

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 2023 Bering Sea and Aleutian Islands (BSAI) SAFE report.

Changes in the data

1. The model-based survey age compositions were updated with data through 2023, and mean survey weight at age was added for 2023.
2. The estimate of the total catch made through the end of 2023 was updated, and the 2024 catch was extrapolated based on the catch through October 1, and the mean proportion caught for the remainder of the year over the past 5 years.
3. The 2024 model-based estimate of the combined EBS and NBS NMFS survey biomass and standard error (1982-2024) were used.

Changes in the assessment methods

There has been no change in the assessment methodology since 2023.

Summary of Results

The model presented in this assessment includes interpolated survey bottom temperature within the summer bottom trawl area < 100 m as a covariate on survey catchability, as well as National Marine Fisheries Service eastern Bering Sea survey start date and the interaction of start date and temperature (Nichol et al. 2019). Female natural mortality was fixed at 0.12 while allowing the model to estimate male natural mortality. The model uses model-based vector autoregressive spatio-temporal (VAST) survey indices and age compositions from the combined EBS and NBS survey areas.

In the eastern Bering Sea (EBS) bottom trawl survey conducted in 2024, the EBS yellowfin sole model-based biomass estimate was 7% higher than estimated for 2023, at 2,022,780 t. Spawning biomass estimated by Model 23.0 for 2025 was $1.56 * B_{MSY}$. The 2025 B_{MSY} was 479,711 t and female spawning biomass was 748,076 t. Therefore, yellowfin sole continues to qualify for management under Tier 1a. The 1978-2018 age-1 recruitments and the corresponding spawning biomass estimates were used to fit the stock recruitment curve and determine the Tier 1 harvest recommendations. Tier 3 estimates were also calculated, which is typical for this assessment. This assessment updates last year's model with total and spawning biomass estimates for 2025 that are lower than the 2023 estimates for 2025. This year's recommended ABC and OFL are lower than the 2023 assessment, coincident with decreased estimates of total and spawning biomass.

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| Quantity | As estimated or <i>specified</i> <i>last</i> year for: | | As estimated or <i>recommended</i> <i>this</i> year for: | |
|---------------------------------------|---|-------------|---|-------------|
| | 2024 | 2025 | 2025 | 2026 |
| M (natural mortality rate) | 0.12, 0.125 | 0.12, 0.125 | 0.12, 0.128 | 0.12, 0.128 |
| Tier | 1a | 1a | 1a | 1a |
| Projected total (age 6+) biomass (t) | 2,512,810 t | 2,616,800 t | 2,308,550 t | 2,353,240 t |
| Projected female spawning biomass (t) | 881,640 t | 857,354 t | 748,076 t | 758,695 t |
| B_0 | 1,516,980 t | 1,516,980 t | 1,383,020 t | 1,383,020 t |
| B_{MSY} | 539,657 t | 539,657 t | 479,711 t | 479,711 t |
| F_{OFL} | 0.121 | 0.121 | 0.13 | 0.13 |
| $maxF_{ABC}$ | 0.106 | 0.106 | 0.114 | 0.114 |
| F_{ABC} | 0.106 | 0.106 | 0.114 | 0.114 |
| OFL (t) | 305,298 t | 317,932 t | 299,247 t | 305,039 t |
| $maxABC$ | 265,913 t | 276,917 t | 262,557 t | 267,639 t |
| ABC (t) | 265,913 t | 276,917 t | 262,557 t | 267,639 t |
| Status | 2022 | 2023 | 2023 | 2024 |
| 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 74,288 t in 2024 and 116,803 t used in place of maximum ABC for 2025. This estimate was based on the mean catch over the past 5 years, 2020 - 2024, which includes the extrapolated catch of 74,288 t for 2024.

Catch of yellowfin sole as of October 1, 2024 in the Bering Sea and Aleutian Islands was 59,044 t. Over the past 5 years (2019 - 2023), approximately 79.5% of the catch has taken place by this date. Therefore, the full year's estimate of catch in 2024 was extrapolated to be 74,288 t. This is lower than the average catch over the past ten years, 123,905 t. For projections, future catch for the next 10 years, 2025 - 2034, was estimated to be the mean of the catch from the past five years, 2020 - 2023, and the extrapolated full year's catch for 2024, which resulted in an estimate of 116,803 t, used in place of maximum ABC for 2025.

Yellowfin sole female spawning biomass continues to be above B_{MSY} and the annual harvest remains below the ABC level. Management quantities are given in the results summary table for the 2023 accepted model (Model 23.0) with data through 2024. The projected estimate of total biomass for 2025 was lower by 12% from the 2023 assessment of 2,616,800 t, to 2,308,550 t. The model projection of spawning biomass for 2025, assuming catch for 2024 as described above, was 748,076 t, 13% lower than the projected 2025 spawning biomass from the 2023 assessment of 857,354 t. The 2025 and 2026 ABCs using F_{ABC} from this assessment model were lower than last year's 2025 ABC of 276,917 t; 262,557 t and 267,639 t. The 2025 and 2026 OFLs estimated by Model 23.0 were 299,247 t and 305,039 t.

All Risk Table elements were rated as level 1, "No concern". There were no recommended reductions in ABC.

Responses to SSC and Plan Team comments on Assessments in General

SSC October 2023

When there are time-varying biological and fishery parameters in the model, the SSC requests that a table be included in the SAFE that documents how reference points are calculated.

Response

This table has been included (Table 4.1), and calculation of reference points with time-varying parameters is included in the Analytical Approach section.

SSC October 2023

The SSC is encouraged by the development of One-Step-Ahead (OSA) residuals as an improvement to Pearson residuals for assessing fits to compositional data. The SSC welcomes a presentation on their use

and interpretation, as well as a discussion of how to select one age to remove from the calculation. The SSC recognizes that the first and last age in many assessments prove challenging to fit, and therefore are the target of specific evaluation of residuals, making it problematic to remove them. The SSC encourages exploration of alternative approaches that may include calculating the OSA residuals with multiple ages removed one at a time and/or adding a compositional bin (e.g., age-1 if the first age with appreciable data is age-2). Another approach to consider would be a two-step process, producing the OSA residuals with the youngest age removed, then using those residuals to identify the best fitting age, then removing that age in the next step.

Response

For consistency, all authors at the AFSC remove the last age/length bin, which provides consistency with other NOAA stock assessment groups. Misfit in the dropped bin is still present in the residuals, but active research is ongoing for best practices for OSAs with composition data at the AFSC. We plan to continue with this approach until research indicates otherwise. OSA residuals are included in this assessment.

SSC December 2023

The SSC reiterates that only fishery performance indicators that provide some inference regarding biological status of the stock should be used. SSC recommendation #5 from page 34 of the June 2021 SSC report states: “The SSC recommends that the fishery/community performance column should focus on information that would inform the biological status of the resource (e.g., an unexplained drop in CPUE that could indicate un-modelled stock decline, or a spatial shift indicating changes in species’ range), and not the effects of proposed ABCs on the fishery or communities or bycatch related considerations. The SSC recognizes that the community impact information is critical for informed decision making for TAC setting and recommends this information be included in other Council documents. . .”. Examples of useful indicators include CPUE, fishery spatial and temporal patterns, and catches of thin or unhealthy fish (i.e., poor condition).

Response

Noted.

SSC December 2023

When risk scores are reported, the SSC requests that a brief justification of the score be provided, even when that score indicates no elevated risk.

Response

Noted.

Responses to SSC and Plan Team comments specific to this assessment

SSC December 2023

The SSC requests that the authors update the Analytical Approach section of the SAFE document to clearly describe both (1) how sex-structured population dynamics are represented within this model including assumptions about the sex ratio at recruitment, and (2) describe the likelihood functions that are used to fit this model to data and specifically whether the survey and fishery age composition proportions are assumed to sum to 1.0 across ages within sexes or across ages and sexes. The SSC suggests that greater transparency in methods will help identify how much information on sex ratio at age is being provided to the model.

Response

This has been provided in the Analytical Approach section.

SSC December 2023

The SSC supports the November 2023 BSAI GPT recommendations for the author to conduct a model sensitivity analysis to evaluate the current approach used for natural mortality. The SSC suggests an evaluation of whether it is possible to estimate sex-specific natural mortality, and an evaluation of whether this approach is a significant improvement overestimating a single natural mortality for both sexes.

Response

This will be conducted in a future assessment.

SSC December 2023

The SSC recommends that the author examine and reconcile (if necessary) the seeming contradiction in body conditions between the weight at age matrix in the assessment and the body condition metric presented for the risk table.

Response

Yellowfin sole length-weight residuals have been declining in the northern Bering Sea since 2019 but are above average (overall) in the EBS, based on 2024 data. In the EBS, even though overall the residuals are positive, they are negative in strata 20 which is the northern part of the southern inner domain, which aligns with YFS condition being negative in the northern shelf. Weight at age of yellowfin sole taken by the EBS survey has been increasing over time, which translates to faster growth. Therefore, faster growth and positive length-weight residuals are present in the EBS, but negative length-weight residual appear in the NBS. The NBS survey is a shorter time series, so anomalies may not be as reliable as for the EBS survey (Figure 4.1).

SSC December 2023

The SSC recommends the author investigate (or provide discussion of) the sharp decline in the size of the 2017-year class.

Response

The 2017 year class is still apparent in 2023 survey ages and does not appear to have experienced a sharp decline (Figure 4.2). The fishery is unlikely to select this year class until approximately 2024 (not yet aged) or 2025.

SSC December 2023

The SSC notes time-varying fisheries selectivity is modeled beginning in 1954. Time-varying selectivity should only be modeled for periods with informative data in the assessment.

Response

The authors acknowledge this as a target for consideration of a future model change. Catch estimates are available starting in 1954 but not weight or age data.

SSC December 2023

The SSC requests documentation of the early catch-at-age data used in the assessment. The data availability table in the document indicates that the fishery catch-at-age data begin in 1964, but the data tables only show catch-at-age data starting in 1975. Older catch-at-age data should be removed if it cannot be documented.

Response

Table 4.2 provides catches starting in 1954. The data availability table has been corrected to begin fishery catch-at-age data at 1975.

SSC December 2023

The SSC supports the transition to the stock synthesis platform for yellowfin sole but notes that the data available for the yellowfin sole stock assessment is perhaps the best in the world, making yellowfin sole a good test bed for advanced modeling techniques.

Response

Noted.

SSC December 2023

The VAST model for the Northern + Eastern Bering Sea was included in the yellowfin sole assessment in 2022. Since VAST accounts for an unsurveyed portion of the population, the SSC requests that the temperature-dependent catchability relationship be rechecked to confirm that the relationship is still significant and in the same direction as before.

Response

We included a model without the environmental covariates on survey catchability for comparison to check whether it still provides a better fit to the data. The model with the environmental covariates on catchability still provided a better fit to the data (AIC=2957.58 and 386 parameters with environmental covariates, AIC=3003.735 and 382 parameters without).

Introduction

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

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

Year-class strength of flatfishes is thought to be determined during the first few years of life between the pelagic egg and benthic settlement (van der Veer et al., 2015). Temperature in the early life stages can affect egg size, larval duration, size at settlement, as well as the size 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 reside in nearshore nursery grounds during months in which 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 due to their settlement timing, relative to northern rock sole, which seems to be sensitive to temperature. Yellowfin sole settle later in summer, when the influence of the cold pool is weaker and nearshore bottom temperature is relatively stable and high (Yeung and Yang, 2018). In contrast, yellowfin sole migrate across the shelf to spawn near their nursery habitat, rather than relying on currents for larval transport to nursery habitat (Nichol and Acuna, 2001); therefore, their larvae may be less susceptible to variable 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 4.3). Yellowfin sole are managed as a single stock in the BSAI management area as there is presently no direct evidence of stock structure.

Fishery

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 in 1959 - 1962 when catches averaged 404,000 t annually (Figure 4.4, top panel). Catch is typically taken throughout the Bering Sea shelf, as far north as 65°N and low to negligible amounts are taken in the Aleutian Islands (Figure 4.5). 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 continued to dominate through 1984. However, U.S. fisheries developed rapidly during the 1980s in the form of joint ventures, and during the last half of the decade began to dominate and then take all of the catch as the 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 directly allocated fishery resources among BSAI trawl harvesters in consideration of their historic harvest patterns and future harvest 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, fish are processed with heads and viscera removed) vessels and also by providing the ability to form cooperatives within the newly formed Amendment 80 sector. In addition, Amendment 80 also mandated additional 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, no mixing of hauls and no on-deck sorting. The partitioning of TAC (total allowable catch) and PSC (prohibited species catch) among cooperatives has significantly changed the way the annual catch has accumulated (Figure 4.4, lower panel) and the rate of target catch per bycatch ton. There is now a more even and slow attainment of the annual catch 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 environmental standard for sustainable and well-managed fisheries. The certification also applies to all the major flatfish fisheries in the BSAI and GOA.

In 2011, federally permitted vessels using non-pelagic trawl gear whose harvest resulted in flatfish retained catch that was 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 the management action was to reduce damage of non-target animals, particularly those that form habitat structure or support other fisheries while not 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 to Japan, US, and Europe as fillets, among other countries (AFSC 2016). The 1997 catch of 182,814 t (retained and discarded) was the largest since the fishery became completely domestic, but decreased from 1998–2010, averaging 94,004 t (Table 4.2, Table 4.3). From 2011–2014 the catch increased, averaging 155,000 t. The 2013 catch totaled approximately 182,814 t (73% of the ABC), and was the highest annual catch since 1988. Catches have declined since 2013 and the average catch over the past ten years was 123,905 t. The full year's estimate of catch in 2024 was 74,287 t. This estimate was based on catch data downloaded October 1, 2024, and projected forward through the remainder of the year. This estimate represents 26.83% of the 2023 ABC.

Length distributions of yellowfin sole throughout NMFS areas 509, 513, 514, 516, 521, and 524 ranged from 20–50 cm, and were largest in the northern areas 514, 521, and 524 (Figure 4.6).

The CPUE shows a negative correlation with bottom temperature, with increased CPUE in 2022, which was a cooler/average year in the Bering Sea. This relationship does not appear to be strong in all years, including 2023 and 2024, in which temperature was lower but CPUE was down.

Bycatch of yellowfin sole takes place primarily in the directed rock sole fishery, followed by the flathead sole fishery, and smaller amounts in the pollock fisheries (Table 4.4). Catch by month and gear indicates that trawl catches were typically more inshore, while longline gear targeted yellowfin sole along the Bering Sea shelf (Figure 4.7, Figure 4.8). With both geartypes, some of the highest catches took place during spawning season (summer months).

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. Weight-at-age and proportion mature-at-age from studies conducted during the bottom trawl surveys were also used. Estimates of fishery weight-at-age were based on catch-at-age methodology used in the walleye pollock assessment (Ianelli et al. 2019), following Kimura (1989) and modified by Dorn (1992). Age reading capacity was limited in 2024, and new data this year includes 316 ages from the NBS survey, but no new ages for the 2023 EBS survey and no 2023 fishery ages.

| Data source | Year |
|---|--------------------------------|
| Fishery catch | 1954 - 2024 |
| Fishery age composition | 1975 - 2022 |
| Fishery weight-at-age | Catch-at-age methodology |
| Survey biomass and standard error | 1982 - 2024 (not 2020) |
| Bottom temperature | 1982 - 2024 |
| Survey age composition | 1979 - 2023 (not 2020) |
| Annual length-at-age and weight-at-age from surveys | 1979 - 2023 (not 2020) |
| Age at maturity | Combined 1992 and 2012 samples |

Fishery

Age Determination

Yellowfin sole ages have been determined at the AFSC by using the break and burn method on otoliths collected in surveys and from fisheries since 1979. In 2016 the age determination methods for yellowfin sole were validated using the bomb-produced uptake measurement of ^{14}C method (Kastelle et al. 2016). There have been an average of 721 fish aged on EBS trawl surveys since 1982 and 735 fish aged from fishery collections during that time period (Table 4.5). The number of hauls which from which otoliths have been taken from the survey has averaged 46 per year (Table 4.5).

Trends for males and female ages from the fishery indicate that the 2010 year class has been the dominant cohort and the 2015 age class may be entering the fishery as a new dominant cohort at age 7 (Figure 4.9). Survey age data shows a different trend, likely due to higher survey selectivity at younger ages. Survey age data indicates an extremely strong 2017 year class has appeared (Figure 4.2) and persists through age data for 2023, and is expected to appear in fishery age data for 2024 or 2025.

Catch

This assessment uses fishery catch data from 1954-2024 (Table 4.2), and estimates fishery catch-at-age (proportions) from 1975 -2023 (Table 4.6). 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, fisheries managed under other FMPs are tabulated and presented in Table 4.7. Catch per unit effort calculated from fishery trawl data, based on the catch in kg and duration of the tow, does not indicate a strong upward or downward trend through the time series, 1996 - 2024 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.

Numbers at age

The proportion of length at age is taken from aged fishery otoliths. The fishery age composition has always been primarily composed of fish older than 9 years with a large amount of 20+ fish, although the proportion has declined from 90% over age 7 to 70% over age 7 since the 1970's (Table 4.6). The years 2021 and 2022 show the lowest proportions over age 7 (69%) while the most recent year of data (2023) shows an increase to 73%.

Weight-at-age

The fishery weight-at-age composition was based on the catch-at-age methodology of Kimura (1989) and modified by Dorn (1992), as implemented in the 2019 walleye pollock stock assessment (Ianelli et al. 2019). Length-stratified age data were used to construct age-length keys for each stratum and sex. These keys are then applied to randomly sampled catch length frequency data. This method was used to derive the age compositions from 1991–2022 (the period for which all the necessary information was readily available). The catch-at-age estimation method uses a two-stage bootstrap resampling of the data with 1,000 bootstraps. Observed tows were first selected with replacement, followed by resampling actual lengths and age specimens given that set of tows. This method allows an objective way to specify the effective sample size for fitting fishery age composition data within the assessment model. Estimates of fishery mean weights-at-age are a product of this analysis and these were used as input data to the model (Figure 4.11).

Maturity-at-age

Nichol (1995) estimated the age of 50% maturity at 10.5 years based on the histological examination of 639 ovaries collected from yellowfin sole females during the 1992 and 1993 eastern Bering Sea trawl surveys (Table 4.8). Maturity was re-evaluated from a histological analysis of ovaries collected in 2012 (Table 4.8). Results were very similar to the earlier study with only a 2% difference in estimates of yellowfin sole female spawning biomass (TenBrink and Wilderbuer 2015). The current maturity schedule uses estimates derived from both the 1992 and the 2012 collections (Table 4.8). For yellowfin sole sexual maturity occurs well after the age of entry into the fishery. Yellowfin sole females are 82% selected to the fishery by age 10 whereas they have been found to be only 40% mature at this age.

A new study was published in 2022 which provided a new analysis of the maturity-at-age schedule of 209 yellowfin sole samples taken from the northern Bering Sea (TenBrink 2022). The maturity curve resulting from this study was very similar to that of previous studies ($A_{50\%}$ 95% confidence interval: 9.47–10.76 years). This maturity curve was not incorporated into the 2024 assessment because samples were taken from the northern Bering Sea only, but this information may be incorporated into a future assessment model.

Survey*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., in review). Temperatures in 2024 were lower than in 2023 and slightly below the mean for the time series (Figure 4.10).

Length and Weight-at-Age

Sex-specific size at age used in the model is based on the length-weight relationships from the time-series of survey observations over all years since 1971. The use of empirical annual observed population mean weight-at-age (time-varying) from the trawl survey allows for time-varying (year effect on growth) in the age-structured stock assessment model. We have found that weight-at-age has increased over the time series, and the most recent estimates are among the highest observed (Figure 4.12). In the future, this relationship may be used to forecast growth patterns; however, the use of empirical weight at age provides the changes over time directly into the model.

Survey Biomass Estimates and Population Age Composition Estimates

Indices of relative abundance available from AFSC surveys showed high NMFS surveys biomass estimates in the 1980s (Table 4.9). 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 1982–2024 (Figure 4.13). The CPUE for 2024 was the third lowest in the time series, at 3,153 kg/km^2 . The lowest occurred in 1999, 2,524 kg/km^2 , which corresponded to the lowest survey biomass estimate for yellowfin sole in the eastern Bering Sea, and this year's estimate represents an increase from 2023.

Biomass estimates for yellowfin sole from the annual bottom trawl survey on the eastern Bering Sea shelf showed a doubling of survey biomass between 1975 and 1979 with a further increase to over 3.3 million t in 1981 (Table 4.10 and Figure 4.14). 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 an even trend at high levels of abundance for yellowfin sole, with the exception of the results from the 1999 and 2000 summer surveys, which were at lower levels. Surveys from 2001-2005 estimated an increase each year but the estimates since 2006 indicate a stable level with some annual variability. However, the 2012 estimate is a 19% decrease from 2011 and the 2013 and 2014 surveys have estimated a 17% increase over 2012. Similarly, there was a 24% decrease from 2014 to 2015 followed by a 48% increase from 2015 to 2016, the highest biomass estimate since 1984. Fluctuations of these magnitudes are unreasonable considering the elements of slow growth and long life span of yellowfin sole combined with low to moderate exploitation rate, characteristics which should produce more gradual changes in abundance (Table 4.9).

The 2024 EBS trawl survey estimate for yellowfin sole biomass was and increase from the 2023 estimate, which represented the second lowest from the time series. Overall, a declining pattern has been observed since 2016 (Table 4.9, Figure 4.14), in addition to a longer term declining pattern since 2005. Similarly, in the northern Bering Sea, yellowfin sole biomass estimates were the lowest in the time series in 2023 at 2,023 t (Table 4.11).

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 and has moved southward in 2024 (Figure 4.15). The VAST analysis 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 been declining since 2018 and the area occupied in the northern Bering Sea has been on a slowly increasing trend over most of the time series since 2000 (Figure 4.16).

Variability of yellowfin sole survey biomass estimates (Figure 4.14) 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. The coastal areas are sufficiently large enough to offer a substantial refuge for yellowfin sole from the current survey.

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 also 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 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. In the current year, 2024, survey biomass estimates were up for the EBS (Table 4.9, and there was no 2024 NBS survey Table 4.11). The combined EBS+NBS VAST estimate for 2024 resulted in a shift downward for the entire time series (Figure 4.18), which resulted in lower estimates of biomass and reference points.

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 in 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 4.18, Figure 4.19).

Yellowfin sole population numbers-at-age are estimated based on otolith collections from annual EBS bottom trawl surveys Table 4.12. The occurrence of yellowfin sole in trawl survey hauls and associated collections of lengths and age structures since 1982 have not changed significantly (Table 4.5). 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 4.7.

The survey age data from 2021 through 2023 indicate that the dominant age class was spawned in 2017 (Figure 4.2). This appears to be a significant age class that may have contributed to the increase in biomass in 2024.

Northern Bering Sea survey

Trawl survey sampling was extended to the northern Bering Sea in 2010, 2017, 2018, 2019, 2021, 2022, and 2023. The trawl surveys conducted in 2010, 2017, 2019, 2021, 2022, and 2023 occupied the same areas with similar sampling densities. 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. 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 shifts southward during recent years of cooler temperatures (Figure 4.15). The spatial distribution of the yellowfin sole stock in the eastern and northern Bering Sea appears continuous, and the survey data from the region occupied by the entire population has been included since 2022.

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 was no Norton Sound survey in 2022.

VAST abundance

The software versions of dependent programs used to generate model-based estimates were equivalent or later than these minimum standards: R (4.0.2), MKL libraries via Microsoft R Open (4.0.2), INLA (21.11.22), Matrix (1.4-0), TMB (1.7.22), VAST (3.9.0), cpp VAST_v13_1_0, FishStatsUtils (2.10.0), DHARMa (0.4.5).

For model-based indices in the Bering Sea, we fitted observations of biomass per unit area from all grid cells and corner stations in the 83-112 bottom trawl survey of the EBS, 1982-2023, including exploratory northern extension samples in 2001, 2005, 2006, as well as 83-112 samples available in the NBS in 1982, 1985, 1991, 2010, 2017-2019, and 2021-2024 surveys. Assimilating these data therefore required extrapolating into unsampled areas. This extrapolation was facilitated by including a spatially varying response (Thorson 2019a) to the mean bottom temperature for EBS shelf strata with bottom depth <100 m (excluding northwest strata 82 and 90) from an interpolated temperature product computed using the *coldpool* R package. This spatially varying response was estimated for both linear predictors of the delta-model, and detailed comparison of results for EBS pollock has shown that it has a small but notable effect on these indices and resulting stock assessment outputs (O’Leary et al. 2020). All models were fitted in the *VAST* R package (Thorson and Barnett 2017; Thorson 2019b).

We used a Poisson-link delta-model (Thorson 2018) involving two linear predictors, and a gamma distribution to model positive catch rates. We extrapolated population density to the entire EBS and NBS in each year, using AFSC GAP-vetted extrapolation grids within FishStatsUtils. These extrapolation grids are defined using 3705 m (2 nmi) \times 3705 m (2 nmi) cells; this results in 36,690 extrapolation-grid cells for the eastern Bering Sea and 15,079 in the northern Bering Sea. We used bilinear interpolation to interpolate densities from 750 “knots” to these extrapolation grid cells; knots were approximately evenly distributed over space, in proportion to the dimensions of the extrapolation grid. We estimated geometric anisotropy (how spatial autocorrelation declines with differing rates over distance in some cardinal directions than others) and included a spatial and spatio-temporal term for both linear predictors. To facilitate interpolation of density between unsampled years, we specified that the spatio-temporal fields were structured over time as initially as an AR(1) process (where the magnitude of autocorrelation was estimated as a fixed effect for each linear predictor). However, during initial model runs, the AR(1) correlation parameter ρ was estimated to be close to 1 for the first linear predictor. As a result, the model was collapsed into a simpler structure by specifying $\rho = 1$, i.e., modeling spatiotemporal variation as a random walk, for both linear predictors. We do not include any temporal correlation for intercepts, which we treated as fixed effects for each linear predictor and year. Finally, we used epsilon bias-correction to correct for retransformation bias (Thorson and Kristensen 2016).

We checked model fits for convergence by confirming that (1) the derivative of the marginal likelihood with respect to each fixed effect was sufficiently small (less than ~ 0.001) and (2) that the Hessian matrix was positive definite. We then checked for evidence of model fit by computing Dunn-Smyth randomized quantile residuals (Dunn and Smyth 1996) and visualizing these using a quantile-quantile plot within the *DHARMa* R package (Hartig 2021). We also evaluated the distribution of these residuals over space in each year, and inspected them for evidence of residual spatio-temporal patterns.

Model-based estimates for the entire time series will change slightly from year to year of new data, because of the AR1 correlation between spatiotemporal fields. In 2024 we did not conduct the NBS survey, so all NBS estimates are based on EBS survey estimates and the past spatial and temporal correlation between regions (Figure 4.21). Both the design and model-based estimate slightly increase for the EBS in 2024 and either slightly decline in the NBS or remain the same (Figure 4.18).

VAST estimates of age compositions

For model-based estimation of age compositions in the Bering Sea, observations of numerical abundance-at-age were fitted at each sampling location. This was made possible by applying a year-specific, region-specific (EBS and NBS) age-length key to records of numerical abundance and length-composition. These estimates were computed in VAST, assuming a Poisson-link delta-model (Thorson 2018) involving two linear predictors, and a gamma distribution to model positive catch rates. Density covariates were not computed in estimation

of age composition for consistency with models used in the previous assessment and due to computational limitations. The same extrapolation grid was used as implemented for abundance indices, but here spatial and spatiotemporal fields were modeled with a mesh with coarser spatial resolution than the index model, using 50 knots. This reduction in the spatial resolution of the model, relative to that used abundance indices, was necessary due to the increased computational load of fitting multiple age categories and using epsilon bias-correction. The same diagnostics were implemented to check convergence and model fit as those used for abundance indices. The age composition estimates for the separate EBS and NBS regions are shown, but the combined were used in the assessment (Figure 4.22, Figure 4.23).

Data weighting

Model-based and VAST survey age composition data were weighted using the methodology of Francis (2011). Specifically, survey age composition data in Model 23.0 was initially weighted based on the number of hauls from which otoliths were collected. Stage 2 weighting was performed using Equation TA1.8 of Francis (2011) for three iterations. The mean survey age composition weights were used to weight fishery age composition data, as a constant annual value. The effective sample size weights for the fishery and survey are provided in Table 4.13.

Analytic Approach

General Model Structure

The abundance, mortality, recruitment and selectivity of yellowfin sole were assessed with a stock assessment model using the AD Model Builder language (Fournier et al. 2012; Ianelli and Fournier 1998). The model is a separable catch-age analysis that uses survey estimates of biomass and age composition as auxiliary information (Fournier and Archibald 1982). The assessment model simulates the dynamics of the population and compares the expected values of the population characteristics to the characteristics observed from surveys and fishery sampling programs. This was accomplished by the simultaneous estimation of the parameters in the model using the maximum likelihood estimation procedure. The fit of the simulated values to the observable characteristics was optimized by maximizing a log(likelihood) function given some distributional assumptions about the observed data.

The model includes starts in 1954 includes ages one through 20+. In the 20+ group, fish older than twenty are allowed to accumulate into an age category that includes fish of age twenty and older (20+). Since the sex-specific weight-at-age for yellowfin sole diverges after age of maturity (about age 10 for 40% of the stock), with females growing larger than males, the current assessment model is coded to accommodate the sex-specific aspects of the population dynamics of yellowfin sole. The model allows for the input of sex-specific estimates of fishery and survey age composition and weight-at-age and provides sex-specific estimates of population numbers, fishing mortality, fishery and survey age composition and allows for the estimation of sex-specific natural mortality and catchability. The model retains the utility to fit combined sex data inputs, and fishery and survey selectivity are not split by sex.

The suite of parameters estimated by the model are classified by three 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 |

The AD Model Builder software fits the data components using automatic differentiation (Griewank 2000) software developed as a set of libraries (AUTODIFF C++ library).

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 1979-81. Allowing the model to tune to these early survey estimates would underestimate the true pre-1982 biomass, thus exaggerating the degree to which biomass increased during that period. Although this underestimate would have little effect on the estimate of current yellowfin sole biomass, it would affect the spawner and recruitment estimates for the time-series. Hence, the pre-1982 survey biomass estimates were omitted from the analysis.

Total mortality Z in the model was modeled as the sum of fishing mortality F and natural mortality M , such that total mortality in year t at age a is $Z_{t,a} = F_{t,a} + M_x$. The subscript x refers to sex.

Fishing mortality at each year and age, $F_{t,a}$, was the product of age-specific fishing gear selectivity s_a and the median year-effect of fishing mortality μ^F , with normally distributed error,

$$F_{t,a} = s_a \mu^F e^{\epsilon_t^F}, \epsilon_t^F \sim N(0, \sigma_F^2),$$

where ϵ_t^F is the residual year-effect of fishing mortality and σ_F is the standard deviation of fishing mortality. Age-specific fishing selectivity s_a was calculated using the logistic equation

$$s_a = \frac{1}{1 + e^{(-\alpha + age\beta)}}.$$

Catch in year t for age a fish $C_{t,a}$ (both sexes combined) was calculated:

$$C_{t,a} = \frac{F_{t,a}}{Z_{t,a}} (1 - e^{-Z_{t,a}}) N_{t,a},$$

where $N_{t,a}$ is the number of fish at time t , age a . Total catch in each year C_t was the sum of catch over all ages, $C_t = \sum_a C_{t,a}$, and the proportion at age in catch was $P_{t,a} = \frac{C_{t,a}}{C_t}$.

Recruitment from 1956-1977 was modeled as $N_{t,1} = R_t = R_0 e^{\tau_t}$, $\tau_t \sim N(0, \sigma_R^2)$, where R_0 is the geometric mean of the modeled age 1 recruitment from 1956-1975, and σ_R is the standard deviation of recruitment.

Recruitment from 1978-2024 was determined using the Ricker stock recruitment curve,

$$R = \alpha S e^{-\beta S},$$

where S is the spawning stock biomass (Ricker 1958). Parameters α and β were estimated by fitting spawning biomass and recruitment during the period 1978-2018, and are shown from Model 23.0 (Figure 4.24).

The number of fish in year $t + 1$ at age a was the number of fish in the previous year subjected to natural and fishing mortality,

$$N_{t+1,a+1} = N_{t,a} e^{-Z_{t,a}}.$$

The “plus group” included all fish age 20 and older included fish surviving from age 19 as well as those age 20 and higher,

$$N_{t+1,A} = N_{t,a} e^{-Z_{t,A-1}} + N_{t,A} e^{-Z_{t,A}}.$$

Spawning biomass was calculated as the product of weight-at-age and the number of mature females at each age,

$$S_t = \sum N_{t,a} W_{t,a} \phi_a,$$

where ϕ_a is the proportion of mature females at age a and $W_{a,t}$ is the mean body weight in kg of fish age a in year t . Survey biomass was assumed to be the product of catchability q , survey selectivity s_a , and the biomass,

$$Biomass_{survey,t} = q \sum N_{t,a} W_{t,a} s_a.$$

In the model, fishery selectivity is annually varying. The fishery selectivity estimate two years prior to the current year is used for MSY and reference-point calculations (2022 if the current year is 2024). Fishery selectivity is required to calculate yield per recruit and biomass per recruit, which are in-turn used to calculate maximum sustainable yield. Survey catchability is also annually varying, based on survey start date and bottom temperature. However, this parameter is not incorporated directly into reference point calculations (Table 4.1).

Description of sex-specific parameterization in the model

There are sex-specific parameters for length-weight relationships, weight-at-age (for fishery and survey), and proportions-at-age (for fishery and survey). The total proportion of males and female proportions at age sum to 1, and the total proportion of females and males sums to the proportion of each estimated in the population. The NBS+EBS survey proportion at age has been estimated using VAST since 2022. The catch-at-age methodology of Kimura (1989) was used to estimate mean fishery weights-at-age in the model, separately for males and females. As of 2023, selectivity is combined for males and sexes; they share the same selectivity parameters, as it was found to improve the fit to the data. Fishery selectivity is estimated annually while survey selectivity is constant over time.

The initial male and female proportions at age are based on the mean initial proportions (a single estimated value), that is modified for each age by a vector of sex-specific initial devs. For the 20 years prior to the start year in the model, sex-specific natural mortality is applied to calculate numbers at age. In subsequent years, recruitment of males and females does not differ. Total biomass is the sum of male and female numbers at age, as are other derived quantities for the population.

Several aspects of the likelihood include male-and female- specific parameterization. The recruitment likelihood includes the initial male and female deviations as well as the combined recruitment deviations throughout the modeled time period. Finally, the age likelihood includes the fit to the fishery and survey age compositions, which are split by sex.

Description of Alternative Models

In this assessment we considered Model 23.0 used in the 2023 assessment updated with 2024 data. No alternative models are presented.

Parameters Estimated Outside the Assessment Model

Weight at age

Parameters of the von Bertalanffy growth curve were estimated for yellowfin sole, by sex, from 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 |

A sex-specific length-weight relationship was also calculated from the survey database using the power function, $Weight(g) = a * Length(cm)^b$, where a and b are parameters estimated to provide the best fit to the data.

Weight at age from the survey time series were evaluated as follows. Survey weights at age were available from 1984 through 2019 (19,074 records). Weight-at-age was calculated for all ages 1-19 as well as the age 20 plus group (all ages 20 and over). There were some gaps due to years in which no fish of a particular age had been collected. Where possible, these gaps were filled with survey length at age data converted to weight at age. Between 1971 through 2019, there were lengths associated with aged yellowfin sole for more years than weights. Lengths at age were converted to weights at age and used to fill gaps using a sex-specific length-weight relationship based on all available current data. The relationship between weight and length was calculated using the power function, $Weight(g) = a * Length(cm)^b$, where a and b are parameters estimated to provide the best fit to the data. The parameter estimates and the number of individual data points are shown below.

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

Finally, annual age categories for which no length-at-age or weight-at-age were available were filled by calculating weight at age (using the power relationship described above) from a mean overall length at age for males and females from 1971-2019 data.

The mean weight at age from 2023 was used as an estimate for weight at age in 2024, as the 2024 ages have not yet been processed.

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 Weststad 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 Model 23.0.

Maturity

Yellowfin sole maturity schedules were estimated from in-situ observations from two studies as discussed in the “Data” section (Table 4.8).

AIC

The Akaike Information Criterion was calculated from the hessian and objective function value OFV of the ADMB output .par file to compare models 23.0 and 23.0_noEC. The hessian $Hess$ was transformed back into the original parameter space and the marginal likelihood $Likelihood_{MAR}$ was estimated as:

$$Likelihood_{MAR} = -0.5 * Hess_T - OFV, \quad (1)$$

The marginal likelihood was then used to calculate AIC, as follows:

$$AIC = 2 * k - 2 * Likelihood_{MAR}, \quad (2)$$

where k is the number of parameters used in the model.

Parameter Estimates

A list of selected parameters estimated inside the model are shown for Model 23.0 with 2023 data in Table 4.14 and for Model 23.0 with 2023 dadta in Table 4.15.

Parameters Estimated Inside the Assessment Model

There were 382 estimated by Model 23.0 in 2023 and 386 estimated by Model 23.0 in 2024. The increase was due to an additional estimate of fishing mortality, 2 fishery selectivity parameters, and a recruitment deviation estimate for 2024. Key parameters are presented below:

| Fishing mortality | Selectivity | Survey catchability | Recruitment deviation | Spawner-recruit | M | Total |
|-------------------|-------------|---------------------|-----------------------|-----------------|-----|-------|
| 72 | 184 | 4 | 72 | 2 | 1 | 386 |

The selectivity parameters include 2 parameters for survey selectivity, 2x71 for fishery selectivity, and 2x20 selectivity parameters used for MSY estimates. There are also 2x19 initial deviations for the initial population size and one mean initial size estimate.

Selectivity

Survey selectivity was constant and a single curve was estimated for males and females (Figure 4.25). Time-varying fishing selectivity curves were estimated because there have been annual changes in management, vessel participation and likely gear selectivity (Figure 4.26). The selectivity pattern is increasing logistic for the fishery and survey. The oldest year-classes in the surveys and fisheries were truncated at 20 and allowed to accumulate into the 20+ age category. A logistic equation was used to model fishery selectivity and is a function of time-varying parameters specifying the age and slope at 50% selection, φ_t and η_t , respectively. The fishing selectivity (S^f) for age a and year t is modeled as,

$$S_{a,t}^f = [1 + e^{\eta_t(a-\varphi_t)}]^{-1}, \quad (3)$$

where φ_t and η_t are time-varying and partitioned (for estimation) into parameters representing the mean and a vector of deviations (log-scale) conditioned to sum to zero. The deviations are constrained by a lognormal prior with a variance that was iteratively estimated. The process of iterating was to first set the variance to a high value to estimate the deviations. The next step was to compare the variability of model estimates. The variance of the model estimates was then rounded up slightly and fixed for subsequent runs. The 2024 values were fixed as the average of the 3 most recent years.

Fishing Mortality

The fishing mortality rates (F) for each age and year are calculated to approximate the catch weight by solving for F while still allowing for observation error in catch measurement. A large emphasis (300) was placed on the catch likelihood component to force the model to closely match the observed catch.

Survey Catchability

Past assessments have examined the relationship between estimates of survey biomass and bottom water temperature. To better understand how water temperature may affect the catchability of yellowfin sole to the survey trawl, catchability was estimated for each year in the stock assessment model as:

$$q = e^{-\alpha + \beta T}, \quad (4)$$

where q is catchability, T is the average annual bottom water temperature anomaly at survey stations less than 100 m, and α and β are parameters estimated by the model. The catchability equation has two parts. The $e^{-\alpha}$ term is a constant or time-independent estimate of q . The second term, $e^{\beta T}$ is a time-varying (annual) q which responds to metabolic aspects of herding or distribution (availability) which can vary annually with bottom water temperature. The result of incorporating bottom temperature to estimate annual q has resulted in an improved fit to the survey (described in the 2018 BSAI yellowfin sole assessment).

The survey catchability model includes survey start date (expressed as deviation in days (- and +) from the average survey start date of June 4th). This feature has been used since 2018, and its interaction with annual bottom water temperature is added to the catchability equation as:

$$q = e^{-\alpha + \beta T + \gamma S + \mu T:S}, \quad (5)$$

where T =survey bottom temperature (averaged per year for all stations <100 m), S =survey start date, and $T : S$ =interaction of T and S . Earlier survey start dates usually encounter colder water and since the timing of the survey start date is positively correlated with bottom water temperature, improvement in fitting the

survey biomass estimates can be gained by estimating two new parameters (μ and γ). Akaike information criterion (AIC) were used to determine if the additional variables (S and $T : S$) improved the regression fit. The improvement in fit was more than offset by the additional two parameters (Nichol et al. 2019).

