Chapter 2: Assessment of the Pacific cod stock   
in the Gulf of Alaska

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November 2024

This report may be cited as: Hulson, P.-J. F., S. J. Barbeaux, B. Ferriss, K. Echave, J. Nielsen, S. McDermott, B. Laurel, A. Abookire, I. Spies, and S. K. Shotwell. 2024. Assessment of the Pacific cod stock in the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK. Available from <https://www.npfmc.org/library/safe-reports/>.



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# Executive Summary

Pacific cod in the Gulf of Alaska are assessed on an annual stock assessment schedule to coincide with the availability of new survey data. We use a statistical age-structured model as the primary assessment tool for Gulf of Alaska Pacific cod which qualifies as a Tier 3 stock. This assessment consists of a population model, which uses survey and fishery data to generate a historical time series of population estimates, and a projection model, which uses results from the population model to predict future population estimates and recommended harvest levels. All data and results (including model input files and plots), as well as documents and presentations pertaining to this assessment can be found at this [link](https://afsc-assessments.github.io/goapcod/2024_Assessment/November_Models/) and by following the QR code provided in the title page of this document.

## Summary of Changes in Assessment Inputs

Relative to last year’s assessment, the following changes have been made in the current assessment:

### Changes in the input data

1. Federal and state catch data for 2024 were updated and preliminary federal and state catch data for 2025 were included;
2. Commercial federal and state fishery size composition data for 2024 were updated, and preliminary commercial federal and state fishery size composition data for 2025 were included;
3. Commercial federal conditional age-at-length data for 2024 were included;
4. AFSC longline survey Pacific cod abundance index and length composition data for the GOA for 2025 were included;
5. AFSC bottom trawl survey abundance index and length composition data for 2025 were included;

### Changes in the methodology

There have been no changes to this year’s model and the methodology remains the same as model 24.0 accepted in 2024.

## Summary of Results

Model 24.0 indicates that the stock remains at low levels but is above *B20%*; for 2025 the stock is estimated to be at *B28.7%*, less than *B40%*, placing it in sub-tier “b” of Tier 3. For the 2025 fishery, we recommend the maximum allowable ABC of 32,141 t. This ABC is less than 1% different from the 2024 ABC of 32,272 t. The 2025 ABC is 14% larger than the 2025 ABC projected in last year’s assessment. The corresponding reference values are summarized in the following table, with the recommended ABC and OFL values in bold. The stock is not being subject to overfishing, is not currently overfished, nor is it approaching a condition of being overfished.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Quantity** | As estimated or *specified last* year for: | | As estimated or *specified this* year for: | |
| 2024 | 2025 | 2025 | 2026 |
| *M* (natural mortality rate) | 0.46\* | 0.46\* | 0.49\* | 0.49\* |
| Tier | 3b | 3b | 3b | 3b |
| Projected total (age 0+) biomass (t) | 184,242 | 202,618 | 177,497 | 200,521 |
| Female spawning biomass (t) |  |  |  |  |
| Projected | 51,959 | 47,698 | 46,920 | 44,674 |
|  |  |  |  |  |
| *B100%* | 175,187 | 175,187 | 163,585 | 163,585 |
| *B40%* | 70,075 | 70,075 | 65,434 | 65,434 |
| *B35%* | 61,315 | 61,315 | 57,255 | 57,255 |
| *FOFL* | 0.52 | 0.48 | 0.57 | 0.51 |
| *maxFABC* | 0.42 | 0.38 | 0.46 | 0.43 |
| *FABC* | 0.42 | 0.38 | 0.46 | 0.43 |
| OFL (t) | 38,712 | 33,970 | **38,688** | 36,459 |
| maxABC (t) | 32,272 | 28,184 | 32,141 | 30,193 |
| ABC (t) | 32,272 | 28,184 | **32,141** | 30,193 |
| **Status** | As determined *last* year for: | | As determined *this* year for: | |
| 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 |

*\*Base natural mortality M varies between 0.49 and 0.82*

*\*\* Assumed 2024 catch to be the 2024 ABC. For 2026 projections the 2025 catch was assumed to be at the projected ABC.*

## Area apportionment

Using the random effects model (as applied within the *rema* R-package, Sullivan *et al.* 2022) with the trawl survey biomass estimates through 2023, the area-apportioned ABCs are:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Western | Central | Eastern | Total |
| Area apportionment | 27.10% | 63.80% | 9.10% | 100% |
| 2025 ABC | 8,710 | 20,506 | 2,925 | 32,141 |
| 2026 ABC | 8,182 | 19,263 | 2,748 | 30,193 |

# Introduction

The stock assessment described in this document is an update assessment, in which only data since the last assessment has been updated and included in the stock assessment model. The stock assessment model used this year to provide management recommendations is a model in which no methodological changes have been made since the last accepted model in 2024, model 24.0. Within this document we only include the SAFE sections in which data or model results have been updated since the last assessment. The sections that are not included in this SAFE document can be found in the previous full assessment (link), and will be again be included and updated when the next full assessment is conducted.

# Fishery

## Fishery history and management measures

For a full description of the fishery history and management measures see Hulson *et al.* 2022. Here we summarize this section and refer to the relevant Tables and Figures. Catches of Pacific cod since 1991 by gear type and jurisdiction are shown in Table 2.1; catches prior to that are listed in Thompson *et al.* (2011). Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components; Figure 2.3 shows landings by gear since 1977. The history of Total Allowable Catch (TAC), Acceptable Biological Catch (ABC), Overfishing Level (OFL), and State of Alaska Guideline Harvest Levels (GHL) are summarized since 1991 and compared with the time series of aggregate commercial catches in Table 2.2 (data prior to 1991 are shown in Hulson *et al.* 2022). The complete history of allocation (in percentage terms) by regulatory area within the GOA is shown in Table 2.3. Catch reported in Tables 2.1 and 2.2 include discarded Pacific cod, estimated retained and discarded amounts are shown in Table 2.4.

## Recent fishery performance

The distribution of directed cod fishing is distinct to gear type. Figure 2.4 shows the recent distribution of catch since 2015 for the three major gear types. Figure 2.5 shows the distribution of observed catch for the most recent year of catch data (2024) for the three major gear types, as well as the distinction between observed and electronic monitored catch.

In 2024 the federal TAC was set at 23,766 t and state GHL set at 8,506 t (Table 2.2). As of October 17, 2024 a total of 23,171 t (72% of the ABC) have been harvested (Table 2.1). State fisheries have harvested 6,311 t (74% of the GHL) and federal fisheries 16,860 t (71% of the TAC). In 2024 38% of the Pacific cod catch was by trawl, 32% by pot gear, and 28% by longline, while jig and other gear harvested 2% (Table 2.1).

The largest component of incidental catch of other targeted groundfish species in the GOA Pacific cod fisheries by weight are skate species in combination followed by walleye pollock, arrowtooth flounder, sablefish, and octopus (Table 2.5). Shallow-water flatfish, sharks (predominantly spiny dogfish), and demersal shelf rockfish also make up a major component of the bycatch in these fisheries. The largest component of prohibited species catch is Bairdi tanner crab, followed by halibut and Golden king crab (Table 2.6). Incidental catch of non-target species in the GOA Pacific cod fishery are listed in Table 2.7.

# Data

This section describes updates to the data used in the current assessment. The following table and Figure 2.10 presents the data included in this assessment (the years shown in bold font are those that are new to this assessment).

|  |  |  |  |
| --- | --- | --- | --- |
| **Data** | **Source** | **Type** | **Years** |
| Federal and state fishery catch, by gear type (trawl, pot, and longline) | AKFIN | Metric tons | 1977 – **2025** |
| Federal and state fishery catch-at-length, by gear type | AKFIN, ADF&G | Frequency observed at length (in cm) | 1977 – **2025** |
| GOA NMFS bottom trawl survey abundance | AKFIN | Total numbers | 1990 – **2025** |
| AFSC Sablefish Longline survey Pacific cod Relative Population Numbers | AKFIN | RPN | 1990 – **2025** |
| GOA NMFS bottom trawl survey length composition | AKFIN | Number at length (in cm) | 1990 – **2025** |
| GOA NMFS bottom trawl survey conditional age-at-length | AKFIN | Proportion age at length | 1990 – 2023 |
| AFSC Sablefish Longline survey Pacific Cod length composition | AKFIN | RPN at length (in cm) | 1990 – **2025** |
| Federal fishery conditional age-at-length | AKFIN | proportion age at length | 2007 – **2024** |
| CFSR bottom temperature indices | National Center for Atmospheric Research | temperature anomaly at mean depth for P. cod size bins | 1979 – 2024 |

## Fishery:

### Catch Biomass

Catches for the period 1991-2025 are shown for the three main gear types in Table 2.1, with the catches for 2025 presented through October 17, 2024. The current year’s catch within the assessment model is assumed to reach the full Total Allowable Catch (TAC) and state Guideline Harvest Level (GHL). Three fishery fleets were modeled (by gear categories); trawl (all trawl types), longline (longline and jig) and pot.

### Length Composition

Fishery length compositions are presently available by gear for at least one gear type in every year from 1977 through December of 2025. The length composition observed in 2025 for each gear type are consistent with recent observed length compositions.

### Age composition

Age data collected since 2007 from the commercial fishery were used to develop an annual conditional length-at-age matrix for each fishery. The condition age-at-length observed in 2024 do not indicate any notable departures from those observed in recent years.

## Surveys:

### AFSC bottom trawl survey

The 2025 survey was conducted with two chartered vessels that accomplished 526 stations following the protocols of Stauffer (2004) and von Szalay and Raring (2018). In 2025 the survey followed a restratified… pull in appendix results here…

The spatial distribution of Pacific cod in the trawl survey is highly variable (Fig. 2.11)… compare 2021-2025

#### Biomass and abundance estimates

Since the time-series low in 2017, the Pacific cod biomass and abundance estimates from the bottom trawl survey have been indicating an increasing trend in the population (Table 2.10). Compared to the 2023 survey, the 2025 trawl survey biomass estimate increased by 39.2% and the abundance estimate increased by 49.6%. Both of these values were associated with a coefficient of variation (CV) of 23%, which is larger than recent CVs, however, are within the range of CVs for the trawl survey time-series.

#### Length Composition

The bottom trawl survey 2025 length composition was observed to be bi-modal, with a mode at 15-20 cm (representing catches of age-1 cod) and a mode at 35-70 cm (representing catches of adult cod).

#### Age Composition

Otoliths for bottom trawl survey age composition are collected in each survey and are used as conditional age-at-length data within the GOA Pacific cod assessment. This data was not updated in the current assessment as compared to the 2024 assessment.

### AFSC longline survey

The AFSC longline survey samples the continental slope and major gullies in the GOA, providing data to calculate relative abundance in this area (Rutecki et al. 2016, Siwicke and Malecha 2024). The survey is primarily directed at sablefish, but also catches considerable numbers of Pacific cod. The survey was conducted in 2025 after missing a year in 2024.

Pacific cod catch in the longline survey primarily occur in the western and central GOA (Fig. 2.12), with inconsistent peaks in catch. The location of 2023 survey catches were similar to the 2022 survey, with consistent increases in catch in the western GOA in 2023 compared to 2022.

#### Factors affecting availability to the longline survey

Yang *et al.* 2019 showed that GOA Pacific cod exhibit a depth relationship with temperature, in which Pacific cod move to deeper depths in warmer years and shallower depths in colder years. We display this relationship for different size classes using area-weighted observed bottom temperatures and CPUE weighted depth of Pacific cod in the AFSC bottom trawl survey (Figure 2.13). The general trend for each size class is a shallower depth distribution during colder than average years, and a deeper depth distribution in warmer than average years. Within Figure 2.13 we include the depth strata of the AFSC longline survey (solid horizontal lines) with text that indicate the proportion of hachis (i.e., longline skates) that are deployed by the longline survey in these depth strata to display the overlap of GOA Pacific cod depth distribution with the longline survey. We note that availability to the longline survey in colder than average years may be less than in warmer than average years. We also note the limited depth range of fish larger than 81 cm as compared to fish smaller than 81 cm. While the depth distribution of larger fish displays the same relationship with temperature as smaller fish, larger fish are not present in as deep of depths as the smaller fish, even in warmer than average years.

#### Abundance index

The AFSC longline survey has been observing a generally increasing trend in the Relative Population Number (RPN) index of Pacific cod abundance since the time-series low in 2019 (Table 2.#). In 2025, compared to the most recent longline survey in 2023, the RPN index decreased by 5%. This decrease in the GOA-wide RPN was the result of a reduction in the RPN value in the Eastern GOA subregion, whereas both the Western and Central GOA subregions indicated an increase in the RPN index in 2025 compared to 2023. The GOA-wide mean CPUE from the longline survey increased by 7% in 2025 compared to 2023.

#### Length composition

The observed 2025 longline survey was unimodal and consistent with previous survey length compositions.

### Other auxiliary indices updated but not fit in model

#### Laurel and Litzow age-0 index

Beach seine sampling of age-0 cod was conducted in 2025. The beach seine age-0 CPUE index resulted in estimated values in 2025 that were consistent with 2024 and 2023, all which are below the time-series average (Figure 2.#).

#### Alaska Department of Fish and Game bottom trawl survey

The Alaska Department of Fish and Game (ADFG) bottom trawl survey index has resulted in an increasing trend in the Pacific cod population since the time-series low in 2016. In 2025 the ADFG bottom trawl survey of cod biomass decreased by 15% and the index of cod abundance decreased by 9% compared to 2024.

#### Commercial fishery indices

Non-targeted catch of Pacific cod in other directed fisheries is examined as an indicator of population trends. We examine two disparate fisheries to evaluate trends in incidental catch of Pacific cod: the pelagic walleye pollock fishery and the bottom trawl shallow water flatfish fishery. The occurrence of Pacific cod in the pelagic pollock fishery appears to be an index of abundance that is particularly sensitive to 2 year old Pacific cod, which are thought to be more pelagic. As an index of recruitment abundance, we track the incidence of occurrence as proportion of hauls with cod in the central GOA pollock A season. The shallow water flatfish fishery tracks a larger portion of the adult population of Pacific cod. As an index of the adult population abundance we track the catch rates in tons of Pacific cod per ton of all species caught in the shallow water flatfish fishery. For the walleye pollock fishery in the central GOA, abundance of small cod in pelagic trawls has exhibited an alternating trend in the most recent 5 years, with larger catches in 2022 and 2024 and smaller catches in 2021, 2023, and 2025 (Fig. 2.9). The catch of Pacific cod in the shallow water flatfish fisheries has seen an increasing trend since the time series low in 2017.The 2024 and 2025 values are the largest in the recent time series and only smaller than the 2014 value since 2008 (Fig. 2.9). It should be noted that none of these indices are controlled for gear, vessel, effort, or fishing practice changes.

## Environmental indices

The Climate Forecast System Reanalysis (CFSR) temperature index was not updated for 2025 because it has been discontinued. An alternative environmental index will be used in the next full assessment.

# Analytic Approach

We use Model 24.0 in this assessment (described in Hulson *et al.* 2024). The model for this year was run in SS3 version 3.30.22.1 (Methot and Wetzell 2013). The SS3 control and forecast files for this year’s model can be found at the link provided in the *Executive Summary* section of this document.

# Results

## Model Evaluation

Model evaluation criteria included changes to the negative-log likelihood, model adherence to biological principles and assumptions, the relative sizes of the negative-log likelihood components, how well the model fits to the survey indices, the survey and fishery length composition, and conditional age-at-length data, reasonable curves for fishery and survey selectivity, retrospective pattern, and model behavior during sensitivity analyses.

For Model 24.0 the likelihoods appear well defined with the gradient of the objective function at less than 1e-5 (the final gradient was 6.45e-6). Convergence of Model 24.0 was further examined by “jittering” starting parameters by a factor of 5% over 50 runs to evaluate if models had converged to local minima. Jitter analysis revealed that Model 24.0 was insensitive to perturbations of parameter start values on the order of 5% with a total of 46 of the 50 jitter runs converged and 74% of the converged models resulting in estimates at the lowest MLE from the accepted models.

Overall, Model 24.0 results in reasonable fits to the data, estimates biologically plausible parameters with reasonable amounts of uncertainty (Table 2.14), and produces consistent patterns in abundance compared to previous assessments (Figure 2.Retro). Model 24.0 fits the AFSC bottom trawl and longline survey indices reasonably well (Fig. 2.25), although, positive residuals have persisted in the fit to the longline survey since 2018. Fits to the length composition data for the years in which the data are available are shown in Appendix 2.3 (Figures 2.3.1 to 2.3.9). The aggregated fit from Model 24.0 to the fishery length composition data and one-step-ahead residuals do not indicate any serious model misspecification, although, there are a few outlier residuals that result in the fit to each fleet (Fig. 2.26). Model 24.0 fits well to the survey length composition data in aggregate, while there are some outliers present in the one-step ahead residuals (Fig. 2.27). The Pearson residuals that resulted from Model 24.0 across the length composition data fit do not indicate alarming patterns across time or length (Fig. 2.28). Model 24.0 fits to the available conditional age-at-length are shown for the years in which data are available in Appendix 2.3 (Figures 2.3.10 to 2.3.27). While there are many processes that conditional age-at-length inform within an assessment model, a primary process that is informed is the estimation of growth. In general, Model 24.0 fits AFSC bottom trawl survey length and weight observations well (Fig. 2.29). The estimated current year selectivity (Fig 2.19) and time-dependent selectivity (Fig. 2.30) estimated by Model 24.0 are consistent with previous assessment results.

Overall, Model 24.0 yields reasonable results and we continue to use it to recommend the 2025 ABC and OFL.

## Time Series Results

### Definitions

The biomass estimates presented here will be defined in two ways: 1) total biomass was defined as age 0+ biomass, consisting of the biomass of all fish aged 0 years or greater in a given year; and 2) spawning biomass was defined as the biomass of all spawning females in a given year. The recruitment estimates presented here are defined as numbers of age-0 fish in a given year; actual recruitment to fishery and survey depends on selectivity curves as estimated (noting that there are no indices involving age-0 Pacific cod). All results presented are from Model 24.0, additional results (including standard SS3 plots and estimated numbers at age and length) can be found at the link provided in the *Executive Summary* section of this document

### Biomass

Total biomass estimates show a long decline from their peak in 1988 (Table 2.15 and Fig. 2.31) to a low in 2006 and then an increase to another peak in 2014, after which there was a sharp decline through 2018 followed by a slight increase through 2024 and is forecasted to increase through 2029. Spawning biomass (Table 2.15 and Fig. 2.31) shows a similar trend of decline since the late 1980s with a peak in 1989 to a low in 2008. There was then a short increase in spawning biomass coincident with the maturation of the 2005-2008 year classes through 2014, after which the decline continued to lowest level in 2019 and 2020. The spawning biomass then slightly increased in 2021 and 2022 and is projected to slightly decrease through 2026 and then increase through 2029.

### Recruitment and Numbers-at-Age

The recruitment predictions in Model 24.0 (Table 2.16 and Fig. 2.32) show above average recruitment for most of the 1980s, below average recruitment from the mid-1990s to mid-2000s, above average recruitment from the mid-2000s to 2013, and below average recruitment since. Numbers-at-age, with the mean age, are shown in Figure 2.33. Overall, the model estimates a decrease in the mean age since 2019.

### Fishing Mortality

Fishing mortality appears to have increased steadily with the decline in abundance from 1990 through a peak in 2008 with continued high fishing mortality through 2017 (Table 2.17 and Fig. 2.34). 2017 had the highest total exploitation rate of the time series. The period between 1990 and 2008 saw both a decline in recruitment paired with increases in catch. The period of increasing fishing mortality was mainly attributed to the rise in the pot fishery, which also shows the largest increase in continuous F (Fig. 2.34). In 2018 through 2020 there was a sharp decrease in fishing mortality coincident with the drastic cuts in ABC and closure of the federal directed fishery in 2020. In 2021 with the reopening of the federal fishery mortality once again increased, but remained lower than observed in the previous decade prior to 2017. In retrospect the phase plane plots (Fig. 2.35) show that F was estimated to have been above the ABC control rule advised levels from 2015 to 2017 and biomass has been below *B35%*since 2017, and projected to continue to be below through 2026. It should be noted that this plot shows what the current model predicts, not what the past assessments had estimated.

### Uncertainty Results

MCMC were conducted with the R package *adnuts* (Monnahan and Kristensen 2018, Monnahan *et al.* 2020). 2,500,000 MCMC iterations were thinned to every 2000th iteration and the first half of the iterations were removed to account for the burn-in period. The MCMC chains for these parameters appear well mixed, with a minimum ESS of 311 and maximum Rhat of 1.03 for these key parameters (Fig. 2.36) and the MCMC histograms are well defined and bracket the MLE estimates (Fig. 2.37).

## Harvest Recommendations

### Amendment 56 Reference Points

Amendment 56 to the GOA Groundfish Fishery Management Plan (FMP) defines the “overfishing level” (OFL), the fishing mortality rate used to set OFL (*FOFL*), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (*FABC*) may be less than this maximum permissible level, but not greater. Because reliable estimates of reference points related to maximum sustainable yield (MSY) are currently not available but reliable estimates of reference points related to spawning per recruit are available, Pacific cod in the GOA have generally been managed under Tier 3 of Amendment 56. Tier 3 uses the following reference points: *B40%*, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; *F35%*, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing; and *F40%*, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing. The following formulae apply under Tier 3:

*3a) Stock status:* *B/B40%* > 1

*FOFL* = *F35%*

*FABC* < *F40%*

*3b) Stock status:* 0.05 < *B/B40%* < 1

*FOFL* = *F35%* × (*B/B40%* - 0.05) × 1/0.95

*FABC* < *F40%* × (*B/B40%* - 0.05) × 1/0.95

*3c) Stock status:* *B/B40%* < 0.05

*FOFL* = 0

*FABC* = 0

Other useful biomass reference points which can be calculated using this assumption are *B100%* and *B35%*, defined analogously to *B40%*. These reference points are estimated as follows, based on this year’s model, Model 24.0:

|  |  |  |  |
| --- | --- | --- | --- |
| Reference point: | *B35%* | *B40%* | *B100%* |
| Spawning biomass: | 57,255 t | 65,434 t | 163,585 t |

For a stock exploited by multiple gear types, estimation of *F35%* and *F40%* requires an assumption regarding the apportionment of fishing mortality among those gear types. For this assessment, the apportionment was based on this year’s model’s estimates of fishing mortality by gear for the five most recent complete years of data.

### Specification of OFL and Maximum Permissible ABC

For Model 24.0 spawning biomass for 2025 is estimated by this year’s model to be 49,605 t at spawning. This is below the *B40%* value of 65,218 t, thereby placing Pacific cod in sub-tier “b” of Tier 3. Given this, the model estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2025 and 2026 as follows (2026 values are predicated on the assumption of the full TAC and GHL being taken in 2024 and that the 2025 catch will be at maximum ABC in the projection):

|  |  |  |  |
| --- | --- | --- | --- |
| Units | Year | Overfishing  Level (OFL) | Maximum  Permissible ABC |
| Harvest amount | 2025 | 38,688 | 32,141 |
| Harvest amount | 2026 | 33,099 | 30,193 |
| Fishing mortality rate | 2025 | 0.57 | 0.46 |
| Fishing mortality rate | 2026 | 0.51 | 0.43 |

The age 0+ biomass projections for 2025 and 2026 from this year’s model are 180,671 t and 199,305 t, respectively.

