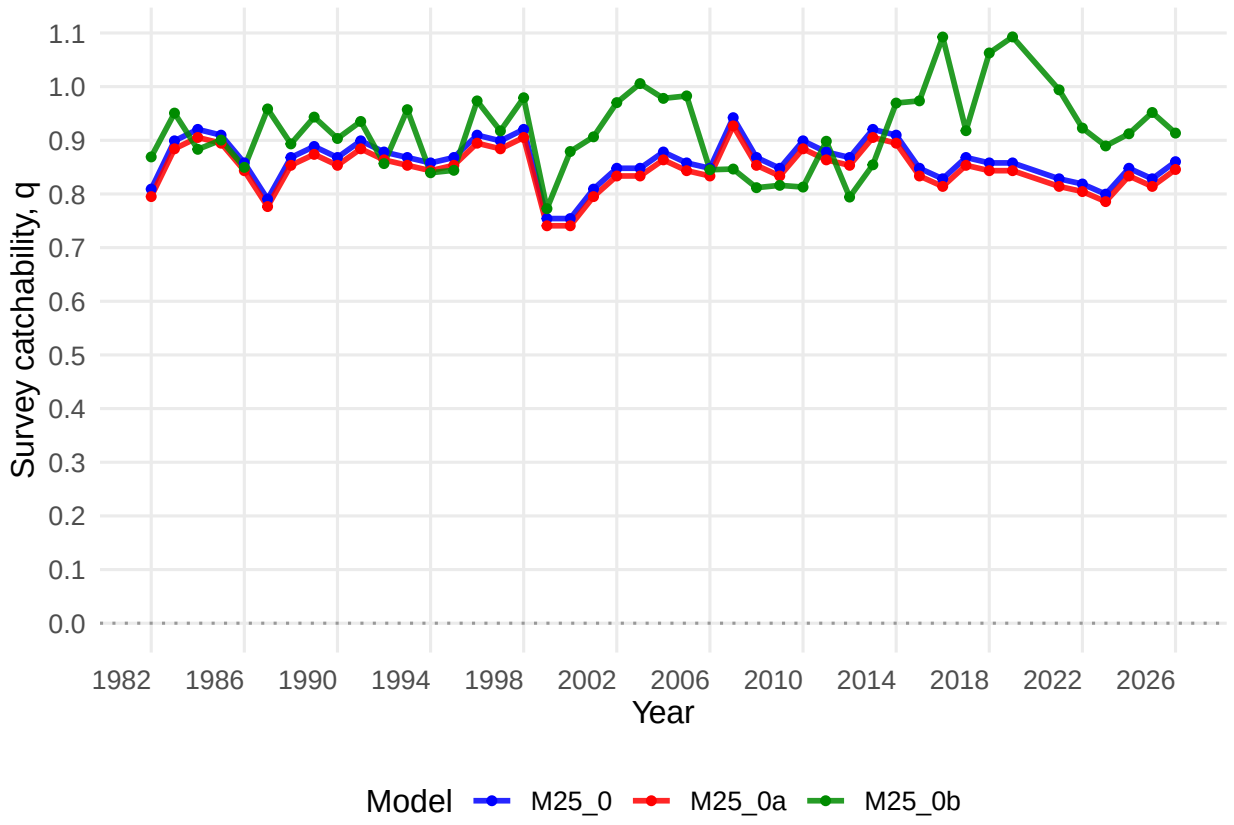
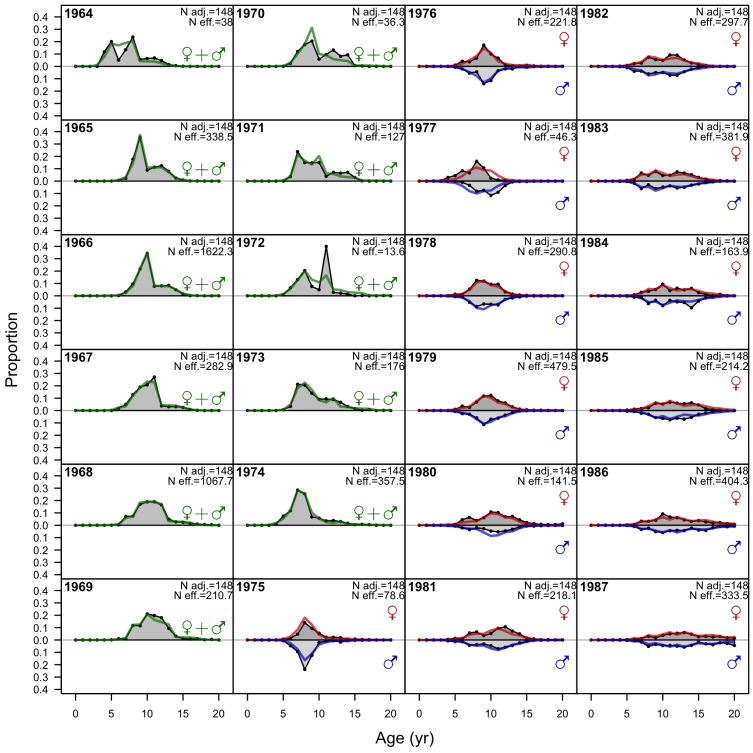
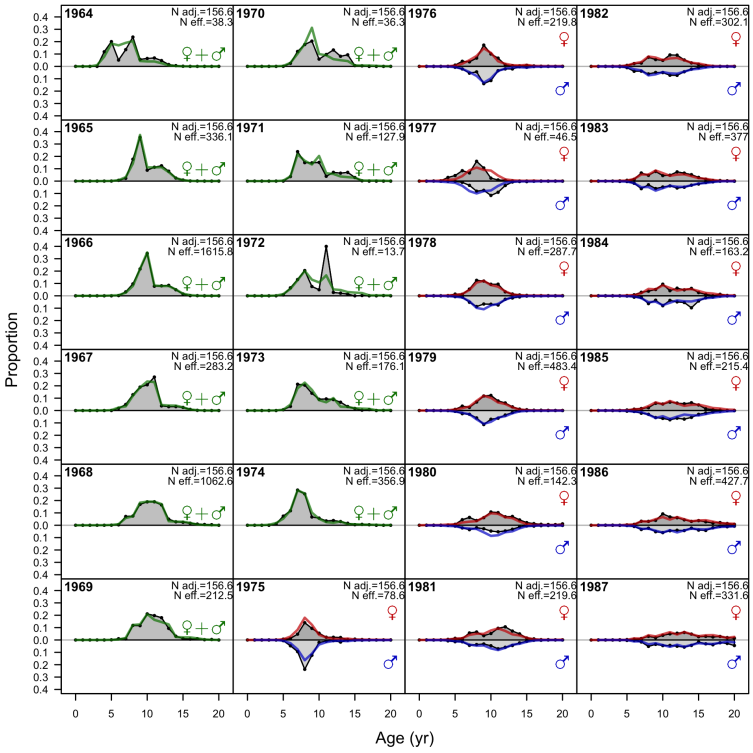


Figure 4.34: Survey catchability for yellowfin sole Models 25.0, 25.0a, and 25.0b, 1982 - 2026.