Spawner-Recruit Estimation

Annual recruitment estimates from 1978-2018 were constrained to fit a Ricker (1958) form of the stock recruitment relationship as follows:

$$R = \alpha S e^{-\beta S}, \quad (6)$$

where R is age 1 recruitment, S is female spawning biomass in metric tons the previous year, and α and β are parameters estimated by the model. This stock recruitment curve expresses a peak level of recruitment at an intermediate stock abundance and density dependence at higher stock sizes. The spawner-recruit fitting is estimated in a later phase after initial estimates of survival, numbers-at-age and selectivity are obtained.

Results

Model Evaluation

For this assessment, Model 23.0 is presented with updated data for 2024. Model 23.0 was the accepted model in the 2023 yellowfin sole stock assessment.

Model 23.0 estimated male natural mortality 0.128 to be higher than female natural mortality 0.12, which is in common with known life history parameters of other Alaska flatfish. For example, arrowtooth flounder males are assumed to have higher natural mortality, consistent with their skewed sex ratio (Wilderbuer and Turnock 2009). Higher natural mortality for male flatfish has been assumed for flatfish from other regions as well (Maunder and Wong 2011).

Model 23.0 fit the data well overall. Survey selectivity estimated as a single curve indicated that 50% selectivity occurred between 4 and 5 years, and fully selected by age 7 (Figure 4.25). The predicted fit to survey biomass was similar (Figure 4.27), as were total biomass, numbers at age, and spawning stock biomass (Figure 4.28, and Figure 4.29).

Model 23.0 (Figure 4.30) indicates a shift towards higher survey catchability, than Model 23.0 from 2023, corresponding with lower bottom temperatures than in 2023 (Figure 4.17). The proportion female was estimated to be lower and closer to 50% in Model 23.0 (2024) than Model 23.0 from 2023 (Figure 4.31).

Model 23.0 similarly provided a good fit the survey age compositions (Figure 4.32), as well as the fishery age compositions (Figure 4.33) and survey biomass (Figure 4.14).

Given the uncertainty of the productivity of yellowfin sole at low spawning stock sizes, and because the AFSC policy for reference point time-series selection is to use the post 1977 regime shift values unless there is a compelling reason to do otherwise, the productivity of yellowfin sole in this assessment was estimated by fitting the 1977-2018 spawner-recruit data in the model. The resulting stock recruitment curve shows average recruitment for the years 2019-2024 except 2020 which was above average (Figure 4.24).

A series of alternative models were included to demonstrate the addition of data sources. VAST data requires that indices for survey biomass and age composition be recalculated each year (Figure 4.34). The addition of the 2024 fishery catch (and final 2023 catch) in Model 23.0 2024a reduced biomass and spawning biomass in the final 5 years. The addition of the survey biomass and standard deviation in Model 23.0 2024b shifted spawning biomass and biomass downward over the final 20 years. The addition of the VAST survey age composition in Model 23.0 2024 shifted biomass further downward over the final 50 years of the model.

Time Series Results

The data was updated in 2024 to include current values of catch, survey biomass estimates, and survey age compositions from 2023. The latest year of fishery weight-at-age data was included (2022), as no new fishery ages were available for 2023. The eight past years in the Bering Sea have had bottom temperature anomalies above the mean, to varying degrees, but 2023 and 2024 have been near and below average. The temperature-dependent q adjustment for 2024 was 1.16.

Residual Patterns

One step ahead (OSA) residuals have replaced Pearson residuals for the current assessment because they are independent and identically distributed (iid), and normally distributed. They were calculated by removing the last age bin. For the fishery, the male and female patterns are similar for age compositional data (Figure 4.35), but generally the scale was below 2 standard deviations. For the survey, males and females show similar patterns, and the patterns are typically small-scale and generally do not exceed one standard deviation (Figure 4.36). Both the fishery and survey show a reverse S-shaped curve in the Q-Q plot, indicating a heavy-tailed but symmetric distribution. The standardized deviation of normalized residuals (SDNR) was ~ 0.75 for the survey and fishery. In general SDNR much greater than 1 is not consistent with a good fit to the data. A value less than 1 indicates that the data was fitted better than expected, and is not a cause for concern (Francis 2011).

Fishing Mortality and Selectivity

The full-selection fishing mortality, F , has averaged 0.078 over the 5 years, 2020 -2024 (Table 4.16). Model estimated selectivities, Figure 4.25 and Figure 4.26 indicate that yellowfin sole are 50% selected by the fishery at about age 9 and nearly fully selected by age 13, with annual variability. Based on results from the stock assessment model, annual average exploitation rates of yellowfin sole since 1977 ranged from 3% to 7% of the total biomass, and have averaged approximately 4%.

Abundance Trends

Model 23.0 estimated catchability q at an average value of 1.2 for the period 1982-2024 which resulted in a model estimate of the 2024 age 2+ total biomass at 2.412 million t (Table 4.10). Model results indicate that yellowfin sole total biomass (age 2+) was at low levels during most of the 1960s and early 1970s (700,000-1,000,000 t) after a period of high exploitation (Table 4.10, Figure 4.29). 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 current model indicates that the population is increasing and predicts that it will continue to increase through 2026. The present biomass is estimated at 70% of the peak 1984 level. The female spawning biomass has also declined since the peak in 1985, with a 2024 estimate of 751,023 t and 748,076 t for 2025 (Table 4.17).

Allowing q to be correlated with annual bottom temperature and survey start date provides a better fit to the bottom trawl survey estimates than using a q fixed at the average value (Fig. 4.18, Wilderbuer et al. 2018). Both the trawl survey and the stock assessment model indicate that the yellowfin sole resource (total biomass) increased during the 1970s and early 1980s to a peak level during the mid-1980s. The yellowfin sole population biomass slowly decreased over the 23 years since the mid-1990s as the majority of year-classes during those years were below average strength. Average to above average recruitment from 2006 to 2009 is expected to maintain the abundance of yellowfin sole at a level above B_{MSY} in the near future. The stock assessment projection model indicates a generally stable trend in female spawning biomass through 2037 if the fishing mortality rate continues at the same level as the average of the past 5 years (Figure 4.37).

The VAST model for the Northern + Eastern Bering Sea has been used in the yellowfin sole assessment since 2022. We included a model without the environmental covariates on survey catchability (Model 23.0_noEC) to check whether it provides a better fit to the data with the VAST indices, because VAST accounts for an unsurveyed portion of the population. The model with the environmental covariates on catchability still provided a better fit to the data; AIC=2957.58 and 386 parameters with environmental covariates,

AIC=3003.735 and 382 parameters without (Table 4.18), justifying the continued use of the environmental covariates on survey catchability.

Recruitment Trends

The primary reason for the sustained increase in abundance of yellowfin sole during the 1970s and early 1980s was the recruitment of a series of stronger than average year-classes spawned in 1967-1976 (Figure 4.38). The 1981 year-class was the strongest observed (and estimated) during the time series, followed by the 1983 year-class. Survey age composition estimates and the assessment model also estimate that the 1987 and 1988 year-classes were average and the 1986 and 1988 year-classes were above average. Recruitment since 1990 has been below the long-term average in most years, and the 2015 - 2020 year-classes appear to be one of the lowest on record (Figure 4.38). Recruitment for years subsequent to 2020 may be less reliable given the lack of survey data to confirm recruitment estimates. Given the large proportion of new recruits from the 2017 year class that are apparent in survey age composition data, it is probable that future assessments will indicate higher recruitment in 2017.

Retrospective Analysis

A within-model retrospective analysis was included for Model 23.0. 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 4.39). The same series of VAST survey estimates was used for each retrospective peel (rather than replacing the series with previous years estimates). Retrospective differences in female spawning biomass between sequential years for yellowfin sole indicate that the 2024 model with the final year of data removed provided higher estimates of SSB than the full 2024 model (Figure 4.40). Mohn's rho for Model 23.0 in 2024 was 0.042, smaller than the 2023 Mohn's rho of 0.06. The directionality of the retrospective peels can provide insight into the retrospective pattern. For Model 23.0 the first four retrospective peels were positively different from the terminal year, but the remaining peels resulted in an upward shift of the entire time series (Figure 4.40), indicating that information in the 3-4 terminal years result in a downward shift of the time series. However, the Mohn's rho values presented here are within the range of acceptable values and do not indicate any significant retrospective issues in Model 23.0. The Mohn's rho does not exceed the rule of thumb guideline for long-lived stocks proposed by Hurtado-Ferro et al. (2015), which includes flatfish, that values of Mohn's rho higher than 0.20 or lower than -0.15 may be an indication of a retrospective pattern.

Other diagnostics

Several alternative models were used for comparative purposes. Model 23.0_noEC removed the environmental covariates (bottom temperature and survey start date) on survey catchability.

We also present several models that show the effect of the different data sources. All alternative models used data through 2024. Model 23.0 2024a included fishery catch through 2024 but did not have the current estimates of survey age composition or the 2024 VAST survey index. Model 23.0 2024b added the 2024 VAST survey index to Model 23.0 2024a but did not include the updated survey age composition.

Harvest Recommendations

Scenario Projections and Two-Year Ahead Overfishing Level

In addition to the seven standard harvest scenarios, Amendments 48/48 to the BSAI and GOA Groundfish Fishery Management Plans require projections of the likely OFL two years into the future. The 2024 numbers at age from the stock assessment model are projected to 2025 given the 2024 estimated full year's catch, and then a 2025 catch of 123,905 t was applied to the projected 2025 population biomass to obtain the 2025 OFL.

The SSC determined in December 2006 that yellowfin sole would be managed under the Tier 1 harvest guidelines, and therefore future harvest recommendations would be based on maximum sustainable yield MSY and the associated fishing effort F_{MSY} values calculated from a spawner-recruit relationship. MSY is an equilibrium concept and its value is dependent on both the spawner-recruit estimates which are assumed to represent the equilibrium stock size-recruitment relationship and the model used to fit the estimates. In

the yellowfin sole stock assessment model, a Ricker form of the stock-recruit relationship was fit to various combinations of these data and estimates of F_{MSY} and B_{MSY} were calculated, assuming that the fit to the stock-recruitment data represents the long-term productivity of the stock (details provided in Wilderbuer et al. 2018). The 2025 ABC is calculated using Tier 1 methodology. The Tier 1 harvest level is calculated as the product of the harmonic mean of F_{MSY} and the geometric mean of the 2025 biomass estimate.

The geometric mean of the 2025 biomass estimate, B_{gm} , is estimated using the equation $B_{gm} = e^{\ln(B) - (cv^2/2)}$, where B is the point estimate of the 2025 biomass from the stock assessment model and cv^2 is the coefficient of variation of the point estimate (a proxy for sigma). The harmonic mean of F_{MSY} , F_{har} is estimated as $F_{har} = e^{\ln(F_{MSY}) - (\ln(sd^2)/2)}$, where F_{MSY} is the peak mode of the F_{MSY} distribution and sd^2 is the square of the standard deviation of the F_{MSY} distribution.

In 2006 the SSC selected the 1978-2001 data set for the Tier 1 harvest recommendation. Using this approach for the 2025 harvest (now the 1978-2018 time-series) recommendation (Model 23.0), the $F_{ABC} = F_{Hmean} = 0.114$. The estimate of age 6+ total biomass for 2025 is 2,308,550 t. The calculations outlined above give a Tier 1 ABC harvest recommendation of 262,557 t and an OFL of 299,247 t for 2025. This results in an 12% (36,690 t) buffer between ABC and OFL.

The stock assessment analysis must also consider harvest limits, usually described as overfishing fishing mortality levels with corresponding yield amounts. Amendment 56 to the BSAI FMP sets the Tier 1 harvest limit at the F_{MSY} fishing mortality value. The overfishing limit mortality values, ABC fishing mortality values and their corresponding yields are given as follows:

| Harvest level | F value | 2025 Yield |
|-------------------------------------|---------|------------|
| Tier 1 $F_{OFL} = F_{MSY}$ | 0.13 | 299,247 t |
| Tier 1 $F_{ABC} = F_{harmonicmean}$ | 0.114 | 262,557 t |

A complete record of catch, ABC, and OFL since 1980 is available in Table 4.19.

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 seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), which was implemented in 1977.

For each scenario, the projections begin with the vector of 2024 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2025 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2024. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1,000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios support the alternative harvest strategies analyzed in the Alaska Groundfish Harvest Specifications Final Environmental Impact Statement. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2025, are as follows (max F_{ABC} refers to the maximum permissible value of F_{ABC} under Amendment 56):

- Scenario 1: In all future years, F is set equal to max F_{ABC} . (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
- Scenario 2: In all future years, F is set equal to a constant fraction of max F_{ABC} , where this fraction is equal to the ratio of the F_{ABC} value for 2024 recommended in the assessment to the max F_{ABC} for 2025.

(Rationale: When F_{ABC} is set at a value below $\max F_{ABC}$, it is often set at the value recommended in the stock assessment.)

- Scenario 3: In all future years, F is set equal to the 2019 - 2023 average F . (Rationale: For some stocks, TAC can be well below ABC , and recent average F may provide a better indicator of F_{TAC} than F_{ABC} .)
- Scenario 4: In all future years, F is set equal to $F_{60\%}$. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)
- Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

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

- Scenario 6: In all future years, F is set equal to F_{OFL} . (Rationale: This scenario determines whether a stock is overfished. If the stock is 1) above its MSY level in 2024 or 2) above 1/2 of its MSY level in 2024 and expected to be above its MSY level in 2034 under this scenario, then the stock is not overfished.)
- Scenario 7: In 2025, F is set equal to $\max F_{ABC}$, and in all subsequent years, F is set equal to F_{OFL} . (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its MSY level in 2026 or 2) above 1/2 of its MSY level in 2026 and expected to be above its MSY level in 2036 under this scenario, then the stock is not approaching an overfished condition.)

Simulation results shown in Table 4.20 indicate that yellowfin sole are not currently overfished and are not approaching an overfished condition. If fishing continues at the same fishing mortality as in the past 5 years, the stock is projected to remain well above B_{MSY} (Figure 4.37). A phase plane figure of the estimated time-series of yellowfin sole female spawning biomass (FSB) relative to the harvest control rule indicates that the stock is above B_{MSY} , has been consistently fished below F_{MSY} for decades (Figure 4.41)

The ABC and OFL based on the recommended model 23.0 for 2025 and 2026 assuming average catch rates are shown in the following table.

| Year | Catch | FSB | Geom. mean 6+ biomass | ABC | OFL |
|------|---------|---------|-----------------------|---------|---------|
| 2025 | 116,803 | 748,076 | 2,308,550 | 262,557 | 299,247 |
| 2026 | 116,803 | 758,695 | 2,353,240 | 267,639 | 305,039 |

Risk Table

Assessment related considerations

The BSAI yellowfin sole assessment is based on surveys conducted annually on the EBS shelf from 1982-2024, annually except for 2020 due to the COVID-19 pandemic. Fish ages, derived from otoliths collected during the surveys and the fishery to calculate annual estimates of population and fishery age composition, have been validated. Survey age composition data is used in the assessment from 1982-2023. The assessment model exhibits good fits to all compositional and abundance data, and converges to a single minima in the likelihood surface. Recruitment estimates track strong year-classes that are consistent with the data. The retrospective pattern and Mohn's rho value, 0.042, indicate that there are no significant time varying trends that are not accounted for by the model (Figure 4.39).

We propose a level 1 designation for the assessment category in the risk table.

Population dynamics considerations

Stock assessment model results indicate that yellowfin sole total biomass (age 2+) was at low levels during most of the 1960s and early 1970s (700,000-1,000,000 t) after a period of high exploitation. Sustained above-average recruitment from 1967-1976 combined with light exploitation resulted in a biomass increase to a peak in 1985. The population biomass has since been in a slow decline over the time series since a peak in the mid-1980s. Only the 1991, 1995 and 2003 year-classes have achieved levels observed during the 1970s. The 2023 survey estimate is the second lowest in the time series since 1982, while the 2024 survey estimate is an increase from 2023. The current model for 2024 estimates B_{MSY} at 479,711 t. Projections indicate that the FSB will remain above the B_{MSY} level through 2038. The large 2017 year class will be age 8 in 2025 and will become selected by the fishery as it grows. This is predicted to result in higher population size estimates for the yellowfin sole stock.

Given the increase observed in 2024 as well as the incoming 2017 year class, we propose a level 1 designation for the population dynamics category in the risk table.

Environmental/ecosystem considerations

Environmental processes: The eastern Bering Sea (EBS) experienced a prolonged period of above-average thermal conditions from 2014 through 2021. Since 2021, and continuing from August 2023–August 2024, thermal conditions in the EBS have been close to historical baselines of many metrics. There have been no sustained marine heatwaves over the southeastern or northern Bering Sea shelves since January 2021 (Callahan and Lemagie, 2024), and observed (Rohan and Barnett, 2024) modeled (Kearney, 2024) EBS bottom temperatures were mostly near-normal over the past year. Sea surface temperatures (SSTs) and bottom temperatures were near the long-term means in all regions by summer 2024. Notable deviations include (i) warm SSTs in the outer domain from fall 2023 through spring 2024 and (ii) unusually warm bottom temperatures in the northern outer domain since spring 2024 that may indicate an intrusion of shelf water (Callahan et al., 2024).

Atmospheric conditions are one of the primary drivers that impact the oceanographic setting in the EBS. Both the North Pacific Index (NPI) and Aleutian Low Index (ALI) provide complementary views of the atmospheric pressure system in the North Pacific. During winter 2023-2024, the NPI was average (Siddon, 2024) and the strength and location of the Aleutian Low Pressure System were both near climatological averages (Overland and Wang, 2024). Thus, despite delayed formation of sea ice in fall 2023 (Thoman, 2024), cold winds from the Arctic helped advance sea ice to near-normal extent by mid-winter. Near-normal sea ice extent and thickness (Thoman, 2024b, 2024c) may have contributed to a cold pool (<2°C water) of average spatial extent (Siddon, 2024), though the footprint of the coldest waters (<0°C) in 2024 was 75% smaller than in 2023 (Rohan and Barnett, 2024b).

December 2023 had significant along-shelf winds (to the southeast) that could have driven offshore Ekman transport. Weaker, but more sustained winds that also favored offshore transport occurred from March to May 2024 (Hennon, 2024). Beginning in May and continuing through summer 2024, persistent storms resulted in a deeper mixed layer, which entrained deeper, cooler water, such that SSTs remained cooler through at least August 2024 (Stabeno, 2024).

For projections into 2025, the National Multi-Model Ensemble (NMME) predicts that SSTs over the EBS are expected to be near normal (anomalies within <0.5°C of the 1982–2010 baseline) (Lemagie, 2024). With the expected transition to La Niña, cooler conditions in the EBS may follow. Relatively cool SSTs may contribute to earlier formation of sea ice than has been observed over the last several years (Thoman, 2024b). Yellowfin sole (YFS) demonstrate earlier migration to spawning grounds and earlier spawning events under warmer conditions. In addition, somatic growth of YFS increases in warmer temperatures. A proposed thermal window (Yeung et al., 2021) suggests continued warming over the EBS shelf may result in temperatures above the thermal physiological maximum of YFS. Adult YFS are distributed off-shelf in winter, therefore may have experienced average (northern shelf) to cooler (southern shelf) bottom temperature conditions this past winter (Callahan et al., 2024). Yellowfin sole move inshore during summer for spawning and young-of-the-year (YOY) rear in inshore habitats. Therefore, offshore Ekman transport may have hindered on-shelf migration

(Hennon, 2024) and YOY may have experienced average hatching and rearing temperatures in 2024 (Callahan et al., 2024).

Prey: Early life stages of YFS may consume pelagic zooplankton, such as small copepods. The Rapid Zooplankton Assessment in the southeastern Bering Sea (SEBS) in spring noted moderate abundance of small copepods, but low abundance of large copepods along the middle shelf (higher in the outer shelf) and near-zero abundance of euphausiids in the RZA, which is typical for the spring. In summer, small copepods remained abundant throughout the region. Large copepods remained in low abundance while euphausiids increased, especially towards the northern portion of the SEBS. In fall, both small and large copepods as well as euphausiids were in low abundance, but increased towards the north. In the northern Bering Sea (NBS) in fall, small copepods had moderate and consistent abundances throughout the sampling grid, large copepods were patchy with the highest values north and south of St. Lawrence Island, and euphausiids were very low (Kimmel et al., 2024).

The dominant prey of adult YFS are polychaete worms, miscellaneous worms, clams, and benthic amphipods. Direct measurements of infaunal abundance trends are not available, however, abundance trends of motile epifauna that also consume infauna (i.e., indirect measurements) are quantified from the bottom trawl survey. Trends in motile epifauna biomass indicate benthic productivity, although individual species and/or taxa may reflect varying time scales of productivity. The biomass of motile epifauna increased from 2023 to 2024 and remains above the long term mean (Siddon, 2024). No direct or indirect measures of prey availability exist for the northern Bering Sea shelf.

In 2024, adult fish condition (as measured by length-weight residuals) over the SEBS was above average; no survey occurred in the NBS in 2024 (Prohaska et al., 2024). Over the southern shelf, trends in motile epifauna, as an indirect measure of prey availability, mirror trends in adult fish condition, increasing from 2023 to 2024.

Competitors: Competitors for YFS prey resources include other benthic foragers, like northern rock sole and flathead sole. The trend in biomass of the benthic foragers guild from the standard bottom trawl survey grid increased from 2023 to 2024, but remained below the time series mean. Trends in benthic forager biomass indirectly indicate availability of infauna (i.e., prey of these species), suggesting competition for prey resources remains low in 2024 (Siddon, 2024).

Predators: Predators of YFS include Pacific cod and Pacific halibut, which are included in the apex predator guild. The biomass of apex predators measured during the standard bottom trawl survey in 2024 was nearly equal to their value in 2023 and below their long term mean. However, the trend in the apex predator guild is largely driven by Pacific cod, which decreased 5.5% from 2023 (Siddon, 2024). While an increase in Pacific cod abundance may represent increased predation pressure for YFS, the spatial distribution of Pacific cod may provide a potential refuge from predation in the inner domain. The biomass of Pacific halibut decreased from 2023 to 2024, therefore represents no increase in predation pressure.

Summary for Environmental/Ecosystem considerations:

- **Environment:** The EBS shelf experienced oceanographic conditions that were largely average based on historical time series of multiple metrics over the past year (August 2023 - August 2024). Adult YFS may have experienced average to cooler bottom temperatures in the off-shelf region during winter 2023/2024 (based on ROMS) and YOY may have experienced average bottom temperatures in inshore spawning and rearing habitats during summer 2024 (based on BTS). Cooler temperatures may result in delayed migration to spawning grounds, delayed spawning, and decreased somatic growth.
- **Prey:** Sufficient prey may have been available for early life stages of YFS (small copepods) and for adult YFS (via trends in motile epifauna) over the SEBS shelf based on trends in fish condition.
- **Competition:** The trend in biomass of benthic foragers increased from 2023 to 2024 but remained below the time series mean, indicating competition for prey resources remains low in 2024.
- **Predation:** Trends in biomass of Pacific cod and Pacific halibut both declined from 2023 to 2024, along with potential spatial refuge from predation in the inner domain, suggest no increase in predation pressure.

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

Fishery performance considerations

The 2024 fishery CPUE has declined since 2023, but overall, CPUE is within the range observed over the past several decades. Fishing reports in 2024 indicate that the yellowfin sole CPUE was good, but that halibut bycatch was high. Due to low prices for yellowfin sole and a surplus of frozen product on the market, fishing has been lower in 2024. 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.

We propose a level 1 designation for the fishery performance category in the risk table.

| Assessment consideration | Population dynamics | Environmental ecosystem | Fishery performance |
|--------------------------|---------------------|-------------------------|---------------------|
| Level 1: No concern | Level 1: No concern | Level 1: No concern | Level 1: No concern |

We recommend no reduction in ABC based on this risk table assessment.

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Tables

Table 4.1: How time-varying parameters were incorporated into reference point calculations.

| Time-varying parameter | Usage |
|------------------------|---|
| Fishery selectivity | The 2022 estimates were used to calculate MSY and reference points. |

Table 4.2: Foreign and domestic catch (t) of yellowfin sole 1954-2024. 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 2024 was downloaded October 1, 2024. The extrapolated catch for the full year was 74,288 t.

| Year | Foreign | Domestic | | | Total |
|------|---------|----------|---------|------------------|---------|
| | | JVP | DAP | Aleutian Islands | |
| 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 |
| 1978 | 138,433 | | | | 138,433 |
| 1979 | 99,019 | | | | 99,019 |
| 1980 | 77,768 | 9,623 | | | 87,391 |
| 1981 | 81,255 | 16,046 | | | 97,301 |
| 1982 | 78,331 | 17,381 | | | 95,712 |
| 1983 | 85,874 | 22,511 | | | 108,385 |
| 1984 | 126,762 | 32,764 | | | 159,526 |
| 1985 | 100,706 | 126,401 | | | 227,107 |
| 1986 | 57,197 | 151,400 | | | 208,597 |
| 1987 | 1,811 | 179,613 | 4 | | 181,428 |
| 1988 | | 213,323 | 9,833 | | 223,156 |
| 1989 | | 151,501 | 1,664 | | 153,165 |
| 1990 | | 69,677 | 14,293 | | 83,970 |
| 1991 | | | 117,303 | | 117,303 |
| 1992 | | | 145,386 | 3.6 | 145,382 |
| 1993 | | | 105,810 | | 105,810 |
| 1994 | | | 140,050 | 0.2 | 140,050 |
| 1995 | | | 124,752 | 5.6 | 124,746 |
| 1996 | | | 129,659 | 0.4 | 129,659 |
| 1997 | | | 182,814 | 1.2 | 182,813 |
| 1998 | | | 101,155 | 4.7 | 101,150 |
| 1999 | | | 69,234 | 12.8 | 69,221 |

| | | | | |
|------|---------|------|---------|---------|
| 2000 | 84,071 | 12.5 | 84,058 | 84,071 |
| 2001 | 63,579 | 14.5 | 63,564 | 63,579 |
| 2002 | 74,986 | 28.5 | 74,957 | 74,986 |
| 2003 | 79,806 | 0.4 | 79,806 | 79,806 |
| 2004 | 75,511 | 8.8 | 75,502 | 75,511 |
| 2005 | 94,385 | 1.8 | 94,383 | 94,385 |
| 2006 | 99,160 | 3.8 | 99,156 | 99,160 |
| 2007 | 120,964 | 2.4 | 120,962 | 120,964 |
| 2008 | 148,894 | 0.5 | 148,893 | 148,894 |
| 2009 | 107,513 | 1.1 | 107,512 | 107,513 |
| 2010 | 118,624 | 0.2 | 118,624 | 118,624 |
| 2011 | 151,158 | 1.1 | 151,157 | 151,158 |
| 2012 | 147,187 | 1.1 | 147,186 | 147,187 |
| 2013 | 164,944 | 0.3 | 164,944 | 164,944 |
| 2014 | 156,772 | 0.3 | 156,772 | 156,772 |
| 2015 | 126,937 | 0 | 126,937 | 126,937 |
| 2016 | 135,324 | 0.2 | 135,324 | 135,324 |
| 2017 | 132,220 | 0.6 | 132,219 | 132,220 |
| 2018 | 131,496 | 4.5 | 131,491 | 131,496 |
| 2019 | 128,051 | 4.6 | 129,061 | 128,051 |
| 2020 | 133,799 | 11.1 | 133,788 | 133,799 |
| 2021 | 108,788 | 53.9 | 108,734 | 108,788 |
| 2022 | 154,253 | 8.7 | 154,245 | 154,253 |
| 2023 | 112,889 | 1.3 | 112,888 | 112,889 |
| 2024 | 59,044 | 0 | 59,044 | 59,044 |

Table 4.3: Estimates of retained and discarded (t) yellowfin sole caught in Bering Sea fisheries from 1991 through October 1, 2024, and the proportion discarded.

| 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 | 106,785 | 2,003 | 0.02 |
| 2022 | 151,493 | 2,760 | 0.02 |
| 2023 | 111,154 | 1,735 | 0.02 |
| 2024 | 59,692 | 1,156 | 0.02 |

Table 4.5: 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 | Hauls w nages | N. otoliths | N. ages (survey) | N. ages (fishery) | V10 |
|------|-------------|----------------|------------|------------------|---------------|-------------|------------------|-------------------|-----|
| 1982 | 329 | 246 | 37,023 | 35 | 35 | 744 | 744 | 2432 | |
| 1983 | 353 | 256 | 33,924 | 37 | 37 | 709 | 709 | 1178 | |
| 1984 | 355 | 271 | 33,894 | 56 | 56 | 821 | 796 | 338 | |
| 1985 | 353 | 261 | 33,824 | 44 | 43 | 810 | 802 | 840 | |
| 1986 | 354 | 249 | 30,470 | 34 | 34 | 739 | 739 | 1503 | |
| 1987 | 357 | 224 | 31,241 | 16 | 16 | 798 | 798 | 1071 | |
| 1988 | 373 | 254 | 27,138 | 14 | 14 | 543 | 543 | 1361 | |
| 1989 | 374 | 236 | 29,672 | 24 | 24 | 740 | 740 | 1462 | |
| 1990 | 371 | 251 | 30,257 | 28 | 28 | 792 | 792 | 1220 | |
| 1991 | 372 | 248 | 27,986 | 26 | 26 | 742 | 742 | 935 | |
| 1992 | 356 | 229 | 23,628 | 16 | 16 | 606 | 606 | 1203 | |
| 1993 | 375 | 242 | 26,651 | 20 | 20 | 549 | 549 | 1020 | |
| 1994 | 375 | 269 | 24,448 | 14 | 14 | 526 | 522 | 573 | |
| 1995 | 376 | 254 | 22,116 | 20 | 20 | 654 | 647 | 554 | |
| 1996 | 375 | 247 | 27,505 | 16 | 16 | 729 | 721 | 314 | |
| 1997 | 376 | 262 | 26,034 | 11 | 11 | 470 | 466 | 397 | |
| 1998 | 375 | 310 | 34,509 | 15 | 15 | 575 | 570 | 426 | |
| 1999 | 373 | 276 | 28,431 | 31 | 31 | 777 | 770 | 487 | |
| 2000 | 372 | 255 | 24,880 | 20 | 20 | 517 | 511 | 583 | |
| 2001 | 375 | 251 | 26,558 | 25 | 25 | 604 | 593 | 491 | |
| 2002 | 375 | 246 | 26,309 | 32 | 32 | 738 | 723 | 486 | |
| 2003 | 376 | 241 | 27,135 | 37 | 37 | 699 | 695 | 590 | |
| 2004 | 375 | 251 | 26,103 | 26 | 26 | 725 | 712 | 483 | |
| 2005 | 373 | 251 | 24,658 | 35 | 35 | 663 | 653 | 494 | |
| 2006 | 376 | 246 | 28,470 | 39 | 39 | 428 | 426 | 490 | |
| 2007 | 376 | 247 | 24,790 | 66 | 66 | 779 | 772 | 496 | |
| 2008 | 375 | 238 | 25,848 | 65 | 65 | 858 | 830 | 542 | |
| 2009 | 376 | 235 | 22,018 | 70 | 70 | 783 | 751 | 515 | |
| 2010 | 376 | 228 | 20,619 | 77 | 77 | 841 | 827 | 535 | |
| 2011 | 376 | 228 | 21,665 | 65 | 64 | 784 | 753 | 525 | |
| 2012 | 376 | 242 | 23,519 | 72 | 72 | 992 | 973 | 504 | |
| 2013 | 376 | 232 | 23,261 | 70 | 70 | 821 | 803 | 670 | |
| 2014 | 376 | 219 | 20,229 | 52 | 52 | 799 | 790 | 502 | |
| 2015 | 376 | 223 | 20,830 | 73 | 73 | 878 | 875 | 622 | |
| 2016 | 376 | 242 | 92,368 | 69 | 69 | 884 | 876 | 495 | |
| 2017 | 376 | 258 | 25,767 | 78 | 78 | 896 | 886 | 595 | |
| 2018 | 376 | 262 | 27,285 | 68 | 68 | 724 | 720 | 608 | |
| 2019 | 376 | 270 | 25,669 | 67 | 67 | 836 | 832 | 589 | |
| 2020 | - | - | - | - | - | - | - | 660 | |
| 2021 | 376 | 234 | 18,757 | 201 | 200 | 1030 | 983 | 700 | |
| 2022 | 376 | 238 | 16,765 | 195 | 195 | 619 | 581 | 635 | - |
| 2023 | 376 | 233 | 15,501 | 172 | 172 | 514 | 508 | - | |
| 2024 | 350 | 212 | 15,673 | 160 | - | 479 | - | - | |

Table 4.6: Yellowfin sole fishery catch-at-age (proportions) estimated by the model, 1975-2023 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 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------------------------------------|
| 1975 | 0.1467 | 0.2972 | 0.2256 | 0.0952 | 0.0561 | 0.0253 | 0.0181 | 0.0224 | 0.0082 | 0.0073 | 0.0043 | 0.9064 |
| 1976 | 0.0973 | 0.1665 | 0.2709 | 0.1947 | 0.0831 | 0.0496 | 0.0225 | 0.0161 | 0.0200 | 0.0073 | 0.0065 | 0.9345 |
| 1977 | 0.1622 | 0.2064 | 0.1738 | 0.1629 | 0.0879 | 0.0337 | 0.0195 | 0.0087 | 0.0062 | 0.0077 | 0.0028 | 0.8718 |
| 1978 | 0.0891 | 0.1947 | 0.2193 | 0.1631 | 0.1416 | 0.0736 | 0.0278 | 0.0159 | 0.0071 | 0.0051 | 0.0063 | 0.9436 |
| 1979 | 0.0591 | 0.1422 | 0.2159 | 0.1894 | 0.1256 | 0.1046 | 0.0536 | 0.0201 | 0.0115 | 0.0052 | 0.0037 | 0.9309 |
| 1980 | 0.0679 | 0.0818 | 0.1499 | 0.1951 | 0.1614 | 0.1053 | 0.0874 | 0.0448 | 0.0168 | 0.0096 | 0.0043 | 0.9243 |
| 1981 | 0.0821 | 0.1070 | 0.0991 | 0.1462 | 0.1673 | 0.1302 | 0.0828 | 0.0680 | 0.0347 | 0.0130 | 0.0075 | 0.9379 |
| 1982 | 0.0623 | 0.1399 | 0.1306 | 0.0943 | 0.1213 | 0.1304 | 0.0989 | 0.0622 | 0.0509 | 0.0260 | 0.0097 | 0.9265 |
| 1983 | 0.0802 | 0.0916 | 0.1546 | 0.1218 | 0.0815 | 0.1018 | 0.1082 | 0.0818 | 0.0514 | 0.0420 | 0.0214 | 0.9363 |
| 1984 | 0.0366 | 0.0964 | 0.0976 | 0.1528 | 0.1166 | 0.0770 | 0.0959 | 0.1018 | 0.0769 | 0.0483 | 0.0395 | 0.9394 |
| 1985 | 0.0244 | 0.0625 | 0.1192 | 0.0981 | 0.1408 | 0.1043 | 0.0683 | 0.0847 | 0.0899 | 0.0679 | 0.0426 | 0.9027 |
| 1986 | 0.0438 | 0.0478 | 0.0833 | 0.1224 | 0.0902 | 0.1246 | 0.0912 | 0.0595 | 0.0737 | 0.0782 | 0.0590 | 0.8737 |
| 1987 | 0.0225 | 0.0595 | 0.0537 | 0.0833 | 0.1174 | 0.0855 | 0.1178 | 0.0862 | 0.0562 | 0.0696 | 0.0739 | 0.8256 |
| 1988 | 0.0566 | 0.0491 | 0.0928 | 0.0599 | 0.0782 | 0.1037 | 0.0741 | 0.1016 | 0.0742 | 0.0484 | 0.0600 | 0.7986 |
| 1989 | 0.0073 | 0.0840 | 0.0633 | 0.1002 | 0.0583 | 0.0733 | 0.0963 | 0.0686 | 0.0940 | 0.0686 | 0.0447 | 0.7586 |
| 1990 | 0.0400 | 0.0284 | 0.2037 | 0.0856 | 0.0915 | 0.0455 | 0.0546 | 0.0708 | 0.0503 | 0.0689 | 0.0503 | 0.7896 |
| 1991 | 0.0366 | 0.1427 | 0.0510 | 0.2127 | 0.0683 | 0.0668 | 0.0325 | 0.0388 | 0.0503 | 0.0358 | 0.0490 | 0.7845 |
| 1992 | 0.0212 | 0.0539 | 0.1884 | 0.0567 | 0.2073 | 0.0620 | 0.0587 | 0.0281 | 0.0334 | 0.0432 | 0.0307 | 0.7836 |
| 1993 | 0.0232 | 0.0318 | 0.0624 | 0.1861 | 0.0531 | 0.1929 | 0.0579 | 0.0550 | 0.0264 | 0.0314 | 0.0406 | 0.7608 |
| 1994 | 0.0243 | 0.0421 | 0.0536 | 0.0843 | 0.2019 | 0.0502 | 0.1707 | 0.0498 | 0.0467 | 0.0224 | 0.0265 | 0.7725 |
| 1995 | 0.0452 | 0.0791 | 0.0850 | 0.0675 | 0.0793 | 0.1683 | 0.0402 | 0.1348 | 0.0392 | 0.0367 | 0.0176 | 0.7929 |
| 1996 | 0.0222 | 0.0863 | 0.1142 | 0.0933 | 0.0632 | 0.0696 | 0.1444 | 0.0342 | 0.1144 | 0.0332 | 0.0311 | 0.8061 |
| 1997 | 0.0259 | 0.0496 | 0.1356 | 0.1274 | 0.0861 | 0.0541 | 0.0582 | 0.1196 | 0.0283 | 0.0945 | 0.0274 | 0.8067 |
| 1998 | 0.0354 | 0.0419 | 0.0623 | 0.1402 | 0.1207 | 0.0795 | 0.0497 | 0.0533 | 0.1096 | 0.0259 | 0.0866 | 0.8051 |
| 1999 | 0.0114 | 0.0435 | 0.0480 | 0.0660 | 0.1403 | 0.1178 | 0.0770 | 0.0480 | 0.0515 | 0.1059 | 0.0250 | 0.7344 |
| 2000 | 0.0139 | 0.0394 | 0.1213 | 0.0878 | 0.0784 | 0.1273 | 0.0948 | 0.0592 | 0.0363 | 0.0388 | 0.0796 | 0.7768 |
| 2001 | 0.0185 | 0.0395 | 0.0791 | 0.1612 | 0.0867 | 0.0677 | 0.1049 | 0.0770 | 0.0479 | 0.0294 | 0.0313 | 0.7432 |
| 2002 | 0.0231 | 0.0283 | 0.0577 | 0.0985 | 0.1695 | 0.0827 | 0.0620 | 0.0946 | 0.0691 | 0.0429 | 0.0263 | 0.7547 |
| 2003 | 0.0243 | 0.1142 | 0.0833 | 0.0909 | 0.0975 | 0.1346 | 0.0608 | 0.0445 | 0.0675 | 0.0492 | 0.0305 | 0.7973 |
| 2004 | 0.0205 | 0.0491 | 0.1685 | 0.0912 | 0.0841 | 0.0844 | 0.1142 | 0.0513 | 0.0374 | 0.0567 | 0.0413 | 0.7987 |
| 2005 | 0.0333 | 0.0528 | 0.0831 | 0.1936 | 0.0834 | 0.0697 | 0.0677 | 0.0906 | 0.0405 | 0.0296 | 0.0448 | 0.7891 |
| 2006 | 0.0587 | 0.0744 | 0.0816 | 0.0919 | 0.1767 | 0.0698 | 0.0565 | 0.0542 | 0.0722 | 0.0322 | 0.0235 | 0.7917 |
| 2007 | 0.0338 | 0.0901 | 0.0882 | 0.0812 | 0.0848 | 0.1589 | 0.0623 | 0.0503 | 0.0482 | 0.0642 | 0.0287 | 0.7907 |
| 2008 | 0.0551 | 0.0723 | 0.1273 | 0.0906 | 0.0712 | 0.0699 | 0.1283 | 0.0500 | 0.0402 | 0.0385 | 0.0513 | 0.7947 |
| 2009 | 0.0400 | 0.0832 | 0.0878 | 0.1293 | 0.0844 | 0.0642 | 0.0624 | 0.1141 | 0.0444 | 0.0357 | 0.0342 | 0.7797 |
| 2010 | 0.0755 | 0.0897 | 0.1151 | 0.0862 | 0.1093 | 0.0679 | 0.0508 | 0.0492 | 0.0898 | 0.0349 | 0.0281 | 0.7965 |
| 2011 | 0.0332 | 0.1277 | 0.1102 | 0.1130 | 0.0766 | 0.0936 | 0.0575 | 0.0429 | 0.0415 | 0.0757 | 0.0294 | 0.8013 |
| 2012 | 0.0393 | 0.0639 | 0.1675 | 0.1102 | 0.0999 | 0.0647 | 0.0779 | 0.0476 | 0.0355 | 0.0343 | 0.0626 | 0.8034 |
| 2013 | 0.0312 | 0.0574 | 0.0758 | 0.1704 | 0.1046 | 0.0926 | 0.0595 | 0.0716 | 0.0437 | 0.0326 | 0.0315 | 0.7709 |
| 2014 | 0.0245 | 0.0587 | 0.0810 | 0.0823 | 0.1619 | 0.0948 | 0.0826 | 0.0529 | 0.0635 | 0.0387 | 0.0289 | 0.7698 |
| 2015 | 0.0209 | 0.0440 | 0.0817 | 0.0887 | 0.0795 | 0.1496 | 0.0865 | 0.0751 | 0.0480 | 0.0577 | 0.0352 | 0.7669 |
| 2016 | 0.0418 | 0.0712 | 0.0932 | 0.1052 | 0.0839 | 0.0661 | 0.1191 | 0.0679 | 0.0587 | 0.0375 | 0.0450 | 0.7896 |
| 2017 | 0.0244 | 0.1048 | 0.1110 | 0.0999 | 0.0939 | 0.0701 | 0.0541 | 0.0969 | 0.0551 | 0.0477 | 0.0305 | 0.7884 |
| 2018 | 0.0146 | 0.0434 | 0.1396 | 0.1174 | 0.0944 | 0.0851 | 0.0627 | 0.0482 | 0.0862 | 0.0490 | 0.0424 | 0.7830 |
| 2019 | 0.0261 | 0.0335 | 0.0647 | 0.1518 | 0.1104 | 0.0844 | 0.0749 | 0.0550 | 0.0422 | 0.0754 | 0.0429 | 0.7613 |
| 2020 | 0.0329 | 0.0582 | 0.0492 | 0.0702 | 0.1418 | 0.0973 | 0.0728 | 0.0642 | 0.0470 | 0.0360 | 0.0644 | 0.7340 |
| 2021 | 0.0609 | 0.0570 | 0.0689 | 0.0468 | 0.0611 | 0.1199 | 0.0815 | 0.0608 | 0.0536 | 0.0392 | 0.0301 | 0.6798 |
| 2022 | 0.0765 | 0.0866 | 0.0617 | 0.0639 | 0.0408 | 0.0521 | 0.1014 | 0.0687 | 0.0513 | 0.0451 | 0.0330 | 0.6811 |
| 2023 | 0.1171 | 0.0971 | 0.0872 | 0.0554 | 0.0553 | 0.0349 | 0.0445 | 0.0865 | 0.0586 | 0.0437 | 0.0385 | 0.7188 |

