2A. Assessment of the Pacific cod stock in the Aleutian Islands

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Executive summary

The Aleutian Islands (AI) and eastern Bering Sea (EBS) Pacific cod stocks were first managed separately in 2014. Since 2014, age-structured models have been explored in assessments but harvest specifications for Aleutian Islands (AI) Pacific cod have been managed under Tier 5. This document presents three age structured models for the Aleutian Islands Pacific cod stock, as well as two Tier 5 harvest specification models.

Age structured models:

- Model 24.1: This model includes a timeblock on natural mortality from 2016 - 2024. The breakpoint between 2015 and 2016 corresponds to a shift to warmer temperatures in the Aleutian Islands during the past decade (Xiao and Ren 2022). This is the preferred model.
- Model 24.0: This is a sensitivity model, which is similar to Model 24.1 but does not contain the natural mortality timeblock from 2016-2024.
- Model 24.1a: This model shows sensitivity to the Richards vs. von Bertalanffy growth curves. It differs from Model 24.1 in its growth curve, using the von Bertalanffy rather than the Richards growth curve.

Tier 5 random effects model:

- Model 13.4: There has been no change to the input data for the Tier 5 models; they use existing biomass estimates from 1991 - 2024 implemented using the REMA package. The natural mortality estimate ($M = 0.34$) used in past models is retained for 2024.
- Model 24.2: This is the same Tier 5 model as 13.4, except it assumes natural mortality, $M = 0.417$. This is the preferred Tier 5 model because it assumes a new externally estimated natural mortality requested by the SSC and Plan Team in 2023.

Summary of changes in assessment inputs

The following substantive changes have been made to the Aleutian Islands Pacific cod age structured assessment relative to the November 2023 assessment.

Changes in the input data (Tier 3 models)

- Realized catches for 2023, as well as a preliminary catch estimate through September 22, 2024. The current year's catch was projected to the end of the year based on the proportion caught over the past 5 years after this the period prior to September 22.
- Commercial fishery size compositions for 2023, as well as preliminary size composition from the 2024 commercial fisheries through September 22.
- The 2024 survey biomass index and error estimates are incorporated, as well as the 2024 length compositions and estimate of survey input sample size.
- The maturity curve was updated through September 2024 with observer records of maturity at length.
- The fishery length composition sample sizes were updated with the number of hauls per year, weighted such that the mean is equivalent to the mean survey input sample size.

Changes in the input data (Tier 5 model)

- The Tier 5 model uses survey biomass estimates from 1991 - 2024.
- Model 24.2 incorporates a new fixed M, 0.417.

Changes in the assessment methodology

- Initial F was estimated based on the average catch from 1981-1990.
- Natural mortality was estimated externally using (http://barefootecologist.com.au/shiny_m.html) and fixed at 0.417, except in Model 24.1 after 2015 (which incorporated a time block on natural mortality), in response to SSC comments.
- The timeblock on natural mortality from 2016-2024 (Model 24.1) was estimated.
- A Richards growth curve was estimated within the models, except Model 24.1a which used the von Bertalanffy growth curve.
- Maximum age was changed from 10^+ to 13^+.
- Fishery length composition did not incorporate a plus group (max = 143 cm) whereas previous models used a plus group of 117^+ cm.
- The time of settlement was changed to indicate that larvae settle as juveniles in the same year as spawning, rather than in the following year, for biological accuracy and consistency with other cod models.

Summary of Results

The 2024 catch of Pacific cod in the Aleutian Islands as of September 22, 2024 was 3,570 t. Over the past 5 years (2019 - 2023), 76.3% of the catch has taken place by this date. Therefore, the full year's estimate of catch in 2024 was extrapolated to be 4,676 t. This is lower than the average catch over the past five years of 13,435 t.

Model 24.1 improved the fit to the data over Model 24.0. Model 24.1 estimated a total biomass of 73,679 t, a spawning biomass of 25,078 t, and an exploitable biomass of 58,208 t for 2025. Model 24.1 ABCs were 13,376 t and 12,973 t for 2025 and 2026. Model 24.1 OFLs were 16,782 t and 16,273 t for 2025 and 2026 (Table 2A.1).

The random effects model which estimated biomass used in Tier 5 models 13.4 and 24.2 estimated an exploitable biomass of 51,504 t. This is comparable with the exploitable survey biomass estimated by Model 24.1 (58,208 t). The Model 13.4 Tier 5 ABCs and OFLs for 2025 and 2026 are 13,133 t and 17,511 t (Table 2A.2). Note the Tier 5 ABCs and OFLs are the same for 2025 and 2026. The Tier 5 Model 24.2 estimated higher OFLs (21,477 t) and ABCs (16,107 t) for 2025 and 2026 due to the higher natural mortality parameter (Table 2A.2).

We prefer adopting the Tier 3 model 24.1 for ABC/OFL and status determimation advice under the FMP. This model makes use of more information (fishery and survey lengths, survey ages, maturity curve) and allows the Council to have clear advice on the status of this important stock. We recommend a reduction in ABC for the Tier 5 model to the Tier 3 recommended ABC.

Summary table for Model 24.2. The Tier 5 Model 13.4 was the accepted model in 2023.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2024	2025	2025	2026
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	5	5	5	5
Biomass (t)	54,165	54,165	51,503	51,503
F_{OFL}	0.34	0.34	0.417	0.417
$maxF_{ABC}$	0.255	0.255	0.313	0.313
F_{ABC}	0.255	0.255	0.313	0.313
OFL	18,416	18,416	21,477	21,477
$maxABC$	12,431	12,431	16,107	16,107
ABC	12,431	12,431	13,376	12,973
Status	2022	2023	2023	2024
Overfishing	No	n/a	No	n/a

Summary table for Model 24.1. The Tier 5 Model 13.4 was the accepted model in 2023. *Natural mortality estimated within 2016-2024 timeblock.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2024	2025	2025	2026
M (natural mortality rate)	0.34	0.34	0.42, 0.57*	0.42, 0.57*
Tier	5	5	3b	3b
Projected total (age 1+) biomass (t)	54,165	54,165	73,679	77,731
Projected female spawning biomass (t)	-	-	25,078	24,729
$B_{100\%}$	-	-	102,361	102,361
$B_{40\%}$	-	-	40,944	40,944
$B_{35\%}$	-	-	35,826	35,826
F_{OFL}	0.34	0.34	0.655	0.645
$maxF_{ABC}$	0.255	0.255	0.502	0.494
F_{ABC}	0.255	0.255	0.502	0.494
OFL	18,416	18,416	16,782	16,273
$maxABC$	12,431	12,431	13,376	12,973
ABC	12,431	12,431	13,376	12,973
Status	2022	2023	2023	2024
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Responses to SSC and Plan Team Comments on Assessments in General

SSC October 2023

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

Response

We have incorporated OSA residuals in this assessment.

SSC December 2023

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

Response

Noted.

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC December 2023

When estimating catch for projections, a more realistic value than maxABC should be considered, given that maxABC has not been achieved in recent years.

Response

We used 0.4*maxF_{ABC} for all future years, which yields F = 0.201 for all future years for Model 24.1, F = 0.288 for Model 24.1a, and F = 0.333 for Model 24.0. This is much lower than the 2031 - 2039 F_{ABC} = 0.804 in Scenario 1 for Model 24.1, F_{ABC} = 1.156 for Model 24.1a, and F_{ABC} = 0.813 for Model 24.0.

SSC December 2023

The SSC recommends a sensitivity analysis and a possible prior on M. It is surprising that estimating M was difficult in the data-rich EBS Pacific cod assessment, but estimating M in the AI cod assessment was successful with fewer data points. The SSC encourages further collaboration among authors of the three cod assessments with regard to the treatment of M.

Plan Team September 2023

The Plan Team favors constraining M. They recommend M with a prior based on a reasonable approach.

Response to the two comments above in regard to M

Based on further collaboration among cod assessment authors with regard to the treatment of M, we have estimated M outside the model using the *Then_lm* methodology (http://barefootecologist.com.au/shiny_m.html), which resulted in a value of 0.417. A sensitivity was performed (Table 2A.3), and results are discussed below.

SSC December 2023

Public comment further highlighted challenges with the risk table. Elevated risk was identified but a recommended reduction from maximum ABC or rationale for no reduction was not presented for the base model. Their view was that AI cod have declined within the AI region, though they were uncertain as to the magnitude of the decline.

Response

In the 2024 assessment we have the same Risk Table scores as in 2023 (see Risk Table section). We recommend a reduction in ABC for the Tier 5 model to the Tier 3 recommended ABC.

SSC December 2023

Fishery CPUE would be more appropriate to consider under fishery performance in the risk table.

Response

Fishery CPUE is not indicative of abundance or stock status. Declines in CPUE may be attributed to the timing of the fishery relative to spawning season or other factors such as hyperaggregation during spawning in the trawl fishery (Rose and Kulka 1999). Standardized surveys are needed to understand whether declines in fishery CPUE are indicative of declines or increases in Aleutian Islands Pacific cod stock size.

SSC December 2023

There were three parameters for natural mortality (M) where only two were required. This is confusing and might have influenced the model results in ambiguous ways that were not fully described in the document. Standard practice would be to estimate two lognormal parameters for the two M blocks.

Response

The M timeblock in Model 24.1 is now estimated using only a single parameter as suggested.

SSC December 2023

Similarly, there were three parameters estimated for time varying growth where only two were required. As a result, the SSC has the same concerns as noted in the previous bullet. In addition, the author presented a slide showing almost identical growth coefficients for time varying kappa in two periods, suggesting that time-varying growth may not be needed.

Response

Time-varying growth was removed from the model based on this suggestion.

SSC December 2023

The 'q sensitivity' model, where q is calculated analytically but was almost identical to the estimated value, resulted in significant impacts on model results, indicating potential convergence issues or other inconsistencies in the model.

Response

Noted. This statement was in reference to the 2023 assessment. There have been numerous changes and improvements to the model since 2023. Table 2A.3 lists eight changes and details bridging model analysis towards the final recommended model.

SSC December 2023

The SSC recommends that the authors present a simplified version of the original September 23.0 model with minimal time varying parameters alongside a preferred model or set of models in September 2024.

Response

Based on this comment, Model 24.0 is provided which represents a simplified version of the September 23.0 model.

SSC December 2023

In the ESR, the need for an indicator of winter bottom temperature during spawning was noted, possibly derived from winter fisheries data, to assess potential detrimental effects of high temperatures in the AI on spawning and egg survival.

Response

The ESR group indicated that reliable bottom temperatures in the Aleutians in winter is difficult. The ROMS model does not capture the Aleutians, which would require observational data, which is infrequent and may not be properly calibrated.

For the future, the marine mammal laboratory at AFSC has placed a mooring at Unimak Pass for 3 years which could provide bottom temperature throughout the year. This data is not available currently. In addition, bottom temperatures in some regions remain relatively constant year round so that summer data could serve as a potential indicator.

SSC December 2023

Although the SSC previously recommended that AI Pacific cod be on an annual cycle, the SSC welcomes author and GPT feedback on whether moving to a biennial assessment would be beneficial to allow for more model development time, while coinciding with new AI survey data. Because 2024 will have a new survey, this consideration for a biennial cycle could begin after 2024, especially if a Tier 3 model is accepted in 2024.

Response

Noted.

SSC October 2024

One change that was unexpectedly impactful was the move to the Richard's growth curve. As the BSAI GPT noted, the change in likelihood between the model with the LVB growth and the model with the Richard's growth curves was quite substantial, given that the change represented the addition of one parameter only and the difference in shape of the two growth curves was fairly similar. The SSC concurs with the BSAI GPTs recommendation to explore how such a large improvement in likelihood occurred despite similar growth curves.

Response

The substantial change was a result of the bridging method, and is addressed in Results of Tier 3 models. In a new set of bridging models, the Richards growth curve still provides a better fit to the data, but the improvement is closer to what would be expected.

SSC October 2024

The presentation to the BSAI GPT highlighted disparities in the conditional age at length fits at larger ages, but this was not discussed in the document. The SSC would appreciate some written evaluation of this in the final 2024 SAFE document.

Response

Conditional age at length plots and discussion have been added to this document.

SSC October 2024

The BSAI GPT endorsed bringing forward models 24.1, 24.0, and Tier 5 models for November, recommending an additional bridging model 24.1a, which uses von Bertalanffy growth instead of the Richard's curve. The SSC concurs with this recommendation and suggests an additional model run below.

Response

We have incorporated this request into the 2024 assessment.

SSC October 2024

While the use of the Richard's curve resulted in the most dramatic change in the likelihood, an important new feature of Model 24.1 was the inclusion of a natural mortality block. The SSC appreciates the author's effort at incorporating climate related parameters, but the current parameterization assumes that there is a distinct mechanism identified for the natural mortality block and that it is consistent over time without an identified threshold for returning to baseline natural mortality. The temperature thresholds identified in Laurel and Rogers (2020) point to hatch success having a narrow optimum temperature range. If hatch success was the main driver, then the SSC suggests it might be more appropriate to consider a recruitment covariate that utilizes bottom temperature predictions at the time of spawning based upon ROMS or future CEFI models. Additionally, if the higher mortality affects young ages or all ages, then the rationale for the two year lag becomes unclear. The higher temperatures in the AI are also lower than what were identified as high temperatures in the GOA. Regardless, future efforts could be enhanced by tying parameters to a specific covariate which would adjust to baseline when it returns to "normal". Thus the SSC recommends one additional model "24.0b" which removes the block on M and uses the LVB growth model as a simpler but improved model from last year as an alternative. The SSC appreciates the climate related explorations and welcomes future efforts to include environmental covariates.

Response

This new model ("24.0b") was not presented due to the short turnaround between the October 2024 SSC meeting and the November assessment deadlines. We note that Model 24.0b would likely not be considered for management because it would removes two features that have been shown to deteriorate the fit to the data.

We acknowledge that we do not fully understand the physiological effect that a prolonged heatwave would have on natural mortality in Aleutian Islands Pacific cod. Recent experimental work indicates that Pacific cod early life stages are sensitive to warming, negatively impacting survival rates from the embryo through juvenile stages (Laurel et al. 2023). Larval hatch rate decreases with temperature above the optimal range for incubation (Laurel and Rogers 2020), and survival from hatch to the post-flexion stage is considerably lower in warming (Slesinger et al. 2024). Juveniles, while more tolerant of warming, have reduced condition and liver lipid content, which is a critical energy source that is likely to affect overwintering success (Copeman et al. 2022). We acknowledge that if hatch success is a driver of natural mortality, then an environmentally-linked recruitment covariate may be appropriate for future research.

We also acknowledge that heat stress has been shown to increase bioenergetic consumption rates, and that prey may become a limiting factor after prolonged periods of high temperature, which can result in higher mortality rates. Below average length-weight residuals have been observed in Aleutian Islands Pacific cod in all regions since 2012 (Figure 2A.1). The observations of lower fish condition, heatwave conditions, and decline in survey estimates of biomass are consistent with the hypothesis that high temperatures have imposed a cumulative stress effect on cod in the Aleutian Islands, resulting in climate-induced mortality. The natural mortality timeblock in Model 24.1 provides a better fit to the data. While this does not represent a comprehensive understanding of the effect of heat stress on Aleutian Islands Pacific cod, Model 24.1 is an improvement over Model 24.0.

We agree that future efforts should tie parameters to a specific covariate which would adjust to baseline when it returns to "normal". This is an aspect of the Model 24.1 that will improve with more time and data. If covariates indicate normal conditions moving forward, then the timeblock on M will be implemented over a limited number of years, and the model will return to the base M for the following years.

SSC October 2024

Consider a prior for M that accounts for maximum ages beyond what has been observed in recent survey data, which likely reflect a truncated age structure.

Response

The base value of natural mortality was calculated using all available age data for Aleutian Islands Pacific cod, from NMFS surveys 1991 - 2022. Properly incorporating natural mortality is important because it affects the magnitude of reference points, and populations with higher natural mortality will produce higher estimates of ABC and OFL. Populations whose age structure have been truncated due to climate effects or fishing mortality are subject to natural mortality *plus* the added mortality due to either fishing or climate or both. This increase in natural mortality should not be attributed to natural mortality; rather it would be more appropriate to utilize climate or fishing mortality parameters to account for the truncated age structure. We support estimation of the base value of M using all available Pacific cod data.

SSC October 2024

Check total catches as they were inconsistent between tables 2A.5 and 2A.6.

Response

Noted.

SSC October 2024

Ensure that the "F ballpark" penalty is turned off in the final estimation phase. It appeared from likelihood profiles that this penalty was still turned on at the end of model runs. This is a convergence aid and should not be affecting model results at the end of convergence.

Response

This penalty has been turned off.

Introduction

Pacific cod (*Gadus macrocephalus*) ranges across the northern Pacific Ocean from Santa Monica Bay, California, northward along the North American coast, Gulf of Alaska, Aleutian Islands, and Bering Sea north to Norton Sound; and southward along the Asian coast from the Gulf of Anadyr to the northern Yellow Sea. Cod occurs at depths from shoreline to 500 m (Ketchen 1961, Bakkala et al. 1984). The southern limit of the species' distribution is about 34°N latitude, and until recently its northern limit was approximately 65°N latitude (Stevenson and Lauth 2019). However, in recent years Pacific cod has been observed in the Chukchi sea (Cooper et al. 2023). Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area.

Separate harvest specifications for Pacific cod have been set for the Bering Sea and Aleutian Islands regions since the 2014 season. Pacific cod were managed in the combined EBS and AI (BSAI) region from 1977 through 2013.

Life history

Pacific cod in the EBS form large spawning aggregations, and are believed to spawn once per year (Sakurai and Hattori 1996, Stark 2007), between February and April (Neidetcher et al. 2014). Shimada and Kimura (1994) identified major spawning areas between Unalaska and Unimak Islands, and seaward of the Pribilof Islands along the shelf edge. Neidetcher et al. (2014) identified spawning concentrations north of Unimak Island, in the vicinity of the Pribilof Islands, at the shelf break near Zhemchug Canyon, and adjacent to islands in the central and western Aleutian Islands along the continental shelf. Pacific cod are known to undertake seasonal migrations as part of an annual migration between summer feeding grounds and winter spawning grounds, the timing and duration of which may be variable (Savin 2008). Travel distances have been observed in excess of 500 nautical miles (nmi), with a large number of travel distances in excess of 100 nmi (Shimada and Kimura 1994). Eggs hatched between 16-28 days after spawning in a laboratory study, with peak hatching on day 21 (Abookire et al. 2007, Hurst et al. 2009). Settlement in the Gulf of Alaska is reported to occur from July onward (Blackburn and Jackson 1982, Abookire et al. 2007, Laurel et al. 2007), which, given a mean spawning date of mid-March (Neidetcher et al. 2014), and assuming that settlement occurs immediately after transformation, and subtracting about 20 days for the egg stage, implies that the larval life stage might last about 90 days. In the laboratory study by Hurst et al. (2010), postflexion larvae were all younger than 106 days post-hatching, and juveniles were all older than 131 days post-hatching, so it might be inferred that transformation typically takes place between 106 and 131 days after hatching.

Several studies have demonstrated an impact of temperature on survival and hatching of eggs and development of embryos and larvae (e.g., Laurel et al. 2008, Hurst et al. 2010, Laurel et al. 2011, Laurel et al. 2012, Bian et al. 2014, Bian et al. 2016). Recruitment of Pacific cod has been shown to be influenced by temperature (e.g., Doyle et al. 2009, Hurst et al. 2012). Pacific cod eggs are demersal (Thomson 1963). After hatching, Pacific cod larvae move quickly to surface waters (Rugen and Matarese 1988, Hurst et al. 2009), and may be transported considerable distances. Rugen and Materese concluded that larval Pacific cod were transported from waters near the Kenai peninsula and Kodiak Island to locations as far as Unimak Island. In the Gulf of Alaska, it is thought that movement of larvae has a significant shoreward component (Rugen and Materese, Abookire et al. 2001 and 2007, Laurel et al. 2007), but it is not obvious that this is always the case elsewhere in the species' range (Hurst et al. 2012). For example, Hurst et al. (2015) found that age-0 Pacific cod in the EBS were most abundant in waters along the Alaska peninsula to depths of 50 m.

Cold environments allow Pacific cod larvae to bridge gaps in prey availability (i.e., timing and magnitude), but negatively impact survival over longer periods (Laurel et al. 2011). Under warmer conditions, mismatches in prey significantly impacted growth and survival; however, both yolk reserves and compensatory growth mechanisms reduced the severity of mismatches occurring in the first 3 weeks of development (Laurel et al. 2011). Larval retention of Pacific cod during the month of April appears to be important to late spring abundance in the Gulf of Alaska, but it is unknown whether this result holds elsewhere in the species' range (Doyle et al. 2009).

Juvenile Pacific cod typically settle near the seafloor (Abookire et al. 2007, Laurel et al. 2007). Some studies of Pacific cod in the Gulf of Alaska, and also some studies of Atlantic cod, suggest that young-of-the-year cod are dependent on eelgrass, but this may not be the case elsewhere in the species' range. Key nursery habitat for age-0 Pacific cod across most of its range typically consists of sheltered embayments. Age-0 Pacific cod have also been observed in the shelf-pelagic zone (Hurst et al. 2012, Parker-Stetter et al. 2013). Habitat use of age-0 Pacific cod in the EBS occurs along a gradient from coastal-demersal (bottom depths $<$ 50 m) to shelf-pelagic (bottom depths 60-80 m), with densities near the coastal waters of the Alaska peninsula much higher than elsewhere (Hurst et al. 2015). Hurst et al. (2012) found evidence of density-dependent habitat selection at the local scale, but no consistent shift in distribution of juvenile Pacific cod in response to interannual climate variability. Habitat use by age-0 Pacific cod in the EBS may be related to temperature and the distribution of large-bodied demersal predators (Hurst et al. 2015). Similarly, the habitat distribution of age-0 Atlantic cod is influenced by predators (Gotceitas et al. 1997).

Adult Pacific cod in the EBS are strongly associated with the seafloor (Nichol et al. 2007), suggesting that fishing activity has the potential to disturb habitat. Diel vertical migration has also been observed (Nichol et al. 2013). Patterns varied significantly by location, bottom depth, and time of year, with daily depth changes averaging 8 m. Although little is known about the likelihood of age-dependent natural mortality in adult Pacific cod, it has been suggested that Atlantic cod may exhibit increasing natural mortality with age (Greer-Walker 1970). At least one study (Ueda et al. 2006) indicates that age 2 Pacific cod may congregate more, relative to age 1 Pacific cod, in areas where trawling efficiency is reduced (e.g., areas of rough substrate), causing their selectivity to decrease. Also, Atlantic cod have been shown to dive in response to a passing vessel (Ona and Godø 1990, Handegard and Tjøstheim 2005), which may complicate attempts to estimate catchability (q) or selectivity. It is not known whether Pacific cod exhibit a similar response.

Genetic population structure

Low-coverage whole-genome sequencing analysis of 429 samples of Pacific cod from known spawning regions during spawning season indicated population structure similar to what was previously known, but with finer resolution and greater power owing to the larger number of markers. Using 1,922,927 polymorphic SNPs, the pattern of population structure mostly resembles isolation-by-distance, in which samples from proximate spawning areas are more genetically similar than samples from more distant areas. Isolation-by-distance was observed from western Gulf of Alaska (Kodiak and the Shumagin Islands) through Unimak Pass and the eastern Aleutian Islands. Previous studies have reported an isolation-by-distance pattern in Pacific cod using microsatellite markers (Cunningham et al. 2009 and Spies 2012) and reduced-representation sequencing (Drinan et al. 2018). Within the isolation-by-distance pattern, there were some distinct breaks in the population structure. The most significant genetic break occurs between western and eastern Gulf of Alaska

(GOA) spawning samples, indicated by previous research that highlighted the zona pellucida gene region (Spies et al. 2021). Aleutian Island populations are highly diverged at a several genomic regions that are likely adaptively significant (Spies et al. 2022). These adaptive differences provide further support for the Aleutian Island management unit that was established as distinct from the Bering Sea in 2013.

Movement

In 2017, large scale movement was noted into the northern Bering Sea (NBS) by Eastern Bering Sea stocks (Spies et al. 2020). Tagging studies (e.g., Shimada and Kimura 1994) have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA). Pacific cod likely return to their natal origin to spawn during winter months (January - April) but perform feeding migrations during other months.

Recent research has been performed to understand whether cod move into or out of the Aleutian Islands during summer, outside of spawning season (Schaal et al. 2024, submitted). All of 145 summer-caught cod taken from two locations in the Aleutian Islands assigned back to the Aleutian Islands spawning stock. This result indicates no/minimal movement into our out of the Aleutians during summer when cod are known to perform feeding migrations. Previous tagging studies in groundfish species including Pacific cod and Pacific halibut (*Hippoglossus stenolepis*) also indicate limited movement in the Aleutian Islands (Bryan et al. 2021; Loher 2022). While further work is needed to gain a mechanistic understanding of limited movement in this region, our understanding is that this Pacific cod population is self-sustaining and locally adapted, with little movement into, or out of, the Aleutian Islands.

Response to climate stress

Warming in the Aleutian Islands may decrease Pacific cod recruitment. Experimental work indicates that Pacific cod early life stages are sensitive to warming, negatively impacting survival rates from the embryo through juvenile stages (Laurel et al. 2023). Larval hatch rate decreases with temperature above the optimal range for incubation, ~4-6°C (Laurel and Rogers 2020), and survival from hatch to the post-flexion stage is considerably lower in warming (10°C) (Slesinger et al. 2024). Juveniles, while more tolerant of warming (16°C) based on survival and growth rates, have reduced condition and liver lipid content (unpublished), which is a critical energy source that is likely to affect overwintering success (Copeman et al. 2022). Gene expression analyses point to inflammation, altered lipid metabolism, and energetic limitations as mechanisms of mortality and lower condition in larvae and juveniles in response to warming (Spencer et al. in revision, unpublished). Warmer conditions may favor individuals that are more capable of allocating energy and regulating inflammation in warmer conditions, resulting in genetic/demographic shifts. This experimental work was conducted using individuals collected from the Gulf of Alaska spawning aggregation, which is genetically distinct from those that spawn near the Aleutian Islands, and therefore may differ in terms of thermotolerances.

Fishery and Management History

History of the fishery

During the early 1960s, Japanese vessels began harvesting Pacific cod in the Aleutian Islands. However, these catches were not large, and by the time the Magnuson Fishery Conservation and Management Act went into effect in 1977, foreign catches of Pacific cod in the AI had not exceeded 4,200 t (Table 2A.4). Joint venture fisheries began operations in the AI in 1981, and peaked in 1987, with catches totaling over 10,000 t. Foreign fishing for AI Pacific cod ended in 1986, followed by an end to joint venture fishing in 1990 (Table 2A.5). Domestic fishing for AI Pacific cod began in 1981, with a peak catch of over 43,000 t in 1992 (Table 2A.6).

Historically, Pacific cod were caught throughout the Aleutian Islands. For the last five years prior to enactment of additional Steller sea lion (*Eumetopias jubatus*) protective regulations in 2011, the proportions of Pacific cod catch in statistical areas 541 (Eastern AI), 542 (Central AI), and 543 (Western AI) averaged 58%, 19%, and 23%, respectively. For the period 2011-2014, the average distribution has was 84%, 16%, and 0%, respectively. In 2015, area 543 was reopened to limited fishing for Pacific cod (see "Management History" below). The average catch distribution for 2019-2024 (through September 22, 2024) was 58% from the eastern

Aleutian Islands (NMFS area 541), 30% from the central Aleutian Islands (NMFS area 542), and 12% from the western Aleutian Islands (NMFS area 543).

Catches of Pacific cod taken in the AI for the periods 1964-1980, 1981-1990, and 1991-2024 are shown in Table 2A.4, Table 2A.5, and Table 2A.6, respectively. The catches in Table 2A.4 and Table 2A.5 are broken down by fleet sector (foreign, joint venture, domestic annual processing). The catches in Table 2A.5 are also broken down by gear to the extent possible. The catches in Table 2A.6 are broken down by gear. Table 2A.7 breaks down catches from 1994-2024 by statistical area (area breakdowns not available prior to 1994), both in absolute terms and as proportions of the yearly totals.

Management History

Appendix 1 from the 2021 Aleutian Islands stock assessment and fishery evaluation lists implemented amendments to the BSAI Groundfish FMP that reference Pacific cod explicitly.

History with Respect to the EBS Stock

Prior to 2014, the AI and EBS Pacific cod stocks were managed jointly, with a single TAC, ABC, and OFL. Beginning with the 2014 fishery, the two stocks have since been managed separately.

The history of acceptable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate (i.e., all-gear, combined area) commercial catches in Table 2A.8. Note that, prior to 2014, this time series pertains to the combined BSAI region, so the catch time series differs from that shown in Table 2A.4, Table 2A.5, and Table 2A.6, which pertain to the AI only. Total catch has been less than the OFL in every year since 1993. Instances where catch exceeds TAC can typically be attributed to the fact that the catches listed in Table 2A.8 are total catches (i.e., Federal plus State), whereas the TAC applies only to the Federal catch.

In the 11 years that AI Pacific cod have been managed separately from EBS Pacific cod, the ratio of Federal catch to TAC has ranged from 0.4 to 0.96. The catch/TAC ratio in 2024 (complete through September 22) was 0.44, which is the lowest ratio observed since 2015.

ABCs were first specified in 1980. Prior to separate management of the AI and EBS stocks in 2014, TAC averaged about 83% of ABC, and aggregate commercial catch averaged about 92% of TAC (since 1980). Changes in ABC over time are typically attributable to three factors: 1) changes in resource abundance, 2) changes in management strategy, and 3) changes in the stock assessment model. Because ABC for all years through 2013 were based on the EBS assessment model (with an expansion factor for the AI), readers are referred to the Eastern Bering Sea Pacific cod stock assessment for a history of changes in that model (Thompson et al. 2018). During the period of separate AI and EBS management, the assessment of the AI stock has been based on a simple, random effects (Tier 5) model.

History with Respect to the State Fishery

Beginning with the 2006 fishery, the State of Alaska managed a fishery for AI Pacific cod inside State waters, with a guideline harvest level (GHL) equal to 3% of the BSAI ABC. Beginning with the 2014 fishery, this practice was modified by establishing two separate GHL fisheries, one for the AI and one for the EBS. The table below shows the formulas that have been used to set the State GHL for the AI.

If 90% of the Aleutian Islands GHL is harvested by November 15 of the preceding year, the GHL increases by 4%. However, the GHL cannot exceed 39% or 6,804 t. If the 2025 ABC remains at the value that was specified in 2024 (12,431 t), the above formula would result in a GHL of 5,386 t in 2024, which is the maximum allowed (39%) of the ABC. The total caught in the state fishery through the end of 2023 was 4,511 t (Table 2A.6). During the period in which a State fishery has existed: 1) TAC has been set so that the sum of the TAC and GHL would not exceed the ABC, 2) catch in the Federal fishery has been kept below TAC, and 3) total catch (Federal+State) has been kept below ABC.

History with Respect to Steller Sea Lion Protection Measures

The National Marine Fisheries Service (NMFS) listed the western population segment of Steller sea lions as endangered under the ESA in 1997. Since then, protection measures designed to protect potential Steller sea

Year	Formula
2014	0.03*(EBS ABC + AI ABC)
2015	0.03*(EBS ABC + AI ABC)
2016	0.27*AI ABC
2017	0.27*AI ABC
2018	0.27*AI ABC
2019	0.31*AI ABC
2020	0.35*AI ABC or 6,804 t, whichever is less
2021	0.39*AI ABC or 6,804 t, whichever is less
2022	0.39*AI ABC or 6,804 t, whichever is less
2023	0.35*AI ABC or 6,804 t, whichever is less
2024	0.35*AI ABC or 6,804 t, whichever is less

lion prey from the potential effects of groundfish fishing have been revised several times. One such revision was implemented in 2011, remaining in effect through 2014. This revision prohibited the retention of Pacific cod in Area 543. The latest revision, implemented in 2015, replaced this prohibition with a "harvest limit" for Area 543 determined by subtracting the State GHL from the AI Pacific cod ABC, then multiplying the result by the proportion of the AI Pacific cod biomass in Area 543 (see "Area Allocation of ABC," under "Harvest Recommendations," in the "Results" section).

Current directed fishery

Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including pot, trawl and longline components (Figure 2A.2). Pacific cod in the Aleutian Islands are exploited in the federal and state fisheries. The management quantities in this document pertain to the federal fishery; however, a proportion of the federal quota is allocated to the state fishery. In 2024, there was no state catch reported (as of September 22) (Figure 2A.2). In 2024, the federal fishery consisted of 5% pot gear, 2% longline gear, and 92% trawl gear.

An average of 13% of the total Pacific cod catch in the Aleutian Islands has taken place in non-target fisheries from 1993-2023. Over the past 5 years, the non-target fishery catch of Pacific cod has averaged 2,324 t and the targeted fishery has averaged 10,583 t, out of a total average of 12,907 t (Table 2A.9).

Discards

The catches shown in Table 2A.5 and Table 2A.6 include estimated discards. Discard amounts and rates of Pacific cod in the AI Pacific cod fisheries are shown for each year 1993-2024 in Table 2A.10. Amendment 49, which mandated increased retention and utilization of Pacific cod, was implemented in 1998. From 1991-1998, discard rates in the Pacific cod fishery averaged 5.6%. Since 1998, they have averaged about 1.0%.

Data

The data used in the age structured models include fishery catch and size compositions, survey biomass and standard error, and age compositions from survey data (Table 2A.11 and Figure 2A.3). Partial catch information for 2024 was available and was extrapolated to estimate the catch for the full year. On average, 76.3% of the annual catch occurs by this date, as estimated by catch statistics for the past 5 full years, 2019 - 2023. The full year's estimate of catch of Pacific cod in the Aleutian Islands for 2024 was 4,676 t. Overall, catches have decreased for all gear types since 2020 (Figure 2A.2).

The data used in the Tier 5 Model included biomass estimates and associated error for the NMFS Aleutian Island research surveys, 1991-2022 (Table 2A.12).

Fishery Data

There are three predominant gear types in the Aleutian Islands Pacific cod fishery; pot, trawl, and longline, which are implemented at different times of the year (Figure 2A.4). During spawning season (January - April), mature Pacific cod aggregate for spawning at known locations. During these months, over the past 5 years (January 1, 2020 - September 22, 2024), pot and trawl gear were primarily used (26.9% trawl, 70.9% pot, 2.2% longline). After spawning, Pacific cod typically disperse for feeding (although some do not); during May through December, cod were primarily caught with trawl gear, followed by longline and pot gear (49% trawl, 47.4% longline, 3.7% pot). While the spawning season is approximately half the time of non-spawning (4 vs. 8 months), the majority, 62%, of the annual catch (during the time period January 1, 2020 - September 22, 2024) took place during spawning season. Catches have exceeded TAC harvest recommendations in five of the nine years since 2013, but have never exceeded the OFL (Table 2A.8).

CPUE aggregated over gear types for the number and weight of fish show similar trends, indicating that there has been no large shifts in the weight of individual fish (Spies et al. 2023). Recent declines in CPUE may be attributed to the timing of the fishery relative to spawning season or other factors such as hyperaggregation during spawning in the trawl fishery (Rose and Kulka 1999). Standardized surveys are needed to understand whether declines in fishery CPUE represent declines in Aleutian Islands Pacific cod stock size. Recent declines in CPUE may also be due to less effort in targeted Pacific cod fishing. The amount of targeted Pacific cod fishing has decreased since 2018, but the catch in the atka mackerel and rockfish fisheries has remained the same or increased (Figure 2A.5, Table 2A.9).

Length data taken by fishery observers is used in the model (Table 2A.11). The number of hauls from which lengths are taken are somewhat proportional to the magnitude of fishing, and the number of hauls which recorded cod lengths was highest in 2001 (Table 2A.13).