Model 25.0



Model 25.0a



Model 25.0b

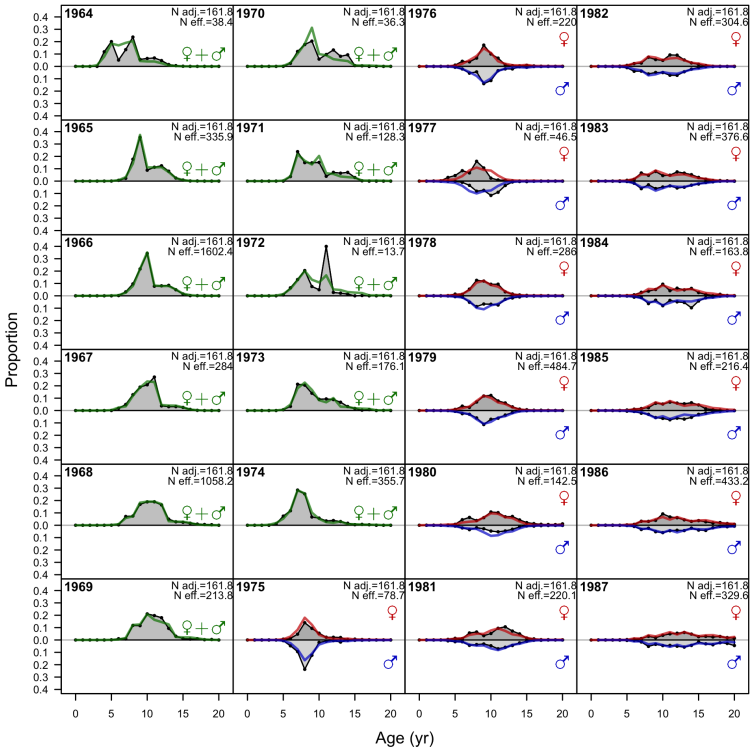
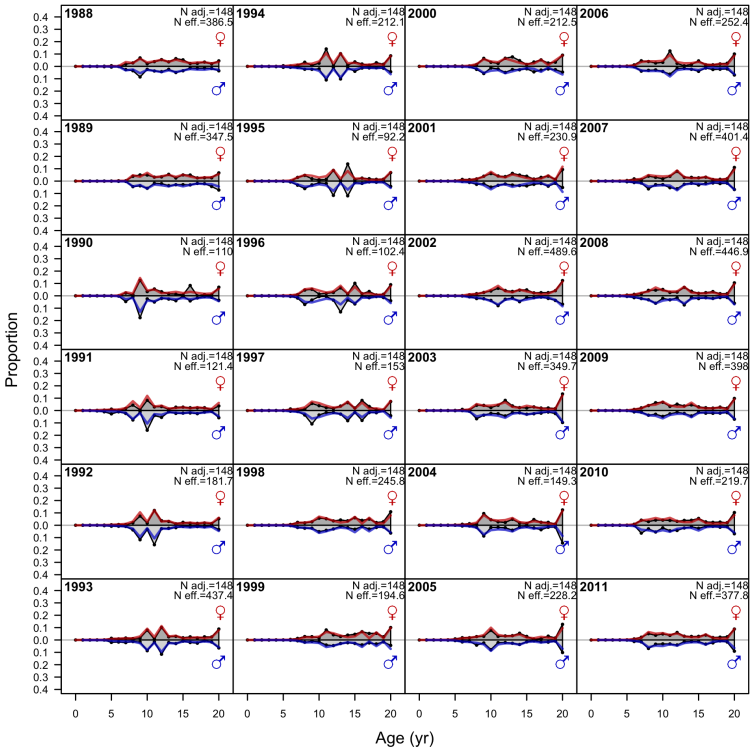
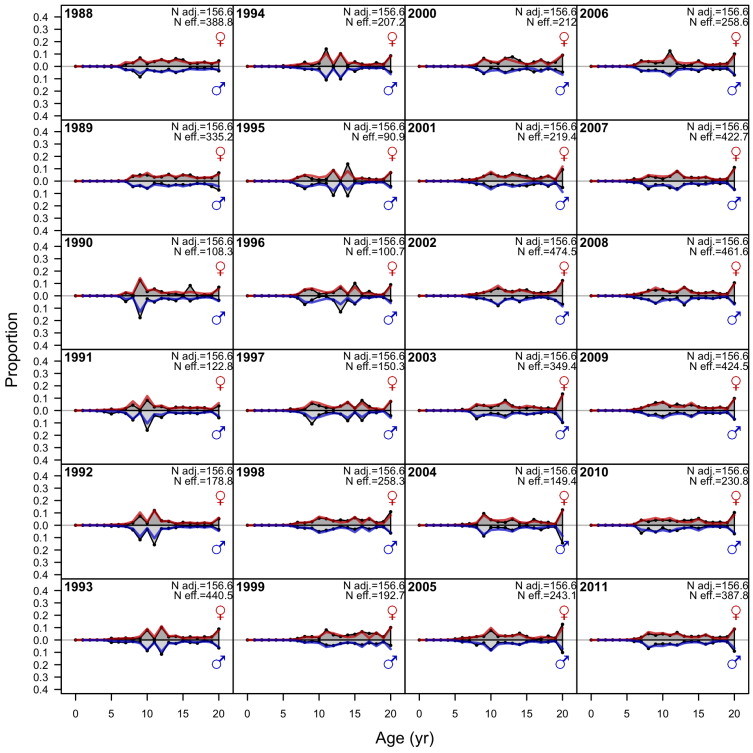


Figure 4.35: Fit to fishery age composition (1954 - 1987) Models 25.0, 25.0a, 25.0b.

Model 25.0



Model 25.0a



Model 25.0b

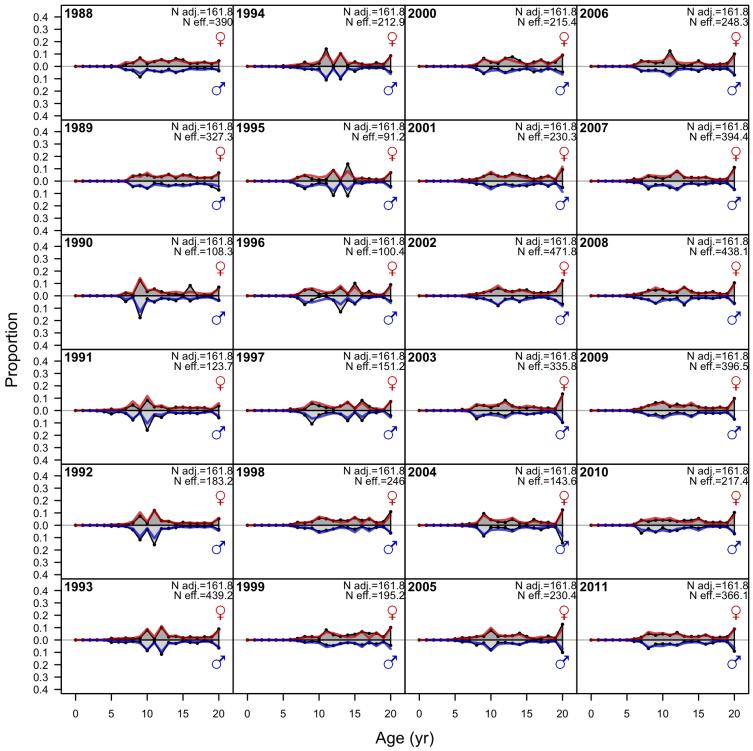
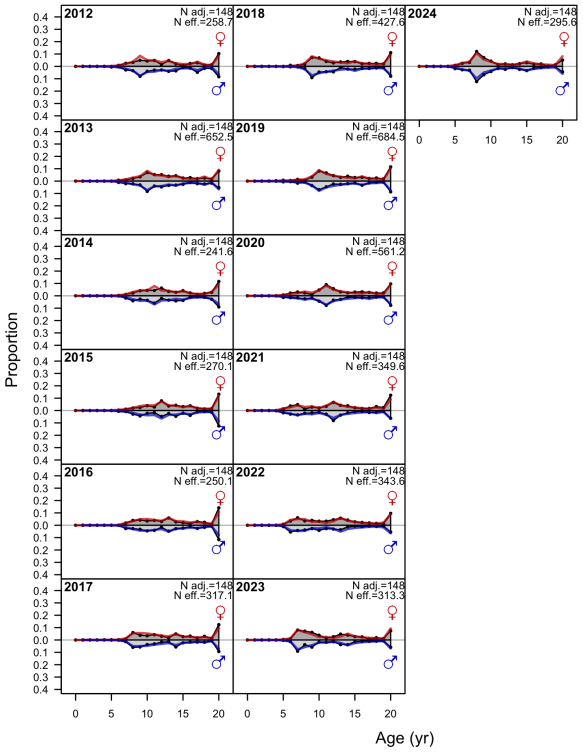
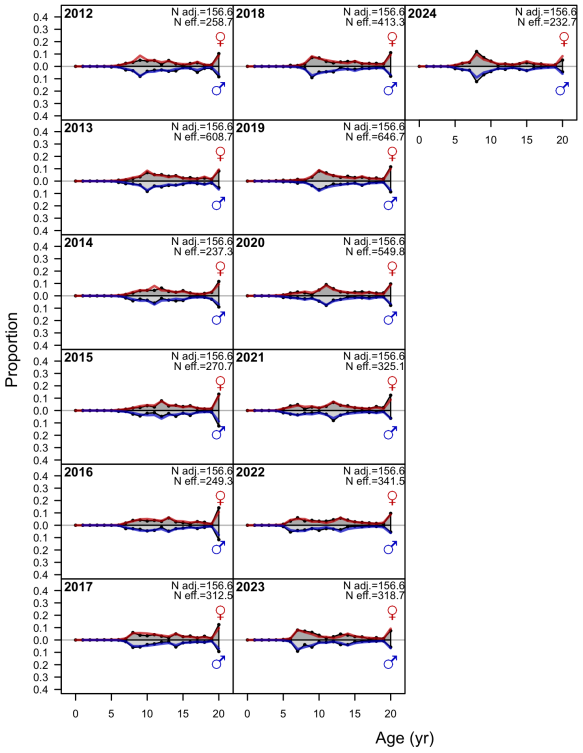