### Risk Table and ABC Recommendation

#### Assessment-related considerations.

The GOA Pacific cod assessment does not show a strong retrospective pattern in recent estimates of spawning biomass, either in the data retrospective or in the model retrospective across recent assessments (Fig. 2.20). The retrospective pattern in spawning biomass in the current assessment is negative, which means that as years of data were added to the model the estimates of spawning biomass increase. All in all, Model 24.0 is responding appropriately to observed data sources. An additional assessment concern, as it relates to projecting biomass and management quantities, is that the projection model uses mean recruitment from 1977 – 2022 to project biomass into future years. However, Model 24.0 continues to estimate below average recruitment since 2014. Therefore, given these recent low recruitment estimates it is likely that the forecasted spawning biomass is overly optimistic. However, the effect on the two-year projections to result in ABC and OFL recommendations is not largely impacted by this recruitment assumption, as the year classes that are assumed to be at mean recruitment aren’t contributing much to the overall level of spawning biomass in the short term. For the reasons that Model 24.0 is fitting the available data reasonably well, does not have a concerning retrospective pattern, and the mean recruitment assumption in the projections does not have a large impact on short term ABC and OFL recommendations, we rate the assessment considerations category at level 1, with typical to moderately increased uncertainty.

#### Population dynamics considerations

Female spawning biomass is estimated to decrease over the next 2 years, then increase in the medium-term once the projected year classes (i.e., based on mean recruitment since 1977) begin contributing to the SSB (Fig. 2.31). To reiterate, mean recruitment levels have not been estimated in the model since 2014 so the increase in the medium term is likely overly optimistic. Auxiliary information on recruitment from non-target fishery sources and the beach seine survey of age-0 fish surveys suggest a very weak 2019 year class, a strong 2020 year class, and above average 2017, 2018, and 2022 year classes. How these indices relate to overall recruitment into the fishery and population is currently unknown, as they have yet to materialize in the estimates of recent recruitment in the assessment. However, in the observations of length composition (and age composition) from the AFSC bottom trawl survey these stronger year classes are present, but not estimated well by the model. While the 2023 observations of population scale from both the fitted data sources (bottom trawl survey and longline survey) and the monitored data sources (ADFG trawl survey) indicate an increase in abundance compared to 2022, this increase has yet to translate to a recovery of the cod stock in the GOA to historical levels. Because of the persistent low levels of observed and estimated abundance we continue to rate the population dynamics considerations category at level 2, increased concern.

#### Ecosystem considerations

The most recent data available suggest an ecosystem risk level 1 – no apparent ecosystem concerns. The 2023/2024 El Niño event had moderate impacts in the GOA, bringing warmer waters to the surface in winter and at depth in the winter and spring, but not exceeding known thermal thresholds for cod or elevating adult metabolic demands. Spawning conditions were average to slightly below average based on heatwave and habitat suitability with average cross-shelf transport to nursery habitat. Prey availability for larval/juvenile cod (zooplankton) was average to above average (increased euphausiids), while prey availability for adult cod was mixed but less well-monitored (e.g., declining Tanner crab biomass). Adult ration current year projection remains below average. There is no expected change in cod predation (moderate), but biomass consumed projections were higher than in 2023. Competition for zooplankton may be reduced due to low returns of pink salmon. Upcoming 2025 winter and spring surface temperatures are predicted to be cooler than average, in alignment with weak La Niña conditions, allowing more dissipation of heat at depth. An extended written description of these Ecosystem Considerations can be found in Appendix 4 of the Gulf of Alaska Ecosystem Status Report (Ferriss 2024). Appendix 2.1 provides a detailed look at environmental/ecosystem considerations specific to this stock within the ecosystem and socioeconomic profile. Broad-scale information on environmental and ecosystem considerations are provided by the Gulf of Alaska Ecosystem Status Report.

#### Fishery-informed stock considerations

Where data were available catch-per-unit effort measures in the GOA fisheries showed mixed signals. It should be noted that catch levels and fishery participation have been low over the past 4 years in comparison with previous years. Bycatch in other fisheries still remain low compared to fisheries prior to the 2014-2016 marine heatwave, with the exception of the shallow water flatfish fishery, within which Pacific cod catch has increased. We consider the concern level to be 1 – no apparent concerns.

#### Summary and ABC recommendation

These results are summarized in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| *Assessment-related considerations* | *Population dynamics considerations* | *Ecosystem considerations* | *Fishery Performance considerations related to health of the stock* |
| Level 1: Normal | Level 2: Increased concerns | Level 1: Normal | Level 1: Normal |

From 2008-2017 the GOA Plan Team and SSC recommended setting the ABC at the maximum permissible level under Tier 3. For 2018 through 2019 an ABC was recommended below the maximum ABC in an attempt to ensure the 2019 and 2020 SSB would remain above *B20%*. For 2020 although the ABC was set at the maximum the stock was below *B20%* and because of the rules in place to protect forage for Steller sea lions the directed federal fishery was be required to remain closed. However, for added precaution both the federal TAC and state GHL were reduced. Biological reference points from GOA Pacific cod SAFE documents for years 2002 – 2025 are provided in Table 2.18. While the largest score of the risk table is level 2, we do not recommend that ABC be set below the maximum permissible.

For 2025 the spawning stock biomass is projected to be above *B20%*, and despite a drop in spawning biomass in 2026 is projected to remain above *B20%* in 2026.

### Area Allocation of Harvests

Using the *rema* R package with the AFSC bottom trawl survey biomass through 2023 (Fig. 2.38), the area-apportioned ABCs for the two-year projections of Model 24.0 would be:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Western | Central | Eastern | Total |
| Area apportionment | 27.10% | 63.80% | 9.10% | 100% |
| 2025 ABC | 8,710 | 20,506 | 2,925 | 32,141 |
| 2026 ABC | 8,182 | 19,263 | 2,748 | 30,193 |

### 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). Year-end catch for 2024 was set equal to the 2024 ABC. 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.

Selectivity used in the projections was the mean selectivity since 2000, recruitment was based on average recruitment from 1977-2022 and growth and mortality were as estimated in 2024.

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 follow (“*max* *FABC*” refers to the maximum permissible value of *FABC* under Amendment 56):

*Scenario 1*: In all future years, *F* is set equal to *max* *FABC*. (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 the author’s recommend level, max ABC.

*Scenario 3*: In all future years, *F* is set equal to the 2020‑2024 average *F*. (Rationale: For some stocks, TAC can be well below ABC, and recent average *F* may provide a better indicator of *FTAC* than *FABC*.)

*Scenario 4*: In all future years, *F* is set equal to the *F75%*. (Rationale: This scenario was developed by the NMFS Regional Office based on public feedback on alternatives.

*Scenario 5*: In all future years, *F* is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA’s requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as *B35%*):

*Scenario 6*: In all future years, *F* is set equal to *FOFL*. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above half of its *BMSY* level in 2024 and above its *BMSY* level in 2034 under this scenario, then the stock is not overfished.)

*Scenario 7:* In 2025 and 2026, *F* is set equal to max *FABC*, and in all subsequent years*, F* is set equal to *FOFL*. (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.)

Scenarios 1 through 7 were projected 15 years from 2024 in Model 24.0 (Table 2.19). Scenarios 3, 4, and 5 (no fishing) project the stock to be below *B35%* until 2027, scenarios 1, 2, 6, and 7 have the stock below *B35%* until 2028. Fishing at the maximum permissible rate indicate that the spawning stock will be below *B35%* in 2025 through 2027 due to poor recruitment and high mortality in 2015-2017. Under an assumption of environmental conditions at the 1977-2022 mean, the stock recovers above *B35%* by 2027.

Our projection model run under these conditions indicates that for Scenario 6, the GOA Pacific cod stock although below *B35%* in 2024 at 52,034 t will be above its MSY value in 2034 at 74,698 t and therefore would not be classified as overfished.

Projections 7 with fishing at the OFL after 2025 results in an expected spawning biomass of 74,739 t by 2036 and would therefore not be approaching an overfished condition.

Under Scenarios 6 and 7 for Model 24.0 the GOA Pacific cod stock would not currently be considered overfished, nor would it be approaching an overfished status. The 2023 OFL given Model 24.0 would have produced a sum of apical F of 0.36 in 2023.

# Literature Cited

A’mar, T., and W. Pallson. 2015. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 173-296. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

Anderson, P. J., and J. F. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series 189: 117-123

Atkinson, D. (1994). Temperature and organism size-a biological law for ectotherms? Advances in Ecological Research, 25, 1–58.

Barbeaux. S. J., T. A’mar, and W. Palsson. 2016. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, P. 175-324. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Barbeaux. S. J., K. Aydin, B. Fissel, K. Holsman, W. Palsson, K. Shotwell, Q. Yang, and S. Zador. 2018. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Barbeaux. S. J., K. Aydin, B. Fissel, K. Holsman, W. Palsson, K. Shotwell, and S. Zador. 2019. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

Barbeaux. S. J., B. Ferriss, B. Laurel, M. Litzow, S. McDermott, J. Nielsen, W. Palsson, I. Spies, and M. Wang. 2021. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Baty, F., C. Ritz, S. Charles, M. Brutsche, J. Flandrois, and M. Delignette-Muller. 2015. A Toolbox for Nonlinear Regression in R: The Package nlstools. Journal of Statistical Software, 66(5), 1-21. URL <http://www.jstatsoft.org/v66/i05/>

Betts, M., H. D. G. Maschner, and D. S. Clark. 2011. Zooarchaeology of the ‘Fish That Stops’, in Madonna L. Moss and Aubrey Cannon, eds., *The Archaeology of North Pacific Fisheries*, University of Alaska Press, Fairbanks, Alaska, 188.

Bürkner, P.-C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. Journal of Statistical Software, 80(1), 1–28.

Burnham, K. P., and D. R. Anderson. 2002. Model Selection and Mulimodel Inference. New York: Springer.

Cahalan, J., J. Gasper, and J. Mondragon. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-286, 46 p.

Carpenter, B., A. Gelman, M. D. Hoffman, D. Lee, B. Goodrich, M. Betancourt, M. Brubaker, J. Guo, P. Li, and A. Riddell. 2017. Stan: A Probabilistic Programming Language. Journal of Statistical Software, 76(1), 1–32.

Echave, K. B., D. H. Hanselman, M. D. Adkison, and M. F. Sigler. 2012. Inter-decadal changes in sablefish, *Anoplopoma fimbria*, growth in the northeast Pacific Ocean. Fish. Bull. 210: 361-374

Faunce, C., J. Sullivan, S. Barbeaux, J. Cahalan, J. Gasper, S. Lowe, and R. Webster. 2017. Deployment performance review of the 2016 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-358, 75 p.

Ferriss, B.E. 2024. Ecosystem Status Report 2024: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska 99501.

Hulson, P.-J. F., S. J. Barbeaux, B. Ferriss, S. McDermott, and I. Spies. 2022. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Kastelle, C. R., T. E. Helser, J. L. McKay, C. G. Johnston, D. M. Anderl, M. E. Matta, and D. G. Nichol. 2017. Age validation of Pacific cod (*Gadus macrocephalus*) using high-resolution stable oxygen isotope (δ 18O) chronologies in otoliths. Fisheries research, 185, pp.43-53.

Laurel, B. J., A. A. Abookire, S. J. Barbeaux, L. Z. Almeida, L. A. Copeman, J. Duffy-Anderson, T. P. Hurst, M. A. Litzow, T. Kristiansen, J. A. Miller, W. Palsson, S. Rooney, H. L. Thalmann and L. A. Rogers. 2023. Pacific cod in the Anthropocene: An early life history perspective under changing thermal habitats. Fish and Fisheries, 24, 959–978.

Methot, R. D., and C. R. Wetzell. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish. Rsch. 142:86-99.

Methot, R. D., and I. G. Taylor. 2011. Adjusting for bias due to variability of estimated recruitments in fishery assessment models. Can. J. Fish. Aquat. Res. 68(10):1744-1760.

Monnahan C. C., and K. Kristensen. 2018. No-U-turn sampling for fast Bayesian inference in ADMB and TMB: Introducing the adnuts and tmbstan R packages. PLoS ONE 13(5):e0197954.

Monnahan, C.C., T.A. Branch, J.T. Thorson, I.J. Stewart, and C.S. Szuwalksi. 2020. Overcoming long Bayesian run times in integrated fisheries stock assessments. ICES Journal of Marine Science.

Nichols, N. W., P. Converse, and K. Phillips. 2015. Annual management report for groundfish fisheries in the Kodiak, Chignik, and South Alaska Peninsula Management Areas, 2014. Alaska Department of Fish and Game, Fishery Management Report No. 15-41, Anchorage.

Punt, A.E., Smith, D.C., KrusicGolub, K., Robertson, S., 2008. Quantifying age-reading error for use in fisheries stock assessments, with application to species in Australia’s southern and eastern scalefish and shark fishery. Can. J. Fish. Aquat. Sci. 65 (9), 1991–2005.

R Core Team. 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rose, G.A. and D. W. Kulka. 1999. Hyperaggregation of fish and fisheries: how catch-per-unit-effort increased as the northern cod (*Gadus morhua*) declined. Canadian Journal of Fisheries and Aquatic Sciences, 56(S1), pp.118-127.

Rutecki, T. L., C. J. Rodgveller, and C. R. Lunsford. 2016. National Marine Fisheries Service longline survey data report and survey history, 1990–2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-324, 329 p.

Saha, S., J. M. Solé, R. Arasa, M. Picanyol, [M. Á. González](https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/journal/articles.aspx?searchCode=M%c2%aa+%c3%81ngeles+Gonz%c3%a1lez&searchField=authors&page=1), [A. Domingo-Dalmau](https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/journal/articles.aspx?searchCode=Anna+Domingo-Dalmau&searchField=authors&page=1), [M. Masdeu](https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/journal/articles.aspx?searchCode=Marta+Masdeu&searchField=authors&page=1), [I. Porras](https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/journal/articles.aspx?searchCode=Ignasi+Porras&searchField=authors&page=1), and [B. Codina](https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/journal/articles.aspx?searchCode=Bernat+Codina&searchField=authors&page=1). 2010. The NCEP Climate Forecast System Reanalysis. Bulletin of American Meteorological Society, 91, 1015-1057.

Shimada, A. M., and D. K. Kimura. 1994. Seasonal movements of Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea and adjacent waters based on tag-recapture data. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 92:800-816.

Siwicke, K., and P. Malecha. 2024. The 2023 longline survey of the Gulf of Alaska and eastern Bering Sea on the FV Alaskan Leader: Cruise Report AL-23-01. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-480, 39 p.

Spalinger, K.. 2006. Bottom trawl survey of crab and groundfish: Kodiak, Chignik, South Peninsula, and eastern Aleutian management districts, 2005. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services.

Stark, J. W.. 2007. Geographic and seasonal variations in maturation and growth of female Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska and Bering Sea. Fish. Bull. 105:396–407.

Stauffer, G.. 2004. NOAA protocols for groundfish bottom trawl surveys of the Nation’s fishery resources. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-65, 205 p.

Sullivan, J., C. Monnahan, P. Hulson, J. Ianelli, J. Thorson, and A. Havron. 2022. REMA: a consensus version of the random effects model for ABC apportionment and Tier 4/5 assessments. Plan Team Report, Joint Groundfish Plan Teams, North Pacific Fishery Management Council. 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Thompson, G. G., Z. T. A’mar, and W. A. Palsson. 2011. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Torrejon-Magallanes, J.. 2020. sizeMat: Estimate Size at Sexual Maturity. R package version 1.1.2.

von Szalay, P. G., and N. W. Raring. 2018. Data report: 2017 Gulf of Alaska bottom trawl survey. NOAA Tech. Mem NMFS-AFSC-374. 260 p.

Walters, C.. 2003. Folly and fantasy in the analysis of spatial catch rate data. Canadian Journal of Fisheries and Aquatic Sciences, 60(12), pp.1433-1436.

West, C. F., M. A. Etnier, S. Barbeaux, M. A. Partlow, and A. M. Orlov. 2020. Size distribution of Pacific cod (*Gadus macrocephalus*) in the North Pacific Ocean over 6 millennia. Quaternary Research, pp.1-21.

Yang, Q., E. D. Cokelet, P. J. Stabeno, L. Li, A. B. Hollowed, W. A. Palsson, N. A. Bond, and S. J. Barbeaux. 2019. How “The Blob” affected groundfish distributions in the Gulf of Alaska. Fisheries Oceanography, 28(4), pp.434-453.

# Tables

##### Table 2.1. Catch (t) for 1991 through 2024 by jurisdiction and gear type (as of 2024-10-17)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Federal | | | | | State | | | |  |
| Year | Trawl | Long-line | Pot | Other | Subtot | Long-line | Pot | Other | Subtot | Total |
| 1991 | 58,092 | 7,630 | 10,464 | 115 | 76,301 | - | - | - | - | 76,301 |
| 1992 | 54,593 | 15,675 | 10,154 | 325 | 80,747 | - | - | - | - | 80,747 |
| 1993 | 37,806 | 8,963 | 9,708 | 11 | 56,488 | - | - | - | - | 56,488 |
| 1994 | 31,447 | 6,778 | 9,161 | 100 | 47,486 | - | - | - | - | 47,486 |
| 1995 | 41,875 | 10,978 | 16,055 | 77 | 68,985 | - | - | - | - | 68,985 |
| 1996 | 45,990 | 10,196 | 12,040 | 53 | 68,279 | - | - | - | - | 68,279 |
| 1997 | 48,406 | 10,978 | 9,065 | 26 | 68,475 | - | 7,368 | 1,327 | 8,695 | 77,170 |
| 1998 | 41,570 | 10,012 | 10,510 | 29 | 62,121 | - | 9,183 | 1,320 | 10,503 | 72,624 |
| 1999 | 37,167 | 12,363 | 19,015 | 70 | 68,615 | - | 12,410 | 1,518 | 13,928 | 82,543 |
| 2000 | 25,443 | 11,660 | 17,351 | 54 | 54,508 | - | 10,399 | 1,644 | 12,043 | 66,551 |
| 2001 | 24,383 | 9,910 | 7,171 | 155 | 41,619 | - | 7,829 | 2,083 | 9,912 | 51,531 |
| 2002 | 19,810 | 14,666 | 7,694 | 176 | 42,346 | - | 10,578 | 1,714 | 12,292 | 54,638 |
| 2003 | 18,884 | 9,525 | 12,765 | 161 | 41,335 | 62 | 7,943 | 3,242 | 11,247 | 52,582 |
| 2004 | 17,513 | 10,326 | 14,966 | 400 | 43,205 | 51 | 10,602 | 2,765 | 13,418 | 56,623 |
| 2005 | 14,549 | 5,732 | 14,749 | 203 | 35,233 | 26 | 9,653 | 2,673 | 12,352 | 47,585 |
| 2006 | 13,132 | 10,244 | 14,540 | 118 | 38,034 | 55 | 9,146 | 662 | 9,863 | 47,897 |
| 2007 | 14,775 | 11,539 | 13,573 | 44 | 39,931 | 270 | 11,378 | 682 | 12,330 | 52,261 |
| 2008 | 20,293 | 12,106 | 11,229 | 63 | 43,691 | 317 | 13,438 | 1,568 | 15,323 | 59,014 |
| 2009 | 13,976 | 13,968 | 11,951 | 206 | 40,101 | 676 | 9,919 | 2,500 | 13,095 | 53,196 |
| 2010 | 22,035 | 16,538 | 20,116 | 429 | 59,118 | 826 | 14,604 | 4,045 | 19,475 | 78,593 |
| 2011 | 16,456 | 16,622 | 29,233 | 722 | 63,033 | 1,033 | 16,675 | 4,627 | 22,335 | 85,368 |
| 2012 | 20,084 | 14,467 | 21,238 | 722 | 56,511 | 866 | 15,940 | 4,613 | 21,419 | 77,930 |
| 2013 | 21,706 | 12,836 | 17,011 | 476 | 52,029 | 1,088 | 14,156 | 1,303 | 16,547 | 68,576 |
| 2014 | 26,917 | 14,735 | 19,957 | 1,046 | 62,655 | 1,007 | 18,445 | 2,838 | 22,290 | 84,945 |
| 2015 | 22,268 | 13,047 | 20,653 | 408 | 56,376 | 577 | 19,719 | 2,808 | 23,104 | 79,480 |
| 2016 | 15,217 | 8,123 | 19,248 | 346 | 42,934 | 803 | 18,609 | 1,708 | 21,120 | 64,054 |
| 2017 | 13,041 | 8,965 | 13,426 | 67 | 35,499 | 155 | 13,011 | 62 | 13,228 | 48,727 |
| 2018 | 3,818 | 3,033 | 4,013 | 121 | 10,985 | 310 | 3,660 | 195 | 4,165 | 15,150 |
| 2019 | 4,535 | 2,763 | 3,732 | 178 | 11,208 | 358 | 3,820 | 329 | 4,507 | 15,715 |
| 2020 | 3,427 | 586 | 30 | - | 4,043 | 529 | 1,779 | 491 | 2,799 | 6,842 |
| 2021 | 5,986 | 3,834 | 3,427 | 52 | 13,299 | 558 | 4,230 | 1,085 | 5,873 | 19,172 |
| 2022 | 8,207 | 5,775 | 4,912 | 3 | 18,897 | 372 | 5,658 | 994 | 7,024 | 25,921 |
| 2023 | 6,473 | 5,177 | 4,069 | 378 | 16,097 | 563 | 3,653 | 1,412 | 5,628 | 21,725 |
| 2024 | 6,399 | 4,754 | 5,388 | 319 | 16,860 | 528 | 4,293 | 1,490 | 6,311 | 23,171 |

##### Table 2.2. History of Pacific cod catch (t, includes catch from State waters), Federal TAC (does not include State guideline harvest level, GHL), ABC, OFL and State of Alaska GHL (1997-Present) since 1991. Catch for 2024 is current through 2024-10-17 and includes catch from State of Alaska fisheries. See Hulson et al. 2022 (Table 2.2) for catch history prior to 1991.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Catch | TAC | ABC | OFL | GHL |
| 1991 | 76,301 | 77,900 | 77,900 | - | - |
| 1992 | 80,747 | 63,500 | 63,500 | 87,600 | - |
| 1993 | 56,488 | 56,700 | 56,700 | 78,100 | - |
| 1994 | 47,486 | 50,400 | 50,400 | 71,100 | - |
| 1995 | 68,985 | 69,200 | 69,200 | 126,000 | - |
| 1996 | 68,279 | 65,000 | 65,000 | 88,000 | - |
| 1997 | 77,170 | 69,115 | 81,500 | 180,000 | 12,385 |
| 1998 | 72,624 | 66,060 | 77,900 | 141,000 | 11,840 |
| 1999 | 82,543 | 67,835 | 84,400 | 134,000 | 16,565 |
| 2000 | 66,551 | 59,800 | 76,400 | 102,000 | 17,685 |
| 2001 | 51,531 | 52,110 | 67,800 | 91,200 | 15,690 |
| 2002 | 54,638 | 44,230 | 57,600 | 77,100 | 13,370 |
| 2003 | 52,582 | 40,540 | 52,800 | 70,100 | 12,260 |
| 2004 | 56,623 | 48,033 | 62,810 | 102,000 | 14,777 |
| 2005 | 47,585 | 44,433 | 58,100 | 86,200 | 13,667 |
| 2006 | 47,897 | 52,264 | 68,859 | 95,500 | 16,595 |
| 2007 | 52,261 | 52,264 | 68,859 | 97,600 | 16,595 |
| 2008 | 59,014 | 50,269 | 66,493 | 88,660 | 16,224 |
| 2009 | 53,196 | 41,807 | 55,300 | 66,600 | 13,493 |
| 2010 | 78,593 | 59,563 | 79,100 | 94,100 | 19,537 |
| 2011 | 85,368 | 65,100 | 86,800 | 102,600 | 21,700 |
| 2012 | 77,930 | 65,700 | 87,600 | 104,000 | 21,900 |
| 2013 | 68,576 | 60,600 | 80,800 | 97,200 | 20,200 |
| 2014 | 84,945 | 64,738 | 88,500 | 107,300 | 23,762 |
| 2015 | 79,480 | 75,202 | 102,850 | 140,300 | 27,648 |
| 2016 | 64,054 | 71,925 | 98,600 | 116,700 | 26,675 |
| 2017 | 48,727 | 64,442 | 88,342 | 105,378 | 23,900 |
| 2018 | 15,150 | 13,096 | 18,000 | 23,565 | 4,904 |
| 2019 | 15,715 | 12,368 | 17,000 | 23,669 | 4,632 |
| 2020 | 6,842 | 6,431 | 14,621 | 17,794 | 2,537 |
| 2021 | 19,172 | 17,321 | 23,627 | 28,977 | 6,306 |
| 2022 | 25,921 | 24,111 | 32,811 | 39,555 | 8,700 |
| 2023 | 21,725 | 18,103 | 24,634 | 29,737 | 6,531 |
| 2024 | 23,171 | 23,766 | 32,272 | 38,712 | 8,506 |