Survey Data

The National Marine Fisheries Service (NMFS) conducts biennial daytime summer trawl surveys in the Aleutian Islands. Survey biomass is estimated by extrapolating the weight from individual trawls with the measured path of the trawl area to the total area surveyed. The net used in the Aleutian Islands survey is a high-rise poly-Noreastern 4 seam bottom trawl (27.2 m headrope, 36.8 m footrope, Nichol et al. 2007). Survey biomass estimates and standard error for Pacific cod are available for the survey years 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, and 2022 (Table 2A.14). A survey is currently underway during 2024, and a survey biomass estimate will be available for the November assessment. Aleutian Islands surveys prior to 1991 were not used in the model because they were not standardized to current survey methodology; therefore, data from the 1980, 1983, and 1987 surveys were excluded. Survey data includes NMFS areas 541, 542, and 543. The Aleutian Islands bottom trawl survey does include NMFS areas 518 and 519, but these were not included in data for this model because they are not considered part of the Aleutian Islands management area.

Survey age data is available for each survey, 1991-2022. The number of cod aged from the survey has ranged between 500 and 1,200 and the number of hauls ranges from 76-173 (Table 2A.15). Length composition data from the surveys is also used in the model (Figure 2A.3). All survey data are specified in model as from July, the midpoint of NMFS surveys.

The time series of NMFS bottom trawl survey biomass is shown for Areas 541-543 (Eastern, Central, and Western AI, respectively), together with their respective coefficients of variation, in Table 2A.12. These estimates pertain to the Aleutian management area, and so are smaller than the estimates pertaining to the Aleutian survey area that were reported in BSAI Pacific cod stock assessments prior to 2013. Over the long term, the trawl survey biomass data indicate a decline, and the 2022 estimate of biomass is the lowest in the time series. The total biomass estimate for Pacific cod in the Aleutian Islands declined from over 180,000 t in 1991 to 51,539 t in the current year. Recent declines took place in the eastern Aleutians (>50% decline) and in the central Aleutians (32% decline) from the last survey in 2018 to the current survey in 2022. The western Aleutian Islands stock of Pacific cod increased from 11,425 t to 13,661 t (20% increase) between 2018 and 2022 (Figure 2A.6, Figure 2A.7 and Table 2A.12).

The most recent longline survey estimate was also the lowest in the time series, but the longline survey data was not incorporated into the Tier 5 model or the age stuctured models (Table 2A.14). The longline survey was designed to target sablefish, and how well it documents the abundance of Pacific cod is uncertain.

Analytic Approach [Tier 5 model]

Model 13.4

Model 13.4 is the Tier 5 random effects model recommended by the Survey Averaging Working Group, which has been accepted by the Plan Team and SSC since the 2013 assessment for the purpose of setting AI Pacific cod harvest specifications. The Tier 5 random effects model is programmed using the ADMB software package (Fournier et al. 2012) as a "random walk" state-space model. The only parameter in Model 13.4 is the log of the log-scale process error standard deviation. When used to implement the Tier 5 harvest control rules, the Tier 5 models also require an estimate of the natural mortality rate. The Tier 5 random effects model assumes that the observation error variances are equal to the sampling variances estimated from the haul-by-haul survey data. The log-scale process errors and observations are both assumed to be normally distributed.

Recent estimates of natural mortality indicate that estimates have ranged from 0.20 to 0.96 for Pacific cod (Table 2A.16). A natural mortality estimate of 0.34 been used in the most recent Aleutian Islands Pacific cod assessment, as well as the 2022 and prior BSAI cod assessments (Thompson et al. 2018). This value was based on Equation 7 of Jensen (1996) and an age at maturity of 4.9 years (Stark 2007). The value of 0.34 adopted in 2007 replaced the value of 0.37 that had been used in all BSAI Pacific cod stock assessments from 1993 through 2006. In response to a request from the SSC, the 2008 assessment included a discussion of alternative values and a justification for the value chosen (Thompson et al. 2008). Using the variance for the age at 50% maturity published by Stark (0.0663), the 95% confidence interval for M extends from about 0.30 to 0.38. The value of 0.34 for natural mortality was used for the 2024 Tier 5 Model 13.4, as in previous years.

Under Tier 5, F_{OFL} is set equal to the natural mortality, F_{OFL} = M, and the fishing mortality rate to achieve the acceptable biological catch is 75% of M, $F_{ABC} \leq 0.75\times$M.

Model 24.2

A new base value for natural mortality, 0.417, was introduced as a base model for age structured models. Therefore, M = 0.417 is presented as an alternative calculation for the Tier 5 reference points in Model 24.2, and is preferred over Model 13.4 because of the updated M.

Analytic Approach [Age structured models]

Stock Synthesis Version 3.30.21 was used to run the the age structured models in this assessment. Stock Synthesis requires that prior distributions and initial values be associated with all internally estimated time-invariant parameters. For age structured models presented in this assessment, all parameters were fit freely without informative priors.

The following are features of the age structured models that are consistent with the 2023 models.

- Single sex model, 1:1 male female ratio.
- Survey age and length data were input as conditional age-at-length.
- Recruitment estimated as a mean with lognormally distributed deviations.
- Maturity-at-age was estimated externally using observer data, then input into the model.
- Single-fleet fishery that combines trawl, longline, and pot fishery data, weighted by quarter, gear, and NMFS area, from 1991 - current year (through September 22).
- All parameters were constant over time except for natural mortality after 2015 in Model 24.1.
- Survey and fishery selectivity were modeled as logistic and constant over time.
- Trawl survey catchability was incorporated analytically.

Data weighting and model tuning

Survey length and age input sample sizes generated by bootstrapping the number of hauls from which length and age data were taken using the methodology of Hulson et al. (2023). Fishery length composition input sample sizes were based on the number of hauls, and scaled to the mean survey input sample size (so that the mean fishery length composition input sample size was the same as the survey mean input sample size). This did not result in a change in likelihood, but is preferred over a constant sample size approach to weighting compositional data because it considers the number of hauls in each year and therefore the varying informational content. This approach is consistent among the Aleutian Islands, EBS, and GOA Pacific cod assessment models.

Age and length composition data from survey and length composition data from the fishery were weighted using the methodology of Francis (2011) in an iterative process (Table 2A.15, Table 2A.13). Input sample sizes for age comps by length bin were equal to the actual number of fish aged in those categories (whole numbers). The marginal compositions were weighted using the bootstrapping method of Hulson et al. (2023).

The parameter for variance in recruitment, sigmaR, was tuned prior to Francis weighting, using a feature in SS3 that provides an estimate based on model output. The value used in Models 24.0, 24.1 and 24.1a was 0.8.

Parameters Estimated Outside the Assessment Model

Maturity

The maturity-at-length is modeled by the relationship:

$$Maturity_{length} = \frac{1}{1+e^{-(A+Blength)}},$$

where A and B are parameters in the relationship.

A study based on a collection of 129 female fish in February, 2003, from the Unimak Pass area, NMFS area 509, found that 50% of female fish become mature at approximately 4.88 years ($L_{50\%}$) and 58.0 cm, A=-4.7143, B=0.9654 (i.e. Tables 2 and 4 in Stark 2007). This maturity ogive is used in the Bering Sea Pacific cod assessment but was not used in this assessment, because the fish in the sample were not from the Aleutian Islands.

Observers routinely collect maturity at length from Pacific cod. An alternative maturity curve was developed based on observer records of maturity from the Aleutian Islands. This parameterization is advantageous because it is based on more records that were taken from Aleutian Islands cod, and is incorporated into age-structured models presented here. Maturity was updated in 2024, resulting in the addition of 16 new visual maturity samples, which did not result in a large change to the maturity curve parameters. There were 1,347 records of visual maturity data from the Aleutian Islands (see table below) during the months January – March since 2008. These were used to estimate a maturity ogive by length using the R package *sizeMat*, which estimates the length of fish at gonad maturity. Maturity was considered a binomial response varable and variables were fitted to the logistic function above for maturity, and the length at which 50% of cod are mature is $L_{50\%} = -A/B$ (Table 2A.17). Maturity was converted from maturity-at-length to maturity-at-age for Table 2A.17. This method was accepted by the Plan Team (September 2022) and SSC (October 2022). Maturity data used in the model are based on length, rather than age. Reanalysis in 2024 shifted the age at 50% maturity from 54.9 to 55.5 cm (Confidence intervals = 53.7 - 57.3), A = -8.589, B = 0.155, but this did not result in a change to the maturity-at-age.

Ageing error

After 2007, there was a shift in our understanding of the first two checks deposited at early ages in Pacific cod. Prior to 2007 they were thought to be true annuli, but subsequently determined not to be. Therefore, geing bias was not incorporated in the model, as all ages used were aged subsequent to 2007, after which time ageing methodology has been consistent and considered non-biased. Ageing error was applied to ages 2-13+. The standard deviation at the first age was 0.57 and 1.16 at the maximum age.

There were 10,134 records of aged and lengthed Pacific cod taken from NMFS research surveys between 1991 and 2022 (1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022). The maximum age observed was 13.

Natural mortality

Natural mortality is notoriously difficult to estimate inside assessment models, because it is typically correlated with other parameters. The SSC and Plan Team have suggested implementing a new methodology for estimating natural mortality externally to the model in 2024, similar to the methodology used in the eastern Bering Sea Pacific cod model since 2023. Implementing a fixed value for natural mortality allows for better estimation of parameters that may be constrained by M. For EBS cod, M was calculated as 0.3866.

For the base model, natural mortality was fixed at a value calculated using the *Then_lm* method (http://barefootecologist.com.au/shiny_m.html), which is the same methodology used to calculate natural mortality, M, for the eastern Bering Sea Pacific cod assessment model.

Research suggests that longevity-based predictions of natural mortality rate are more precise than growth-based estimates (Hamel & Cope, 2022; Then et al., 2015). Longevity can be recorded either as the maximum aged specimen, or the average of the five maximum ages (Sullivan et al., 2022).

The value of M was recalculated for Aleutian Islands Pacific cod to account for different growth patterns and different maximum ages. For example, the maximum age observed in the eastern Bering Sea was 14, while the maximum age observed in the Aleutian Islands was 13. The age data used for this analysis was the same as in the assessment, from all survey years including the most recent survey in 2022 (Table 1). Based on these values, natural mortality M for Aleutian Islands Pacific cod was 0.417. The difference is likely due to faster growth and lower maximum age observed in Aleutian Islands Pacific cod.

A natural mortality estimate of 0.34 been used in the most recent Aleutian Islands Pacific cod assessment, as well as the 2022 and prior BSAI cod assessments (Thompson et al. 2018). This value was based on Equation 7 of Jensen (1996) and an age at maturity of 4.9 years (Stark 2007). The value of 0.34 adopted in 2007 replaced the value of 0.37 that had been used in all BSAI Pacific cod stock assessments from 1993 through 2006. In response to a request from the SSC, the 2008 assessment included a discussion of alternative values and a justification for the value chosen (Thompson et al. 2008). Using the variance for the age at 50% maturity published by Stark (0.0663), the 95% confidence interval for M extends from about 0.30 to 0.38.

Parameters Estimated Inside the Assessment Model

Growth

The Richards growth curve was used to fit growth within the models, but sensitivity to the von Bertalanffy growth curve is shown in Model 24.1a, which uses the von Bertalanffy growth curve (Table 2A.3). The Richards growth curve adds an additional parameter to the logistic growth curve to account for non-symmetrical growth at early ages and maximum ages. Although the Von Bertalanffy growth curve was used in previous iterations of the age structured model, we found that the Richards growth curve improved the fit to the data. The Richards growth curve is also used in the Eastern Bering Sea and the Gulf of Alaska Pacific cod stock assessments. The Richards growth curve improves the fit to the conditional age at length, reducing the CV on age 1 and younger (Figure 2A.8). Overall, the conditional age at length provides a good fit to the data.

None of these models incorporate time-varying growth because it is not justifed by size at age data. Pacific cod growth in the Aleutian Islands has not changed significantly throughout the timeseries; therefore. Timeblocks on growth were explored in 2023, but resulted in minimal changes to parameters.

Length at age

Pacific cod do not exhibit sexually dimorphic growth; males and females grow at the same rate. Therefore, the model did not distinguish between males and females. Growth is rapid at younger ages (Figure 2A.9) and was estimated within the model using the Richards growth curve as described above. Incorporating all length age and length bins were important for fitting growth.

There was no observed change in growth over time. Therefore, only constant growth was used in the age structured models. We explored fixing the length of fish (L1) at early ages (1.0 years) at external estimates, but opted for model estimation of length at L1.

Selectivity

Selectivity for the fishery and the survey were fit (separately) using monotonically increasing asymptotic logistic curve (Figure 2A.10). We considered dome-shaped and selectivity in our September report but a better fit to the data was achieved with logistic selectivity curves.

The fishery is modeled as a single-fleet fishery that combines trawl, longline, and pot fishery data. While these geartypes do catch different distributions of fish, past model explorations for the EBS and Aleutian Islands stock assessment models showed that there is insufficient data to merit three separate fishery selectivity curves.

Natural mortality

Model 24.1 used a time block which estimated natural mortality from 2016 - 2024, but it was fixed at M = 0.417 from the beginning of the time series through 2015 (Table 2A.3). The timeblock on natural mortality estimated a single value, rather than a base value with deviations. Estimating a single parameter is advantageous because it reduces the number of parameters estimated and reduces uncertainty.

Model 24.1 (and 24.1a) accounted for changing environmental conditions due to the shift in temperature through the 2016-2024 time block on natural mortality. The year 2016 was selected because this it is two years after the beginning of the documented thermal shift (Xiao and Ren 2022) (Figure 2A.11). While this thermal shift has not been documented as an ecological regime shift, it is significant and should be considered as a potential factor for changes in abundance or distribution. The time block did not start earlier because it incorporated a ~two year lag for effects of higher temperatures to be observed, the effect of cumulative stress that increased temperatures can incur (e.g. Barbeaux et al. 2018, Laurel and Rogers 2020). Pacific cod are known to respond poorly to temperatures that exceed their preferred thermal range; therefore, increased natural mortality due to the thermal shift may be the optimal model configuration. The lag also corresponded to the time required for cod to grow to a size/age at first survey selectivity. The assumption that increased natural mortality due to higher temperatures is supported by evidence in the laboratory and in situ, and includes all life stages (Laurel et al. 2008, Barbeaux et al. 2020). Accordingly, the time block on natural mortality in Model 24.1 indicated higher natural mortality which was freely esetimated and not on a bound (0.57). As of August 2024, heatwave conditions in the Aleutian Islands appear to be less extreme than in past years during all months with the exception of August in the western Aleutians, but periods of moderate heatwave conditions have occurred (Figure 2A.12). The timeblock on natural mortality in Models 24.1 and 24.0A improves the fit to survey index of abundance, particularly later years in the survey (Figure 2A.13). The survey index declined from 2018 - 2022; therefore, the spawning stock size relative to unfished is lowest for the models that include the natural mortality timeblock (Figure 2A.14).

Catchability

Experiments have been performed that measure whole-gear efficiency (the proportion of fish passing between the otter doors of a bottom trawl that are subsequently captured), and these studies can inform catchability. Somerton (2004) used an 83-112 Eastern Trawl trawl net in the eastern Bering Sea and found no evidence that Pacific cod were herded into the net (Somerton et al. 2004). Another study estimated 47.3% of cod in the water column to be available to the trawl used on the eastern Bering Sea trawl survey and 91.6% are available to the trawl used on the Gulf of Alaska and Aleutian Islands surveys (Nichol et al. 2007). This study was based on results showing that 95% of cod were found within 10 m of the seafloor, based on 286 archival tagged cod off Kodiak Island in the Gulf of Alaska and off Unimak Pass in the eastern Bering Sea, Alaska (Nichol et al. 2007). More recently Rand et al. (2022) found no evidence for difference in mean size of Pacific cod caught by the survey and the fishery in the eastern Bering Sea. However, the Aleutian Islands presents a more complex environment, with rocky and steep habitat that is not consistently trawlable (Logerwell et al. 2005). It is plausible that this habitat could lead to survey catchability <1 in the Aleutian Islands.

Recruitment

Recruitment was estimated for all years in the model, excluding the final 3 years, as there was little data to inform it (1991 - 2021). Recruitment after 2021 through the forecast period 2039 used the mean 1991 - 2021 age-0 recruitment. During the 13 years prior to 1991, initial age comps are estimated, and during that period the model uses the MLE of initial/virgin recruitment.

Other parameters

The total likelihood and the number of parameters estimated for each model is shown in Table 2A.3. In this table, we calculated a rough estimate of AIC, using AIC = 2 x the number of parameters + 2 x total log likelihood. There is one additional parameter in Model 24.1 than 24.0 due to the estimation of natural mortality during 2016 - 2024. There is also one fewer parameter in Model 24.1a due to the von Bertalanffy growth curve which uses 3 parameters rather than 4 in the Richards growth curve. Parameters such as recruitment deviations are effectively less than one parameter; however, growth parameters and natural mortality are full parameters. Given that the AIC is a rough estimate, we provide information on the total likelihood and other estimates when discussing model fit to the data.

Description of Alternative Models

Model 24.1 is the preferred age structured model, and Models 24.1a and 24.0 are "sensitivity models", presented to show sensitivity to the Richards growth curve and the timeblock on natural mortality, respectively.

Age Structured Model Results (Tier 3)

Model 24.1 includes the addition of a time block on natural mortality with a break in 2015, corresponding with the thermal shift in 2013/2014 with a 2-year lag (Xiao and Ren 2022). This results in the best fit to the data and the lowest AIC, and is a significant improvement over Model 24.0, which does not include this timeblock parameter (Table 2A.3). In Pacific cod, a sustained increase in foraging demand has been documented during marine heat waves (Barbeaux et al. 2020). Winter heatwaves compound this effect by increasing demand for prey resources during months when demand typically declines. The availability of sufficient prey has been shown to be limiting through bottom-up availability in quality and quantity of lower-trophic prey, and competition with other higher level predators seeking similar prey resources (Barbeaux et al. 2020). Length-weight residuals, also referred to as fish condition, are a measure of fish weight vs. body length, and are an indicator of somatic growth. Poor fish condition is expected to be correlated with bioenergetic estimates for high metabolic demand, and Pacific cod length-weight residuals have been below average in all regions of the Aleutian Islands since the 2012 survey, for over a decade (Figure 2A.1). This period of low fish condition corresponds with the recent heatwave in the Aleutian Islands. Natural mortality was estimated higher in the timeblock as expected due to thermal stress 0.57, over M = 0.417. The incorporation of the natural mortality time block in Model 24.1 improved the fit to the survey index and the overall likelihood compared with Model 24.0, which did not incorporate the natural mortality timeblock (Table 2A.3).

Model 24.1 also represents an improvement over Model 24.1a, with the incorporation of the Richards growth curve. The Richards growth curve improved the fit to the data, specifically the survey, recruitment, and length composition likelihood components (Table 2A.3) over Model 24.1a that used the von Bertalanffy growth curve. The Richards growth curve allows for an inflection point between younger (age 2) and older cod (age 4+) that is not available in the von Bertalanffy. This provides a different slope, which is straighter, matches cod growth data better, and provides a smooth transition from age 1, in which growth is linear to age 2. It also results in a smaller maximum size and tighter confidence intervals (Figure 2A.15). We note that the Richards growth curve improved the likelihood (Model 24.1a vs. 24.1) from 547 to 534, with the addition of a single parameter. which is a reasonable improvement. In the September report (https://meetings.npfmc.org/Meeting/Details/3056), there were seven features, removed sequentially in a sensitivity analysis. These features included the choice of maximum length, natural mortality timeblock, CV on young growth, shape of the survey selectivity curve, maximum age, initial fishing mortality, fixed vs. estimated natural mortality, and the shape of the growth curve. As each model progressed, better model options were replaced with the less desirable alternative. In the final model, the Richards growth curve was replaced by the von Bertalanffy growth curve. A drastic decline in model fit appeared in the model with the the von Bertalanffy growth curve vs. the Richards growth curve. However, this decline was partially due to the method by which the sensitivity analysis was performed. Because seven desirable features were removed from the final model, it showed a considerably poorer fit to the data, as the cumulative effect of multiple less desirable features. In the current assessment, bridging is performed with no more than one feature removed from Model 24.1.

AIC and total likelihood were lowest for Model 24.1 (Table 2A.3), indicating a better fit to the data despite the addition of an estimated timeblock parameter and the additional Richards growth parameter. Improvements in Model 24.1 over Model 24.0 are notable in the survey and length composition likelihood components, as well as the fit to the survey index and AIC (Figure 2A.16, Table 2A.3). Model 24.1 provided better fits to survey, length composition, age composition, and recruitment likelihoods than Model 24.1a. Given the improvements in the model specficiation relative to fits to the data and improved assumptions, Model 24.1 is the recommended candidate for management. The timeseries of total biomass (ages 1 and above) for Models 24.1, 24.1a, and 24.0 is provided in Table 2A.18, the timeseries of estimated spawning biomass with 95% confidence intervals in Table 2A.19, and age-0 recruitment (1000s of fish) with confidence intervals in Table 2A.20. Parameters estimated by each model are provided in Table 2A.21 and Table 2A.22.

Based on Model 24.1, total biomass declined from approximately 176,848 t in 1992 to a timeseries low of 73,679 t in 2025 (Table 2A.18). The trawl survey estimate of biomass was 50,382 t in 2023, similar to but lower than the 2022 estimate, which was the previous lowest estimate in the timeseries. Female spawning biomass has followed a similar overall declining trend as total biomass in all models (Table 2A.19, with the peak spawning biomass occurring by the early 1990s for all models. For Model 24.1, spawning biomass reached its lowest point of 47,568 t in 2022.

In Models 24.1 and 24.1a, an increase occurs in recruitment deviations during 2015 - 2020, corresponding with the natural mortality timeblock (Figure 2A.17). In contrast, Model 24.0 accounted for the decrease in survey indices of abundance by reduced recruitment during 2010 - 2020. Presumably, the increase in recruitment in Model 24.1 was a response to the higher natural mortality. There is little evidence that Pacific cod recruitment increases during heatwave conditions, although recent research indicates that warm conditions increase mortality in overwintering age-0 cod, which may be consistent with model results indicating that mortality occurs during later stages of development (Spencer et al. Submitted). In the Gulf of Alaska, abundance declined with increasing ocean temperature during egg and larval phases, and the age-0 cod were larger (Abookire et al. 2022). The Gulf of Alaska is a broad, shallow shelf, quite different from the Aleutian Islands archipelago, a partially submerged mountain range in which cod habitat consists of narrow and steep terrain (Logerwell et al. 2005). Some life history stages of Pacific cod in the Aleutian Islands may escape warm temperatures by moving to deeper water, unlike cod in the Gulf of Alaska. Survey length compositions, which include age 1 and 2 cod, indicate that the proportion of age 1 cod decreased in 2002 and 2004 from previous years, and then increased to a stable proportion over the remainder of years through 2022 (Figure 2A.18). This is consistent with a decrease in recruitment during the early 2000s, and a subsequent increase (Figure 2A.17). Aggregated over time, the fit to fishery and survey length frequencies is not affected by the growth curve or natural mortality time block (Figure 2A.19).

Finally, the stock appears to have declined to close to $B_{20}\%$, despite relatively light fishing (Figure 2A.20, Figure 2A.21). Models 24.0 and 24.1 both indicate a period of high recruitment during the 1990s, followed by lower recruitment from 2001 - 2010 (Figure 2A.22). This lower recruitment during 2001 - 2010 may have resulted in declining stock sizes. For Model 24.1, the mean age-0 recruitment during 2001 - 2010 was 42,836 (x1,000) and the mean used for forecasting, was 61,854 (x1,000). Model 24.0 used a somewhat lower estimate for forecasting, 59,243 (x1,000). A second reason for the low stock sizes despite low fishing mortality is climate-related mortality. While Model 24.1 provides a link between the modeled population dynamics and climate, future research may develop more complex understanding of the relationship between climate stress and stock size.

Evaluation of Models and Associated Uncertainty

The fit to the length composition data using one-step-ahead (OSA) residuals generally showed no large-scale pattern of over or under-fitting and appear to support the assumption of randomly distributed error (Figure

2A.23, Figure 2A.24, Figure 2A.25). The OSA residuals are similar among the three models (24.1, 24.1a, and 24.0), with some residual patterns that are small in magnitude. For the fishery length compositions, patterns of positive residuals are present that indicate slightly heavy tails, characterized by positive residuals around 50 cm and 100 cm. There are few outliers which do not show a strongly discernable pattern. Survey residuals generally fit, although a pattern of small positive residuals are present around 50 cm and at approximately 20 cm representing 1 year old fish. There are some outlier residuals at age 1 length frequencies, but these outliers are present in fewer than half the years. The standardized deviation of normalized residuals (SDNR) is approximately 1 for all models. In general SDNR much greater than 1 is not consistent with a good fit to the data while SDNR less than 1 indicates that the data was fitted better than expected, and is not a cause for concern (Francis 2011). The model fit to observed length frequency distributions for survey and fishery show a similar fit for all models (Figure 2A.23, Figure 2A.24, Figure 2A.25).

Observed and expected length frequencies for the fishery (Figure 2A.26) and the survey (Figure 2A.27), and observed age frequencies (Figure 2A.28) provide insight into the data and model fits. The fishery and survey length compositions show that predominant sizes were larger in 2024 than in 2022, indicating an ageing population, while indication of incoming age 1 and 2 year classes. The 2022 age frequencies indicate more 3 year olds than in 2018, and have not yet been read for 2024 (Figure 2A.28).

Sensitivity to Model Specification

Sensitivity model runs were performed in the September Pacific cod assessment. Models provided information on sensitivity to the following features: the choice of maximum length, natural mortality timeblock, CV on young growth, shape of the survey selectivity curve, maximum age, initial fishing mortality, fixed vs. estimated natural mortality, and the shape of the growth curve.

Convergence Status and Criteria

Convergence was determined by successful inversion of the Hessian matrix and a maximum gradient component of less than 1e-4 (this value was 9.3e-05 for Model 24.1, 1.2e-05 for Model 24.0, and 1.1e-05 for Model 24.1a). A jitter analysis revealed that the proposed Model 24.1 and sensitivity models 24.1a and 24.0 are insensitive to perturbations of parameter start values on the order of 10% (Figure 2A.29, Figure 2A.30, Figure 2A.31). All of the jittered model runs went to the maximum likelihood estimate and all parameters were estimated within their pre-specified bounds. All model runs implemented within the jitter test had total negative log likelihood values equal to or less than the base model. Therefore, based on the jitter test, there was no evidence to reject the hypothesis that the base model successfully converged.

Likelihood Profiles on Key Parameters

Likelihood profiles have been performed on several key parameters: catchability (Figure 2A.32) and initial recruitment (R0, Figure 2A.33). The likelihood profile for initial recruitment (R0) used values between 10.4 and 12.0 in increments of 0.2 (Figure 2A.33). The profile suggests that the global MLE for R0 is approximately 11.4, and the range of R0 with likelihood values <1.96, indicating an acceptable range, is 11.0 - 11.5. Index data indicates that initial recruitment is somewhat higher, while length data indicates R0 is somewhat lower. The global estimate is between these two and similar to the model estimate of recruitment, 0.9. Maximum likelihood estimates of R0 were between 11.0 and 11.5 for all three models (Table 2A.21 Table 2A.22).

A likelihood profile on survey catchability (q) was performed, and results are presented as the logarithm of catchability followed by the actual catchability (not logarithm) in parentheses. Log(q) was profiled from -0.8 to 0.8 (q = 0.45 to 2.22) in increments of 0.1, and showed conflict among data sources (Figure 2A.32). Index data suggested that survey catchability was -0.5 (q = 0.6), and recruitment suggested even lower. In contrast, F ballpark indicated higher ln(q), at 0.8 (q = 2.22). The age and length data were both close to zero, and the MLE was approximately -0.2 (q = 0.82). We estimated catchability in all models analytically, as the exploitable biomass estimated by the model divided by the survey estimate of biomass. This results in the same estimate as estimating catchability with a uniform prior, but provides a more parsimonious alternative. The calculated catchability for Model 24.1 was 0.87 (Table 2A.3).

Parameters used in forecasting

Due to the time-block on natural mortality in Model 24.1, forecasts were performed using the base value of natural mortality used in Model 24.1 from 1991-2015, M = 0.417. We justify this choice as follows. As populations experience the stress of climate change, natural mortality will increase in response, as in Model 24.1 (Szuwalski et al. 2023). Incorporating increased natural mortality in harvest rates implies a ‘double-threat’, because adapting the harvest control rule to changing environmental conditions would result in both lower biomass targets and higher harvest rates (Szuwalski et al. 2023). Populations that have declined as a result of climate stress (or fishing mortality) are subject to natural mortality *plus* the added mortality due to either fishing or climate or both. Therefore, projections are based on the time period in which natural mortality is fixed at the base value of 0.417, and do not incorporate an increase due to climate change. Further, the heatblock M has a big impact on advice and would confer large changes if future versions of the models change the size of the estimate.

While other parameters, such as recruitment, can be affected by climate change, we used mean recruitment over all years it was estimated (1991 - 2021). In addition to simplifying assumptions in projections, this choice did not change results notably. For all other parameters (except M) the entire time series was used in projections. Recruitment from 2022 - 2024 was not estimated, as there was little data to inform it.

Retrospective analysis

A ten-year retrospective analysis was conducted by sequential removal of all data annually beginning with 2024 and ending with 2014, for Models 24.0 and 24.1 (Figure 2A.34). By age ten, a cohort of fish have reached their asymptotic length, are considered 100% mature and fully selected by the survey. We note that the timeblock challenges the assumptions of the retrospective analysis because model parameterization is not constant over time. Therefore, a retrospective analysis may be inappropriate for Model 24.1; however, we have included it here to illustrate the improvement of Model 24.1 over Model 24.0. For Model 24.1, the mean terminal spawning biomass estimate from each of these retrospective models was within the 95% confidence interval of the current base model for the first five years, but deviated as the number of years in the 2016-2024 timeblock was reduced. Retrospective plots for the two age structured models indicate an improved pattern for Model 24.1 over Model 24.0 (Figure 2A.34).

Model 24.0 produced Mohn’s rho value of 0.573, while Model 24.1 produced a smaller retrospective pattern, 0.149 (Figure 2A.34). Hurtado-Ferro (2015) provides some guidance on the range of acceptable values for Mohn’s rho. For a flatfish-like species with M = 0.2, the lower and upper bounds were given as -0.15 and 0.2. For a sardine-like species with M = 0.34, the lower and upper bounds were given to be -0.22 and 0.3. If Mohn’s rho were entirely dependent on M (likely an oversimplification), then an equation for the lower and upper limits could be developed from these guidelines as follows: $Rho_{lowerbound} = -0.08 - 0.35 * M$ and $Rho_{upperbound} = 0.10 + 0.50 * M$. Using these guidelines, and noting that the base value of natural mortality for Models 24.0 and 24.1 was 0.417, lower and upper bounds would be -0.23 and 0.31. Given these guidelines, the Mohn’s rho is within acceptable bounds for Model 24.1 but is outside of acceptable values for Model 24.0 (Figure 2A.34).

Without incorporating a timeblock on natural mortality, the model cannot fit recent declines in total biomass documented by the Aleutian Islands survey, as illustrated by the poor retrospective pattern in Model 24.0 (e.g. Mohn’s rho >0.4, Figure 2A.34).

Historical retrospectives (between models)

This was not performed, no previous Tier 3 assessment models have been used for this stock.

Tier 5 Model Results

The Tier 5 ABCs and OFLs for 2025 and 2026 for Models 13.4 and 24.2 incorporate random effect estimates of Aleutian Island Pacific cod biomass from 1991 - 2024 (Table 2A.12). The 2024 survey biomass estimate was 50,382 t, 2% lower than the 2022 estimate. The random effects model estimated an exploitable biomass of 51,504 t, which resulted in OFLs (17,511 t) and ABCs (13,133 t) for 2025 and 2026. Model 24.2 calculated Tier 5 ABCs and OFLs with the previously described estimate of natural mortality (M = 0.417), which resulted in higher OFLs (21,477 t) and ABCs (16,107 t) for 2025 and 2026 (Table 2A.2). We recommend the use of age structured Model 24.1 for reference point setting and harvest quantities.

Projections and Harvest Recommendations

A Kobe plot demonstrating the stock status uncertainty over SSB/SSB_{MSY} and F/F_{MSY} indicates that the stock has shifted from $>SSB_{MSY}$ in 1991 to a lower stock status $<SSB_{MSY}$. Uncertainty was generated by drawning 1,000 points from a joint multivariate normal posterior for SSB and F. The results (for Model 24.1) indicate a 96.4% probability that the stock status is between ~$SSB_{12\%}$ and $SSB_{35\%}$, and that the fishing mortality rate is below F_{40} (Figure 2A.35). Stock status is similar for Model 24.1a (Figure 2A.36), but higher for Model 24.0, which indicates a 52% chance the stock status is greater than $SSB_{35\%}$ (Figure 2A.37). Phase plane plots indicate a similar stock status for current and future years (Figure 2A.20); stock status is above $B_{20\%}$ and is predicted to remain so through 2026. Model 24.0 indicates a higher stock status than Model 24.1 ((Figure 2A.21)).

This is consistent with other analyses: Table 2A.3 indicates that the proportion of unfished biomass is 19%, and fishing mortality has been low relative to management quantities (Table 2A.8, Figure 2A.2).

Amendment 56 Reference Points

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines the "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (F_{ABC}) may be less than this maximum permissible level, but not greater.

Under Tier 5, F_{OFL} is set equal to the natural mortality, F_{OFL} = M, and the fishing mortality rate to achieve the acceptable biological catch is 75% of M, $F_{ABC} \leq 0.75\times$M.

Table 2A.2 includes estimates of harvest specifications, OFL, maximum permissible ABC, and the associated fishing mortality rates for 2025 and 2026 for the Tier 5 reference points for Tier 5 Models 13.4 and 24.2. Note that the 95% confidence intervals for the Tier 5 estimates of biomass are shown in Table 2A.23. Model 24.2 is the preferred Tier 5 model for 2024 because it is consistent with Plan Team and SSC recommendations for an externally estimated estimate of natural mortality.

Specification of OFL and Maximum Permissible ABC

The Tier 3 models and projections were conducted using the Stock Synthesis program. Models 24.1, 24.1a, and 24.0 indicate that the Aleutian Islands Pacific cod stock is not subjected to overfishing and not overfished. If fishing continues at its average rate for the past 5 years, female spawning biomass is predicted to be above $B_{35\%}$ by 2029 (Table 2A.24, Table 2A.25, Table 2A.26). Projections of catch for Aleutian Islands Pacific cod 2025 through 2037 based on the seven harvest scenarios are shown as figures for Models 24.1, 24.1a, and 24.0 Projections for Aleutian Islands Pacific cod 2025 through 2037 are presented for Models 24.1, 24.1a and 24.0 for catches (Figure 2A.38, Figure 2A.39, Figure 2A.40) and stock status (Figure 2A.41, Figure 2A.42, Figure 2A.43).

For stocks in Tiers 4-6, no determination can be made of overfished status or approaching an overfished condition as information is insufficient to estimate the MSY stock level. Under Model 13.4, ABC and OFL for 2025 and 2026 are 13,133 t and 17,511 t. Under Model 24.2, ABC and OFL for 2025 and 2026 are 16,107 t and 21,477 t.

Under Model 24.1, ABCs for 2025 and 2026 are 13,376 t and 12,973 t, and OFLs are 16,782 t and 16,273 t (Table 2A.1).

Standard Harvest Scenarios and Projection Methodology

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 Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For all models, the year-end catch for 2024 was estimated to be 4,676 t, as described above. In the event that catch is likely to be less than the recommended ABC in either of the first two projection years, Scenario 2 must be conducted, using the best estimates of catch in those two years (otherwise, Scenario 2 can be omitted if the author's recommended ABCs for the next two years are equal to the maximum permissible ABCs).

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

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

Aleutian Islands Pacific cod was not managed with a Tier 3 model two years ago; therefore, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.201 for all future years for Model 24.1, F = 0.288 for Model 24.1a, and F = 0.333 for Model 24.0. This is much than the 2031 - 2039 $F_{ABC} = 0.804$ in Scenario 1 for Model 24.1, $F_{ABC} = 1.156$ for Model 24.1a, and $F_{ABC} = 0.813$ for Model 24.0.