Figure 4.36: Fit to fishery age composition (1988 - 2011) Models 25.0, 25.0a, 25.0b.

Model 25.0



Model 25.0a



Model 25.0b

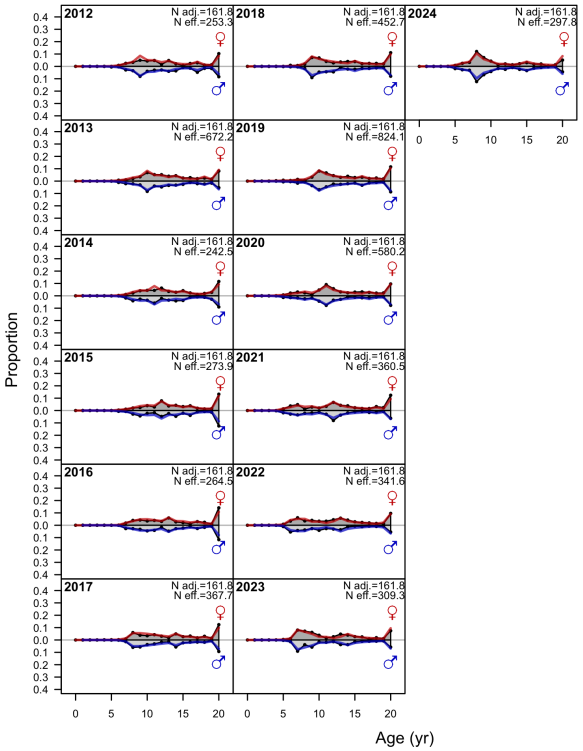
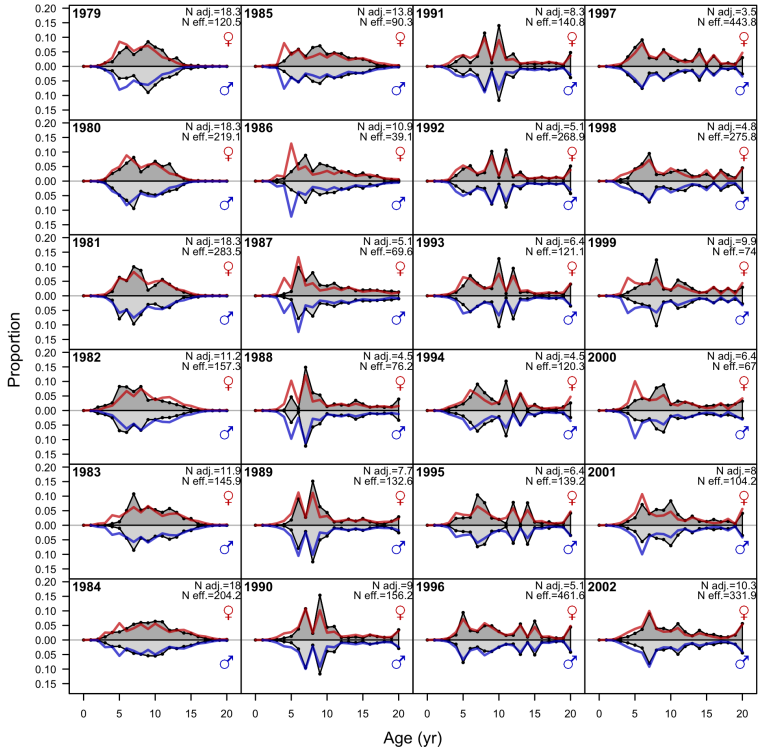
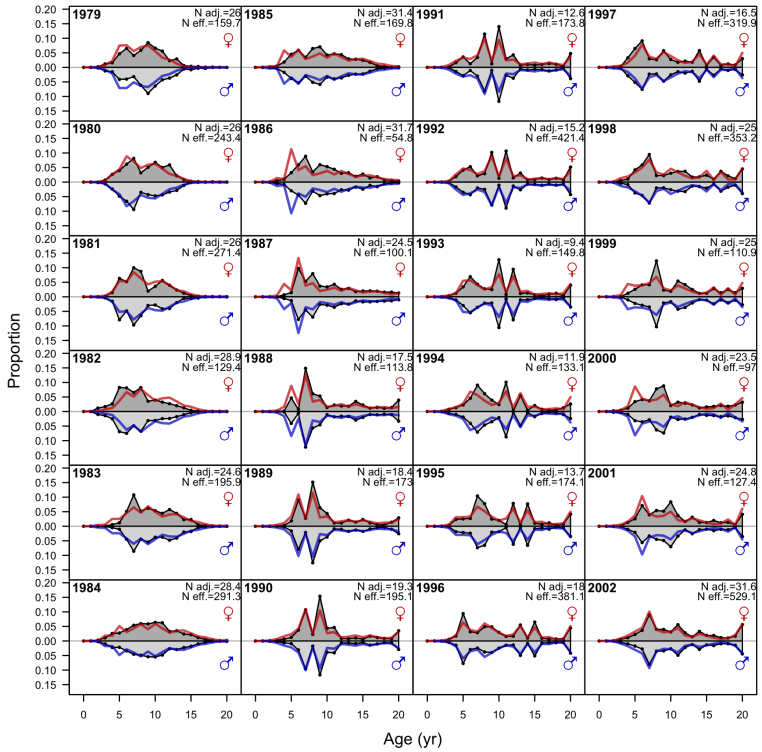


Figure 4.37: Fit to fishery age composition (2012 - 2024) Models 25.0, 25.0a, 25.0b.