##### Table 2.3. History of GOA Pacific cod allocations by regulatory area (in percent) for 1991-2024, and proposed for 2025 (in parentheses). See Barbeaux *et al.* (2018) for 1977-1990.

|  |  |  |  |
| --- | --- | --- | --- |
| Year(s) | Western | Central | Eastern |
| 1991 | 33 | 62 | 5 |
| 1992 | 37 | 61 | 2 |
| 1993-1994 | 33 | 62 | 5 |
| 1995-1996 | 29 | 66 | 5 |
| 1997-1999 | 35 | 63 | 2 |
| 2000-2001 | 36 | 57 | 7 |
| 2002 | 39 | 55 | 6 |
| 2002 | 38 | 56 | 6 |
| 2003 | 39 | 55 | 6 |
| 2003 | 38 | 56 | 6 |
| 2004 | 36 | 57 | 7 |
| 2004 | 35.3 | 56.5 | 8.2 |
| 2005 | 36 | 57 | 7 |
| 2005 | 35.3 | 56.5 | 8.2 |
| 2006 | 39 | 55 | 6 |
| 2006 | 38.54 | 54.35 | 7.11 |
| 2007 | 39 | 55 | 6 |
| 2007 | 38.54 | 54.35 | 7.11 |
| 2008 | 39 | 57 | 4 |
| 2008 | 38.69 | 56.55 | 4.76 |
| 2009 | 39 | 57 | 4 |
| 2009 | 38.69 | 56.55 | 4.76 |
| 2010 | 35 | 62 | 3 |
| 2010 | 34.86 | 61.75 | 3.39 |
| 2011 | 35 | 62 | 3 |
| 2011 | 35 | 62 | 3 |
| 2012 | 35 | 62 | 3 |
| 2012 | 32 | 65 | 3 |
| 2013 | 38 | 60 | 3 |
| 2014 | 37 | 60 | 3 |
| 2015 | 38 | 60 | 3 |
| 2016 | 41 | 50 | 9 |
| 2017 | 41 | 50 | 9 |
| 2018 | 44.9 | 45.1 | 10 |
| 2019 | 44.9 | 45.1 | 10 |
| 2020 | 33.8 | 57.8 | 8.4 |
| 2021 | 33.8 | 57.8 | 8.4 |
| 2022 | 30.3 | 60.2 | 9.5 |
| 2023 | 30.3 | 60.2 | 9.5 |
| 2024 | 27.1 | 63.8 | 9.1 |
| *2025* | *27.1* | *63.8* | *9.1* |

##### Table 2.4. Estimated retained and discarded GOA Pacific cod (t, as of 2024-10-17)

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Discarded | Retained | Total |
| 1991 | 1,427 | 74,873 | 76,300 |
| 1992 | 3,920 | 76,827 | 80,747 |
| 1993 | 5,886 | 50,602 | 56,488 |
| 1994 | 3,122 | 44,363 | 47,485 |
| 1995 | 3,546 | 65,439 | 68,985 |
| 1996 | 7,555 | 60,725 | 68,280 |
| 1997 | 4,828 | 72,342 | 77,170 |
| 1998 | 1,732 | 70,893 | 72,625 |
| 1999 | 1,645 | 80,898 | 82,543 |
| 2000 | 1,378 | 65,174 | 66,552 |
| 2001 | 1,904 | 49,627 | 51,531 |
| 2002 | 3,715 | 50,923 | 54,638 |
| 2003 | 2,485 | 50,097 | 52,582 |
| 2004 | 1,268 | 55,355 | 56,623 |
| 2005 | 1,043 | 46,541 | 47,584 |
| 2006 | 1,852 | 46,045 | 47,897 |
| 2007 | 1,448 | 50,813 | 52,261 |
| 2008 | 3,307 | 55,707 | 59,014 |
| 2009 | 3,944 | 49,252 | 53,196 |
| 2010 | 3,097 | 75,496 | 78,593 |
| 2011 | 2,178 | 83,189 | 85,367 |
| 2012 | 949 | 76,981 | 77,930 |
| 2013 | 4,560 | 64,016 | 68,576 |
| 2014 | 5,302 | 79,643 | 84,945 |
| 2015 | 1,723 | 77,758 | 79,481 |
| 2016 | 868 | 63,187 | 64,055 |
| 2017 | 711 | 48,016 | 48,727 |
| 2018 | 604 | 14,546 | 15,150 |
| 2019 | 1,194 | 14,522 | 15,716 |
| 2020 | 1,748 | 5,094 | 6,842 |
| 2021 | 1,404 | 17,769 | 19,173 |
| 2022 | 1,677 | 24,245 | 25,922 |
| 2023 | 1,873 | 19,852 | 21,725 |
| 2024 | 2,026 | 21,145 | 23,171 |

##### Table 2.5. Weight of groundfish bycatch (t, by assessed stock), discarded (D) and retained (R), for 2020 – 2024 for GOA Pacific cod as target species (as of 2024-10-17).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2020 | | | 2021 | | 2022 | | 2023 | | 2024 | |
| Stock | | D | R | D | R | D | R | D | R | D | R |
| Arrowtooth flounder | | 50.4 | 0.3 | 147.5 | 2 | 82.8 | 14.3 | 81 | 0.6 | 90.7 | 0.8 |
| Atka mackerel | | - | - | 2.9 | 0 | 0.5 | - | 0.1 | - | 0.1 | - |
| Deep-water flatfish | | 0.2 | - | 1.2 | - | 2.4 | - | 7.2 | - | 0.3 | 0.1 |
| Demersal shelf rockfish | | 0.1 | 0.6 | 9.4 | 12.3 | 9.2 | 8.4 | 30.4 | 30.6 | 12.6 | 14.8 |
| Dusky rockfish | | - | 0.8 | 2.5 | 2.3 | 2.4 | 1.9 | 1.2 | 1.7 | 1.3 | 3.1 |
| Flathead sole | | 0.1 | - | 18.1 | 2.8 | 7.5 | 1.3 | 10.7 | 0.3 | 38.7 | 0.3 |
| Northern rockfish | | - | - | 3.4 | 1 | 0.4 | 0.8 | 2.6 | 0.2 | 0.8 | 0.1 |
| Octopus | | 0 | 12 | 14.4 | 23.3 | 49.5 | 60.2 | 72.2 | 41.2 | 37 | 66 |
| Other rockfish | | 0.4 | 0.1 | 7.4 | 0.4 | 45.4 | 1.2 | 18 | 0.7 | 1.9 | 0.3 |
| Pacific Ocean perch | | 0 | 7.8 | 0.2 | 1.5 | 0.8 | 6.2 | 0 | - | 1.1 | 0.1 |
| Rex sole | | 0.1 | - | 1.6 | 0 | 8.6 | 0.2 | 7.8 | - | 3 | - |
| Rougheye and Blackspotted rockfish | | 0.1 | 0.2 | 2.4 | 0.8 | 0.3 | 0.3 | 0.7 | 0.8 | 0.9 | 0.1 |
| Sablefish | | 5.5 | 24.4 | 64.1 | 64.5 | 104.5 | 17 | 42.5 | 34.9 | 23.1 | 0.4 |
| Shallow-water flatfish | | 0.1 | 0 | 18.7 | 0.6 | 31.7 | 100.2 | 22.2 | 1.4 | 89.6 | 72.8 |
| Shortraker rockfish | | 0.1 | 0 | 4.6 | 0.4 | 1.3 | 0.6 | 1.5 | 0.1 | 0.1 | - |
| Skarks | | 14.5 | 0.3 | 162.2 | 0 | 68.2 | 0.2 | 71.6 | - | 13 | 0.2 |
| Skates | | 12.1 | 4.2 | 508.4 | 106.6 | 692.5 | 217.8 | 660.3 | 188.3 | 326.2 | 137.7 |
| Thornyheads | | 0 | - | 0.4 | 0.6 | 1.6 | 2.7 | 6.7 | 0.4 | 1.7 | - |
| Walleye pollock | | 11.4 | 4.4 | 271.9 | 21.8 | 132.1 | 50.4 | 68.6 | 36 | 4.4 | 59.2 |
| Total | | 99 | 55.5 | 1252 | 253.7 | 1260.5 | 492.9 | 1127.4 | 360.8 | 656.7 | 359.1 |

##### Table 2.6. Prohibited species catch (t for halibut and herring, counts for crab and salmon) for 2020 – 2024 for GOA Pacific cod as target species (as of 2024-10-17).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Species | 2020 | 2021 | 2022 | 2023 | 2024 |
| Bairdi Tanner Crab | 166 | 30,372 | 24,691 | 27,117 | 10,771 |
| Blue King Crab | 0 | 0 | 0 | 0 | 0 |
| Chinook Salmon | 0 | 3,827 | 0 | 857 | 9 |
| Golden (Brown) King Crab | 19 | 26 | 16 | 81 | 280 |
| Halibut | 19 | 599 | 353 | 409 | 317 |
| Herring | 0 | 0 | 0 | 0 | 0 |
| Non-Chinook Salmon | 0 | 0 | 0 | 0 | 8 |
| Opilio Tanner (Snow) Crab | 9 | 0 | 0 | 0 | 0 |
| Red King Crab | 0 | 10 | 0 | 0 | 0 |

##### Table 2.7. Incidental catch (t or birds by number) of non-target species groups by GOA Pacific cod fisheries (as of 2023-10-20). 0.00 indicates ≤0.005 tons, a blank indicates no catch or confidential data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Species Group | 2020 | 2021 | 2022 | 2023 | 2024 |
| Benthic urochordata | - | - | 0 | 0.01 | 0.05 |
| Birds - Gull | - | 7.73 | 36.27 | 44.92 | - |
| Birds - Northern Fulmar | - | 21.27 | 224.79 | 17.92 | - |
| Birds - Short-tailed Albatross | - | - | - | 2.04 | - |
| Birds - Unidentified | - | 9.33 | - | 404.15 | - |
| Birds - Unidentified Albatross | - | - | 11.04 | - | - |
| Bivalves | - | 0 | 0.63 | 0.01 | 0.22 |
| Brittle star unidentified | - | - | 0.02 | 0.01 | 0.01 |
| Corals Bryozoans - Corals Bryozoans Unidentified | 0.18 | 0.08 | 0.07 | 0.58 | 0.01 |
| Eelpouts | - | - | 0.02 | 0.08 | 0.05 |
| Giant Grenadier | - | 79.55 | 48.08 | 43.61 | - |
| Greenlings | - | 0.45 | 0.29 | 0.35 | 0.28 |
| Grenadier - Rattail Grenadier Unidentified | - | 0.12 | 0.07 | 0 | 0.04 |
| Hermit crab unidentified | - | 0.01 | 0.08 | 0.04 | 0.03 |
| Invertebrate unidentified | 0.11 | 0.01 | 0.75 | 1.85 | 0.02 |
| Misc crabs | - | 0.14 | 0.05 | 4.17 | 0.21 |
| Misc crustaceans | - | - | 0 | 0 | 0.04 |
| Misc fish | 7.71 | 33.35 | 34.69 | 23.38 | 99.79 |
| Pacific Sand lance | - | - | - | 0.08 | - |
| Sculpin | - | 119.66 | 175.62 | 123.35 | 49.15 |
| Scypho jellies | 0.02 | 0.19 | 0.03 | 0.07 | 0.52 |
| Sea anemone unidentified | 0 | 1.09 | 1.1 | 1.67 | 2.32 |
| Sea pens whips | - | 0.04 | 1.43 | 0.14 | 0.52 |
| Sea star | 1.66 | 18.44 | 22.45 | 30.36 | 50.11 |
| Snails | 0.06 | 0.27 | 2.19 | 3.62 | 0.52 |
| Sponge unidentified | - | 0.05 | 1.11 | 0.69 | 1.15 |
| Squid | - | - | - | 0.09 | 0.01 |
| State-managed Rockfish | - | 2.24 | 2.31 | 1.89 | 0.3 |
| urchins dollars cucumbers | - | 0.03 | 0.64 | 0.2 | 0.61 |

##### Table 2.8. Pacific cod catch (t) by trip target in Gulf of Alaska groundfish fisheries (as of 2024-10-17).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Trip Target | 2020 | 2021 | 2022 | 2023 | 2024 | Average |
| Pacific Cod | 2,678 | 14,345 | 20,006 | 15,216 | 19,959 | 14,441 |
| Pollock - bottom | 899 | 2,841 | 3,355 | 3,769 | 362 | 2,245 |
| Halibut | 717 | 560 | 1,076 | 1,372 | 1,499 | 1,045 |
| Arrowtooth Flounder | 1,237 | 379 | 415 | 514 | 646 | 638 |
| Rockfish | 170 | 660 | 670 | 448 | 352 | 460 |
| Shallow Water Flatfish - GOA | 938 | 254 | 222 | 137 | 150 | 340 |
| Pollock - midwater | 141 | 74 | 121 | 209 | 163 | 141 |
| Sablefish | 49 | 58 | 34 | 30 | 40 | 42 |
| Rex Sole - GOA | 14 | - | 22 | - | - | 18 |
| Flathead Sole | - | 3 | - | - | - | 3 |
| Grand Total | 6,843 | 19,174 | 25,921 | 21,726 | 23,171 | 19,367 |
| Non-Pacific cod trip target total | 4,165 | 4,829 | 5,915 | 6,510 | 3,212 | 4,926 |

##### Table 2.9. Noncommercial fishery catch (t); total source amounts less than 10 kg were omitted (as of 2024-10-17)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | 2019 | 2020 | 2021 | 2022 | 2023 |
| AFSC Annual Longline Survey | 5.5 | 10.2 | 13.1 | 14.7 | 15.3 |
| GOA Shelf and Slope Walleye Pollock Acoustic-Trawl Survey | - | - | 0.1 | - | - |
| Gulf of Alaska Bottom Trawl Survey | 7.8 | - | 7.9 | - | 10 |
| IPHC Annual Longline Survey | 105 | 30 | 75.3 | 34.8 | 79.4 |
| Large-Mesh Trawl Survey | 7.3 | 7.9 | 5 | 6.2 | 8 |
| Small-Mesh Trawl Survey | 0.3 | 0.7 | 0.1 | 0.1 | 0.1 |
| Sport Fishery | 78.6 | 70.1 | 182.4 | 168.1 | 284.8 |
| Summer Acoustic-Trawl Survey of Walleye Pollock in the Gulf of Alaska | 0.1 | - | - | - | - |
| Total | 204.6 | 118.9 | 283.9 | 223.9 | 397.6 |

##### Table 2.10. GOA AFSC Longline survey estimated Relative Population Numbers (RPNs), and bottom trawl survey estimated biomass (t) and numbers of fish (‘Abundance’, in 1000s) shown along with coefficients of variation (in parentheses).

|  |  |  |  |
| --- | --- | --- | --- |
| Year | RPN | Biomass (t) | Abundance |
| 1990 | 116,434 (13.9%) | 416,788 (15.3%) | 212,436 (20.7%) |
| 1991 | 110,061 (14.1%) | - | - |
| 1992 | 136,383 (8.7%) | - | - |
| 1993 | 153,950 (11.4%) | 405,782 (18.1%) | 225,779 (19.3%) |
| 1994 | 96,563 (9.4%) | - | - |
| 1995 | 120,710 (10%) | - | - |
| 1996 | 84,535 (14.1%) | 538,153 (20%) | 319,416 (21.5%) |
| 1997 | 104,647 (16.9%) | - | - |
| 1998 | 125,877 (11.5%) | - | - |
| 1999 | 91,480 (11.3%) | 306,413 (12.6%) | 166,639 (11.2%) |
| 2000 | 54,316 (14.5%) | - | - |
| 2001 | 33,841 (18.1%) | 257,614 (20.4%) | 158,424 (18%) |
| 2002 | 51,903 (17%) | - | - |
| 2003 | 59,952 (15%) | 297,402 (15%) | 159,749 (12.9%) |
| 2004 | 53,109 (11.8%) | - | - |
| 2005 | 29,864 (21.4%) | 308,175 (26.2%) | 139,895 (20.8%) |
| 2006 | 34,316 (19.7%) | - | - |
| 2007 | 34,994 (14%) | 232,035 (13.9%) | 192,306 (17.5%) |
| 2008 | 26,881 (22.8%) | - | - |
| 2009 | 68,395 (13.8%) | 752,651 (30.3%) | 573,603 (28.6%) |
| 2010 | 86,725 (13.8%) | - | - |
| 2011 | 93,743 (14.1%) | 500,975 (13.6%) | 348,035 (17.7%) |
| 2012 | 63,768 (14.8%) | - | - |
| 2013 | 48,553 (16.2%) | 506,362 (14.8%) | 337,992 (15.2%) |
| 2014 | 69,665 (14.3%) | - | - |
| 2015 | 88,482 (15.9%) | 253,932 (10.5%) | 196,555 (12%) |
| 2016 | 83,887 (17.2%) | - | - |
| 2017 | 39,575 (10.1%) | 107,324 (12.8%) | 56,199 (11.7%) |
| 2018 | 23,857 (12.1%) | - | - |
| 2019 | 14,933 (18.5%) | 181,581 (21.8%) | 127,118 (24.7%) |
| 2020 | 19,459 (21.8%) | - | - |
| 2021 | 30,830 (16.2%) | 174,414 (8.8%) | 90,914 (8.7%) |
| 2022 | 23,393 (15.9%) | - | - |
| 2023 | 30,802 (20.9%) | 231,185 (12.6%) | 138,683 (12.1%) |

##### Table 2.11. Values for parameters estimated outside the GOA Pacific cod assessment model.

|  |  |
| --- | --- |
| Parameter | Value |
| Ageing error SD at age-0 | 0.11 |
| Ageing error SD at age-10 | 1.13 |
| Ageing bias at age-0 | 1.31 |
| Ageing bias at age-10 | 2.17 |
| Weight-length coefficient | 3.40E-06 |
| Weight-length exponent | 3.27 |
| Length at 50% maturity | 53.7 |
| Slope of maturity | -0.27 |

##### Table 2.12. Number of parameters (categorized by parameter type) for the author’s recommended model.

|  |  |
| --- | --- |
| Parameter | Number |
| Recruitment/Initial abundance | *--* |
| Early Init Devs | 10 |
| Early Rec Dev | 1 |
| Main Rec Dev | 47 |
| log(mean recruitment) | 1 |
| 1976 R reg. | 1 |
| Biology | *--* |
| Growth (LVB) | 5 |
| Natural Mortality | 2 |
| Catchability/Selectivity | *--* |
| Survey catchability (trawl) | 1 |
| Survey catchability (longline) | 2 |
| Trawl survey selex | 16 |
| Longline survey selex | 5 |
| Trawl fishery selex | 19 |
| Trawl fishery selex devs | 39 |
| Longline fishery selex | 15 |
| Longline fishery selex devs | 24 |
| Pot fishery selex | 8 |
| Total | 196 |

##### Table 2.14. Key parameter estimates with standard deviations (SD) estimated from the author’s recommended model.

|  |  |  |
| --- | --- | --- |
| Name | Value | SD |
| Biology | -- | -- |
| Beginning of year length at age-1 (cm) | 17.43 | 0.314 |
| Beginning of year length at age-10 (cm) | 99.46 | 0.015 |
| Growth rate | 0.19 | 0.002 |
| SD in length-at-age for age-1 | 4.01 | 0.187 |
| SD in length-at-age for age-10 | 8.99 | 0.345 |
| Natural mortality (2014-2016) | 0.82 | 0.053 |
| Natural mortality (all years) | 0.49 | 0.023 |
| Recruitment/Abundance | -- | -- |
| log(mean recruitment) | 13.09 | 0.213 |
| 1976 Regime adjustment | -0.68 | 0.19 |
| Survey catchability | -- | -- |
| Bottom trawl survey | 1.28 | 0.125 |
| Longline survey | 1.16 | 0.108 |
| Longline survey environmental coefficient | 0.94 | 0.411 |