- Scenario 3: In all future years, F is set equal to the average of the five most recent years. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)
- Scenario 4: In all future years, the upper bound on F_{ABC} is set at $F_{75\%}$. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)
- Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

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

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

F_{limit}

The fishing mortality rate (based on Model 24.1) that would have produced a catch for last year equal to last year's OFL of 12,732 t is 0.578. This was produced with the full model, with higher natural mortality during the final nine years, and therefore is higher than the reference table may indicate. This value will be reported in the Aleutian Islands Pacific cod SARA file as the F_LIMIT and included in the species information system (SIS) output.

Risk Table

Assessment Considerations

To date the SSC has categorized this stock in Tier 5 where a reliable biomass estimate and estimate of M is available. The biomass estimate has come from a smoother of survey estimates (using REMA). This guides the Council in setting the ABC and OFL. As noted above, we prefer the SSC adopt the age-structured assessment model (24.1) for advice using Tier 3 because of the available estimates of recruitment, biomass, and SPR rates that this model provides. A benefit of a Tier 3 categorization is that the Council can be informed on the status determination of the stock (under Tier 5 such information is unavailable). Therefore, given our assessment refinements incorporating ecosystem and biological sampling, our assessment concerns are level 1, no concern.

Population Dynamics Considerations

The long-term (1991-2024) trawl survey biomass trend is downward and the 2024 index is the lowest of the time series (Figure 2A.6). Research indicates that Aleutian Islands cod have do not move out of the region and it is unlikely that the decline is due to emigration.

We consider the current stock size atypical, considering the survey biomass time series. Therefore, population dynamics considerations were rated as level 2.

Environmental/Ecosystem Considerations

Environment: The average bottom temperature from the Aleutian Islands bottom trawl survey (165°W – 172°E, 30-500 m) was close to the 20-year mean (1991–2012) for all subareas but still above the long term mean. This is in contrast with the four survey years prior, which were generally warmer than average for bottom temperatures. The bottom temperature means are similar across all four regions (Howard and Laman, 2024) and values close to the long term mean is considered a positive indicator. Satellite sea surface temperatures show a step increase in 2014 with higher temperatures both in summer and winter (Xiao and Ren 2023). Sea surface temperatures were above the mean through winter across all subregions. Over the eastern Aleutian Islands, there were few days of marine heatwave (MHW) status relative to the mean over the last decade, which was also the case in 2021 and 2022. At times during late summer, over 75% of the western Aleutians were in MHW status. While there were also warm anomalies and MHWs over 25% of the central and eastern Aleutians in summer, these were not sufficient to register in the spatial mean (Lemagie and Callahan, 2024).

Pacific cod are typically found between 3.5–5.7°C (range 2.8 to 6.9°C) and an average depth of 164 m (range 22 – 435) in the Aleutian Islands based on data from the bottom trawl survey. In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish. However, Holsman and Aydin (2015) found adult Pacific cod consumption in the Aleutian Islands increases up to 4°C and decreases past 5°C. While the continued decrease in average bottom temperature in 2024 is favorable, the fact that the sea surface temperatures continue to be above the long term average in winter and summer is considered to have a negative effect. Pacific cod are particularly sensitive to the impacts of increased temperatures due to a combination of their energetic demands, diet, as seen in the Gulf of Alaska during the 2014–2016 heatwave (Barbeaux et al. 2020). In addition, Pacific cod eggs adhere to the seafloor and with demersal egg hatching success above 20% restricted to temperatures between 3-6°C and they spawn between January and May. Warmer winter temperatures may impact their overwinter survival.

Prey: Atka mackerel and pollock are primarily planktivorous fish, feeding largely on copepods and euphausiids followed by pelagic amphipods and pelagic gelatinous filter feeders. While Atka mackerel and pollock >250 mm showed a fish condition below the long term average, which decreases their nutritional value and quality as prey (Howard and Laman 2024, Ortiz 2024), pollock 100-250 mm had a high fish condition 2 std. dev. above the long term mean. Pacific cod stomachs collected in the bottom trawl survey in the western and central Aleutians (areas 543, 542) have shown decreases of Atka mackerel in its diet, previously one of their primary prey items, over the past few years (Ortiz and Zador 2023), potentially reflecting scarcer and lower quality prey available for Pacific cod. The reverse has happened in area 541, where Atka mackerel was not generally a common prey in earlier years, but has now increased to over 20% of Pacific cod diet by biomass since 2014, replacing sculpins. The improved quality of small pollock as prey may have prevented a further decrease in the fish condition of Pacific cod, as it stayed similar to that observed in 2022 which had improved compared to the previous three survey years. Still the fish condition of Pacific cod has remained below average since 2012.

As a generalist, Pacific cod is able to compensate for the lower availability of any one type of prey, having the ability to easily switch between fish and benthic crustacean prey. The increase in prey quantity and quality may be offset by the dominance of rockfish (POP and Northern Rockfish) within the pelagic foragers guild, previously comprising a larger proportion of pollock and Atka mackerel in the early 1990s. This year, piscivorous and planktivorous seabirds had mostly below average reproductive success, around Buldir signaling foraging conditions that did not allow them to rear chicks successfully, which may in turn signal suboptimal foraging conditions for groundfish as well. In contrast, planktivorous and piscivorous seabirds at Aiktak (eastern Aleutians) had above average reproductive success, signaling a potential gradient in foraging conditions with better conditions towards the east (Rojek et al. 2024). Competitors and predators: Among the fish apex predators, piscivores and invertivores (e.g. arrowtooth flounder, Pacific halibut) continue declining except for sculpins and sablefish (Ortiz, 2024). As of 2023, Steller sea lions were declining in the western Aleutians offset by increases in the east (Sweeney and Gelatt, 2024), and harbor seals are also declining (London et al. 2018). Piscivorous and planktivorous seabirds at Aiktak are reproducing successfully and puffins are feeding on pollock, but their abundance trend is unknown as is that of common murres (Rojek et al 2024).

Despite the cooler temperatures, and good quality small pollock, the fish condition of cod stayed similar to that in 2022 as opposed to continue to improve. This together with continued warm winter and potentially suboptimal foraging conditions in the western Aleutians suggests there still remain some adverse signals relevant to the stock, but the pattern is not consistent across all areas.

Environmental/ ecosystem considerations were rated as level 2 (multiple indicators showing consistent adverse signals a) across the same trophic level, and/or b) up or down trophic levels (i.e., predators and prey).

Fishery Performance Considerations

Trends in CPUE can be examined for evidence of population trends, although other factors can affect CPUE besides population dynamics. Trends in catch are available from fishery data through 2024, and consistently indicate a downward trend (Figure 2A.2).

The fishery reports that lack of catcher-vessel (CV) trawl effort in the Aleutian Islands is not due to lack of interest. The Aleutian Islands fishery often gets pre-empted by the Bering Sea fishery given the later timing of aggregation in the Aleutians and the lack of an Aleutian set-aside of the CV sector appointment. For the trawl CVs, the early part of the A season catch rates in the Bering Sea are often better. By March, CPUE for trawl CVs is generally better in the Aleutian Islands. Unfortunately the CV trawl cod fishery in the Aleutian Islands is often closed by then.

In some years (e.g. 2020) the BSAI CV trawl fleet took a large portion or all of their A season quota in the Bering Sea before the Aleutian Islands cod aggregate (for spawning). The Adak processor was closed in 2020 through 2023, and is unlikely to open for the 2024 A season, so no local processing plant is available. This results in fewer smaller pot and hook-and-line vessels unless a floating processor or tender is available to assist.

Fishery performance considerations were rated as level 1.

Risk Summary

The ratings of the four categories are summarized below:

Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance
Level 1: Normal	Level 2: Increased concerns	Level 2: Increased concerns	Level 1: Normal

Based on this risk table, we recommend a reduction in ABC for the Tier 5 Model 24.2. We recommend the Tier 3 Model 24.1 ABC be used in place of the Model 24.2 ABC.

Area Allocation of ABC

As noted in the “Management History” subsection of the “Fishery” section, the current Steller sea lion protection measures require an estimate of the proportion of the Aleutian Islands Pacific cod stock residing in Area 543, which will be used to set the harvest limit in 543 after subtraction of the State GHL from the overall AI ABC. Since 2018, the Area 543 proportion has been calculated in Tier 5 model based on the most recent estimate of biomass in Area 543 relative to the estimate from the total area. Using Aleutian Islands trawl survey data from 1991 - 2024, this proportion is 32%. This represents an increase, as 15.7% was used between 2018 and 2022. The proportion allocated to the western Aleutian Islands region 543 would remain 32% after the State GHL is subtracted from the overall AI ABC whether a Tier 5 or Tier 3b harvest strategy is adopted.

Status Determination

Under the MSFCMA, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition? The official AI catch estimate for the most recent complete year (2023) is 7,910 t. This is less than the 2022 AI OFL of 27,400 t and also the AI ABC of 20,600. Therefore, the AI Pacific cod stock is not being subjected to overfishing. Because this stock is managed under Tier 5, no determination can be made with respect to overfished status. If the status changes to Tier 3, it would not be considered subjected to overfishing.

Ecosystem Considerations

Ecosystem effects on the stock

A primary ecosystem phenomenon affecting the Pacific cod stock seems to be the occurrence of periodic “regime shifts,” in which central tendencies of key variables in the physical environment change on a scale spanning several years to a few decades (Zador, 2011). One well-documented example of such a regime shift occurred in 1977, and shifts occurring in 1989 and 1999 have also been suggested (e.g., Hare and Mantua 2000). Because the data time series in the models presented in this assessment do not begin until 1991, the 1977 regime shift should not be a factor in any of the quantities presented here, although it may indeed have had an impact on the stock.

The prey and predators of Pacific cod have been described or reviewed by Albers and Anderson (1985), Livingston (1989, 1991), Lang et al. (2003), Westrheim (1996), and Yang (2004). The composition of Pacific cod prey varies to some extent by time and area. In terms of percent occurrence, some of the most common items in the diet of Pacific cod in the BSAI and GOA have been polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, some of the most common dietary items have been euphausids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, common dietary items include walleye pollock, fishery offal, yellowfin sole, and crustaceans. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include Pacific cod, halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffin. Major trends in the most important prey or predator species could be expected to affect the dynamics of Pacific cod to some extent.

Fishery Effects on the Ecosystem

Potentially, fisheries for Pacific cod can have effects on other species in the ecosystem through a variety of mechanisms, for example by relieving predation pressure on shared prey species (i.e., species which serve as prey for both Pacific cod and other species), by reducing prey availability for predators of Pacific cod, by altering habitat, by imposing bycatch mortality, or by "ghost fishing" caused by lost fishing gear.

Incidental Catch Taken in the Pacific Cod Fisheries

Incidental catches taken in the Pacific cod target fisheries, expressed as proportions of total incidental EBS catches (i.e., across all targets) for the respective species, are summarized in several tables. For the purpose of generating these tables, Pacific cod targets were those identified as such in the AKFIN database (https://akfin.psmfc.org/). Catches for 2024 in each of these tables are incomplete, through the end of October 2024. The Pacific cod fishery using trawl gear (Table 2A.27) and fixed gear Table 2A.28 take a small proportion of the incidental catch of FMP species (1991-2024). FMP species are more commonly caught in the Pacific cod trawl fishery than with longline gear (Table 2A.27, Table 2A.28). In the Pacific cod trawl fishery, flatfish are most commonly caught FMP species, followed by Atka mackerel and occasionally sharks and skates. During some years from 1991-2024, the proportional catch of octopus and longnose skate was high in the Pacific cod trawl (Table 2A.29) and longline (Table 2A.30) fisheries, although incidental catch of squid and members of the former "other species" complex taken by trawl gear was lower. Similarly, the Pacific cod fishery accounts for a large proportion of several crab species bycatch (Table 2A.31). Discard mortality of halibut taken in the Pacific cod fishery from 1991-2024, aggregated across gear types, has declined during this time period. The proportion of incidental catch of non-target species groups taken from 2003-2024, excluding bird species, aggregated across gear types Table 2A.32 varies from very little to almost all of the bycatch in a given year.

Steller Sea Lions

Pacific cod is one of the four most important prey items of Steller sea lions in terms of frequency of occurrence averaged over years, seasons, and sites, and is especially important in winter in the GOA and BSAI (Pitcher 1981, Calkins 1998, Sinclair and Zeppelin 2002). The size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds (Livingston (ed.), 2002). A study conducted in 2002-2005 using pot fishing gear demonstrated that the local concentration of cod in the Unimak Pass area is very dynamic, so that fishery removals did not create a measurable decline in fish abundance (Conners and Munro 2008). A preliminary tagging study in 2003–2004 showed some cod remaining in the vicinity of the release area in the southeast Bering Sea for several months, while other fish moved distances of 150 km or more north-northwest along the shelf, some within two weeks (Rand et al. 2015).

Seabirds

In the BSAI and GOA, the northern fulmar (*Fulmarus glacialis*) comprises the majority of seabird bycatch, primarily in the longline fisheries, including the fixed gear fishery for Pacific cod (Livingston (ed.) 2002). Shearwater (*Puffinus* spp.) distribution overlaps with the Pacific cod longline fishery in the Bering Sea, and with trawl fisheries in general in both the Bering Sea and GOA. Black-footed albatross (*Phoebastria nigripes*) is taken in much greater numbers in the GOA longline fisheries than the Bering Sea longline fisheries, but is not taken in the trawl fisheries. The distribution of Laysan albatross (*Phoebastria immutabilis*) appears to overlap with the longline fisheries in the central and western Aleutians. The distribution of short-tailed albatross (*Phoebastria albatrus*) also overlaps with the Pacific cod longline fishery along the Aleutian chain, although the majority of the bycatch has taken place along the northern portion of the Bering Sea shelf edge; in contrast, only two have been recorded in the GOA. Some success has been obtained in devising measures to mitigate fishery-seabird interactions. For example, on vessels larger than 60 ft. LOA, paired streamer lines of specified performance and material standards have been found to significantly reduce seabird incidental take. Typically bycatch of bird species in the Pacific cod trawl and longline fisheries is low, although in some years a large proportion of certain species were taken in the Pacific cod fisheries (Table 2A.33.

Data Gaps and Research Priorities

Longer-term research needs include improved understanding of: 1) the spatial dynamics, trophic and other interspecific relationships, and the relationship between climate and recruitment, 2) ecology of species that interact with Pacific cod, including estimation of interaction strengths, biomass, carrying capacity, and resilience, and 3) the physiological response of cod to thermal stress using gene expression studies in an experimental setting.

An age-based histological maturity curve would be ideal and is a research priority for the model.

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Tables

Table 2A.1: Summary table with a comparison of Models 24.1, 24.1a, and 24.0. *Asterisk denotes natural mortality estimated in the timeblock 2016-2024. The 2025 and 2026 ABCs for Model 24.2 are based on Model 24.1, and are used in place of the maxABC for Model 24.2.

	Model 24.1		Model 24.1a		Model 24.0	
Quantity	2025	2026	2025	2026	2025	2026
M (natural mortality rate)	0.42, 0.57*	0.42, 0.57*	0.42, 0.56*	0.42, 0.56*	0.42	0.42
Tier	3	3	3	3	3	3
Projected total (age 1+) biomass (t)	73,679	77,731	70,151	74,284	89,608	83,115
Projected female spawning biomass (t)	25,078	24,729	23,410	23,148	31,388	26,475
$B_{100\%}$	102,361	102,361	94,685	94,685	82,429	82,429
$B_{40\%}$	40,944	40,944	37,873	37,873	32,971	32,971
$B_{35\%}$	35,826	35,826	33,139	33,139	28,850	28,850
F_{OFL}	0.655	0.645	0.959	0.947	1.088	0.909
$maxF_{ABC}$	0.502	0.494	0.719	0.71	0.833	0.494
F_{ABC}	0.502	0.695	0.719	0.71	0.833	0.695
OFL	16,782	16,273	17,037	16,541	31,205	22,230
$maxABC$	13,376	12,973	13,399	13,021	25,439	17,925
ABC	13,376	12,973	13,399	13,021	25,439	17,925
Status	2023	2024	2023	2024	2023	2024
Overfishing	No	n/a	No	n/a	No	n/a
Overfished	n/a	No	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No	n/a	No

Table 2A.2: Summary table with a comparison of Models 13.4 and 24.2 proposed for 2024. Model 13.4 (2023) was the tier 5 model used in 2023. M represents natural mortality rate. Note the 2024 accepted ABC and OFL were adjusted from the 2024 model values for OFL and ABC.

	Model 13.4 (2023) As estimated or *specified last* year for:		Model 13.4 As estimated or *recommended this* year for:		Model 24.2 As estimated or *recommended this* year for:	
Quantity	2024	2025	2025	2026	2025	2026
M	0.34	0.34	0.34	0.34	0.417	0.417
Tier	5	5	5	5	5	5
Biomass (t)	54,165	54,165	51,503	51,503	51,503	51,503
F_{OFL}	0.34	0.34	0.34	0.34	0.417	0.417
$maxF_{ABC}$	0.255	0.255	0.255	0.255	0.313	0.313
F_{ABC}	0.255	0.255	0.255	0.255	0.313	0.313
OFL	18,416	18,416	17,511	17,511	21,477	21,477
$maxABC$	12,431	12,431	13,133	13,133	16,107	16,107
ABC	12,431	12,431	13,133	13,133	13,376	12,973
Status	2022	2023	2023	2024	2023	2024
Overfishing	No	n/a	No	n/a	No	n/a

Table 2A.3: Comparison of likelihoods and model parameters among Models 24.1, 24.1a, and 24.0. The likelihood components, derived quantities, and parameter estimates for each model are shown below Results.

Features	M24.1	M24.1a	M24.0
2024 Params (X)/Alt. Params (0)			
M timeblock 2016-2024/ None	X	X	0
Richards Growth/ von B growth	X	0	X
Results			
TOTAL_like	534.148	547.266	544.019
Survey_like	-8.87	-7.606	-1.241
Length_comp_like	140.884	133.085	140.844
Age_comp_like	402.559	420.1	403.169
Recruitment_like_thousands	-0.43	0.608	0.355
Recr_Virgin_millions	80.596	75.858	62.969
SR_BH_steep	1	1	1
Natural mortality	0.417	0.417	0.417
NatM_BLK2repl_2016	0.572	0.564	NA
SmryBio_unfished	247,377	228,381	193,473
SSB_Virgin_thousand_mt	200.904	183.868	157.101
SSB_2024_thousand_mt	50.537	46.708	55.314
Bratio_2024	0.252	0.254	0.352
SPRratio_2024	0.188	0.165	0.197
Ret_Catch_MSY	31,133	29,262	24,372
SR_LN(R0)	11.2972	11.2366	11.0504
Survey catchability (q)	0.87	0.961	0.931
Size_DblN_peak_FshComb(1)	101.037	107.458	102.345
Size_DblN_top_logit_FshComb(1)	25	25	25
Size_DblN_ascend_se_FshComb(1)	6.636	6.754	6.681
Size_DblN_peak_Srv(2)	69.729	73.635	68.749
Size_DblN_ascend_se_Srv(2)	6.519	6.712	6.54
Number of parameters	55	54	54
AIC	1178.296	1202.532	1196.038

Table 2A.4: Catch of Pacific cod in the Aleutian Islands by foreign, domestic, and joint venture fisheries, 1964-1980. Note that joint venture fisheries did not commence until 1981, and domestic catch information is not available prior to 1988.

Year	Foreign	Joint Venture	Domestic	Total
1964	241	0	0	241
1965	451	0	0	451
1966	154	0	0	154
1967	293	0	0	293
1968	289	0	0	289
1969	220	0	0	220
1970	283	0	0	283
1971	2,078	0	0	2,078
1972	435	0	0	435
1973	977	0	0	977
1974	1,379	0	0	1,379
1975	2,838	0	0	2,838
1976	4,190	0	0	4,190
1977	3,262	0	0	3,262
1978	3,295	0	0	3,295
1979	5,593	0	0	5,593
1980	5,788	0	0	5,788

Table 2A.5: Summary of catches of Pacific cod (t) in the Aleutian Islands by gear type. All catches include discards. Domestic annual catch by gear is not available prior to 1988.

Year	Foreign			Joint Venture	Domestic			Total
	Trawl	Longline	Total	Trawl	Trawl	Longline and pot	Total	
1981	2,680	235	2,915	1,749	-	-	2,770	7,434
1982	1,520	476	1,996	4,280	-	-	2,121	8,397
1983	1,869	402	2,271	4,700	-	-	1,459	8,430
1984	473	804	1,277	6,390	-	-	314	7,981
1985	10	829	839	5,638	-	-	460	6,937
1986	5	0	5	6,115	-	-	786	6,906
1987	0	0	0	10,435	-	-	2,772	13,207
1988	0	0	0	3,300	1,698	167	1,865	5,165
1989	0	0	0	6	4,233	303	4,536	4,542
1990	0	0	0	0	6,932	609	7,541	7,541

Table 2A.6: Federal and state fishery Pacific cod catch in metric tons by year, 1991-2024. To avoid confidentiality problems, federal longline and pot catches have been combined. "Other" gear types include gill net and jig. Catches for 2024 are through September 22. The state fishery catch is included in the total, and broken out as a separate column from 2006 onward. State data for 2024 are preliminary.

Year	Trawl	Longline+Pot	Other	Total	State
1991	3,414	6,383	0	9,797	0
1992	14,558	28,425	83	43,067	0
1993	17,311	16,860	32	34,204	0
1994	14,382	7,156	0	21,539	0
1995	10,574	5,959	0	16,534	0
1996	21,178	10,429	0	31,609	0
1997	17,349	7,725	88	25,164	0
1998	20,530	14,195	0	34,726	0
1999	16,437	11,624	68	28,130	0
2000	20,361	19,289	32	39,684	0
2001	15,826	18,361	19	34,207	0
2002	27,929	2,871	0	30,800	0
2003	31,478	978	0	32,456	0
2004	25,770	3,102	0	28,873	0
2005	19,613	3,067	12	22,693	0
2006	20,062	4,141	7	24,211	3,720
2007	28,631	5,716	6	34,354	4,140
2008	21,826	9,193	208	31,228	4,266
2009	20,821	7,739	20	28,581	2,039
2010	18,872	10,133	0	29,006	3,966
2011	9,382	1,506	0	10,888	265
2012	12,138	6,059	21	18,219	5,209
2013	8,122	5,489	0	13,612	4,793
2014	6,765	3,817	0	10,583	4,450
2015	6,129	3,080	0	9,209	161
2016	11,535	1,696	0	13,231	882
2017	8,536	6,633	0	15,170	2,946
2018	10,118	10,239	55	20,414	5,695
2019	10,293	8,710	140	19,144	6,168
2020	4,319	9,939	5	14,264	6,777
2021	3,463	10,544	0	14,007	6,710
2022	3,649	8,202	0	11,851	5,402
2023	3,728	4,182	0	7,910	4,511
2024	3,038	531	0	3,570	0

Table 2A.7: Summary of 1994-2024 catches (t) of Pacific cod in the AI, by NMFS statistical area (area breakdowns not available prior to 1994). Catches for 2024 are through September 22.

Year	Total Catch			Proportions		
	Western	Central	Eastern	Western	Central	Eastern
1994	2,059	7,441	12,039	0.096	0.345	0.559
1995	1,713	5,086	9,735	0.104	0.308	0.589
1996	4,023	4,509	23,077	0.127	0.143	0.730
1997	894	4,440	19,830	0.036	0.176	0.788
1998	3,487	9,299	21,940	0.100	0.268	0.632
1999	2,322	5,276	20,532	0.083	0.188	0.730
2000	9,073	8,799	21,812	0.229	0.222	0.550
2001	12,767	7,358	14,082	0.373	0.215	0.412
2002	2,259	7,133	21,408	0.073	0.232	0.695
2003	2,997	6,707	22,752	0.092	0.207	0.701
2004	3,649	6,833	18,391	0.126	0.237	0.637
2005	4,239	3,582	14,873	0.187	0.158	0.655
2006	4,570	4,675	14,967	0.189	0.193	0.618
2007	4,974	4,692	24,689	0.145	0.137	0.719
2008	7,319	5,555	18,355	0.234	0.178	0.588
2009	7,929	6,899	13,754	0.277	0.241	0.481
2010	8,213	6,292	14,501	0.283	0.217	0.500
2011	24	1,770	9,095	0.002	0.163	0.835
2012	29	2,816	15,374	0.002	0.155	0.844
2013	47	2,884	10,682	0.003	0.212	0.785
2014	29	1,039	9,514	0.003	0.098	0.899
2015	3,170	2,364	3,676	0.344	0.257	0.399
2016	2,550	1,607	9,074	0.193	0.121	0.686
2017	3,371	3,768	8,031	0.222	0.248	0.529
2018	2,694	4,065	13,655	0.132	0.199	0.669
2019	1,340	5,298	12,507	0.070	0.277	0.653
2020	1,972	5,131	7,161	0.138	0.360	0.502
2021	1,715	3,791	8,502	0.122	0.271	0.607
2022	1,237	3,016	7,599	0.104	0.254	0.641
2023	589	2,004	5,317	0.074	0.253	0.672
2024	653	1,324	1,593	0.183	0.371	0.446

Table 2A.8: Pacific cod catch in metric tons by year, total allowable catch (TAC), acceptable biological catch (ABC), and overfishing limit (OFL), 1991-2024. Note that specifications were combined for the Bering Sea and Aleutian Islands cod stocks through 2013 and are shown for the Aleutian Islands alone for 2013 onwards. Catch for 2024 is through September 22. ABC, OFL, and TAC for 2024 are based on last year's model output.

Year	Catch (t)	ABC	TAC	OFL
1991	9,797	229,000	229,000	-
1992	43,067	182,000	182,000	188,000
1993	34,204	164,500	164,500	192,000
1994	21,539	191,000	191,000	228,000
1995	16,534	328,000	250,000	390,000
1996	31,609	305,000	270,000	420,000
1997	25,164	306,000	270,000	418,000
1998	34,726	210,000	210,000	336,000
1999	28,130	177,000	177,000	264,000
2000	39,684	193,000	193,000	240,000
2001	34,207	188,000	188,000	248,000
2002	30,800	223,000	200,000	294,000
2003	32,456	223,000	207,500	324,000
2004	28,873	223,000	215,500	350,000
2005	22,693	206,000	206,000	365,000
2006	24,211	194,000	189,768	230,000
2007	34,354	176,000	170,720	207,000
2008	31,228	176,000	170,720	207,000
2009	28,581	182,000	176,540	212,000
2010	29,006	174,000	168,780	205,000
2011	10,888	235,000	227,950	272,000
2012	18,220	314,000	261,000	369,000
2013	13,608	307,000	260,000	359,000
2014	10,603	15,100	6,997	20,100
2015	9,216	17,600	9,422	23,400
2016	13,245	17,600	12,839	23,400
2017	15,202	21,500	15,695	28,700
2018	20,414	21,500	15,695	28,700
2019	19,200	20,600	14,214	27,400
2020	14,250	20,600	13,796	27,400
2021	12,882	20,600	13,796	27,400
2022	10,547	20,600	13,796	27,400
2023	7,312	13,812	8,425	18,416
2024	3,570	12,431	8,080	18,416

Table 2A.9: Catch of Pacific cod from 1993-2024 in non-target and targeted fisheries, as of September 22, 2024. Inconsistencies in the final year of catch estimates are the result of delays in data processing. Catches in the previous table are updated prior to catches in the catch by target fishery (this table).

Year	Non-target							Target	Overall
	Atka mackerel	Flatfish	Halibut	Pollock	Rockfish	Other	Total non-target	Pacific cod	Total
1994	6,855	3	0	11	358	0	7,244	14,295	21,539
1995	4,456	25	0	47	207	37	5,713	10,822	16,534
1996	8,675	0	0	10	394	10	9,173	22,436	31,609
1997	1,988	0	0	216	110	0	2,359	22,804	25,164
1998	3,709	19	0	1	114	33	3,891	30,836	34,726
1999	2,415	16	0	0	173	2	2,660	25,471	28,130
2000	2,088	66	0	0	115	24	2,377	37,308	39,684
2001	2,018	3	0	0	194	6	2,287	31,920	34,207
2002	1,265	2	0	0	70	4	1,433	29,369	30,800
2003	1,895	9	91	0	264	5	2,275	30,182	32,456
2004	2,109	0	91	0	132	0	2,335	26,538	28,873
2005	2,154	0	236	0	83	1	2,479	20,215	22,693
2006	1,526	29	88	0	83	2	1,741	22,470	24,211
2007	1,785	34	19	1	85	1	1,933	32,422	34,354
2008	1,005	0	86	1	220	8	1,327	29,901	31,228
2009	2,022	0	14	0	84	5	2,145	26,437	28,581
2010	1,616	13	15	377	84	0	2,116	26,890	29,006
2011	1,488	94	65	0	136	5	1,795	9,093	10,888
2012	1,265	21	26	0	115	0	1,432	16,786	18,220
2013	853	230	174	9	390	0	1,659	11,951	13,608
2014	908	141	94	0	225	0	1,369	9,233	10,603
2015	2,253	27	43	0	580	0	2,903	6,313	9,216
2016	2,495	63	61	1	544	0	3,164	10,080	13,245
2017	3,913	1	78	0	673	2	4,667	10,510	15,202
2018	3,308	5	59	2	509	0	3,901	16,514	20,414
2019	2,197	33	78	0	928	0	3,249	15,896	19,200
2020	2,176	45	74	0	770	0	3,067	11,196	14,250
2021	1,951	16	77	0	526	0	2,590	11,417	12,882
2022	0	0	0	0	0	0	0	9,209	10,547
2023	2,195	26	79	0	415	0	2,715	5,197	7,312
2024	1,763	13	3	0	82	0	1,861	650	2,511

Table 2A.10: Discarded Pacific cod (t) and discard rates for Pacific cod caught in the Aleutian Islands, for the period 1993 - September 22, 2024. Note that Amendment 49, which mandated increased retention and utilization, was implemented in 1998.

Year	Discards (t)	Total catch (t)	Proportion discarded
1993	1,508	4,208	0.358
1994	3,484	21,539	0.162
1995	3,180	16,534	0.192
1996	3,137	31,609	0.099
1997	2,107	25,164	0.084
1998	638	34,726	0.018
1999	514	28,130	0.018
2000	692	39,685	0.017
2001	471	34,207	0.014
2002	734	30,801	0.024
2003	332	32,457	0.010
2004	317	28,873	0.011
2005	489	22,694	0.022
2006	310	24,211	0.013
2007	554	34,355	0.016
2008	204	31,229	0.007
2009	208	28,582	0.007
2010	203	29,006	0.007
2011	91	10,889	0.008
2012	70	18,220	0.004
2013	253	13,612	0.019
2014	122	10,583	0.012
2015	95	9,210	0.010
2016	104	13,232	0.008
2017	150	15,170	0.010
2018	273	20,414	0.013
2019	151	19,145	0.008
2020	142	14,264	0.010
2021	179	14,008	0.013
2022	156	11,852	0.013
2023	169	7,911	0.021
2024	35	2,510	0.014

Table 2A.11: Sources of data used in the age structured models, Model 24.0 and 24.1. *Data current through August 15, 2024.

Source	Type	Years
Fishery (Trawl, Pot, LL)	Catch biomass	1991-2024*
Fishery (Trawl, Pot, LL)	Length composition	1991-2024
AI bottom trawl survey	Biomass estimate + Length composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022, 2024
AI bottom trawl survey	Age composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022, 2024

Table 2A.12: Aleutian Islands bottom trawl survey biomass estimates, proportion, and standard error by NMFS area for Pacific cod, for all years used in the model.

Biomass (t)				
Year	Western	Central	Eastern	Total
1991	39,729	64,926	75,515	180,169
1994	51,538	78,081	23,797	153,416
1997	30,252	28,239	14,357	72,848
2000	36,456	47,117	43,298	126,870
2002	24,687	25,241	23,623	73,551
2004	20,731	51,852	9,637	82,219
2006	22,033	43,349	19,480	84,861
2010	11,207	23,277	21,341	55,826
2012	14,804	30,592	13,514	58,911
2014	8,488	47,032	18,088	73,608
2016	19,496	45,138	19,775	84,409
2018	20,596	49,251	11,425	81,272
2022	14,045	23,837	13,661	51,543
2024	18,379	22,188	9,817	50,383

Proportion by area				
Year	Western	Central	Eastern	Total
1991	0.221	0.360	0.419	1
1994	0.336	0.509	0.155	1
1997	0.415	0.388	0.197	1
2000	0.287	0.371	0.341	1
2002	0.336	0.343	0.321	1
2004	0.252	0.631	0.117	1
2006	0.260	0.511	0.230	1
2010	0.201	0.417	0.382	1
2012	0.251	0.519	0.229	1
2014	0.115	0.639	0.246	1
2016	0.231	0.535	0.234	1
2018	0.253	0.606	0.141	1
2022	0.272	0.462	0.265	1
2024	0.365	0.440	0.195	1

Biomass coefficient of variation				
Year	Western	Central	Eastern	Total
1991	0.112	0.370	0.092	0.141
1994	0.390	0.301	0.292	0.206
1997	0.208	0.230	0.261	0.134
2000	0.270	0.222	0.429	0.185
2002	0.264	0.329	0.245	0.164
2004	0.207	0.304	0.169	0.200
2006	0.188	0.545	0.233	0.288
2010	0.257	0.223	0.409	0.189
2012	0.203	0.241	0.264	0.148
2014	0.276	0.275	0.236	0.187
2016	0.496	0.212	0.375	0.184
2018	0.217	0.242	0.175	0.159
2022	0.159	0.227	0.202	0.126
2024	0.202	0.207	0.566	0.161

Table 2A.13: The number of hauls in which length observations were taken for the fishery length composition data, by year, fishery effective sample size (ESS), survey input sample size (ISS), and survey ESS. The input sample size for the fishery was scaled to the mean ISS for the survey.

Year	Fishery Hauls	Fishery ESS	Survey ISS	Survey ESS
1991	291	22	355	14
1992	1823	136	-	-
1993	829	62	-	-
1994	548	41	136	5
1995	620	46	-	-
1996	893	66	-	-
1997	440	33	575	23
1998	1496	111	-	-
1999	1626	121	-	-
2000	2561	190	664	26
2001	2967	221	-	-
2002	1170	87	819	33
2003	1220	91	-	-
2004	1251	93	1030	41
2005	1076	80	-	-
2006	1030	77	538	21
2007	1411	105	-	-
2008	1339	100	-	-
2009	1207	90	-	-
2010	1779	132	851	34
2011	455	34	-	-
2012	612	46	733	29
2013	507	38	-	-
2014	248	18	1067	43
2015	479	36	-	-
2016	406	30	1158	46
2017	608	45	-	-
2018	707	53	1009	40
2019	474	35	-	-
2020	443	33	-	-
2021	424	32	-	-
2022	187	14	953	38
2023	34	3	-	-
2024	45	3	629	25

Table 2A.14: Aleutian Islands bottom trawl biomass estimates (t) and longline survey relative population numbers and standard error for Pacific cod, for all years used in the models.

Year	Trawl Survey Biomass (t)	S.E.	Longline Survey Index	S.E.
1991	180,170	0.140		-
1992		-		-
1993		-		-
1994	153,416	0.204		-
1995		-		-
1996		-	88,627	0.113
1997	72,848	0.133		-
1998		-	131,813	0.086
1999		-		-
2000	126,870	0.183	167,593	0.099
2001		-		-
2002	73,551	0.163	84,667	0.137
2003		-		-
2004	82,219	0.198	69,171	0.148
2005		-		-
2006	84,861	0.282	102,621	0.096
2007		-		-
2008		-	77,184	0.164
2009		-		-
2010	55,826	0.187	83,973	0.132
2011		-		-
2012	58,911	0.147	82,422	0.111
2013		-		-
2014	73,608	0.185	98,559	0.200
2015		-		-
2016	84,409	0.182	129,751	0.120
2017		-		-
2018	81,272	0.158	168,708	0.141
2019		-		-
2020		-	109,521	0.086
2021		-		-
2022	51,539	0.126	63,701	0.137
2023		-		-
2024	50,383	0.161		-

Table 2A.15: Survey age composition sample size data, by year, including the number of individual fish, number of hauls, and effective sample size for each year. Input sample sizes were generated using the methodology of Hulson et al (2023). Effective sample sizes are tuned using Francis weighting methodology described in the text.