Model 25.0



Model 25.0a



Model 25.0b

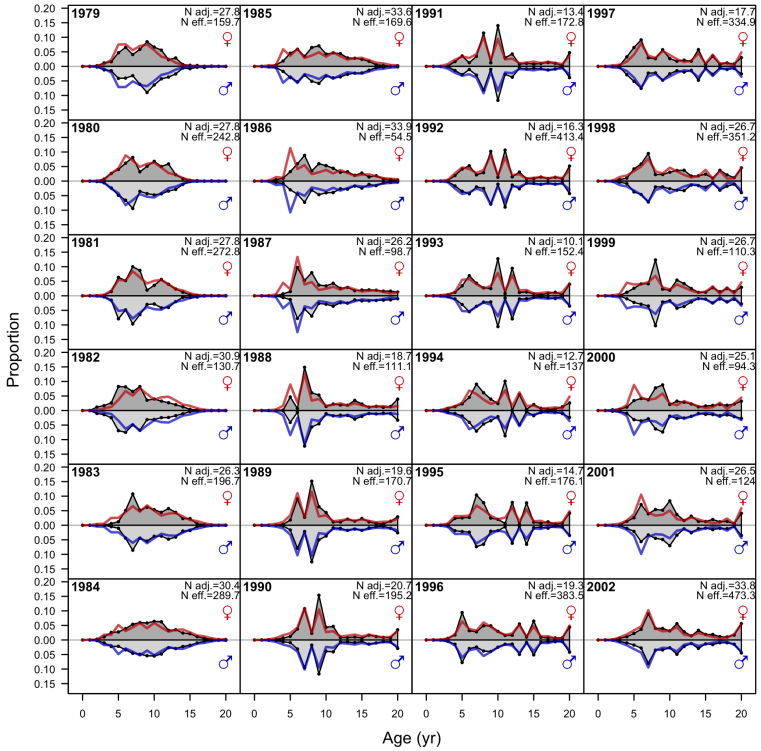
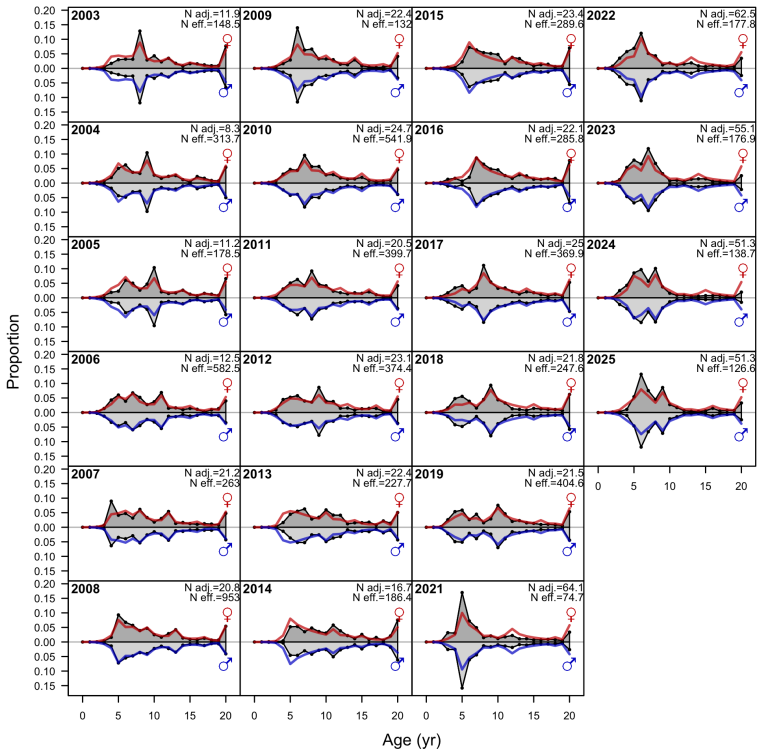
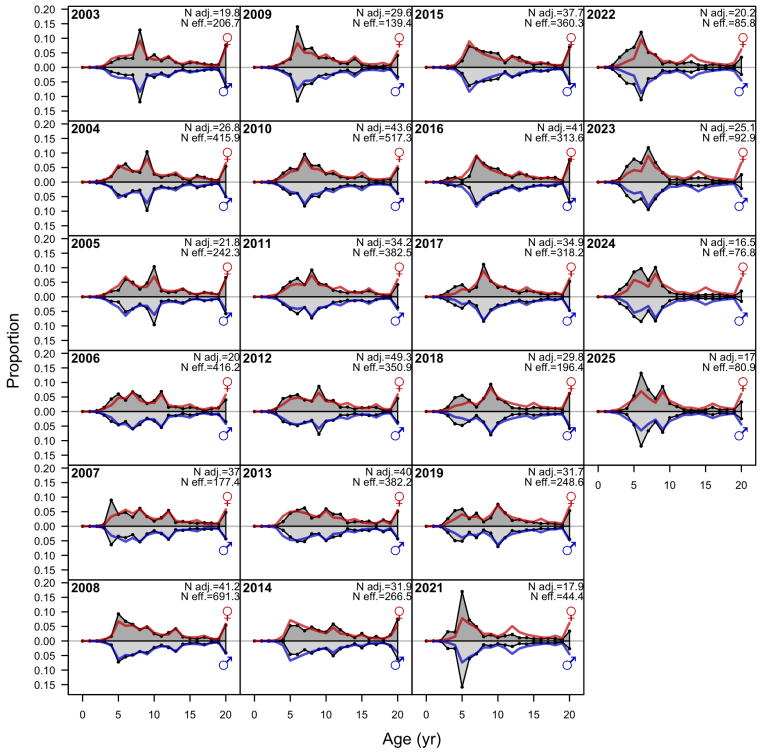


Figure 4.38: Fit to survey age composition (1979 - 2002) Models 25.0, 25.0a, 25.0b.

Model 25.0



Model 25.0a



Model 25.0b

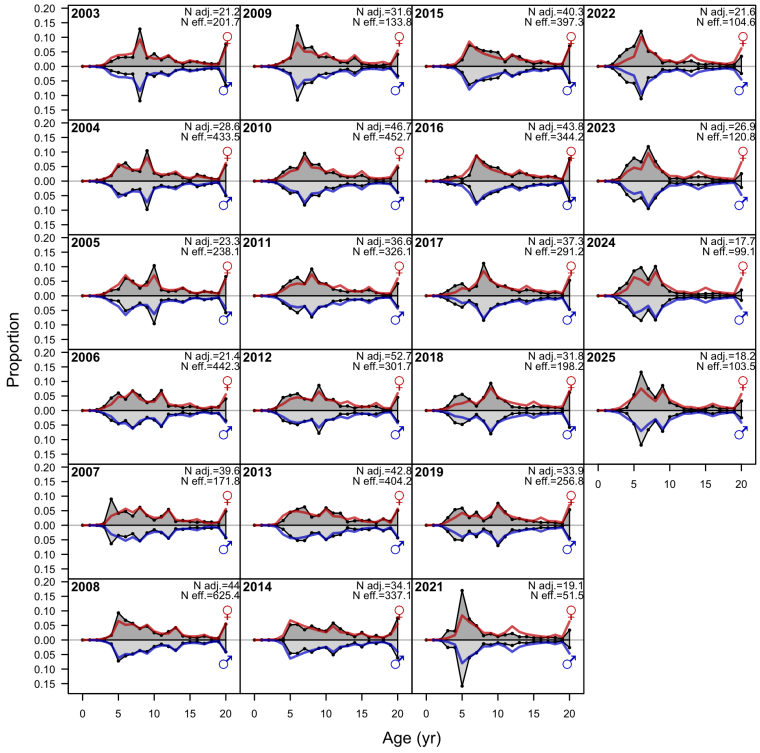


Figure 4.39: Fit to survey age composition (2003 - 2026) Models 25.0, 25.0a, 25.0b.