##### Table 2.15. Estimated female spawning biomass (t), standard deviation in spawning biomass (SD), and total biomass (t, age 0+) from the 2023 accepted assessment (denoted as ‘Previous’) and the author’s recommended model (denoted as ‘Current’).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | Previous Sp.Bio | Previous SD[Sp.Bio] | Previous Tot.Bio. | Current Sp.Bio | Current SD[Sp.Bio] | Current Tot.Bio. |
| 1977 | 86,688 | 15,935 | 272,441 | 82,030 | 18,624 | 263,078 |
| 1978 | 98,380 | 17,214 | 289,235 | 93,526 | 20,289 | 274,934 |
| 1979 | 97,764 | 16,847 | 330,096 | 91,392 | 19,576 | 306,236 |
| 1980 | 96,006 | 15,934 | 386,068 | 86,468 | 18,181 | 367,433 |
| 1981 | 111,789 | 18,228 | 418,191 | 100,306 | 21,344 | 404,096 |
| 1982 | 134,330 | 21,932 | 443,790 | 128,098 | 27,305 | 429,094 |
| 1983 | 145,538 | 23,772 | 485,373 | 138,760 | 29,352 | 464,679 |
| 1984 | 149,802 | 24,401 | 530,505 | 140,462 | 29,869 | 506,907 |
| 1985 | 168,636 | 25,105 | 587,423 | 156,013 | 31,122 | 571,308 |
| 1986 | 197,792 | 25,243 | 647,087 | 185,062 | 32,452 | 643,066 |
| 1987 | 220,914 | 24,054 | 698,761 | 213,389 | 33,340 | 705,665 |
| 1988 | 231,754 | 21,809 | 724,226 | 228,887 | 32,111 | 733,973 |
| 1989 | 243,438 | 19,800 | 733,137 | 243,403 | 30,496 | 738,995 |
| 1990 | 246,919 | 17,780 | 724,593 | 246,430 | 27,784 | 722,469 |
| 1991 | 230,939 | 15,820 | 694,233 | 227,089 | 24,492 | 680,037 |
| 1992 | 214,700 | 14,233 | 673,111 | 207,464 | 21,875 | 646,435 |
| 1993 | 201,964 | 13,093 | 647,461 | 190,501 | 19,878 | 613,356 |
| 1994 | 207,132 | 12,396 | 630,312 | 191,073 | 18,675 | 593,657 |
| 1995 | 211,697 | 11,446 | 601,250 | 193,714 | 17,173 | 562,274 |
| 1996 | 194,439 | 9,959 | 541,257 | 176,600 | 14,814 | 500,923 |
| 1997 | 169,657 | 8,367 | 489,569 | 152,166 | 12,234 | 448,772 |
| 1998 | 142,072 | 7,078 | 436,698 | 125,266 | 10,174 | 401,629 |
| 1999 | 125,720 | 6,289 | 391,753 | 109,867 | 9,138 | 365,436 |
| 2000 | 108,573 | 5,720 | 340,653 | 96,878 | 8,662 | 324,871 |
| 2001 | 95,796 | 5,163 | 311,814 | 88,328 | 8,115 | 306,187 |
| 2002 | 88,198 | 4,683 | 307,313 | 84,006 | 7,558 | 310,405 |
| 2003 | 82,954 | 4,429 | 300,217 | 82,664 | 7,400 | 311,203 |
| 2004 | 84,857 | 4,465 | 286,487 | 88,050 | 7,629 | 302,383 |
| 2005 | 82,850 | 4,406 | 263,066 | 87,817 | 7,438 | 280,139 |
| 2006 | 76,512 | 4,062 | 251,563 | 81,816 | 6,620 | 264,404 |
| 2007 | 68,076 | 3,711 | 258,308 | 72,894 | 5,786 | 261,734 |
| 2008 | 63,092 | 3,638 | 288,235 | 65,126 | 5,343 | 282,345 |
| 2009 | 67,152 | 3,999 | 329,541 | 64,976 | 5,702 | 320,013 |
| 2010 | 86,782 | 4,889 | 382,329 | 82,099 | 7,028 | 370,972 |
| 2011 | 99,472 | 5,860 | 404,507 | 94,676 | 8,458 | 394,847 |
| 2012 | 107,730 | 6,958 | 411,061 | 103,497 | 9,906 | 399,102 |
| 2013 | 114,120 | 8,126 | 433,983 | 110,310 | 11,073 | 414,288 |
| 2014 | 118,695 | 9,489 | 500,671 | 111,288 | 11,831 | 463,262 |
| 2015 | 86,062 | 5,895 | 394,061 | 79,084 | 7,540 | 362,383 |
| 2016 | 70,066 | 4,279 | 277,065 | 62,598 | 5,599 | 255,983 |
| 2017 | 53,898 | 3,435 | 177,128 | 48,276 | 4,390 | 161,564 |
| 2018 | 47,454 | 3,547 | 156,630 | 42,448 | 4,549 | 137,613 |
| 2019 | 48,468 | 3,492 | 168,218 | 41,786 | 4,293 | 146,791 |
| 2020 | 51,108 | 3,576 | 176,942 | 41,907 | 4,216 | 159,919 |
| 2021 | 59,590 | 3,794 | 186,120 | 50,256 | 4,537 | 178,117 |
| 2022 | 61,228 | 3,989 | 180,883 | 55,452 | 4,940 | 180,403 |
| 2023 | 55,170 | 4,034 | 173,300 | 54,246 | 5,070 | 174,394 |
| 2024 | 51,959 | 4,225 | 184,242 | 52,034 | 5,160 | 174,445 |
| 2025 | - | - | - | 46,920 | 5,643 | 177,497 |

##### Table 2.16. Age-0 recruitment (millions) and standard deviation of age-0 recruits by year from the 2023 accepted assessment (denoted as ‘Previous’) and the author’s recommended model (denoted as ‘Current’). Highlighted are the 1977 and 2012 year classes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | Previous Recruitment | Previous SD[Rec] | Current Recruitment | Current SD[Rec] |
| 1977 | 0.79 | 0.18 | 1.18 | 0.36 |
| 1978 | 0.4 | 0.11 | 0.39 | 0.14 |
| 1979 | 0.34 | 0.09 | 0.37 | 0.13 |
| 1980 | 0.42 | 0.11 | 0.65 | 0.21 |
| 1981 | 0.62 | 0.14 | 0.7 | 0.23 |
| 1982 | 0.63 | 0.15 | 0.94 | 0.3 |
| 1983 | 0.56 | 0.16 | 0.68 | 0.27 |
| 1984 | 0.54 | 0.15 | 0.9 | 0.3 |
| 1985 | 0.73 | 0.15 | 0.88 | 0.25 |
| 1986 | 0.52 | 0.11 | 0.61 | 0.17 |
| 1987 | 0.51 | 0.09 | 0.66 | 0.16 |
| 1988 | 0.55 | 0.09 | 0.66 | 0.16 |
| 1989 | 0.54 | 0.09 | 0.69 | 0.16 |
| 1990 | 0.7 | 0.11 | 0.78 | 0.17 |
| 1991 | 0.45 | 0.08 | 0.57 | 0.13 |
| 1992 | 0.41 | 0.07 | 0.43 | 0.1 |
| 1993 | 0.29 | 0.05 | 0.36 | 0.08 |
| 1994 | 0.33 | 0.05 | 0.42 | 0.09 |
| 1995 | 0.44 | 0.06 | 0.54 | 0.11 |
| 1996 | 0.29 | 0.04 | 0.4 | 0.08 |
| 1997 | 0.3 | 0.04 | 0.36 | 0.07 |
| 1998 | 0.24 | 0.03 | 0.34 | 0.07 |
| 1999 | 0.33 | 0.04 | 0.51 | 0.1 |
| 2000 | 0.38 | 0.05 | 0.5 | 0.1 |
| 2001 | 0.27 | 0.04 | 0.3 | 0.06 |
| 2002 | 0.18 | 0.03 | 0.26 | 0.05 |
| 2003 | 0.22 | 0.03 | 0.3 | 0.06 |
| 2004 | 0.26 | 0.03 | 0.3 | 0.06 |
| 2005 | 0.39 | 0.05 | 0.54 | 0.1 |
| 2006 | 0.58 | 0.07 | 0.74 | 0.13 |
| 2007 | 0.45 | 0.06 | 0.54 | 0.1 |
| 2008 | 0.57 | 0.07 | 0.79 | 0.15 |
| 2009 | 0.43 | 0.06 | 0.43 | 0.09 |
| 2010 | 0.42 | 0.06 | 0.52 | 0.11 |
| 2011 | 0.54 | 0.09 | 0.81 | 0.17 |
| 2012 | 1.05 | 0.17 | 1.18 | 0.27 |
| 2013 | 0.69 | 0.13 | 0.72 | 0.19 |
| 2014 | 0.27 | 0.06 | 0.24 | 0.07 |
| 2015 | 0.26 | 0.05 | 0.28 | 0.07 |
| 2016 | 0.26 | 0.04 | 0.28 | 0.06 |
| 2017 | 0.2 | 0.03 | 0.3 | 0.06 |
| 2018 | 0.16 | 0.02 | 0.21 | 0.04 |
| 2019 | 0.09 | 0.02 | 0.18 | 0.04 |
| 2020 | 0.15 | 0.03 | 0.19 | 0.04 |
| 2021 | 0.18 | 0.04 | 0.22 | 0.05 |
| 2022 | 0.24 | 0.06 | 0.21 | 0.07 |
| 2023 | 0.38 | 0.18 | 0.41 | 0.19 |
| 2024 | - | - | 0.49 | 0.24 |
| Mean 1977 - (Final year - 2) | 0.42 |  | 0.52 |  |

##### Table 2.17. Estimated fishing mortality in terms of apical F and total exploitation for the author’s recommended model.

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Sum Apical F | SD[F] | Total Exploitation |
| 1977 | 0.012 | 0.003 | 0.009 |
| 1978 | 0.058 | 0.013 | 0.044 |
| 1979 | 0.077 | 0.018 | 0.049 |
| 1980 | 0.191 | 0.046 | 0.096 |
| 1981 | 0.123 | 0.027 | 0.089 |
| 1982 | 0.09 | 0.019 | 0.069 |
| 1983 | 0.115 | 0.025 | 0.079 |
| 1984 | 0.075 | 0.016 | 0.047 |
| 1985 | 0.064 | 0.016 | 0.025 |
| 1986 | 0.094 | 0.022 | 0.039 |
| 1987 | 0.066 | 0.016 | 0.047 |
| 1988 | 0.063 | 0.009 | 0.046 |
| 1989 | 0.078 | 0.012 | 0.059 |
| 1990 | 0.182 | 0.021 | 0.1 |
| 1991 | 0.212 | 0.024 | 0.112 |
| 1992 | 0.247 | 0.027 | 0.125 |
| 1993 | 0.185 | 0.019 | 0.092 |
| 1994 | 0.154 | 0.015 | 0.08 |
| 1995 | 0.23 | 0.021 | 0.123 |
| 1996 | 0.25 | 0.022 | 0.136 |
| 1997 | 0.34 | 0.029 | 0.172 |
| 1998 | 0.395 | 0.034 | 0.181 |
| 1999 | 0.534 | 0.048 | 0.226 |
| 2000 | 0.477 | 0.046 | 0.205 |
| 2001 | 0.386 | 0.037 | 0.168 |
| 2002 | 0.436 | 0.041 | 0.176 |
| 2003 | 0.421 | 0.039 | 0.169 |
| 2004 | 0.432 | 0.038 | 0.187 |
| 2005 | 0.394 | 0.04 | 0.17 |
| 2006 | 0.425 | 0.04 | 0.181 |
| 2007 | 0.487 | 0.041 | 0.2 |
| 2008 | 0.602 | 0.055 | 0.209 |
| 2009 | 0.506 | 0.047 | 0.166 |
| 2010 | 0.6 | 0.056 | 0.212 |
| 2011 | 0.584 | 0.057 | 0.216 |
| 2012 | 0.473 | 0.048 | 0.195 |
| 2013 | 0.388 | 0.041 | 0.166 |
| 2014 | 0.574 | 0.06 | 0.183 |
| 2015 | 0.771 | 0.074 | 0.219 |
| 2016 | 0.783 | 0.071 | 0.25 |
| 2017 | 0.737 | 0.08 | 0.302 |
| 2018 | 0.229 | 0.026 | 0.11 |
| 2019 | 0.237 | 0.025 | 0.107 |
| 2020 | 0.095 | 0.009 | 0.043 |
| 2021 | 0.24 | 0.022 | 0.108 |
| 2022 | 0.305 | 0.028 | 0.144 |
| 2023 | 0.256 | 0.025 | 0.125 |
| 2024 | 0.416 | 0.045 | 0.185 |

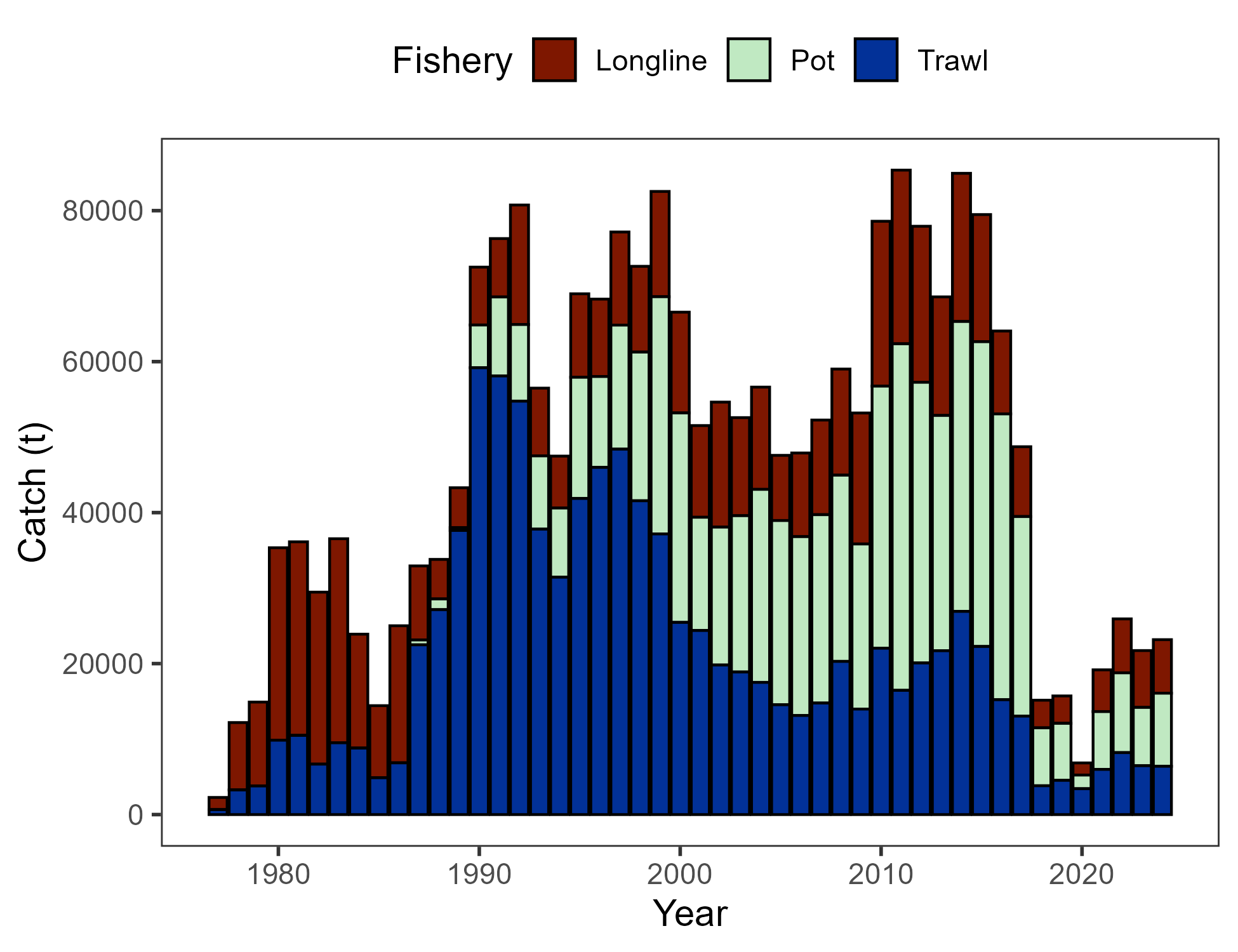
##### Table 2.18. Biological reference points from GOA Pacific cod SAFE documents for years 2002 – 2024, and recommended for 2025 from the author’s recommended model (in italics).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | SB100% | SB40% | F40% | OFLy+1 | maxABCy+1 |
| 2002 | 212,000 | 85,000 | 0.41 | 82,000 | 57,600 |
| 2003 | 226,000 | 90,300 | 0.35 | 88,300 | 52,800 |
| 2004 | 222,000 | 88,900 | 0.34 | 103,000 | 62,810 |
| 2005 | 211,000 | 84,400 | 0.31 | 91,700 | 58,100 |
| 2006 | 329,000 | 132,000 | 0.56 | 165,000 | 68,859 |
| 2007 | 259,000 | 103,000 | 0.46 | 136,000 | 68,859 |
| 2008 | 302,000 | 121,000 | 0.49 | 108,000 | 66,493 |
| 2009 | 255,500 | 102,200 | 0.52 | 88,000 | 55,300 |
| 2010 | 291,500 | 116,600 | 0.49 | 117,600 | 79,100 |
| 2011 | 256,300 | 102,500 | 0.42 | 124,100 | 86,800 |
| 2012 | 261,000 | 104,000 | 0.44 | 121,000 | 87,600 |
| 2013 | 234,800 | 93,900 | 0.49 | 111,000 | 80,800 |
| 2014 | 227,800 | 91,100 | 0.54 | 120,100 | 88,500 |
| 2015 | 316,500 | 126,600 | 0.5 | 155,400 | 102,850 |
| 2016 | 325,200 | 130,000 | 0.41 | 116,700 | 98,600 |
| 2017 | 196,776 | 78,711 | 0.53 | 105,378 | 88,342 |
| 2018 | 168,583 | 67,433 | 0.34 | 23,565 | 19,401 |
| 2019 | 172,240 | 68,896 | 0.29 | 23,669 | 19,665 |
| 2020 | 187,780 | 75,112 | 0.22 | 17,794 | 14,621 |
| 2021 | 180,111 | 72,045 | 0.33 | 28,977 | 23,627 |
| 2022 | 165,508 | 66,203 | 0.5 | 39,555 | 32,811 |
| 2023 | 167,414 | 66,966 | 0.41 | 29,737 | 24,634 |
| 2024 | 175,187 | 70,075 | 0.42 | 38,712 | 32,272 |
| *2025* | *163,585* | *65,434* | *0.46* | *38,688* | *32,141* |

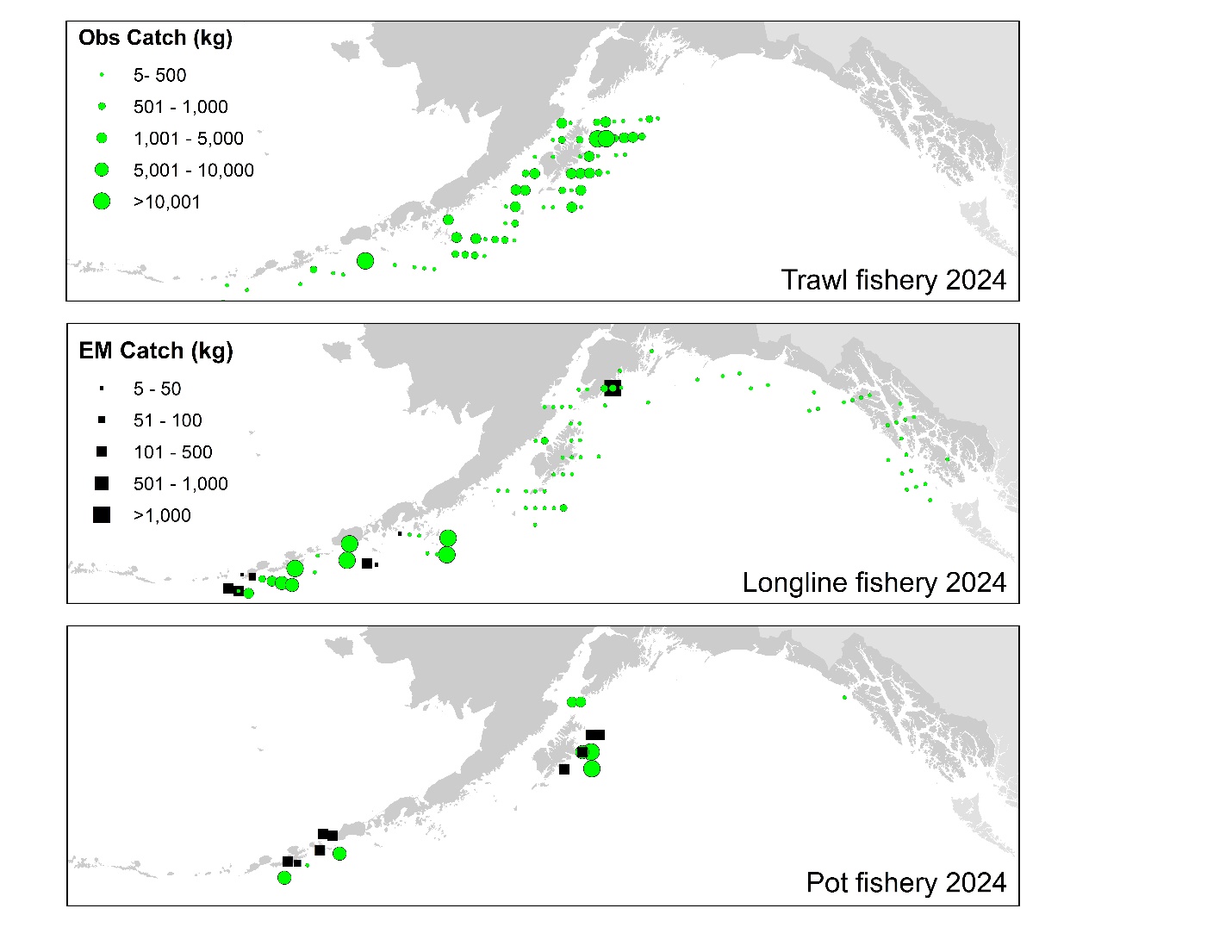
##### Table 2.19. Results for the projection scenarios from the author’s recommended model. Catch in tons, fishing mortality (F), and Female spawning stock biomass (SSB) in tons for the 7 standard projection scenarios.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 | Scenario 7 |
| Catch | - | - | - | - | - | - | - |
| 2024 | 32,272 | 32,272 | 32,272 | 32,272 | 32,272 | 32,272 | 32,272 |
| 2025 | 32,141 | 32,141 | 17,068 | 24,894 | 0 | 38,688 | 32,141 |
| 2026 | 30,193 | 30,193 | 18,559 | 25,910 | 0 | 33,099 | 30,193 |
| 2027 | 39,135 | 39,135 | 22,193 | 34,345 | 0 | 42,529 | 47,236 |
| 2028 | 59,122 | 59,122 | 28,182 | 51,305 | 0 | 64,447 | 65,766 |
| 2029 | 71,693 | 71,693 | 34,726 | 59,975 | 0 | 81,372 | 81,288 |
| 2030 | 77,378 | 77,378 | 40,106 | 66,388 | 0 | 85,646 | 85,547 |
| 2031 | 80,257 | 80,257 | 43,764 | 70,070 | 0 | 87,493 | 87,442 |
| 2032 | 81,475 | 81,475 | 45,973 | 71,878 | 0 | 88,136 | 88,115 |
| 2033 | 81,994 | 81,994 | 47,328 | 72,767 | 0 | 88,370 | 88,361 |
| 2034 | 82,197 | 82,197 | 48,086 | 73,169 | 0 | 88,448 | 88,444 |
| 2035 | 82,275 | 82,275 | 48,495 | 73,347 | 0 | 88,474 | 88,473 |
| 2036 | 82,302 | 82,302 | 48,700 | 73,418 | 0 | 88,482 | 88,481 |
| 2037 | 82,312 | 82,312 | 48,803 | 73,446 | 0 | 88,484 | 88,484 |
| F | - | - | - | - | - | - | - |
| 2024 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 |
| 2025 | 0.46 | 0.46 | 0.23 | 0.34 | 0 | 0.57 | 0.46 |
| 2026 | 0.43 | 0.43 | 0.23 | 0.34 | 0 | 0.51 | 0.43 |
| 2027 | 0.49 | 0.49 | 0.23 | 0.4 | 0 | 0.57 | 0.61 |
| 2028 | 0.61 | 0.61 | 0.23 | 0.49 | 0 | 0.72 | 0.73 |
| 2029 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2030 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2031 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2032 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2033 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2034 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2035 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2036 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| 2037 | 0.65 | 0.65 | 0.23 | 0.49 | 0 | 0.81 | 0.81 |
| SSB | - | - | - | - | - | - | - |
| 2024 | 52,034 | 52,034 | 52,034 | 52,034 | 52,034 | 52,034 | 52,034 |
| 2025 | 46,920 | 46,920 | 46,920 | 46,920 | 46,920 | 46,920 | 46,920 |
| 2026 | 44,674 | 44,674 | 50,121 | 47,277 | 56,435 | 42,351 | 44,674 |
| 2027 | 50,138 | 50,138 | 58,758 | 53,782 | 70,845 | 47,229 | 50,138 |
| 2028 | 61,936 | 61,936 | 74,590 | 66,425 | 92,276 | 58,532 | 59,276 |
| 2029 | 72,038 | 72,038 | 92,772 | 78,210 | 117,044 | 67,594 | 67,574 |
| 2030 | 78,526 | 78,526 | 108,404 | 87,525 | 140,496 | 71,714 | 71,633 |
| 2031 | 82,012 | 82,012 | 119,484 | 93,154 | 159,756 | 73,627 | 73,578 |
| 2032 | 83,558 | 83,558 | 126,438 | 96,043 | 174,087 | 74,330 | 74,308 |
| 2033 | 84,258 | 84,258 | 130,941 | 97,548 | 185,302 | 74,604 | 74,595 |
| 2034 | 84,540 | 84,540 | 133,526 | 98,248 | 192,983 | 74,698 | 74,694 |
| 2035 | 84,651 | 84,651 | 134,940 | 98,564 | 197,984 | 74,730 | 74,729 |
| 2036 | 84,689 | 84,689 | 135,652 | 98,690 | 201,034 | 74,740 | 74,739 |
| 2037 | 84,702 | 84,702 | 136,008 | 98,741 | 202,897 | 74,742 | 74,742 |