Year	Number of aged fish	Number of hauls	Input sample size	Effective sample size
1991	919	121	39	6
1994	1174	150	25	4
1997	845	99	67	11
2000	828	111	153	25
2002	1270	173	162	26
2004	775	107	169	28
2006	754	105	105	17
2010	673	94	156	25
2012	599	83	126	21
2014	557	76	153	25
2016	681	95	142	23
2018	575	80	197	32
2022	765	192	253	41

Table 2A.16: Estimates of natural mortality, M, for Pacific cod throughout their range. Values marked with asterisks * have been used in stock assessments.

Region	Reference Author	Year	M estimate
EBS*	Low	1974	0.375
EBS	Wespestad et al.	1982	0.700
EBS	Bakkala and Wespestad	1985	0.450
EBS	Thompson and Shimada	1990	0.290
EBS	Thompson and Methot	1993	0.370
EBS*	Shimada and Kimura	1994	0.960
EBS*	Shi et al.	2007	0.450
EBS	Thompson et al.	2007	0.340
EBS	Thompson	2016	0.360
GOA	Thompson and Zenger	1993	0.270
GOA	Thompson and Zenger	1995	0.500
GOA	Thompson et al.	2007	0.380
GOA*	Barbeaux et al.	2016	0.470
BC*	Ketchen	1964	0.595
BC*	Fournier	1983	0.650
Korea*	Jung et al.	2009	0.820
Japan*	Ueda et al.	2004	0.200

Table 2A.17: Maturity at age ogives based on histological data (Stark 2007), and updated for this assessment with data from 2008-2024 (1,347 records), converted from lengths to ages. Observer-based maturity curves were used in age structured models.

Age	Stark 2007	Observer 2024
1	0.023	0.007
2	0.058	0.073
3	0.140	0.338
4	0.299	0.667
5	0.528	0.861
6	0.746	0.945
7	0.885	0.977
8	0.953	0.990
9	0.982	0.995
10	0.993	0.998

Table 2A.18: Estimates of total biomass for Models 24.1, 24.1a, and 24.0.

Year	Model 24.1	Model 24.1a	Model 24.0
	Biomass (t)	Biomass (t)	Biomass (t)
1989	252,077	235,237	203,044
1990	226,606	210,473	177,444
1991	162,186	151,822	154,505
1992	176,848	166,687	170,353
1993	160,270	150,756	154,660
1994	150,923	140,935	145,832
1995	152,383	143,540	147,858
1996	158,044	150,212	154,129
1997	151,546	144,018	148,197
1998	154,860	148,619	151,991
1999	153,228	148,470	150,719
2000	158,827	153,414	156,409
2001	154,829	148,785	152,364
2002	156,623	151,193	154,079
2003	160,232	155,385	157,596
2004	158,231	152,905	155,456
2005	153,179	147,321	150,254
2006	147,358	140,671	144,262
2007	136,441	130,167	133,169
2008	116,969	112,173	113,364
2009	103,630	100,139	99,252
2010	95,154	92,271	89,418
2011	86,592	83,181	78,869
2012	92,063	87,212	81,631
2013	89,652	83,760	75,525
2014	92,795	86,379	73,191
2015	102,560	95,780	74,713
2016	117,763	110,768	78,643
2017	112,544	106,144	79,149
2018	104,637	98,063	77,388
2019	93,015	86,811	70,806
2020	85,088	79,970	66,293
2021	82,936	79,044	67,380
2022	80,102	76,580	69,238
2023	76,696	72,736	72,704
2024	74,386	70,327	79,454

Table 2A.19: Estimates of female spawning biomass for Models 24.1, 24.1a, and 24.0, with upper and lower 95% confidence intervals.

Year	Model 24.1			Model 24.1a			Model 24.0		
	Biomass (t)	LCI	UCI	Biomass	LCI	UCI	Biomass	LCI	UCI
1989	204,722	146,397	263,046	189,370	136,584	242,155	164,859	121,402	208,315
1990	179,461	121,095	237,826	164,815	111,963	217,666	139,479	95,909	183,048
1991	112,158	84,619	139,696	102,219	79,920	124,517	105,057	80,363	129,750
1992	126,083	98,586	153,579	115,572	93,151	137,992	120,247	95,209	145,284
1993	113,236	86,107	140,364	103,933	81,651	126,214	108,329	83,410	133,247
1994	110,103	83,357	136,848	100,568	78,588	122,547	105,533	80,822	130,243
1995	111,645	86,135	137,154	102,158	81,108	123,207	107,364	83,709	131,018
1996	113,100	89,764	136,435	104,516	85,081	123,950	109,289	87,602	130,975
1997	105,247	84,392	126,101	98,347	80,981	115,713	102,133	82,738	121,527
1998	106,317	87,246	125,387	99,561	83,759	115,362	103,733	85,980	121,485
1999	98,920	81,159	116,680	93,343	78,532	108,153	96,718	80,149	113,287
2000	103,998	86,180	121,815	99,095	83,966	114,223	102,031	85,339	118,722
2001	103,904	85,208	122,599	98,261	82,328	114,194	101,999	84,431	119,566
2002	103,864	84,377	123,350	97,685	81,033	114,337	101,854	83,517	120,190
2003	105,473	85,421	125,524	99,755	82,456	117,054	103,360	84,479	122,240
2004	109,819	89,320	130,317	103,958	86,213	121,702	107,600	88,325	126,874
2005	115,094	94,796	135,391	108,109	90,656	125,561	112,699	93,693	131,704
2006	115,583	96,638	134,527	108,372	92,200	124,543	113,049	95,421	130,676
2007	106,816	90,160	123,471	100,491	86,355	114,626	104,254	88,913	119,594
2008	86,170	71,903	100,438	81,081	69,011	93,151	83,606	70,660	96,551
2009	70,586	57,805	83,368	66,857	55,931	77,782	67,894	56,528	79,260
2010	62,710	49,930	75,490	59,654	48,541	70,767	59,514	48,423	70,605
2011	57,551	43,770	71,333	54,682	42,657	66,707	53,209	41,606	64,811
2012	66,351	51,042	81,660	62,278	48,985	75,571	60,106	47,690	72,522
2013	64,734	48,397	81,070	59,808	45,765	73,851	56,321	43,659	68,982
2014	64,020	46,915	81,125	58,761	44,084	73,439	52,990	40,469	65,510
2015	66,703	48,416	84,990	61,225	45,458	76,992	51,867	39,581	64,152
2016	74,589	53,821	95,357	68,814	50,677	86,951	53,572	41,380	65,764
2017	72,280	53,293	91,266	67,119	50,500	83,739	54,419	42,003	66,836
2018	69,491	51,685	87,298	64,624	49,100	80,148	54,926	41,993	67,859
2019	60,588	43,974	77,202	56,002	41,645	70,359	49,960	36,591	63,329
2020	51,313	36,010	66,615	47,391	34,166	60,615	44,291	30,803	57,779
2021	48,050	33,783	62,318	44,652	32,250	57,053	43,307	29,808	56,806
2022	47,568	33,846	61,290	44,671	32,588	56,753	44,577	30,804	58,349
2023	49,069	35,038	63,100	46,257	33,758	58,755	49,082	34,186	63,979
2024	50,446	35,559	65,333	47,159	33,863	60,455	55,810	39,124	72,495

Table 2A.20: Estimates of recruitment for Models 24.1, 24.1a, and 24.0 with upper and lower 95% confidence intervals.

Year	Model 24.1			Model 24.1a			Model 24.0		
	Recruitment	LCI	UCI	Recruitment	LCI	UCI	Recruitment	LCI	UCI
1989	82,122	61,824	109,086	78,155	59,212	103,157	66,099	50,811	85,986
1990	82,122	61,824	109,086	78,155	59,212	103,157	66,099	50,811	85,986
1991	58,821	38,678	89,455	60,039	39,750	90,683	58,483	38,389	89,094
1992	63,242	40,563	98,602	57,857	35,709	93,740	62,362	39,774	97,778
1993	125,225	95,497	164,205	129,045	98,633	168,833	126,016	96,295	164,909
1994	41,875	24,603	71,272	41,191	24,041	70,574	40,967	23,877	70,288
1995	92,079	66,931	126,675	88,932	63,655	124,246	91,096	66,168	125,414
1996	142,241	111,640	181,229	143,079	111,887	182,965	141,793	111,437	180,417
1997	74,748	52,819	105,782	72,519	50,557	104,021	73,925	52,201	104,689
1998	73,961	52,820	103,565	72,808	51,649	102,634	72,778	51,942	101,973
1999	112,667	85,204	148,981	112,516	85,005	148,929	111,376	84,270	147,200
2000	121,742	94,189	157,353	119,076	91,443	155,058	120,792	93,561	155,948
2001	62,179	43,285	89,320	64,918	45,147	93,345	61,368	42,675	88,249
2002	49,534	32,754	74,908	49,683	32,679	75,533	48,582	32,048	73,646
2003	57,790	39,192	85,214	58,338	39,561	86,028	56,951	38,618	83,986
2004	33,638	18,564	60,951	29,340	15,390	55,931	32,215	17,586	59,014
2005	74,403	53,122	104,209	77,330	55,431	107,882	72,376	52,001	100,733
2006	55,959	37,572	83,343	53,918	35,482	81,934	52,586	35,478	77,943
2007	65,915	46,809	92,819	65,333	46,412	91,969	59,539	42,752	82,918
2008	48,397	32,945	71,096	45,373	30,701	67,057	41,347	28,558	59,862
2009	29,637	17,765	49,443	28,669	17,131	47,977	23,881	14,548	39,199
2010	50,210	33,366	75,557	47,110	31,137	71,277	37,374	25,641	54,477
2011	45,074	28,526	71,222	44,565	28,379	69,982	31,032	20,471	47,041
2012	82,700	56,212	121,668	77,350	52,671	113,591	51,058	37,404	69,697
2013	81,437	52,649	125,968	80,035	51,946	123,311	45,288	32,176	63,743
2014	102,354	64,598	162,175	95,486	60,421	150,899	50,097	36,124	69,476
2015	60,450	33,140	110,267	57,904	31,870	105,203	27,207	16,983	43,586
2016	97,538	51,541	184,587	86,586	45,642	164,259	37,447	23,647	59,299
2017	110,531	58,600	208,481	104,642	55,339	197,868	42,106	26,564	66,740
2018	116,397	65,000	208,434	113,423	63,563	202,393	48,119	31,676	73,097
2019	106,224	60,248	187,281	100,259	57,175	175,806	48,723	31,495	75,373
2020	67,959	34,861	132,482	58,520	29,592	115,728	35,408	19,713	63,596
2021	57,068	26,378	123,467	56,140	26,063	120,925	34,237	16,671	70,309
2022	76,193	63,933	90,805	73,935	62,733	87,137	59,243	54,458	64,447
2023	76,193	63,933	90,805	73,935	62,733	87,137	59,243	54,458	64,447
2024	76,193	63,933	90,805	73,935	62,733	87,137	59,243	54,458	64,447

Table 2A.21: Key parameter values estimated in Model 24.1.

	Model 24.1	
Parameter	Value	StDev
L_at_Amin_Fem_GP_1	14.0937	0.6830
L_at_Amax_Fem_GP_1	123.3850	3.8950
VonBert_K_Fem_GP_1	0.2204	0.0255
Richards_Fem_GP_1	0.3997	0.1409
NatM_uniform_Fem_GP_1_BLK2repl_2016	0.5703	0.0371
SR_LN(R0)	11.3160	0.1456
Early_InitAge_13	-0.5720	0.6366
Early_InitAge_12	-0.4122	0.6720
Early_InitAge_11	-0.5497	0.6402
Early_InitAge_10	-0.6957	0.6101
Early_InitAge_9	-0.8089	0.5816
Early_InitAge_8	-0.7854	0.5557
Early_InitAge_7	-0.4913	0.5019
Early_InitAge_6	-0.4192	0.4796
Early_InitAge_5	0.4638	0.2724
Early_InitAge_4	0.4842	0.2384
Early_InitAge_3	-0.1385	0.2721
Early_InitAge_2	0.8011	0.1946
Early_InitAge_1	-0.0693	0.2745
Main_RecrDev_1991	-0.0431	0.2529
Main_RecrDev_1992	0.0294	0.2617
Main_RecrDev_1993	0.7125	0.1971
Main_RecrDev_1994	-0.3829	0.3044
Main_RecrDev_1995	0.4051	0.2091
Main_RecrDev_1996	0.8399	0.1821
Main_RecrDev_1997	0.1965	0.2190
Main_RecrDev_1998	0.1860	0.2135
Main_RecrDev_1999	0.6068	0.1933
Main_RecrDev_2000	0.6843	0.1894
Main_RecrDev_2001	0.0124	0.2319
Main_RecrDev_2002	-0.2149	0.2541
Main_RecrDev_2003	-0.0608	0.2443
Main_RecrDev_2004	-0.6019	0.3322
Main_RecrDev_2005	0.1919	0.2137
Main_RecrDev_2006	-0.0930	0.2344
Main_RecrDev_2007	0.0708	0.2077
Main_RecrDev_2008	-0.2381	0.2218
Main_RecrDev_2009	-0.7286	0.2785
Main_RecrDev_2010	-0.2014	0.2254
Main_RecrDev_2011	-0.3093	0.2461
Main_RecrDev_2012	0.2976	0.2066
Main_RecrDev_2013	0.2822	0.2266
Main_RecrDev_2014	0.5108	0.2335
Main_RecrDev_2015	-0.0158	0.3062
Main_RecrDev_2016	0.4627	0.3226
Main_RecrDev_2017	0.5877	0.3176
Main_RecrDev_2018	0.6394	0.2892
Main_RecrDev_2019	0.5423	0.2836
Main_RecrDev_2020	0.0817	0.3419
Main_RecrDev_2021	-0.1070	0.4030
InitF_seas_1_flt_1FshComb	0.0635	0.0141
Size_DblN_peak_FshComb(1)	100.9820	4.2392
Size_DblN_ascend_se_FshComb(1)	6.6345	0.1238
Size_DblN_peak_Srv(2)	69.7066	2.6162
Size_DblN_ascend_se_Srv(2)	6.5209	0.1180

Table 2A.22: Key parameter values estimated in Models 24.1a and 24.0.

Model 24.1a			Model 24.0		
Parameter	Value	StDev	Parameter	Value	StDev
L_at_Amin_Fem_GP_1	10.9891	0.4120	L_at_Amin_Fem_GP_1	13.9883	0.6853
L_at_Amax_Fem_GP_1	144.9340	4.5449	L_at_Amax_Fem_GP_1	123.9430	3.9162
VonBert_K_Fem_GP_1	0.1187	0.0061	VonBert_K_Fem_GP_1	0.2153	0.0247
NatM_uniform_Fem_GP_1_BLK2repl_2016	0.5631	0.0370	Richards_Fem_GP_1	0.4310	0.1372
SR_LN(R0)	11.2665	0.1423	SR_LN(R0)	11.0989	0.1348
Early_InitAge_13	-0.6373	0.6258	Early_InitAge_13	-0.4474	0.6635
Early_InitAge_12	-0.4816	0.6570	Early_InitAge_12	-0.3254	0.6935
Early_InitAge_11	-0.6270	0.6256	Early_InitAge_11	-0.4456	0.6623
Early_InitAge_10	-0.7727	0.5971	Early_InitAge_10	-0.5766	0.6315
Early_InitAge_9	-0.8690	0.5705	Early_InitAge_9	-0.6735	0.6023
Early_InitAge_8	-0.8304	0.5520	Early_InitAge_8	-0.6320	0.5768
Early_InitAge_7	-0.5308	0.5000	Early_InitAge_7	-0.3008	0.5181
Early_InitAge_6	-0.4740	0.4984	Early_InitAge_6	-0.2394	0.4983
Early_InitAge_5	0.4956	0.2742	Early_InitAge_5	0.6804	0.2684
Early_InitAge_4	0.5179	0.2393	Early_InitAge_4	0.6939	0.2335
Early_InitAge_3	-0.0618	0.2665	Early_InitAge_3	0.0555	0.2696
Early_InitAge_2	0.7893	0.1972	Early_InitAge_2	1.0002	0.1889
Early_InitAge_1	0.0313	0.2710	Early_InitAge_1	0.1412	0.2710
Main_RecrDev_1991	0.0269	0.2496	Main_RecrDev_1991	0.1682	0.2486
Main_RecrDev_1992	-0.0101	0.2800	Main_RecrDev_1992	0.2324	0.2599
Main_RecrDev_1993	0.7921	0.1966	Main_RecrDev_1993	0.9359	0.1887
Main_RecrDev_1994	-0.3498	0.3072	Main_RecrDev_1994	-0.1878	0.3047
Main_RecrDev_1995	0.4198	0.2154	Main_RecrDev_1995	0.6114	0.2036
Main_RecrDev_1996	0.8953	0.1833	Main_RecrDev_1996	1.0538	0.1742
Main_RecrDev_1997	0.2158	0.2252	Main_RecrDev_1997	0.4025	0.2138
Main_RecrDev_1998	0.2198	0.2166	Main_RecrDev_1998	0.3869	0.2084
Main_RecrDev_1999	0.6550	0.1936	Main_RecrDev_1999	0.8124	0.1869
Main_RecrDev_2000	0.7117	0.1915	Main_RecrDev_2000	0.8935	0.1825
Main_RecrDev_2001	0.1051	0.2313	Main_RecrDev_2001	0.2164	0.2273
Main_RecrDev_2002	-0.1624	0.2558	Main_RecrDev_2002	-0.0173	0.2511
Main_RecrDev_2003	-0.0018	0.2440	Main_RecrDev_2003	0.1417	0.2402
Main_RecrDev_2004	-0.6891	0.3579	Main_RecrDev_2004	-0.4281	0.3359
Main_RecrDev_2005	0.2800	0.2125	Main_RecrDev_2005	0.3813	0.2077
Main_RecrDev_2006	-0.0806	0.2448	Main_RecrDev_2006	0.0619	0.2313
Main_RecrDev_2007	0.1114	0.2093	Main_RecrDev_2007	0.1861	0.2048
Main_RecrDev_2008	-0.2531	0.2269	Main_RecrDev_2008	-0.1785	0.2202
Main_RecrDev_2009	-0.7122	0.2820	Main_RecrDev_2009	-0.7274	0.2769
Main_RecrDev_2010	-0.2156	0.2307	Main_RecrDev_2010	-0.2795	0.2224
Main_RecrDev_2011	-0.2711	0.2450	Main_RecrDev_2011	-0.4655	0.2405
Main_RecrDev_2012	0.2803	0.2087	Main_RecrDev_2012	0.0324	0.1954
Main_RecrDev_2013	0.3144	0.2267	Main_RecrDev_2013	-0.0875	0.2076
Main_RecrDev_2014	0.4909	0.2350	Main_RecrDev_2014	0.0134	0.2012
Main_RecrDev_2015	-0.0093	0.3057	Main_RecrDev_2015	-0.5970	0.2664
Main_RecrDev_2016	0.3931	0.3263	Main_RecrDev_2016	-0.2776	0.2624
Main_RecrDev_2017	0.5825	0.3211	Main_RecrDev_2017	-0.1603	0.2600
Main_RecrDev_2018	0.6631	0.2897	Main_RecrDev_2018	-0.0269	0.2376
Main_RecrDev_2019	0.5341	0.2834	Main_RecrDev_2019	-0.0200	0.2452
Main_RecrDev_2020	-0.0184	0.3527	Main_RecrDev_2020	-0.3532	0.3175
Main_RecrDev_2021	-0.0739	0.4018	Main_RecrDev_2021	-0.4009	0.3864
InitF_seas_1_flt_1FshComb	0.0826	0.0195	InitF_seas_1_flt_1FshComb	0.0847	0.0189
Size_DblN_peak_FshComb(1)	107.4340	4.4699	Size_DblN_peak_FshComb(1)	102.1890	4.3932
Size_DblN_ascend_se_FshComb(1)	6.7550	0.1137	Size_DblN_ascend_se_FshComb(1)	6.6783	0.1242
Size_DblN_peak_Srv(2)	73.5965	3.2385	Size_DblN_peak_Srv(2)	68.7024	2.6232
Size_DblN_ascend_se_Srv(2)	6.7122	0.1276	Size_DblN_ascend_se_Srv(2)	6.5414	0.1223

Table 2A.23: Biomass (t) estimated by the REMA model, 1991 - 2024, with lower (UCI) and upper (UCI) 95% confidence bounds.

Year	Biomass	LCI	UCI
1991	169,618	130,803	219,951
1992	157,176	112,519	219,558
1993	145,647	103,326	205,302
1994	134,963	100,674	180,932
1995	115,651	82,973	161,197
1996	99,101	72,064	136,282
1997	84,920	66,521	108,408
1998	90,108	65,864	123,275
1999	95,612	69,249	132,013
2000	101,453	76,848	133,936
2001	91,064	67,587	122,696
2002	81,738	64,011	104,376
2003	81,043	59,981	109,500
2004	80,353	61,194	105,511
2005	78,498	56,291	109,464
2006	76,685	55,149	106,630
2007	72,452	49,633	105,761
2008	68,452	46,508	100,749
2009	64,673	45,249	92,436
2010	61,103	46,243	80,738
2011	61,601	45,613	83,194
2012	62,104	49,266	78,288
2013	66,526	49,775	88,915
2014	71,263	55,220	91,968
2015	74,547	55,129	100,806
2016	77,983	59,993	101,368
2017	76,835	56,782	103,970
2018	75,705	58,793	97,481
2019	69,479	49,806	96,923
2020	63,766	44,879	90,601
2021	58,522	42,548	80,492
2022	53,709	43,392	66,480
2023	52,595	39,365	70,271
2024	51,503	39,490	67,171

Table 2A.24: Projections of Aleutian Islands Pacific cod female future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 24.1. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.201 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2024	4676.0	4676.00	4676.0	4676.0	4676	4676.0	4676.0
2025	13376.0	5801.60	14965.5	10370.9	0	16782.3	13376.0
2026	12973.1	6578.65	14255.1	11162.5	0	14447.5	12973.1
2027	13943.0	7313.83	14232.1	12520.9	0	15034.7	17485.3
2028	16779.3	8300.53	15538.7	15187.8	0	18136.3	18952.4
2029	20940.4	9623.06	17871.4	19008.1	0	22649.4	22798.2
2030	25110.7	11161.70	20578.4	23014.3	0	26908.1	26865.3
2031	27903.8	12686.30	23002.4	25658.0	0	29483.7	29444.3
2032	29033.5	13973.30	24705.4	26574.6	0	30321.4	30310.3
2033	29217.9	14919.00	25670.7	27046.7	0	30346.9	30347.0
2034	29151.0	15547.90	26139.1	27240.3	0	30248.9	30250.2
2035	29095.3	15939.50	26345.8	27310.1	0	30205.7	30206.2
2036	29077.4	16172.00	26432.0	27333.9	0	30199.5	30199.6
2037	29075.9	16305.90	26466.8	27341.9	0	30202.0	30201.9
2038	29077.4	16380.80	26480.4	27344.6	0	30203.7	30203.6
2039	29078.2	16421.30	26485.4	27345.3	0	30204.1	30204.1

Year	Scenarios						
F	1	2	3	4	5	6	7
2024	0.182799	0.182799	0.182799	0.182799	0.182799	0.182799	0.182799
2025	0.501524	0.200610	0.571432	0.376143	0.000000	0.654657	0.501523
2026	0.493924	0.200610	0.571432	0.390278	0.000000	0.605936	0.493922
2027	0.525474	0.200610	0.571432	0.423165	0.000000	0.635602	0.685919
2028	0.592475	0.200610	0.571432	0.478131	0.000000	0.718571	0.733744
2029	0.674654	0.200610	0.571432	0.544611	0.000000	0.819250	0.821464
2030	0.746648	0.200610	0.571432	0.605111	0.000000	0.903102	0.902244
2031	0.788981	0.200610	0.571432	0.635223	0.000000	0.947906	0.947261
2032	0.804035	0.200610	0.571432	0.635223	0.000000	0.960540	0.960380
2033	0.805902	0.200610	0.571432	0.635223	0.000000	0.960283	0.960292
2034	0.804782	0.200610	0.571432	0.635223	0.000000	0.958571	0.958593
2035	0.804011	0.200610	0.571432	0.635223	0.000000	0.957900	0.957908
2036	0.803788	0.200610	0.571432	0.635223	0.000000	0.957826	0.957827
2037	0.803779	0.200610	0.571432	0.635223	0.000000	0.957873	0.957872
2038	0.803801	0.200610	0.571432	0.635223	0.000000	0.957900	0.957900
2039	0.803813	0.200610	0.571432	0.635223	0.000000	0.957906	0.957906

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2024	25223.30	25223.30	25223.30	25223.30	25223.30	25223.30	25223.30
2025	25078.35	25078.35	25078.35	25078.35	25078.35	25078.35	25078.35
2026	24729.25	27807.65	24090.55	25943.95	30199.95	23364.00	24729.25
2027	26178.35	31435.65	25113.90	27958.00	36220.65	24407.85	26178.35
2028	29255.70	36361.70	28235.75	31324.05	43381.25	27327.25	27861.15
2029	33030.15	42381.30	32659.80	35395.30	51564.00	30869.75	30947.70
2030	36336.85	48733.40	37262.15	39100.30	60157.50	33820.25	33790.05
2031	38281.20	54362.00	40931.90	41472.10	68183.00	35396.70	35374.05
2032	38972.65	58700.00	43278.20	42602.55	75022.50	35841.30	35835.65
2033	39058.40	61734.00	44544.05	43149.30	80510.00	35832.25	35832.55
2034	39006.95	63721.00	45149.95	43372.30	84752.00	35772.00	35772.75
2035	38971.55	64961.00	45418.45	43454.75	87921.00	35748.40	35748.65
2036	38961.30	65702.00	45531.45	43483.65	90197.50	35745.80	35745.80
2037	38960.90	66132.00	45577.40	43493.65	91791.00	35747.45	35747.40
2038	38961.90	66373.50	45595.45	43496.95	92875.00	35748.40	35748.40
2039	38962.45	66503.50	45602.15	43497.95	93589.50	35748.60	35748.60

Table 2A.25: Projections of Aleutian Islands Pacific cod female future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 24.1a. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.288 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2024	4676.0	4676.00	4676.0	4676.0	4676	4676.0	4676.0
2025	13399.4	5865.09	15423.9	10426.4	0	17037.1	13399.4
2026	13021.8	6756.85	14490.0	11307.3	0	14470.1	13021.8
2027	13984.9	7565.81	14303.4	12684.4	0	15040.1	17755.2
2028	16682.5	8563.42	15517.5	15223.3	0	18047.4	18857.6
2029	20645.6	9873.39	17825.0	18841.5	0	22402.1	22522.5
2030	24550.1	11412.60	20506.1	22593.4	0	26377.1	26325.1
2031	27142.1	12970.20	22894.6	24829.5	0	28730.0	28692.1
2032	28221.9	14326.70	24577.9	25802.8	0	29514.4	29505.8
2033	28408.9	15357.30	25520.4	26327.2	0	29538.9	29540.0
2034	28338.5	16057.00	25950.5	26538.3	0	29437.7	29439.2
2035	28278.9	16490.30	26118.0	26605.2	0	29393.9	29394.4
2036	28261.1	16739.70	26176.4	26622.7	0	29389.2	29389.2
2037	28260.8	16876.60	26195.4	26626.8	0	29392.6	29392.6
2038	28262.9	16948.40	26201.3	26627.6	0	29394.5	29394.5
2039	28263.9	16983.90	26202.9	26627.7	0	29394.8	29394.8

Year	Scenarios						
F	1	2	3	4	5	6	7
2024	0.264916	0.264916	0.264916	0.264916	0.264916	0.264916	0.264916
2025	0.719174	0.287670	0.849735	0.539381	0.000000	0.958961	0.719177
2026	0.710410	0.287670	0.849735	0.561430	0.000000	0.885666	0.710409
2027	0.761090	0.287670	0.849735	0.611963	0.000000	0.937276	1.014850
2028	0.860575	0.287670	0.849735	0.692484	0.000000	1.064360	1.084900
2029	0.979076	0.287670	0.849735	0.787542	0.000000	1.212690	1.214710
2030	1.079050	0.287670	0.849735	0.871319	0.000000	1.330290	1.328710
2031	1.136430	0.287670	0.849735	0.901900	0.000000	1.390980	1.390080
2032	1.156720	0.287670	0.849735	0.901900	0.000000	1.407790	1.407630
2033	1.158960	0.287670	0.849735	0.901900	0.000000	1.406970	1.407010
2034	1.157090	0.287670	0.849735	0.901900	0.000000	1.404300	1.404330
2035	1.155910	0.287670	0.849735	0.901900	0.000000	1.403330	1.403340
2036	1.155610	0.287670	0.849735	0.901900	0.000000	1.403270	1.403270
2037	1.155630	0.287670	0.849735	0.901900	0.000000	1.403370	1.403370
2038	1.155670	0.287670	0.849735	0.901900	0.000000	1.403410	1.403410
2039	1.155690	0.287670	0.849735	0.901900	0.000000	1.403420	1.403420

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2024	23579.65	23579.65	23579.65	23579.65	23579.65	23579.65	23579.65
2025	23410.25	23410.25	23410.25	23410.25	23410.25	23410.25	23410.25
2026	23148.00	26061.30	22376.45	24289.95	28369.50	21765.40	23147.95
2027	24664.50	29603.65	23443.40	26306.10	34275.15	22923.60	24664.50
2028	27641.45	34279.30	26484.55	29518.70	41203.75	25775.55	26236.35
2029	31187.40	39857.60	30643.50	33311.35	48968.20	29104.20	29149.50
2030	34179.05	45588.85	34787.20	36653.85	56938.00	31743.20	31707.85
2031	35895.80	50575.50	37975.95	38748.35	64287.50	33105.25	33085.10
2032	36503.00	54371.50	39945.65	39824.35	70539.00	33482.50	33478.85
2033	36570.10	56988.00	40949.60	40336.90	75596.50	33464.10	33465.05
2034	36514.30	58663.50	41384.05	40530.15	79581.00	33404.10	33404.90
2035	36478.70	59672.00	41549.35	40589.95	82615.50	33382.30	33382.50
2036	36469.80	60246.00	41606.70	40605.70	84831.00	33381.10	33381.10
2037	36470.35	60561.00	41625.35	40609.45	86404.50	33383.20	33383.20
2038	36471.75	60726.00	41631.10	40610.20	87484.50	33384.20	33384.20
2039	36472.30	60807.50	41632.75	40610.25	88196.50	33384.30	33384.30

Table 2A.26: Projections of Aleutian Islands Pacific cod female future catch, full selection fishing mortality rates (F), and spawning biomass (SSB) for seven future harvest scenarios, based on Model 24.0. SSB and catch are in metric tons (t). For Scenario 2, we used the value 0.4 as a multiplier on F_{ABC} for all future years, which yields F = 0.333 for all future years.

Year	Scenarios						
Catch	1	2	3	4	5	6	7
2024	4676.0	4676.0	4676.0	4676.0	4676	4676.0	4676.0
2025	25439.8	11613.4	19599.6	20131.4	0	31205.0	25439.8
2026	17925.5	11873.4	17641.1	16520.8	0	18551.3	17925.5
2027	17588.1	12263.1	16944.3	16536.1	0	18302.3	21889.3
2028	19770.9	13131.9	17699.7	18422.4	0	20951.7	21781.6
2029	21758.2	14223.6	18940.8	20313.9	0	22991.7	23025.6
2030	22544.7	15152.5	19880.4	20978.0	0	23565.9	23487.6
2031	22631.0	15776.1	20391.1	21215.4	0	23520.6	23483.5
2032	22565.7	16141.7	20625.2	21289.7	0	23431.8	23425.0
2033	22524.1	16341.4	20723.7	21306.9	0	23401.0	23402.5
2034	22512.8	16447.2	20763.6	21309.7	0	23398.7	23400.1
2035	22512.6	16501.7	20779.3	21309.6	0	23401.3	23401.8
2036	22513.8	16527.4	20784.9	21309.0	0	23402.6	23402.6
2037	22514.4	16539.5	20786.9	21308.6	0	23402.9	23402.9
2038	22514.5	16545.3	20787.6	21308.5	0	23402.9	23402.8
2039	22514.5	16548.0	20787.9	21308.4	0	23402.8	23402.8

Year	Scenarios						
F	1	2	3	4	5	6	7
2024	0.152044	0.152044	0.152044	0.152044	0.152044	0.152044	0.152044
2025	0.832902	0.333161	0.605045	0.624677	0.000000	1.088300	0.832902
2026	0.695334	0.333161	0.605045	0.565792	0.000000	0.825978	0.695334
2027	0.707931	0.333161	0.605045	0.580596	0.000000	0.845039	0.925005
2028	0.762490	0.333161	0.605045	0.622387	0.000000	0.918418	0.935315
2029	0.800973	0.333161	0.605045	0.654595	0.000000	0.963124	0.963211
2030	0.813932	0.333161	0.605045	0.657941	0.000000	0.973548	0.971762
2031	0.814744	0.333161	0.605045	0.657941	0.000000	0.971894	0.971136
2032	0.813403	0.333161	0.605045	0.657941	0.000000	0.969944	0.969830
2033	0.812669	0.333161	0.605045	0.657941	0.000000	0.969343	0.969383
2034	0.812493	0.333161	0.605045	0.657941	0.000000	0.969323	0.969354
2035	0.812500	0.333161	0.605045	0.657941	0.000000	0.969385	0.969393
2036	0.812523	0.333161	0.605045	0.657941	0.000000	0.969412	0.969411
2037	0.812534	0.333161	0.605045	0.657941	0.000000	0.969416	0.969415
2038	0.812536	0.333161	0.605045	0.657941	0.000000	0.969415	0.969414
2039	0.812536	0.333161	0.605045	0.657941	0.000000	0.969414	0.969414

Year	Scenarios						
SSB	1	2	3	4	5	6	7
2024	27905.00	27905.00	27905.00	27905.00	27905.00	27905.00	27905.00
2025	31388.05	31388.05	31388.05	31388.05	31388.05	31388.05	31388.05
2026	26475.50	32021.65	28797.10	28584.35	36796.10	24219.00	26475.55
2027	26925.35	34097.35	29026.65	29289.20	43051.85	24739.90	26925.35
2028	28873.65	37018.50	30884.30	31279.00	49492.75	26745.35	27207.15
2029	30247.85	39729.75	32754.80	32812.50	55333.00	27967.15	27969.50
2030	30710.65	41722.00	33976.70	33469.85	60208.00	28252.00	28203.20
2031	30739.60	42987.30	34611.15	33718.30	64055.00	28206.80	28186.10
2032	30691.75	43720.55	34900.25	33795.20	66961.00	28153.50	28150.40
2033	30665.55	44123.10	35022.90	33813.70	69091.50	28137.10	28138.20
2034	30659.25	44338.80	35073.20	33817.05	70643.00	28136.55	28137.40
2035	30659.50	44450.80	35093.15	33817.15	71746.50	28138.25	28138.45
2036	30660.30	44503.70	35100.30	33816.45	72474.00	28138.95	28138.95
2037	30660.70	44528.70	35102.90	33816.05	72953.00	28139.10	28139.05
2038	30660.75	44540.45	35103.80	33815.90	73269.00	28139.05	28139.05
2039	30660.75	44546.05	35104.15	33815.80	73477.00	28139.00	28139.00

Table 2A.27: Incidental trawl catch of FMP species in the Aleutian Is. Pacific cod target fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all AI FMP fisheries, 1994-2024 (2024 current through October 1).