| Year | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17+ | Total male proportion over age 7 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------------------------------|
| 1975 | 0.1488 | 0.2990 | 0.2252 | 0.0943 | 0.0552 | 0.0247 | 0.0175 | 0.0215 | 0.0078 | 0.0069 | 0.0041 | 0.9050 |
| 1976 | 0.0992 | 0.1683 | 0.2718 | 0.1939 | 0.0821 | 0.0487 | 0.0219 | 0.0156 | 0.0191 | 0.0069 | 0.0061 | 0.9336 |
| 1977 | 0.1643 | 0.2076 | 0.1735 | 0.1614 | 0.0864 | 0.0329 | 0.0188 | 0.0084 | 0.0060 | 0.0073 | 0.0027 | 0.8693 |
| 1978 | 0.0908 | 0.1970 | 0.2202 | 0.1625 | 0.1400 | 0.0722 | 0.0270 | 0.0154 | 0.0068 | 0.0048 | 0.0059 | 0.9426 |
| 1979 | 0.0604 | 0.1442 | 0.2173 | 0.1892 | 0.1245 | 0.1029 | 0.0523 | 0.0195 | 0.0111 | 0.0049 | 0.0035 | 0.9298 |
| 1980 | 0.0696 | 0.0832 | 0.1514 | 0.1955 | 0.1605 | 0.1039 | 0.0856 | 0.0436 | 0.0162 | 0.0092 | 0.0041 | 0.9228 |
| 1981 | 0.0844 | 0.1091 | 0.1003 | 0.1468 | 0.1668 | 0.1288 | 0.0812 | 0.0662 | 0.0336 | 0.0125 | 0.0071 | 0.9368 |
| 1982 | 0.0640 | 0.1427 | 0.1323 | 0.0947 | 0.1210 | 0.1291 | 0.0972 | 0.0607 | 0.0492 | 0.0249 | 0.0093 | 0.9251 |
| 1983 | 0.0827 | 0.0938 | 0.1570 | 0.1227 | 0.0814 | 0.1010 | 0.1066 | 0.0799 | 0.0498 | 0.0404 | 0.0204 | 0.9357 |
| 1984 | 0.0380 | 0.0992 | 0.0997 | 0.1549 | 0.1172 | 0.0769 | 0.0949 | 0.1001 | 0.0750 | 0.0467 | 0.0379 | 0.9405 |
| 1985 | 0.0254 | 0.0645 | 0.1222 | 0.0998 | 0.1421 | 0.1045 | 0.0679 | 0.0835 | 0.0880 | 0.0659 | 0.0411 | 0.9049 |
| 1986 | 0.0457 | 0.0495 | 0.0856 | 0.1248 | 0.0912 | 0.1251 | 0.0909 | 0.0588 | 0.0723 | 0.0761 | 0.0570 | 0.8770 |
| 1987 | 0.0236 | 0.0620 | 0.0555 | 0.0853 | 0.1194 | 0.0863 | 0.1180 | 0.0856 | 0.0554 | 0.0682 | 0.0718 | 0.8311 |
| 1988 | 0.0594 | 0.0512 | 0.0959 | 0.0615 | 0.0796 | 0.1048 | 0.0744 | 0.1011 | 0.0733 | 0.0474 | 0.0583 | 0.8069 |
| 1989 | 0.0077 | 0.0879 | 0.0658 | 0.1033 | 0.0597 | 0.0744 | 0.0970 | 0.0686 | 0.0932 | 0.0675 | 0.0437 | 0.7688 |
| 1990 | 0.0419 | 0.0296 | 0.2105 | 0.0878 | 0.0931 | 0.0460 | 0.0548 | 0.0704 | 0.0497 | 0.0674 | 0.0489 | 0.8001 |
| 1991 | 0.0382 | 0.1477 | 0.0524 | 0.2168 | 0.0691 | 0.0671 | 0.0324 | 0.0384 | 0.0494 | 0.0348 | 0.0473 | 0.7936 |
| 1992 | 0.0222 | 0.0559 | 0.1941 | 0.0580 | 0.2104 | 0.0624 | 0.0586 | 0.0279 | 0.0329 | 0.0422 | 0.0297 | 0.7943 |
| 1993 | 0.0244 | 0.0332 | 0.0645 | 0.1912 | 0.0541 | 0.1951 | 0.0581 | 0.0548 | 0.0261 | 0.0308 | 0.0395 | 0.7718 |
| 1994 | 0.0255 | 0.0440 | 0.0556 | 0.0867 | 0.2061 | 0.0509 | 0.1716 | 0.0497 | 0.0463 | 0.0220 | 0.0259 | 0.7843 |
| 1995 | 0.0475 | 0.0825 | 0.0879 | 0.0692 | 0.0808 | 0.1701 | 0.0403 | 0.1341 | 0.0387 | 0.0360 | 0.0171 | 0.8042 |
| 1996 | 0.0234 | 0.0901 | 0.1182 | 0.0958 | 0.0644 | 0.0704 | 0.1449 | 0.0341 | 0.1131 | 0.0326 | 0.0303 | 0.8173 |
| 1997 | 0.0272 | 0.0517 | 0.1403 | 0.1308 | 0.0877 | 0.0547 | 0.0583 | 0.1191 | 0.0279 | 0.0926 | 0.0267 | 0.8170 |
| 1998 | 0.0373 | 0.0438 | 0.0647 | 0.1444 | 0.1234 | 0.0806 | 0.0500 | 0.0533 | 0.1087 | 0.0255 | 0.0846 | 0.8163 |
| 1999 | 0.0121 | 0.0458 | 0.0501 | 0.0684 | 0.1443 | 0.1203 | 0.0780 | 0.0483 | 0.0514 | 0.1048 | 0.0246 | 0.7481 |
| 2000 | 0.0147 | 0.0413 | 0.1262 | 0.0906 | 0.0803 | 0.1294 | 0.0956 | 0.0592 | 0.0361 | 0.0382 | 0.0778 | 0.7894 |
| 2001 | 0.0195 | 0.0414 | 0.0822 | 0.1661 | 0.0887 | 0.0687 | 0.1057 | 0.0770 | 0.0475 | 0.0289 | 0.0306 | 0.7563 |
| 2002 | 0.0245 | 0.0297 | 0.0601 | 0.1019 | 0.1740 | 0.0842 | 0.0626 | 0.0949 | 0.0688 | 0.0424 | 0.0258 | 0.7689 |
| 2003 | 0.0256 | 0.1191 | 0.0862 | 0.0933 | 0.0993 | 0.1361 | 0.0610 | 0.0443 | 0.0667 | 0.0482 | 0.0297 | 0.8095 |
| 2004 | 0.0215 | 0.0513 | 0.1745 | 0.0937 | 0.0857 | 0.0854 | 0.1147 | 0.0511 | 0.0370 | 0.0557 | 0.0403 | 0.8109 |
| 2005 | 0.0349 | 0.0550 | 0.0858 | 0.1985 | 0.0848 | 0.0704 | 0.0678 | 0.0900 | 0.0400 | 0.0289 | 0.0435 | 0.7996 |
| 2006 | 0.0615 | 0.0774 | 0.0842 | 0.0941 | 0.1794 | 0.0704 | 0.0565 | 0.0538 | 0.0711 | 0.0315 | 0.0228 | 0.8027 |
| 2007 | 0.0355 | 0.0938 | 0.0912 | 0.0833 | 0.0864 | 0.1605 | 0.0625 | 0.0501 | 0.0476 | 0.0629 | 0.0279 | 0.8017 |
| 2008 | 0.0577 | 0.0752 | 0.1313 | 0.0928 | 0.0723 | 0.0705 | 0.1283 | 0.0496 | 0.0396 | 0.0377 | 0.0498 | 0.8048 |
| 2009 | 0.0420 | 0.0867 | 0.0908 | 0.1327 | 0.0860 | 0.0649 | 0.0626 | 0.1135 | 0.0438 | 0.0350 | 0.0333 | 0.7913 |
| 2010 | 0.0791 | 0.0932 | 0.1187 | 0.0882 | 0.1110 | 0.0684 | 0.0508 | 0.0488 | 0.0885 | 0.0341 | 0.0273 | 0.8081 |
| 2011 | 0.0348 | 0.1327 | 0.1136 | 0.1157 | 0.0778 | 0.0944 | 0.0575 | 0.0426 | 0.0409 | 0.0740 | 0.0285 | 0.8125 |
| 2012 | 0.0411 | 0.0665 | 0.1728 | 0.1128 | 0.1014 | 0.0652 | 0.0780 | 0.0473 | 0.0350 | 0.0335 | 0.0607 | 0.8143 |
| 2013 | 0.0328 | 0.0599 | 0.0786 | 0.1751 | 0.1067 | 0.0937 | 0.0598 | 0.0713 | 0.0432 | 0.0320 | 0.0306 | 0.7837 |
| 2014 | 0.0258 | 0.0614 | 0.0841 | 0.0848 | 0.1656 | 0.0962 | 0.0832 | 0.0528 | 0.0629 | 0.0381 | 0.0282 | 0.7831 |
| 2015 | 0.0221 | 0.0462 | 0.0851 | 0.0916 | 0.0815 | 0.1522 | 0.0873 | 0.0753 | 0.0478 | 0.0569 | 0.0345 | 0.7805 |
| 2016 | 0.0441 | 0.0745 | 0.0967 | 0.1083 | 0.0858 | 0.0671 | 0.1199 | 0.0678 | 0.0582 | 0.0369 | 0.0439 | 0.8032 |
| 2017 | 0.0257 | 0.1094 | 0.1150 | 0.1027 | 0.0958 | 0.0710 | 0.0544 | 0.0966 | 0.0546 | 0.0468 | 0.0297 | 0.8017 |
| 2018 | 0.0154 | 0.0455 | 0.1450 | 0.1210 | 0.0965 | 0.0864 | 0.0632 | 0.0482 | 0.0855 | 0.0482 | 0.0414 | 0.7963 |
| 2019 | 0.0276 | 0.0351 | 0.0673 | 0.1567 | 0.1131 | 0.0858 | 0.0756 | 0.0550 | 0.0419 | 0.0743 | 0.0419 | 0.7743 |
| 2020 | 0.0347 | 0.0610 | 0.0511 | 0.0723 | 0.1451 | 0.0988 | 0.0734 | 0.0642 | 0.0466 | 0.0355 | 0.0629 | 0.7456 |
| 2021 | 0.0641 | 0.0595 | 0.0714 | 0.0481 | 0.0624 | 0.1215 | 0.0819 | 0.0607 | 0.0530 | 0.0385 | 0.0293 | 0.6904 |
| 2022 | 0.0804 | 0.0903 | 0.0638 | 0.0656 | 0.0415 | 0.0527 | 0.1017 | 0.0684 | 0.0506 | 0.0442 | 0.0321 | 0.6913 |
| 2023 | 0.1229 | 0.1012 | 0.0902 | 0.0568 | 0.0562 | 0.0352 | 0.0446 | 0.0860 | 0.0579 | 0.0428 | 0.0374 | 0.7312 |

Table 4.7: Total tonnage of yellowfin sole caught in resource assessment surveys in the eastern Bering Sea from 1977-2022.

| Year | Research catch (t) |
|------|--------------------|
| 2006 | 0 |
| 2007 | 0 |
| 2010 | 119 |
| 2011 | 101 |
| 2012 | 83 |
| 2013 | 75 |
| 2014 | 83 |
| 2015 | 65 |
| 2016 | 98 |
| 2017 | 112 |
| 2018 | 73 |
| 2019 | 85 |
| 2020 | 0 |
| 2021 | 72 |
| 2022 | 87 |

Table 4.4: Discarded and retained catch of non-CDQ yellowfin sole, by fishery, in 2023. 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.

| | Gear type | Discarded (t) | Retained (t) |
|--------------------|-----------|---------------|--------------|
| Halibut | HAL | 1 | 0 |
| Other species | HAL | 0 | 0 |
| Pacific cod | HAL | 283 | 0 |
| Alaska Plaice | NPT | 2 | 115 |
| Atka mackerel | NPT | 0 | 4 |
| Flathead sole | NPT | 17 | 2,350 |
| Kamchatka Fl. | NPT | 0 | 0 |
| Other flatfish | NPT | 0 | 0 |
| Other species | NPT | 0 | 0 |
| Pacific cod | NPT | 12 | 28 |
| Pollock - bottom | NPT | 6 | 722 |
| Rock sole | NPT | 192 | 12,731 |
| Rockfish | NPT | 0 | 0 |
| Yellowfin sole | NPT | 1,108 | 95,182 |
| Pacific cod | POT | 110 | 0 |
| Pollock - bottom | PTR | 0 | 0 |
| Pollock - midwater | PTR | 3 | 17 |

Table 4.8: Female yellowfin sole proportion mature at age from Nichol (1995) and TenBrink and Wilderbuer (2015).

| Age | Nichol (1995) | TenBrink and Wilderbuer (2015) | Total |
|-----|--------------------|--------------------------------|----------|
| | 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 4.9: Yellowfin sole design-based (DB) biomass estimates (t) from the annual eastern Bering Sea shelf bottom trawl survey, and model-based (MB) biomass estimates for the combined northern and eastern Bering Sea survey areas (EBS+NBS), with upper (UCI) and lower (LCI) 95% confidence intervals. Note that surveys were not conducted in 2020.

| Year | Model-based estimate (2023) | | | Model-based estimate (2024) | | | Design-based estimate | | |
|------|-----------------------------|-----------|-----------|-----------------------------|-----------|-----------|-----------------------|-----------|-----------|
| | EBS+NBS | LCI | UCI | EBS+NBS | LCI | UCI | EBS | LCI | UCI |
| 1982 | 4,027,030 | 4,026,482 | 4,027,577 | 4,012,970 | 4,012,486 | 4,013,453 | 3,406,341 | 2,818,736 | 3,993,947 |
| 1983 | 4,568,050 | 4,567,398 | 4,568,701 | 4,645,390 | 4,644,776 | 4,646,003 | 3,474,787 | 3,063,656 | 3,885,918 |
| 1984 | 4,185,330 | 4,184,745 | 4,185,914 | 4,246,000 | 4,245,458 | 4,246,541 | 3,159,622 | 2,787,378 | 3,531,866 |
| 1985 | 3,024,480 | 3,024,146 | 3,024,813 | 3,105,250 | 3,104,928 | 3,105,571 | 2,414,441 | 2,096,973 | 2,731,909 |
| 1986 | 2,336,500 | 2,336,219 | 2,336,780 | 2,352,470 | 2,352,216 | 2,352,723 | 1,923,496 | 1,612,859 | 2,234,134 |
| 1987 | 3,022,300 | 3,021,953 | 3,022,646 | 3,087,340 | 3,087,009 | 3,087,670 | 2,530,209 | 2,140,961 | 2,919,458 |
| 1988 | 2,635,670 | 2,635,416 | 2,635,923 | 2,631,620 | 2,631,383 | 2,631,856 | 2,195,923 | 1,774,749 | 2,617,096 |
| 1989 | 2,775,430 | 2,775,116 | 2,775,743 | 2,804,980 | 2,804,683 | 2,805,276 | 2,329,416 | 1,980,460 | 2,678,372 |
| 1990 | 2,622,700 | 2,622,419 | 2,622,980 | 2,633,570 | 2,633,304 | 2,633,835 | 2,192,586 | 1,892,488 | 2,492,683 |
| 1991 | 3,153,540 | 3,153,238 | 3,153,841 | 3,166,840 | 3,166,556 | 3,167,123 | 2,406,530 | 2,127,620 | 2,685,440 |
| 1992 | 2,884,600 | 2,884,144 | 2,885,055 | 2,724,190 | 2,723,808 | 2,724,571 | 2,215,413 | 1,820,065 | 2,610,761 |
| 1993 | 3,137,850 | 3,137,434 | 3,138,265 | 3,130,010 | 3,129,645 | 3,130,374 | 2,484,908 | 2,168,595 | 2,801,220 |
| 1994 | 3,556,680 | 3,556,107 | 3,557,252 | 3,431,940 | 3,431,482 | 3,432,397 | 2,615,721 | 2,271,486 | 2,959,957 |
| 1995 | 2,529,190 | 2,528,843 | 2,529,536 | 2,475,100 | 2,474,807 | 2,475,392 | 2,026,892 | 1,736,109 | 2,317,674 |
| 1996 | 2,723,150 | 2,722,794 | 2,723,505 | 2,735,080 | 2,734,758 | 2,735,401 | 2,230,818 | 1,838,398 | 2,623,237 |
| 1997 | 2,871,530 | 2,871,075 | 2,871,984 | 2,821,510 | 2,821,134 | 2,821,885 | 2,176,543 | 1,919,107 | 2,433,978 |
| 1998 | 3,551,080 | 3,550,259 | 3,551,900 | 3,496,900 | 3,496,186 | 3,497,613 | 2,222,673 | 1,942,539 | 2,502,808 |
| 1999 | 2,020,680 | 2,020,155 | 2,021,204 | 1,817,780 | 1,817,424 | 1,818,135 | 1,266,417 | 1,082,100 | 1,450,734 |
| 2000 | 2,125,330 | 2,124,987 | 2,125,672 | 2,073,620 | 2,073,335 | 2,073,904 | 1,600,280 | 1,398,145 | 1,802,414 |
| 2001 | 2,338,410 | 2,338,025 | 2,338,794 | 2,249,590 | 2,249,282 | 2,249,897 | 1,690,555 | 1,444,657 | 1,936,453 |
| 2002 | 2,603,860 | 2,603,406 | 2,604,313 | 2,521,940 | 2,521,567 | 2,522,312 | 1,923,067 | 1,661,477 | 2,184,657 |
| 2003 | 2,915,860 | 2,915,402 | 2,916,317 | 2,846,410 | 2,846,003 | 2,846,816 | 2,171,729 | 1,752,807 | 2,590,650 |
| 2004 | 3,494,700 | 3,494,133 | 3,495,266 | 3,433,310 | 3,432,805 | 3,433,814 | 2,557,795 | 2,171,491 | 2,944,100 |
| 2005 | 3,568,890 | 3,568,381 | 3,569,398 | 3,504,700 | 3,504,242 | 3,505,157 | 2,840,246 | 2,104,313 | 3,576,179 |
| 2006 | 2,898,850 | 2,898,459 | 2,899,240 | 2,794,580 | 2,794,248 | 2,794,911 | 2,146,498 | 1,829,351 | 2,463,646 |
| 2007 | 2,825,340 | 2,824,942 | 2,825,737 | 2,758,160 | 2,757,813 | 2,758,506 | 2,168,037 | 1,780,455 | 2,555,619 |
| 2008 | 3,012,310 | 3,011,801 | 3,012,818 | 2,842,390 | 2,841,970 | 2,842,809 | 2,112,687 | 1,594,407 | 2,630,968 |
| 2009 | 2,407,410 | 2,407,058 | 2,407,761 | 2,316,830 | 2,316,516 | 2,317,143 | 1,752,059 | 1,445,392 | 2,058,726 |
| 2010 | 3,118,130 | 3,117,799 | 3,118,460 | 2,985,410 | 2,985,112 | 2,985,707 | 2,388,160 | 1,822,160 | 2,954,161 |
| 2011 | 2,876,520 | 2,876,164 | 2,876,875 | 2,812,180 | 2,811,847 | 2,812,512 | 2,422,504 | 1,931,852 | 2,913,156 |
| 2012 | 2,875,650 | 2,875,253 | 2,876,046 | 2,746,000 | 2,745,636 | 2,746,363 | 1,965,412 | 1,688,055 | 2,242,768 |
| 2013 | 2,817,990 | 2,817,656 | 2,818,323 | 2,763,400 | 2,763,092 | 2,763,707 | 2,295,205 | 1,948,003 | 2,642,406 |
| 2014 | 3,047,780 | 3,047,426 | 3,048,133 | 2,981,080 | 2,980,755 | 2,981,404 | 2,531,399 | 2,063,497 | 2,999,301 |
| 2015 | 2,396,930 | 2,396,655 | 2,397,204 | 2,335,960 | 2,335,710 | 2,336,209 | 1,946,300 | 1,655,744 | 2,236,857 |
| 2016 | 3,796,820 | 3,796,422 | 3,797,217 | 3,727,530 | 3,727,150 | 3,727,909 | 2,876,796 | 2,547,622 | 3,205,971 |
| 2017 | 3,711,310 | 3,710,979 | 3,711,640 | 3,502,670 | 3,502,384 | 3,502,955 | 2,805,164 | 2,324,139 | 3,286,190 |
| 2018 | 2,961,540 | 2,961,279 | 2,961,800 | 2,794,610 | 2,794,381 | 2,794,838 | 1,903,041 | 1,673,587 | 2,132,495 |
| 2019 | 2,875,140 | 2,874,905 | 2,875,374 | 2,743,450 | 2,743,241 | 2,743,658 | 2,017,620 | 1,592,272 | 2,442,967 |
| 2021 | 2,476,000 | 2,475,787 | 2,476,212 | 2,372,550 | 2,372,361 | 2,372,738 | 1,633,967 | 1,417,385 | 1,850,550 |
| 2022 | 2,936,470 | 2,936,215 | 2,936,724 | 2,785,320 | 2,785,094 | 2,785,545 | 2,039,968 | 1,773,113 | 2,306,822 |
| 2023 | 2,007,140 | 2,006,955 | 2,007,324 | 1,889,620 | 1,889,460 | 1,889,779 | 1,393,378 | 1,133,407 | 1,653,350 |
| 2024 | - | - | - | 2,022,780 | 2,022,500 | 2,023,059 | 1,503,618 | 1,250,990 | 1,756,245 |

Table 4.10: Model estimates of yellowfin sole age 2+ total biomass (t) from the 2023 and 2024 stock assessments, Model 23.0 (2023) and Model 23.0 (2024). Input survey biomass data is based on model-based (VAST) estimates for the NBS+EBS.

| Model | 23.0 (2023) | 23.0 (2024) | | |
|-------|-------------|-------------|-----------|-----------|
| | Biomass (t) | Biomass (t) | LCI | HCI |
| 1954 | 2,423,160 | 2,739,280 | 2,337,920 | 3,209,560 |
| 1955 | 2,376,930 | 2,684,280 | 2,318,380 | 3,107,930 |
| 1956 | 2,331,800 | 2,614,330 | 2,292,770 | 2,980,970 |
| 1957 | 2,289,230 | 2,531,310 | 2,260,340 | 2,834,770 |
| 1958 | 2,268,840 | 2,458,410 | 2,240,200 | 2,697,870 |
| 1959 | 2,250,120 | 2,380,980 | 2,212,200 | 2,562,630 |
| 1960 | 2,101,830 | 2,173,990 | 2,044,610 | 2,311,560 |
| 1961 | 1,692,110 | 1,709,170 | 1,606,410 | 1,818,500 |
| 1962 | 1,227,300 | 1,180,860 | 1,094,900 | 1,273,570 |
| 1963 | 883,637 | 857,976 | 781,057 | 942,471 |
| 1964 | 924,513 | 897,054 | 815,383 | 986,906 |
| 1965 | 919,805 | 887,860 | 800,698 | 984,511 |
| 1966 | 980,248 | 941,940 | 847,080 | 1,047,420 |
| 1967 | 984,241 | 937,952 | 834,246 | 1,054,550 |
| 1968 | 929,434 | 873,459 | 759,591 | 1,004,400 |
| 1969 | 989,666 | 922,071 | 793,447 | 1,071,550 |
| 1970 | 996,636 | 917,063 | 771,331 | 1,090,330 |
| 1971 | 1,089,240 | 996,884 | 829,408 | 1,198,180 |
| 1972 | 1,201,470 | 1,095,950 | 903,679 | 1,329,130 |
| 1973 | 1,489,500 | 1,370,340 | 1,148,610 | 1,634,870 |
| 1974 | 1,768,630 | 1,636,490 | 1,385,680 | 1,932,690 |
| 1975 | 2,159,530 | 2,004,510 | 1,717,140 | 2,339,980 |
| 1976 | 2,489,620 | 2,321,300 | 2,005,360 | 2,687,000 |
| 1977 | 2,810,960 | 2,632,580 | 2,292,140 | 3,023,590 |
| 1978 | 3,106,430 | 2,919,400 | 2,558,820 | 3,330,800 |
| 1979 | 3,255,780 | 3,062,700 | 2,688,490 | 3,488,990 |
| 1980 | 3,411,190 | 3,214,690 | 2,830,800 | 3,650,630 |
| 1981 | 3,532,460 | 3,337,630 | 2,948,380 | 3,778,270 |
| 1982 | 3,559,160 | 3,372,930 | 2,991,480 | 3,803,030 |
| 1983 | 3,493,000 | 3,313,210 | 2,937,590 | 3,736,850 |
| 1984 | 3,632,020 | 3,453,080 | 3,069,670 | 3,884,380 |
| 1985 | 3,575,340 | 3,403,860 | 3,019,540 | 3,837,090 |
| 1986 | 3,257,450 | 3,094,820 | 2,729,140 | 3,509,490 |
| 1987 | 3,148,250 | 2,991,850 | 2,629,610 | 3,403,990 |
| 1988 | 3,001,610 | 2,854,090 | 2,503,810 | 3,253,370 |
| 1989 | 3,027,420 | 2,867,700 | 2,512,470 | 3,273,140 |
| 1990 | 2,868,040 | 2,716,290 | 2,375,210 | 3,106,350 |
| 1991 | 2,965,970 | 2,805,910 | 2,462,260 | 3,197,530 |
| 1992 | 3,156,260 | 2,975,720 | 2,621,100 | 3,378,330 |
| 1993 | 3,242,770 | 3,044,370 | 2,683,760 | 3,453,430 |
| 1994 | 3,318,830 | 3,106,810 | 2,742,720 | 3,519,230 |
| 1995 | 3,092,680 | 2,889,820 | 2,542,150 | 3,285,020 |
| 1996 | 3,039,190 | 2,832,800 | 2,489,610 | 3,223,300 |
| 1997 | 3,109,230 | 2,885,880 | 2,535,810 | 3,284,280 |
| 1998 | 2,840,060 | 2,625,980 | 2,293,730 | 3,006,350 |
| 1999 | 2,641,850 | 2,440,170 | 2,123,510 | 2,804,060 |
| 2000 | 2,519,430 | 2,326,040 | 2,026,510 | 2,669,840 |

| | | | | |
|------|-----------|-----------|-----------|-----------|
| 2001 | 2,505,700 | 2,312,340 | 2,010,820 | 2,659,070 |
| 2002 | 2,608,310 | 2,402,400 | 2,098,600 | 2,750,190 |
| 2003 | 2,936,550 | 2,703,220 | 2,370,780 | 3,082,270 |
| 2004 | 3,115,450 | 2,861,520 | 2,517,180 | 3,252,960 |
| 2005 | 3,223,170 | 2,952,920 | 2,604,140 | 3,348,410 |
| 2006 | 3,260,800 | 2,986,120 | 2,635,260 | 3,383,690 |
| 2007 | 3,211,900 | 2,937,950 | 2,596,780 | 3,323,940 |
| 2008 | 3,081,100 | 2,820,350 | 2,493,290 | 3,190,310 |
| 2009 | 3,110,560 | 2,840,310 | 2,504,430 | 3,221,220 |
| 2010 | 3,248,490 | 2,964,830 | 2,615,280 | 3,361,090 |
| 2011 | 3,205,520 | 2,926,870 | 2,589,510 | 3,308,170 |
| 2012 | 3,049,110 | 2,770,530 | 2,446,320 | 3,137,710 |
| 2013 | 2,928,580 | 2,655,850 | 2,343,700 | 3,009,570 |
| 2014 | 2,887,920 | 2,611,540 | 2,300,950 | 2,964,050 |
| 2015 | 2,866,870 | 2,581,910 | 2,267,540 | 2,939,870 |
| 2016 | 2,881,680 | 2,586,400 | 2,273,230 | 2,942,700 |
| 2017 | 2,873,180 | 2,536,470 | 2,217,410 | 2,901,440 |
| 2018 | 2,615,040 | 2,330,620 | 2,039,110 | 2,663,810 |
| 2019 | 2,673,750 | 2,374,260 | 2,071,880 | 2,720,770 |
| 2020 | 2,574,660 | 2,288,160 | 1,992,010 | 2,628,340 |
| 2021 | 2,623,810 | 2,337,800 | 2,038,150 | 2,681,510 |
| 2022 | 2,719,490 | 2,424,630 | 2,105,490 | 2,792,140 |
| 2023 | 2,716,370 | 2,373,960 | 2,044,780 | 2,756,140 |
| 2024 | | 2,412,520 | 2,065,680 | 2,817,590 |

Table 4.11: 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. Age data from 2023 was not used in the assessment model.

| Year | Biomass (t) | LCI | HCI | Haul count | Hauls with catch | Hauls with length | Otoliths read | Hauls with otoliths |
|------|-------------|---------|---------|------------|------------------|-------------------|---------------|---------------------|
| 2010 | 427,374 | 331,321 | 523,426 | 141 | 121 | 121 | 351 | 46 |
| 2017 | 434,087 | 336,225 | 531,949 | 143 | 131 | 130 | 536 | 50 |
| 2019 | 520,031 | 395,637 | 644,425 | 144 | 141 | 140 | 0 | 33 |
| 2021 | 496,045 | 392,315 | 599,775 | 144 | 138 | 137 | 0 | 122 |
| 2022 | 548,026 | 365,861 | 730,191 | 144 | 136 | 135 | 362 | 123 |
| 2023 | 393,304 | 314,123 | 472,485 | 116 | 108 | 108 | 316 | 107 |

Table 4.12: Yellowfin sole population numbers-at-age (millions) estimated from the annual EBS bottom trawl surveys, 1987-2023 (Current year data is not yet available and there was no survey in 2020). Data in years 1987 or later come from the ‘plusnw’ extended survey area. Females are presented first, followed by males. Continued on next page.

| Year | Age (Females) | | | | | | | | | | | | | | | |
|------|---------------|-----|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-----|-----|-----|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17+ |
| 1982 | 75 | 368 | 700 | 2,430 | 2,977 | 2,852 | 3,242 | 1,689 | 1,659 | 1,665 | 1,409 | 819 | 493 | 319 | 102 | 68 |
| 1983 | 0 | 9 | 114 | 299 | 1,460 | 2,755 | 1,646 | 2,078 | 1,827 | 1,471 | 2,256 | 1,693 | 576 | 313 | 118 | 54 |
| 1984 | 0 | 106 | 555 | 528 | 855 | 1,490 | 1,682 | 2,223 | 2,159 | 1,882 | 1,083 | 1,167 | 961 | 478 | 348 | 152 |
| 1985 | 0 | 7 | 210 | 876 | 1,156 | 793 | 1,233 | 1,786 | 861 | 1,012 | 1,065 | 750 | 581 | 627 | 400 | 154 |
| 1986 | 0 | 15 | 48 | 437 | 698 | 1,333 | 558 | 1,147 | 1,039 | 754 | 567 | 635 | 392 | 501 | 272 | 307 |
| 1987 | 0 | 0 | 69 | 118 | 787 | 447 | 822 | 252 | 365 | 581 | 344 | 434 | 234 | 261 | 239 | 174 |
| 1988 | 0 | 0 | 6 | 345 | 65 | 1,364 | 501 | 498 | 165 | 215 | 317 | 188 | 326 | 247 | 198 | 152 |
| 1989 | 0 | 0 | 15 | 98 | 721 | 235 | 1,341 | 596 | 449 | 75 | 180 | 310 | 236 | 240 | 185 | 83 |
| 1990 | 0 | 0 | 70 | 102 | 327 | 1,073 | 193 | 1,263 | 410 | 484 | 102 | 72 | 108 | 79 | 232 | 127 |
| 1991 | 0 | 10 | 128 | 250 | 124 | 407 | 900 | 151 | 1,268 | 214 | 527 | 63 | 129 | 87 | 124 | 164 |
| 1992 | 0 | 19 | 240 | 465 | 499 | 203 | 275 | 900 | 91 | 794 | 73 | 297 | 125 | 132 | 163 | 104 |
| 1993 | 0 | 24 | 101 | 361 | 640 | 437 | 271 | 226 | 1,323 | 79 | 872 | 158 | 166 | 69 | 68 | 92 |
| 1994 | 0 | 54 | 95 | 223 | 519 | 907 | 556 | 482 | 285 | 1,172 | 0 | 517 | 44 | 274 | 143 | 42 |
| 1995 | 0 | 19 | 154 | 291 | 183 | 896 | 633 | 277 | 136 | 25 | 639 | 21 | 565 | 105 | 81 | 98 |
| 1996 | 0 | 16 | 151 | 793 | 281 | 271 | 421 | 501 | 200 | 141 | 147 | 583 | 113 | 617 | 45 | 29 |
| 1997 | 0 | 18 | 326 | 506 | 730 | 257 | 240 | 508 | 229 | 114 | 177 | 185 | 502 | 44 | 316 | 76 |
| 1998 | 0 | 10 | 80 | 455 | 402 | 860 | 248 | 194 | 353 | 393 | 352 | 162 | 168 | 252 | 64 | 398 |
| 1999 | 0 | 3 | 62 | 190 | 168 | 179 | 705 | 101 | 104 | 238 | 184 | 181 | 70 | 99 | 170 | 102 |
| 2000 | 0 | 11 | 55 | 250 | 210 | 307 | 449 | 544 | 192 | 200 | 240 | 222 | 66 | 118 | 147 | 111 |
| 2001 | 0 | 1 | 66 | 221 | 478 | 226 | 363 | 371 | 585 | 334 | 74 | 172 | 139 | 115 | 170 | 100 |
| 2002 | 0 | 16 | 119 | 164 | 243 | 748 | 326 | 274 | 216 | 434 | 209 | 86 | 291 | 110 | 144 | 137 |
| 2003 | 0 | 15 | 114 | 236 | 244 | 279 | 1,111 | 218 | 270 | 277 | 243 | 99 | 111 | 164 | 162 | 83 |
| 2004 | 10 | 34 | 198 | 442 | 572 | 418 | 219 | 976 | 224 | 213 | 222 | 223 | 108 | 20 | 170 | 187 |
| 2005 | 0 | 53 | 168 | 196 | 588 | 415 | 232 | 474 | 878 | 221 | 137 | 185 | 337 | 164 | 51 | 181 |
| 2006 | 8 | 68 | 304 | 378 | 278 | 637 | 472 | 177 | 327 | 742 | 134 | 134 | 71 | 157 | 177 | 2 |
| 2007 | 0 | 38 | 520 | 349 | 384 | 276 | 505 | 310 | 125 | 228 | 507 | 120 | 138 | 127 | 105 | 77 |
| 2008 | 0 | 24 | 115 | 742 | 624 | 546 | 357 | 361 | 196 | 128 | 255 | 355 | 152 | 79 | 86 | 119 |
| 2009 | 5 | 38 | 206 | 206 | 1,200 | 601 | 495 | 267 | 212 | 220 | 130 | 139 | 198 | 89 | 43 | 2 |
| 2010 | 0 | 33 | 331 | 390 | 442 | 902 | 559 | 521 | 332 | 338 | 156 | 168 | 136 | 174 | 100 | 50 |
| 2011 | 0 | 14 | 245 | 544 | 713 | 467 | 775 | 414 | 460 | 206 | 228 | 150 | 143 | 146 | 188 | 99 |
| 2012 | 10 | 50 | 231 | 398 | 509 | 296 | 245 | 758 | 258 | 337 | 107 | 157 | 37 | 151 | 129 | 150 |
| 2013 | 0 | 4 | 89 | 271 | 423 | 535 | 258 | 222 | 412 | 408 | 361 | 120 | 136 | 134 | 134 | 95 |
| 2014 | 0 | 0 | 37 | 424 | 387 | 250 | 422 | 233 | 230 | 527 | 343 | 161 | 145 | 230 | 35 | 123 |
| 2015 | 0 | 23 | 3 | 169 | 470 | 352 | 310 | 289 | 251 | 150 | 284 | 260 | 136 | 100 | 81 | 68 |
| 2016 | 1 | 33 | 72 | 46 | 165 | 748 | 569 | 406 | 365 | 302 | 144 | 246 | 231 | 141 | 163 | 171 |
| 2017 | 17 | 80 | 384 | 382 | 123 | 320 | 1,007 | 484 | 338 | 380 | 229 | 149 | 204 | 201 | 149 | 119 |
| 2018 | 0 | 50 | 183 | 263 | 178 | 92 | 265 | 642 | 327 | 232 | 81 | 76 | 42 | 125 | 100 | 104 |
| 2019 | 2 | 124 | 210 | 309 | 157 | 242 | 80 | 211 | 549 | 360 | 130 | 161 | 126 | 124 | 72 | 44 |
| 2020 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2021 | 0 | 259 | 100 | 1,450 | 457 | 318 | 123 | 177 | 95 | 157 | 162 | 109 | 106 | 67 | 55 | 62 |
| 2022 | 0 | 97 | 361 | 282 | 1,406 | 425 | 405 | 88 | 160 | 81 | 127 | 174 | 87 | 73 | 77 | 66 |
| 2023 | 0 | 17 | 132 | 339 | 279 | 752 | 482 | 181 | 32 | 47 | 20 | 125 | 80 | 82 | 54 | 32 |