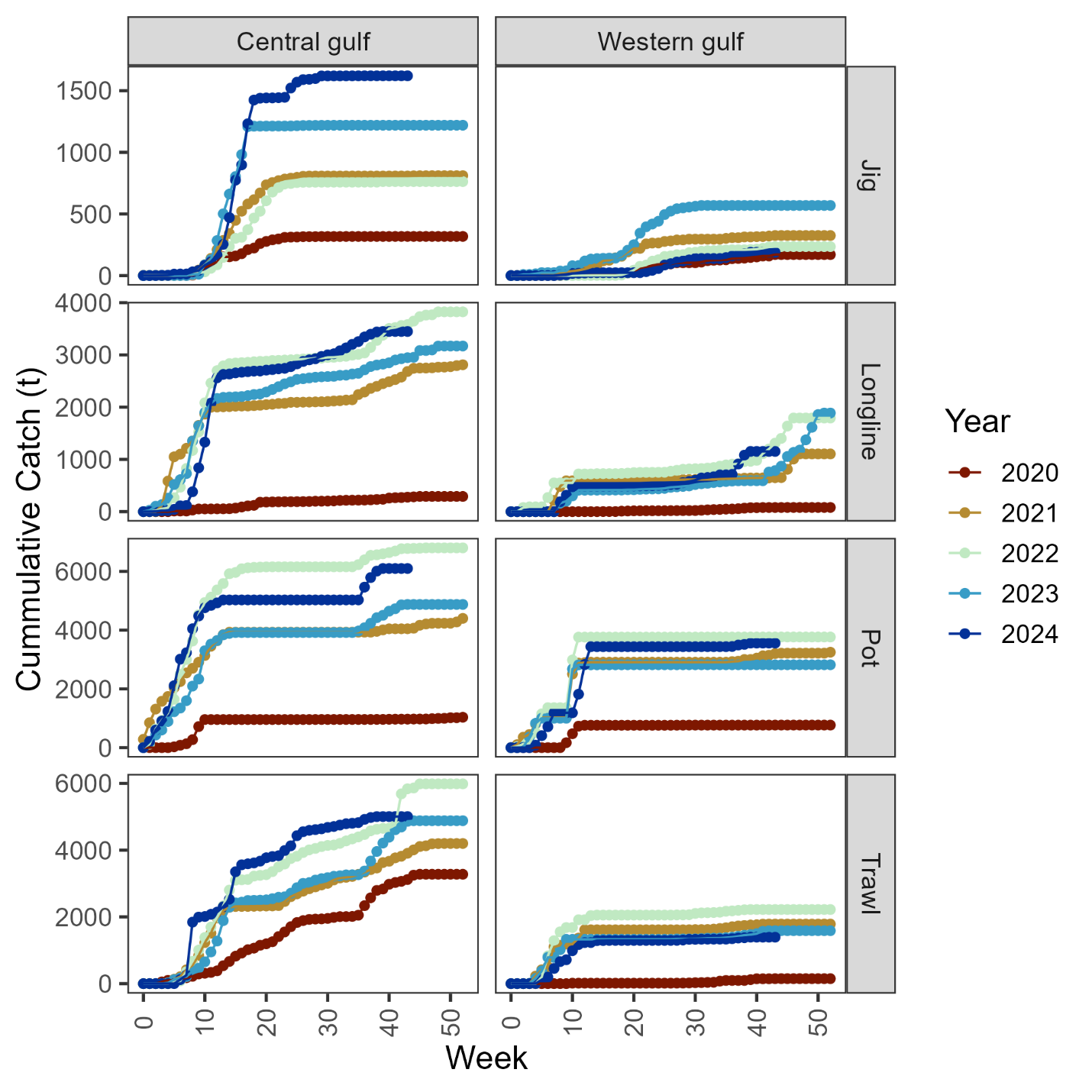
# Figures



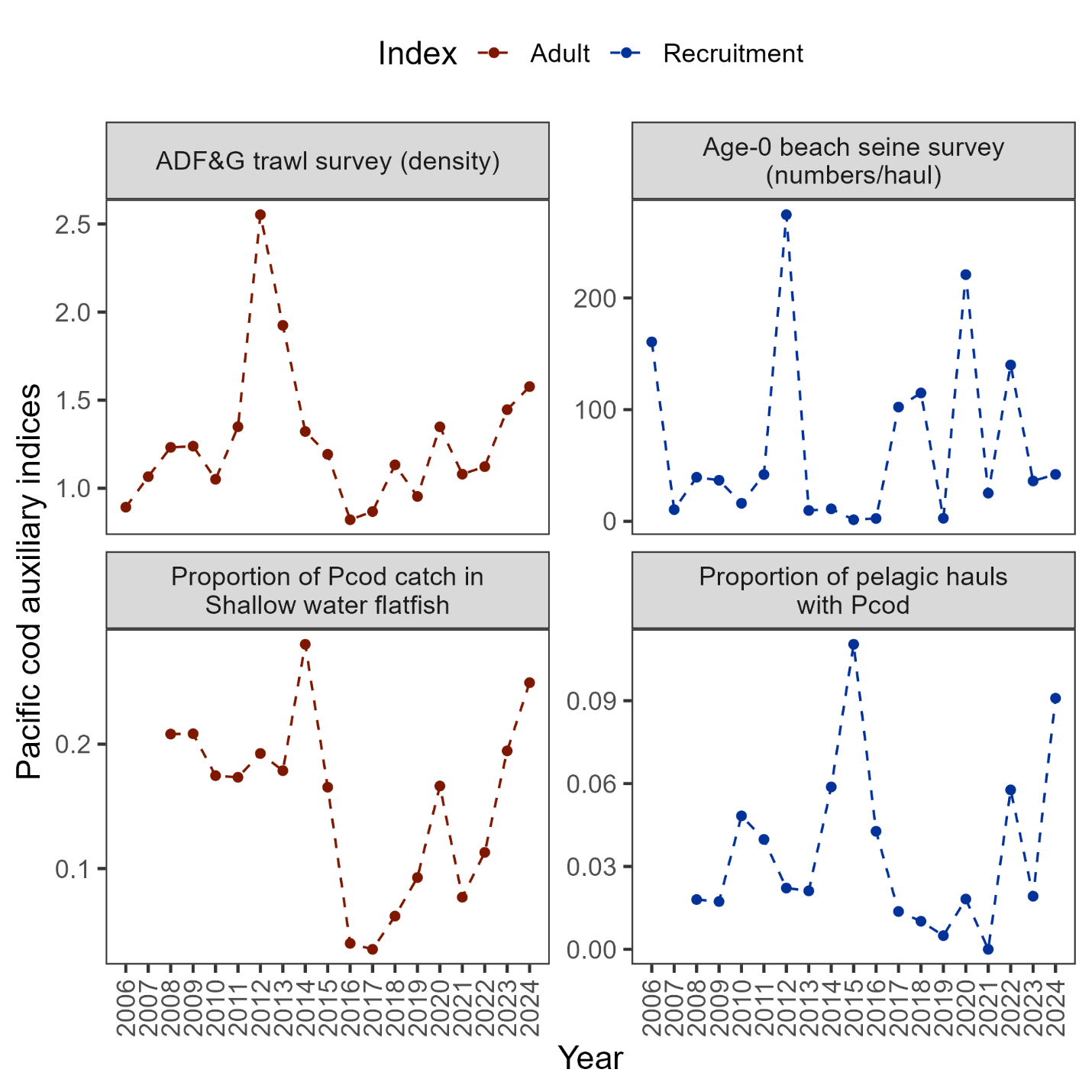
##### Figure 2.3. Commercial catch (mt) of Pacific cod in the GOA in trawl (FshTrawl), longline (FshLL), and pot (FshPot) gear from 1977-2024. Note that 2024 catch was through October 17.



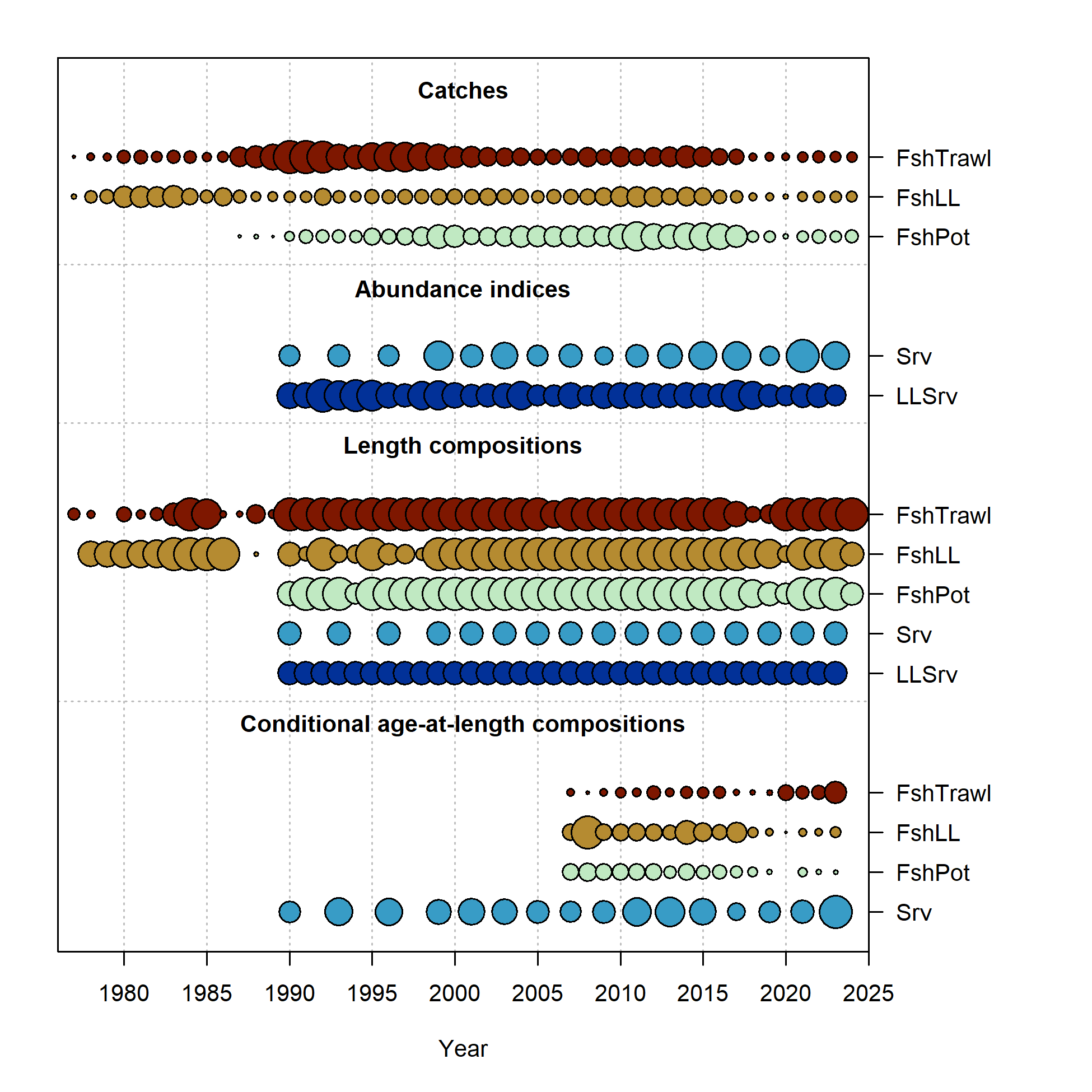
##### Figure 2.5. Observed (Obs) and electronic monitored (EM) commercial catch of Pacific cod in the GOA by 20 km2 grid for 2023. These data include bycatch Pacific cod, but do not include trawl EM data as locations are not yet available.



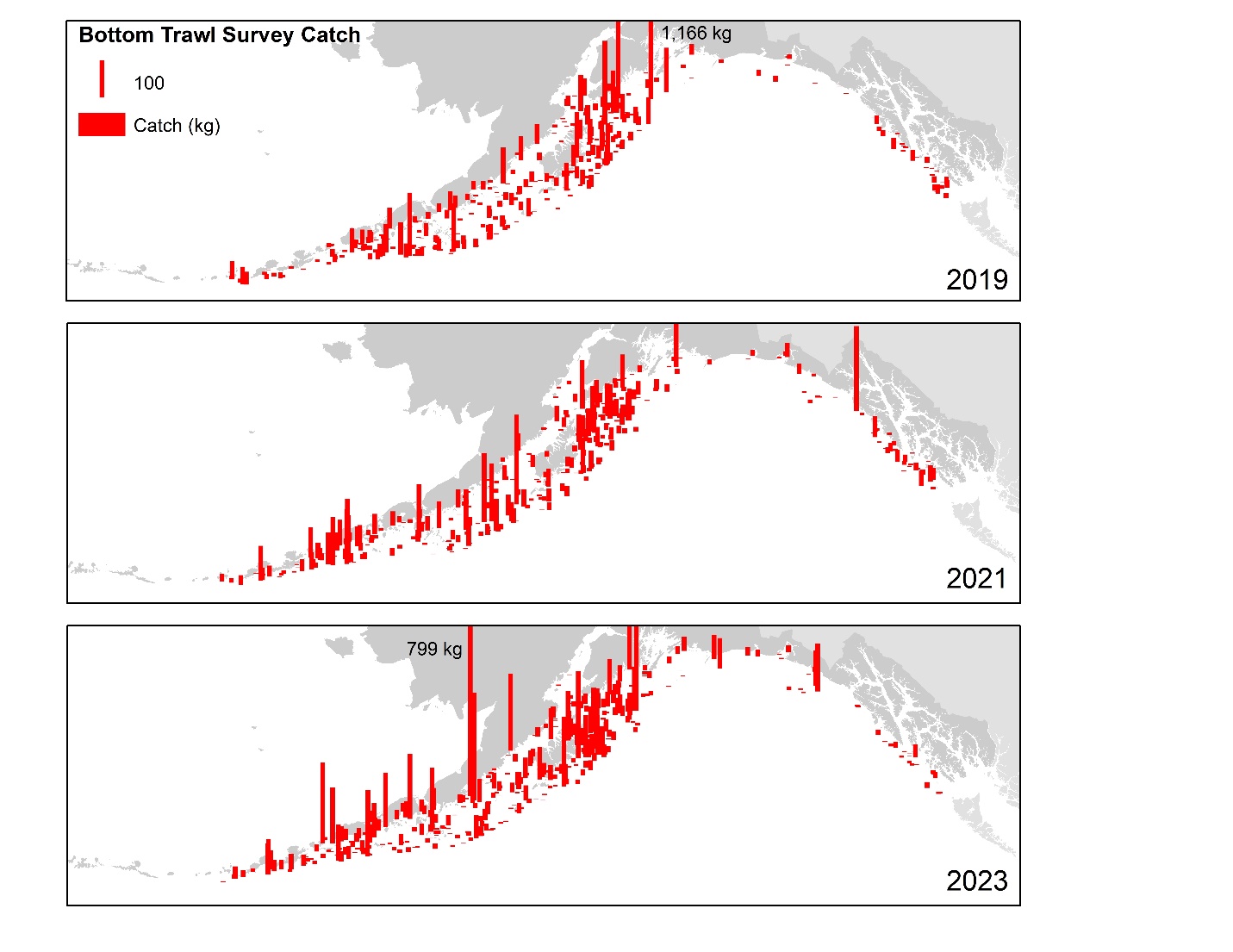
##### Figure 2.8. Cumulative catch week of the year for 2020-2024 by GOA sub-area and fleet (2024 catch through week 43).



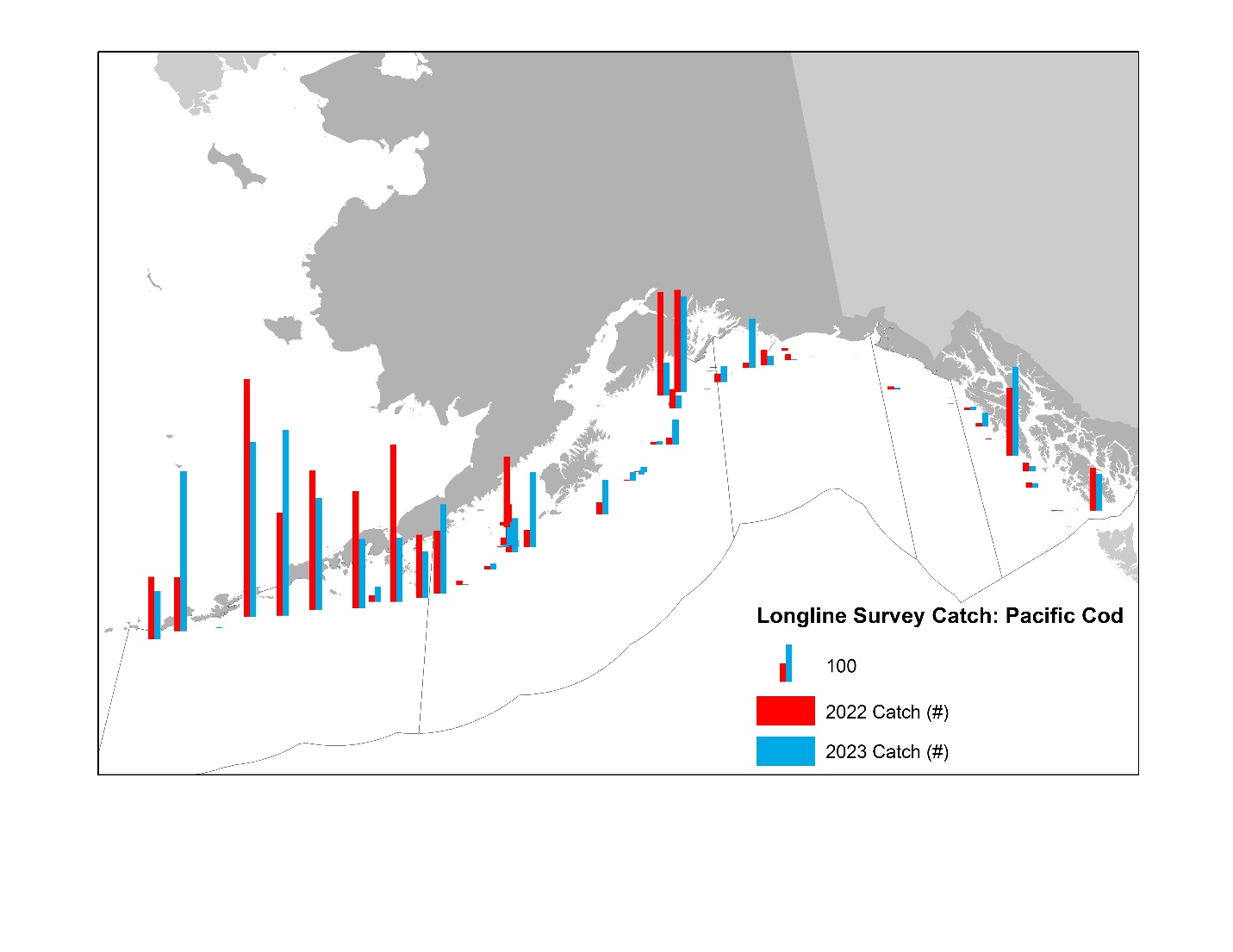
##### Figure 2.9. Auxiliary indices for GOA Pacific cod adult and recruitment abundance. ADFG bottom trawl survey delta-glm density (top left panel) and proportion of Pacific cod bycatch in the GOA shallow water flatfish fishery (bottom left panel) representing indices for adult abundance, and age-0 beach seine survey numbers per haul (top right panel) and proportion of pelagic trawls in the Central GOA A Season (January-April) walleye pollock fishery with Pacific cod present (bottom right panel) representing indices for recruitment.



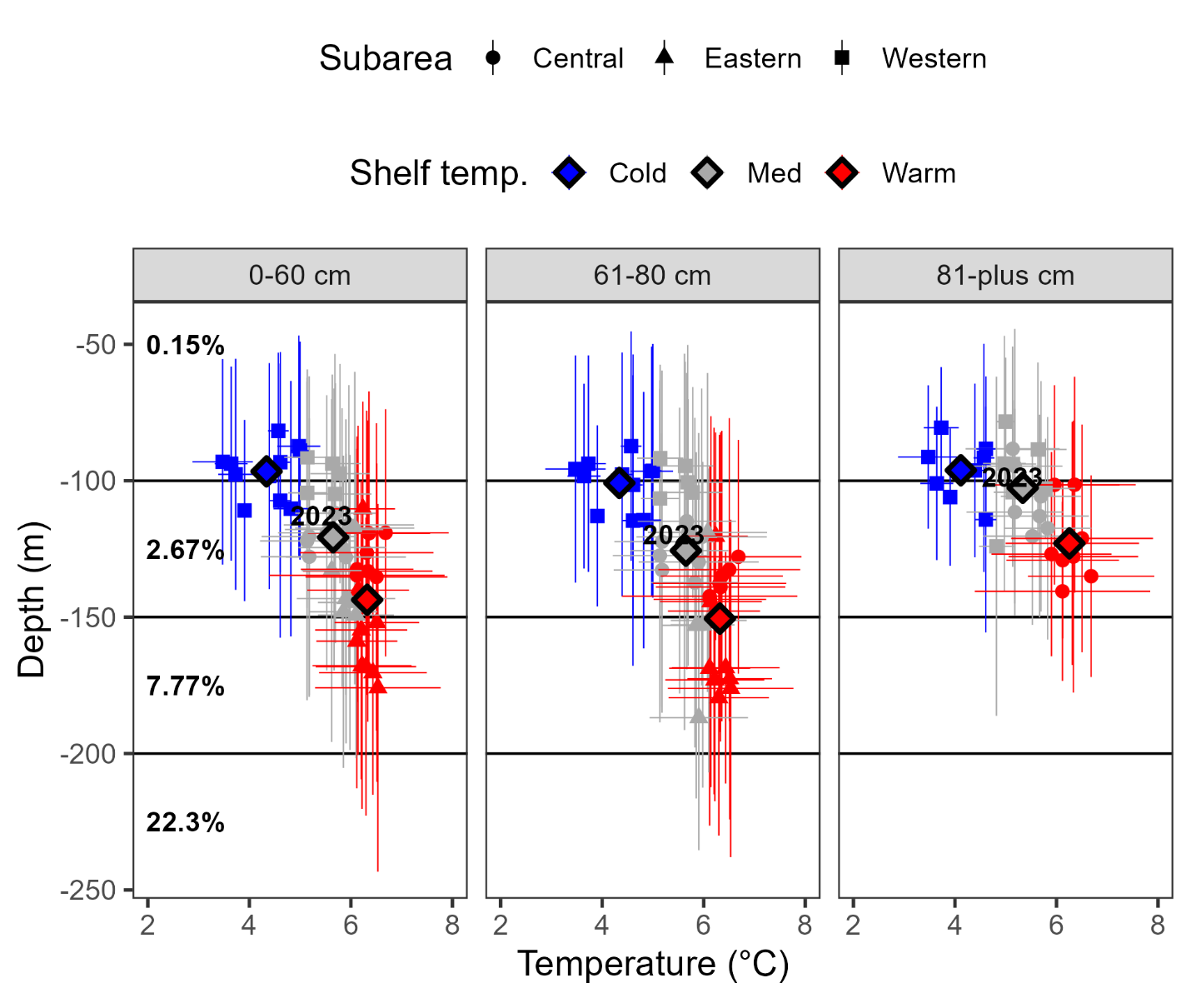
##### Figure 2.10. Data fit in the author’s recommended model. Circles are proportional to total catch for catches, precision for indices and input sample size for compositions and length-at-age observations. Data source include fishery data from trawl (FshTrawl), longline (FshLL), and pot (FshPot) fisheries. Survey data include the AFSC longline (LLSrv) and bottom trawl (Srv) surveys. Note that since the circles are scaled relative to maximum within each type, the plots of scaling across dataset types should not be compared.