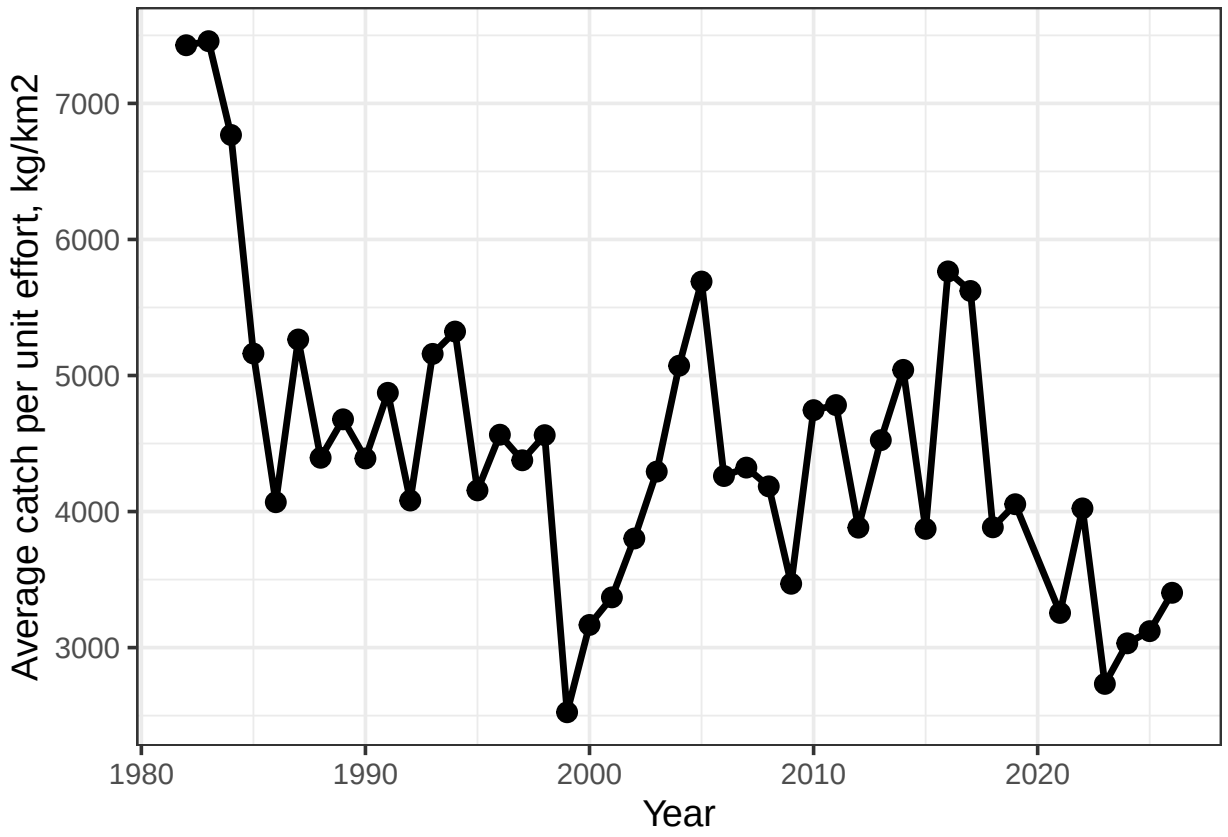


Figure 4.40: Average catch per unit effort on NMFS eastern Bering Sea surveys, 1987-2026, in kg/km2.

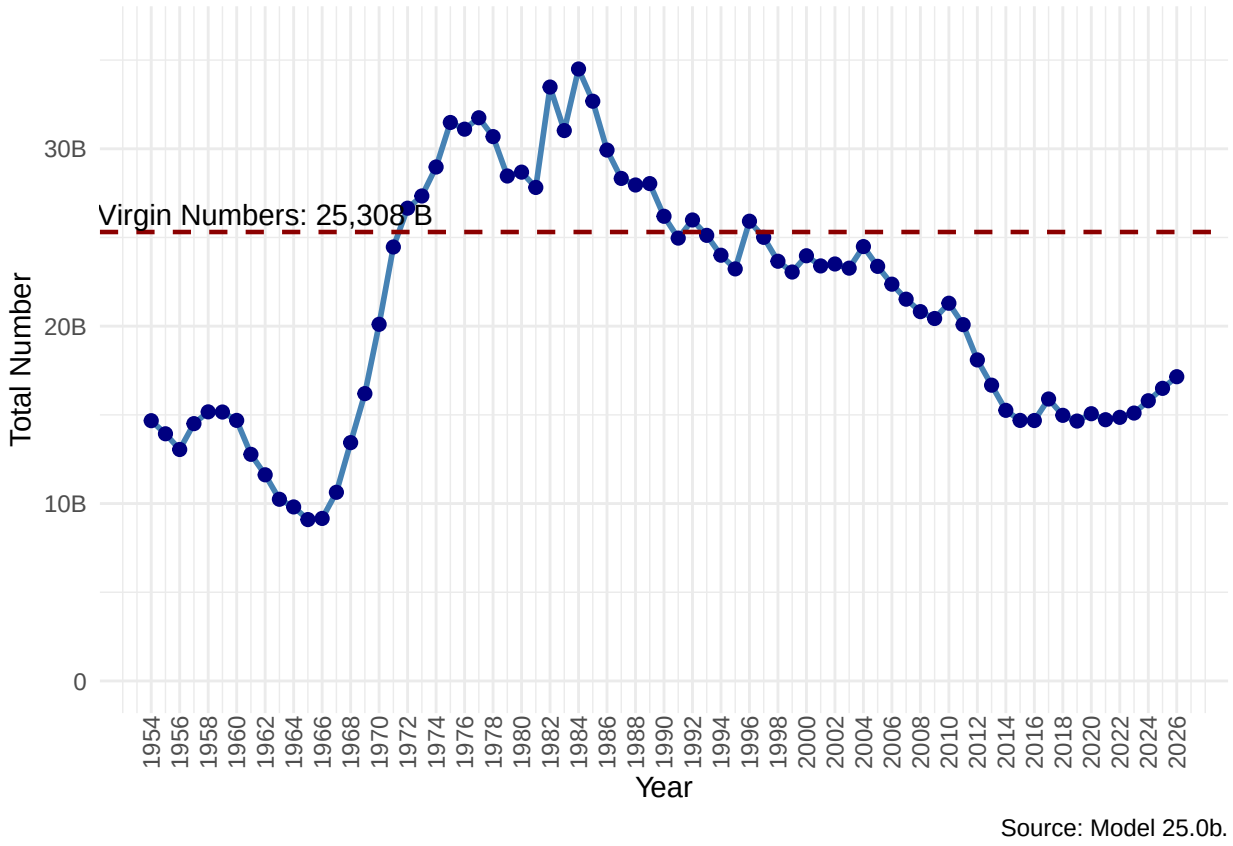


Figure 4.41: Estimated total numbers of yellowfin sole (ages 1-20), 1954 - 2026. Estimate of total number associated with virgin biomass is presented as a horizontal line.