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Arrowtooth Flounder	0.08	0.07	0.04	0.01	0.07	0.04	0.12	0.09	0.08	0.11	0.22	0.24	0.24	0.29	0.14
Atka Mackerel	0.06	0.05	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
BSAI Alaska Plaice	-	-	-	-	-	-	-	-	-	-	-	-	1.00	1.00	1.00
BSAI Kamchatka Flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Other Flatfish	-	-	-	-	-	-	-	-	-	-	-	0.29	0.29	0.25	0.29
BSAI Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.04	0.00
BSAI Shortraker Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.02	0.01
BSAI Skate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Skate and GOA Skate, Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Squid	-	-	-	-	-	-	-	-	-	-	-	0.10	0.11	0.07	0.07
Demersal Shelf Rockfish	-	0.77	-	-	-	-	-	-	-	-	-	-	-	-	-
Flathead Sole	0.00	-	-	0.42	0.41	0.66	0.88	0.92	0.88	0.69	0.95	0.80	0.90	0.72	0.86
Flounder	0.59	0.45	0.35	-	-	-	-	-	-	-	-	-	-	-	-
Greenland Turbot	0.00	0.01	0.00	0.00	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Non TAC Species	-	-	-	-	-	-	-	0.02	0.00	0.02	0.01	-	-	-	-
Northern Rockfish	-	-	-	-	-	-	-	-	-	-	0.03	0.04	0.03	0.05	0.05
Octopus	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-
Other	0.12	0.09	0.05	0.04	0.07	0.10	0.13	0.13	0.12	0.04	0.16	-	-	-	-
Other Flatfish	-	-	-	0.00	0.01	0.03	0.80	0.47	0.48	0.19	0.53	-	-	-	-
Other Rockfish	0.03	0.01	0.01	0.01	0.04	0.25	0.13	0.04	0.03	0.02	0.03	0.03	0.04	0.03	0.02
Other Species	-	-	-	-	-	-	-	-	-	-	-	0.23	0.16	0.13	0.14
Pacific Cod	0.24	0.36	0.33	0.35	0.38	0.60	0.48	0.49	0.46	0.40	0.86	0.90	0.81	0.77	0.76
Pacific Ocean Perch	0.02	0.03	0.01	0.00	0.00	0.01	0.03	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Pollock	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.48	0.63	0.38	0.61	0.48	0.46	0.41	0.18
Rock Sole	0.68	0.56	0.38	0.52	0.55	0.74	0.86	0.93	0.95	0.88	0.93	0.82	0.85	0.80	0.78
Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-
Sablefish	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shallow Water Flatfish	0.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharpchin/Northern Rockfish	0.13	0.07	0.03	0.01	0.02	0.04	0.04	0.03	0.05	0.03	-	-	-	-	-
Shortraker/Rougheye Rockfish	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	-	-	-
Shortraker/Rougheye/Sharpchin/Northern Rockfish	0.65	0.00	-	0.00	-	0.00	-	-	-	-	-	-	-	-	-
Slope Rockfish	0.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squid	0.01	0.02	0.00	0.00	0.00	0.01	0.03	0.01	0.05	0.33	0.05	-	-	-	-
Yellowfin Sole	0.00	-	0.05	0.00	0.36	0.00	0.00	0.20	0.90	0.97	1.00	0.72	1.00	1.00	0.79

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Arrowtooth Flounder	0.16	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.03	0.01	0.02	0.00	0.00	0.00
Atka Mackerel	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
BSAI Alaska Plaice	0.27	1.00	0.24	0.00	-	1.00	1.00	1.00	-	1.00	0.00	0.00	0.98	1.00	-	1.00
BSAI Kamchatka Flounder	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSAI Other Flatfish	0.37	0.28	0.06	0.04	0.01	0.16	0.05	0.16	0.00	0.03	0.01	0.10	0.07	0.09	0.00	0.03
BSAI Rougheye Rockfish	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
BSAI Shortraker Rockfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSAI Skate	-	-	-	-	0.01	0.02	0.01	0.00	0.00	0.02	0.01	0.00	0.01	-	-	-
BSAI Skate and GOA Skate, Other	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00	0.00
BSAI Squid	0.02	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Demersal Shelf Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flathead Sole	0.76	0.55	0.61	0.58	0.46	0.73	0.49	0.26	0.31	0.53	0.23	0.19	0.45	0.07	0.19	0.07
Flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greenland Turbot	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non TAC Species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Rockfish	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Octopus	-	-	-	-	0.14	0.16	0.00	0.00	0.02	0.04	0.01	0.00	0.01	0.00	0.00	0.00
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Flatfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Rockfish	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00
Other Species	0.16	0.06	0.07	0.03	-	-	-	-	-	-	-	-	-	-	-	-
Pacific Cod	0.78	0.66	0.65	0.58	0.70	0.59	0.49	0.52	0.35	0.64	0.26	0.31	0.37	0.09	0.07	0.09
Pacific Ocean Perch	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pollock	0.16	0.04	0.03	0.01	0.05	0.08	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.02	0.01
Rock Sole	0.77	0.75	0.76	0.73	0.70	0.67	0.70	0.65	0.26	0.71	0.59	0.40	0.58	0.01	0.03	0.07
Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00
Sablefish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sculpin	-	-	-	-	0.05	0.06	0.04	0.02	0.01	0.05	0.01	0.01	0.00	0.01	-	-
Shallow Water Flatfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shark	-	-	-	-	0.06	0.00	0.00	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Sharpchin/Northern Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shortraker/Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shortraker/Rougheye/Sharpchin/Northern Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slope Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squid	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
Yellowfin Sole	0.05	0.23	0.03	0.09	0.00	0.11	0.08	0.01	0.00	0.00	0.00	0.05	0.03	0.15	0.00	0.03

Table 2A.28: Incidental longline catch of FMP species taken in the Aleutian Is. target fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all AI FMP fisheries, 1993-2024 (2024 current through October 1).

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Arrowtooth Flounder	0.14	0.05	0.03	0.02	0.02	0.04	0.09	0.06	0.13	0.18	0.03	0.01	0.02	0.04	0.02
Atka Mackerel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSAI Alaska Plaice	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00
BSAI Kamchatka Flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Other Flatfish	-	-	-	-	-	-	-	-	-	-	-	0.00	0.32	0.00	0.01
BSAI Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	0.14	0.02	0.01
BSAI Shortraker Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.09	0.05
BSAI Skate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Skate and GOA Skate, Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BSAI Squid	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00
Demersal Shelf Rockfish	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Flathead Sole	0.00	-	-	0.03	0.08	0.06	0.10	0.01	0.06	0.14	0.01	0.00	0.01	0.01	0.02
Flounder	0.08	0.07	0.02	-	-	-	-	-	-	-	-	-	-	-	-
Greenland Turbot	0.06	0.03	0.01	0.01	0.01	0.03	0.04	0.06	0.03	0.02	0.01	0.02	0.01	0.00	0.02
Non TAC Species	-	-	-	-	-	-	-	0.04	0.06	0.08	0.00	-	-	-	-
Northern Rockfish	-	-	-	-	-	-	-	-	-	-	0.01	0.00	0.01	0.00	0.00
Octopus	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-
Other	0.33	0.54	0.30	0.27	0.22	0.43	0.57	0.44	0.61	0.75	0.25	-	-	-	-
Other Flatfish	-	-	-	0.00	0.01	0.22	0.06	0.06	0.13	0.29	0.01	-	-	-	-
Other Rockfish	0.29	0.07	0.11	0.02	0.08	0.12	0.25	0.09	0.11	0.16	0.06	0.03	0.16	0.04	0.05
Other Species	-	-	-	-	-	-	-	-	-	-	-	0.13	0.33	0.37	0.26
Pacific Cod	0.51	0.49	0.32	0.24	0.18	0.28	0.40	0.28	0.40	0.52	0.09	0.03	0.10	0.12	0.14
Pacific Ocean Perch	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pollock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.09	0.00	0.01	0.01	0.00	0.00
Rock Sole	0.01	0.02	0.02	0.01	0.04	0.02	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-
Sablefish	0.05	0.03	0.04	0.01	0.09	0.04	0.02	0.02	0.02	0.03	0.06	0.01	0.00	0.00	0.03
Sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shallow Water Flatfish	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharpchin/Northern Rockfish	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	-	-	-	-	-
Shortraker/Rougheye Rockfish	0.31	0.17	0.11	0.02	0.12	0.06	0.30	0.21	0.31	0.23	0.08	0.04	-	-	-
Shortraker/Rougheye/Sharpchin/Northern Rockfish	0.01	0.00	-	0.00	-	0.00	-	-	-	-	-	-	-	-	-
Slope Rockfish	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squid	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
Yellowfin Sole	0.00	-	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Arrowtooth Flounder	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.02	0.04	0.04	0.02
Atka Mackerel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BSAI Alaska Plaice	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	-	0.00
BSAI Kamchatka Flounder	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
BSAI Other Flatfish	0.00	0.01	0.35	0.05	0.05	0.13	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.11
BSAI Rougheye Rockfish	0.18	0.27	0.12	0.14	0.01	0.16	0.05	0.01	0.11	0.04	0.34	0.12	0.06	-	-	-
BSAI Shortraker Rockfish	0.06	0.06	0.05	0.17	0.01	0.03	0.04	0.00	0.04	0.00	0.05	0.08	0.32	0.05	0.20	0.01
BSAI Skate	-	-	-	-	0.12	0.29	0.17	0.03	0.24	0.16	0.23	0.22	0.22	-	-	-
BSAI Skate and GOA Skate, Other	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35	0.39	0.36
BSAI Squid	0.00	0.00	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Demersal Shelf Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flathead Sole	0.08	0.13	0.14	0.09	0.01	0.09	0.00	0.00	0.01	0.01	0.06	0.20	0.01	0.12	0.17	0.06
Flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greenland Turbot	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Non TAC Species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Rockfish	0.01	0.02	0.02	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
Octopus	-	-	-	-	0.79	0.50	0.43	0.37	0.78	0.45	0.20	0.04	0.15	0.06	0.18	0.10
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Flatfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Rockfish	0.12	0.12	0.19	0.16	0.02	0.03	0.02	0.00	0.05	0.00	0.03	0.02	0.01	0.05	0.07	0.07
Other Species	0.36	0.34	0.43	0.50	-	-	-	-	-	-	-	-	-	-	-	-
Pacific Cod	0.14	0.18	0.20	0.27	0.11	0.18	0.12	0.03	0.33	0.12	0.24	0.16	0.12	0.25	0.23	0.20
Pacific Ocean Perch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pollock	0.00	0.01	0.02	0.04	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.01
Rock Sole	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	0.10	0.10
Sablefish	0.02	0.03	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01
Sculpin	-	-	-	-	0.17	0.39	0.38	0.12	0.40	0.14	0.32	0.23	0.26	0.32	-	-
Shallow Water Flatfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shark	-	-	-	-	0.02	0.12	0.01	0.01	0.24	0.00	0.06	0.03	0.01	0.02	0.02	0.02
Sharpchin/Northern Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shortraker/Rougheye Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shortraker/Rougheye/Sharpchin/Northern Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slope Rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squid	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-
Yellowfin Sole	0.00	0.23	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00

Table 2A.29: Incidental catch of selected "Other Species" complex species taken in the AI Pacific cod trawl fisheries, 1991-2024 (2024 data current through October 1), expressed as a ratio of bycatch in all fisheries and gears.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
octopus, North Pacific	-	-	-	-	-	-	-	-	1.00	1.00	1.00	0.76	0.30	0.31	0.65	0.07	0.14
Pacific sleeper shark	-	-	-	-	-	-	-	-	-	0.06	-	1.00	0.00	0.30	0.62	0.00	0.01
shark, other	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-
shark, salmon	-	-	-	-	-	-	-	-	-	1.00	-	-	0.00	-	0.00	0.00	0.00
shark, spiny dogfish	-	-	-	-	-	-	-	-	-	-	-	0.00	0.26	0.00	0.00	0.09	0.00
skate, Alaskan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
skate, Aleutian	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
skate, big	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	1.00	0.22	0.02
skate, longnose	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.49	0.00	-
skate, other	-	-	-	-	-	-	-	-	0.98	1.00	1.00	0.29	0.14	0.10	0.10	0.10	0.10
skate, Whiteblotched	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
squid, majestic	0	0.01	0.02	0	0	0	0.01	0.03	0.01	0.05	0.33	0.05	0.10	0.11	0.07	0.07	0.02

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
octopus, North Pacific	0.18	0.07	0.02	0.14	0.16	0.00	0.00	0.02	0.04	0.01	0.00	0.01	0.00	0	0.00	0.01	0.00
Pacific sleeper shark	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00
shark, other	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0	0.00	0.00	-
shark, salmon	-	0.29	0.00	0.39	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0	0.00	0.00	0.21
shark, spiny dogfish	0.00	0.00	0.02	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0	0.00	0.00	0.00
skate, Alaskan	-	-	0.06	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0	0.00	0.00	0.00
skate, Aleutian	-	-	-	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00
skate, big	0.25	0.01	0.00	-	1.00	-	-	0.00	-	-	-	1.00	0.00	-	-	-	-
skate, longnose	0.00	0.76	0.00	-	0.00	-	-	0.00	-	-	-	-	0.00	-	-	-	-
skate, other	0.03	0.04	0.01	0.01	0.03	0.02	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0	0.01	0.02	0.00
skate, Whiteblotched	-	-	-	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00
squid, majestic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-

Table 2A.30: Incidental catch of selected “Other Species” complex species taken in the AI Pacific cod longline fisheries, 1991-2024 (2024 data current through October 1), expressed as a ratio of bycatch in all fisheries and gears.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
octopus, North Pacific	-	-	-	-	-	-	-	-	0	0	0	0.14	0.43	0.42	0.32	0.27	0.45
Pacific sleeper shark	-	-	-	-	-	-	-	-	-	0	-	0.00	0.00	0.00	0.02	0.38	0.01
shark, other	-	-	-	-	-	-	-	-	-	-	-	-	0.00	1.00	-	-	-
shark, salmon	-	-	-	-	-	-	-	-	-	0	-	-	0.00	-	0.00	0.00	0.00
shark, spiny dogfish	-	-	-	-	-	-	-	-	-	-	-	0.00	0.45	0.96	1.00	0.66	0.87
skate, Alaskan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
skate, Aleutian	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
skate, big	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.11	0.00
skate, longnose	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.51	1.00	-
skate, other	-	-	-	-	-	-	-	-	0	0	0	0.04	0.16	0.46	0.48	0.34	0.54
skate, Whiteblotched	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
squid, majestic	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
octopus, North Pacific	0.23	0.50	0.47	0.79	0.50	0.43	0.37	0.78	0.45	0.20	0.04	0.15	0.06	0.18	0.10	0	0.78
Pacific sleeper shark	0.04	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0	0.00
shark, other	-	0.00	-	-	-	-	-	-	-	-	0.00	-	-	0.00	1.00	0	-
shark, salmon	-	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
shark, spiny dogfish	0.55	0.84	0.92	0.43	0.66	0.21	0.05	0.86	0.03	0.17	0.79	0.35	0.22	0.32	0.79	0	0.00
skate, Alaskan	-	-	0.52	0.11	0.08	0.10	0.07	0.17	0.03	0.07	0.19	0.29	0.52	0.35	0.93	0	0.05
skate, Aleutian	-	-	-	0.23	0.24	0.07	0.04	0.13	0.01	0.03	0.04	0.13	0.06	0.07	0.58	0	0.51
skate, big	0.00	0.00	0.55	-	0.00	-	-	0.59	-	-	-	0.00	1.00	-	-	-	-
skate, longnose	1.00	0.24	1.00	-	0.00	-	-	1.00	-	-	-	-	0.82	-	-	-	-
skate, other	0.38	0.58	0.58	0.12	0.41	0.22	0.03	0.32	0.27	0.34	0.30	0.30	0.44	0.45	0.28	0	0.03
skate, Whiteblotched	-	-	-	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.19	0	0.00
squid, majestic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-

Table 2A.31: Incidental catch (herring and halibut in tons, salmon and crab in number of individuals) of prohibited species and discard mortality of halibut taken in the AI fisheries for Pacific cod (all gears), expressed as a proportion of the total for that species taken in all FMP AI fisheries, 1991-2024 (through October 1).

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bairdi Tanner Crab	0.30	0.57	0.70	0.96	0.87	0.91	0.94	1.00	1.00	1.00	0.86	0.99	0.95	1.00	0.98	1.00
Blue King Crab	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	0.30	1.00
Chinook Salmon	0.01	0.02	0.15	0.03	0.23	0.17	0.46	0.71	0.90	1.00	0.46	0.68	0.80	0.73	0.80	0.87
Golden (Brown) King Crab	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.01	0.01
Halibut	0.52	0.81	0.42	0.44	0.46	0.57	0.53	0.82	0.57	0.48	0.74	0.28	0.16	-	-	-
Herring	0.00	0.00	1.00	0.00	0.00	-	0.00	-	-	1.00	-	-	0.01	-	1.00	0.05
Non-Chinook Salmon	0.01	0.22	0.00	0.00	0.00	0.03	0.07	0.03	0.04	0.11	0.22	0.76	0.18	0.44	0.12	0.34
Opilio Tanner (Snow) Crab	0.40	0.30	0.51	0.02	0.01	0.19	0.25	0.52	0.30	0.26	0.34	0.69	0.82	1.00	0.85	0.99
Other King Crab	0.08	0.24	0.04	0.05	0.04	0.10	0.00	0.06	0.23	0.07	0.13	0.03	-	-	-	-
Red King Crab	0.21	0.08	0.33	0.14	0.11	0.05	0.89	0.83	0.98	0.43	0.94	0.97	0.84	0.97	0.84	0.06

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Bairdi Tanner Crab	1.00	1.00	1.00	0.94	0.45	1.00	0.98	0.98	0.00	0.00	0.97	0.99	0.99	1.00	0.99	0.99	0.99
Blue King Crab	1.00	0.78	0.92	1.00	1.00	1.00	1.00	-	0.00	0.00	0.99	0.98	0.99	0.00	0.06	0.00	0.00
Chinook Salmon	0.72	0.83	0.82	0.75	0.55	0.65	0.94	0.62	0.41	0.57	0.21	0.05	0.04	0.00	0.00	0.00	0.07
Golden (Brown) King Crab	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.24	0.06	0.05	0.07	0.20	0.08	0.02
Halibut	-	-	-	0.19	0.04	0.28	0.16	0.18	0.41	0.26	0.36	0.30	0.41	0.39	0.66	0.41	0.07
Herring	0.19	0.25	0.07	0.00	-	0.00	1.00	1.00	-	-	0.00	0.00	0.01	0.99	0.00	0.83	0.00
Non-Chinook Salmon	0.56	0.21	0.17	0.02	0.38	0.00	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00
Opilio Tanner (Snow) Crab	1.00	1.00	1.00	0.99	0.98	0.99	0.91	0.81	0.00	0.00	0.99	0.98	0.95	0.99	0.99	0.98	0.92
Other King Crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red King Crab	0.84	0.77	0.34	0.22	0.32	0.20	0.91	0.16	0.00	0.00	0.61	0.97	0.69	0.92	0.99	1.00	0.94

Table 2A.32: Bycatch of Nontarget and Ecosystem Species for the Aleutian Islands Pacific cod fishery (all gear types), divided by the bycatch in all fisheries and gears in the same region. Bird bycatch is not included in this table. Data is from 1993-2024, and current through October 1 of the final year. Continued on next page.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Benthic urochordata	0.14	0.16	0.42	0.13	0.06	0.03	0.05	0.06	0.01	0.04	0.15
Bivalves	0.99	0.94	0.99	0.99	0.97	0.96	0.78	0.64	0.53	0.76	0.14
Brittle star unidentified	0.00	0.06	0.03	0.39	0.64	0.20	0.01	0.01	0.00	0.00	0.04
Capelin	0.00	-	-	0.00	0.00	1.00	0.00	-	-	1.00	0.11
Bryozoan Unid.	0.41	0.38	0.24	0.33	0.47	0.29	0.38	0.27	0.08	0.09	0.08
Bryozoan Red Tree Coral	0.72	0.01	0.49	0.01	0.91	0.14	0.88	0.00	0.00	0.00	0.00
Dark Rockfish	-	-	-	-	-	0.65	0.53	-	-	-	-
Eelpouts	0.09	0.51	0.14	0.04	0.15	0.02	0.02	0.02	0.00	0.01	0.00
Eulachon	-	-	0.68	0.01	0.00	0.05	0.00	0.00	-	1.00	-
Giant Grenadier	0.30	0.00	0.00	0.08	0.02	0.01	0.00	0.06	0.00	0.01	0.00
Greenlings	0.74	0.20	0.04	0.88	0.24	0.64	0.39	0.50	0.75	0.46	1.00
Pacific Grenadier	-	1.00	-	0.00	0.00	-	0.00	0.40	0.00	-	-
Rattail Grenadier Unid.	0.02	0.01	0.00	0.03	0.21	0.01	0.01	0.10	0.00	0.00	0.02
Gunnels	-	-	0.01	-	-	0.00	-	-	-	-	0.00
Hermit crab unidentified	0.80	0.98	0.11	0.68	0.81	0.86	0.85	0.42	0.24	0.54	0.38
Invertebrate unidentified	0.09	0.13	0.05	0.62	0.18	0.09	0.01	0.22	0.04	0.00	0.00
Large Sculpins	0.51	0.40	0.39	0.45	0.44	-	-	-	-	-	-
Large Sculpins - Bigmouth Sculpin	-	-	-	-	-	0.12	0.14	-	-	-	-
Large Sculpins - Great Sculpin	-	-	-	-	-	0.94	0.95	-	-	-	-
Lg. Sculpins - Hemilepidotus Unid.	-	-	-	-	-	0.96	0.98	-	-	-	-
Lg. Sculpins - Myoxocephalus Unid.	-	-	-	-	-	0.88	1.00	-	-	-	-
Large Sculpins - Plain Sculpin	-	-	-	-	-	1.00	0.97	-	-	-	-
Large Sculpins - Red Irish Lord	-	-	-	-	-	0.12	0.32	-	-	-	-
Large Sculpins - Warty Sculpin	-	-	-	-	-	1.00	1.00	-	-	-	-
Large Sculpins - Yellow Irish Lord	-	-	-	-	-	0.34	0.20	-	-	-	-
Misc crabs	0.73	0.56	0.52	0.50	0.65	0.48	0.47	0.38	0.01	0.10	0.57
Misc crustaceans	0.99	0.29	0.98	0.93	0.33	0.88	0.13	0.38	0.06	0.00	0.00
Misc fish	0.23	0.11	0.12	0.06	0.09	0.06	0.08	0.09	0.05	0.04	0.05
Misc inverts (worms etc)	0.00	0.28	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other osmerids	0.00	-	0.07	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Other Sculpins	0.39	0.40	0.08	0.31	0.17	0.11	0.26	-	-	-	-
Pacific Sand lance	1.00	-	1.00	-	-	1.00	-	0.01	-	-	-
Pacific Sandfish	-	-	-	-	-	-	-	-	-	-	-
Pandalid shrimp	0.06	0.01	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Polychaete unidentified	1.00	0.13	1.00	-	0.15	0.76	0.11	0.00	0.98	0.26	1.00
Saffron Cod	-	-	-	-	-	-	-	-	-	1.00	1.00
Sculpin	-	-	-	-	-	-	-	-	-	-	-
Scypho jellies	0.17	0.48	0.45	0.19	0.06	0.22	0.11	0.21	0.25	0.83	0.97
Sea anemone unidentified	0.85	0.53	0.93	0.78	0.37	0.32	0.47	0.38	0.08	0.14	0.03
Sea pens whips	0.80	1.00	0.96	0.96	0.73	0.36	0.64	0.94	0.94	1.00	0.03
Sea star	0.59	0.73	0.49	0.57	0.57	0.61	0.52	0.63	0.11	0.33	0.22
Snails	0.53	0.52	0.25	0.60	0.48	0.62	0.74	0.35	0.45	0.28	0.29
Sponge unidentified	0.32	0.16	0.33	0.22	0.09	0.03	0.12	0.09	0.03	0.05	0.01
State-managed Rockfish	-	-	-	-	-	-	-	0.61	0.13	0.09	0.21
Stichaeidae	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
urchins dollars cucumbers	0.42	0.53	0.17	0.28	0.42	0.11	0.18	0.11	0.01	0.04	0.02

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Benthic urochordata	0.01	0.01	0.04	0.00	0.03	0.00	0.00	0.07	0.00	0.01	0.00
Bivalves	0.11	0.32	0.33	0.04	0.21	0.05	0.67	0.47	0.77	0.02	0.10
Brittle star unidentified	0.01	0.00	0.00	0.12	0.00	0.00	0.10	0.01	0.01	0.00	0.00
Capelin	1.00	-	-	-	-	-	0.00	-	-	-	-
Bryozoan Unid.	0.02	0.10	0.08	0.13	0.25	0.05	0.40	0.48	0.13	0.00	0.03
Bryozoan Red Tree Coral	0.00	-	-	-	0.00	-	-	-	-	-	-
Dark Rockfish	-	-	-	-	-	-	-	-	-	-	-
Eelpouts	0.00	0.00	0.00	0.05	0.01	0.02	0.00	0.01	0.00	0.00	0.00
Eulachon	-	-	-	-	-	-	0.00	-	-	-	-
Giant Grenadier	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Greenlings	0.68	1.00	0.67	0.48	0.47	0.20	0.10	0.26	0.19	0.00	0.03
Pacific Grenadier	-	-	-	-	-	-	-	-	0.00	-	-
Rattail Grenadier Unid.	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.02	0.00	0.00	0.00
Gunnels	-	0.00	-	0.00	-	-	1.00	0.00	-	-	-
Hermit crab unidentified	0.10	0.00	0.15	0.78	0.54	0.78	0.71	0.96	0.51	0.60	0.03
Invertebrate unidentified	0.01	0.76	0.00	0.51	0.00	0.01	0.02	0.00	0.11	0.00	0.00
Large Sculpins	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Bigmouth Sculpin	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Great Sculpin	-	-	-	-	-	-	-	-	-	-	-
Lg. Sculpins - Hemilepidotus Unid.	-	-	-	-	-	-	-	-	-	-	-
Lg. Sculpins - Myoxocephalus Unid.	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Plain Sculpin	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Red Irish Lord	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Warty Sculpin	-	-	-	-	-	-	-	-	-	-	-
Large Sculpins - Yellow Irish Lord	-	-	-	-	-	-	-	-	-	-	-
Misc crabs	0.19	0.00	0.04	0.59	0.61	0.45	0.72	0.40	0.75	0.59	0.01
Misc crustaceans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc fish	0.04	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.00
Misc inverts (worms etc)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Other osmerids	-	-	-	-	0.00	0.00	0.00	0.00	0.00	-	0.00
Other Sculpins	-	-	-	-	-	-	-	-	-	-	-
Pacific Sand lance	-	1.00	-	-	-	-	0.00	-	0.00	0.00	0.00
Pacific Sandfish	1.00	-	-	-	-	-	0.00	-	-	-	-
Pandalid shrimp	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polychaete unidentified	0.00	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Saffron Cod	-	-	-	-	-	0.00	0.00	-	1.00	1.00	0.00
Sculpin	-	-	-	-	-	-	-	0.43	0.39	0.02	0.14
Scypho jellies	0.65	0.00	0.05	0.85	0.70	0.30	0.31	0.39	0.44	0.14	0.00
Sea anemone unidentified	0.01	0.03	0.08	0.05	0.15	0.02	0.28	0.10	0.10	0.04	0.00
Sea pens whips	0.00	0.34	0.01	0.55	0.30	0.20	0.28	0.46	0.99	0.01	0.00
Sea star	0.23	0.15	0.10	0.33	0.19	0.26	0.41	0.59	0.54	0.13	0.06
Snails	0.16	0.06	0.10	0.67	0.52	0.43	0.56	0.91	0.69	0.12	0.11
Sponge unidentified	0.00	0.02	0.10	0.03	0.06	0.01	0.06	0.04	0.06	0.00	0.04
State-managed Rockfish	0.01	0.18	0.00	0.15	0.49	0.02	0.29	0.33	0.07	0.00	0.05
Stichaeidae	0.00	0.00	0.00	0.00	0.05	-	0.00	0.00	0.00	0.00	0.00
urchins dollars cucumbers	0.03	0.02	0.07	0.06	0.04	0.02	0.11	0.08	0.05	0.00	0.04

Table 2A.33: Bycatch of Nontarget and Ecosystem bird species for the Aleutian Islands Pacific cod fishery, expressed as a proportion of the incidental catch of that species group taken in the longline, trawl, and pot gear FMP AI fisheries 2003-2024 (through October 1).

	Longline																					
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Auklet	0.00	-	-	-	-	-	-	-	-	1.00	-	0	-	-	0.00	0.00	-	-	-	-	-	-
Black-footed Albatross	1.00	-	-	0.00	-	-	-	1.00	0.00	-	0.00	0	0.00	-	-	-	-	-	-	0.00	-	-
Gull	0.01	0.11	0.59	0.46	0.42	1.00	0.59	0.53	0.08	0.06	0.17	-	0.08	0	-	1.00	1.00	1.00	0.43	0.66	0	-
Kittiwake	1.00	-	1.00	-	-	-	-	-	1.00	1.00	1.00	-	-	-	-	1.00	-	0.89	-	-	-	-
Laysan Albatross	0.04	0.00	0.17	0.45	0.23	0.40	0.12	0.30	0.00	0.00	0.00	0	0.22	0	0.00	0.00	-	0.00	-	-	-	0.54
Murre	1.00	-	0.36	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	1.00	-	-	-	-
Northern Fulmar	0.01	0.23	0.25	0.72	0.76	0.26	0.26	0.21	0.10	0.46	0.13	0	0.82	0	0.07	0.01	0.00	0.01	0.60	0.08	0	0.45
Other	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	0.00	-	-
Other Alcid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-
Puffin	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shearwaters	0.10	1.00	0.89	0.00	0.07	1.00	0.21	0.08	0.26	0.26	1.00	0	0.00	0	0.11	0.00	0.14	0.00	0.12	0.05	0	0.04
Short-tailed Albatross	-	-	-	-	-	-	-	1.00	1.00	-	-	-	-	-	-	-	-	1.00	-	-	-	-
Storm Petrels	1.00	-	-	0.00	-	0.00	-	-	-	-	-	-	-	-	-	0.00	-	-	-	0.00	0	-
Unidentified	1.00	1.00	1.00	0.00	0.27	1.00	0.10	0.62	1.00	0.11	0.00	-	-	-	0.00	1.00	-	1.00	0.30	1.00	0	0.00
Unidentified Albatross	-	-	-	0.00	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	1.00

	Non Pelagic Trawl																					
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Auklet	1.00	-	-	-	-	-	-	-	-	0	-	0	-	-	0	0	-	-	-	-	-	-
Gull	0.99	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0	0	0	-	0	0.00	-	0	0	0	0	0	0	-
Laysan Albatross	0.35	0.00	0.43	0.00	0.00	0.00	0.26	0.00	0	0	0	0	0	0.00	0	0	-	0	-	-	-	0
Northern Fulmar	0.00	0.04	0.63	0.10	0.00	0.49	0.05	0.37	0	0	0	0	0	0.81	0	0	0	0	0	0	0	0
Unidentified	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0	0	0	-	-	-	0	0	-	0	0	0	0	0
Unidentified Albatross	-	-	-	1.00	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0

	Pot Gear																					
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Auklet	0	-	-	-	-	-	-	-	-	0.00	-	1.00	-	-	1.00	0.00	-	-	-	-	-	-
Gull	0	0	0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	-	0	0	-	0.00	0.00	0.00	0	0.34	0.00	-
Northern Fulmar	0	0	0	0.01	0.07	0.01	0.03	0.01	0	0.00	0.11	0.03	0	0	0.24	0.01	0.03	0.21	0	0.08	0.02	0
Other	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	1.00	-	-
Shearwaters	0	0	0	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0.00	0	0.00	0.00	0
Storm Petrels	0	-	-	1.00	-	0.00	-	-	-	-	-	-	-	-	-	0.00	-	-	-	0.00	0.00	-
Unidentified	0	0	0	0.00	0.00	0.00	0.00	0.00	0	0.89	0.00	-	-	-	0.00	0.00	-	0.00	0	0.00	1.00	0

Figures

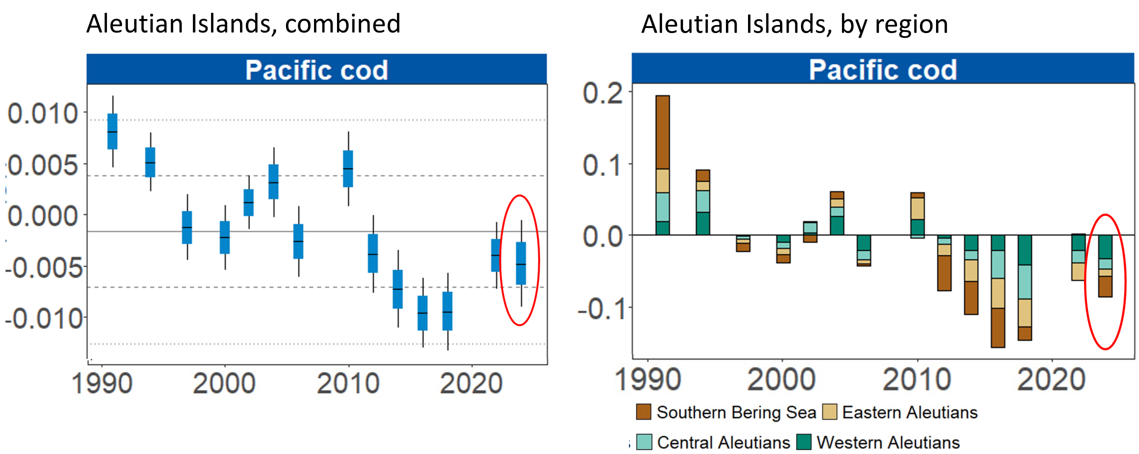


Figure 2A.1: Length-weight residuals for Pacific cod in the combined Aleutian Islands survey region (left), and by area (right), 1991 - 2024.

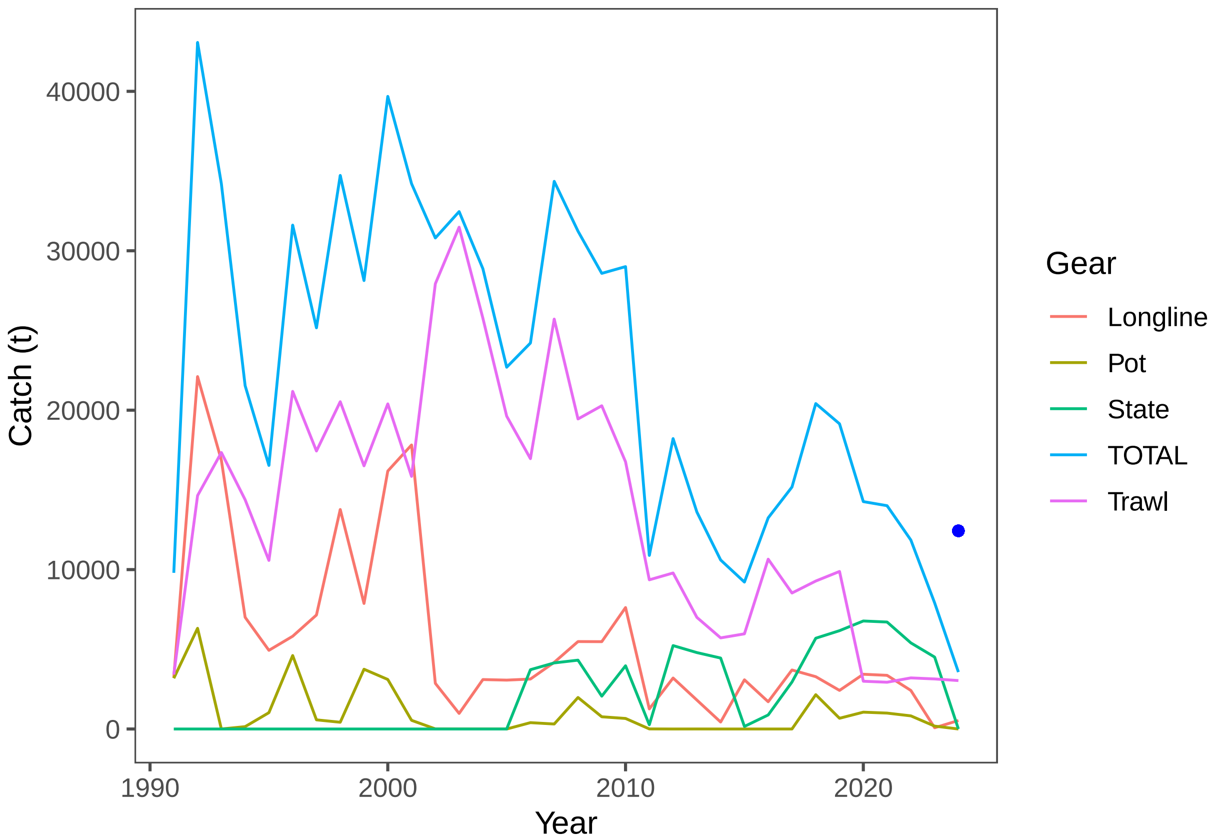


Figure 2A.2: Aleutian Islands Pacific cod catch history, with federal catches by gear type, from 1991-2024 (through September 22). The blue dot represents the ABC for 2024.