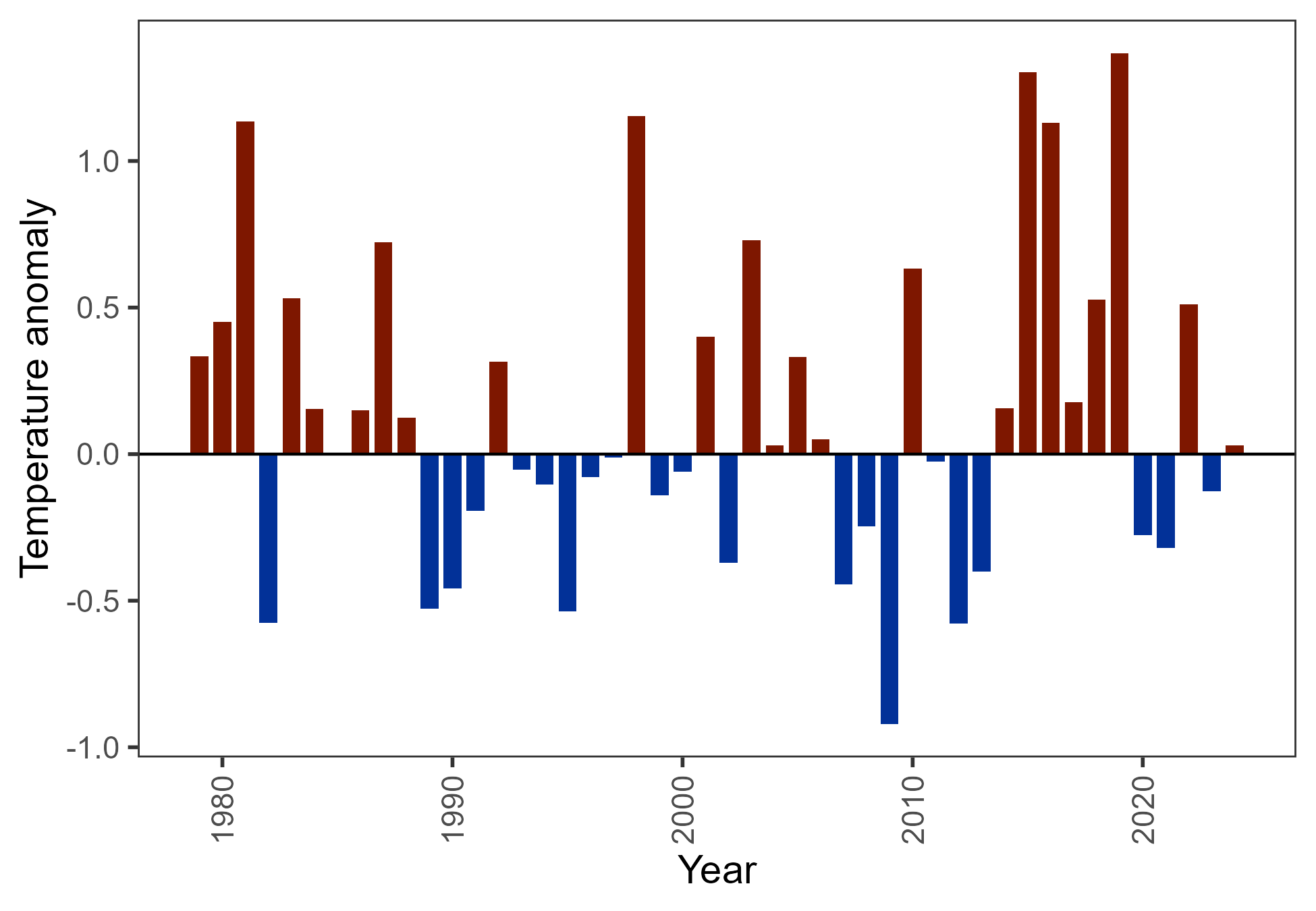
##### Figure 2.11. Distribution of AFSC bottom trawl survey catch (kg) of Pacific cod for 2019-2023.



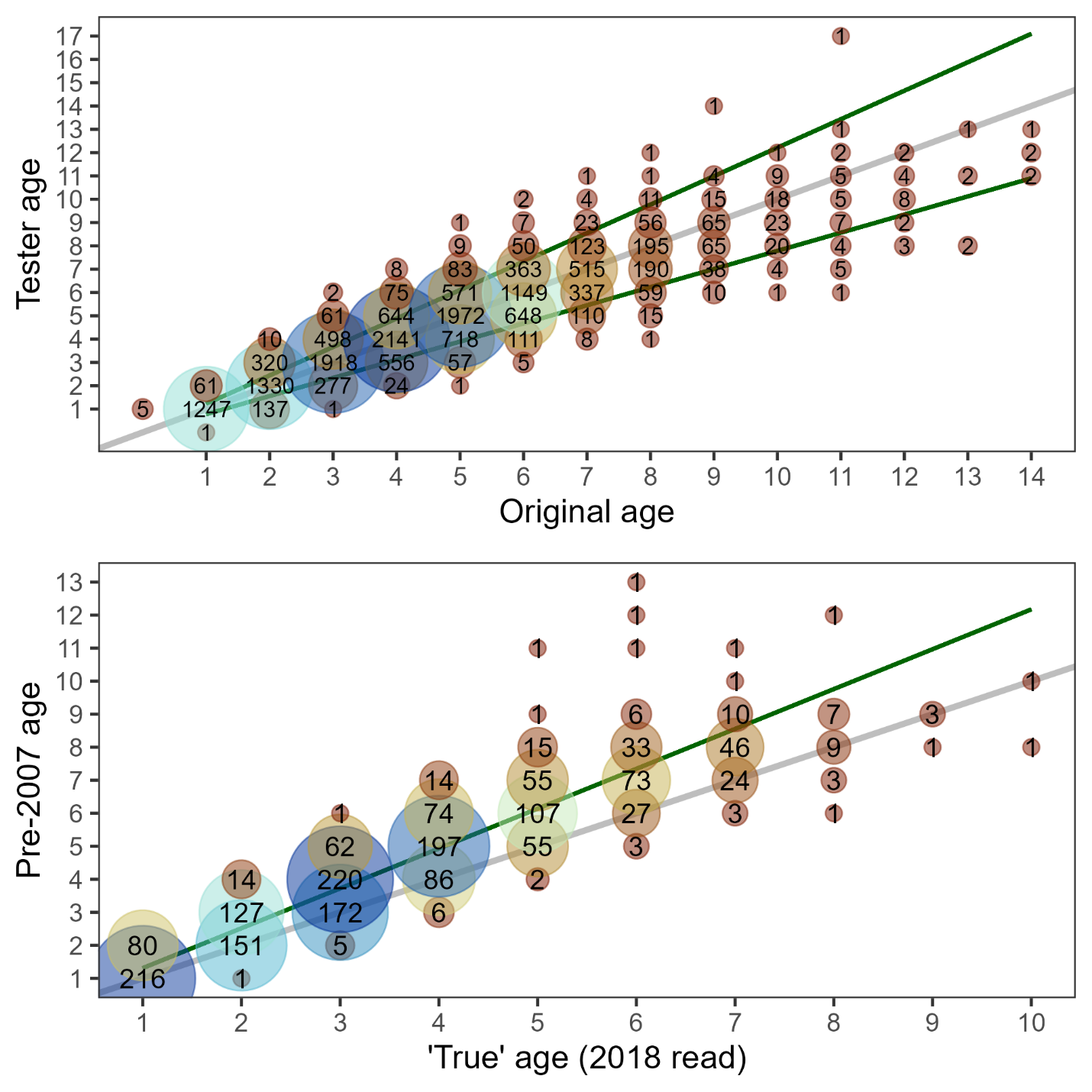
##### Figure 2.12. Distribution of AFSC longline survey catch (numbers) of Pacific cod in 2022 and 2023.



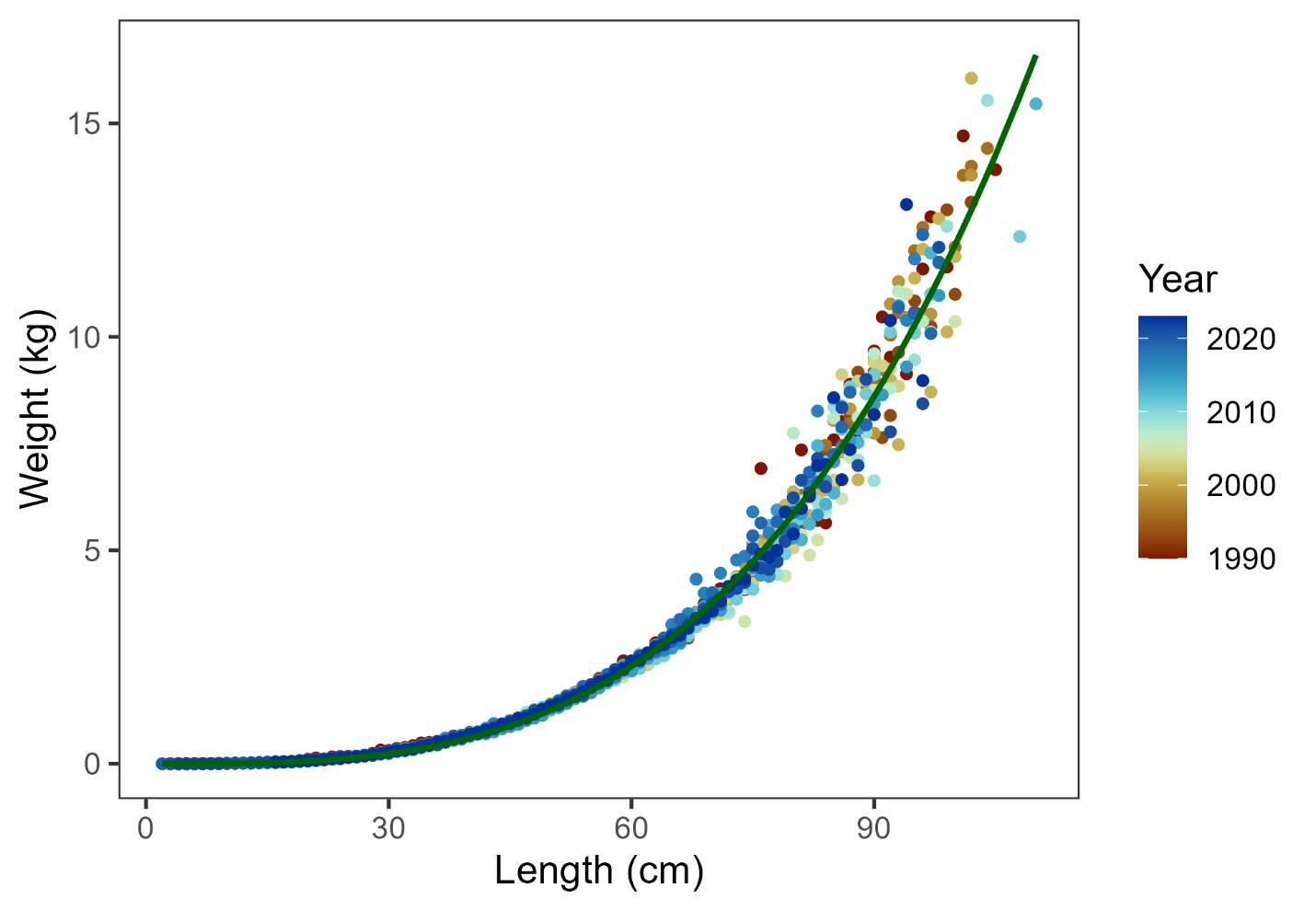
##### Figure 2.13. Area-weighted observed bottom temperature compared to CPUE-weighted depth of Pacific cod from the AFSC bottom trawl survey for different size classes. ‘Cold’, ‘Med’, and ‘Warm’ temperatures are defined as 33% percentiles of observed area-weighted bottom depths. The year of the most recent survey is shown in text, as the average temperature and depth across the Subareas. Horizontal black lines indicate the depth strata for the AFSC longline survey that overlap with GOA Pacific cod depth distribution, and bold black text is the proportion of hatchis deployed by the AFSC longline survey in these depth strata.



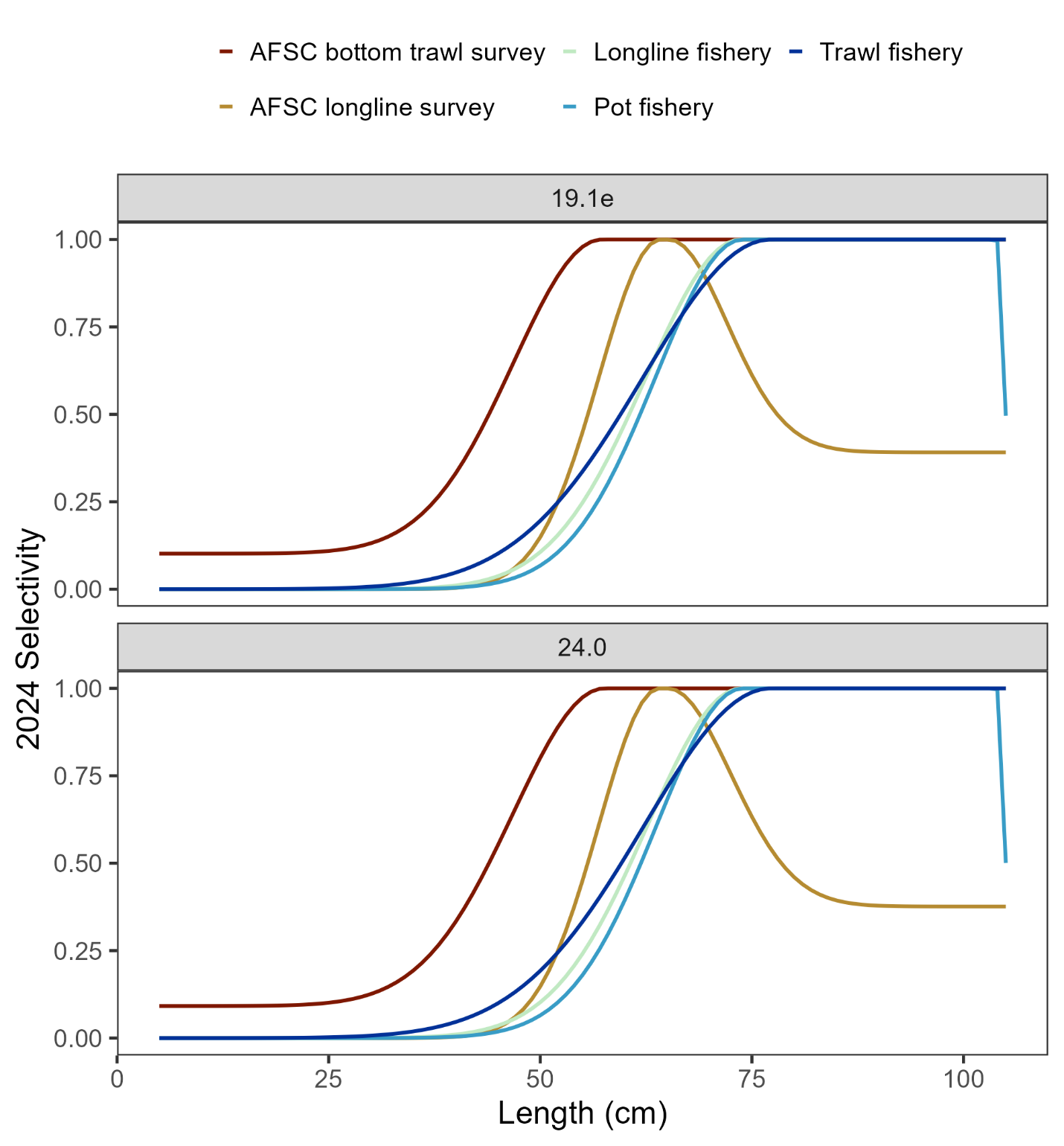
##### Figure 2.14. Climate Forcast System Reanalysis (CFSR) central GOA bottom temperatures anomailies at the AFSC bottom trawl survey mean depths for 0-20 cm Pacific cod in June used as a covariate to the AFSC longline survey catchability.



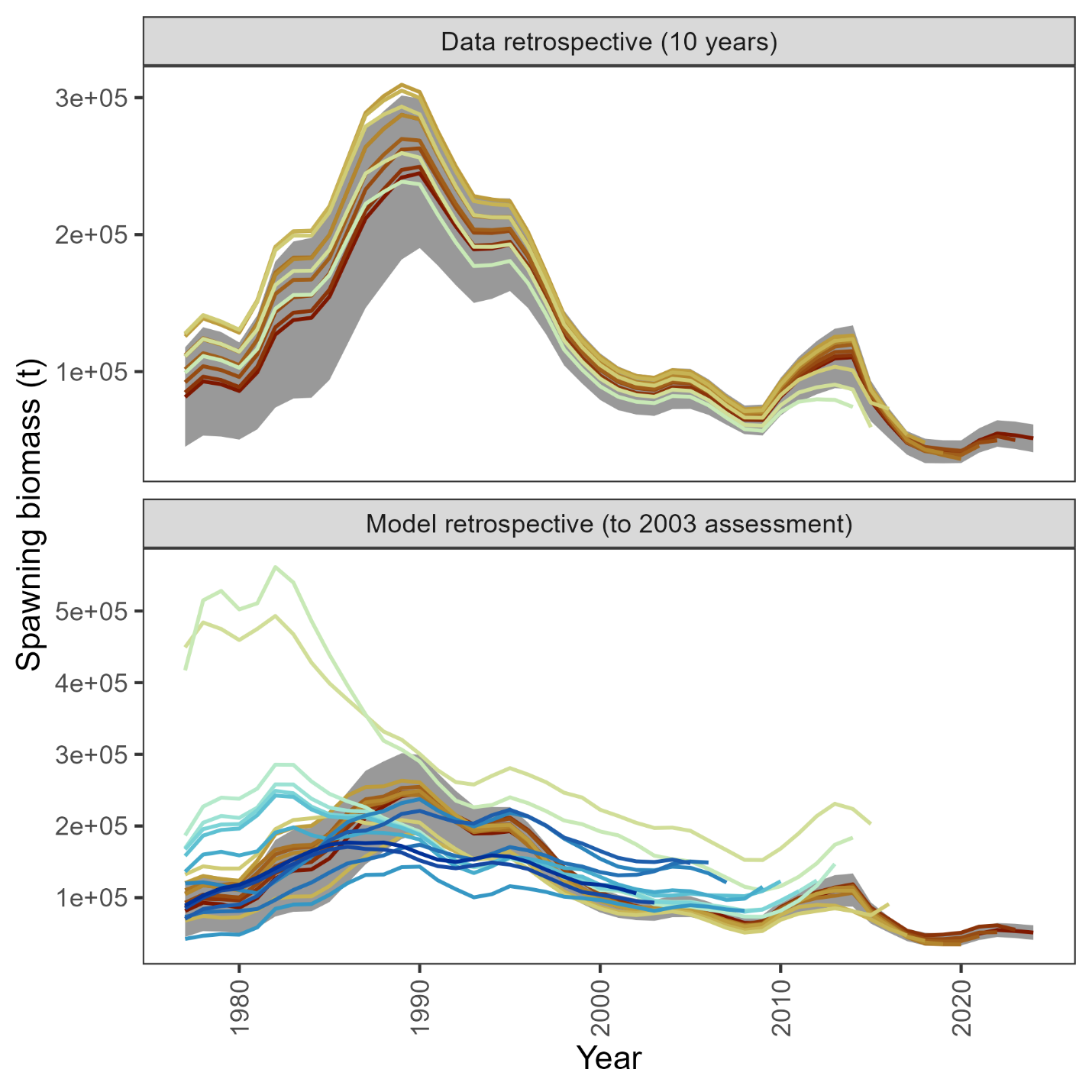
##### Figure 2.15. Reader-tester paired ageing data used to estimate ageing error (top panel) and otoliths read originally in 2007 that were reread in 2018 used to estimate ageing bias (bottom panel). Estimates of uncertainty in age reading (95% confidence intervals) and bias in ageing as estimated by the AgeingError R package are shown with green lines in each panel, one-to-one reference is shown by the grey line in each panel.



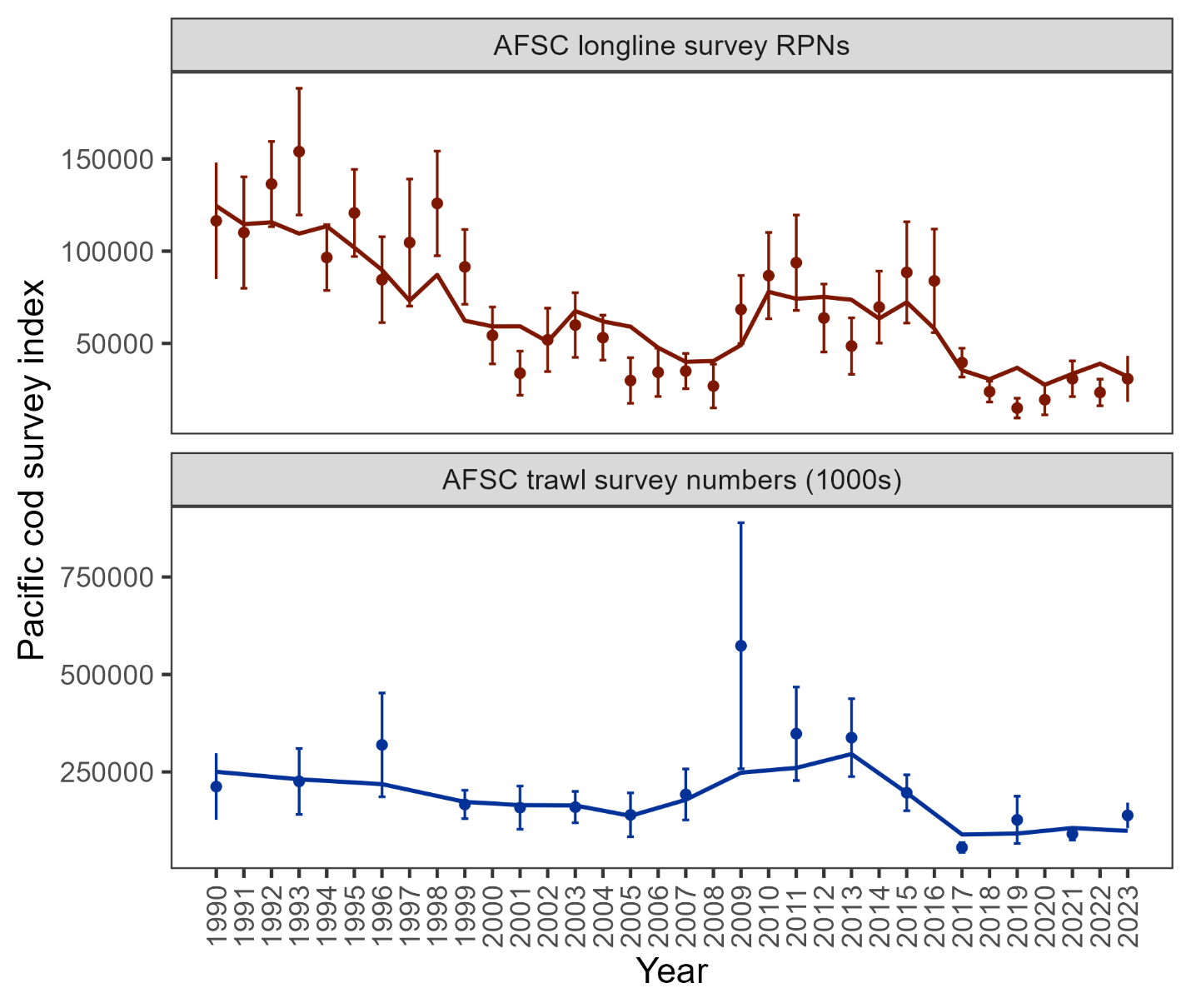
##### Figure 2.16. AFSC bottom trawl survey and age-0 beach seine survey observed weight-at-length (points) and fit used in the recommended assessment shown with the solid green line.