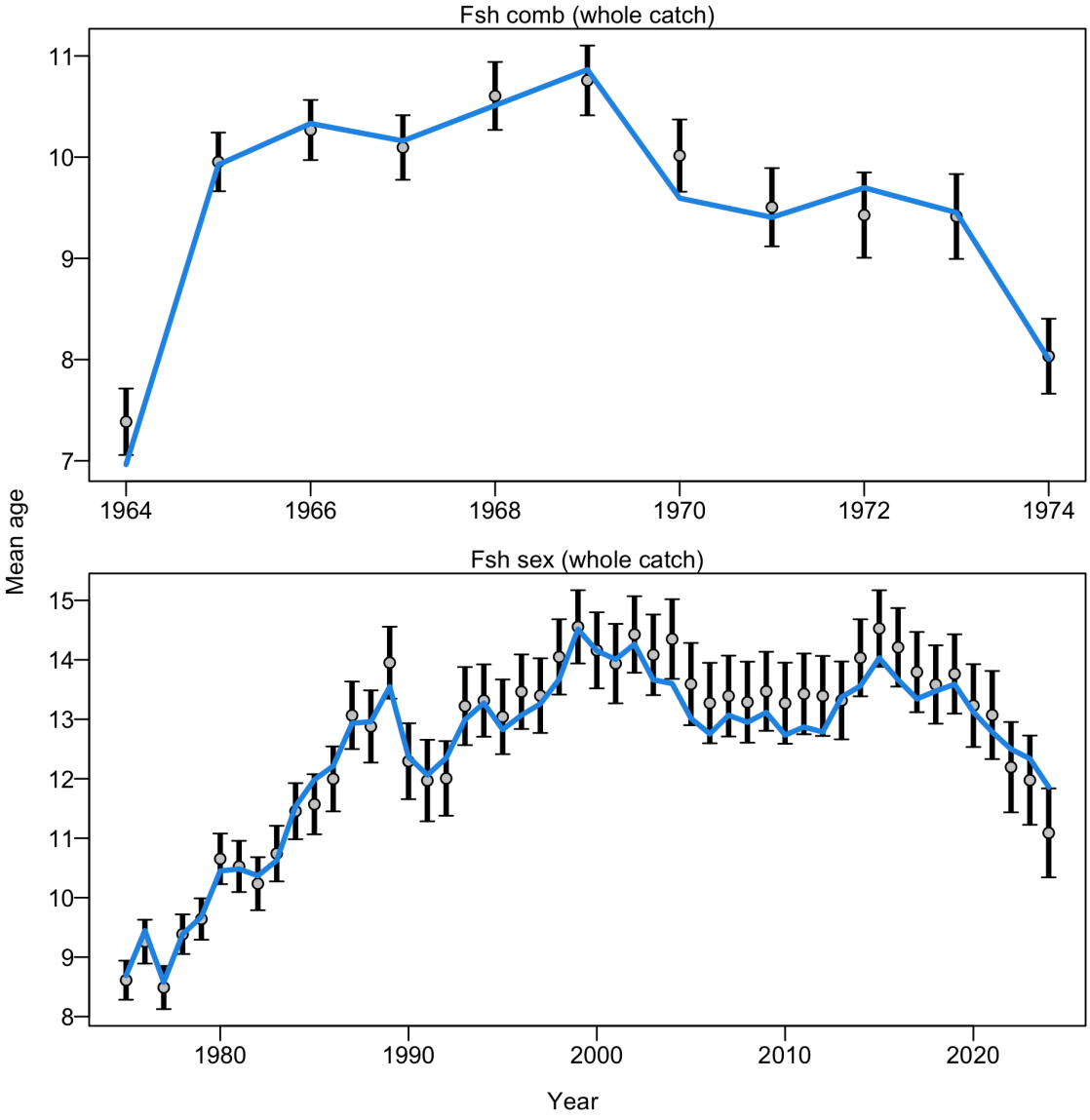
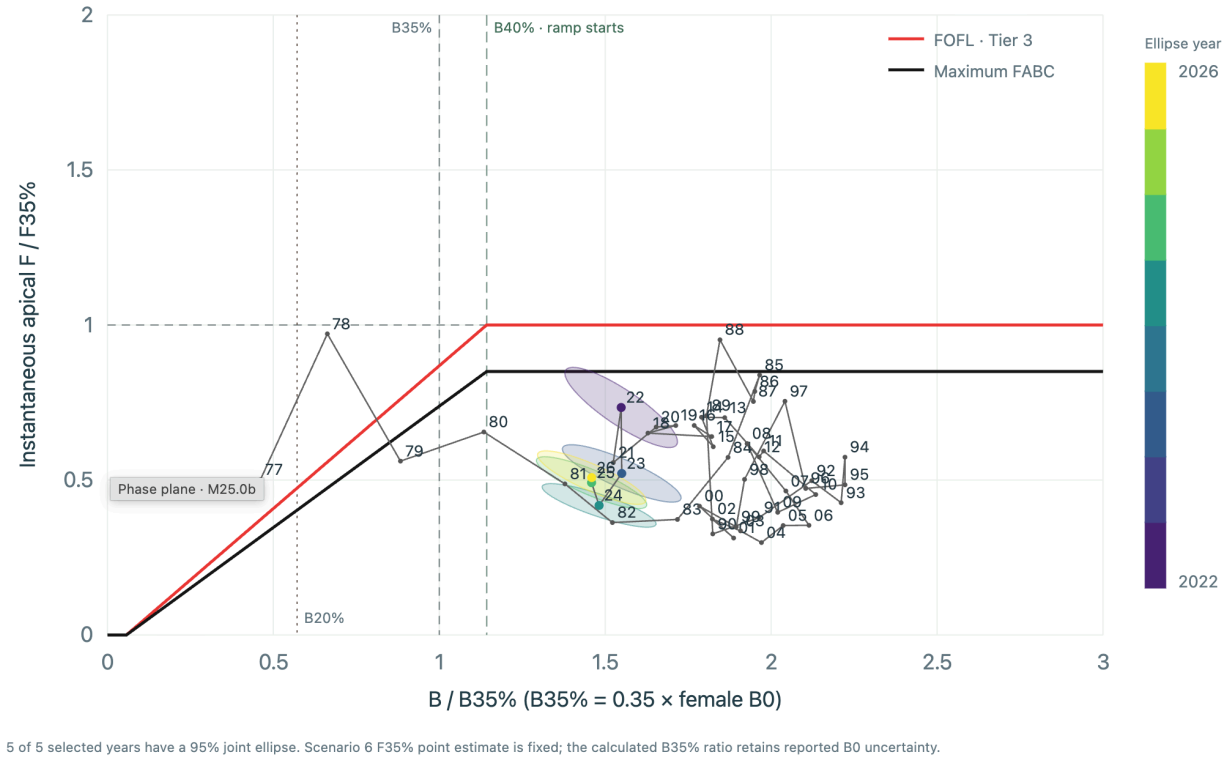


Figure 4.42: Mean fishery age with 95% confidence intervals, Model 25.0b.



5 of 5 selected years have a 95% joint ellipse. Scenario 6 F35% point estimate is fixed; the calculated B35% ratio retains reported B0 uncertainty.

Figure 4.43: Phase plane plot for Model 25.0b with 95% joint uncertainty ellipses colored by year for 2022-2028.

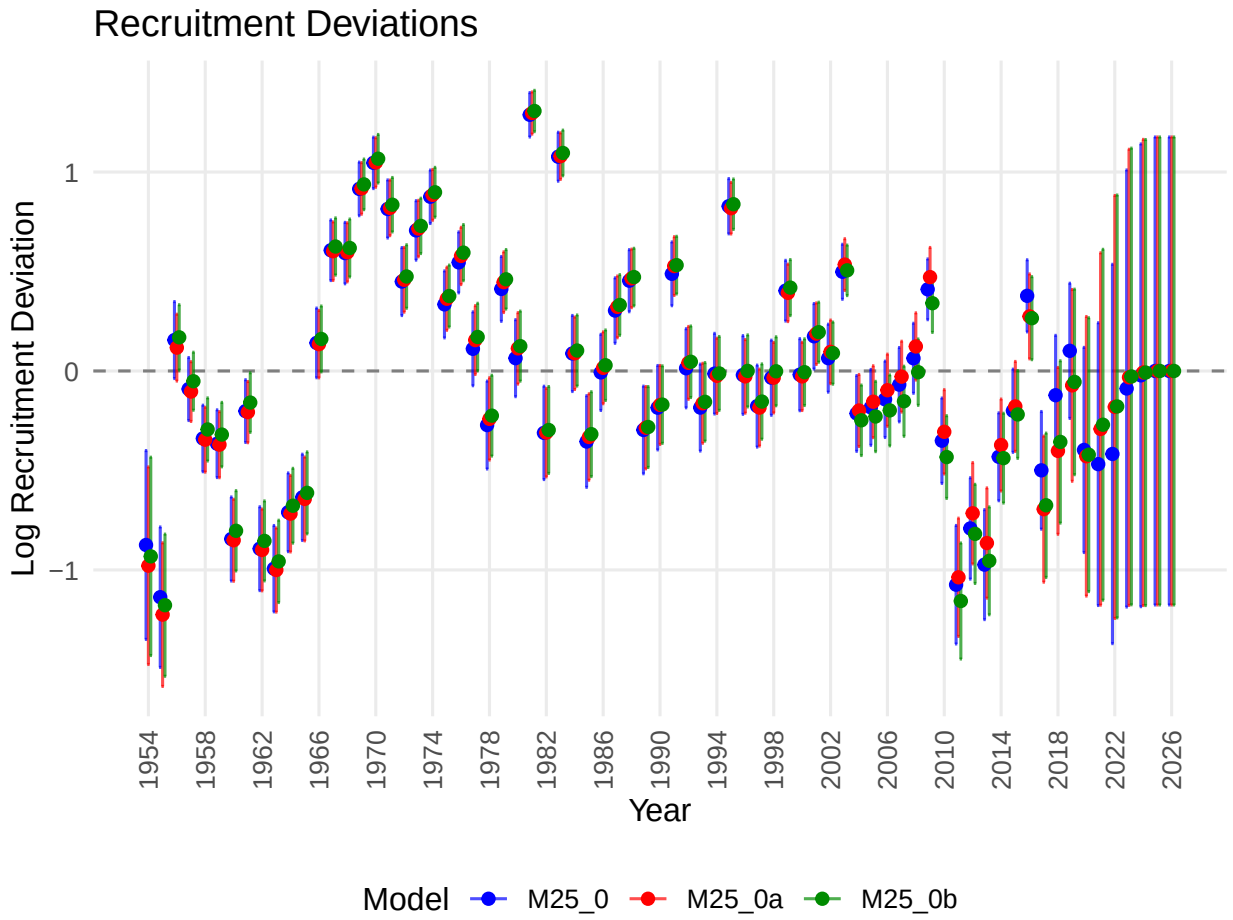


Figure 4.44: Age 1 recruitment deviations estimated by the stock assessment models (25.0, 25.0a, and 25.0b).