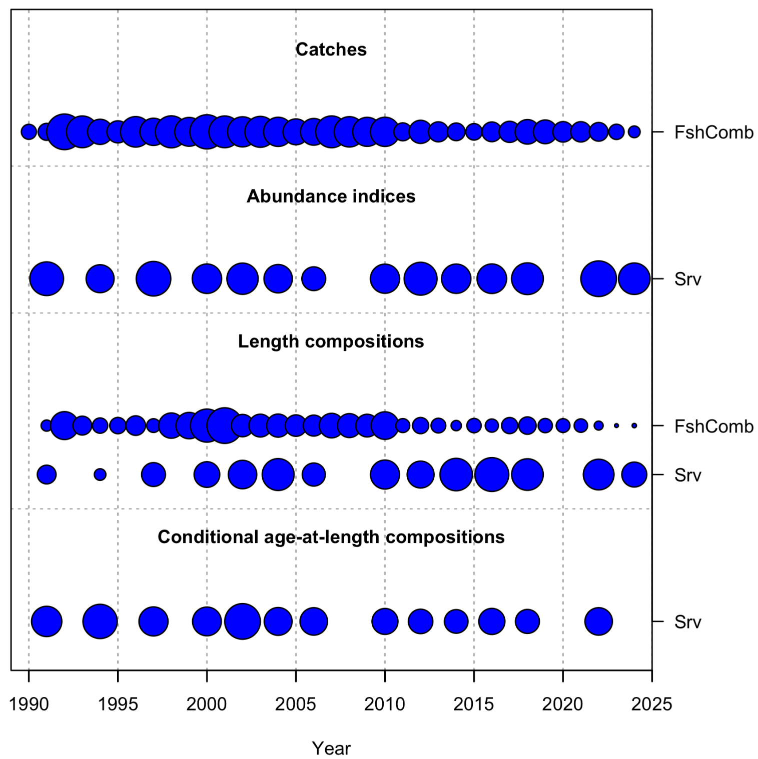


Figure 2A.3: Data sources and relative weight used in Models 24.1, 24.1a, and 24.0.

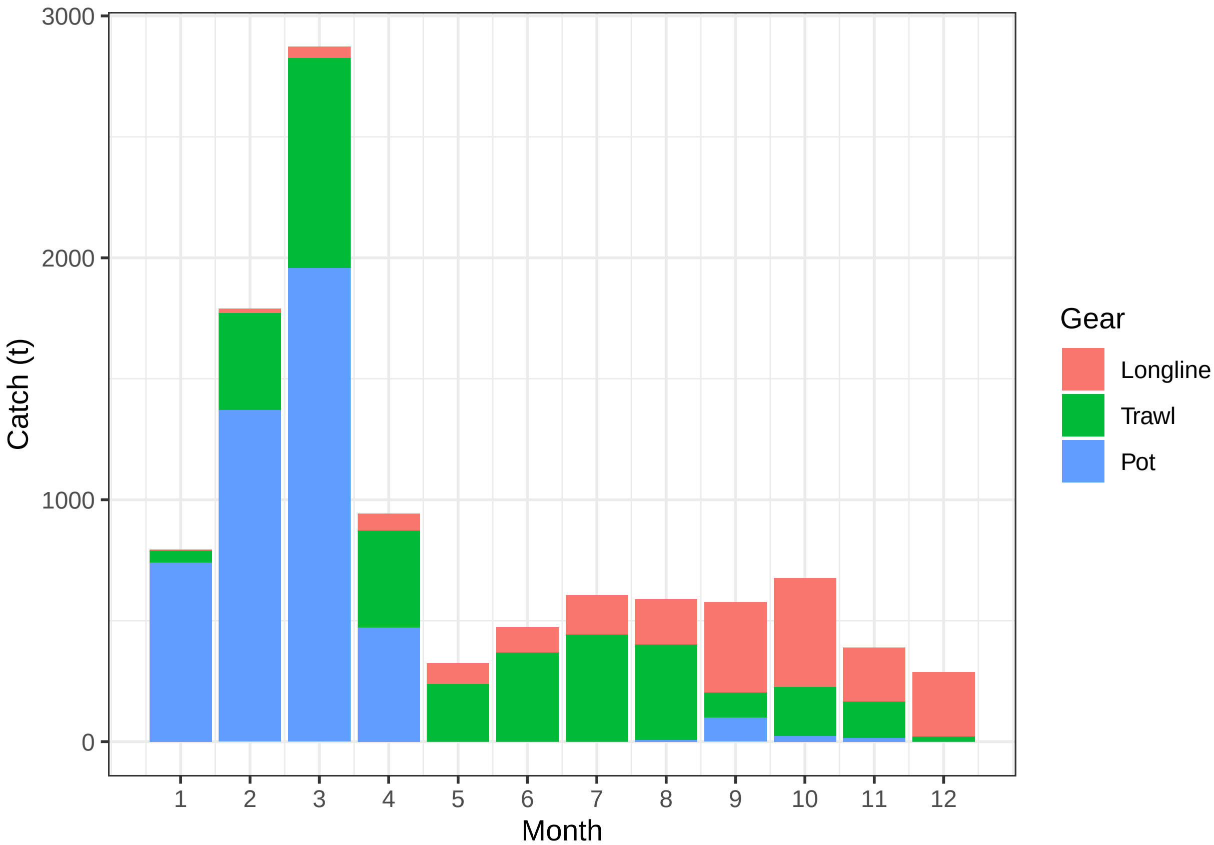


Figure 2A.4: Aleutian Islands Pacific cod average catch (t) by month per year and gear from January 1, 2020 - September 22, 2024.

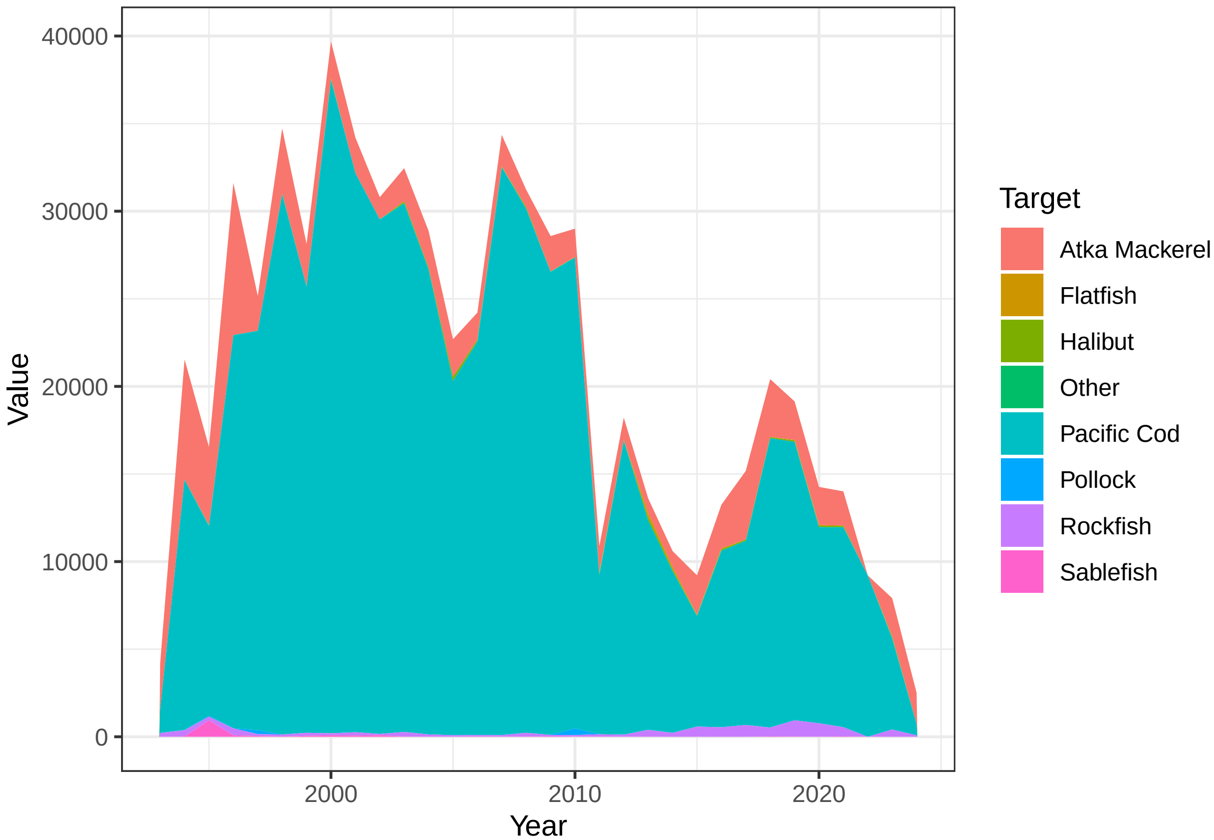


Figure 2A.5: Proportion of Pacific cod caught in targeted fisheries in the Aleutian Islands (541, 542, and 543) from 1991 through September 22, 2024.

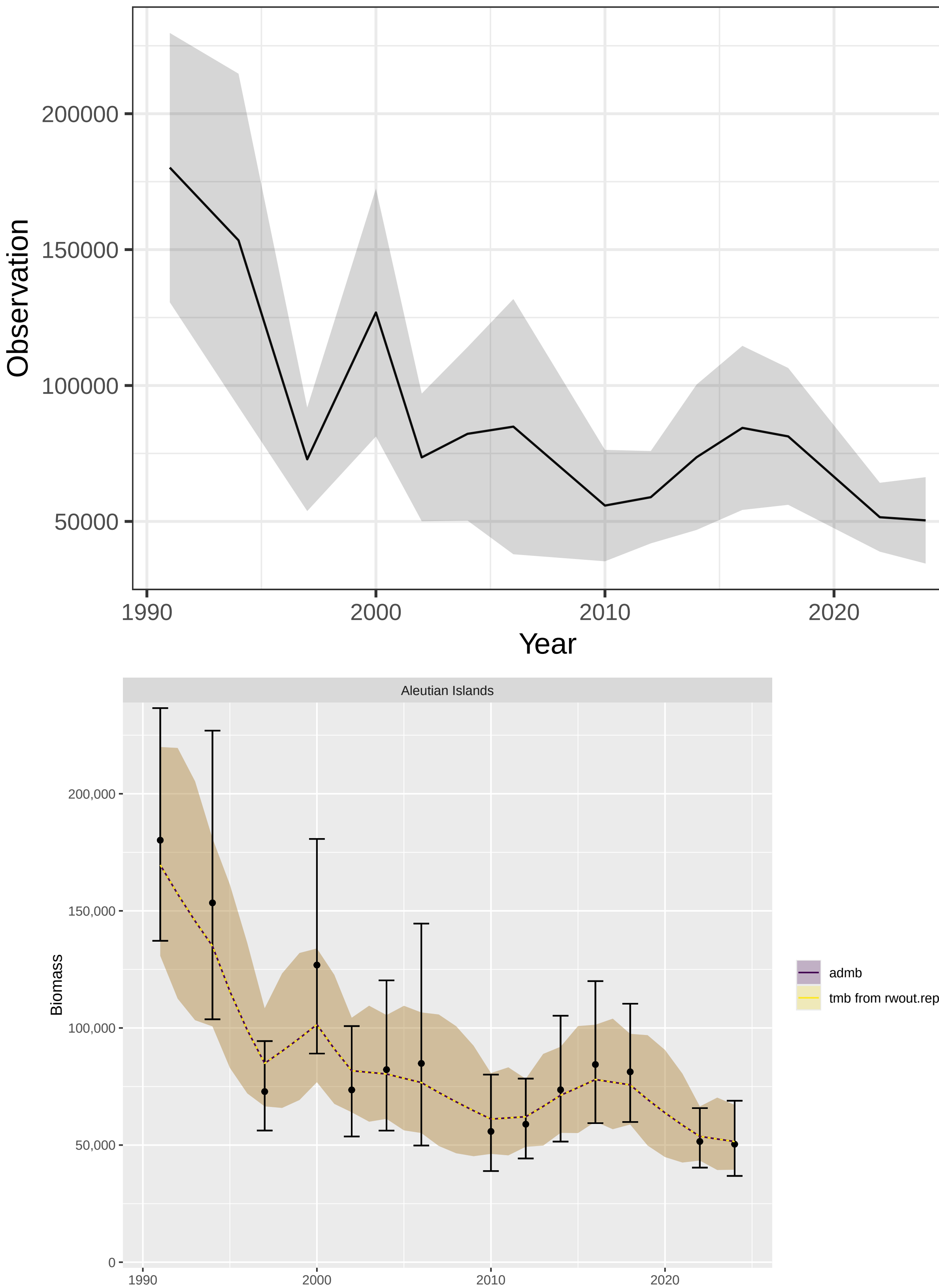


Figure 2A.6: Survey index of biomass with 95% confidence intervals (above) and Tier 5 fit to the survey index using a random effects model (below).

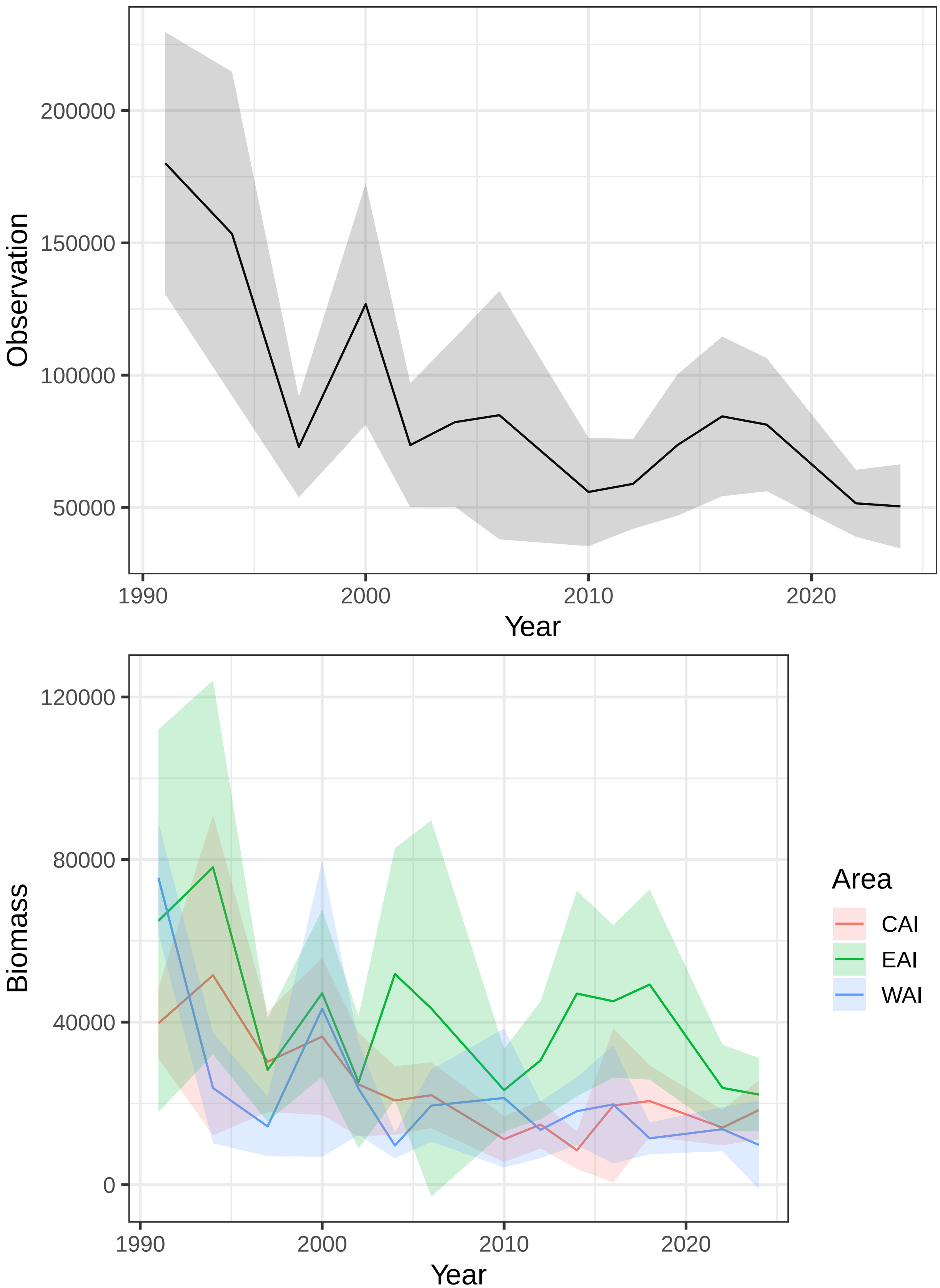


Figure 2A.7: Survey estimate of Pacific cod biomass in the Aleutian Islands, by area.

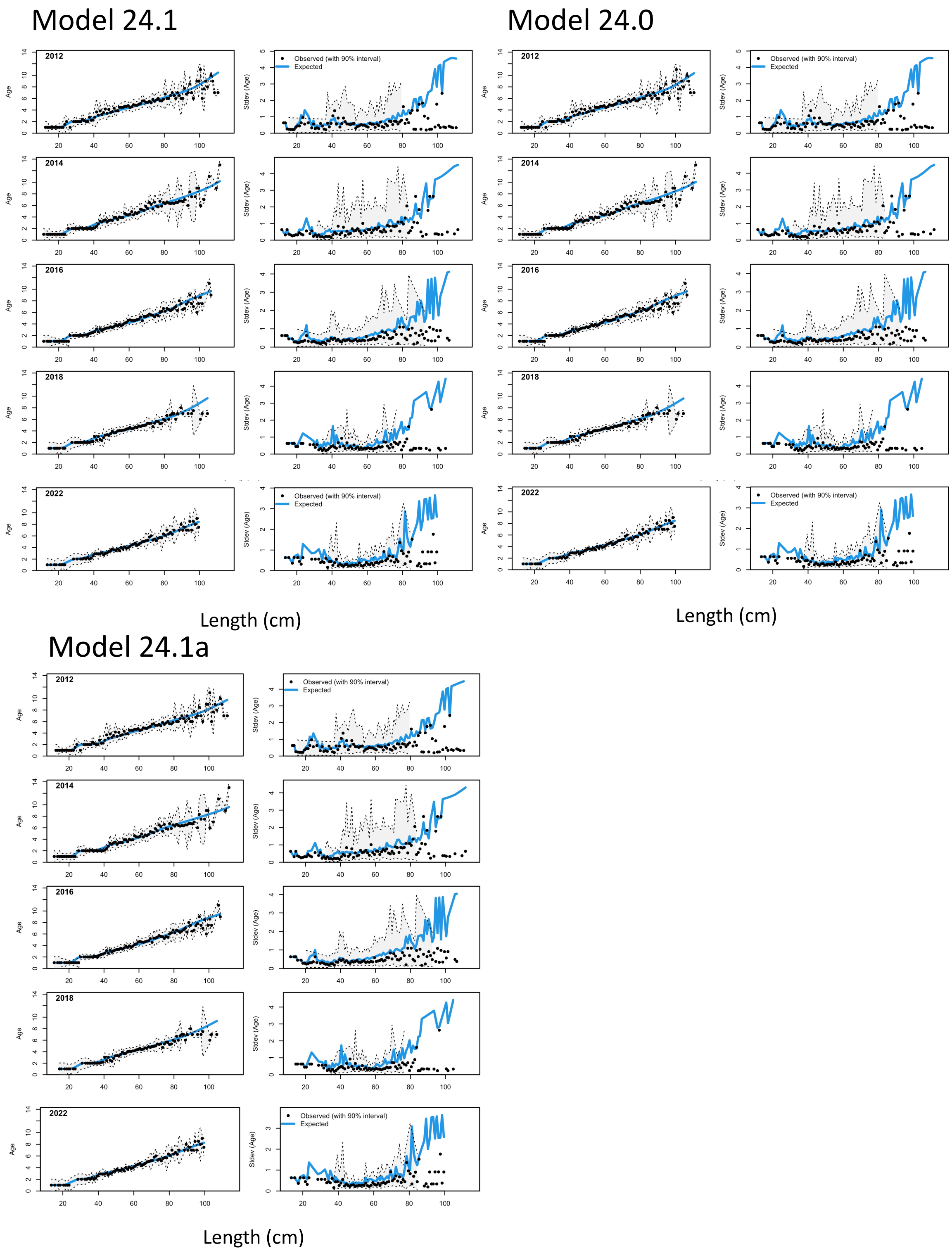


Figure 2A.8: Conditional age at length for the final five years of age data used in the model, for Models 24.1, 24.0, and 24.1a. Models 24.1 and 24.0 fit the Richards growth curve, while Model 24.1a uses the von Bertalanffy growth curve.

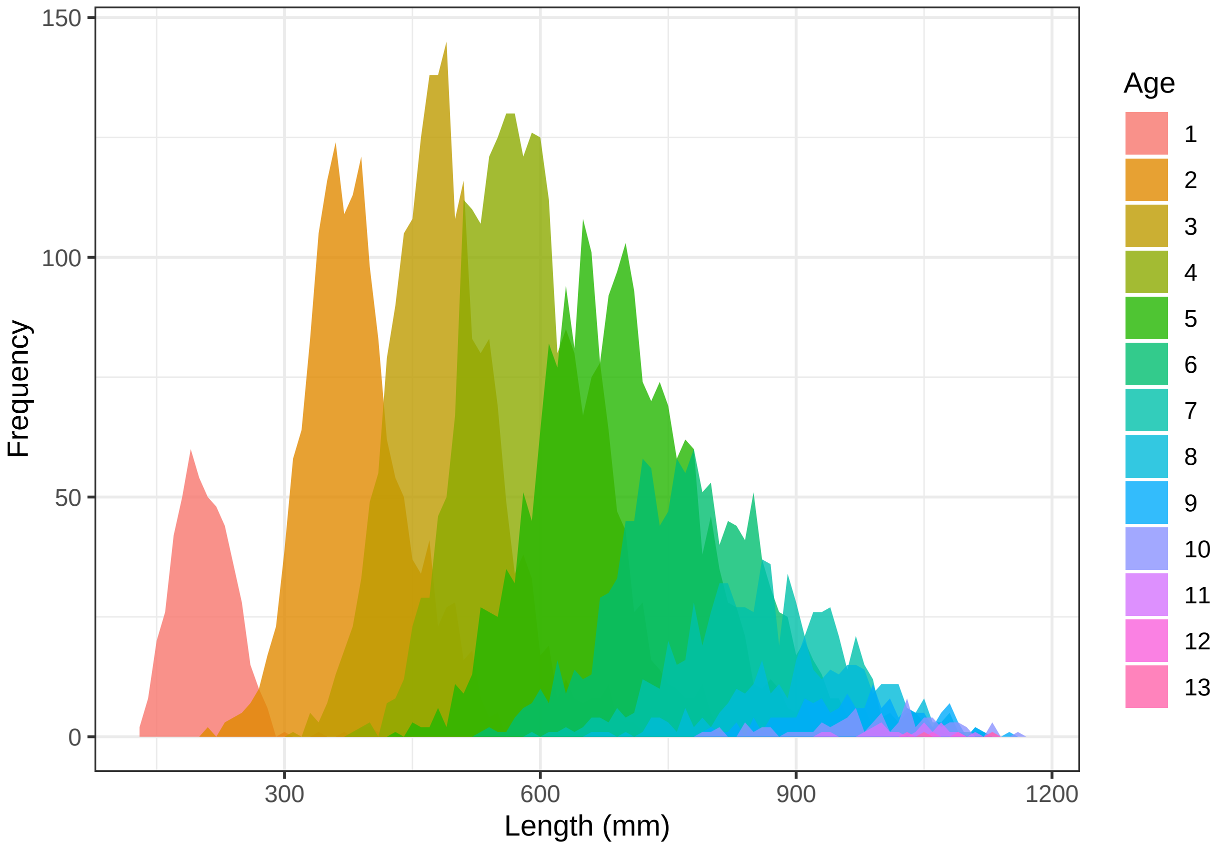


Figure 2A.9: Length frequency by age of cod collected from surveys 1991-2022.

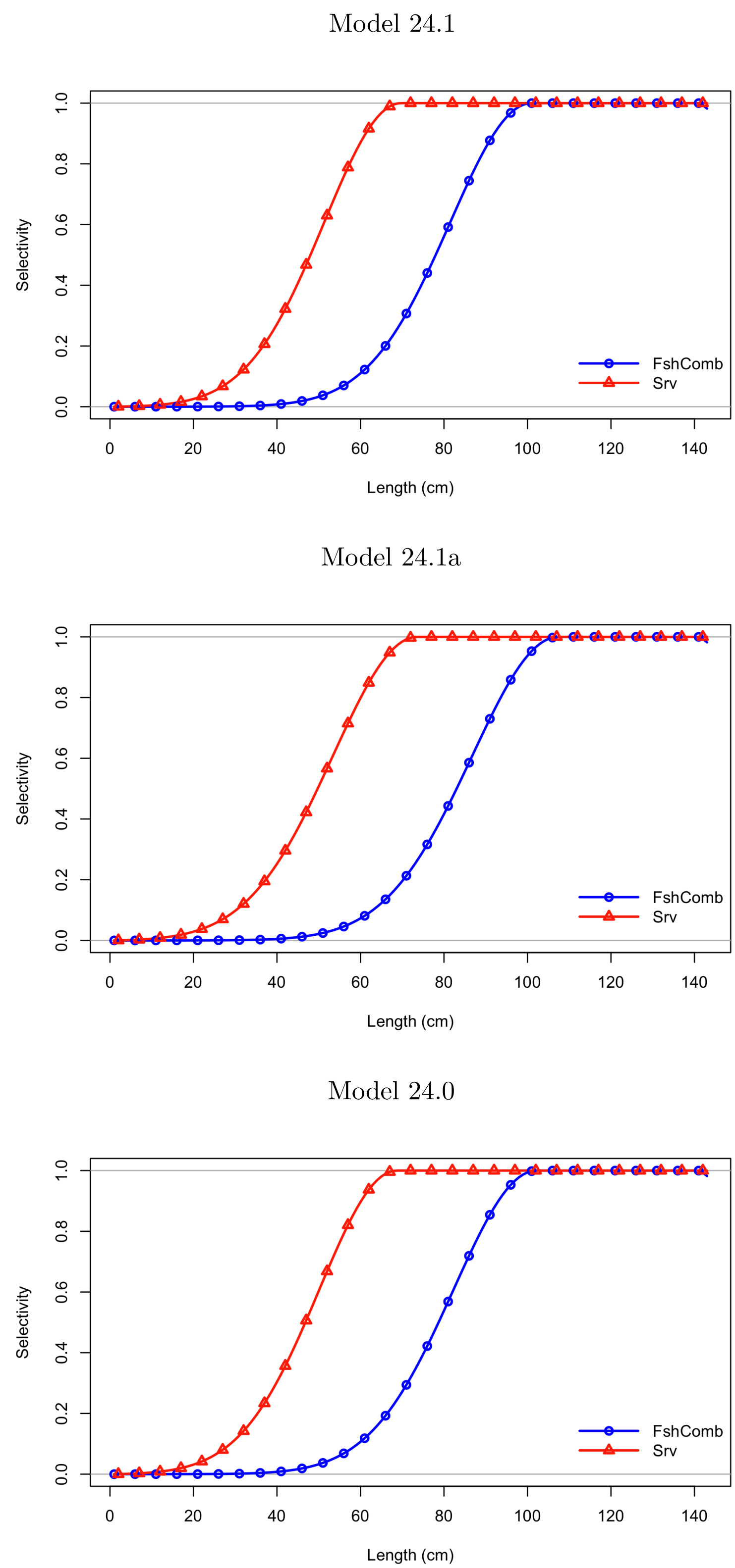


Figure 2A.10: Survey and fishery selectivity curves for Models 24.1, 24.1a, and 24.0.

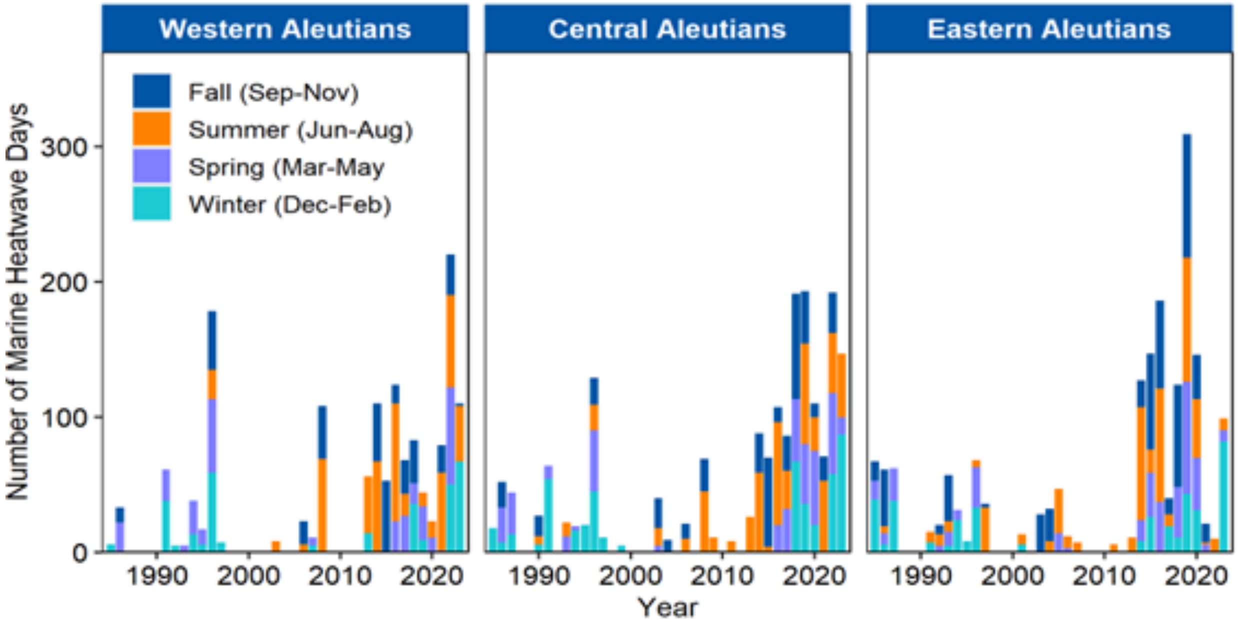


Figure 2A.11: The number of days under heatwave conditions for the western, central, and eastern Aleutian Islands, 1982 - 2023.

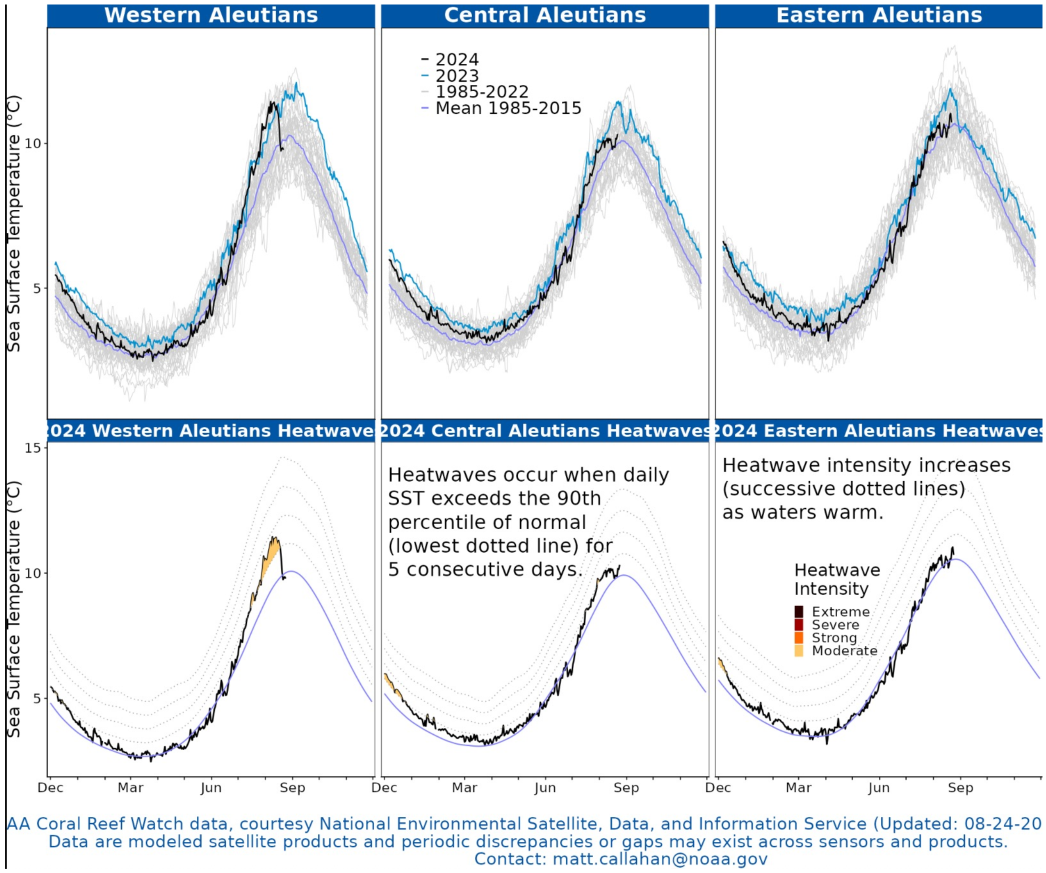
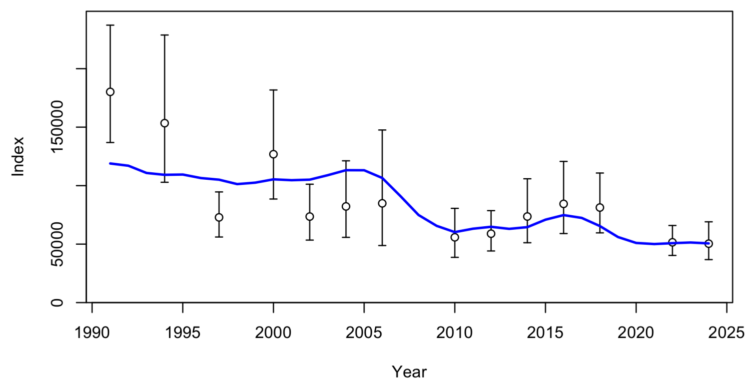
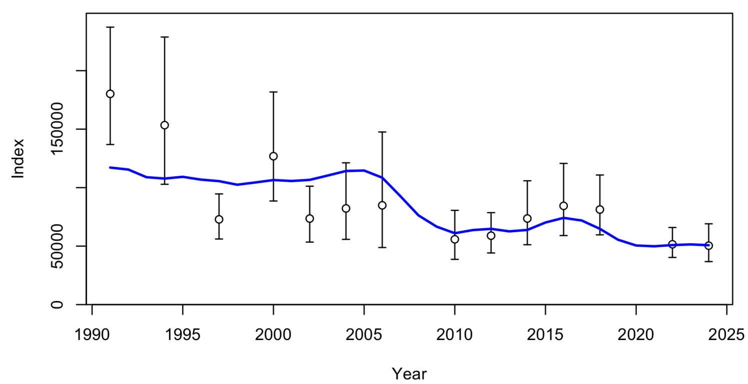


Figure 2A.12: Aleutian Islands mean sea surface temperature for the western, central, and eastern region, 2024 compared with 2023 and previous years. In 2024 there were several short periods considered heatwave conditions in the Aleutian Islands, but less than in previous years.