| Year | Age (Females) | | | | | | | | | | | | | | | |
|------|---------------|-----|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-------|-----|-----|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17+ |
| 1982 | 178 | 388 | 859 | 3,567 | 3,566 | 2,120 | 3,348 | 1,288 | 1,549 | 927 | 943 | 965 | 605 | 16 | 47 | 14 |
| 1983 | 0 | 1 | 126 | 354 | 1,403 | 3,371 | 1,576 | 2,044 | 1,320 | 1,368 | 1,412 | 1,107 | 832 | 1,076 | 151 | 89 |
| 1984 | 0 | 135 | 493 | 646 | 994 | 1,469 | 1,660 | 1,225 | 1,575 | 1,437 | 716 | 758 | 402 | 631 | 244 | 111 |
| 1985 | 0 | 83 | 343 | 833 | 1,107 | 519 | 1,289 | 1,044 | 795 | 893 | 714 | 444 | 516 | 311 | 222 | 33 |
| 1986 | 0 | 25 | 95 | 217 | 747 | 1,303 | 524 | 653 | 568 | 670 | 422 | 410 | 230 | 421 | 163 | 272 |
| 1987 | 0 | 5 | 40 | 104 | 820 | 457 | 655 | 431 | 317 | 267 | 203 | 142 | 102 | 137 | 178 | 212 |
| 1988 | 0 | 2 | 10 | 414 | 46 | 1,088 | 508 | 407 | 78 | 172 | 25 | 163 | 308 | 174 | 25 | 107 |
| 1989 | 0 | 2 | 24 | 182 | 790 | 177 | 1,311 | 515 | 359 | 135 | 50 | 104 | 54 | 205 | 36 | 39 |
| 1990 | 0 | 11 | 48 | 122 | 319 | 895 | 196 | 1,152 | 320 | 265 | 40 | 65 | 67 | 24 | 55 | 73 |
| 1991 | 0 | 0 | 104 | 357 | 140 | 277 | 1,051 | 68 | 1,144 | 331 | 246 | 75 | 65 | 61 | 53 | 92 |
| 1992 | 0 | 0 | 141 | 428 | 543 | 252 | 216 | 779 | 110 | 875 | 186 | 206 | 12 | 12 | 60 | 38 |
| 1993 | 0 | 20 | 53 | 236 | 652 | 396 | 281 | 249 | 1,105 | 70 | 849 | 53 | 53 | 51 | 0 | 49 |
| 1994 | 4 | 22 | 71 | 166 | 428 | 955 | 658 | 308 | 191 | 824 | 26 | 624 | 46 | 132 | 11 | 37 |
| 1995 | 0 | 0 | 170 | 121 | 272 | 673 | 570 | 95 | 181 | 76 | 482 | 14 | 608 | 50 | 25 | 78 |
| 1996 | 0 | 74 | 93 | 822 | 238 | 221 | 414 | 335 | 321 | 138 | 135 | 389 | 59 | 437 | 122 | 93 |
| 1997 | 0 | 10 | 216 | 429 | 804 | 182 | 185 | 449 | 247 | 196 | 216 | 109 | 519 | 79 | 266 | 31 |
| 1998 | 0 | 46 | 67 | 335 | 546 | 797 | 152 | 215 | 194 | 258 | 329 | 143 | 150 | 179 | 108 | 250 |
| 1999 | 0 | 5 | 96 | 136 | 216 | 234 | 556 | 142 | 91 | 300 | 261 | 72 | 52 | 27 | 116 | 34 |
| 2000 | 0 | 0 | 36 | 221 | 261 | 145 | 515 | 590 | 79 | 217 | 135 | 77 | 93 | 79 | 67 | 154 |
| 2001 | 0 | 0 | 82 | 131 | 604 | 310 | 342 | 324 | 514 | 191 | 80 | 144 | 60 | 67 | 129 | 55 |
| 2002 | 0 | 56 | 71 | 153 | 298 | 727 | 304 | 316 | 248 | 419 | 184 | 135 | 207 | 151 | 124 | 20 |
| 2003 | 0 | 24 | 93 | 174 | 251 | 244 | 1,046 | 231 | 354 | 52 | 277 | 169 | 10 | 70 | 56 | 105 |
| 2004 | 4 | 64 | 117 | 478 | 455 | 202 | 400 | 1,005 | 267 | 83 | 199 | 226 | 104 | 48 | 253 | 105 |
| 2005 | 0 | 49 | 168 | 180 | 454 | 458 | 240 | 298 | 1,007 | 124 | 140 | 119 | 132 | 68 | 92 | 127 |
| 2006 | 0 | 102 | 174 | 351 | 334 | 508 | 396 | 290 | 300 | 387 | 117 | 156 | 90 | 39 | 12 | 55 |
| 2007 | 0 | 58 | 486 | 355 | 409 | 286 | 550 | 211 | 167 | 269 | 337 | 100 | 132 | 70 | 60 | 123 |
| 2008 | 0 | 10 | 100 | 667 | 466 | 487 | 347 | 456 | 227 | 145 | 186 | 332 | 63 | 66 | 35 | 104 |
| 2009 | 0 | 65 | 146 | 293 | 961 | 468 | 549 | 250 | 252 | 219 | 79 | 31 | 197 | 30 | 29 | 51 |
| 2010 | 0 | 78 | 201 | 422 | 374 | 1,041 | 466 | 514 | 173 | 191 | 161 | 53 | 118 | 153 | 79 | 54 |
| 2011 | 1 | 7 | 151 | 388 | 486 | 361 | 799 | 402 | 227 | 178 | 78 | 82 | 138 | 104 | 158 | 97 |
| 2012 | 0 | 70 | 277 | 356 | 348 | 277 | 241 | 430 | 300 | 181 | 99 | 68 | 91 | 34 | 101 | 60 |
| 2013 | 0 | 7 | 93 | 369 | 387 | 485 | 213 | 270 | 448 | 201 | 202 | 34 | 90 | 101 | 119 | 19 |
| 2014 | 0 | 0 | 9 | 369 | 400 | 288 | 341 | 313 | 253 | 404 | 208 | 194 | 20 | 193 | 95 | 108 |
| 2015 | 1 | 29 | 36 | 132 | 430 | 335 | 304 | 315 | 321 | 48 | 181 | 132 | 81 | 1 | 81 | 112 |
| 2016 | 0 | 44 | 86 | 20 | 143 | 710 | 548 | 405 | 369 | 126 | 118 | 228 | 182 | 89 | 35 | 92 |
| 2017 | 10 | 121 | 233 | 399 | 107 | 262 | 886 | 502 | 313 | 277 | 196 | 108 | 217 | 156 | 37 | 12 |
| 2018 | 0 | 40 | 175 | 189 | 230 | 72 | 236 | 524 | 261 | 189 | 96 | 77 | 73 | 75 | 69 | 30 |
| 2019 | 0 | 137 | 253 | 234 | 103 | 272 | 110 | 149 | 492 | 272 | 131 | 156 | 85 | 68 | 57 | 95 |
| 2020 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2021 | 0 | 53 | 190 | 1,079 | 518 | 373 | 88 | 107 | 69 | 85 | 159 | 43 | 62 | 37 | 42 | 56 |
| 2022 | 0 | 74 | 121 | 444 | 1,041 | 488 | 308 | 80 | 95 | 62 | 107 | 144 | 67 | 25 | 137 | 67 |
| 2023 | 0 | 0 | 102 | 228 | 238 | 685 | 391 | 182 | 41 | 39 | 18 | 34 | 68 | 81 | 22 | 34 |

Table 4.13: Effective sample sizes used for survey and fishery age compositions, by year: the number of survey hauls from which yellowfin sole otoliths were taken (Survey hauls), survey effective sample size (ESS), and fishery effective sample size.

| Year | Survey hauls | ESS survey | ESS fishery |
|------|--------------|------------|-------------|
| 1979 | 30 | 14 | 21.5 |
| 1980 | 30 | 14 | 21.5 |
| 1981 | 30 | 14 | 21.5 |
| 1982 | 32 | 15 | 21.5 |
| 1983 | 34 | 16 | 21.5 |
| 1984 | 49 | 23 | 21.5 |
| 1985 | 41 | 20 | 21.5 |
| 1986 | 33 | 15 | 21.5 |
| 1987 | 16 | 8 | 21.5 |
| 1988 | 17 | 8 | 21.5 |
| 1989 | 23 | 11 | 21.5 |
| 1990 | 27 | 13 | 21.5 |
| 1991 | 25 | 12 | 21.5 |
| 1992 | 15 | 7 | 21.5 |
| 1993 | 20 | 10 | 21.5 |
| 1994 | 13 | 7 | 21.5 |
| 1995 | 20 | 10 | 21.5 |
| 1996 | 16 | 8 | 21.5 |
| 1997 | 11 | 5 | 21.5 |
| 1998 | 15 | 7 | 21.5 |
| 1999 | 29 | 13 | 21.5 |
| 2000 | 32 | 15 | 21.5 |
| 2001 | 32 | 15 | 21.5 |
| 2002 | 32 | 15 | 21.5 |
| 2003 | 36 | 16 | 21.5 |
| 2004 | 26 | 12 | 21.5 |
| 2005 | 33 | 15 | 21.5 |
| 2006 | 37 | 17 | 21.5 |
| 2007 | 58 | 28 | 21.5 |
| 2008 | 57 | 28 | 21.5 |
| 2009 | 64 | 32 | 21.5 |
| 2010 | 85 | 41 | 21.5 |
| 2011 | 54 | 26 | 21.5 |
| 2012 | 65 | 32 | 21.5 |
| 2013 | 57 | 28 | 21.5 |
| 2014 | 47 | 22 | 21.5 |
| 2015 | 66 | 32 | 21.5 |
| 2016 | 60 | 29 | 21.5 |
| 2017 | 88 | 42 | 21.5 |
| 2018 | 63 | 30 | 21.5 |
| 2019 | 62 | 30 | 21.5 |
| 2021 | 120 | 58 | 21.5 |
| 2022 | 132 | 63 | 21.5 |
| 2023 | 146 | 70 | 21.5 |

Table 4.14: Parameter values and their 95% confidence intervals, Model 23.0 used in 2023. Spawning biomass is presented from 1954 - 2023.

| Name | Value | Standard Deviation | Name | Value | Standard Deviation |
|------------------------------------|-------------|--------------------|----------|------------|--------------------|
| male natural mortality | 1.3657e-01 | 4.9348e-03 | SSB | 1237.30000 | 132.300000 |
| alpha (q-temp model) | 1.0349e-01 | 8.4087e-02 | SSB | 1202.50000 | 132.480000 |
| beta (q-temp model) | 6.8618e-02 | 1.0890e-02 | SSB | 1106.00000 | 126.920000 |
| beta (survey start date) | 5.8988e-03 | 3.0066e-03 | SSB | 1039.10000 | 124.210000 |
| beta (start date/temp interaction) | -2.6649e-03 | 3.1919e-03 | SSB | 1010.80000 | 120.910000 |
| mean log recruitment | 9.3771e-01 | 1.0623e-01 | SSB | 1050.60000 | 120.930000 |
| log_avg_fmort | -6.8001e-01 | 1.6941e-01 | SSB | 1100.30000 | 121.380000 |
| log_avg_fmort | -2.5071e+00 | 1.1524e-01 | SSB | 1122.90000 | 121.530000 |
| sel_slope_fsh_f | 1.2022e+00 | 1.4434e-01 | SSB | 1119.50000 | 119.490000 |
| sel50_fsh_f | 8.1960e+00 | 3.0661e-01 | SSB | 1110.80000 | 118.790000 |
| sel_slope_srv | 1.5805e+00 | 2.3845e-01 | SSB | 1051.50000 | 113.940000 |
| sel50_srv | 4.3214e+00 | 2.0110e-01 | SSB | 1025.00000 | 112.160000 |
| R_logalpha | -4.5682e+00 | 6.3025e-01 | SSB | 967.91000 | 108.950000 |
| R_logbeta | -6.5551e+00 | 4.2407e-01 | SSB | 966.26000 | 108.850000 |
| SSB | 9.4219e+02 | 1.6237e+02 | SSB | 914.91000 | 104.140000 |
| SSB | 9.5082e+02 | 1.5860e+02 | SSB | 977.69000 | 111.060000 |
| SSB | 9.4165e+02 | 1.5262e+02 | SSB | 965.46000 | 107.570000 |
| SSB | 9.1744e+02 | 1.4530e+02 | SSB | 1036.00000 | 113.240000 |
| SSB | 8.8127e+02 | 1.3727e+02 | SSB | 1098.60000 | 117.690000 |
| SSB | 8.0547e+02 | 1.2776e+02 | SSB | 1148.70000 | 121.380000 |
| SSB | 6.1885e+02 | 1.1624e+02 | SSB | 1206.20000 | 126.900000 |
| SSB | 2.9886e+02 | 1.2454e+02 | SSB | 1176.80000 | 123.550000 |
| SSB | 1.1692e+02 | 6.1322e+01 | SSB | 1127.60000 | 118.280000 |
| SSB | 7.5739e+01 | 2.8012e+01 | SSB | 1194.30000 | 126.350000 |
| SSB | 8.4801e+01 | 2.2081e+01 | SSB | 1264.80000 | 134.320000 |
| SSB | 1.0096e+02 | 2.0496e+01 | SSB | 1186.30000 | 124.730000 |
| SSB | 1.2307e+02 | 2.1285e+01 | SSB | 1190.80000 | 126.220000 |
| SSB | 1.3183e+02 | 2.2207e+01 | SSB | 1144.30000 | 121.110000 |
| SSB | 1.3282e+02 | 2.3702e+01 | SSB | 1112.40000 | 119.770000 |
| SSB | 1.3126e+02 | 2.5796e+01 | SSB | 1149.20000 | 124.480000 |
| SSB | 1.1364e+02 | 2.7128e+01 | SSB | 1133.60000 | 122.220000 |
| SSB | 1.0292e+02 | 2.9468e+01 | SSB | 1171.40000 | 128.800000 |
| SSB | 9.6388e+01 | 3.2572e+01 | SSB | 1062.20000 | 114.900000 |
| SSB | 1.0926e+02 | 3.7710e+01 | SSB | 1113.50000 | 121.530000 |
| SSB | 1.3006e+02 | 4.2728e+01 | SSB | 1061.60000 | 118.170000 |
| SSB | 2.0030e+02 | 5.6259e+01 | SSB | 971.29000 | 109.600000 |
| SSB | 2.7573e+02 | 6.5252e+01 | SSB | 980.12000 | 114.090000 |
| SSB | 3.8676e+02 | 7.6949e+01 | SSB | 916.71000 | 109.200000 |
| SSB | 5.2307e+02 | 8.9032e+01 | msy | 479.93000 | 201.030000 |
| SSB | 6.6282e+02 | 1.0056e+02 | Fmsy | 0.17357 | 0.089271 |
| SSB | 8.2029e+02 | 1.1176e+02 | logFmsy | -1.75120 | 0.514320 |
| SSB | 9.6963e+02 | 1.2081e+02 | Fmsyr | 0.11339 | 0.042140 |
| SSB | 1.0474e+03 | 1.2299e+02 | logFmsyr | -2.17690 | 0.371640 |
| SSB | 1.1600e+03 | 1.2857e+02 | | | |
| SSB | 1.2389e+03 | 1.3067e+02 | | | |
| SSB | 1.2764e+03 | 1.3356e+02 | | | |

Table 4.15: Parameter values and their 95% confidence intervals, Model 23.0 with data through 2024. Spawning biomass is presented from 1954 - 2024.

| Name | Value | Standard Deviation | Name | Value | Standard Deviation |
|------------------------------------|-------------|--------------------|----------|------------|--------------------|
| male natural mortality | 1.2770e-01 | 3.7386e-03 | SSB | 1116.60000 | 96.616000 |
| alpha (q-temp model) | 1.5933e-01 | 6.7189e-02 | SSB | 1083.90000 | 96.886000 |
| beta (q-temp model) | 7.4190e-02 | 1.0286e-02 | SSB | 995.94000 | 92.874000 |
| beta (survey start date) | 7.9193e-03 | 2.6824e-03 | SSB | 935.93000 | 90.995000 |
| beta (start date/temp interaction) | -3.7024e-03 | 2.7790e-03 | SSB | 913.79000 | 88.827000 |
| mean log recruitment | 8.0449e-01 | 9.9499e-02 | SSB | 955.08000 | 89.210000 |
| log_avg_fmort | -5.5987e-01 | 1.3098e-01 | SSB | 1003.80000 | 89.890000 |
| log_avg_fmort | -2.4506e+00 | 9.9578e-02 | SSB | 1023.50000 | 90.119000 |
| sel_slope_fsh_f | 1.1922e+00 | 1.1554e-01 | SSB | 1015.90000 | 88.396000 |
| sel50_fsh_f | 8.2175e+00 | 2.7611e-01 | SSB | 1002.60000 | 87.571000 |
| sel_slope_srv | 1.6495e+00 | 1.9312e-01 | SSB | 942.86000 | 83.557000 |
| sel50_srv | 4.2940e+00 | 1.4611e-01 | SSB | 913.54000 | 81.734000 |
| R_logalpha | -4.5416e+00 | 6.1149e-01 | SSB | 857.33000 | 78.900000 |
| R_logbeta | -6.4160e+00 | 4.0102e-01 | SSB | 853.78000 | 78.645000 |
| SSB | 1.0680e+03 | 1.4924e+02 | SSB | 806.52000 | 75.115000 |
| SSB | 1.0787e+03 | 1.4263e+02 | SSB | 861.00000 | 80.083000 |
| SSB | 1.0695e+03 | 1.3401e+02 | SSB | 848.51000 | 77.386000 |
| SSB | 1.0437e+03 | 1.2437e+02 | SSB | 910.36000 | 81.397000 |
| SSB | 1.0047e+03 | 1.1434e+02 | SSB | 964.10000 | 84.460000 |
| SSB | 9.2569e+02 | 1.0254e+02 | SSB | 1005.00000 | 86.784000 |
| SSB | 7.3896e+02 | 8.6008e+01 | SSB | 1052.50000 | 90.445000 |
| SSB | 4.4929e+02 | 4.6924e+01 | SSB | 1022.40000 | 87.561000 |
| SSB | 1.1583e+02 | 4.5154e+01 | SSB | 976.86000 | 83.536000 |
| SSB | 6.3264e+01 | 1.4612e+01 | SSB | 1030.90000 | 88.905000 |
| SSB | 7.7592e+01 | 1.3658e+01 | SSB | 1088.40000 | 94.133000 |
| SSB | 9.5767e+01 | 1.4106e+01 | SSB | 1020.50000 | 87.121000 |
| SSB | 1.1781e+02 | 1.5256e+01 | SSB | 1022.60000 | 87.860000 |
| SSB | 1.2581e+02 | 1.5986e+01 | SSB | 981.73000 | 84.030000 |
| SSB | 1.2553e+02 | 1.6898e+01 | SSB | 950.81000 | 82.865000 |
| SSB | 1.2200e+02 | 1.7953e+01 | SSB | 978.70000 | 85.968000 |
| SSB | 1.0285e+02 | 1.8336e+01 | SSB | 961.43000 | 84.277000 |
| SSB | 8.9917e+01 | 1.9383e+01 | SSB | 985.31000 | 88.489000 |
| SSB | 8.0517e+01 | 2.0950e+01 | SSB | 892.72000 | 79.107000 |
| SSB | 8.8485e+01 | 2.4152e+01 | SSB | 932.14000 | 83.786000 |
| SSB | 1.0376e+02 | 2.7271e+01 | SSB | 884.07000 | 81.611000 |
| SSB | 1.6234e+02 | 3.6060e+01 | SSB | 802.35000 | 75.683000 |
| SSB | 2.2944e+02 | 4.2353e+01 | SSB | 802.29000 | 78.621000 |
| SSB | 3.3130e+02 | 5.0945e+01 | SSB | 786.69000 | 81.091000 |
| SSB | 4.5914e+02 | 6.0191e+01 | SSB | 751.02000 | 77.879000 |
| SSB | 5.9089e+02 | 6.9323e+01 | msy | 453.73000 | 179.900000 |
| SSB | 7.3839e+02 | 7.8331e+01 | Fmsy | 0.18361 | 0.090066 |
| SSB | 8.7700e+02 | 8.5815e+01 | logFmsy | -1.69500 | 0.490540 |
| SSB | 9.4859e+02 | 8.8066e+01 | Fmsyr | 0.12142 | 0.043913 |
| SSB | 1.0509e+03 | 9.2690e+01 | logFmsyr | -2.10850 | 0.361660 |
| SSB | 1.1220e+03 | 9.4800e+01 | | | |
| SSB | 1.1543e+03 | 9.7318e+01 | | | |

Table 4.16: Model estimates of yellowfin sole full selection fishing mortality (Full sel. F) and exploitation rate (Catch/Total Biomass) for Model 23.0 (2023), and 23.0 (2024).

| Year | Model 23.0 (2023) | | Model 23.0 (2024) | |
|------|-------------------|------------------|-------------------|------------------|
| | Full sel. F | Catch/Tot. Biom. | Full sel. F | Catch/Tot. Biom. |
| 1954 | 0.007 | 0.005 | 0.006 | 0.005 |
| 1955 | 0.008 | 0.006 | 0.007 | 0.005 |
| 1956 | 0.014 | 0.011 | 0.012 | 0.009 |
| 1957 | 0.014 | 0.011 | 0.012 | 0.01 |
| 1958 | 0.028 | 0.019 | 0.024 | 0.018 |
| 1959 | 0.132 | 0.082 | 0.112 | 0.078 |
| 1960 | 0.456 | 0.217 | 0.363 | 0.21 |
| 1961 | 1.417 | 0.327 | 0.719 | 0.324 |
| 1962 | 1.062 | 0.343 | 3.528 | 0.356 |
| 1963 | 0.326 | 0.097 | 0.327 | 0.1 |
| 1964 | 0.277 | 0.121 | 0.272 | 0.125 |
| 1965 | 0.212 | 0.059 | 0.21 | 0.061 |
| 1966 | 0.361 | 0.104 | 0.364 | 0.109 |
| 1967 | 0.464 | 0.165 | 0.472 | 0.173 |
| 1968 | 0.265 | 0.091 | 0.271 | 0.096 |
| 1969 | 0.597 | 0.169 | 0.619 | 0.181 |
| 1970 | 0.407 | 0.134 | 0.425 | 0.145 |
| 1971 | 0.491 | 0.147 | 0.533 | 0.161 |
| 1972 | 0.177 | 0.04 | 0.203 | 0.044 |
| 1973 | 0.242 | 0.053 | 0.287 | 0.057 |
| 1974 | 0.074 | 0.024 | 0.085 | 0.026 |
| 1975 | 0.091 | 0.03 | 0.103 | 0.032 |
| 1976 | 0.074 | 0.023 | 0.087 | 0.024 |
| 1977 | 0.044 | 0.021 | 0.048 | 0.022 |
| 1978 | 0.092 | 0.045 | 0.098 | 0.047 |
| 1979 | 0.056 | 0.03 | 0.059 | 0.032 |
| 1980 | 0.045 | 0.026 | 0.049 | 0.027 |
| 1981 | 0.045 | 0.028 | 0.048 | 0.029 |
| 1982 | 0.039 | 0.027 | 0.041 | 0.028 |
| 1983 | 0.042 | 0.031 | 0.044 | 0.033 |
| 1984 | 0.064 | 0.044 | 0.067 | 0.046 |
| 1985 | 0.095 | 0.064 | 0.101 | 0.067 |
| 1986 | 0.092 | 0.064 | 0.097 | 0.067 |
| 1987 | 0.088 | 0.058 | 0.093 | 0.061 |
| 1988 | 0.117 | 0.074 | 0.123 | 0.078 |
| 1989 | 0.089 | 0.051 | 0.094 | 0.053 |
| 1990 | 0.046 | 0.029 | 0.048 | 0.031 |
| 1991 | 0.052 | 0.04 | 0.055 | 0.042 |
| 1992 | 0.068 | 0.046 | 0.071 | 0.049 |
| 1993 | 0.055 | 0.033 | 0.059 | 0.035 |
| 1994 | 0.077 | 0.042 | 0.082 | 0.045 |
| 1995 | 0.07 | 0.04 | 0.074 | 0.043 |
| 1996 | 0.066 | 0.043 | 0.07 | 0.046 |
| 1997 | 0.105 | 0.059 | 0.111 | 0.063 |
| 1998 | 0.069 | 0.036 | 0.075 | 0.039 |
| 1999 | 0.048 | 0.026 | 0.052 | 0.028 |
| 2000 | 0.055 | 0.033 | 0.06 | 0.036 |

| | | | | |
|------|-------|-------|-------|-------|
| 2001 | 0.04 | 0.025 | 0.044 | 0.027 |
| 2002 | 0.047 | 0.029 | 0.051 | 0.031 |
| 2003 | 0.04 | 0.027 | 0.044 | 0.03 |
| 2004 | 0.036 | 0.024 | 0.04 | 0.026 |
| 2005 | 0.042 | 0.029 | 0.046 | 0.032 |
| 2006 | 0.044 | 0.03 | 0.047 | 0.033 |
| 2007 | 0.055 | 0.038 | 0.06 | 0.041 |
| 2008 | 0.071 | 0.048 | 0.077 | 0.053 |
| 2009 | 0.047 | 0.035 | 0.052 | 0.038 |
| 2010 | 0.053 | 0.037 | 0.058 | 0.04 |
| 2011 | 0.068 | 0.047 | 0.073 | 0.052 |
| 2012 | 0.066 | 0.048 | 0.072 | 0.053 |
| 2013 | 0.077 | 0.056 | 0.085 | 0.062 |
| 2014 | 0.078 | 0.054 | 0.086 | 0.06 |
| 2015 | 0.065 | 0.044 | 0.073 | 0.049 |
| 2016 | 0.07 | 0.047 | 0.079 | 0.052 |
| 2017 | 0.068 | 0.046 | 0.076 | 0.052 |
| 2018 | 0.07 | 0.05 | 0.079 | 0.056 |
| 2019 | 0.074 | 0.048 | 0.083 | 0.054 |
| 2020 | 0.078 | 0.052 | 0.088 | 0.058 |
| 2021 | 0.064 | 0.041 | 0.073 | 0.047 |
| 2022 | 0.085 | 0.057 | 0.099 | 0.064 |
| 2023 | 0.047 | 0.028 | 0.076 | 0.048 |
| 2024 | - | - | 0.052 | 0.031 |

Table 4.17: Model estimates of yellowfin sole female spawning biomass (FSB) in the eastern Bering Sea in metric tons (t) and upper (HCI) and lower (LCI) 95% confidence intervals from the 2023 and 2024 stock assessments, including Model 23.0 (2023), and 23.0 (2024).

| Model | 23.0 (2023) | | | 23.0 (2024) | | |
|-------|-------------|-----------|-----------|-------------|---------|-----------|
| | Year | FSB (t) | LCI | HCI | FSB (t) | LCI |
| 1954 | 942,185 | 669,184 | 1,326,560 | 1,068,030 | 808,719 | 1,410,480 |
| 1955 | 950,817 | 682,656 | 1,324,320 | 1,078,680 | 828,962 | 1,403,620 |
| 1956 | 941,647 | 682,378 | 1,299,420 | 1,069,510 | 833,254 | 1,372,750 |
| 1957 | 917,440 | 669,672 | 1,256,880 | 1,043,720 | 823,097 | 1,323,480 |
| 1958 | 881,269 | 646,586 | 1,201,130 | 1,004,710 | 800,770 | 1,260,590 |
| 1959 | 805,469 | 587,675 | 1,103,980 | 925,689 | 742,245 | 1,154,470 |
| 1960 | 618,848 | 426,433 | 898,084 | 738,958 | 585,955 | 931,913 |
| 1961 | 298,863 | 134,248 | 665,332 | 449,285 | 364,797 | 553,341 |
| 1962 | 116,917 | 43,620 | 313,377 | 115,826 | 54,587 | 245,764 |
| 1963 | 75,738 | 37,009 | 154,997 | 63,263 | 40,099 | 99,810 |
| 1964 | 84,800 | 50,807 | 141,537 | 77,591 | 54,712 | 110,039 |
| 1965 | 100,964 | 67,548 | 150,909 | 95,767 | 71,443 | 128,371 |
| 1966 | 123,067 | 87,301 | 173,485 | 117,806 | 91,023 | 152,469 |
| 1967 | 131,833 | 94,348 | 184,210 | 125,811 | 97,676 | 162,049 |
| 1968 | 132,825 | 93,216 | 189,263 | 125,529 | 96,016 | 164,113 |
| 1969 | 131,256 | 88,926 | 193,735 | 122,001 | 91,038 | 163,493 |
| 1970 | 113,644 | 70,969 | 181,980 | 102,854 | 72,208 | 146,505 |
| 1971 | 102,921 | 58,707 | 180,434 | 89,917 | 58,712 | 137,708 |
| 1972 | 96,388 | 49,935 | 186,056 | 80,517 | 48,258 | 134,339 |
| 1973 | 109,262 | 55,857 | 213,726 | 88,485 | 51,764 | 151,255 |
| 1974 | 130,058 | 68,558 | 246,725 | 103,761 | 61,879 | 173,987 |
| 1975 | 200,295 | 115,430 | 347,554 | 162,345 | 104,671 | 251,797 |
| 1976 | 275,727 | 172,869 | 439,786 | 229,439 | 159,100 | 330,875 |
| 1977 | 386,760 | 260,797 | 573,561 | 331,305 | 244,030 | 449,792 |
| 1978 | 523,068 | 373,051 | 733,411 | 459,136 | 353,637 | 596,107 |
| 1979 | 662,815 | 490,181 | 896,249 | 590,894 | 467,687 | 746,558 |
| 1980 | 820,285 | 625,415 | 1,075,870 | 738,390 | 597,586 | 912,371 |
| 1981 | 969,633 | 756,487 | 1,242,830 | 877,001 | 721,457 | 1,066,080 |
| 1982 | 1,047,420 | 828,856 | 1,323,610 | 948,595 | 788,162 | 1,141,680 |
| 1983 | 1,160,050 | 930,045 | 1,446,930 | 1,050,900 | 881,248 | 1,253,200 |
| 1984 | 1,238,910 | 1,003,890 | 1,528,960 | 1,122,000 | 947,837 | 1,328,160 |
| 1985 | 1,276,440 | 1,036,010 | 1,572,670 | 1,154,300 | 975,480 | 1,365,900 |
| 1986 | 1,237,270 | 999,653 | 1,531,370 | 1,116,600 | 939,463 | 1,327,130 |
| 1987 | 1,202,480 | 965,322 | 1,497,910 | 1,083,860 | 906,741 | 1,295,570 |
| 1988 | 1,105,970 | 879,813 | 1,390,260 | 995,939 | 826,819 | 1,199,650 |
| 1989 | 1,039,080 | 818,816 | 1,318,580 | 935,929 | 770,892 | 1,136,300 |
| 1990 | 1,010,820 | 796,426 | 1,282,940 | 913,793 | 752,686 | 1,109,380 |
| 1991 | 1,050,570 | 835,173 | 1,321,530 | 955,079 | 792,655 | 1,150,790 |
| 1992 | 1,100,260 | 883,004 | 1,370,970 | 1,003,760 | 839,459 | 1,200,220 |
| 1993 | 1,122,900 | 904,920 | 1,393,400 | 1,023,470 | 858,505 | 1,220,140 |
| 1994 | 1,119,520 | 904,879 | 1,385,090 | 1,015,920 | 853,937 | 1,208,630 |
| 1995 | 1,110,750 | 897,410 | 1,374,810 | 1,002,560 | 842,146 | 1,193,540 |
| 1996 | 1,051,540 | 847,189 | 1,305,170 | 942,863 | 789,995 | 1,125,310 |
| 1997 | 1,025,010 | 824,082 | 1,274,930 | 913,543 | 764,138 | 1,092,160 |
| 1998 | 967,906 | 773,338 | 1,211,430 | 857,325 | 713,472 | 1,030,180 |
| 1999 | 966,259 | 771,889 | 1,209,570 | 853,779 | 710,404 | 1,026,090 |
| 2000 | 914,905 | 729,169 | 1,147,950 | 806,522 | 669,724 | 971,264 |

| | | | | | | |
|------|-----------|-----------|-----------|-----------|---------|-----------|
| 2001 | 977,689 | 779,568 | 1,226,160 | 860,999 | 715,134 | 1,036,620 |
| 2002 | 965,461 | 773,138 | 1,205,630 | 848,507 | 707,296 | 1,017,910 |
| 2003 | 1,036,050 | 833,149 | 1,288,350 | 910,357 | 761,559 | 1,088,230 |
| 2004 | 1,098,610 | 887,288 | 1,360,270 | 964,100 | 809,421 | 1,148,340 |
| 2005 | 1,148,700 | 930,420 | 1,418,180 | 1,004,960 | 845,821 | 1,194,030 |
| 2006 | 1,206,230 | 977,920 | 1,487,840 | 1,052,460 | 886,542 | 1,249,430 |
| 2007 | 1,176,780 | 954,450 | 1,450,900 | 1,022,400 | 861,729 | 1,213,040 |
| 2008 | 1,127,590 | 914,724 | 1,389,980 | 976,864 | 823,555 | 1,158,710 |
| 2009 | 1,194,250 | 967,065 | 1,474,810 | 1,030,900 | 867,853 | 1,224,570 |
| 2010 | 1,264,790 | 1,023,370 | 1,563,180 | 1,088,450 | 915,860 | 1,293,560 |
| 2011 | 1,186,290 | 961,872 | 1,463,060 | 1,020,500 | 860,584 | 1,210,120 |
| 2012 | 1,190,830 | 963,920 | 1,471,150 | 1,022,570 | 861,395 | 1,213,910 |
| 2013 | 1,144,280 | 926,529 | 1,413,210 | 981,729 | 827,526 | 1,164,670 |
| 2014 | 1,112,410 | 897,460 | 1,378,840 | 950,814 | 798,987 | 1,131,490 |
| 2015 | 1,149,250 | 925,999 | 1,426,320 | 978,700 | 821,298 | 1,166,270 |
| 2016 | 1,133,570 | 914,256 | 1,405,500 | 961,429 | 807,093 | 1,145,280 |
| 2017 | 1,171,400 | 940,773 | 1,458,550 | 985,314 | 823,618 | 1,178,760 |
| 2018 | 1,062,240 | 856,132 | 1,317,970 | 892,719 | 747,991 | 1,065,450 |
| 2019 | 1,113,460 | 895,683 | 1,384,190 | 932,143 | 779,051 | 1,115,320 |
| 2020 | 1,061,580 | 850,278 | 1,325,400 | 884,068 | 735,315 | 1,062,910 |
| 2021 | 971,291 | 775,613 | 1,216,340 | 802,349 | 664,682 | 968,529 |
| 2022 | 980,120 | 777,156 | 1,236,090 | 802,287 | 659,804 | 975,541 |
| 2023 | 916,707 | 722,973 | 1,162,360 | 786,690 | 640,483 | 966,273 |
| 2024 | NA | NA | NA | 751,023 | 610,694 | 923,597 |

Table 4.18: Likelihood components and AIC for Model 23.0 and the same model without the environmental covariates on survey catchability (Model 23.0_noEQ). Survey_q represents the mean over years.

| Likelihood component | Model 23.0 | Model 23.0_noEQ |
|----------------------------|------------|-----------------|
| survey_likelihood | 139.586 | 102.683 |
| catch_likelihood | 0.002 | 0.002 |
| age_likelihood_for_fishery | 99.836 | 103.202 |
| age_likelihood_for_survey | 79.278 | 66.096 |
| recruitment_likelihood | 27.992 | 26.591 |
| selectivity_likelihood | 10.373 | 10.022 |
| F_penalty | 0.130 | 0.129 |
| survey_q | 0.931 | 1.178 |
| Natural mortality (F/M) | 0.12/0.131 | 0.12/0.128 |
| Number of parameters | 386 | 382 |
| AIC | 2957.58 | 3003.735 |

Table 4.19: Yellowfin sole total allowable catch (TAC), overfishing limit (OFL), and acceptable biological catch (ABC) levels, 1980-2024. Catch for the Bering Sea and Aleutian Islands was recorded through October 1, 2024. Data is in metric tons. Estimates for 2024 were calculated using Model 23.0, and the 2024 TAC has not yet been set.

| Year | TAC | ABC | OFL | Catch |
|------|---------|---------|---------|---------|
| 1980 | 117,000 | 169,000 | n/a | 87,391 |
| 1981 | 117,000 | 214,500 | n/a | 97,301 |
| 1982 | 117,000 | 214,500 | n/a | 95,712 |
| 1983 | 117,000 | 214,500 | n/a | 108,385 |
| 1984 | 230,000 | 310,000 | n/a | 159,526 |
| 1985 | 229,900 | 310,000 | n/a | 227,107 |
| 1986 | 209,500 | 230,000 | n/a | 208,597 |
| 1987 | 187,000 | 187,000 | n/a | 181,428 |
| 1988 | 254,000 | 254,000 | n/a | 223,156 |
| 1989 | 182,675 | 241,000 | n/a | 153,165 |
| 1990 | 207,650 | 278,900 | n/a | 83,970 |
| 1991 | 135,000 | 250,600 | n/a | 117,303 |
| 1992 | 235,000 | 372,000 | 452,000 | 145,386 |
| 1993 | 220,000 | 238,000 | 275,000 | 105,810 |
| 1994 | 150,325 | 230,000 | 269,000 | 140,050 |
| 1995 | 190,000 | 277,000 | 319,000 | 124,752 |
| 1996 | 200,000 | 278,000 | 342,000 | 129,659 |
| 1997 | 230,000 | 233,000 | 339,000 | 182,814 |
| 1998 | 220,000 | 220,000 | 314,000 | 101,155 |
| 1999 | 207,980 | 212,000 | 308,000 | 69,234 |
| 2000 | 123,262 | 191,000 | 226,000 | 84,071 |
| 2001 | 113,000 | 176,000 | 209,000 | 63,579 |
| 2002 | 86,000 | 115,000 | 136,000 | 74,986 |
| 2003 | 83,750 | 114,000 | 136,000 | 79,806 |
| 2004 | 86,075 | 114,000 | 135,000 | 75,511 |
| 2005 | 90,686 | 124,000 | 148,000 | 94,385 |
| 2006 | 95,701 | 121,000 | 144,000 | 99,160 |
| 2007 | 136,000 | 225,000 | 240,000 | 120,964 |
| 2008 | 225,000 | 248,000 | 265,000 | 148,894 |
| 2009 | 210,000 | 210,000 | 224,000 | 107,513 |
| 2010 | 219,000 | 219,000 | 234,000 | 118,624 |
| 2011 | 196,000 | 239,000 | 262,000 | 151,158 |
| 2012 | 202,000 | 203,000 | 222,000 | 147,187 |
| 2013 | 198,000 | 206,000 | 220,000 | 164,944 |
| 2014 | 184,000 | 239,800 | 259,700 | 156,772 |
| 2015 | 149,000 | 248,800 | 266,400 | 126,937 |
| 2016 | 144,000 | 211,700 | 228,100 | 135,324 |
| 2017 | 154,000 | 260,800 | 287,000 | 132,220 |
| 2018 | 154,000 | 277,500 | 306,700 | 131,496 |
| 2019 | 154,000 | 263,200 | 290,000 | 128,051 |
| 2020 | 150,700 | 260,918 | 287,307 | 133,800 |
| 2021 | 200,000 | 313,477 | 341,571 | 108,788 |
| 2022 | 250,000 | 354,014 | 377,014 | 154,253 |
| 2023 | 230,000 | 378,499 | 404,882 | 112,889 |
| 2024 | | 262,557 | 299,247 | 59,044 |

Table 4.20: Projections of yellowfin sole female spawning biomass (FSB), future catch, and full selection fishing mortality rates (F) for seven future harvest scenarios. Estimates of FSB and catch are in metric tons (t). All estimates are based on Model 23.0.