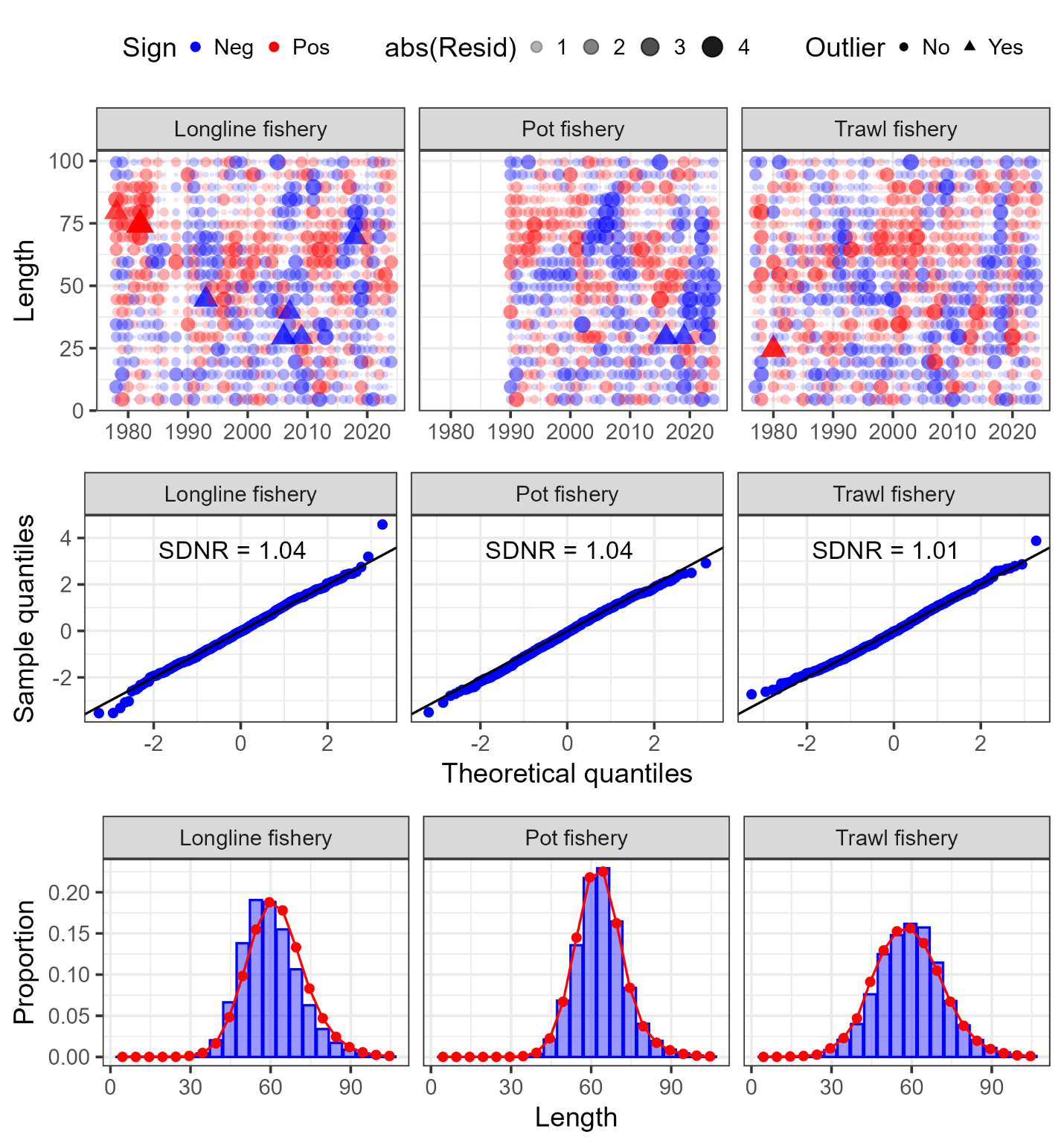
##### Figure 2.19. Comparison among alternative models estimates of current year selectivity with 1 cm length bins (19.1e) and 5 cm length bins (24.0).



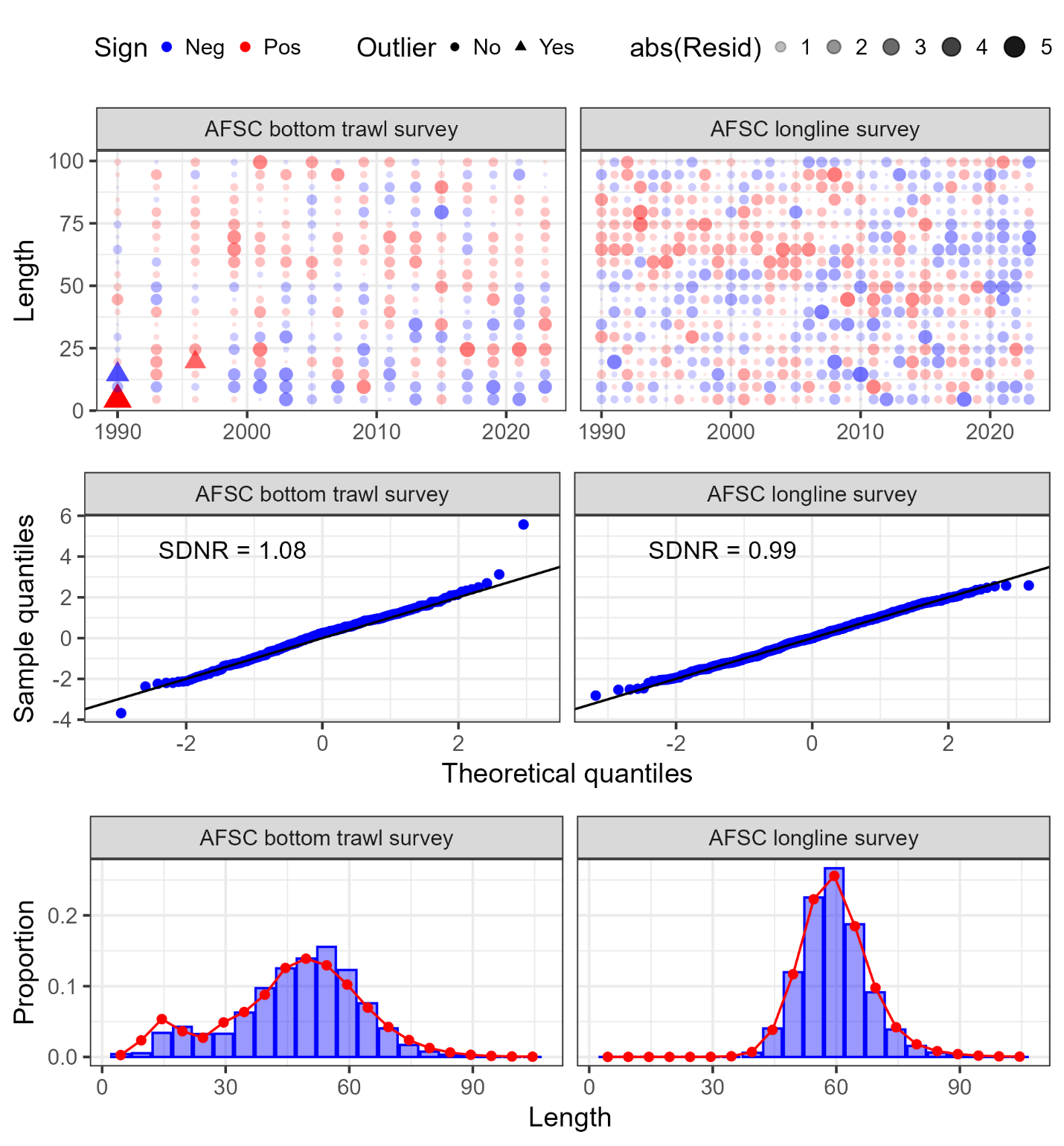
##### Figure 2.20. Retrospective analysis of spawning biomass upon removing data from the author’s recommended model (top panel) and in comparison to previously accepted models (bottom panel). The shaded region is the 95% confidence intervals from the author’s recommended model.



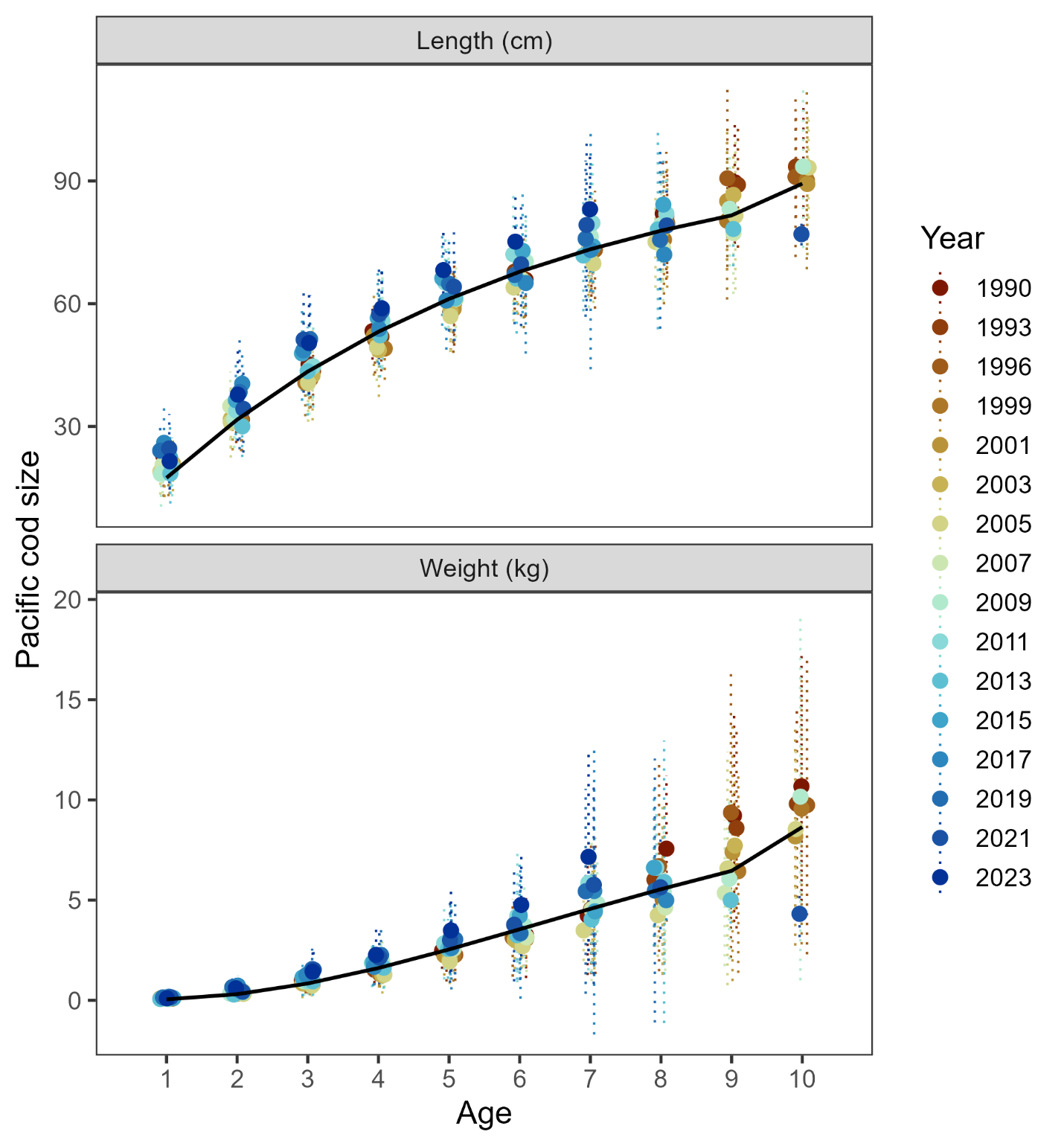
##### Figure 2.25. Population indices fit by the assessment model, including AFSC longline survey relative population numbers (RPN – top panel) and AFSC bottom trawl survey abundance (numbers – bottom panel). Model fit is shown as a solid line and observed data is shown as points (with error bars indicating the 95% confidence intervals).



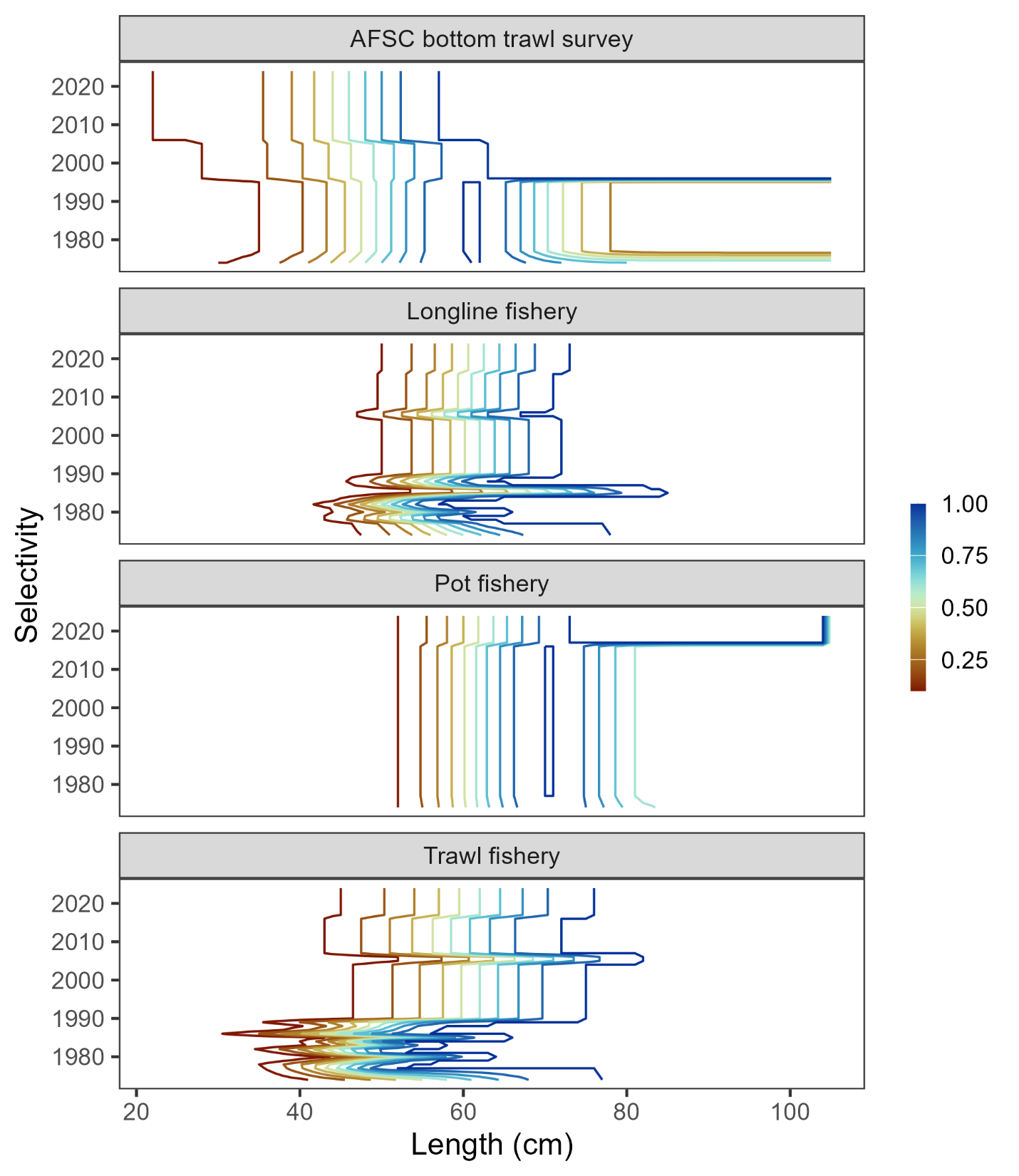
##### Figure 2.26. One-step ahead residuals (top panels), theoretical versus sample quantiles (middle panels), and aggregated model fit (bottom panels) for the fishery length composition data (fleets shown across the columns) fit in the author’s recommended model.



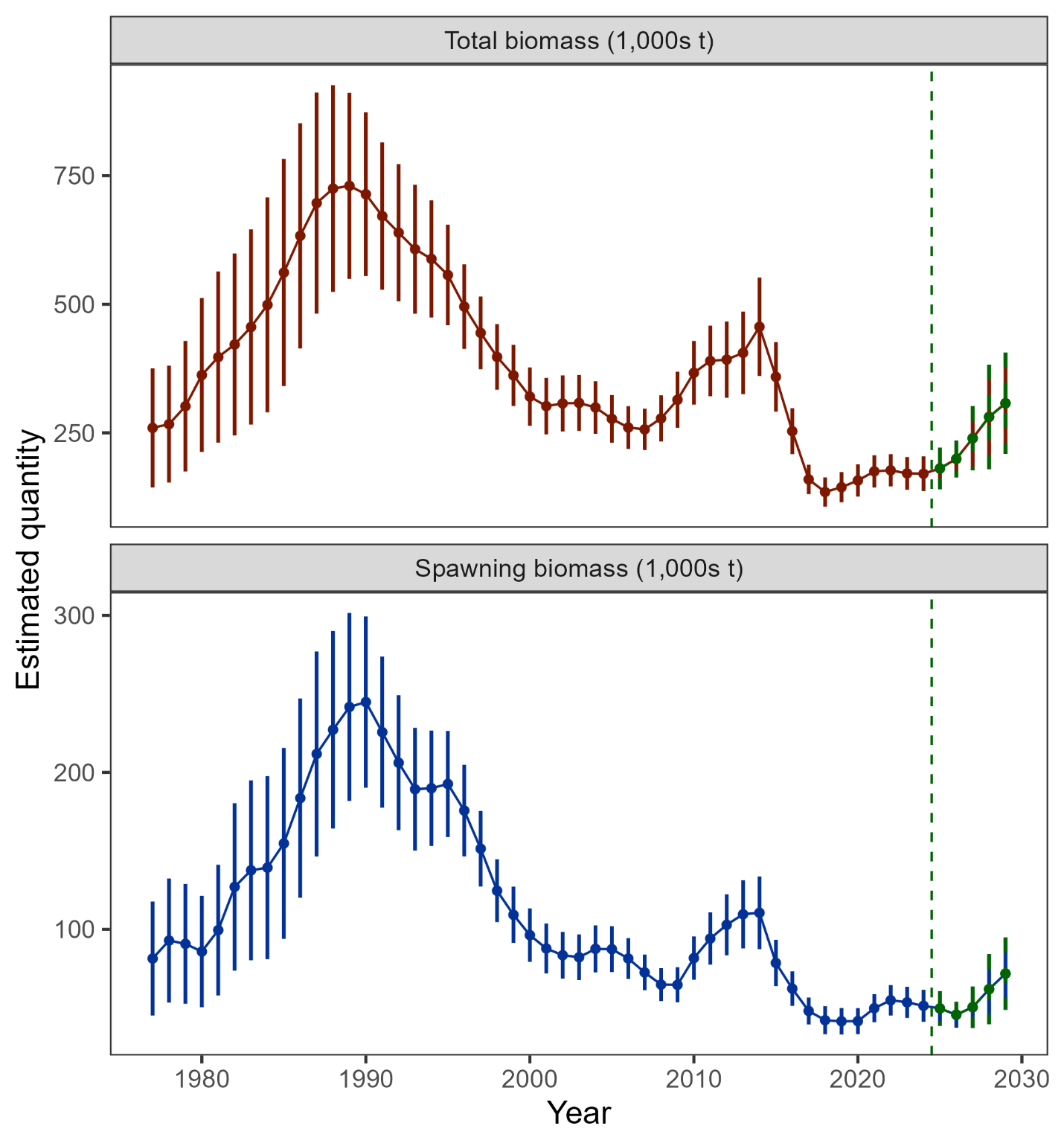
##### Figure 2.27. One-step ahead residuals (top panels), theoretical versus sample quantiles (middle panels), and aggregated model fit (bottom panels) for the survey length composition data (surveys shown across the columns) fit in the author’s recommended model.



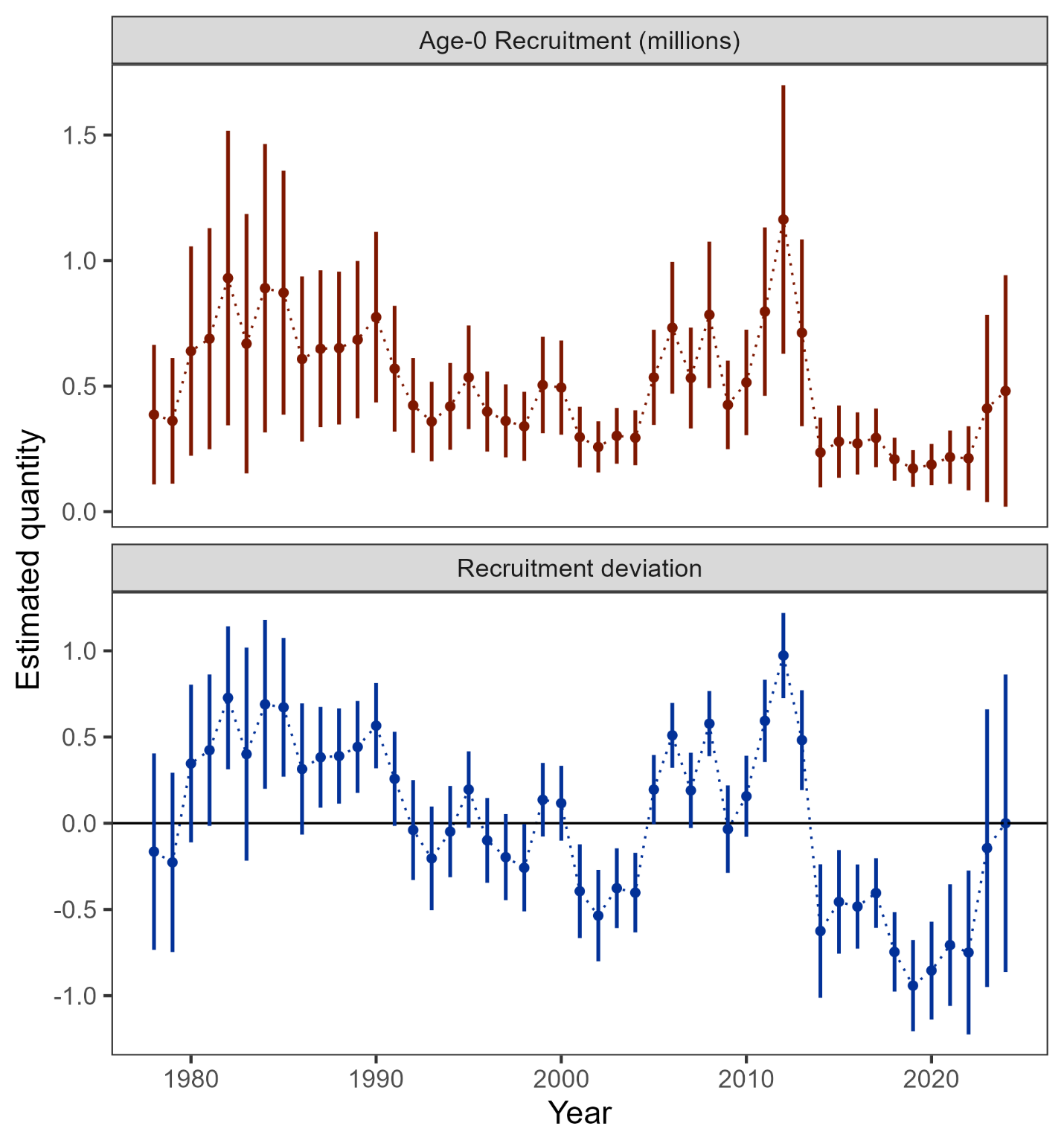
##### Figure 2.29. Author recommended model fit (solid line) to AFSC bottom trawl survey observed mean length-at-age (top panel) and weight-at-age (bottom panel) across the years of the survey (ranges shown are the 95% confidence interval in the yearly mean length or weight).