Model 24.1



Model 24.1a



Model 24.0

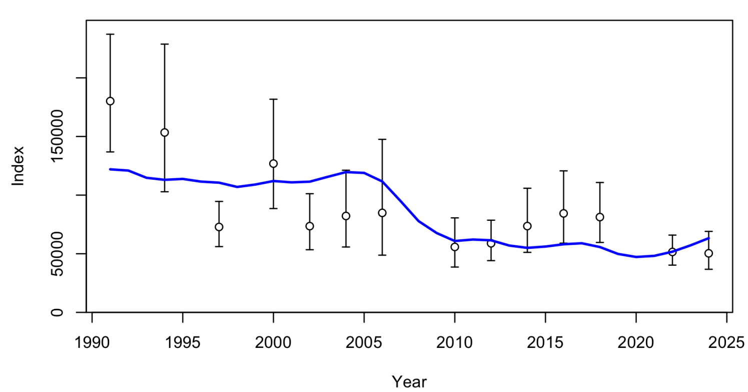


Figure 2A.13: Model fit to survey index for Models 24.1, 24.1a, and 24.0.

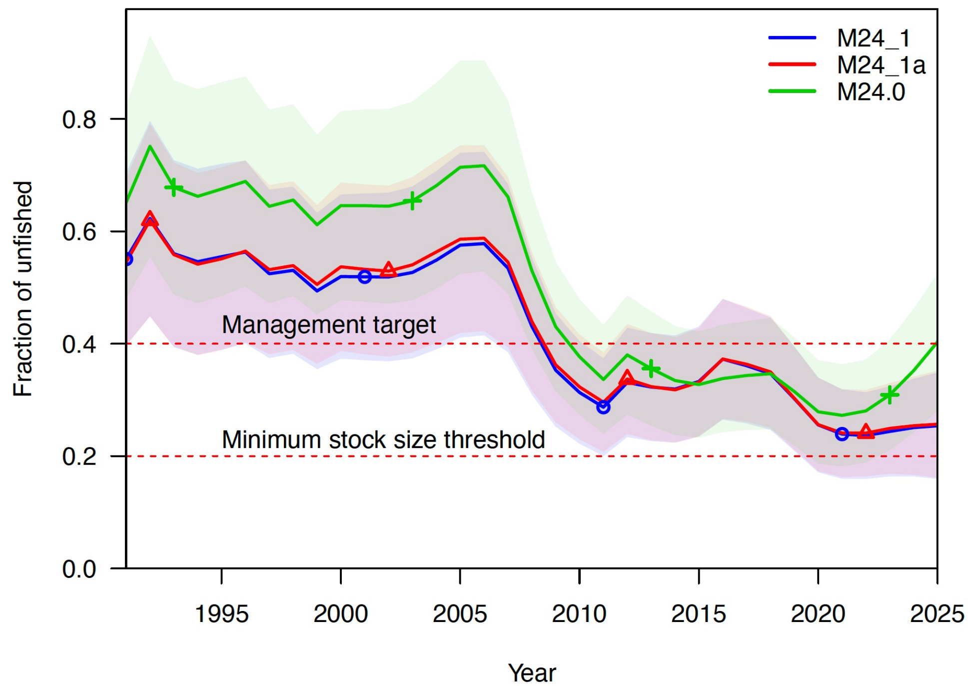
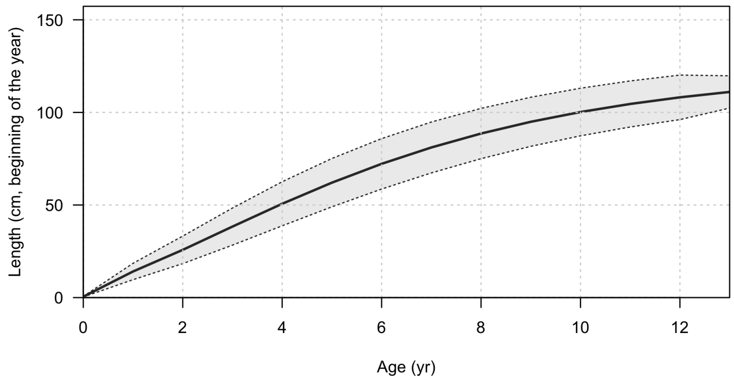
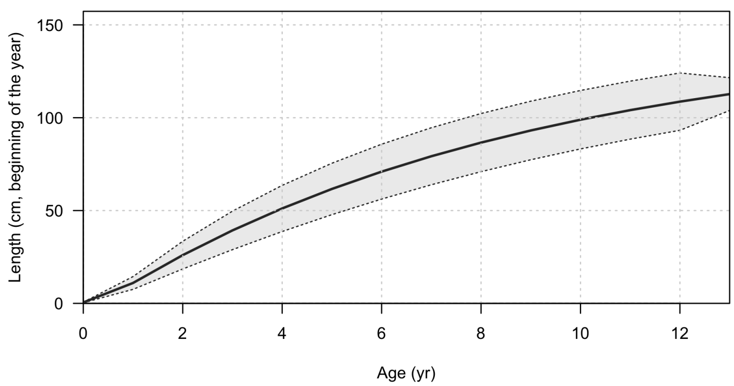


Figure 2A.14: Spawning biomass relative to unfished for all Models 24.1, 24.1a, and 24.0.

Model 24.1



Model 24.1a



Model 24.0

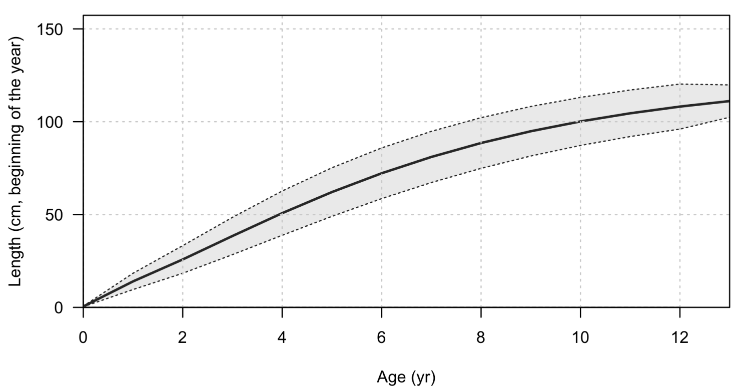


Figure 2A.15: Growth curves for Models 24.1, 24.1a, and 24.0. Model 24.1a used the von Bertalanffy growth curve, the other models used the Richards growth curve.

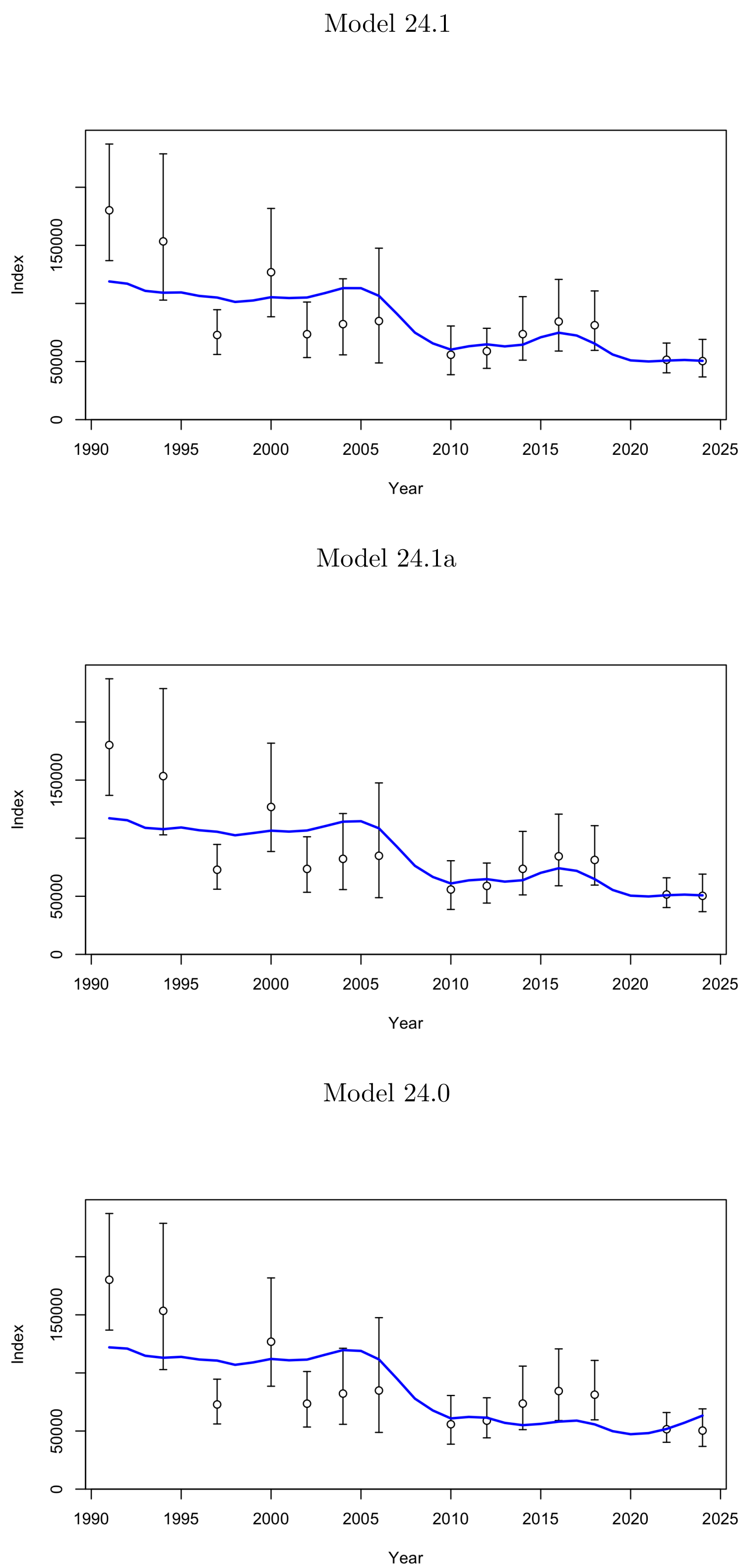


Figure 2A.16: Model 24.0 (upper panel), Model 24.1a (middle panel), and MOdel 24.0 (lower panel) fit to survey index, 1991 - 2024.

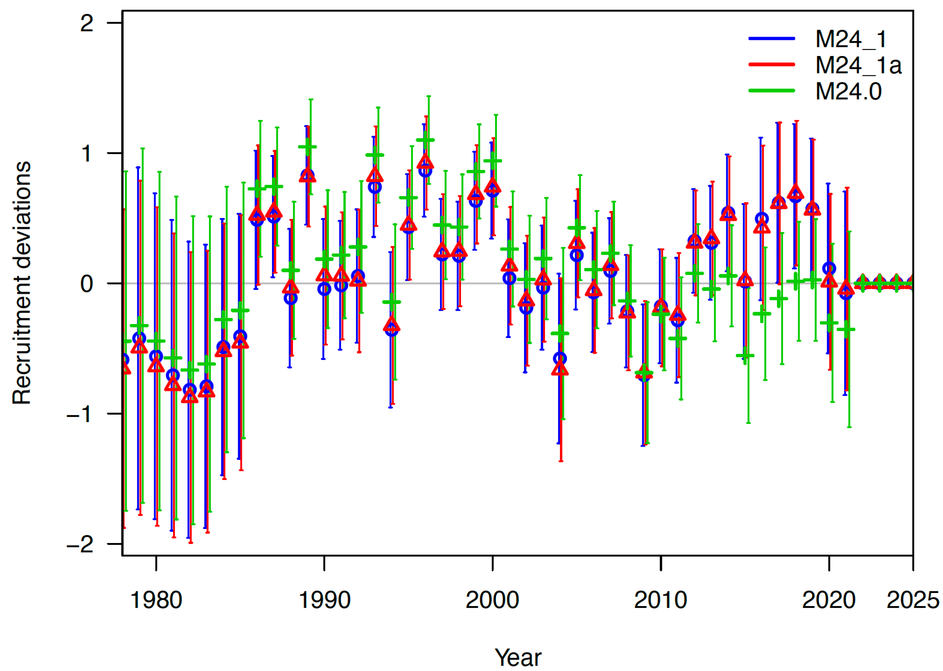
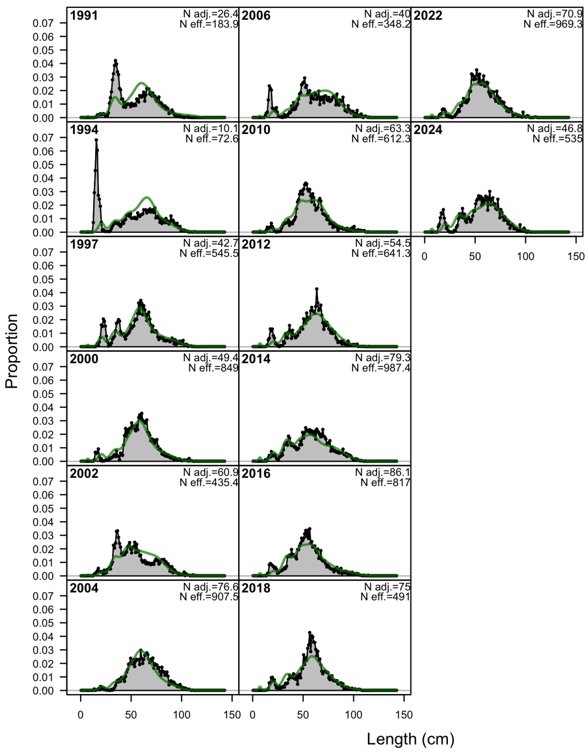
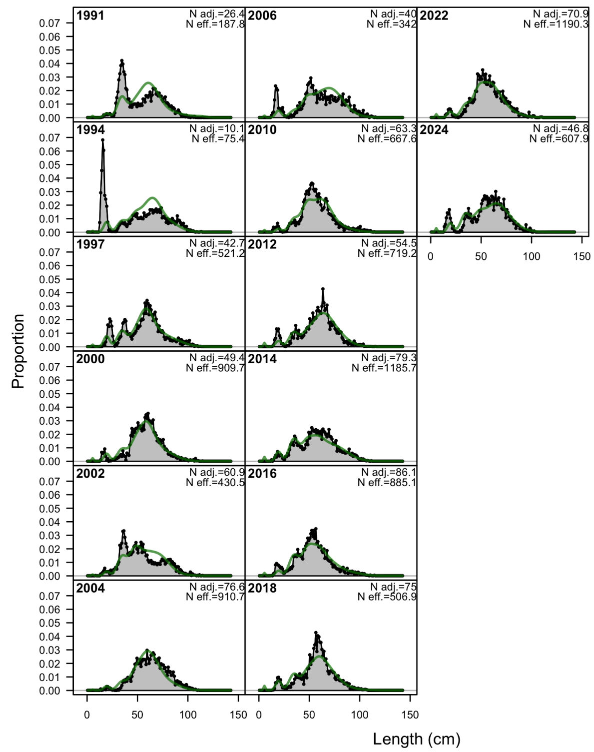


Figure 2A.17: Recruitment estimates for all Models 24.1, 24.1a, and 24.0.

Model 24.1



Model 24.1a



Model 24.0

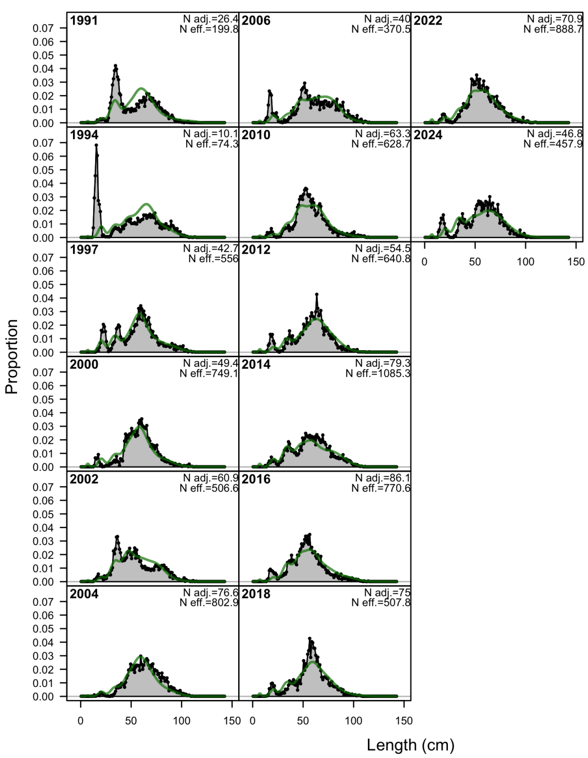
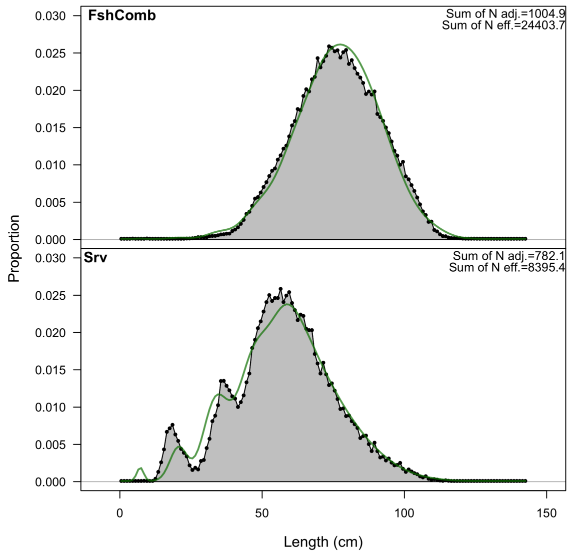
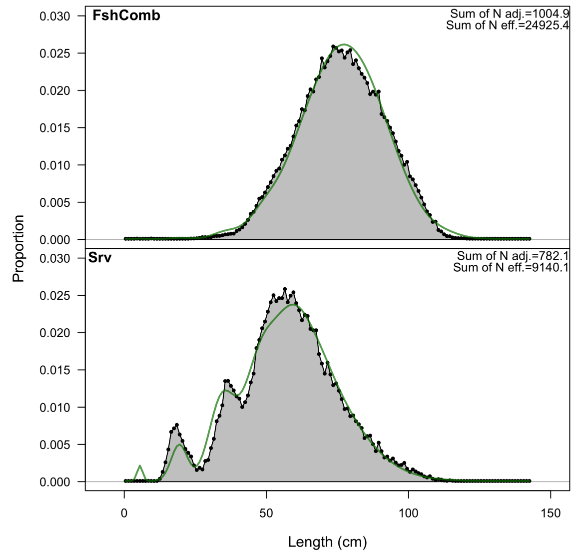


Figure 2A.18: Survey length composition and fit to the length composition, Model 24.1 (upper left), Model 24.1a (upper right), and M24.0 (lower left).

Model 24.1



Model 24.1a



Model 24.0

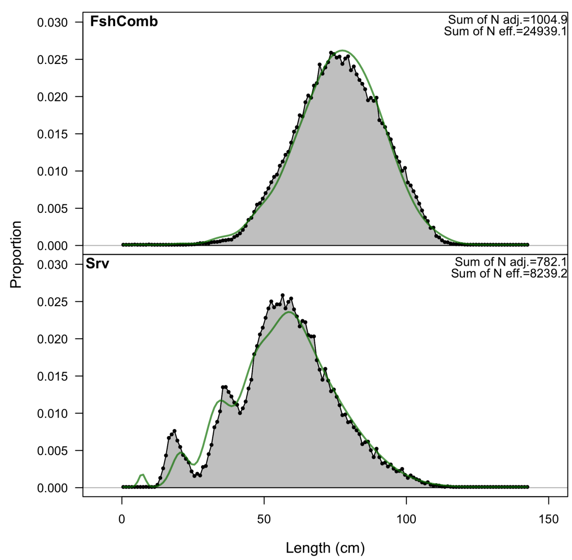


Figure 2A.19: Model fit to observed length frequencies for survey and fishery data, aggregated across time Model 24.1 (upper left) and 24.1a (upper right), 24.0 (below).

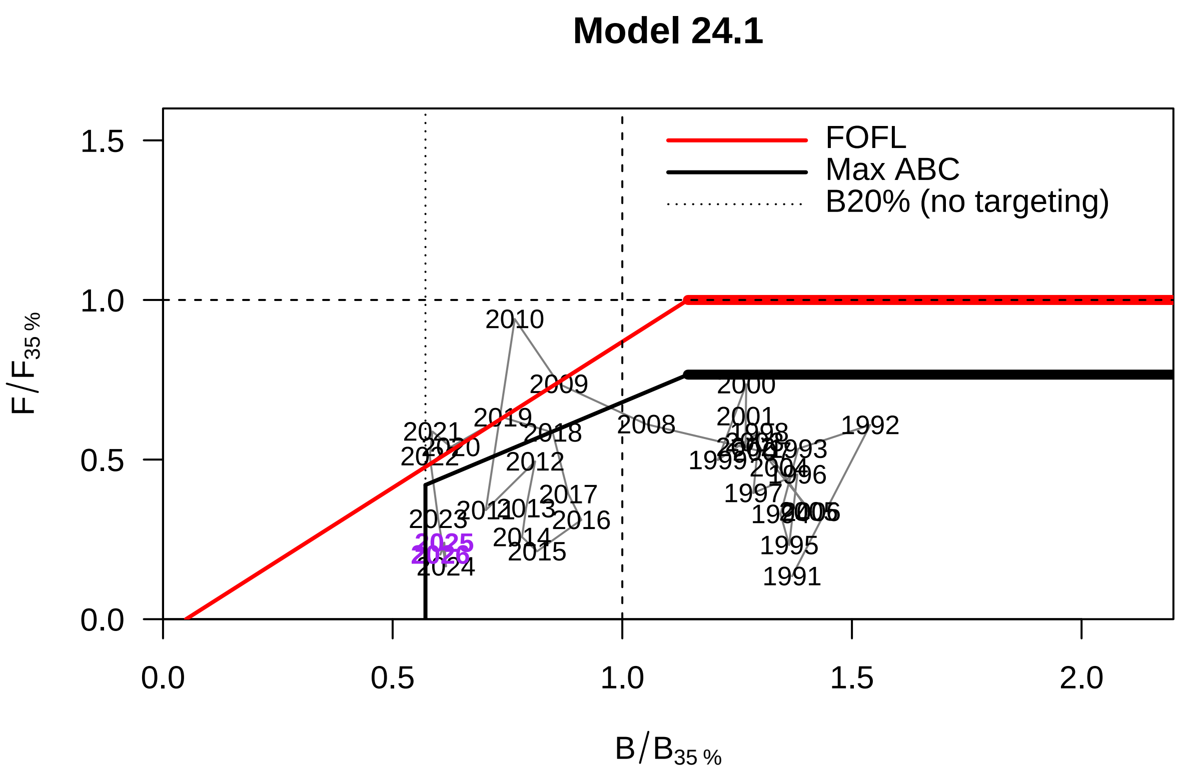


Figure 2A.20: Phaseplane plot for Model 24.1, with forecasted results through 2026. Fishing mortality for 2025 and 2026 were estimated as the mean of the previous two years.

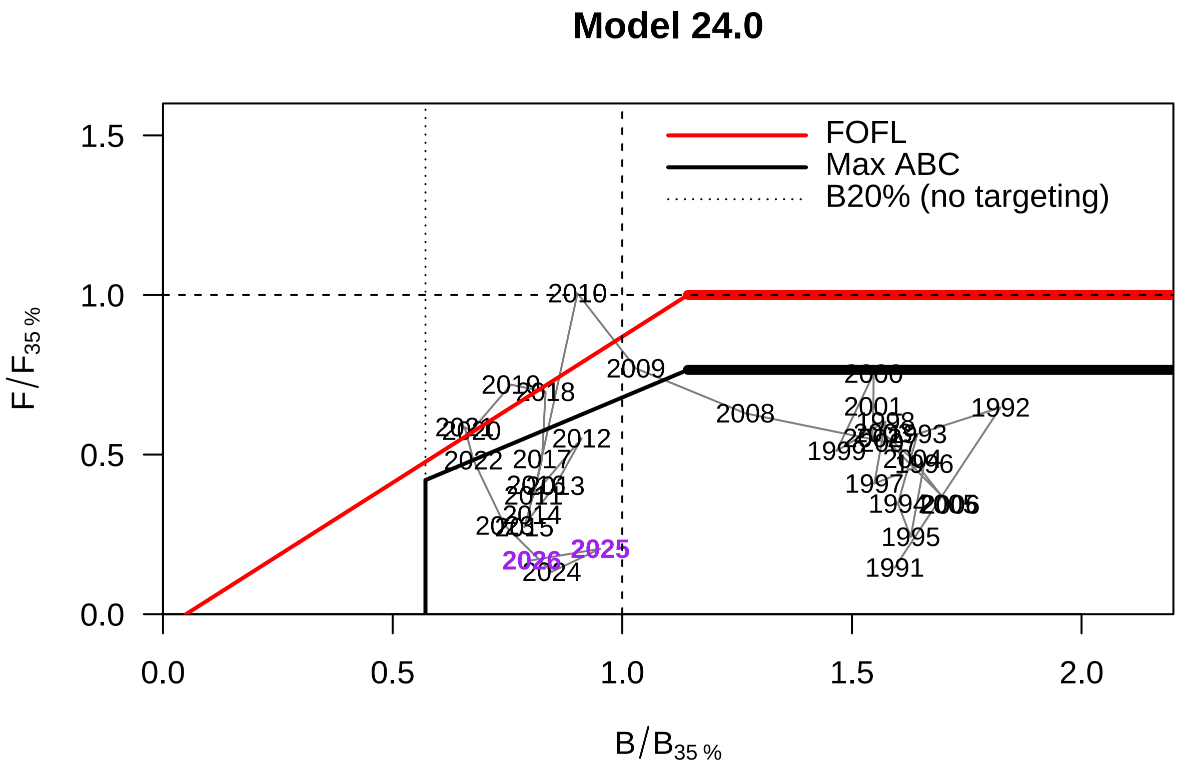
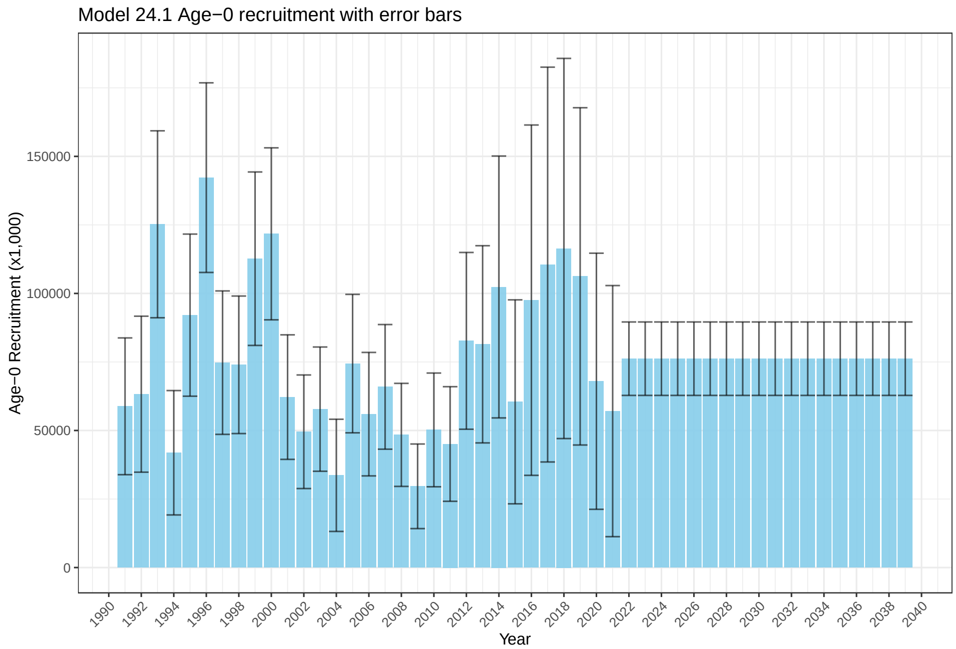


Figure 2A.21: Phaseplane plot for Model 24.0, with forecasted results through 2026. Fishing mortality for 2025 and 2026 were estimated as the mean of the previous two years.



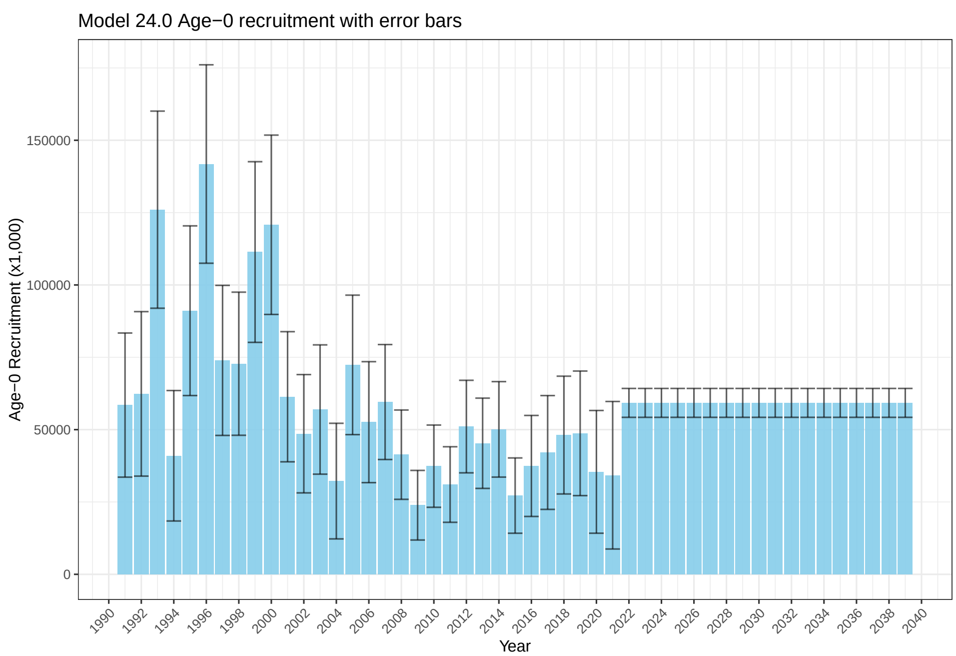


Figure 2A.22: Age-0 recruitment for Aleutian Islands Pacific cod, Model 24.1 (above), Model 24.0 (below). Recruitment deviations are calculated for years 1991 - 2021, and initial/virgin recruitment estimates used for years <1991. Mean recruitment is used for years 2022 onward.

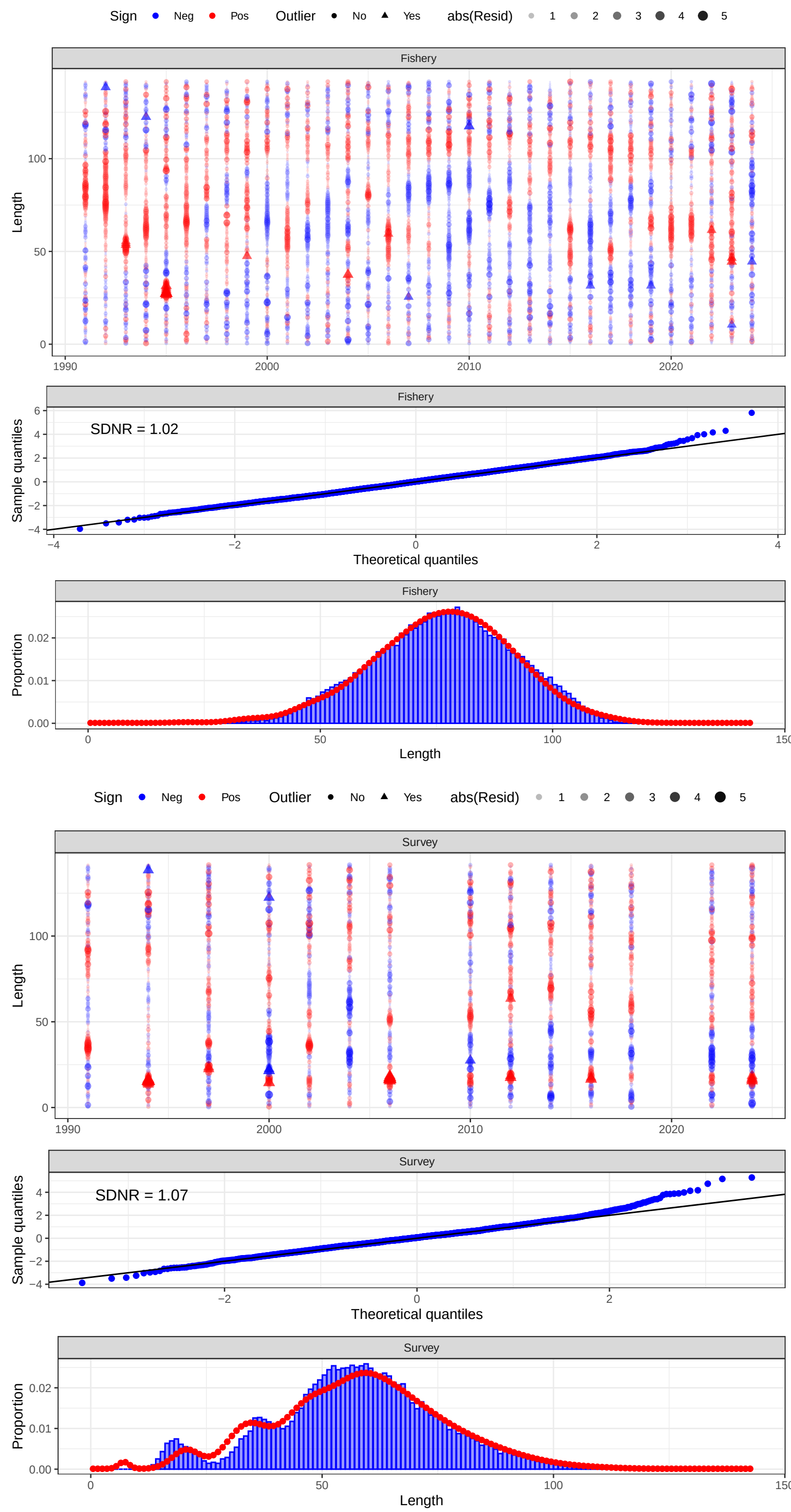


Figure 2A.23: One-step-ahead (OSA) residuals for Model 24.1, fishery (above) and survey (below).

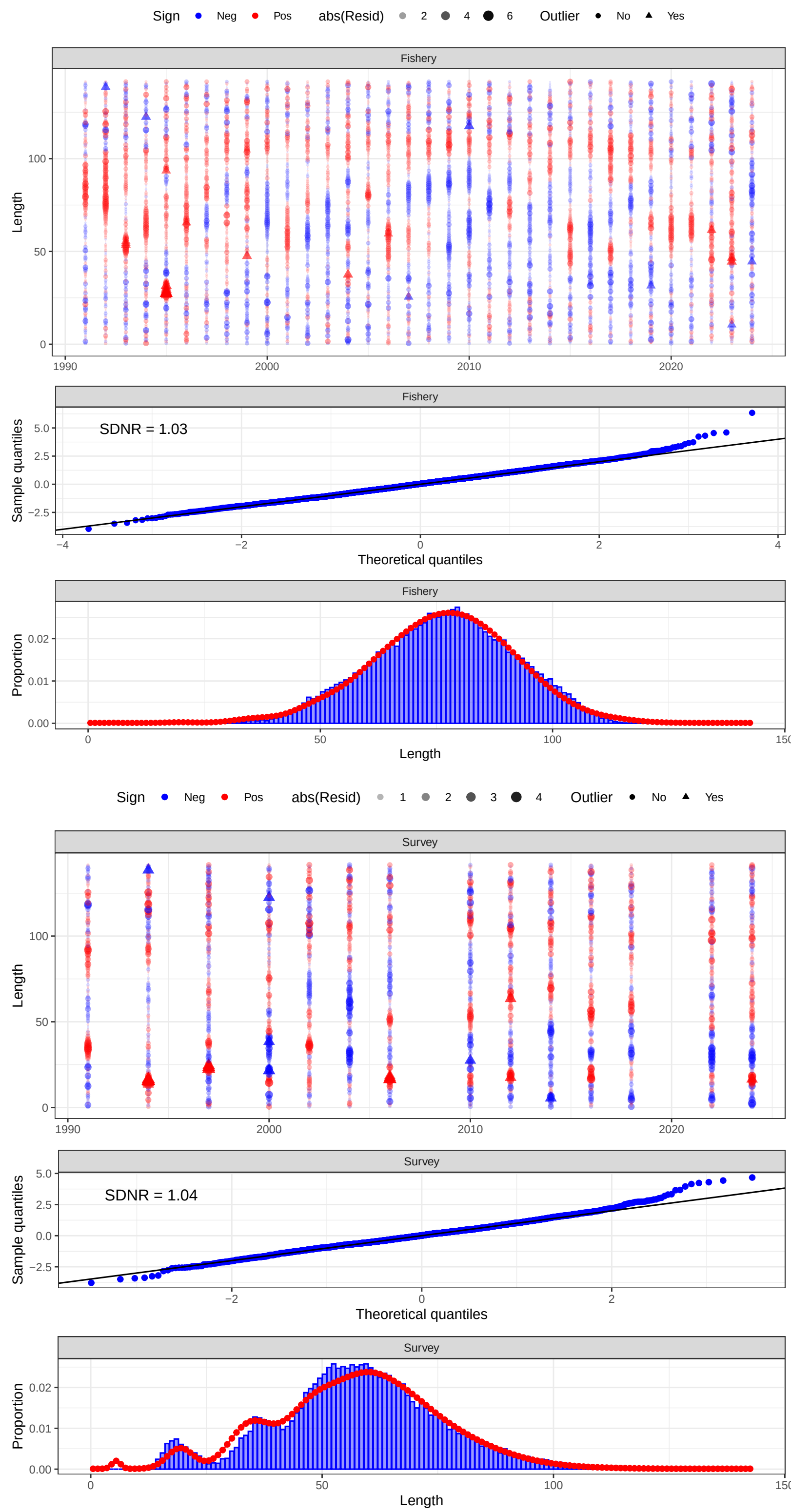


Figure 2A.24: One-step-ahead (OSA) residuals for Model 24.1a, fishery (above) and survey (below).