| Scenarios 1 and 2 Maximum ABC harvest permissible | | | | Scenario 3 Harvest at average F over past 5 years | | | |
|--|---------|---------|-------|--|---------|---------|-------|
| Year | FSB | Catch | F | Year | FSB | Catch | F |
| 2024 | 461,280 | 74,288 | 0.058 | 2024 | 461,280 | 74,288 | 0.058 |
| 2025 | 465,472 | 116,788 | 0.085 | 2025 | 465,472 | 116,788 | 0.085 |
| 2026 | 481,237 | 135,017 | 0.094 | 2026 | 480,596 | 140,855 | 0.098 |
| 2027 | 498,240 | 145,068 | 0.097 | 2027 | 496,244 | 145,614 | 0.098 |
| 2028 | 517,389 | 157,081 | 0.101 | 2028 | 515,793 | 151,745 | 0.098 |
| 2029 | 534,697 | 164,952 | 0.105 | 2029 | 535,462 | 154,617 | 0.098 |
| 2030 | 547,861 | 170,036 | 0.108 | 2030 | 552,690 | 156,398 | 0.098 |
| 2031 | 555,246 | 172,282 | 0.109 | 2031 | 565,131 | 157,932 | 0.098 |
| 2032 | 554,697 | 170,593 | 0.108 | 2032 | 569,472 | 157,993 | 0.098 |
| 2033 | 558,119 | 171,185 | 0.108 | 2033 | 577,206 | 159,739 | 0.098 |
| 2034 | 559,472 | 169,645 | 0.107 | 2034 | 581,995 | 160,223 | 0.098 |
| 2035 | 560,434 | 168,722 | 0.106 | 2035 | 585,334 | 161,157 | 0.098 |
| 2036 | 562,107 | 168,722 | 0.105 | 2036 | 588,522 | 162,449 | 0.098 |
| 2037 | 564,529 | 168,088 | 0.105 | 2037 | 591,860 | 162,517 | 0.098 |

| Scenario 4, Maximum Tier 3 ABC harvest permissible set at F60 | | | | Scenario 5 No fishing | | | |
|--|---------|---------|-------|--------------------------|-----------|---------|-------|
| Year | FSB | Catch | F | Year | FSB | Catch | F |
| 2024 | 461,280 | 74,288 | 0.058 | 2024 | 461,280 | 74,288 | 0.058 |
| 2025 | 465,472 | 116,788 | 0.085 | 2025 | 465,472 | 116,788 | 0.085 |
| 2026 | 487,368 | 78,475 | 0.054 | 2026 | 495,671 | 0 | 0.000 |
| 2027 | 523,709 | 83,933 | 0.054 | 2027 | 558,984 | 0 | 0.000 |
| 2028 | 564,727 | 90,122 | 0.054 | 2028 | 630,439 | 0 | 0.000 |
| 2029 | 605,968 | 94,296 | 0.054 | 2029 | 704,720 | 0 | 0.000 |
| 2030 | 644,408 | 97,666 | 0.054 | 2030 | 778,091 | 0 | 0.000 |
| 2031 | 676,635 | 100,658 | 0.054 | 2031 | 845,416 | 0 | 0.000 |
| 2032 | 697,585 | 102,406 | 0.054 | 2032 | 898,517 | 0 | 0.000 |
| 2033 | 721,406 | 105,101 | 0.054 | 2033 | 955,326 | 0 | 0.000 |
| 2034 | 739,794 | 106,670 | 0.054 | 2034 | 1,003,958 | 0 | 0.000 |
| 2035 | 754,755 | 108,431 | 0.054 | 2035 | 1,046,859 | 0 | 0.000 |
| 2036 | 767,995 | 110,343 | 0.054 | 2036 | 1,085,884 | 0 | 0.000 |
| 2037 | 780,359 | 111,207 | 0.054 | 2037 | 1,122,714 | 0 | 0.000 |

| Alternative 6, Determination of whether yellowfin sole are currently overfished | | | |
|---|---------|---------|-------|
| Year | FSB | Catch | F |
| 2024 | 461,280 | 74,288 | 0.058 |
| 2025 | 462,250 | 145,596 | 0.107 |
| 2026 | 469,597 | 153,431 | 0.109 |
| 2027 | 480,468 | 161,391 | 0.112 |
| 2028 | 494,199 | 171,853 | 0.115 |
| 2029 | 506,921 | 178,074 | 0.118 |
| 2030 | 516,254 | 181,577 | 0.121 |
| 2031 | 520,646 | 182,990 | 0.122 |
| 2032 | 518,147 | 180,567 | 0.121 |
| 2033 | 519,610 | 181,811 | 0.121 |
| 2034 | 519,237 | 180,734 | 0.121 |
| 2035 | 518,578 | 179,888 | 0.120 |
| 2036 | 518,729 | 179,972 | 0.119 |
| 2037 | 519,655 | 179,319 | 0.119 |

| Scenario 7, Determination of whether stock is approaching an overfished condition | | | |
|---|---------|---------|-------|
| Year | FSB | Catch | F |
| 2024 | 461,280 | 74,288 | 0.058 |
| 2025 | 464,722 | 123,525 | 0.090 |
| 2026 | 479,109 | 133,882 | 0.093 |
| 2027 | 493,585 | 169,697 | 0.115 |
| 2028 | 504,898 | 178,576 | 0.118 |
| 2029 | 515,163 | 183,123 | 0.120 |
| 2030 | 522,267 | 185,164 | 0.122 |
| 2031 | 524,806 | 185,415 | 0.123 |
| 2032 | 520,852 | 182,102 | 0.122 |
| 2033 | 521,335 | 182,757 | 0.122 |
| 2034 | 520,305 | 181,261 | 0.121 |
| 2035 | 519,238 | 180,189 | 0.120 |
| 2036 | 519,105 | 180,136 | 0.119 |
| 2037 | 519,852 | 179,401 | 0.119 |

Table 4.21: Mean unsmoothed survey weight-at-age (grams) for yellowfin sole females, 1964-2023.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|------|----|----|----|----|-----|-----|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1964 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1965 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1966 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1967 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1968 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1969 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1970 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1971 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1972 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1973 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1974 | 4 | 15 | 34 | 60 | 91 | 125 | 160.0 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 | 590 |
| 1975 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1976 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1977 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1978 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1979 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1980 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1981 | 8 | 20 | 31 | 55 | 84 | 124 | 165.0 | 217 | 266 | 301 | 341 | 374 | 407 | 428 | 443 | 480 | 483 | 499 | 590 | 590 |
| 1982 | 8 | 20 | 42 | 75 | 98 | 139 | 176.0 | 214 | 233 | 235 | 331 | 359 | 393 | 410 | 436 | 482 | 470 | 476 | 586 | 590 |
| 1983 | 10 | 14 | 26 | 60 | 103 | 162 | 185.0 | 201 | 243 | 255 | 318 | 350 | 391 | 419 | 455 | 503 | 489 | 503 | 605 | 590 |
| 1984 | 14 | 26 | 33 | 57 | 110 | 156 | 177.0 | 222 | 246 | 294 | 318 | 342 | 375 | 418 | 453 | 498 | 492 | 536 | 617 | 590 |
| 1985 | 11 | 16 | 28 | 46 | 77 | 177 | 202.0 | 251 | 286 | 302 | 314 | 341 | 367 | 417 | 450 | 502 | 520 | 556 | 623 | 590 |
| 1986 | 14 | 27 | 23 | 41 | 71 | 103 | 173.0 | 239 | 284 | 338 | 314 | 336 | 366 | 401 | 439 | 490 | 511 | 547 | 628 | 590 |
| 1987 | 10 | 14 | 20 | 47 | 55 | 127 | 179.0 | 256 | 317 | 324 | 331 | 351 | 375 | 411 | 443 | 475 | 519 | 557 | 619 | 590 |
| 1988 | 9 | 12 | 16 | 34 | 66 | 85 | 159.0 | 237 | 286 | 307 | 351 | 364 | 377 | 393 | 418 | 446 | 490 | 528 | 597 | 590 |
| 1989 | 12 | 21 | 33 | 67 | 71 | 112 | 133.0 | 197 | 279 | 339 | 364 | 384 | 402 | 400 | 422 | 445 | 506 | 490 | 570 | 590 |
| 1990 | 11 | 17 | 24 | 38 | 65 | 99 | 126.0 | 197 | 243 | 321 | 389 | 400 | 411 | 405 | 430 | 436 | 475 | 475 | 559 | 590 |
| 1991 | 11 | 16 | 23 | 58 | 56 | 100 | 142.0 | 156 | 238 | 310 | 394 | 421 | 420 | 429 | 446 | 450 | 486 | 481 | 557 | 590 |
| 1992 | 12 | 21 | 29 | 55 | 85 | 121 | 177.0 | 176 | 283 | 305 | 377 | 417 | 430 | 456 | 454 | 464 | 498 | 485 | 562 | 590 |
| 1993 | 15 | 28 | 35 | 64 | 93 | 155 | 165.0 | 232 | 244 | 301 | 368 | 411 | 438 | 469 | 470 | 477 | 506 | 496 | 563 | 590 |
| 1994 | 20 | 46 | 53 | 86 | 87 | 125 | 155.0 | 235 | 276 | 284 | 355 | 405 | 418 | 470 | 472 | 482 | 486 | 504 | 571 | 590 |
| 1995 | 12 | 20 | 28 | 60 | 84 | 123 | 160.0 | 217 | 284 | 332 | 333 | 403 | 412 | 463 | 470 | 478 | 515 | 495 | 575 | 590 |
| 1996 | 11 | 16 | 36 | 51 | 108 | 137 | 167.0 | 202 | 222 | 311 | 322 | 379 | 403 | 448 | 461 | 487 | 509 | 503 | 567 | 590 |
| 1997 | 16 | 34 | 33 | 72 | 85 | 157 | 200.0 | 236 | 260 | 292 | 336 | 383 | 397 | 439 | 457 | 488 | 492 | 514 | 577 | 590 |
| 1998 | 10 | 14 | 36 | 51 | 90 | 104 | 177.0 | 237 | 278 | 279 | 333 | 383 | 391 | 430 | 439 | 478 | 479 | 513 | 576 | 590 |
| 1999 | 9 | 12 | 18 | 37 | 67 | 103 | 131.0 | 239 | 284 | 296 | 331 | 374 | 398 | 417 | 429 | 474 | 484 | 506 | 593 | 590 |
| 2000 | 6 | 8 | 14 | 33 | 36 | 92 | 142.0 | 192 | 211 | 231 | 294 | 336 | 378 | 361 | 393 | 458 | 491 | 522 | 505 | 609 |
| 2001 | 6 | 4 | 8 | 31 | 39 | 62 | 99.0 | 148 | 195 | 242 | 284 | 383 | 392 | 436 | 424 | 442 | 474 | 528 | 530 | 663 |
| 2002 | 6 | 8 | 19 | 27 | 45 | 66 | 105.0 | 156 | 229 | 246 | 276 | 343 | 328 | 394 | 451 | 480 | 504 | 552 | 560 | 631 |
| 2003 | 6 | 8 | 14 | 29 | 56 | 87 | 127.0 | 171 | 224 | 299 | 328 | 357 | 413 | 454 | 417 | 505 | 374 | 600 | 575 | 652 |
| 2004 | 6 | 8 | 14 | 38 | 64 | 101 | 163.0 | 162 | 231 | 300 | 328 | 359 | 440 | 524 | 551 | 476 | 485 | 500 | 500 | 654 |
| 2005 | 6 | 4 | 21 | 40 | 72 | 114 | 156.0 | 217 | 236 | 284 | 349 | 356 | 377 | 464 | 509 | 505 | 612 | 472 | 620 | 693 |
| 2006 | 6 | 6 | 16 | 36 | 76 | 114 | 149.0 | 206 | 236 | 303 | 308 | 360 | 368 | 592 | 493 | 495 | 532 | 568 | 618 | 740 |
| 2007 | 6 | 8 | 16 | 38 | 70 | 113 | 170.0 | 196 | 239 | 330 | 304 | 351 | 361 | 406 | 456 | 466 | 558 | 568 | 683 | 740 |
| 2008 | 6 | 8 | 24 | 31 | 57 | 106 | 140.0 | 203 | 239 | 281 | 309 | 345 | 395 | 432 | 422 | 501 | 567 | 555 | 594 | 660 |
| 2009 | 6 | 6 | 10 | 22 | 51 | 92 | 142.0 | 182 | 248 | 321 | 334 | 377 | 434 | 429 | 433 | 575 | 874 | 556 | 565 | 697 |
| 2010 | 6 | 2 | 16 | 25 | 57 | 84 | 136.0 | 186 | 218 | 343 | 337 | 403 | 446 | 460 | 517 | 557 | 594 | 620 | 744 | 795 |
| 2011 | 6 | 8 | 12 | 30 | 49 | 92 | 145.0 | 210 | 264 | 318 | 329 | 405 | 419 | 441 | 448 | 621 | 534 | 516 | 623 | 696 |
| 2012 | 6 | 6 | 11 | 27 | 53 | 91 | 146.0 | 167 | 258 | 317 | 367 | 321 | 452 | 529 | 502 | 514 | 562 | 654 | 598 | 730 |
| 2013 | 6 | 8 | 12 | 21 | 40 | 102 | 131.0 | 195 | 275 | 318 | 366 | 399 | 415 | 474 | 473 | 518 | 550 | 555 | 606 | 702 |
| 2014 | 6 | 8 | 19 | 16 | 37 | 85 | 145.0 | 201 | 252 | 306 | 368 | 360 | 428 | 421 | 495 | 592 | 536 | 577 | 570 | 715 |
| 2015 | 6 | 8 | 15 | 12 | 40 | 62 | 130.0 | 215 | 262 | 355 | 418 | 437 | 411 | 484 | 474 | 596 | 647 | 593 | 531 | 731 |
| 2016 | 6 | 12 | 25 | 37 | 69 | 86 | 130.0 | 211 | 329 | 378 | 417 | 415 | 517 | 465 | 509 | 522 | 581 | 580 | 618 | 723 |
| 2017 | 6 | 9 | 19 | 51 | 69 | 118 | 21.5 | 187 | 273 | 366 | 382 | 436 | 536 | 503 | 553 | 647 | 601 | 701 | 585 | 824 |
| 2018 | 6 | 8 | 22 | 39 | 88 | 111 | 163.0 | 236 | 248 | 346 | 421 | 447 | 504 | 478 | 542 | 606 | 586 | 571 | 717 | 677 |
| 2019 | 6 | 6 | 21 | 47 | 92 | 160 | 180.0 | 254 | 277 | 346 | 404 | 583 | 503 | 505 | 570 | 680 | 701 | 673 | 698 | 720 |
| 2020 | 6 | 6 | 21 | 47 | 92 | 160 | 180.0 | 254 | 277 | 346 | 404 | 583 | 503 | 505 | 570 | 680 | 701 | 673 | 698 | 720 |
| 2021 | 6 | 6 | 21 | 43 | 103 | 188 | 248.0 | 321 | 365 | 453 | 438 | 478 | 540 | 564 | 592 | 637 | 602 | 635 | 650 | 667 |
| 2022 | 6 | 6 | 17 | 49 | 85 | 151 | 244.0 | 338 | 391 | 437 | 524 | 516 | 518 | 626 | 635 | 646 | 644 | 739 | 784 | 734 |
| 2023 | 6 | 6 | 19 | 40 | 85 | 132 | 211.0 | 312 | 365 | 439 | 534 | 525 | 576 | 597 | 611 | 651 | 723 | 720 | 821 | 868 |

Table 4.22: Mean unsmoothed survey weight-at-age (grams) for yellowfin sole males, 1964-2023.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|------|---|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1964 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1965 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1966 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1967 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1968 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1969 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1970 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1971 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1972 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1973 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1974 | 0 | 4 | 15 | 34 | 60 | 91 | 125 | 160 | 195 | 230 | 263 | 294 | 322 | 348 | 372 | 393 | 412 | 429 | 444 | 481 |
| 1975 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1976 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1977 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1978 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1979 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1980 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1981 | 4 | 14 | 18 | 32 | 54 | 85 | 120 | 156 | 193 | 225 | 253 | 280 | 303 | 324 | 330 | 344 | 355 | 366 | 390 | 423 |
| 1982 | 4 | 11 | 25 | 50 | 83 | 112 | 133 | 142 | 158 | 182 | 242 | 266 | 286 | 309 | 345 | 352 | 361 | 384 | 418 | 420 |
| 1983 | 4 | 5 | 5 | 23 | 57 | 95 | 156 | 156 | 155 | 176 | 233 | 256 | 271 | 295 | 331 | 341 | 344 | 385 | 414 | 417 |
| 1984 | 4 | 10 | 20 | 31 | 57 | 121 | 150 | 181 | 202 | 193 | 223 | 242 | 259 | 281 | 316 | 325 | 330 | 394 | 394 | 406 |
| 1985 | 4 | 11 | 23 | 32 | 51 | 84 | 148 | 186 | 214 | 227 | 218 | 236 | 254 | 269 | 307 | 317 | 340 | 399 | 423 | 399 |
| 1986 | 4 | 9 | 18 | 27 | 34 | 61 | 98 | 176 | 217 | 233 | 215 | 225 | 248 | 257 | 293 | 313 | 322 | 389 | 405 | 389 |
| 1987 | 4 | 8 | 14 | 17 | 27 | 53 | 97 | 157 | 211 | 226 | 228 | 236 | 266 | 269 | 267 | 294 | 306 | 358 | 364 | 386 |
| 1988 | 4 | 7 | 10 | 18 | 45 | 75 | 76 | 138 | 207 | 242 | 238 | 252 | 281 | 278 | 283 | 297 | 314 | 347 | 355 | 381 |
| 1989 | 4 | 7 | 10 | 27 | 47 | 72 | 142 | 130 | 179 | 244 | 252 | 279 | 300 | 298 | 295 | 305 | 336 | 325 | 370 | 377 |
| 1990 | 4 | 9 | 16 | 22 | 44 | 64 | 98 | 120 | 175 | 197 | 261 | 295 | 312 | 309 | 305 | 301 | 324 | 318 | 332 | 377 |
| 1991 | 4 | 9 | 17 | 29 | 51 | 75 | 100 | 132 | 180 | 212 | 266 | 302 | 323 | 328 | 319 | 308 | 341 | 315 | 378 | 379 |
| 1992 | 4 | 9 | 17 | 28 | 53 | 86 | 97 | 125 | 174 | 208 | 262 | 302 | 322 | 368 | 345 | 329 | 349 | 328 | 394 | 373 |
| 1993 | 4 | 9 | 18 | 45 | 56 | 93 | 135 | 145 | 206 | 209 | 257 | 294 | 339 | 369 | 347 | 341 | 362 | 335 | 397 | 372 |
| 1994 | 4 | 23 | 32 | 53 | 76 | 92 | 116 | 182 | 198 | 207 | 255 | 291 | 334 | 367 | 353 | 362 | 355 | 369 | 394 | 387 |
| 1995 | 4 | 10 | 19 | 32 | 59 | 88 | 110 | 154 | 177 | 207 | 250 | 278 | 333 | 361 | 349 | 380 | 359 | 375 | 406 | 399 |
| 1996 | 4 | 10 | 19 | 32 | 54 | 107 | 134 | 163 | 184 | 215 | 241 | 277 | 324 | 349 | 347 | 374 | 355 | 398 | 365 | 410 |
| 1997 | 4 | 8 | 14 | 37 | 64 | 75 | 149 | 174 | 185 | 239 | 240 | 274 | 315 | 308 | 335 | 362 | 363 | 400 | 353 | 427 |
| 1998 | 4 | 10 | 20 | 27 | 49 | 79 | 113 | 156 | 208 | 207 | 244 | 274 | 296 | 308 | 324 | 356 | 354 | 401 | 354 | 429 |
| 1999 | 4 | 6 | 7 | 18 | 37 | 63 | 95 | 123 | 170 | 171 | 241 | 263 | 287 | 292 | 324 | 340 | 362 | 375 | 355 | 434 |
| 2000 | 4 | 8 | 33 | 30 | 34 | 71 | 105 | 157 | 162 | 244 | 218 | 245 | 266 | 272 | 288 | 335 | 304 | 342 | 364 | 428 |
| 2001 | 4 | 8 | 20 | 22 | 32 | 49 | 95 | 151 | 170 | 196 | 244 | 259 | 296 | 299 | 313 | 307 | 362 | 436 | 447 | 410 |
| 2002 | 4 | 8 | 17 | 22 | 53 | 58 | 91 | 146 | 204 | 213 | 232 | 257 | 274 | 309 | 345 | 362 | 334 | 383 | 440 | 423 |
| 2003 | 4 | 8 | 27 | 39 | 53 | 83 | 112 | 170 | 189 | 250 | 265 | 308 | 267 | 443 | 407 | 370 | 360 | 367 | 381 | 469 |
| 2004 | 4 | 8 | 14 | 36 | 59 | 95 | 150 | 158 | 207 | 260 | 321 | 311 | 311 | 368 | 469 | 384 | 414 | 392 | 465 | 464 |
| 2005 | 4 | 4 | 19 | 40 | 72 | 115 | 134 | 162 | 206 | 265 | 291 | 334 | 395 | 312 | 310 | 364 | 391 | 374 | 418 | 446 |
| 2006 | 4 | 8 | 18 | 32 | 67 | 118 | 144 | 183 | 207 | 237 | 233 | 318 | 350 | 417 | 452 | 438 | 352 | 343 | 380 | 449 |
| 2007 | 4 | 8 | 17 | 33 | 67 | 105 | 139 | 177 | 208 | 244 | 287 | 282 | 302 | 351 | 408 | 369 | 339 | 381 | 400 | 449 |
| 2008 | 4 | 8 | 8 | 27 | 50 | 95 | 121 | 181 | 192 | 244 | 270 | 298 | 312 | 346 | 384 | 405 | 373 | 399 | 436 | 481 |
| 2009 | 4 | 8 | 10 | 20 | 42 | 85 | 128 | 155 | 200 | 287 | 276 | 316 | 399 | 338 | 430 | 308 | 439 | 384 | 369 | 481 |
| 2010 | 4 | 8 | 13 | 24 | 48 | 80 | 141 | 167 | 183 | 302 | 315 | 322 | 356 | 414 | 402 | 401 | 417 | 512 | 461 | 501 |
| 2011 | 4 | 4 | 11 | 31 | 59 | 88 | 133 | 188 | 227 | 262 | 341 | 302 | 398 | 338 | 381 | 445 | 409 | 416 | 440 | 523 |
| 2012 | 4 | 8 | 12 | 27 | 53 | 88 | 126 | 183 | 216 | 256 | 283 | 320 | 292 | 422 | 420 | 387 | 431 | 393 | 355 | 475 |
| 2013 | 4 | 8 | 12 | 20 | 41 | 77 | 131 | 189 | 228 | 267 | 269 | 346 | 275 | 371 | 383 | 420 | 456 | 407 | 395 | 487 |
| 2014 | 4 | 8 | 20 | 30 | 59 | 86 | 154 | 188 | 243 | 292 | 313 | 311 | 321 | 332 | 424 | 466 | 429 | 527 | 492 | 495 |
| 2015 | 4 | 6 | 19 | 25 | 38 | 64 | 135 | 202 | 230 | 321 | 361 | 386 | 368 | 367 | 400 | 432 | 445 | 537 | 563 | 494 |
| 2016 | 4 | 8 | 33 | 46 | 50 | 83 | 127 | 190 | 260 | 332 | 327 | 340 | 406 | 394 | 416 | 409 | 443 | 474 | 375 | 505 |
| 2017 | 4 | 8 | 21 | 46 | 76 | 102 | 110 | 170 | 247 | 311 | 347 | 367 | 404 | 380 | 466 | 483 | 614 | 577 | 496 | 573 |
| 2018 | 4 | 8 | 23 | 45 | 89 | 95 | 161 | 178 | 221 | 276 | 316 | 403 | 384 | 435 | 421 | 386 | 424 | 431 | 548 | 484 |
| 2019 | 4 | 8 | 20 | 48 | 97 | 126 | 195 | 206 | 237 | 280 | 324 | 384 | 377 | 384 | 431 | 464 | 434 | 454 | 464 | 507 |
| 2020 | 4 | 8 | 20 | 48 | 97 | 126 | 195 | 206 | 237 | 280 | 324 | 384 | 377 | 384 | 431 | 464 | 434 | 454 | 464 | 507 |
| 2021 | 4 | 8 | 24 | 59 | 110 | 180 | 232 | 250 | 267 | 332 | 331 | 374 | 420 | 428 | 435 | 455 | 462 | 449 | 431 | 448 |
| 2022 | 4 | 4 | 21 | 42 | 82 | 162 | 228 | 266 | 325 | 362 | 383 | 414 | 412 | 435 | 447 | 472 | 499 | 547 | 524 | 570 |
| 2023 | 4 | 7 | 12 | 30 | 83 | 137 | 197 | 222 | 330 | 317 | 394 | 452 | 476 | 441 | 445 | 578 | 469 | 495 | 638 | 563 |

Figures

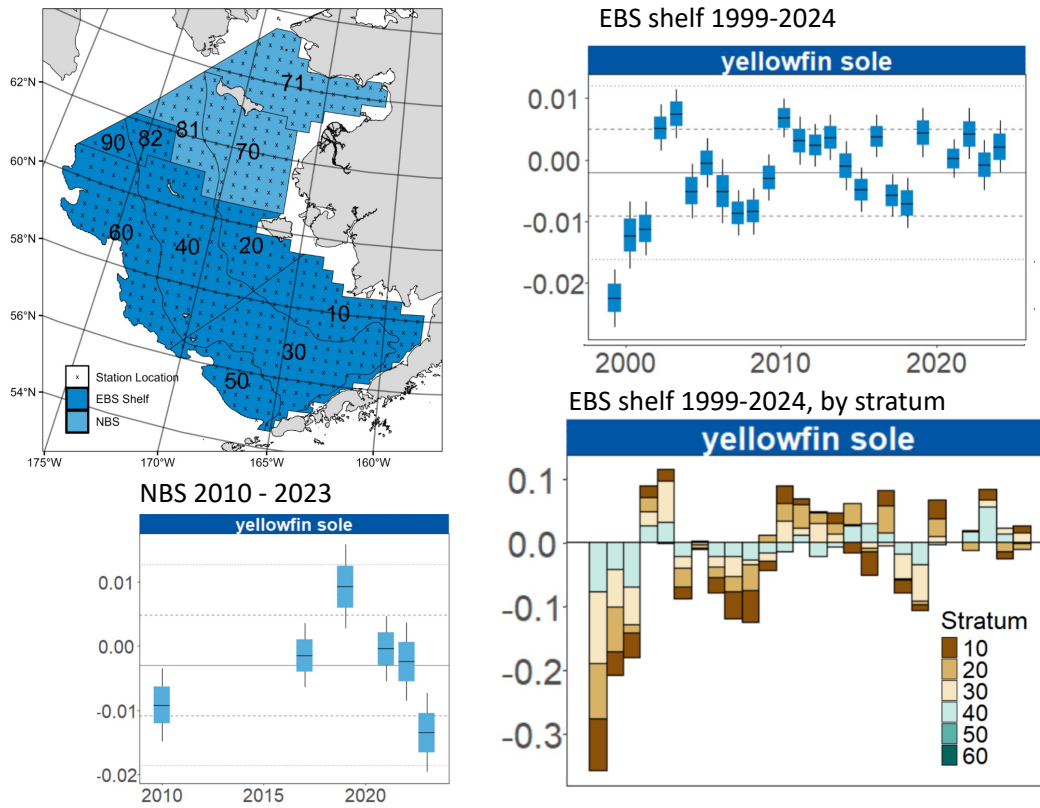


Figure 4.1: Strata map for the eastern and northern Bering Sea (upper left), length-weight residuals of yellowfin sole in the eastern Bering Sea (EBS) combined (upper right), EBS by strata (lower right), and northern Bering Sea (lower left).

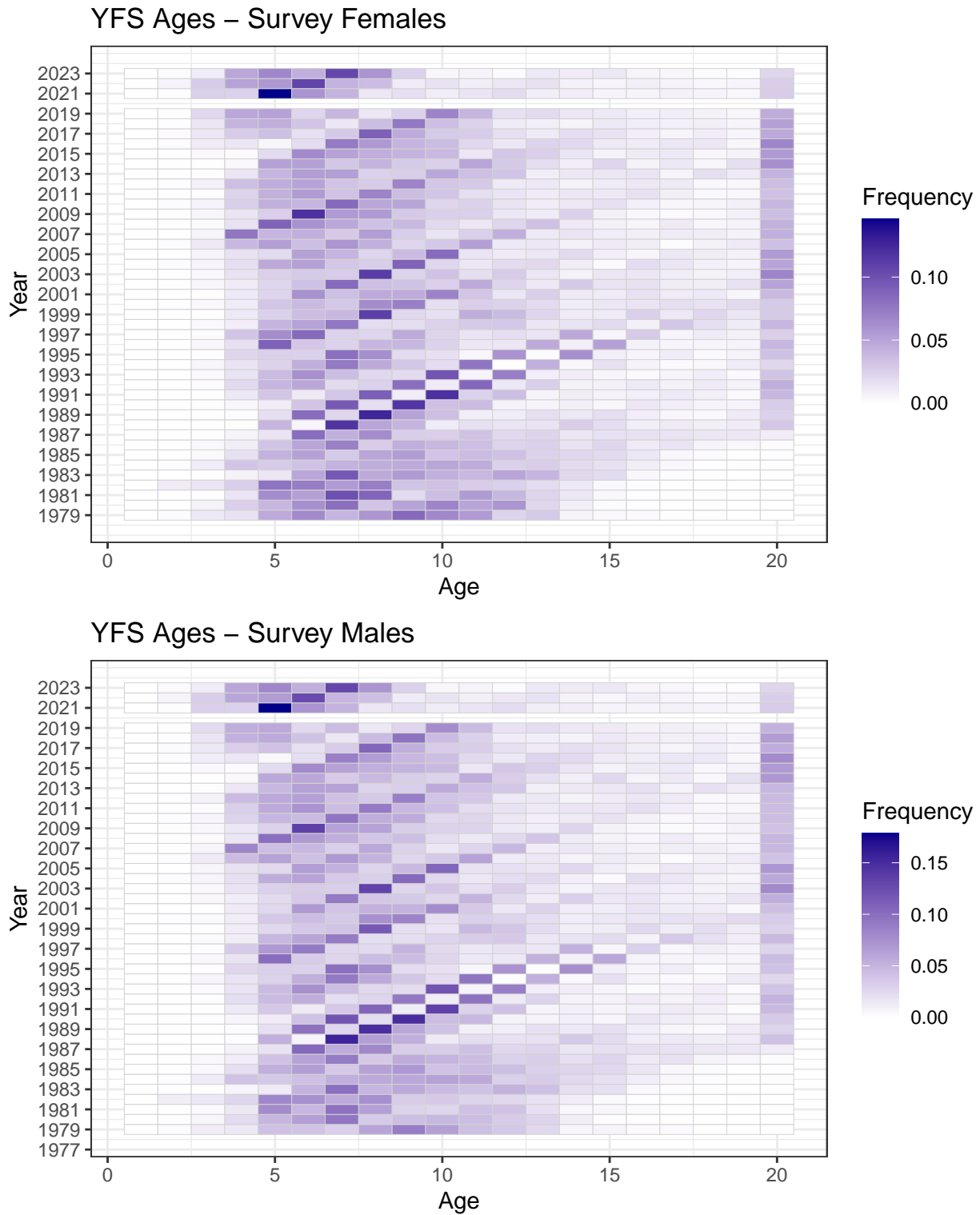


Figure 4.2: Age frequency of yellowfin sole females and males from the AFSC/NMFS research surveys, 1977-2023.

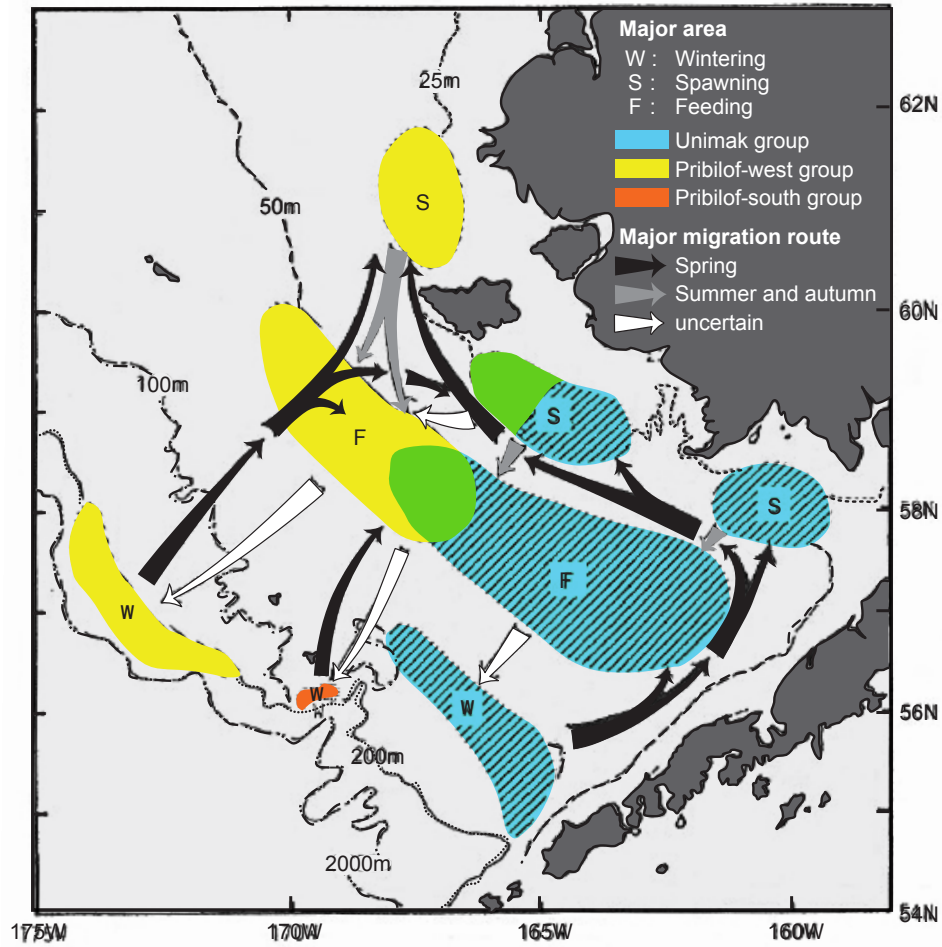


Figure 4.3: Distribution of wintering, spawning, and feeding areas for yellowfin sole in the Bering Sea, and observed regional grouping. Migration routes from wintering to feeding take place in spring, and the dates that yellowfin sole return to their wintering areas are unknown, adapted from Wakabayashi (1989).

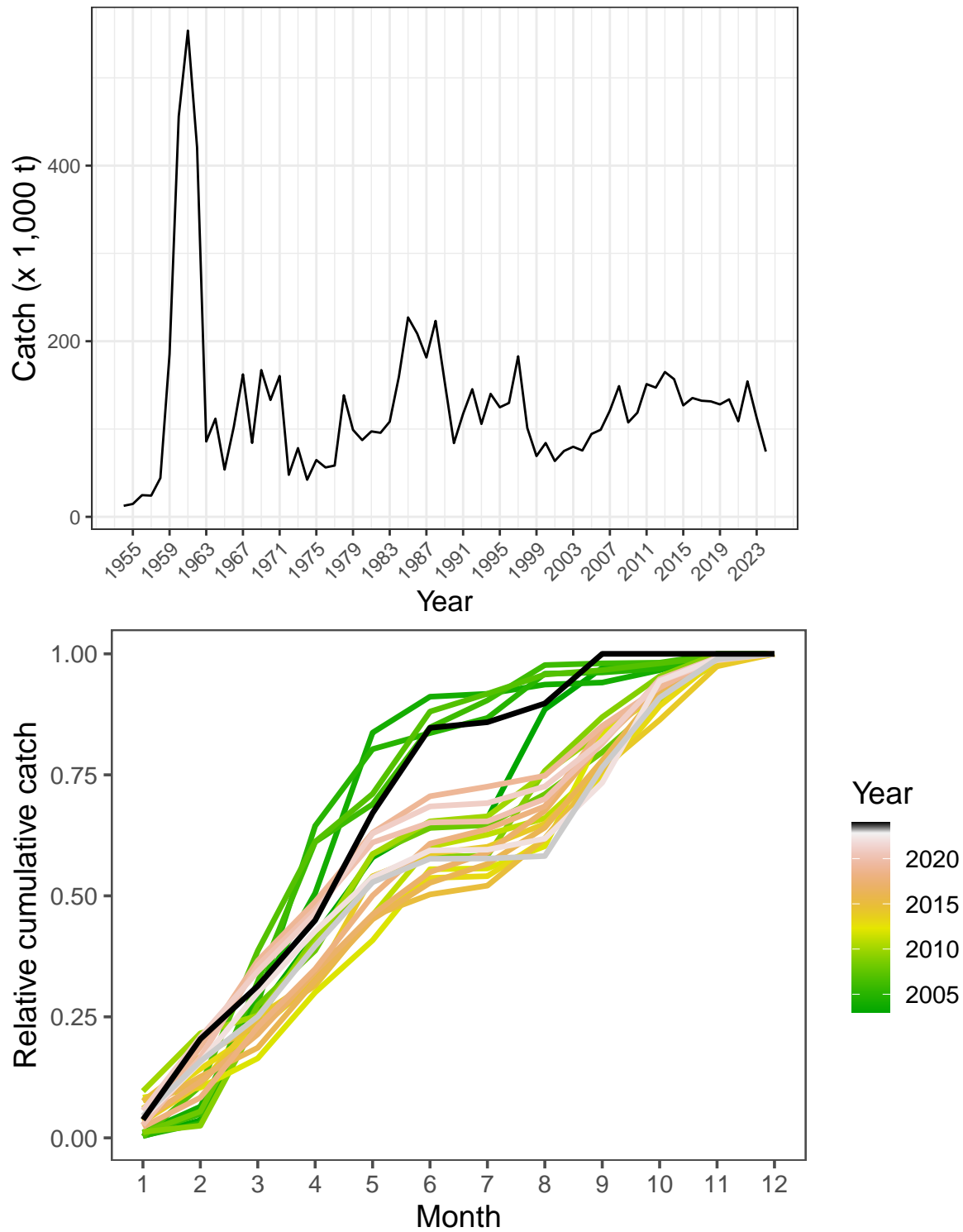


Figure 4.4: Yellowfin sole annual total catch (1,000 t) in the eastern Bering Sea from 2003-2024 (upper panel). Yellowfin sole annual cumulative catch by month and year (non CDQ) 2003-October 1, 2024 (lower panel).

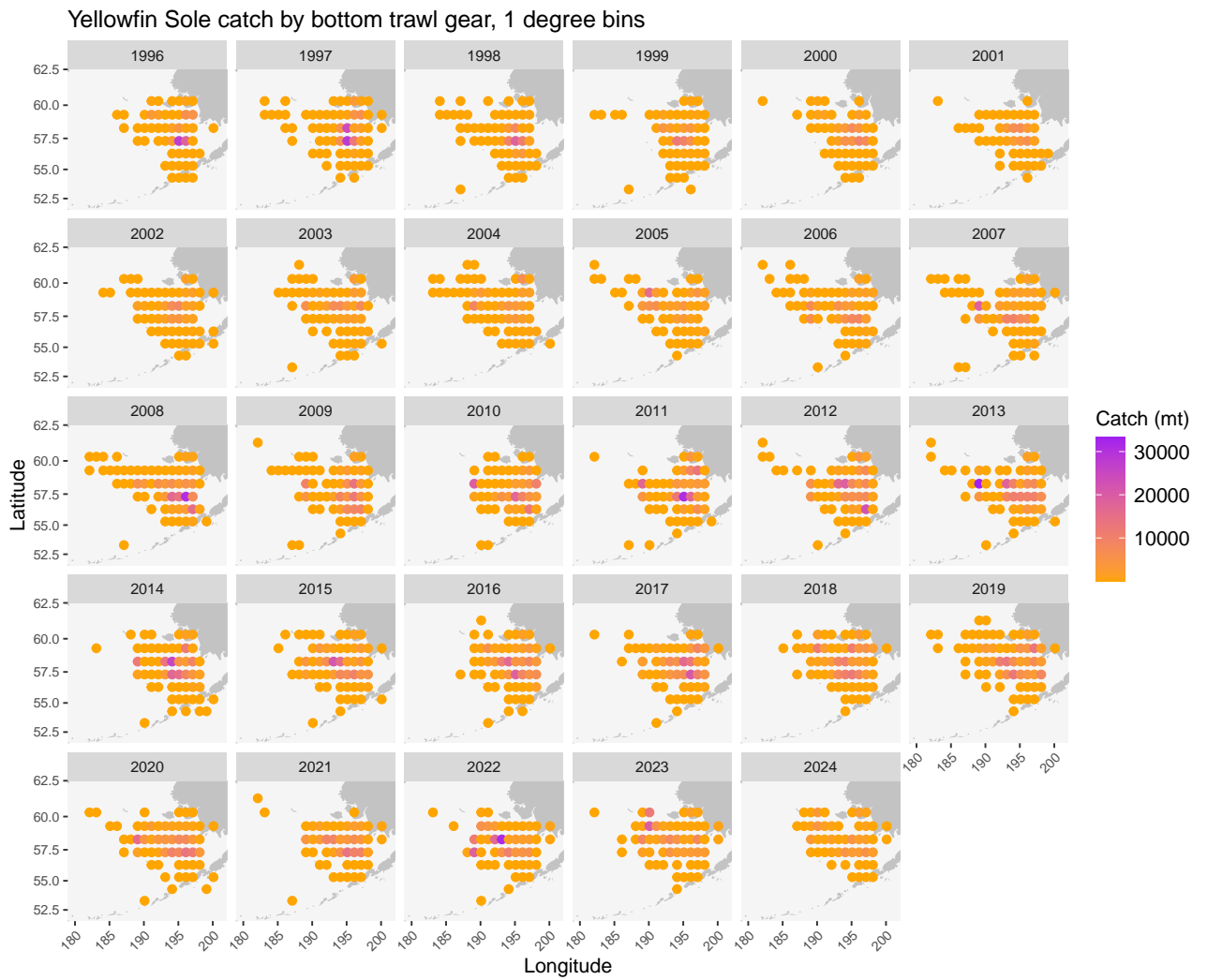


Figure 4.5: Catch of yellowfin sole by non-pelagic trawl gear in the eastern Bering Sea, 2008-2024, by year, reported by observers. Colored circles represent catch of yellowfin sole, with darker shades representing higher catch.