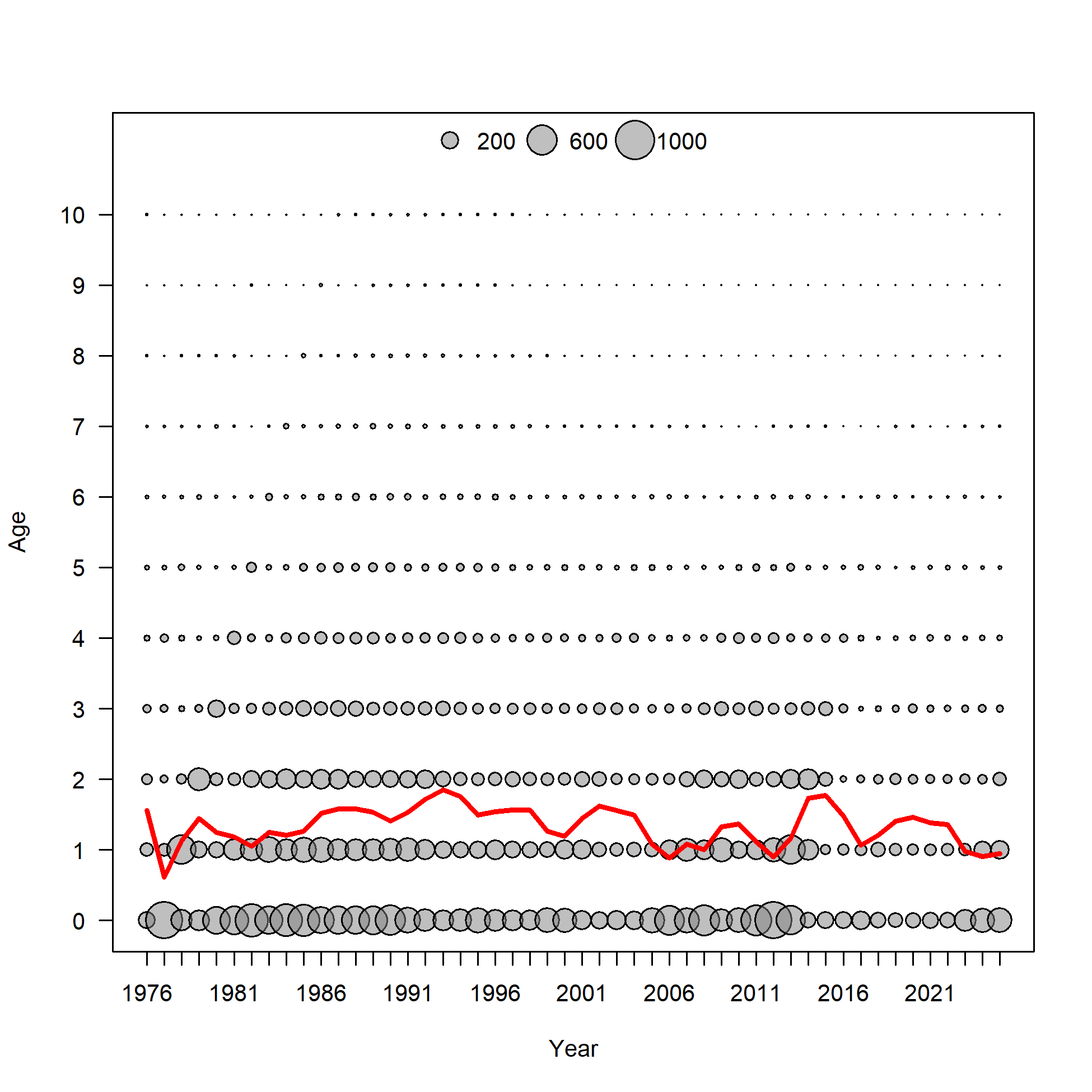
##### Figure 2.30. Estimated selectivity from the author recommended model across time.



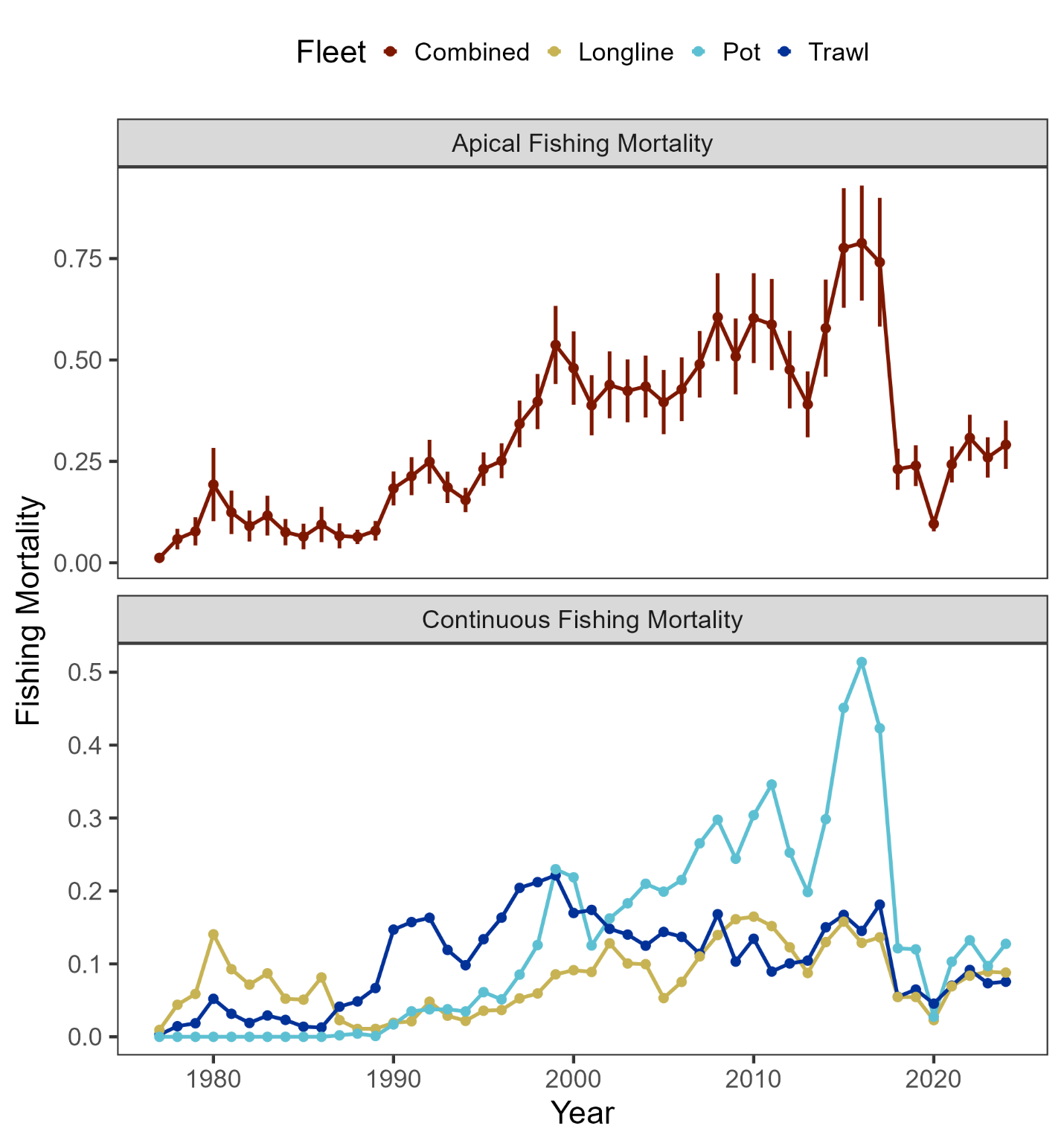
##### Figure 2.31. Estimated total biomass (top panel) and spawning biomass (bottom panel) from the author’s recommended model with 95% confidence intervals. The five-year forecasted biomass values are denoted in green shading and with the vertical dashed line in each plot.

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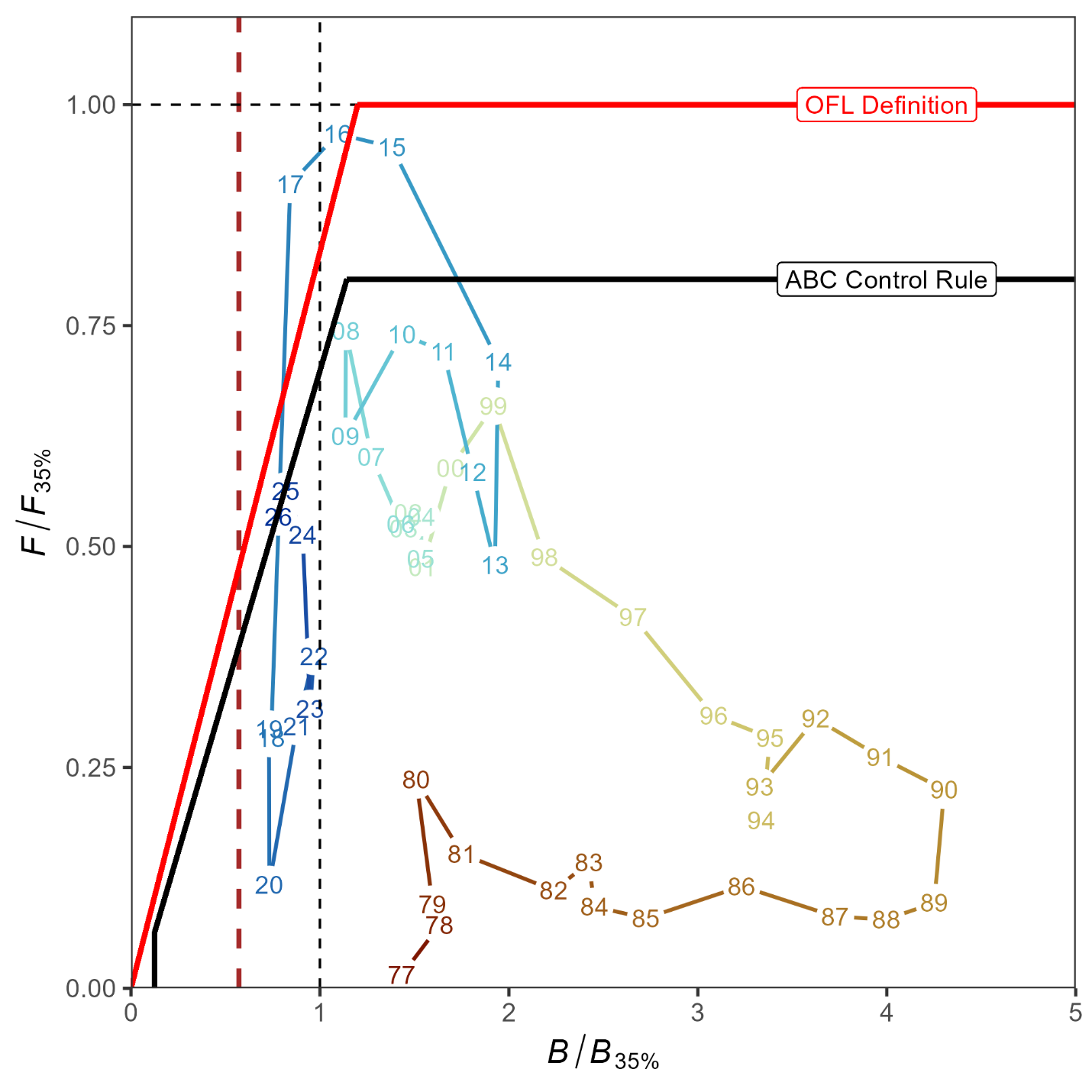
##### Figure 2.32. Age-0 recruitment (top panel) and log recruitment deviations (bottom panel) with 95% confidence intervals from the author’s recommended model.



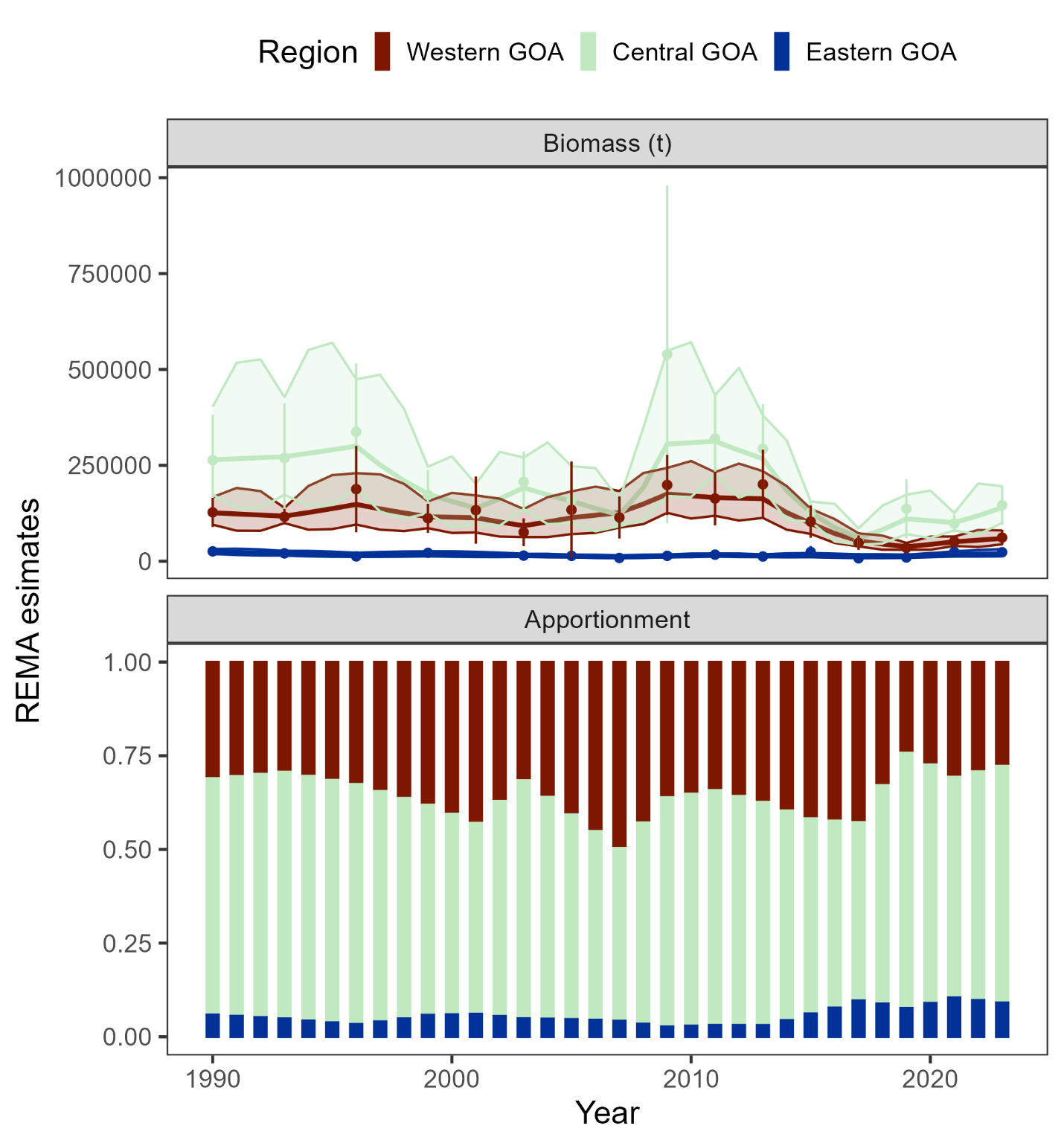
##### Figure 2.33. Predictions of middle of the year number at age with mean age (red line) from the author’s recommended model.



##### Figure 2.34. Sum of apical fishing mortality (top) and continuos fishing mortality by fisheries (bottom) from the author’s recommended model.



##### Figure 2.35. Ratio of historical *F*/*F35%* versus female spawning biomass relative to *B35%* for GOA pacific cod, 1977-2026 from the author’s recommended model. The Fs presented are the sum of the full Fs across fleets. Dashed vertical red line is at B*20%*, Steller sea lion closure rule for GOA Pacific cod.



##### Figure 2.38. REMA results as fit to the AFSC bottom trawl survey by area (top panel) used for apportionment (bottom panel).

# Appendix 2.1 Ecosystem and Socioeconomic Profile of the Pacific cod stock in the Gulf of Alaska - Report Card

The ESP can be found at this [link](https://apps-afsc.fisheries.noaa.gov/Plan_Team/2024/goapcod_app1.pdf).

# Appendix 2.2 Analysis of the Gulf of Alaska Bottom Trawl survey restratification for Pacific cod

Pete Hulson, Steve Barbeaux, and Ingrid Spies

## Executive Summary

To evaluate the restratification…

## Data

Data were used for surveys from 1990…

## Analytic Approach

The design-based approaches were used…

## Results

Reanalysis indicates…

## Literature Cited

Barbeaux. S. J., K. Aydin, B. Fissel, K. Holsman, B. Laurel, W. Palsson, L. Rogers, K. Shotwell, Q. Yang, and S. Zador. 2019. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

Echave, K. B., K. A. Siwicke, J. Sullivan, and B. Ferriss, 2023. Assessment of the Shortraker Rockfish stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

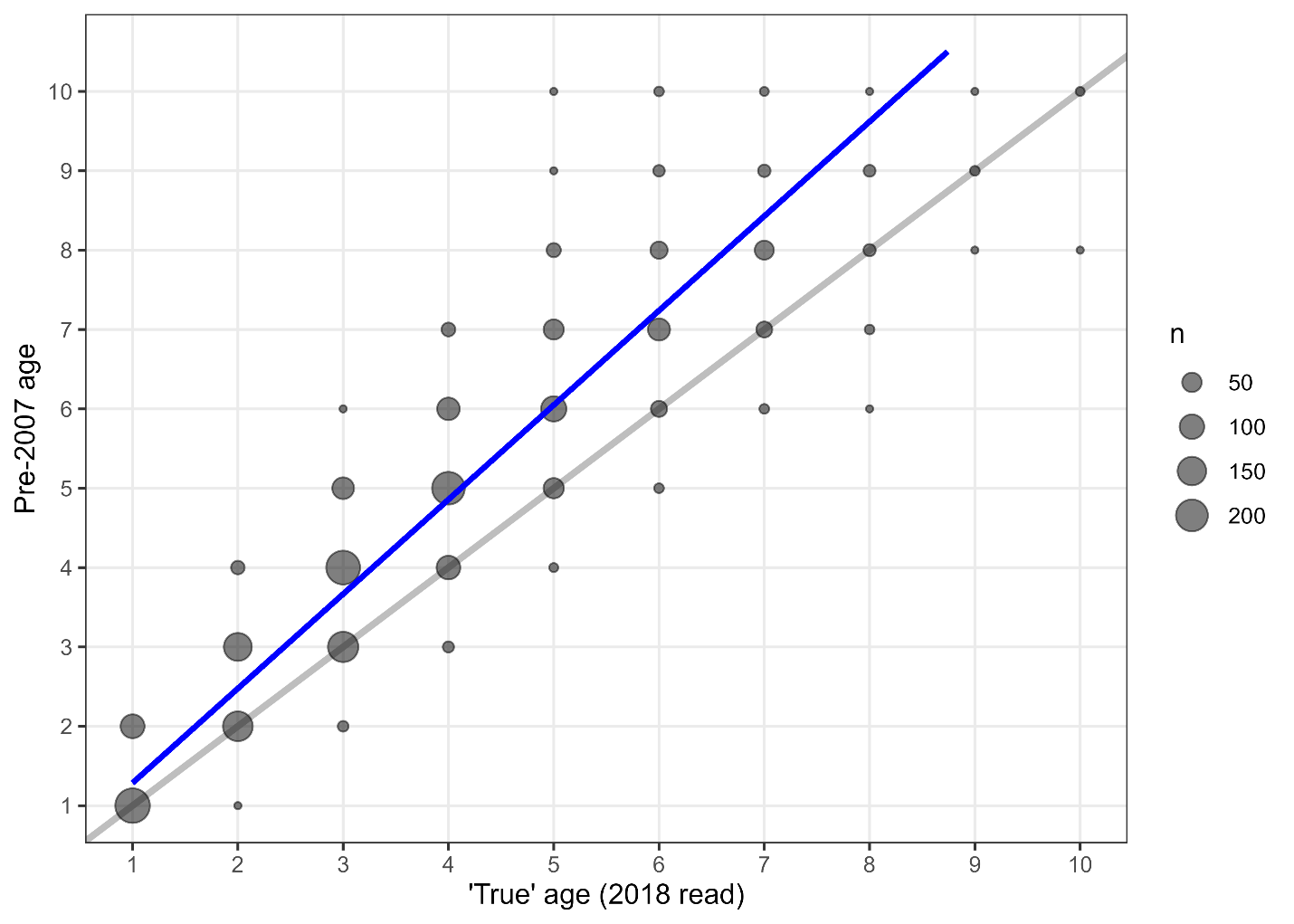
Punt, A.E., Smith, D.C., KrusicGolub, K., Robertson, S., 2008. Quantifying age-reading error for use in fisheries stock assessments, with application to species in Australia’s southern and eastern scalefish and shark fishery. Can. J. Fish. Aquat. Sci. 65 (9), 1991–2005.

## Tables

##### Table 2.2.1. Percent of hauls within fishery length frequency data that sampled less than 10 lengths per haul.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Longline | Pot | Trawl |
| 1991-2012 | 2% | | 4% | 3% |
| 2013 | 12% | | 12% | 2% |
| 2014 | 6% | | 14% | 5% |
| 2015 | 5% | | 8% | 4% |
| 2016 | 13% | | 10% | 4% |
| 2017 | 12% | | 12% | 20% |
| 2018 | 23% | | 6% | 6% |
| 2019 | 22% | | 10% | 6% |
| 2020 | 60% | | -- | 79% |
| 2021 | 20% | | 14% | 72% |
| 2022 | 6% | | 30% | 76% |
| 2023 | 34% | | 36% | 68% |

## Figures



##### Figure 2.2.1. AgeingError R-package fit (blue line) to 2018 ageing compared to pre-2007 ageing (bubbles, with size indicating the number of times the particular age in 2018 matched the age pre-2007; grey line is 1-1 and shown for reference).