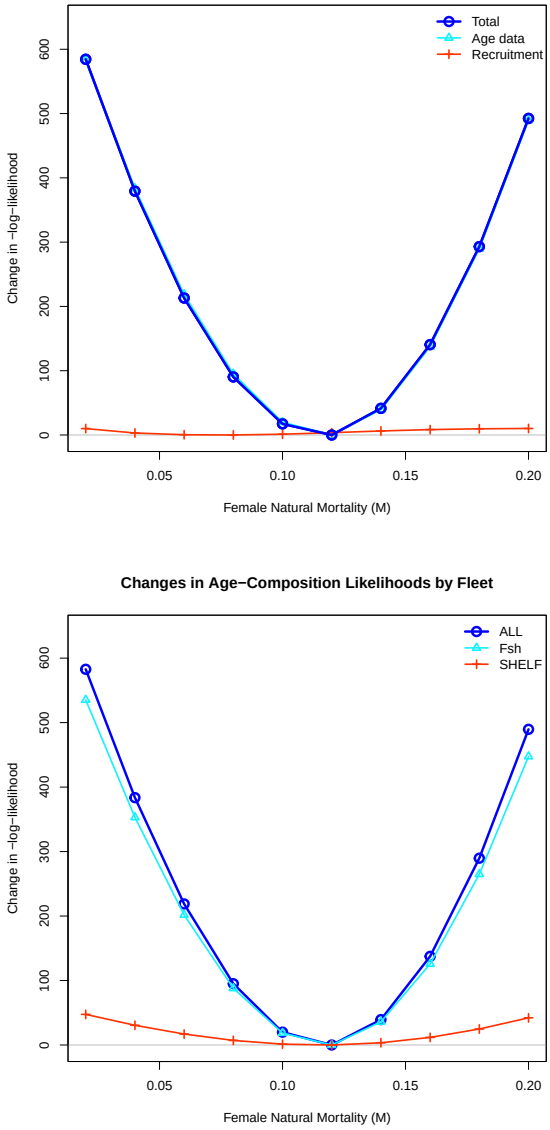


Figure 4.45: Likelihood profile for female natural mortality in Model 25.0b, above, and Piner plot below. Profiles were performed with male natural mortality fixed at its MLE of 0.132.

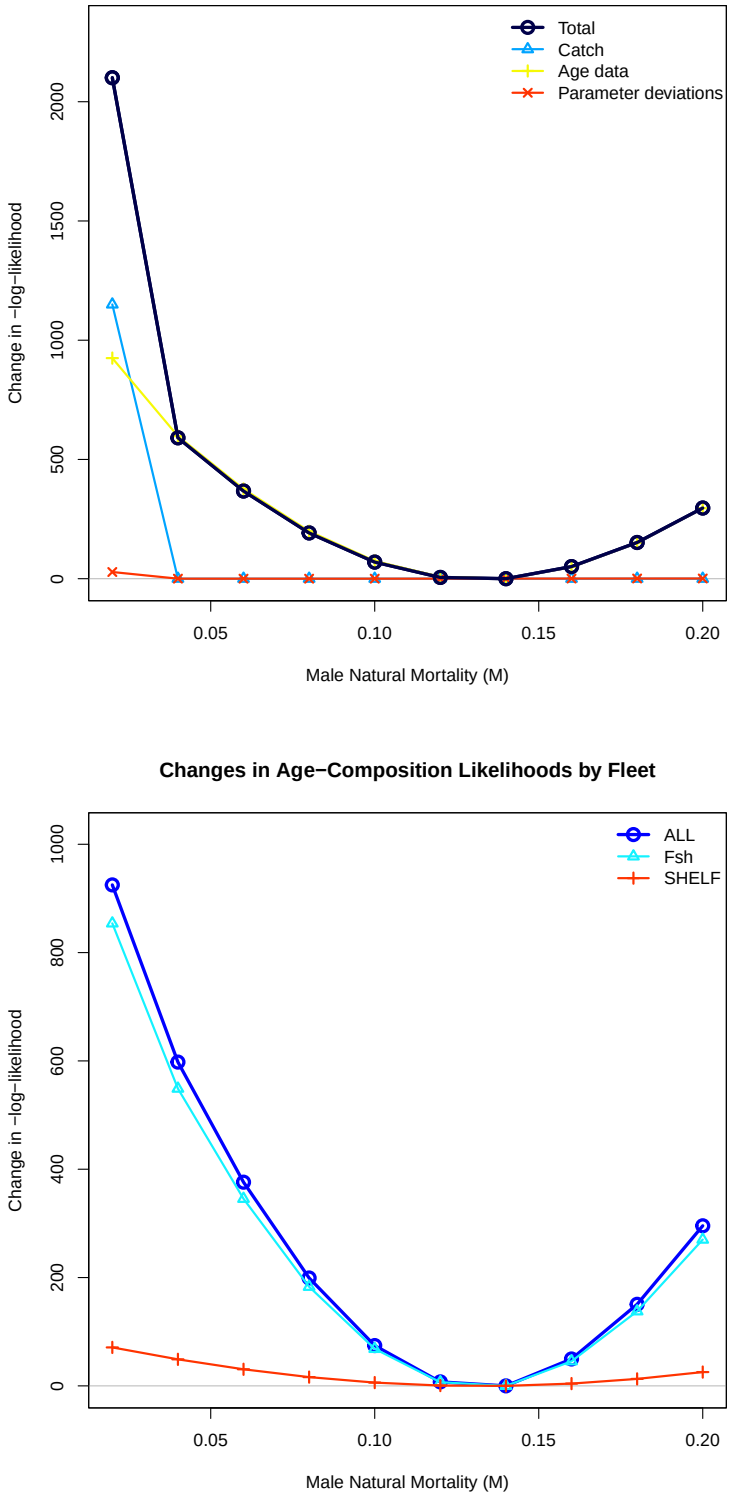


Figure 4.46: Likelihood profile for male natural mortality in Model 25.0b, above, and Piner plot below. Profiles were performed with female natural mortality fixed at 0.12.