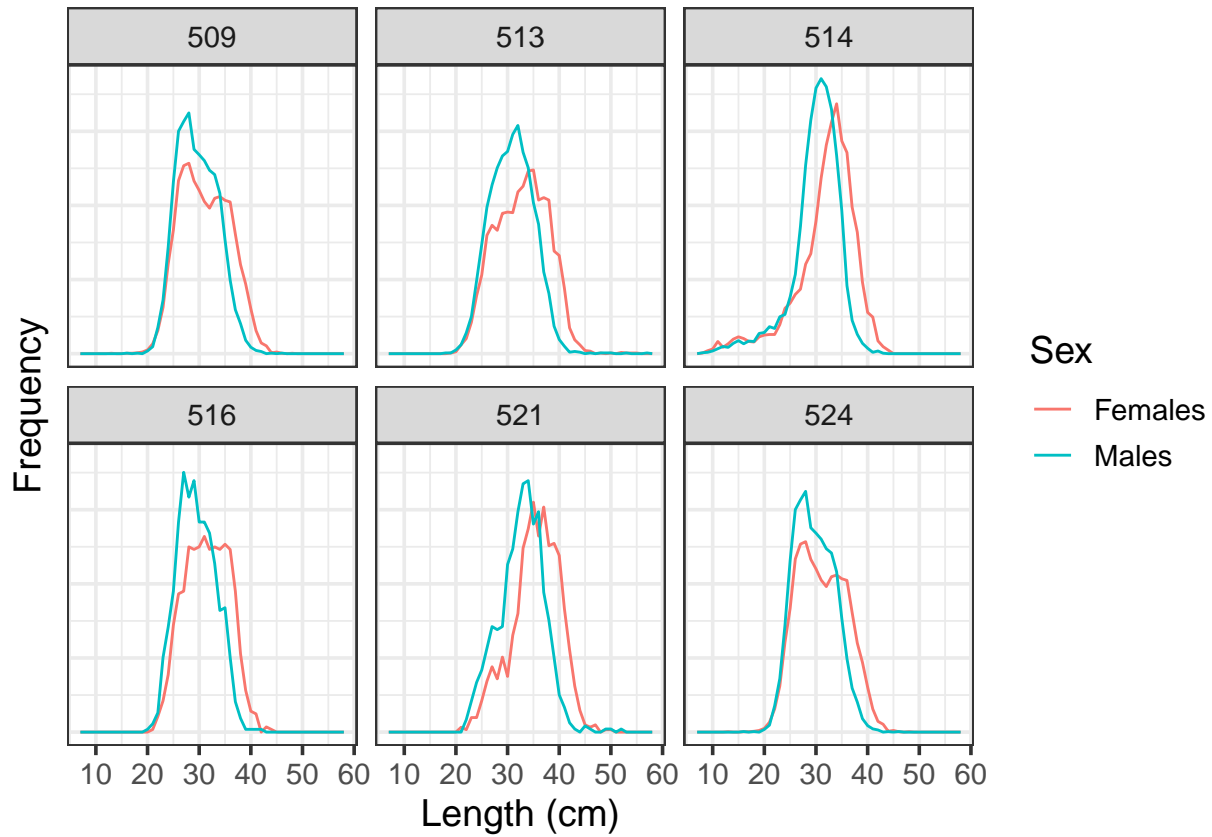


Figure 4.6: Size composition of the yellowfin sole catch in 2024 (through October 17) caught by trawl gear, by subarea, for the primary areas where yellowfin sole are caught, 509, 513, 514, 516, 521, and 524.

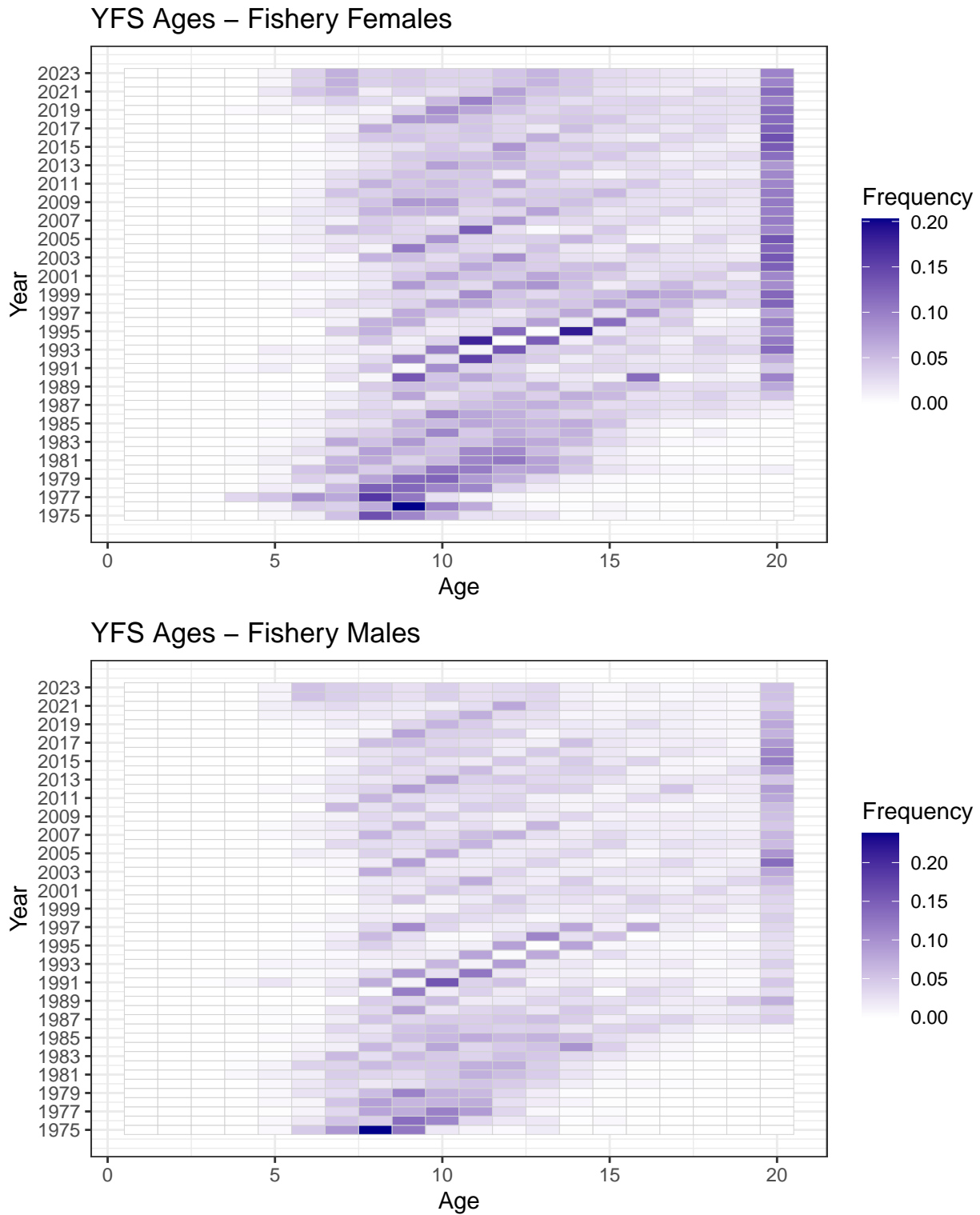


Figure 4.9: Age frequency of females and males from the yellowfin sole fishery, 1975 - 2023.

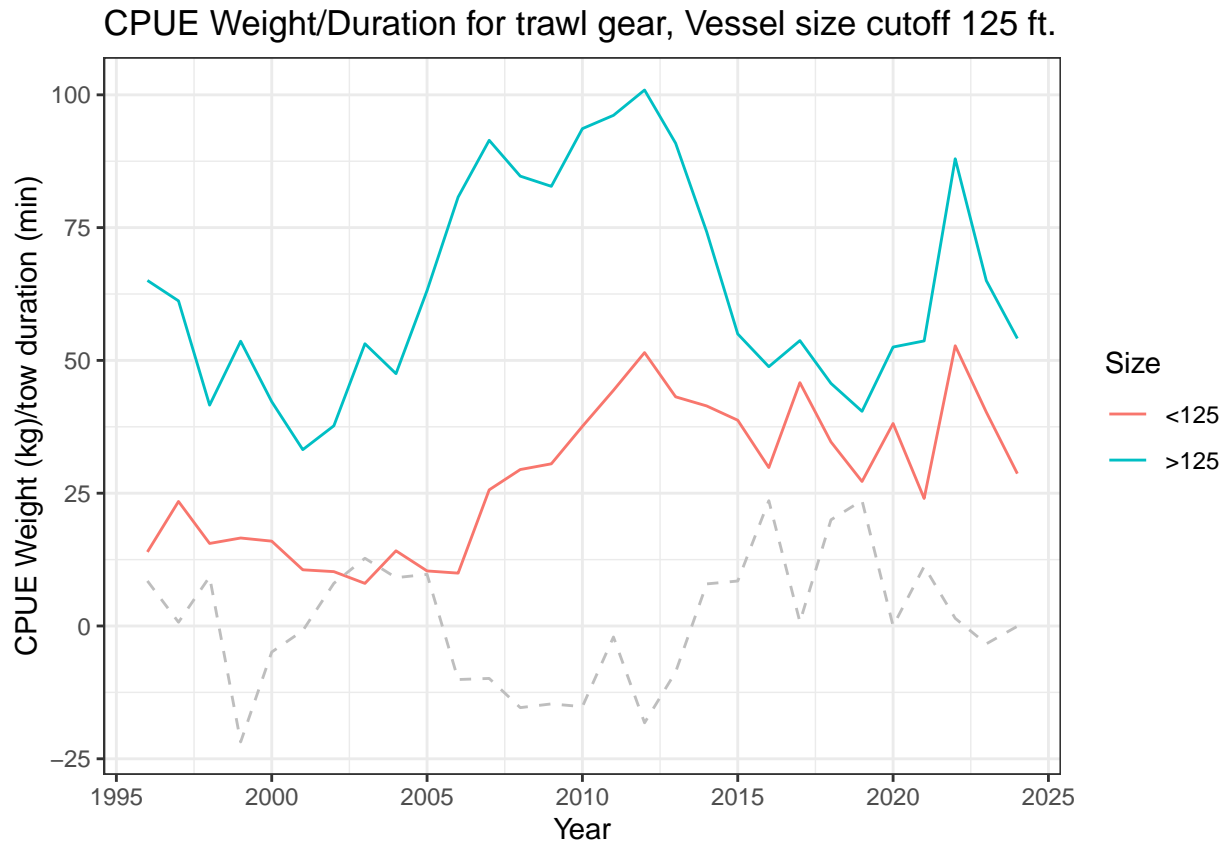


Figure 4.10: Catch per unit effort based on yellowfin sole fishery data, 1996-2024. CPUE weight (kg)/trawl duration (min) is shown for vessels greater and less than 125 ft, and only including self-made tows. Estimates of relative CPUE are complete through October 1, 2024. Results are limited to Catcher/Processor 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 1996-2024 (x10 for visualization) are shown as a dotted line.

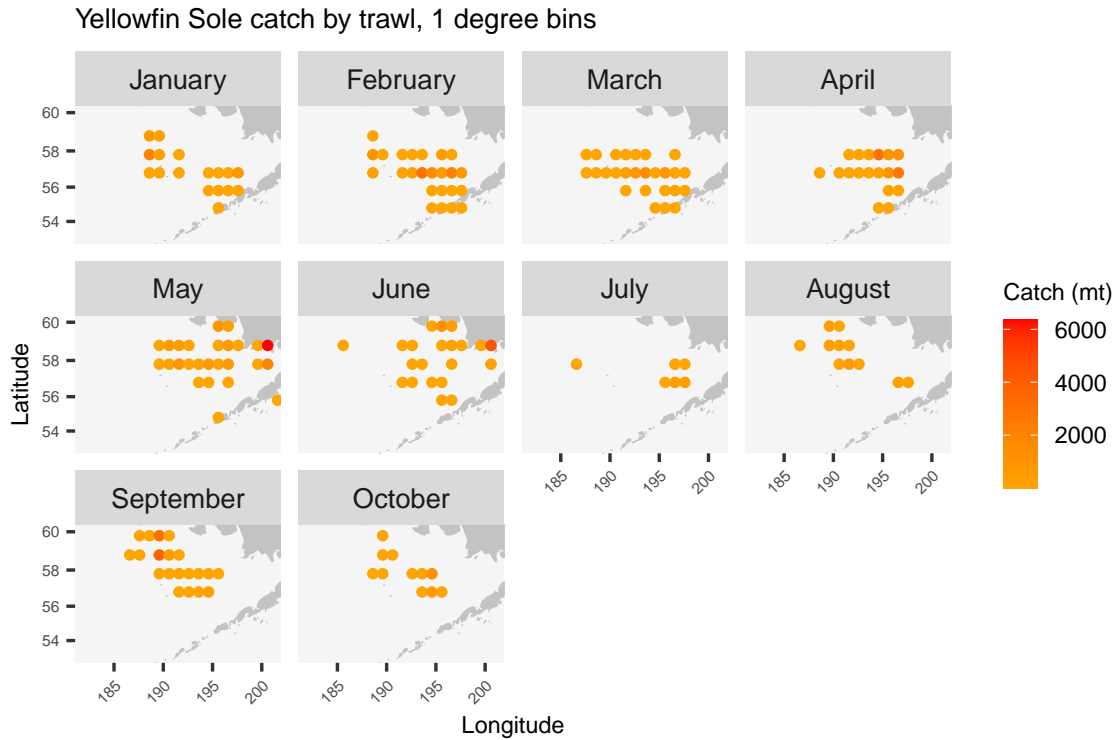


Figure 4.7: Catch of yellowfin sole in the BSAI in 2024 by month (through October 1), reported by observers. Circles represent yellowfin sole catch by the following gear types: non-pelagic trawl, pair trawl, or pelagic trawl.

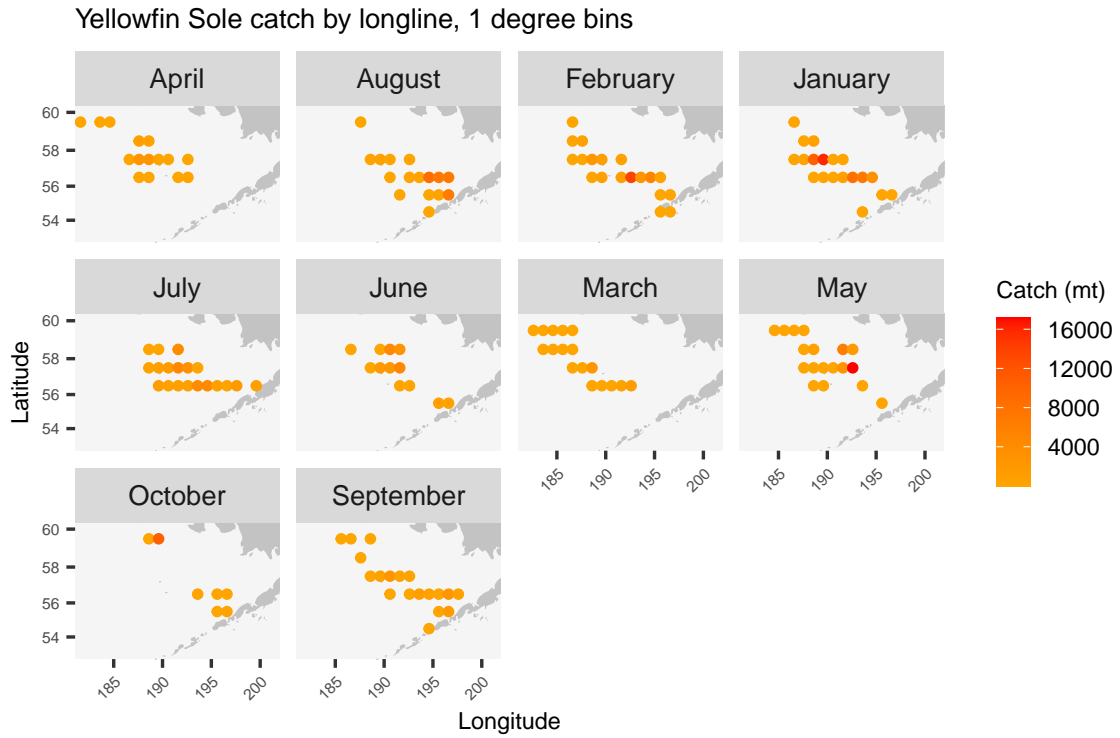


Figure 4.8: Catch of yellowfin sole in the BSAI in 2024 using longline gear by month (through October 1), reported by observers.

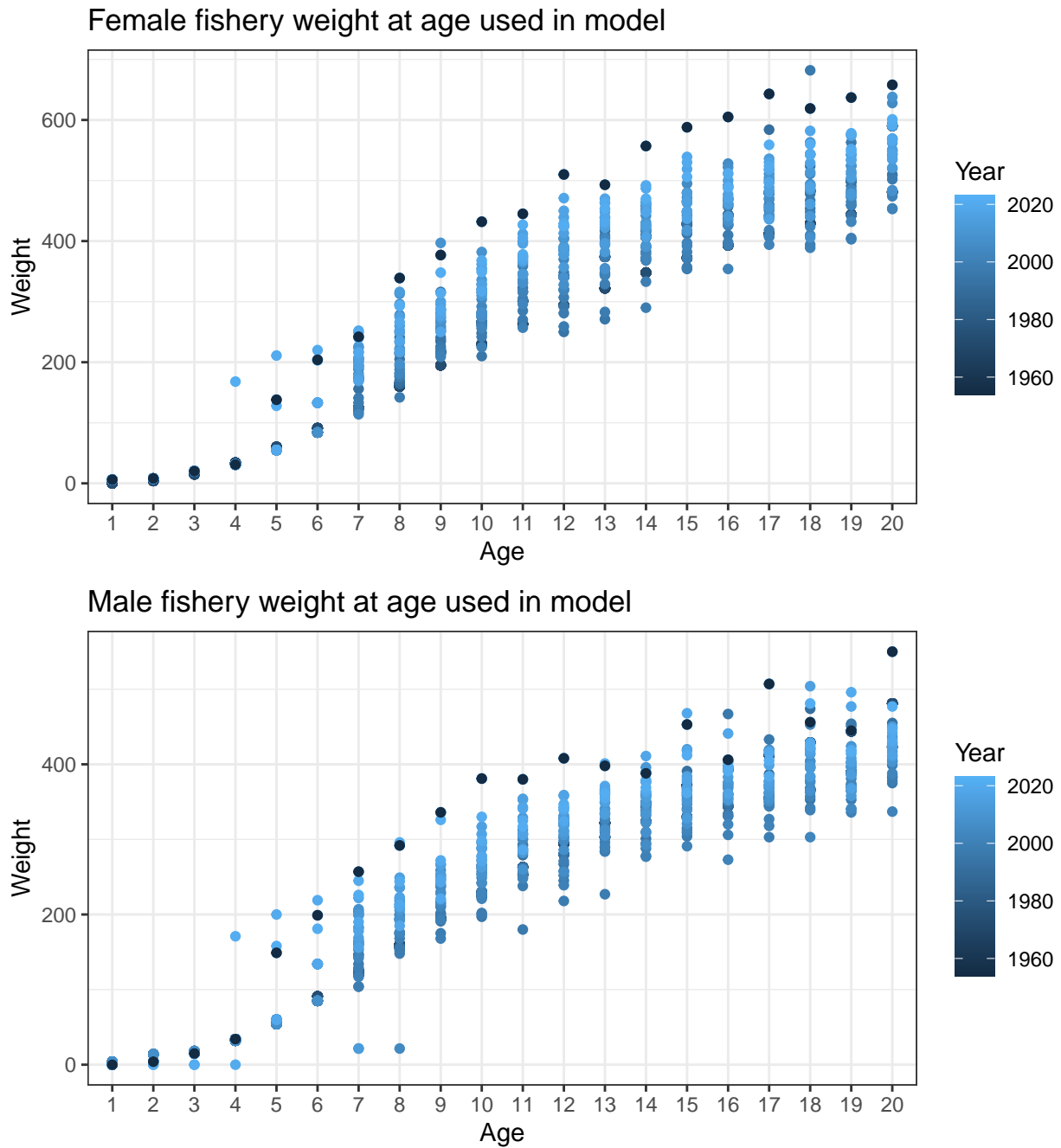


Figure 4.11: Estimates of weight (g) at age for yellowfin sole females and males, based on fishery data 1954-2023, and used in this year's models.

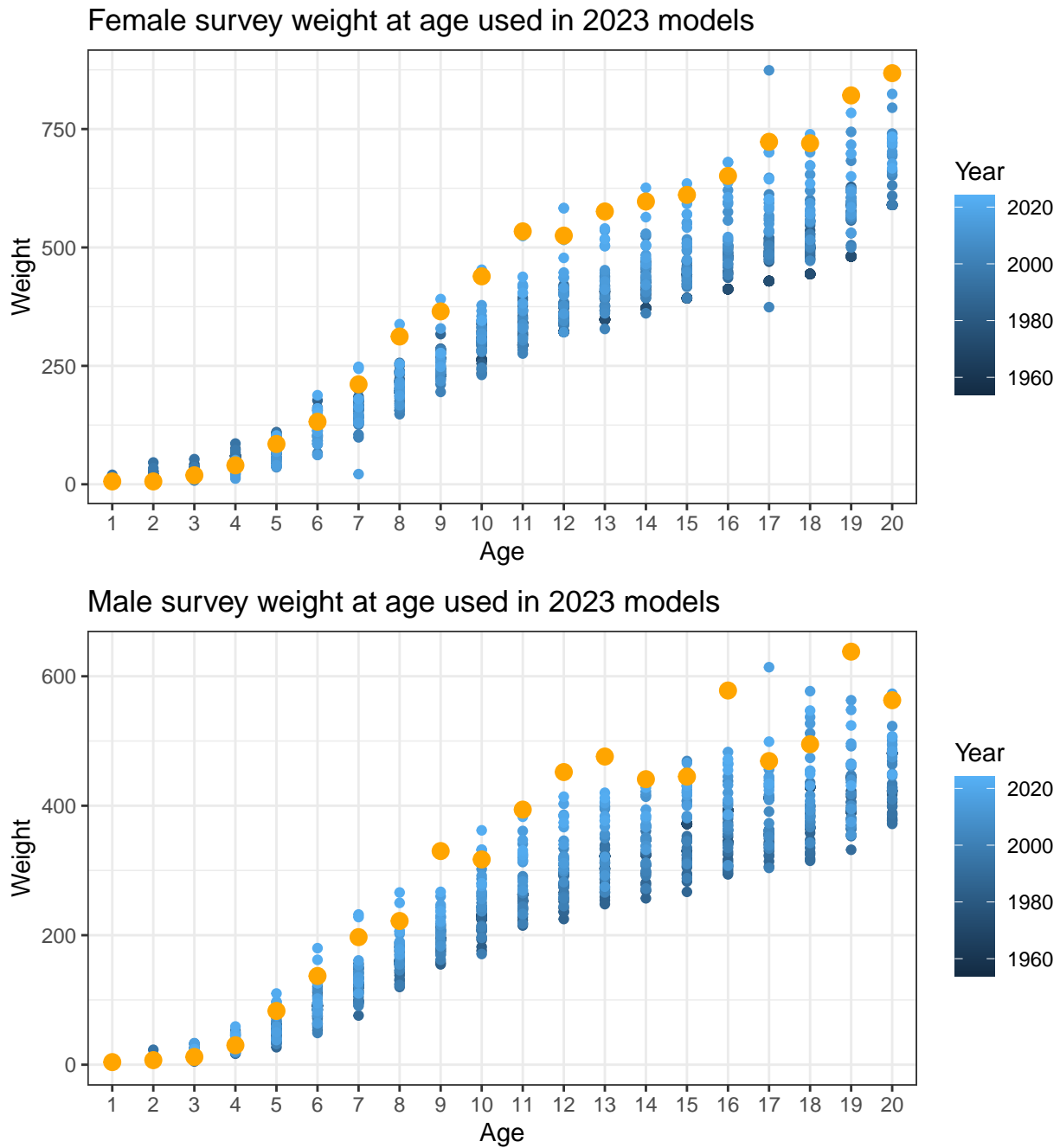


Figure 4.12: Mean weight at age (g) for yellowfin sole females and males from the eastern Bering Sea survey, 1954-2024 used in Model 23.0. Estimates for 2024 are highlighted in yellow.

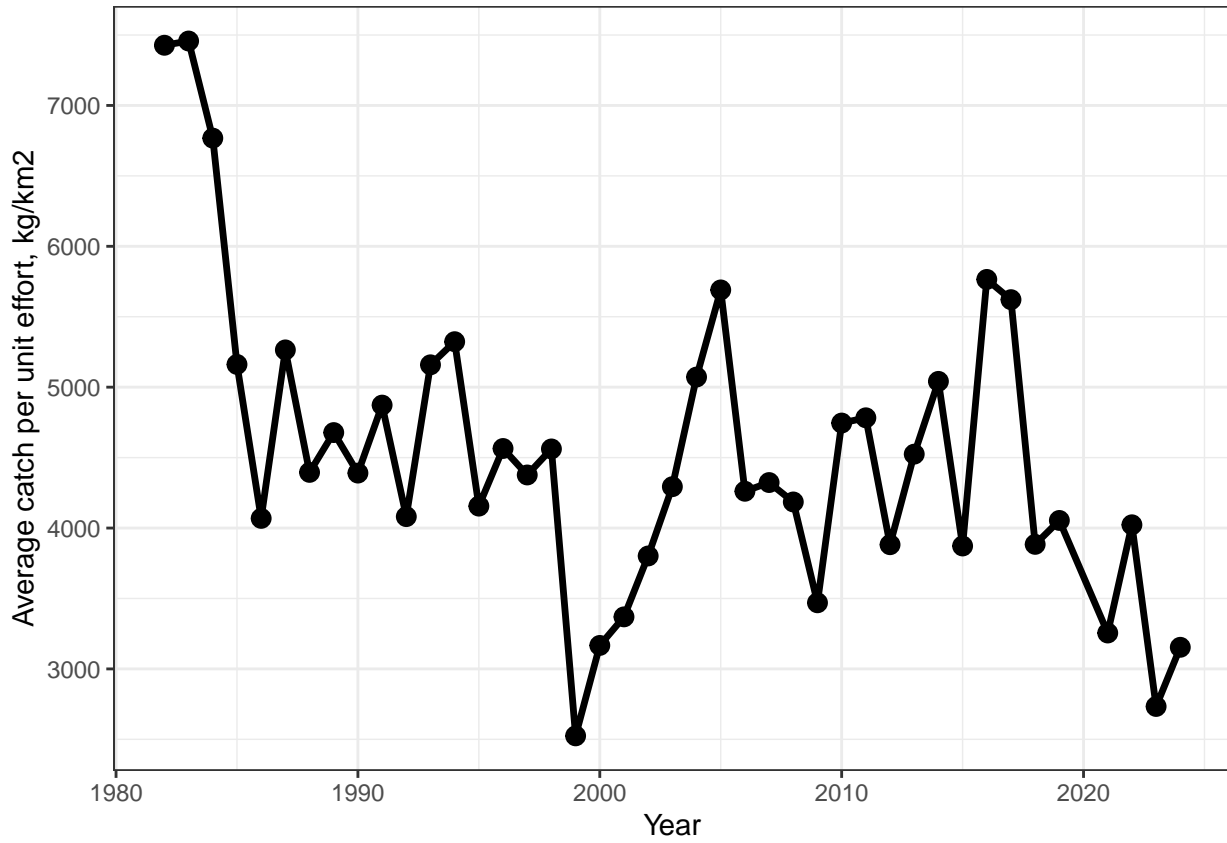


Figure 4.13: Average catch per unit effort on NMFS eastern Bering Sea surveys, 1987-2024, in kg/km2.

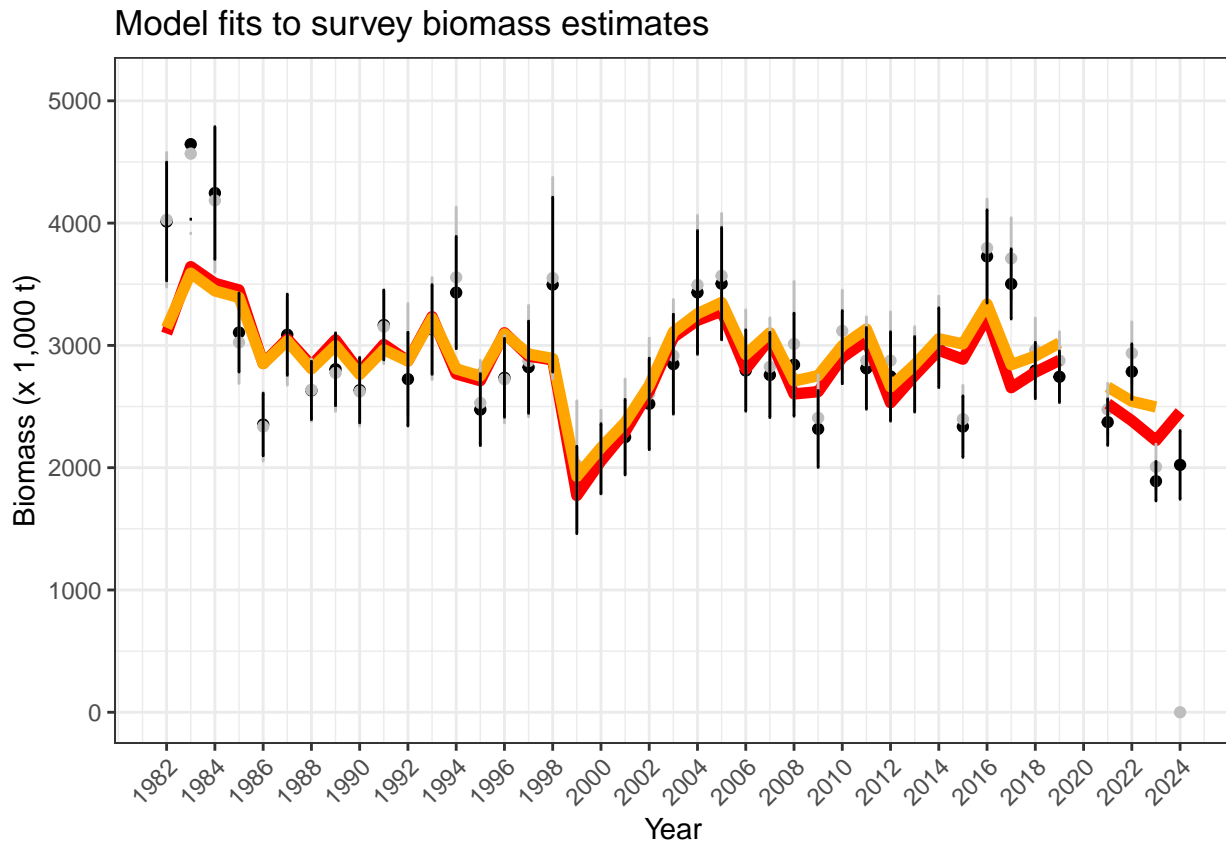


Figure 4.14: Annual eastern Bering Sea bottom trawl survey biomass point estimates and 95% confidence intervals for yellowfin sole, 1982-2024, with 2024 Model 23.0 (red line), 2023 Model 23.0 (orange line). VAST survey estimates with 95% confidence intervals are in grey (2023 estimate) and black (2024 estimate).

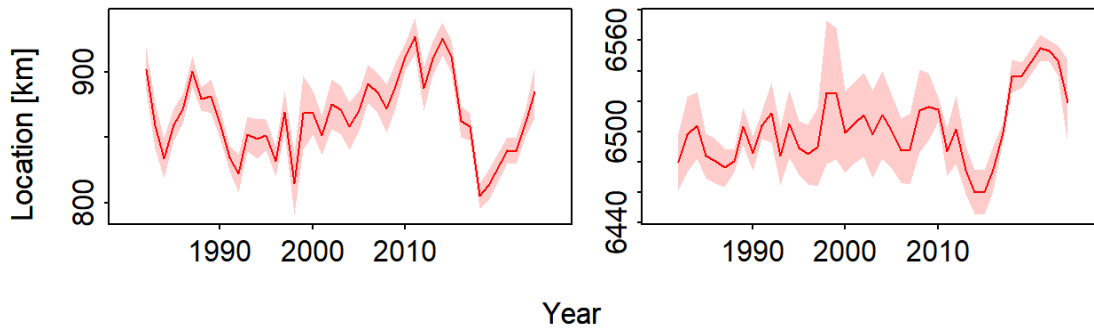


Figure 4.15: Center of gravity plot with eastings (Longitude) in the left panel and northings (Latitude) in the right panel. The units are in kilometers.

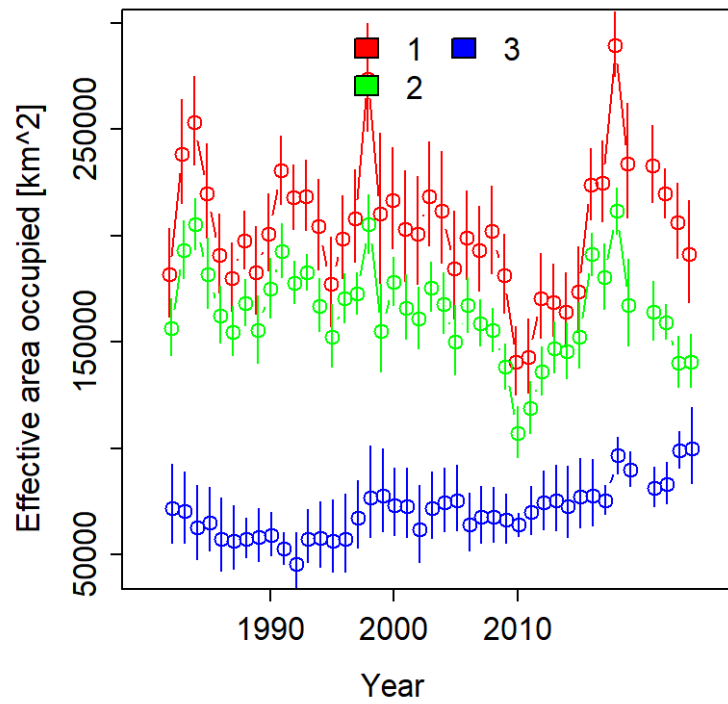


Figure 4.16: The effective area occupied by yellowfin sole, estimated in the VAST analysis, in the eastern Bering Sea (green), northern Bering Sea (blue) and the combined region (red).

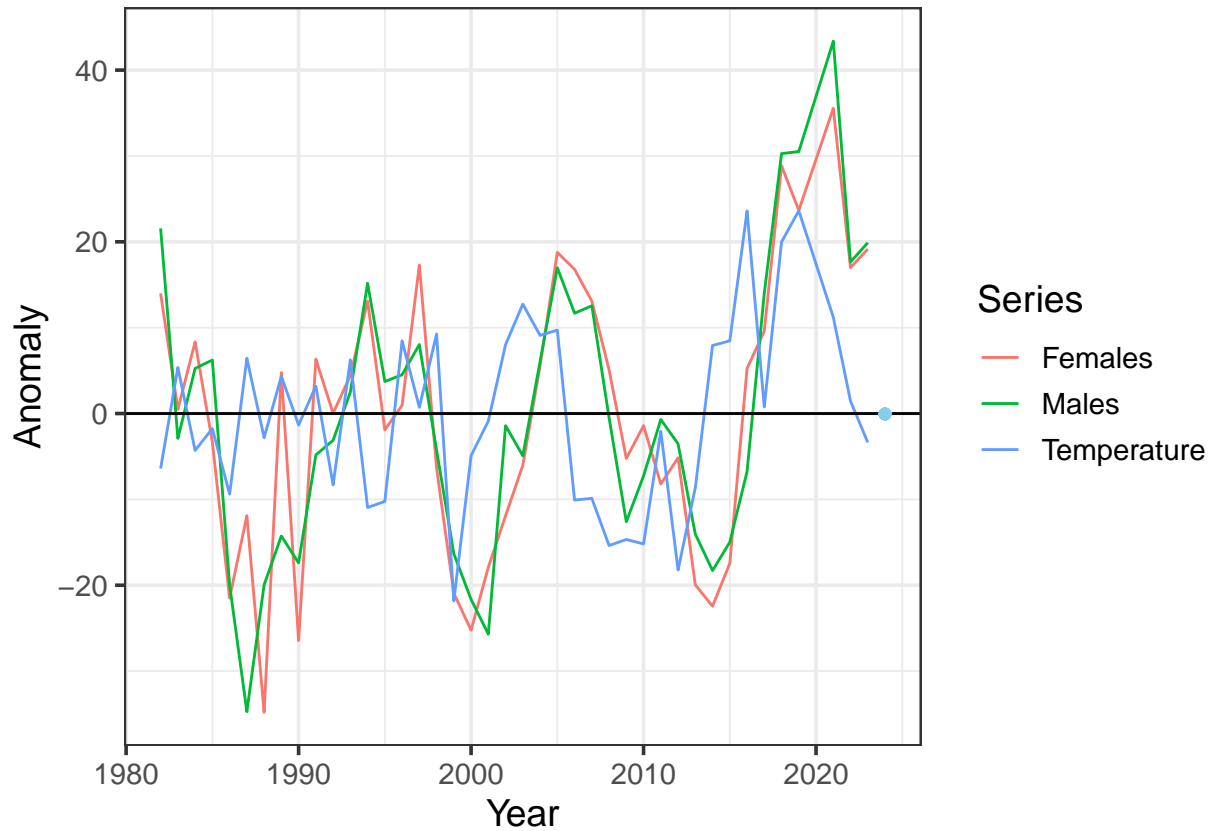


Figure 4.17: Yellowfin sole length-at-age anomalies, for 5-year old males and females, and bottom temperature anomalies from the eastern Bering Sea survey area <100 m. Correspondence in these residuals is apparent with a 2-3 year lag effect from the mid-1990s to 2022 (excluding 2020). Late 1980s and early 1990s pattern may be a density-dependent response in growth from the large 1981 and 1983 year-classes. Note: Bottom temperature anomalies were scaled up by a factor of 10 to demonstrate the pattern and match length anomalies. Age data is not yet available for 2023, but the 2023 temperature anomaly is represented by a blue point.

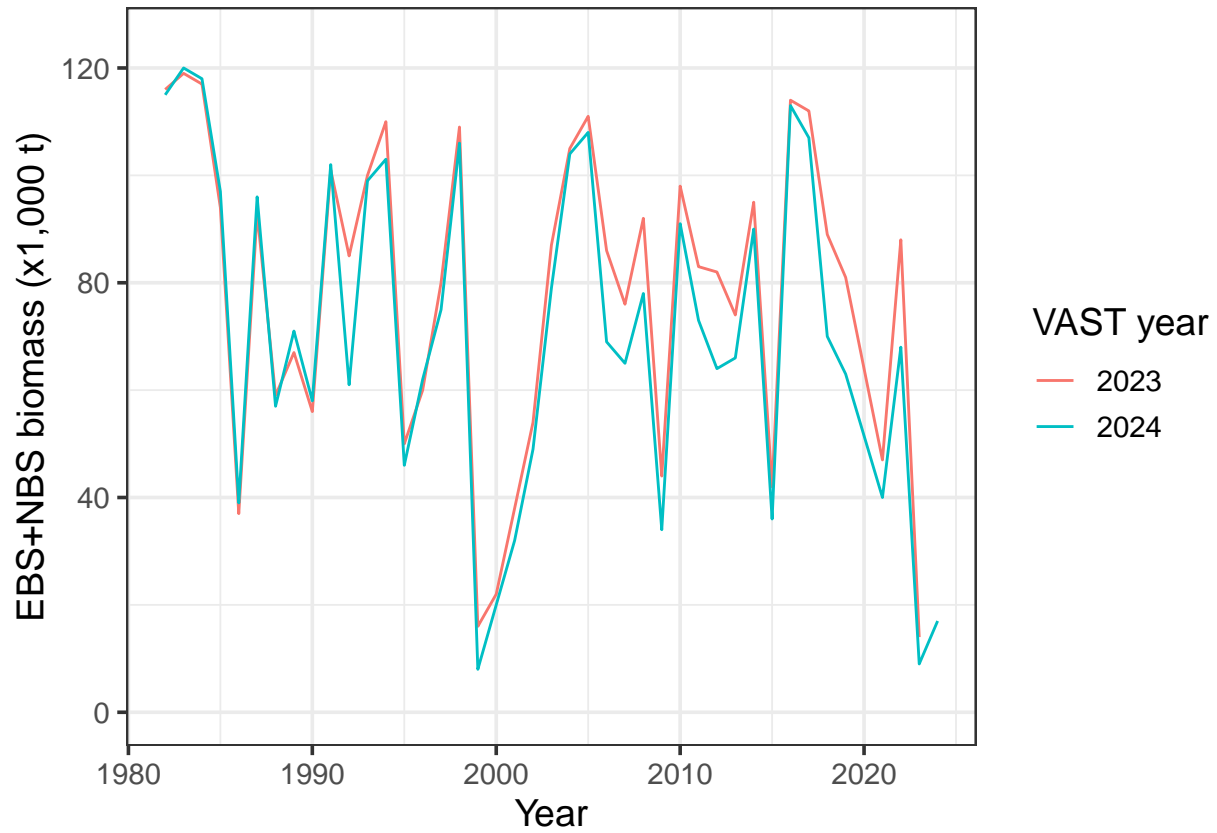


Figure 4.18: VAST biomass estimates for the EBS+NBS, generated in 2023 and 2024. The design-based (DB) timeseries is the design-based estimate of biomass.

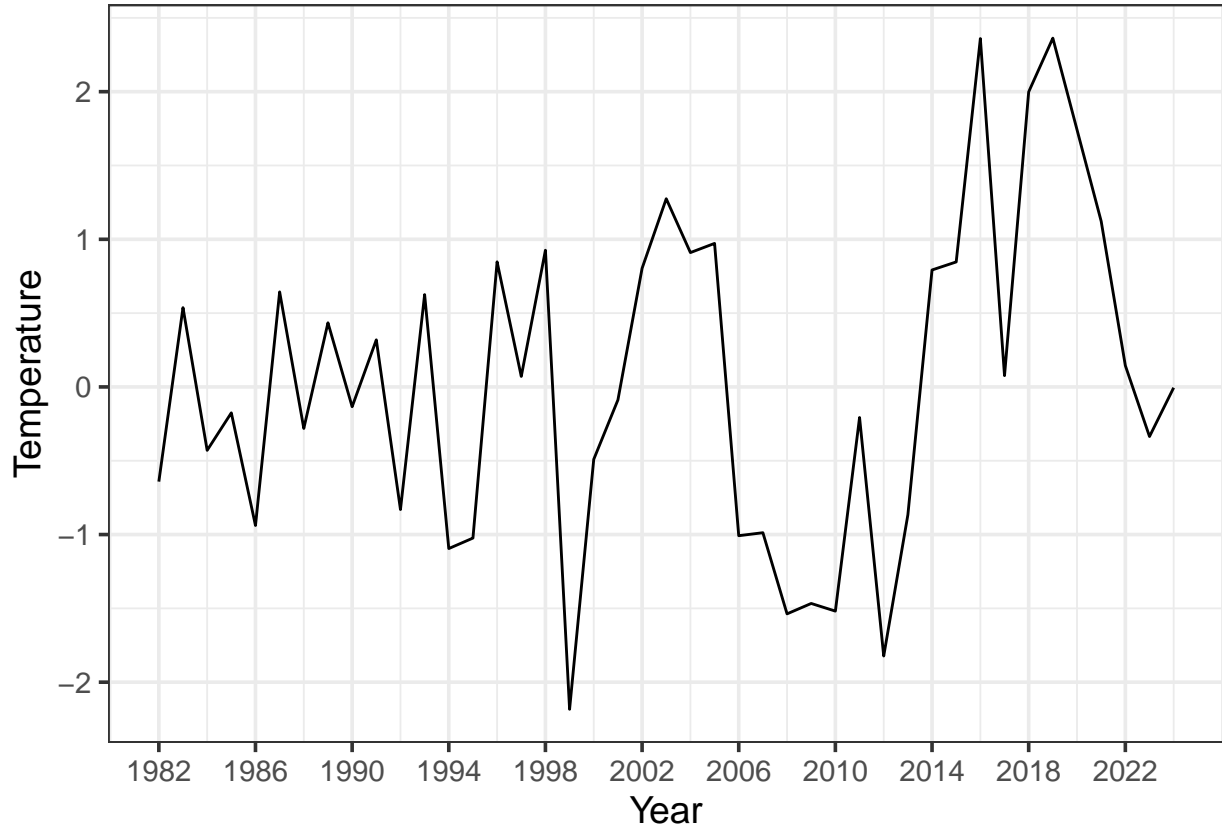


Figure 4.19: Bottom temperature anomalies from the NMFS survey <100 m, 1982-2023.

Average yellowfin sole CPUE in Norton Sound (ADF&G survey)

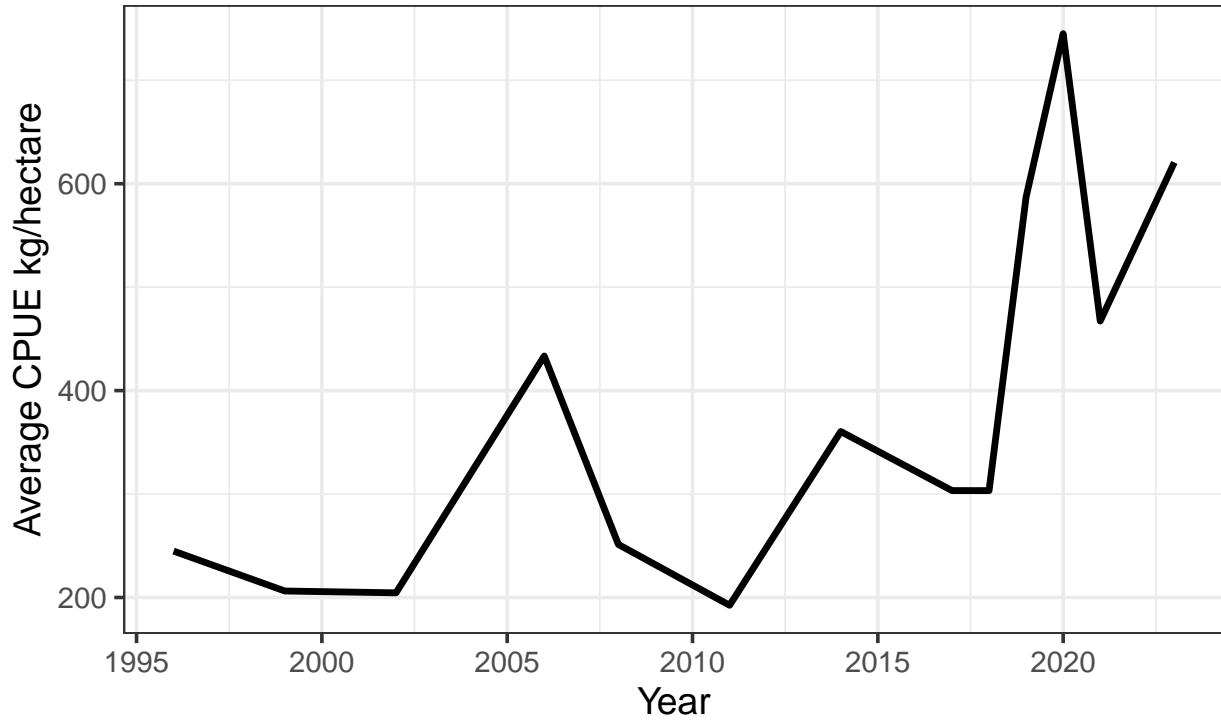


Figure 4.20: Average catch per unit effort (CPUE) of yellowfin sole in Norton Sound, based on ADF&G survey time series, 1996 - 2023.

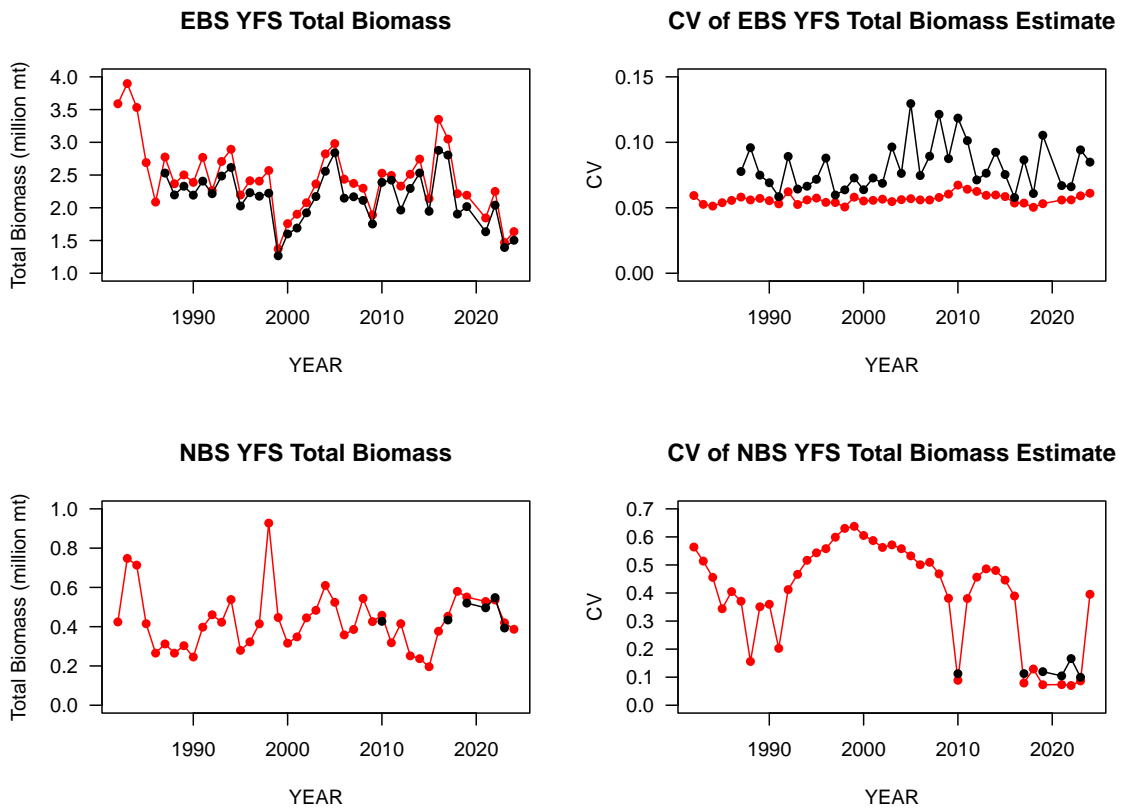


Figure 4.21: Design-based (black) and VAST (red) estimates of biomass and CV for the EBS and NBS in 2024.

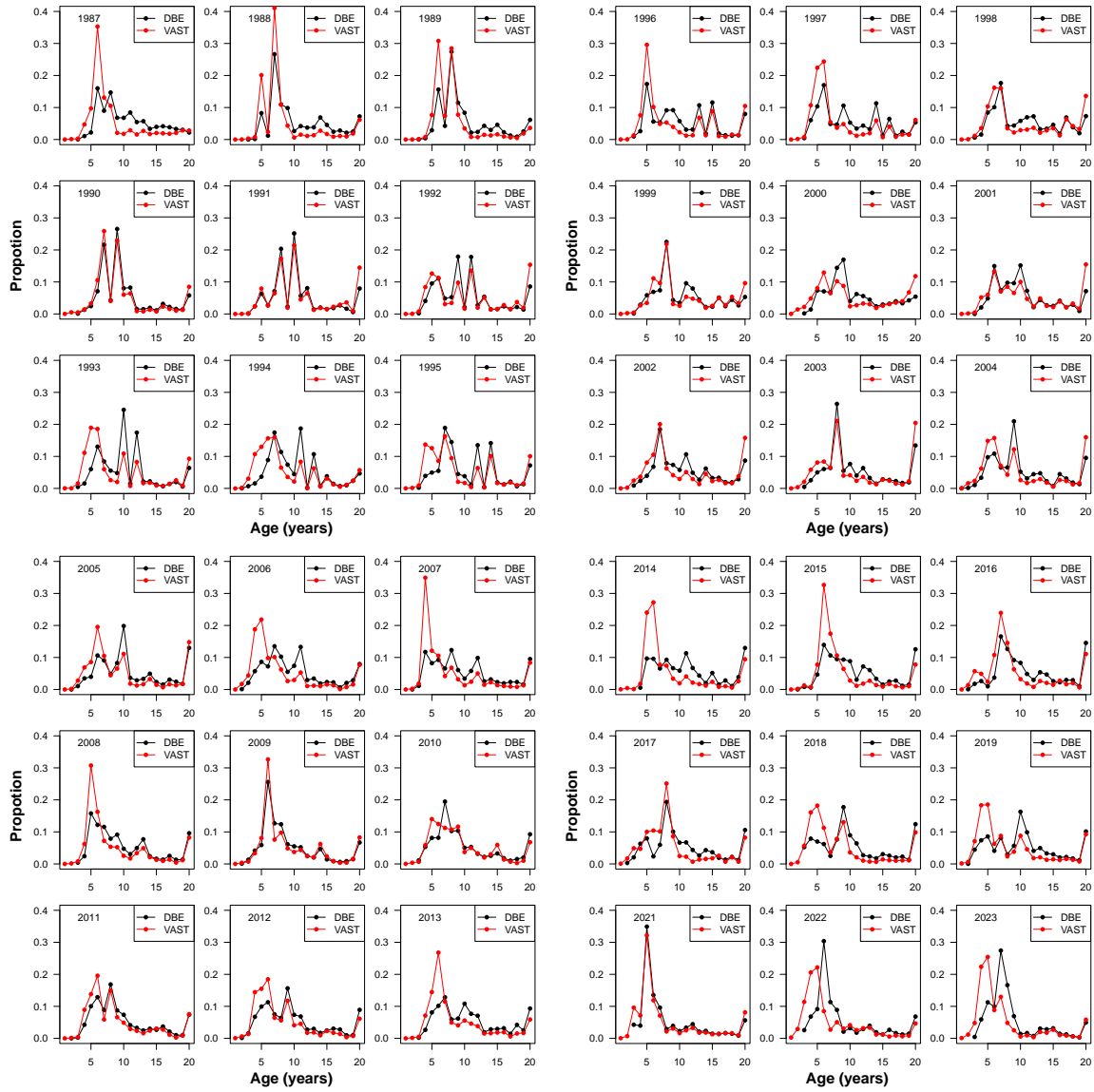


Figure 4.22: Age compositions (design-based and VAST) for all EBS age data, 1987 - 2023.

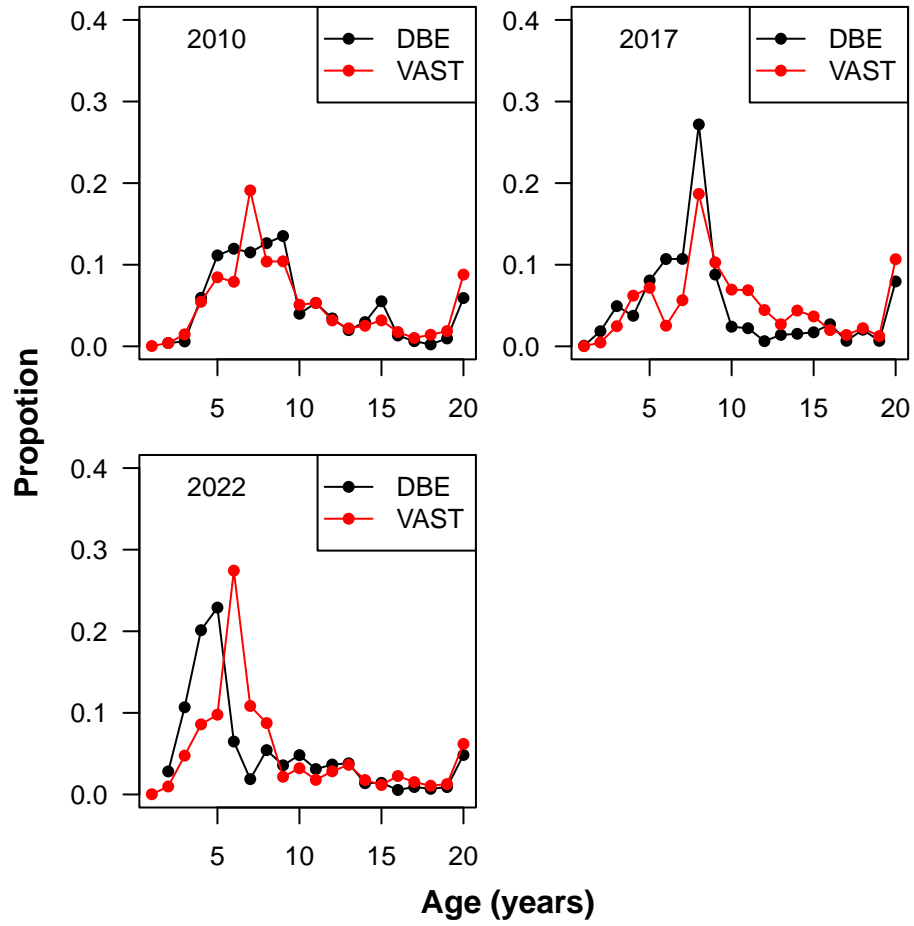


Figure 4.23: Age compositions (design-based and VAST) for all NBS age data.

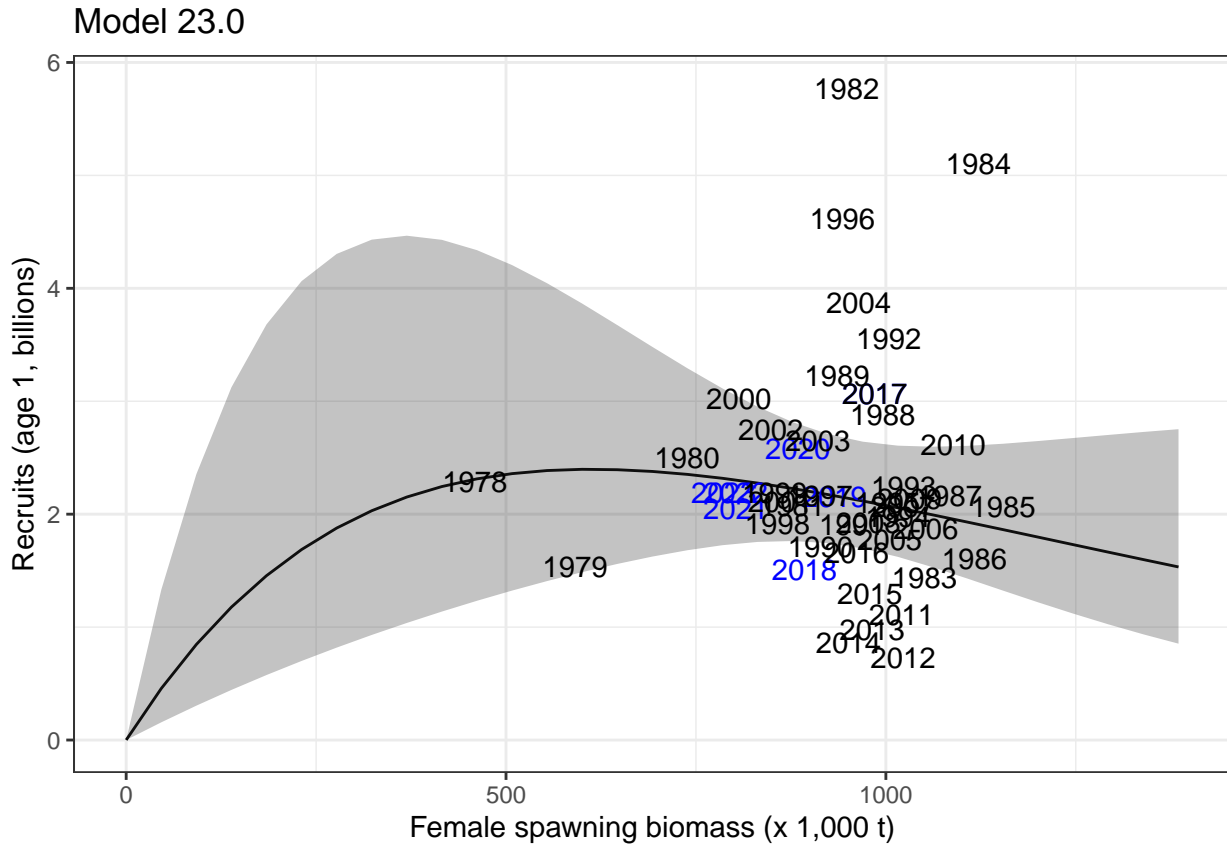


Figure 4.24: Ricker stock recruitment curve for yellowfin sole Model 23.0 with 95% confidence intervals (shaded region) fit to female spawning biomass and recruitment data from 1978-2018. Years in black indicate data used to fit the model, years in blue were not used to fit the model.

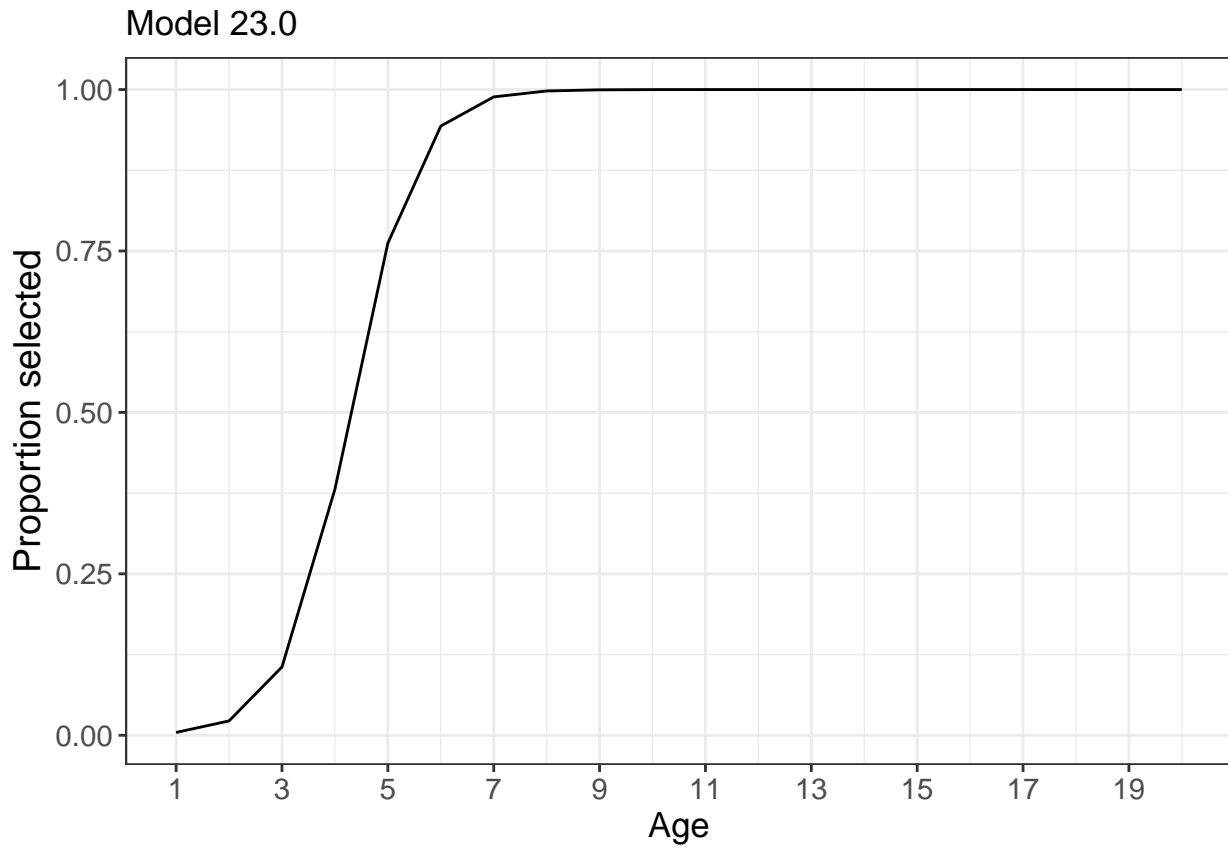


Figure 4.25: Estimate of yellowfin sole survey selectivity, Model 23.0.

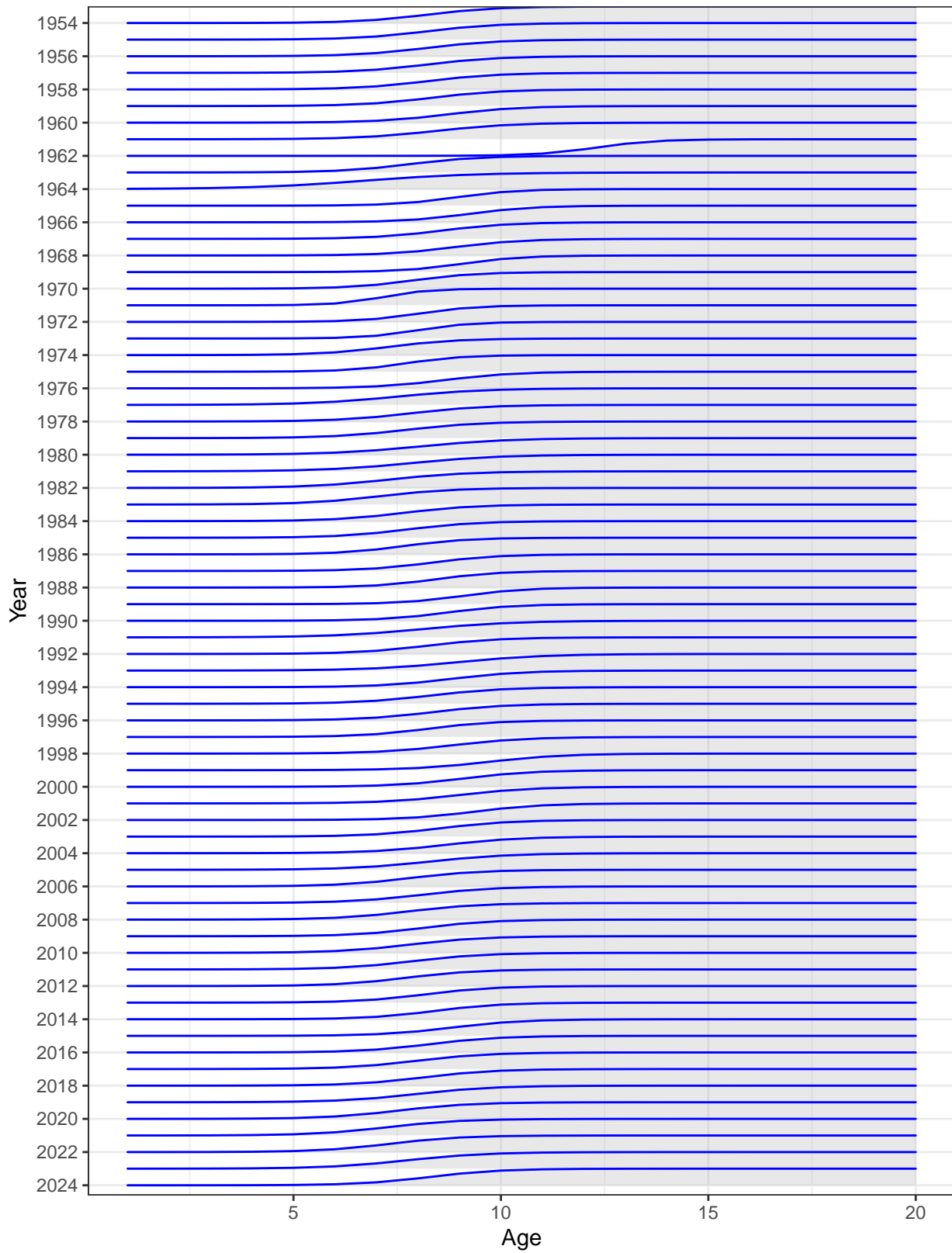


Figure 4.26: Estimate of yellowfin sole fishery selectivity by year, 1954-2024, Model 23.0.

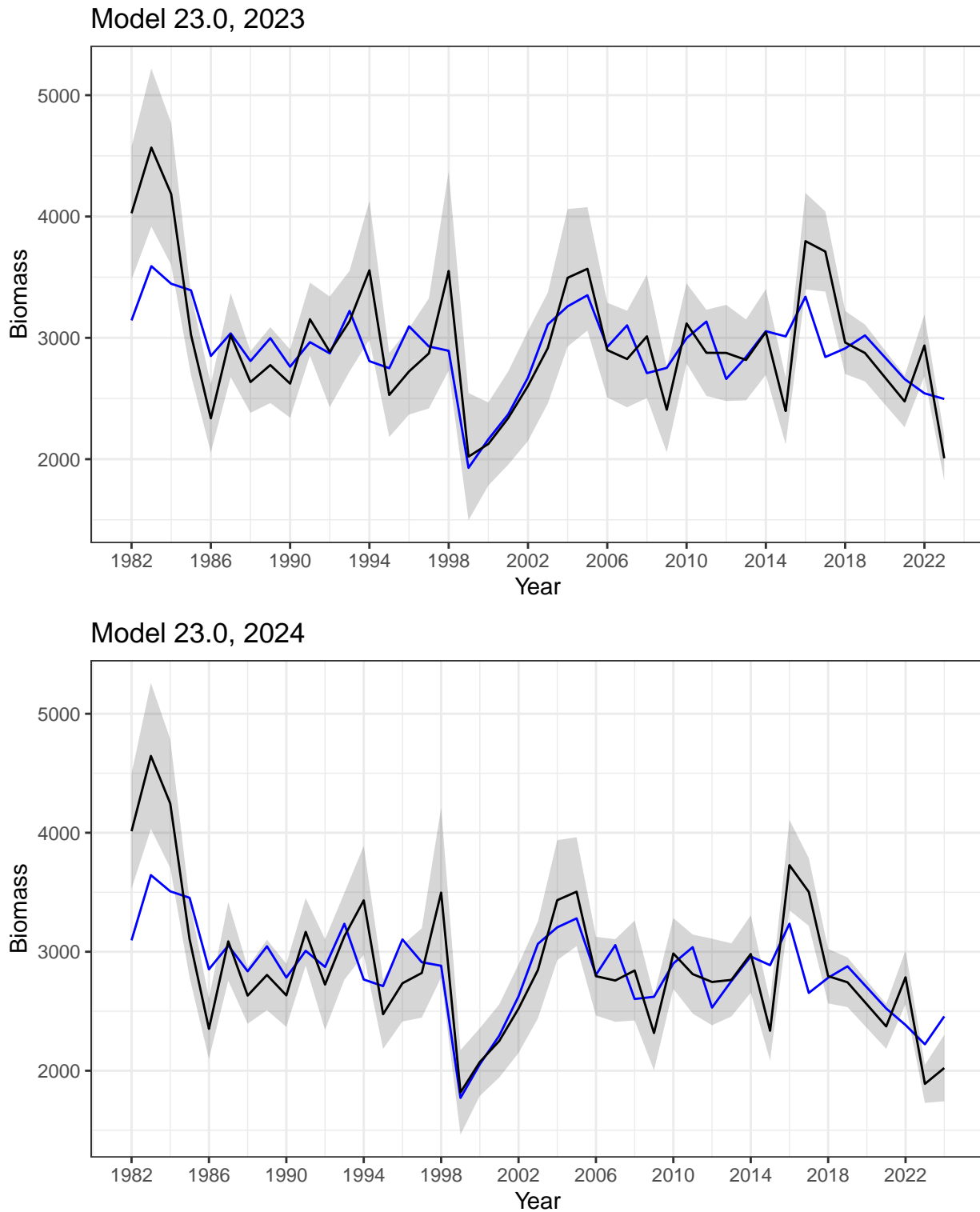


Figure 4.27: Model 23.0 from 2023 (upper panel), Model 23.0 from 2024 (lower panel) fit to NMFS NBS+EBS model-based (VAST) estimates for yellowfin sole, from 1982-2024. The 2024 VAST index differs from the 2023 index due to the addition of an additional year (which affects the entire time series). Blue lines are model estimates, grey represent survey estimates.

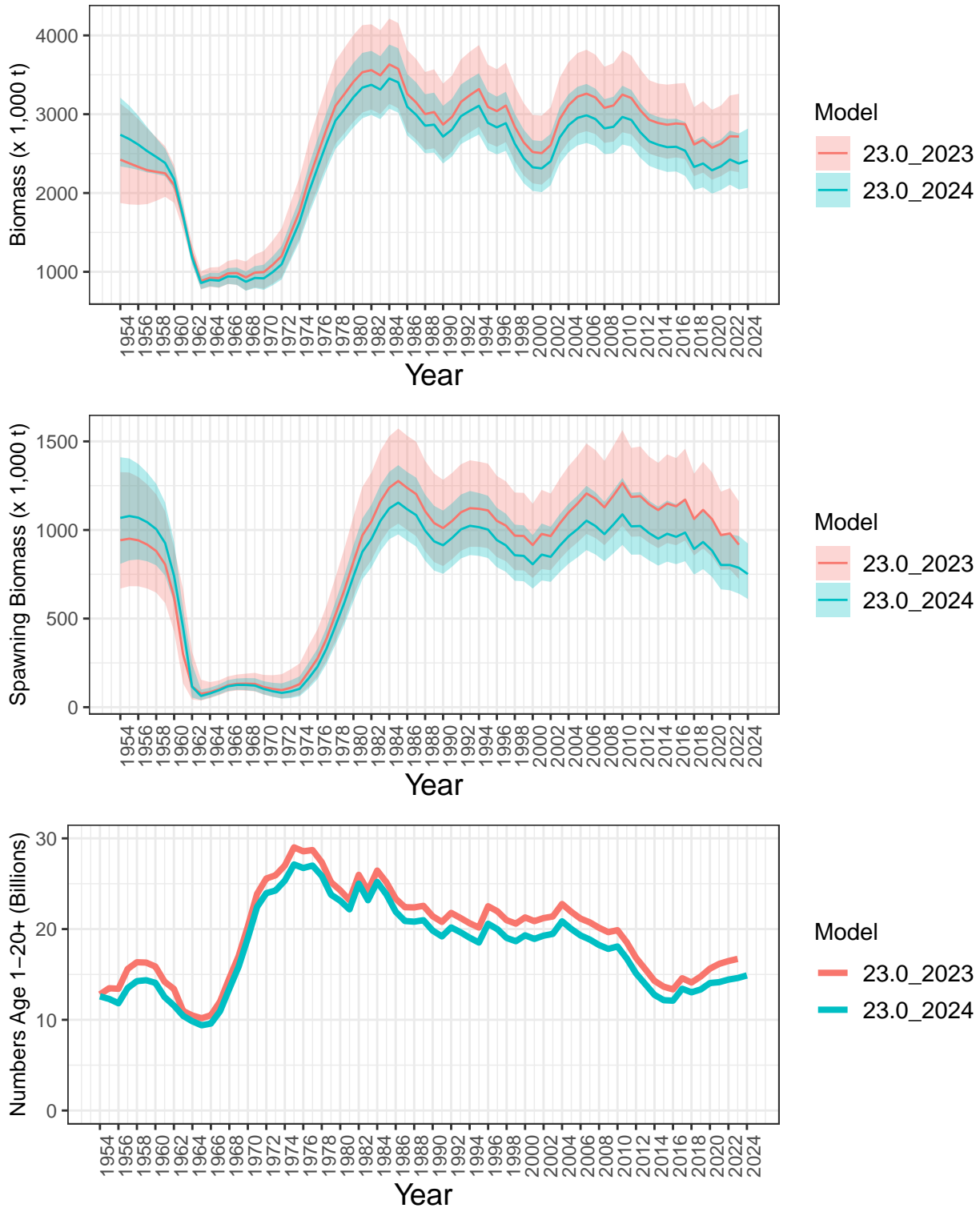


Figure 4.28: Total (age 2+) and spawning stock biomass for yellowfin sole, and total numbers, based on Models 23.0 (2023), 23.0 (2024).

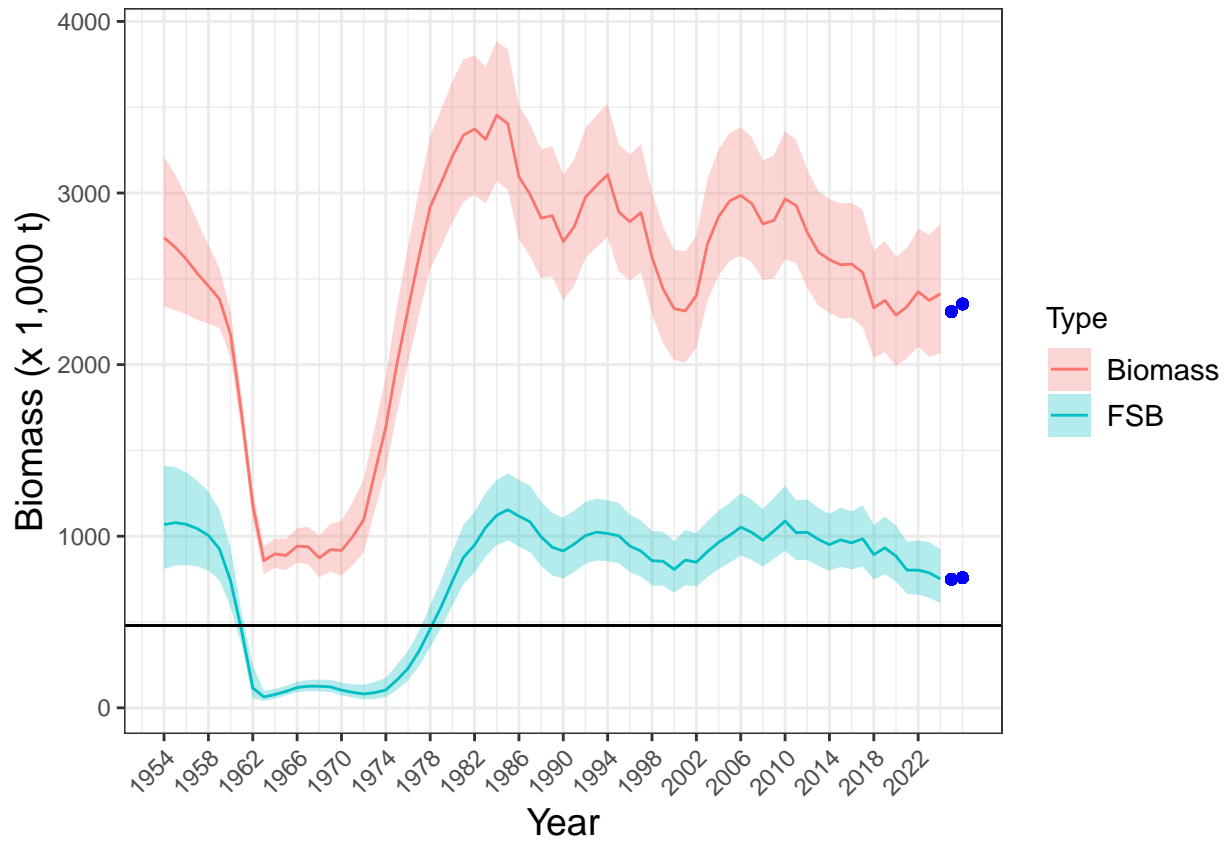


Figure 4.29: Model estimates of yellowfin sole total (age 2+) and female spawning biomass with 95% confidence intervals, 1954-2024, Model 23.0. Dots indicate projections for 2025 and 2026.

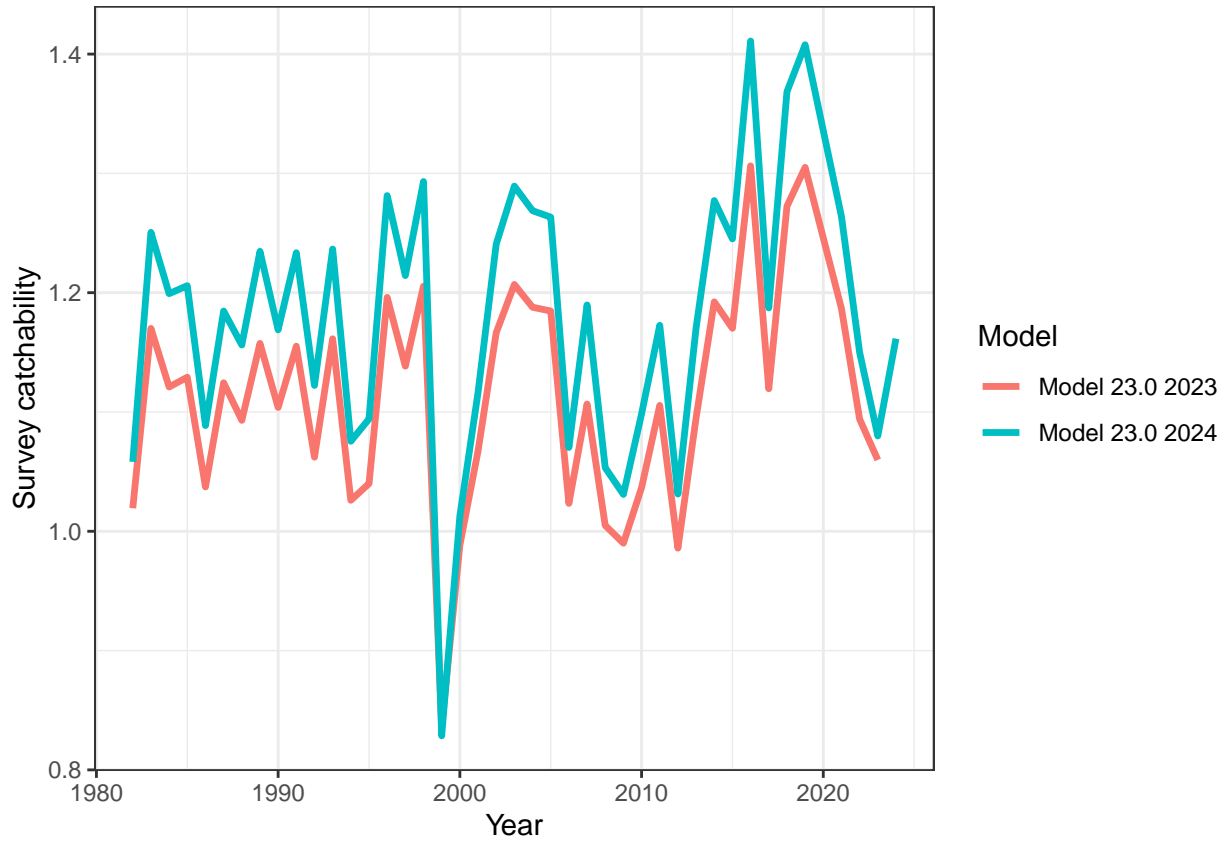


Figure 4.30: Survey catchability for yellowfin sole Model 23.0 (2023 and 2024 versions), 1982-2024.