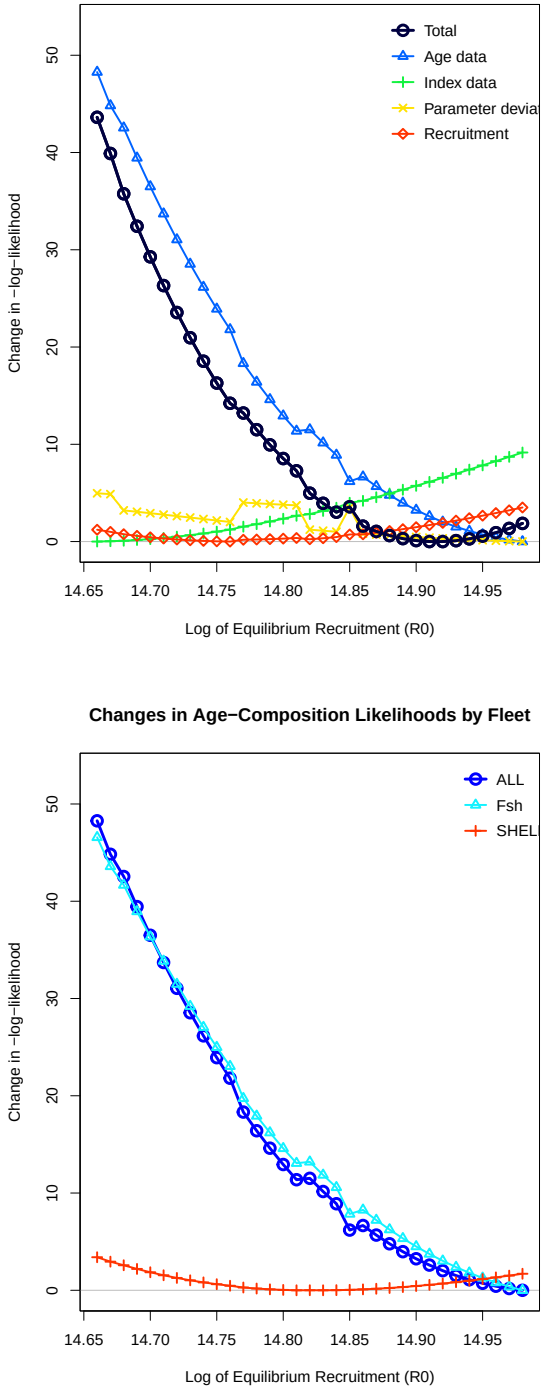
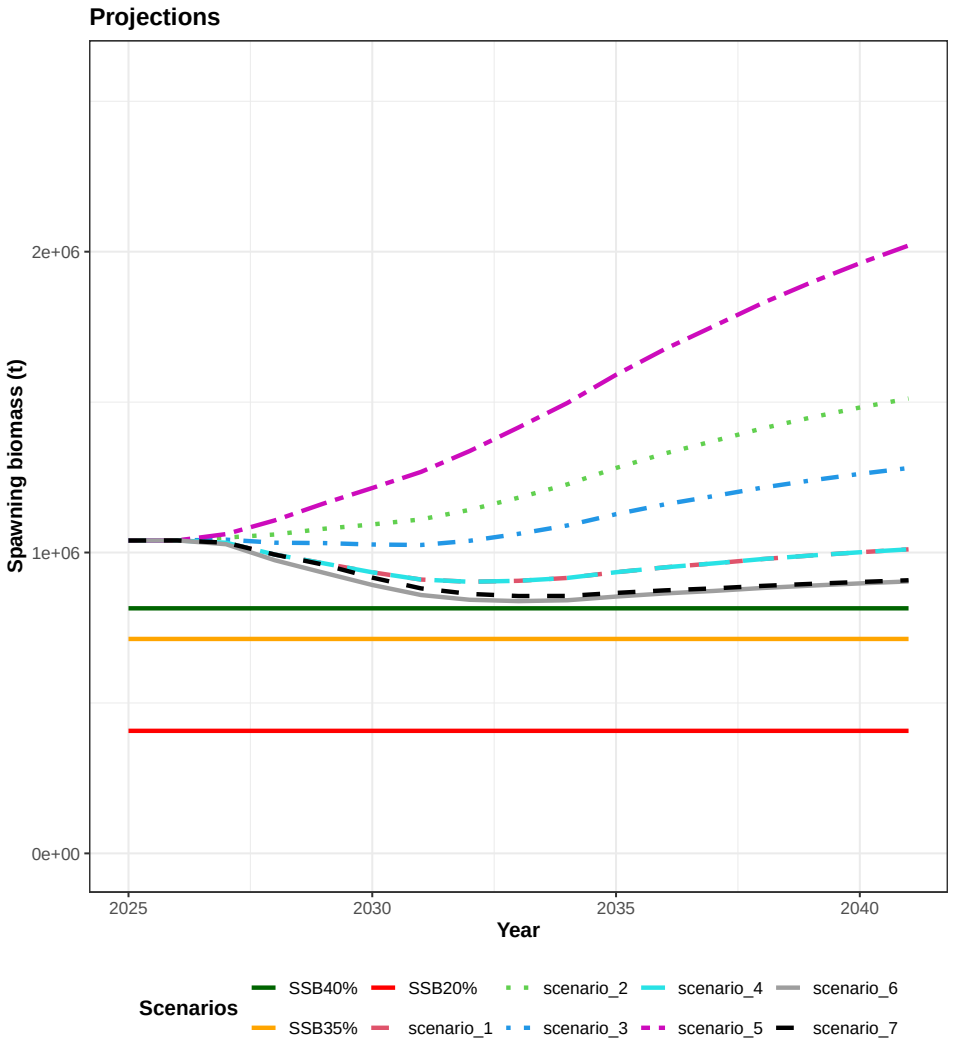


Figure 4.47: Likelihood profile for log initial recruitment in Model 25.0b, above, and Piner plot below. The MLE for this parameter is 14.912.


Projections
Spawning biomass (t)
2e+06
1e+06
0e+00
2025
2030
2035
2040
Year
Scenarios
SSB40%
SSB20%
scenario_2
scenario_4
scenario_6
SSB35%
scenario_1
scenario_3
scenario_5
scenario_7

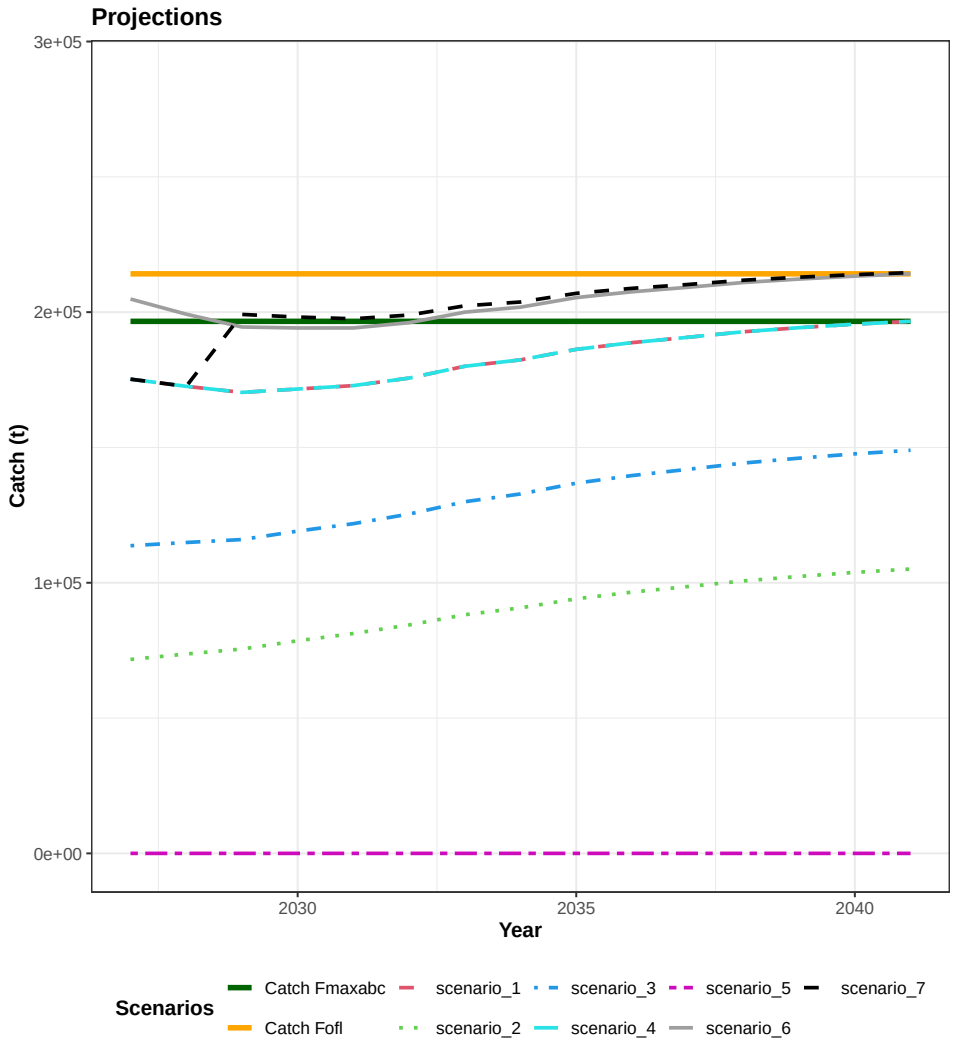


Figure 4.48: Female spawning biomass (t) (above), and projected catch (t) (below) for the seven North Pacific projection scenarios from Model 25.0b.