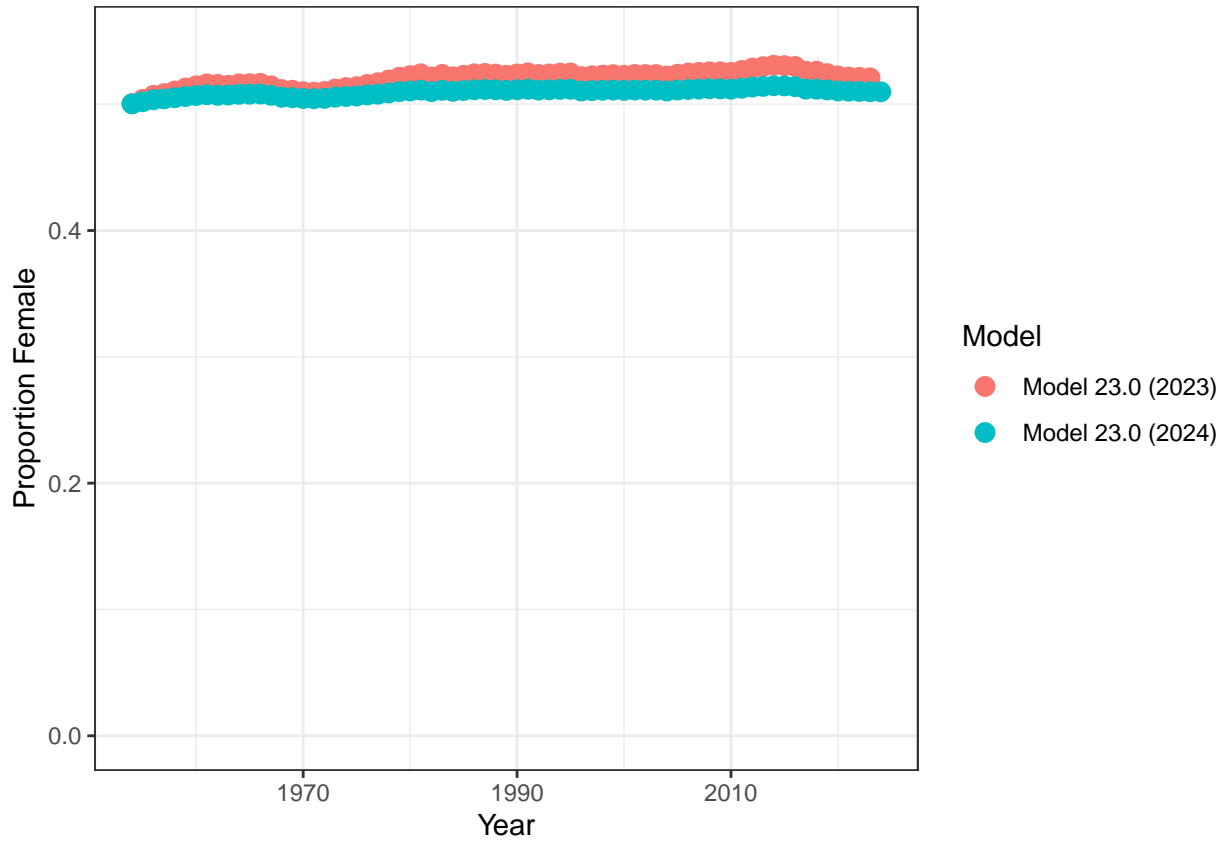


Figure 4.31: Model estimates of the proportion of female yellowfin sole in the population, 1982-2024 for Model 23.0 (from 2023 and 2024)

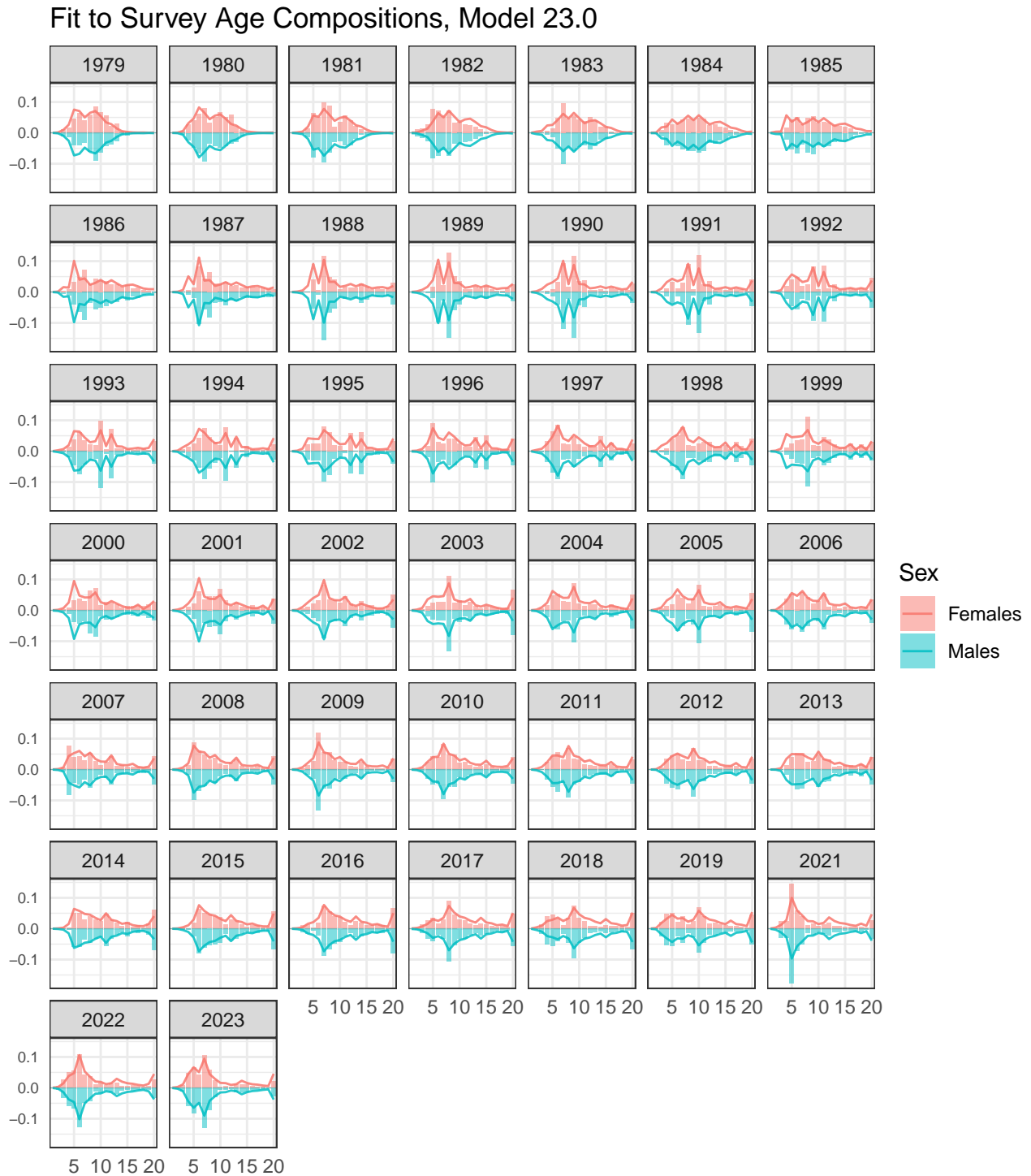


Figure 4.32: Model 23.0 fit to the time-series of yellowfin sole survey age composition, by sex, 1979-2023. The x-axis represents age.

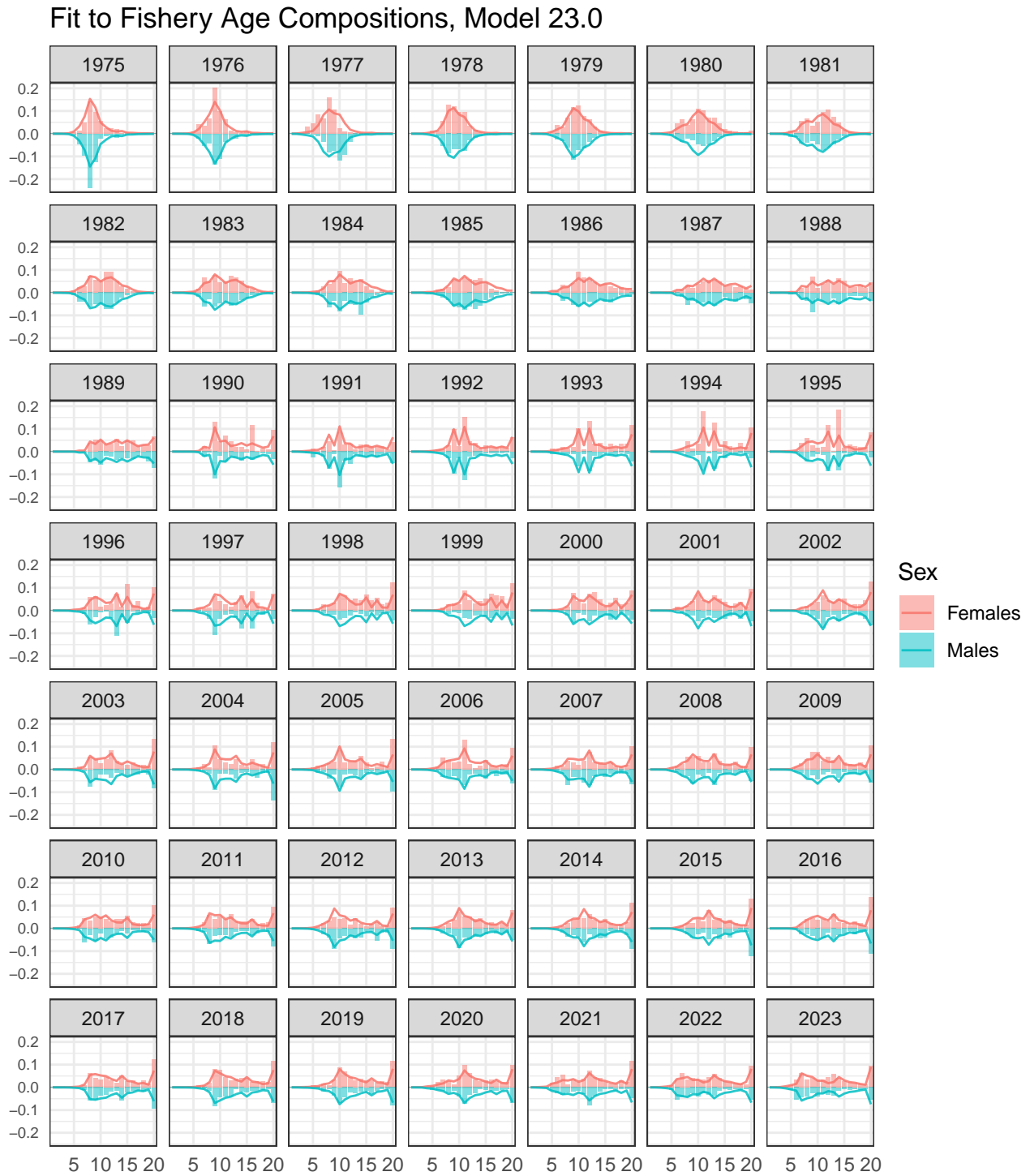


Figure 4.33: Model 23.0 fit to the time-series of yellowfin sole fishery age composition, by sex, 1975-2023. The x-axis represents age.

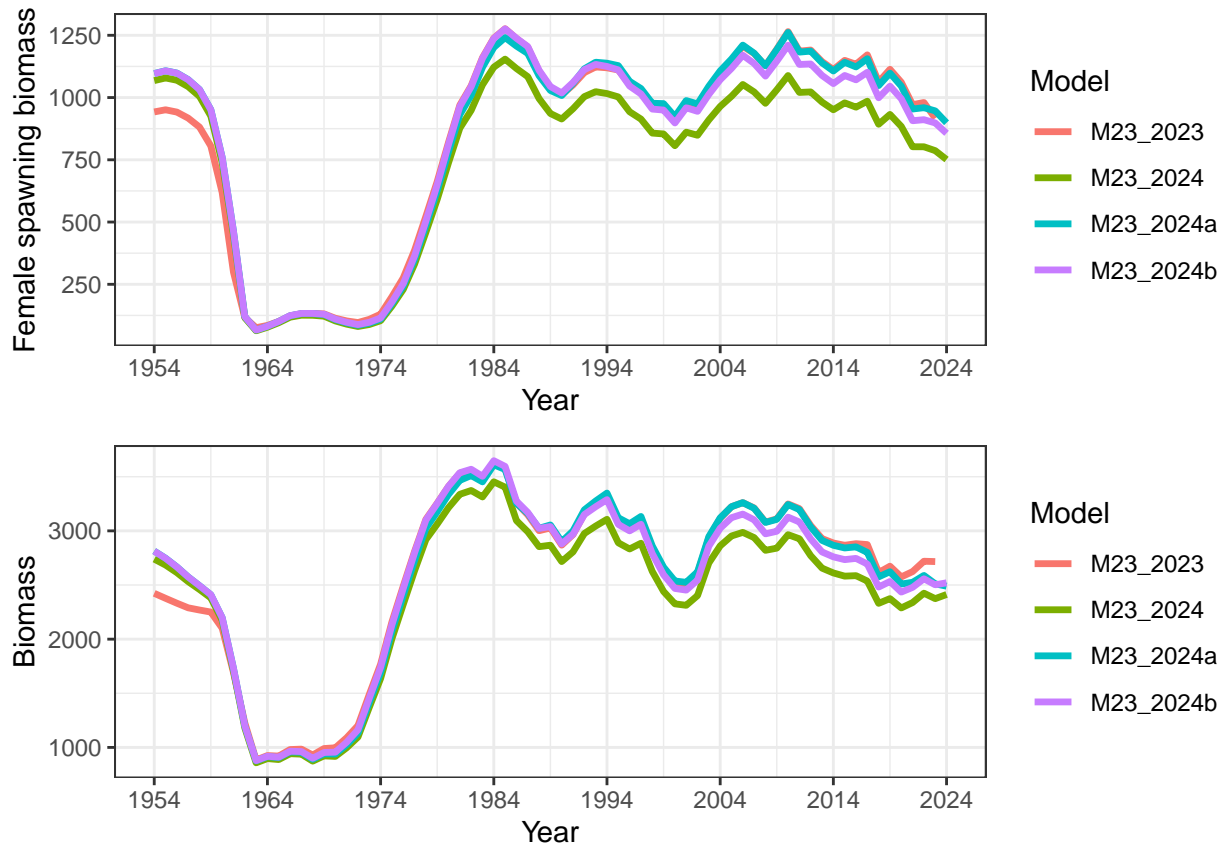


Figure 4.34: Upper panel: Biomass estimates, Lower panel: female spawning biomass. Model 23.0 2024a includes fishery catch through 2024 but not 2023 survey age compositions or 2024 survey index. Model 23.0 2024b added the 2024 survey index to Model 23.0a but not the updated survey age composition.

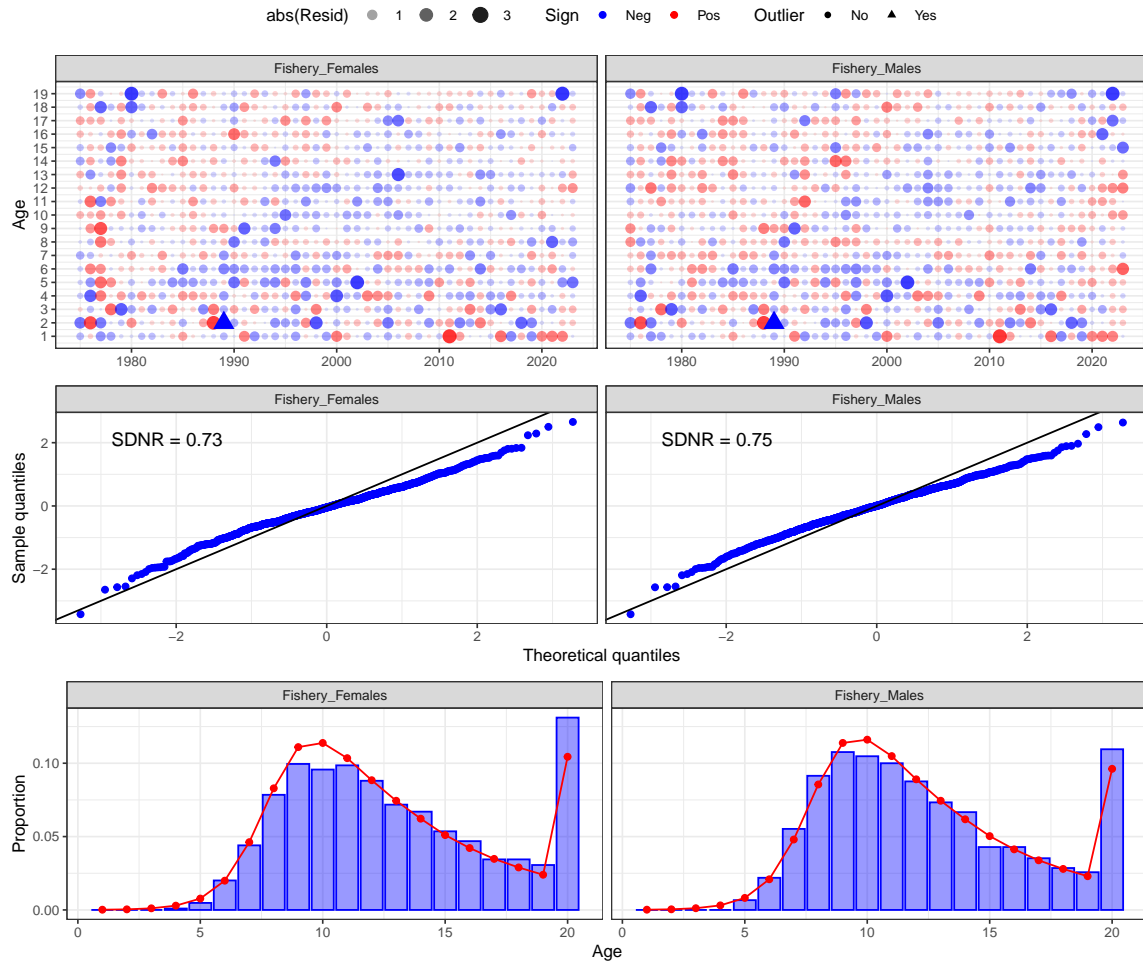


Figure 4.35: One-step ahead residuals for yellowfin sole fishery ages, females and males.

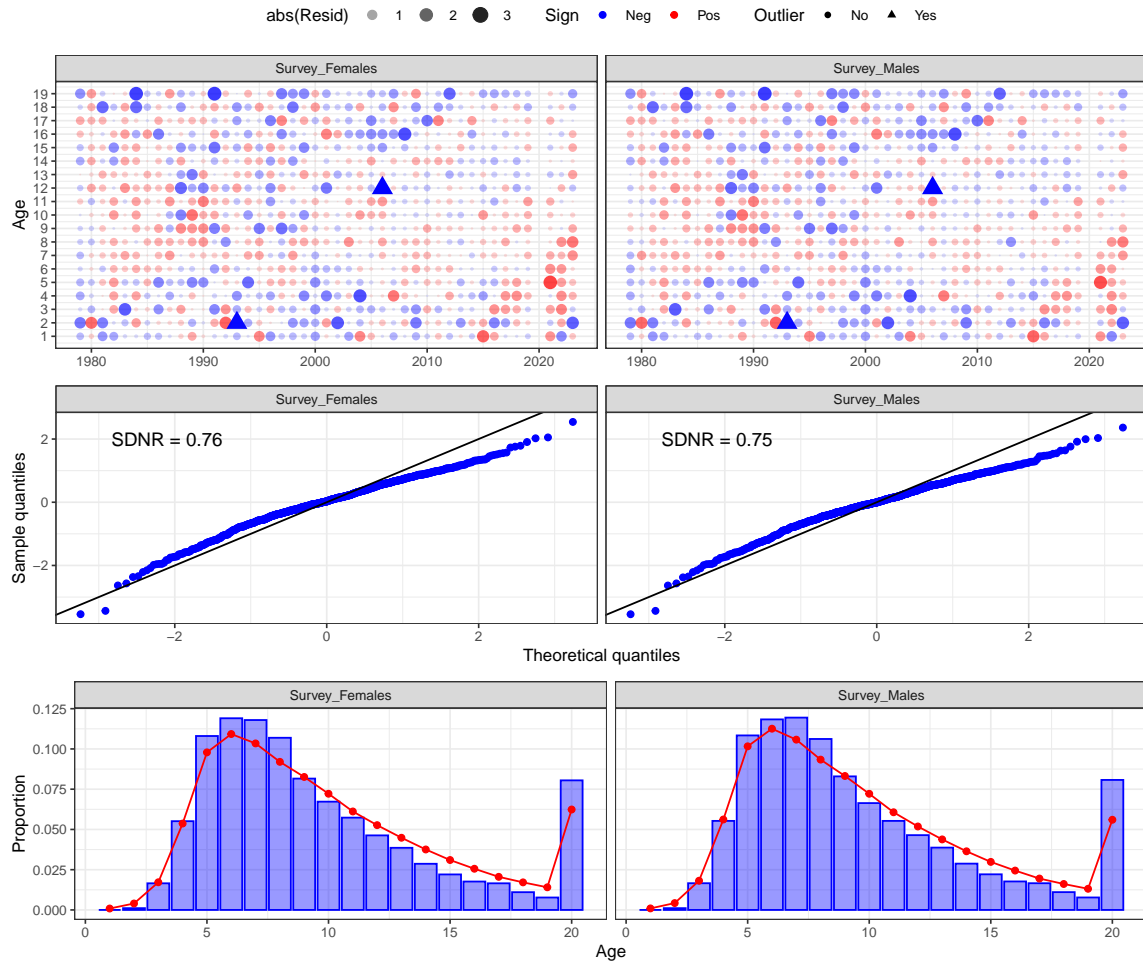


Figure 4.36: One step ahead residuals for yellowfin sole survey ages, females and males.

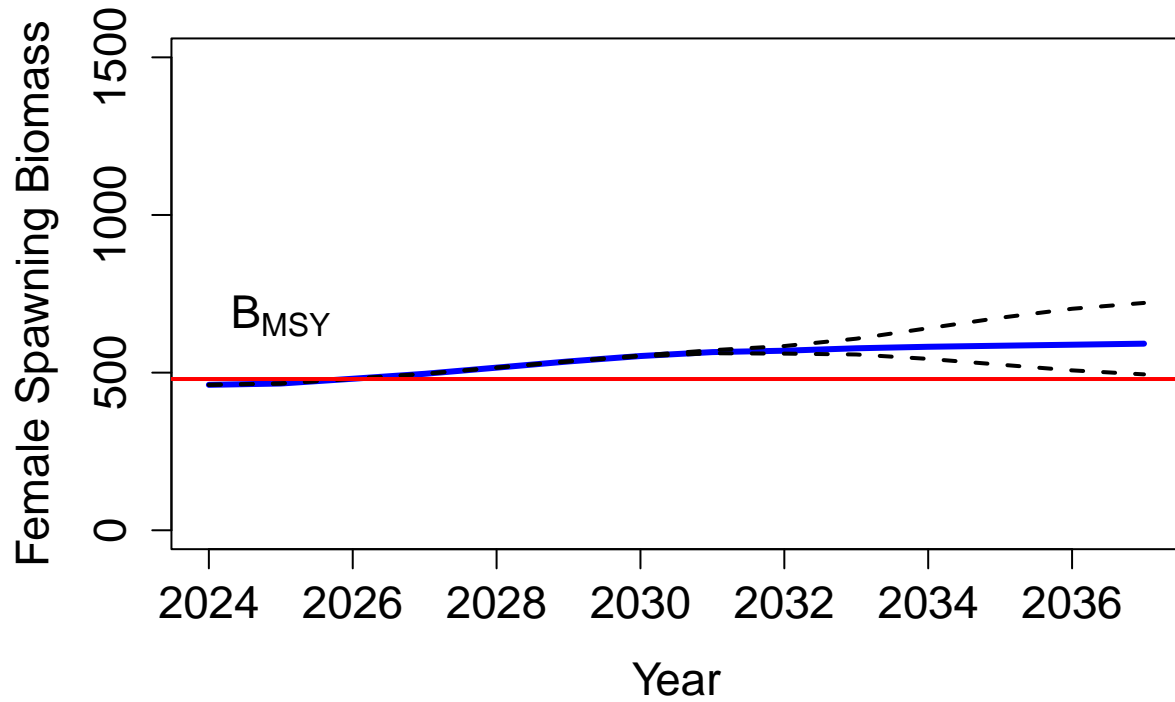


Figure 4.37: Projected yellowfin sole female spawning biomass for 2024 to 2037 (blue line), with 5% and 95% confidence intervals, and fishing at the 5-year (2018-2022) average fishing mortality rate, $F = 0.0846$, Model 23.0.

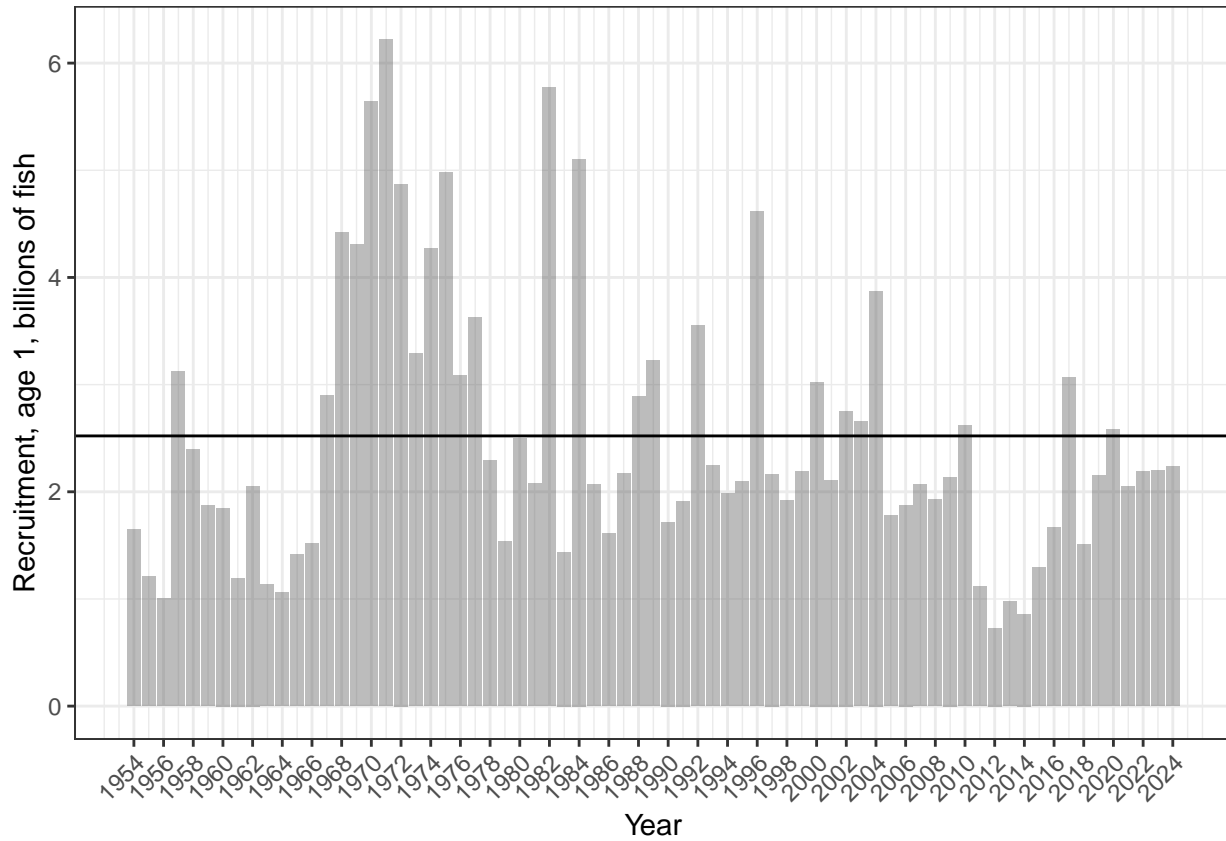


Figure 4.38: Year-class strength of age 1 yellowfin sole estimated by the stock assessment model. The horizontal line represents the average of the estimates from recruitment, 1954-2019, 2.5 billion, Model 23.0.

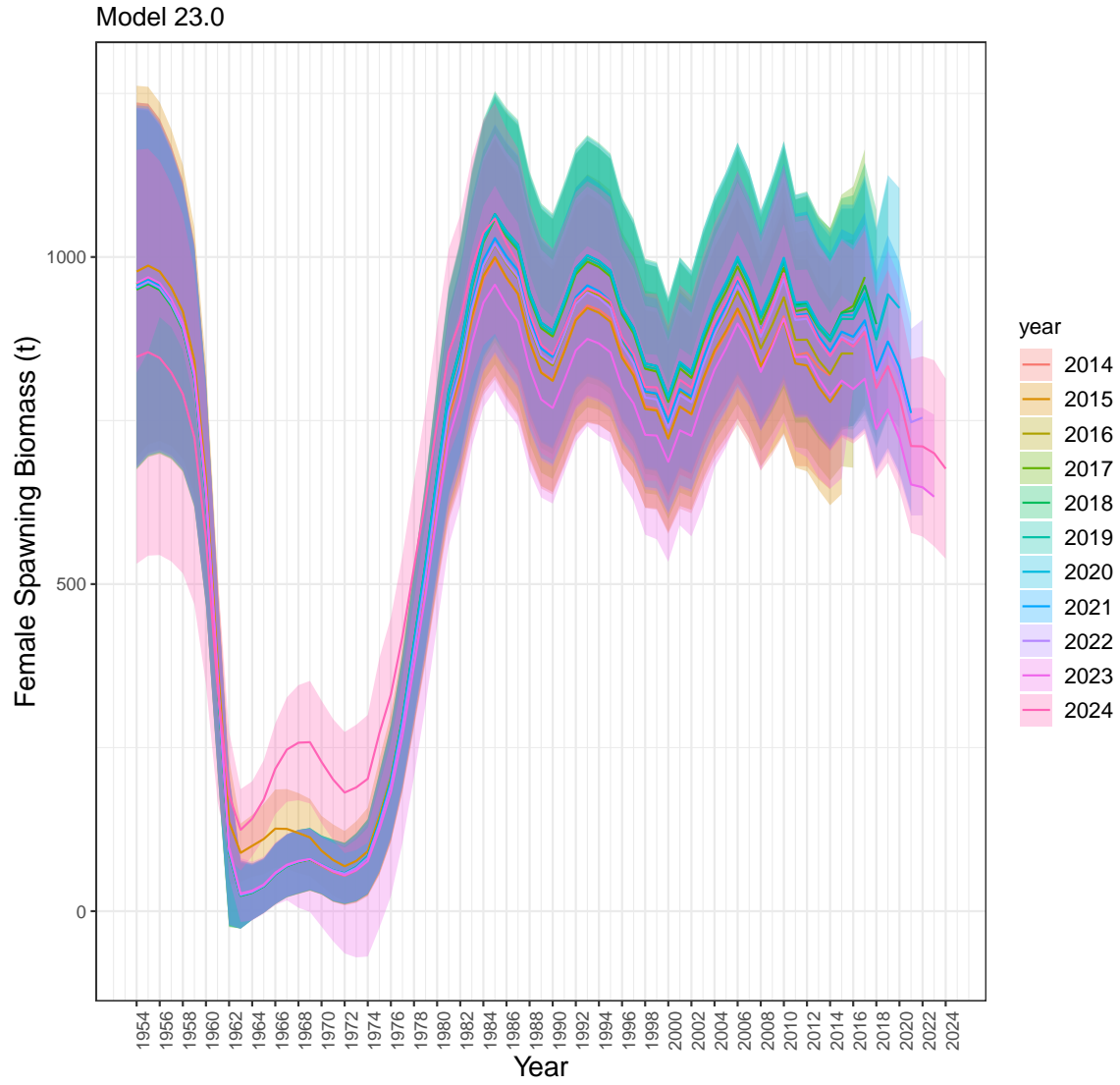


Figure 4.39: Retrospective plot of female spawning biomass for yellowfin sole Model 23.0. Mohn's Rho for this model was 0.06.

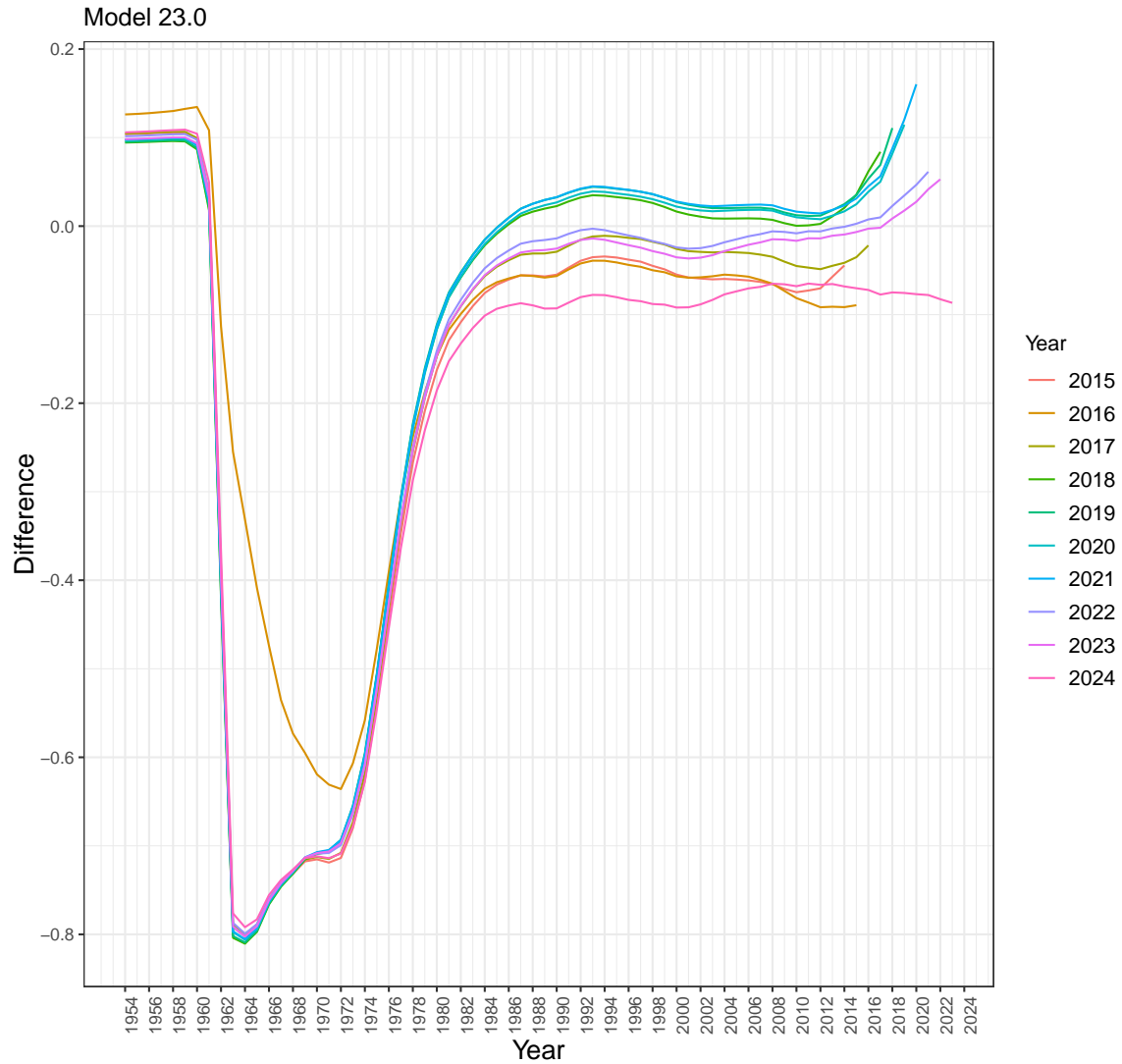


Figure 4.40: Retrospective differences in female spawning biomass between sequential years for yellowfin sole Model 23.0, shown as past years relative to the current year. The 2024 model with the final year of data removed provided higher estimates of SSB than the full 2024 model.

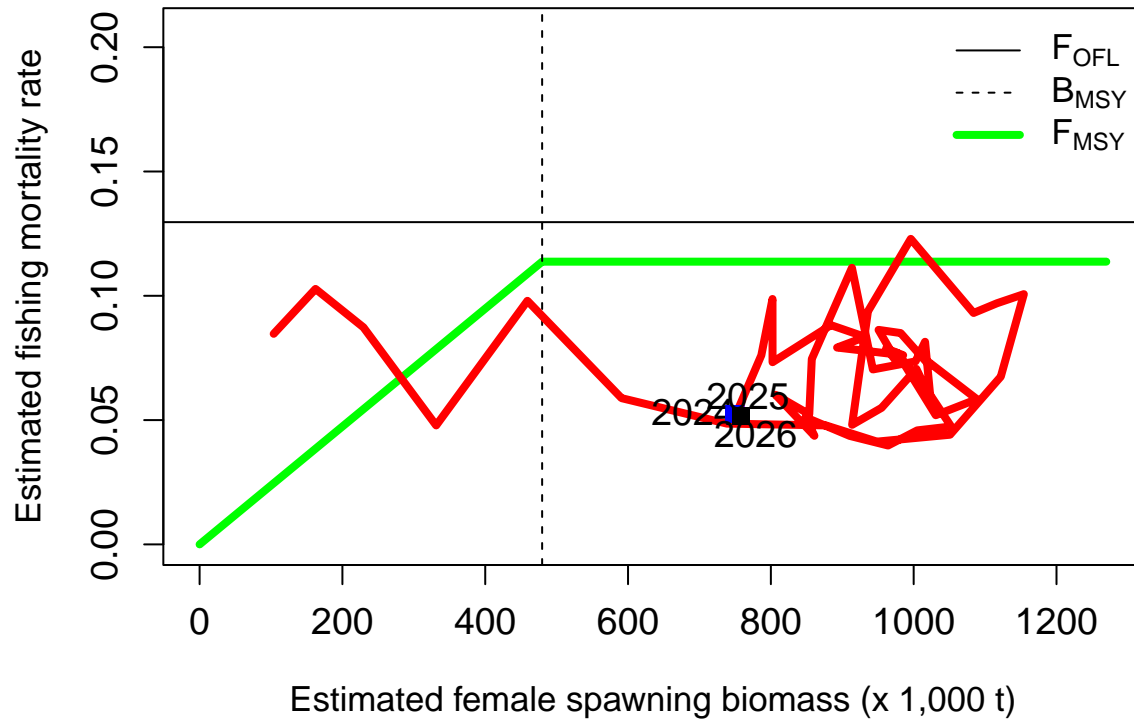


Figure 4.41: Yellowfin sole fishing mortality rate and female spawning biomass from 1975 to 2024 compared to the F35% and F40% control rules, based on Model 23.0. Vertical line is B35%. Squares indicate estimates for 2024, 2025, and 2026.