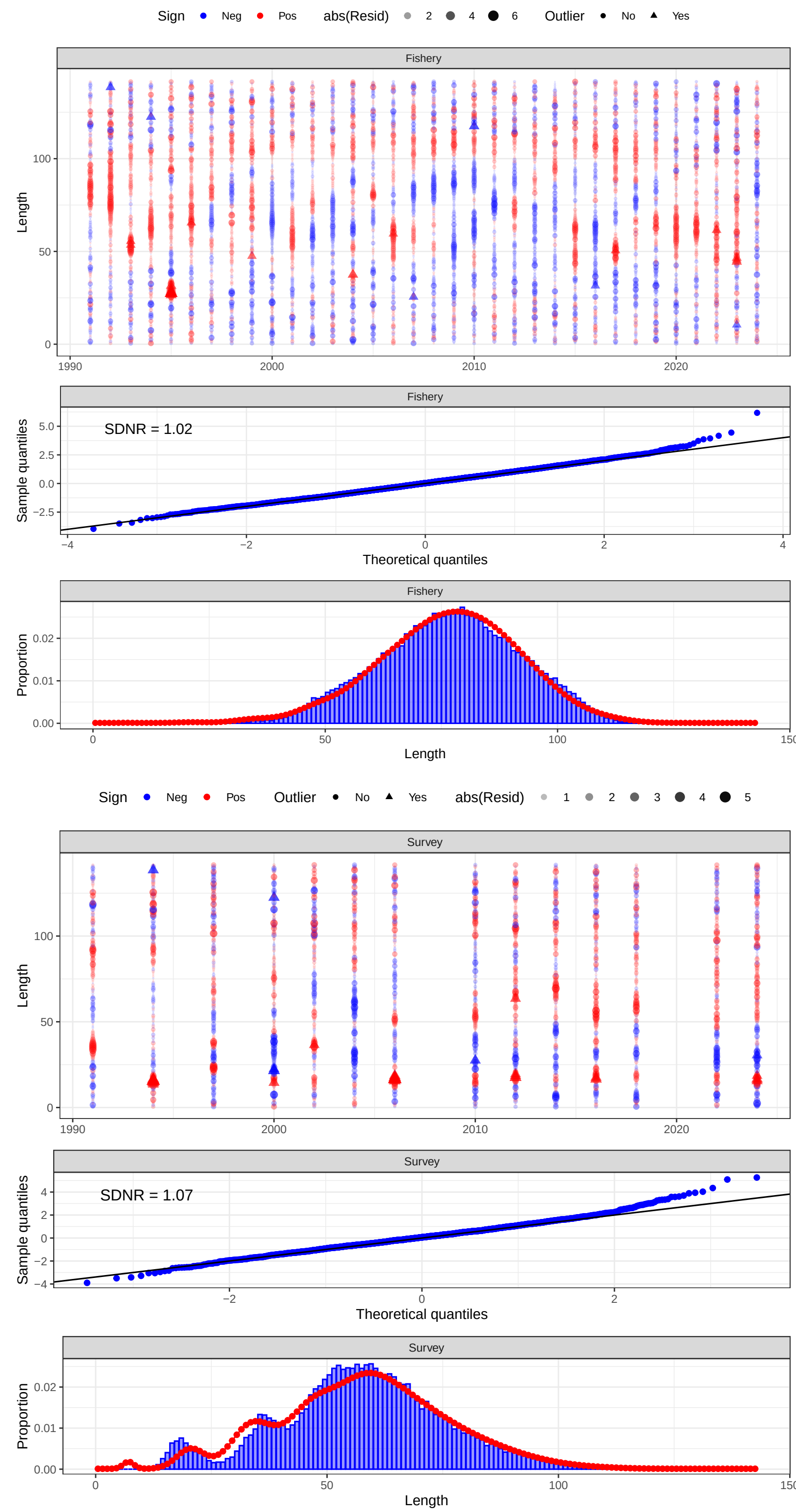


Figure 2A.25: One-step-ahead (OSA) residuals for Model 24.0, fishery (above) and survey (below).

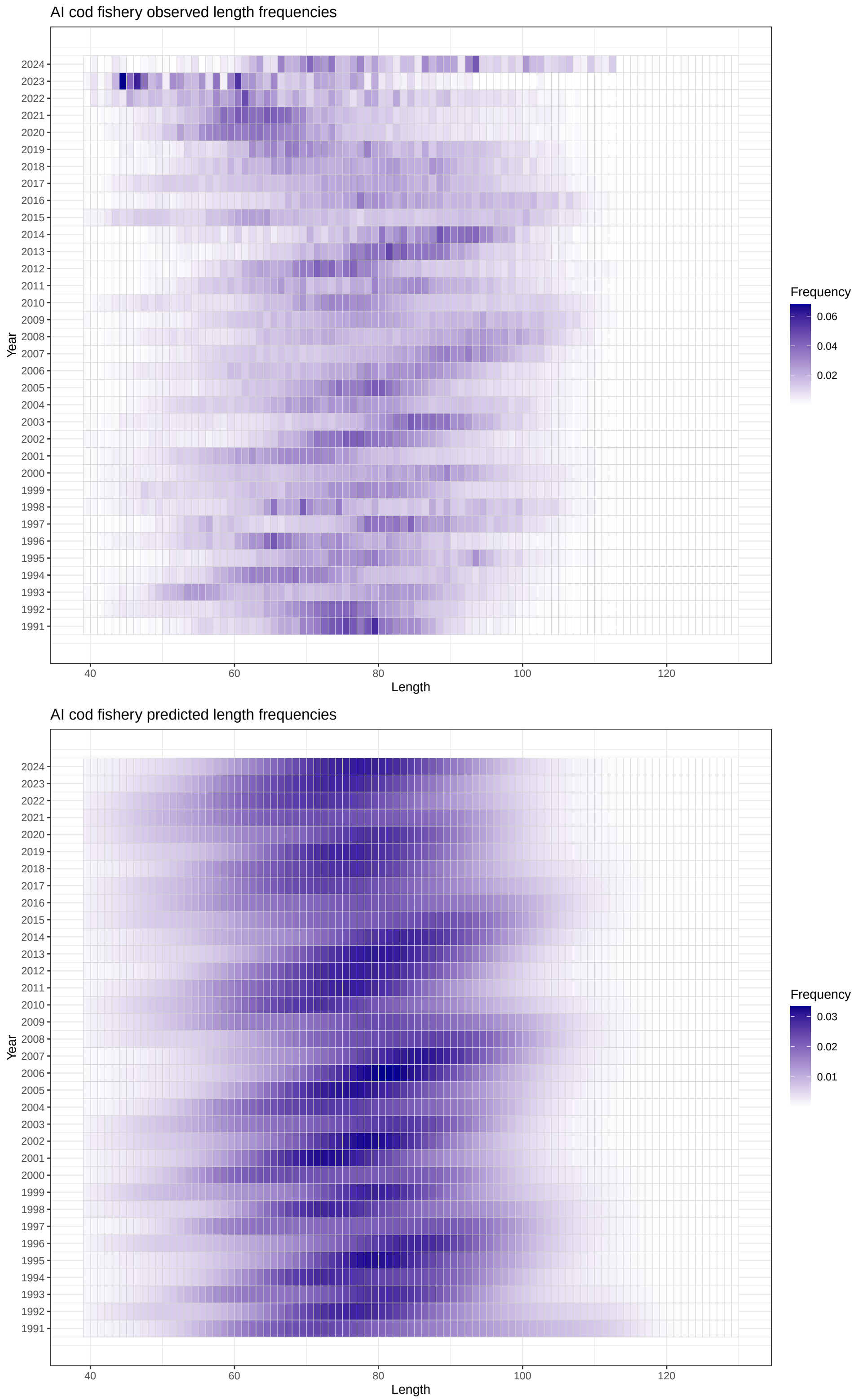


Figure 2A.26: Length frequency of observed (above) and predicted (below) fishery length frequency of Aleutian Islands Pacific cod, 1991 - 2024.

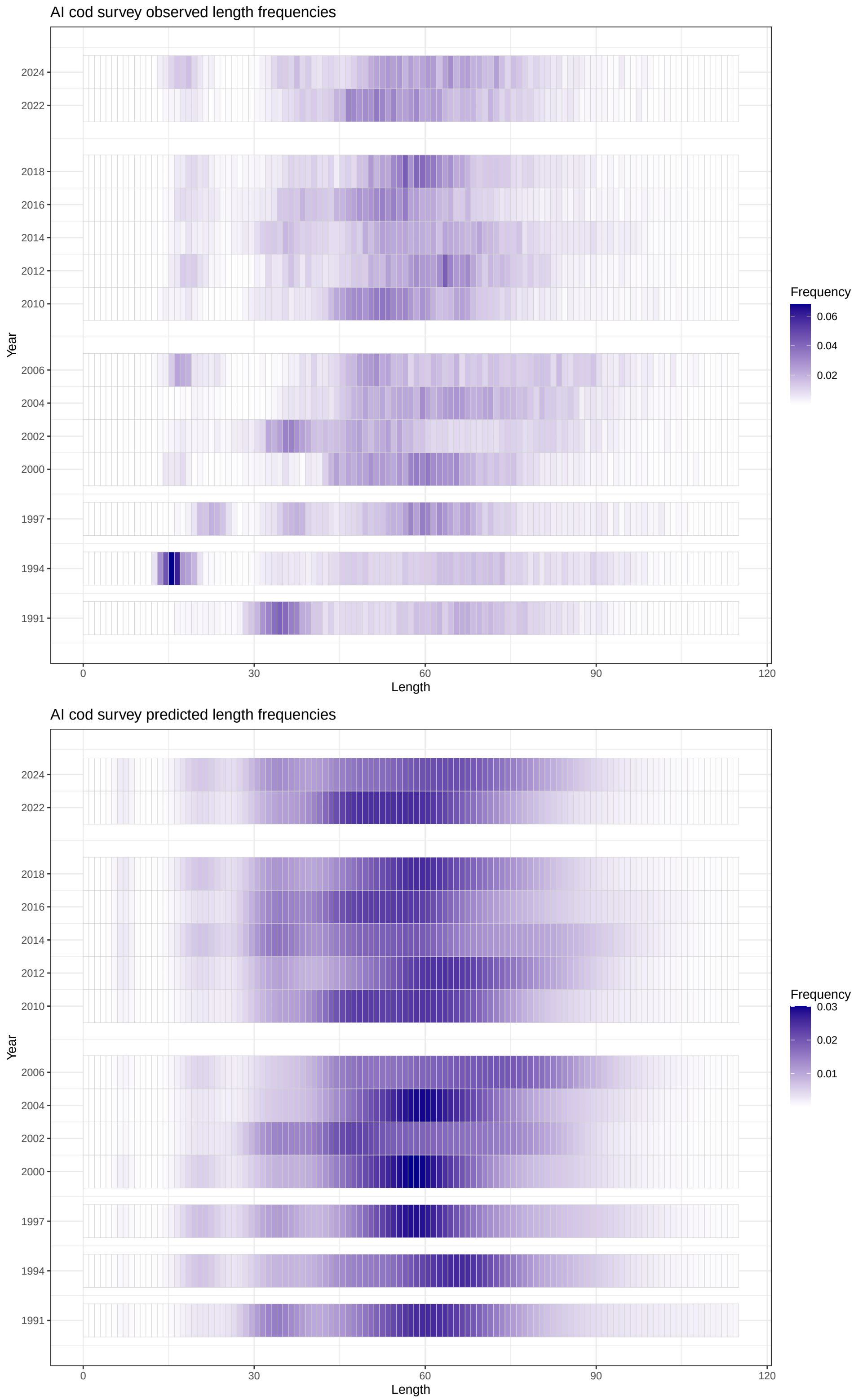


Figure 2A.27: Length frequency of observed (above) and predicted (below) survey length frequency of Aleutian Islands Pacific cod, 1991 - 2024.

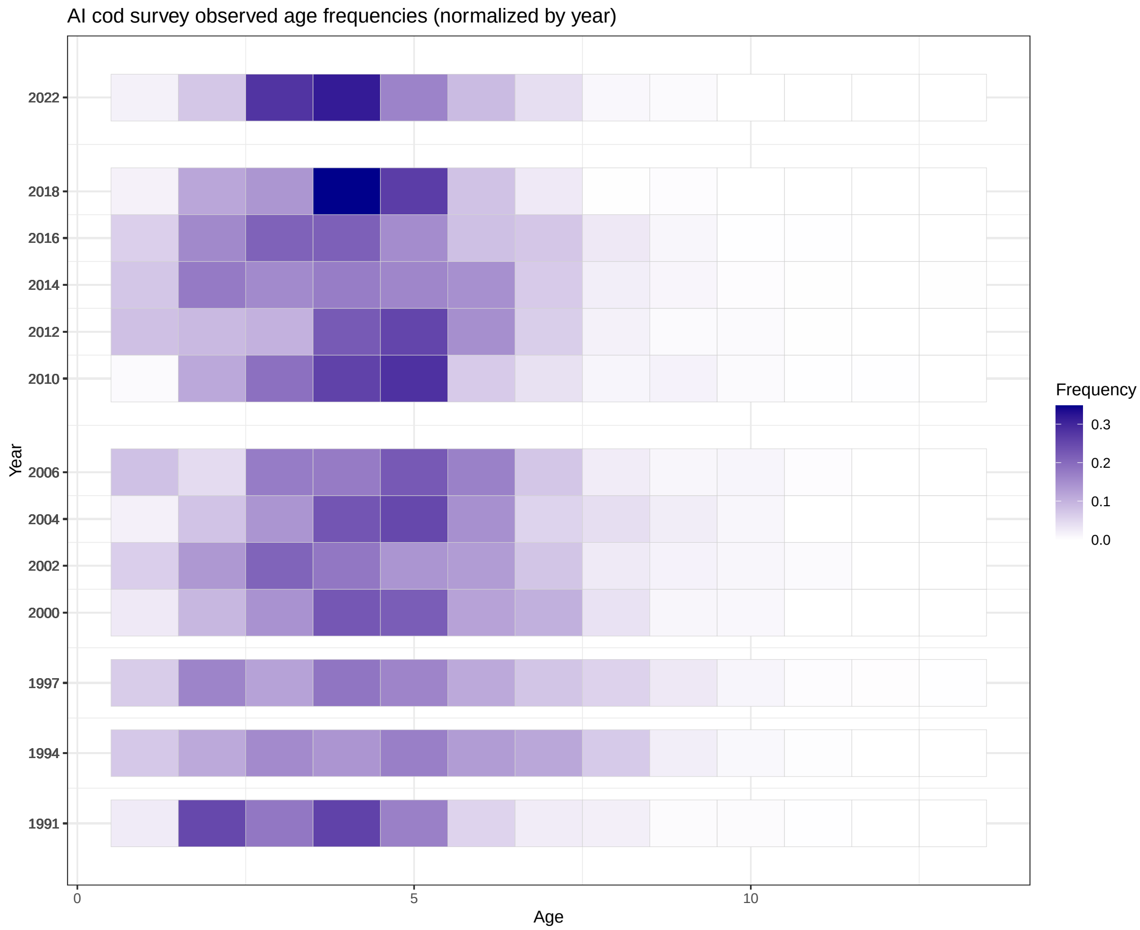


Figure 2A.28: Observed age frequencies of Aleutian Islands Pacific cod, 1991 - 2024.

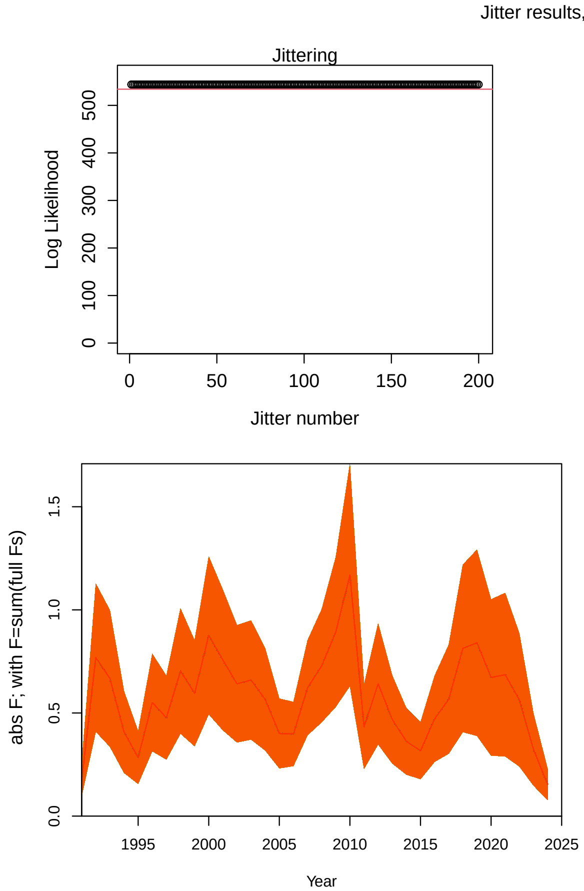


Figure 2A.29: The Model 24.1 jitter diagnostic for global convergence conducted on the Aleutian Islands Pacific cod assessment model 24.1. In the upper left panel, solid black circles represent the total likelihood obtained from 200 jittered model runs and the red horizontal dashed line represents the total likelihood value from the base-case model. The upper right panel is the spawning stock biomass (SSB) from jittered model runs. The lower panel shows the estimate of absolute fishing mortality, F, with F=sum(full Fs).

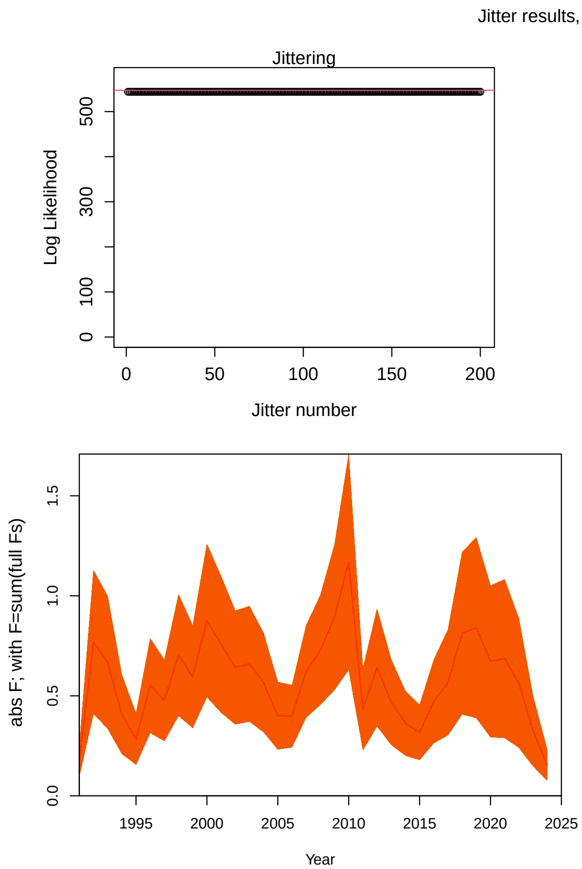


Figure 2A.30: The jitter diagnostic for global convergence conducted on the Aleutian Islands Pacific cod assessment Model 24.1a. In the upper left panel, solid black circles represent the total likelihood obtained from 200 jittered model runs and the red horizontal dashed line represents the total likelihood value from the base-case model. The upper right panel is the spawning stock biomass (SSB) from jittered model runs. The lower panel shows the estimate of absolute fishing mortality, F, with F=sum(full Fs).

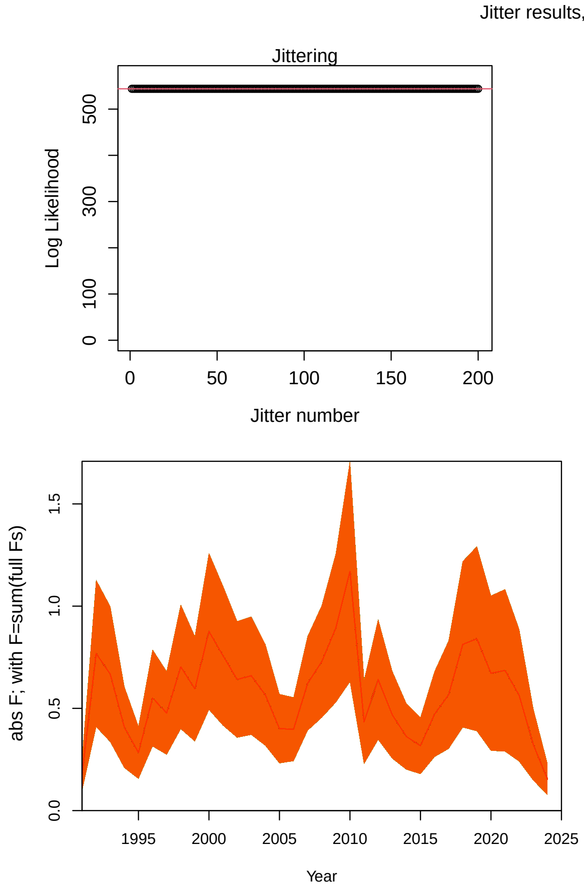


Figure 2A.31: The Model jitter diagnostic for global convergence conducted on the Aleutian Islands Pacific cod assessment model 24.0. In the upper left panel, solid black circles represent the total likelihood obtained from 200 jittered model runs and the red horizontal dashed line represents the total likelihood value from the base-case model. The upper right panel is the spawning stock biomass (SSB) from jittered model runs. The lower panel shows the estimate of absolute fishing mortality, F, with F=sum(full Fs).

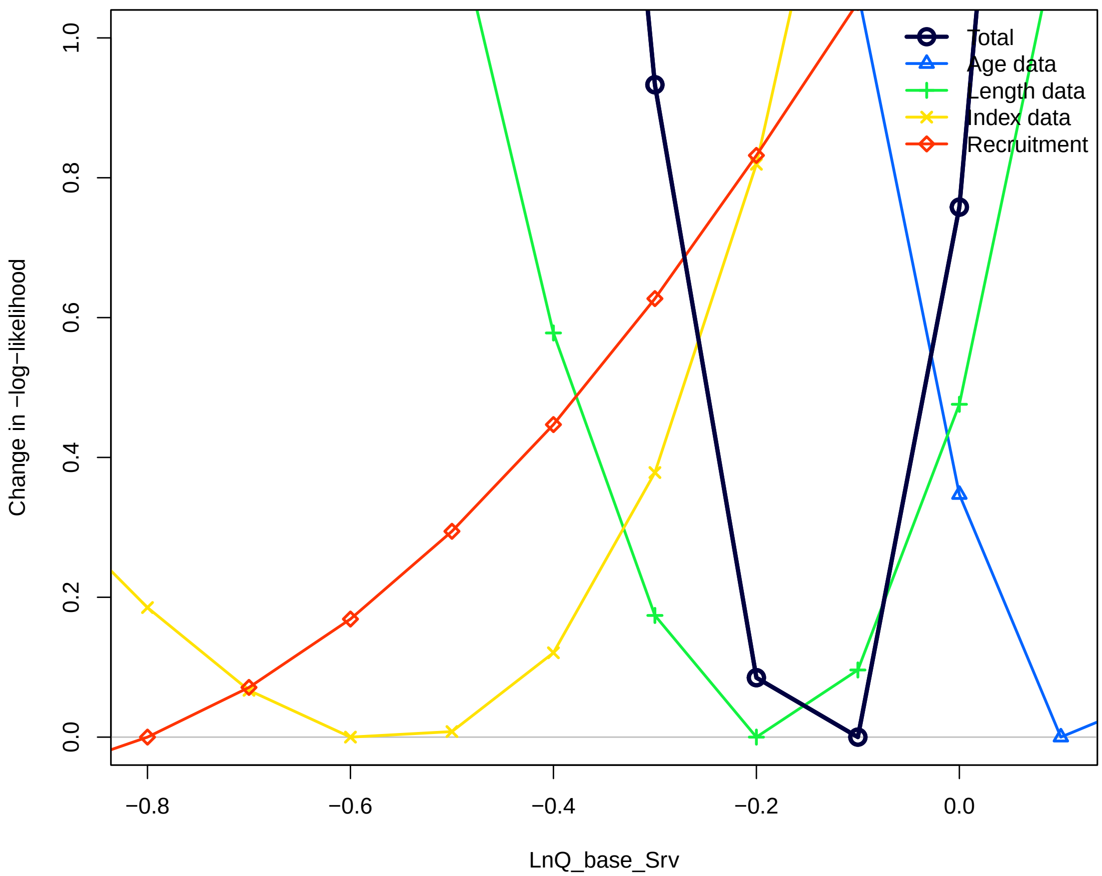


Figure 2A.32: Likelihood profile over the log of catchability (q), from -0.8 to 0.8 in increments of 0.1.

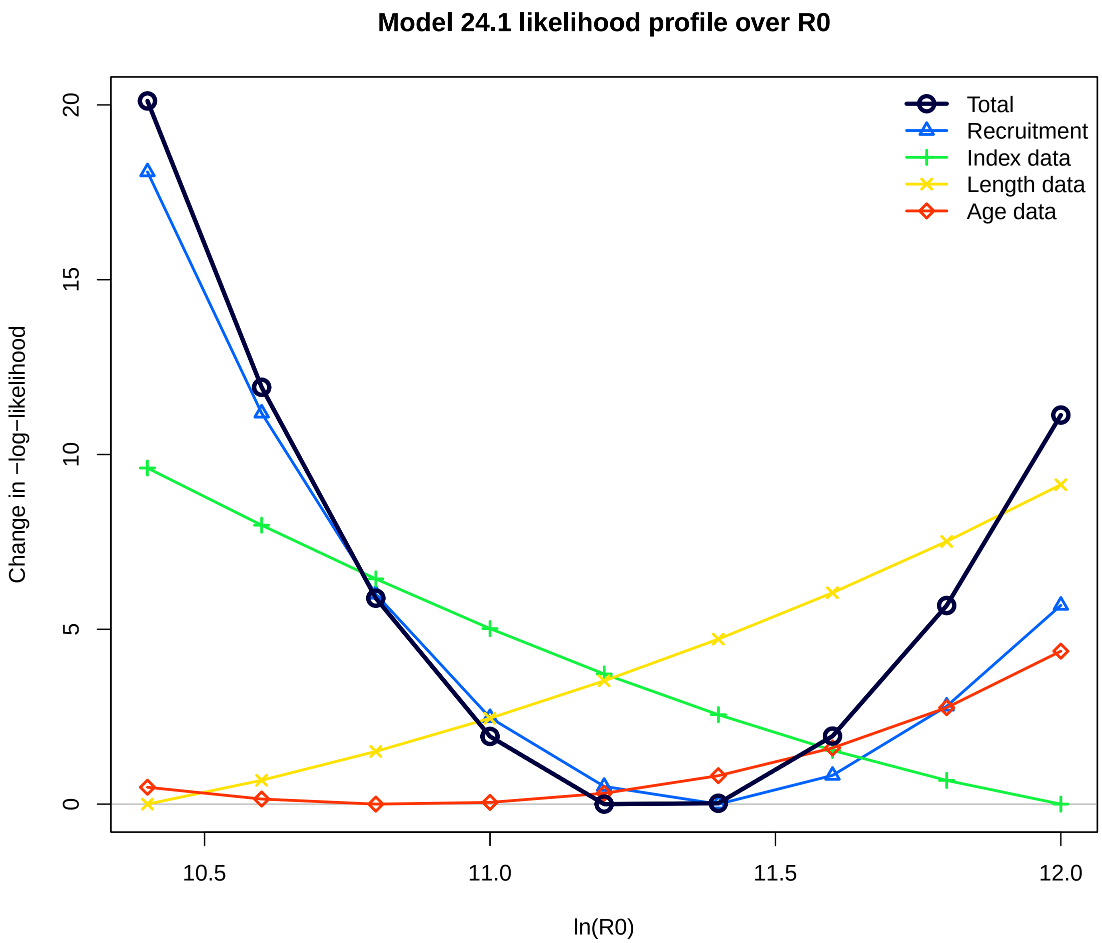
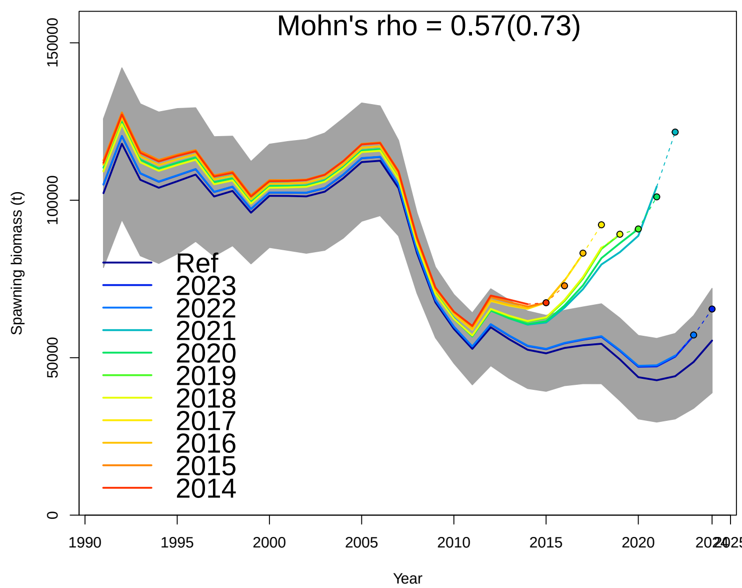


Figure 2A.33: Likelihood profile over initial recruitment, R0, from 10.4 to 12.



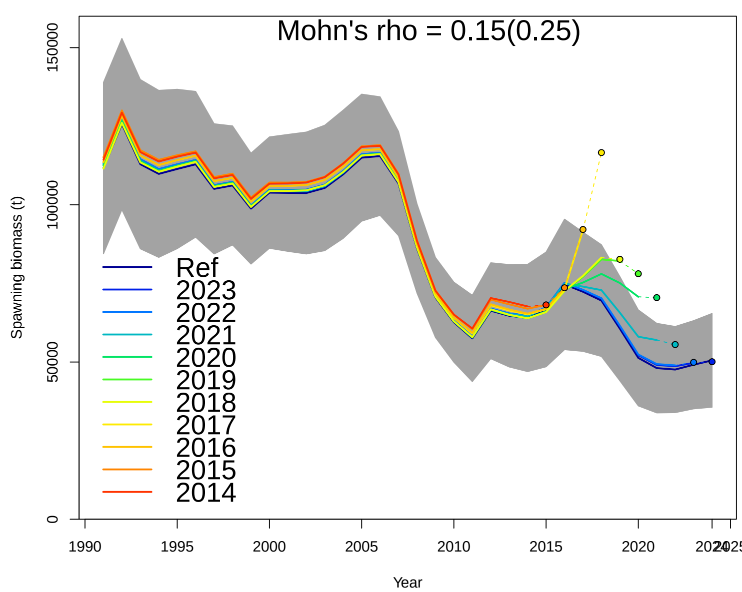


Figure 2A.34: Retrospective plot of spawning biomass, Model 24.0 (upper panel), and Model 24.1 (lower panel). Mohn's rho is presented for each retrospective, followed by the forecasted estimate of rho in parentheses. The shaded area represents the 95% confidence interval around the mean of the base year (full time series).

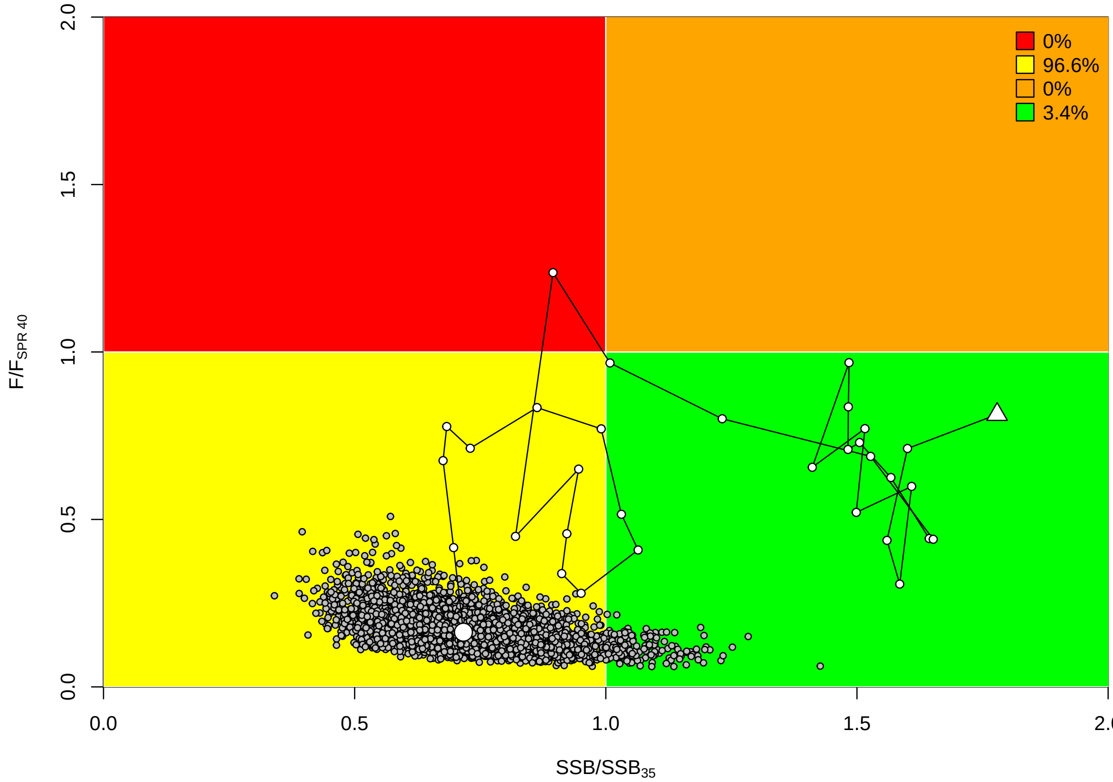


Figure 2A.35: A Kobe plot demonstrating the stock status uncertainty over SSB/SSBmsy and F/Fmsy, indicates a 96.4% probability that the stock status is between SSB8% and SSB35%, and that the fishing mortality rate is below F40%. The triangle represents the first year (1991) and the large circle the final year (2024). Grey dots provide uncertainty among Model 24.1 runs for the stock status in the final year.

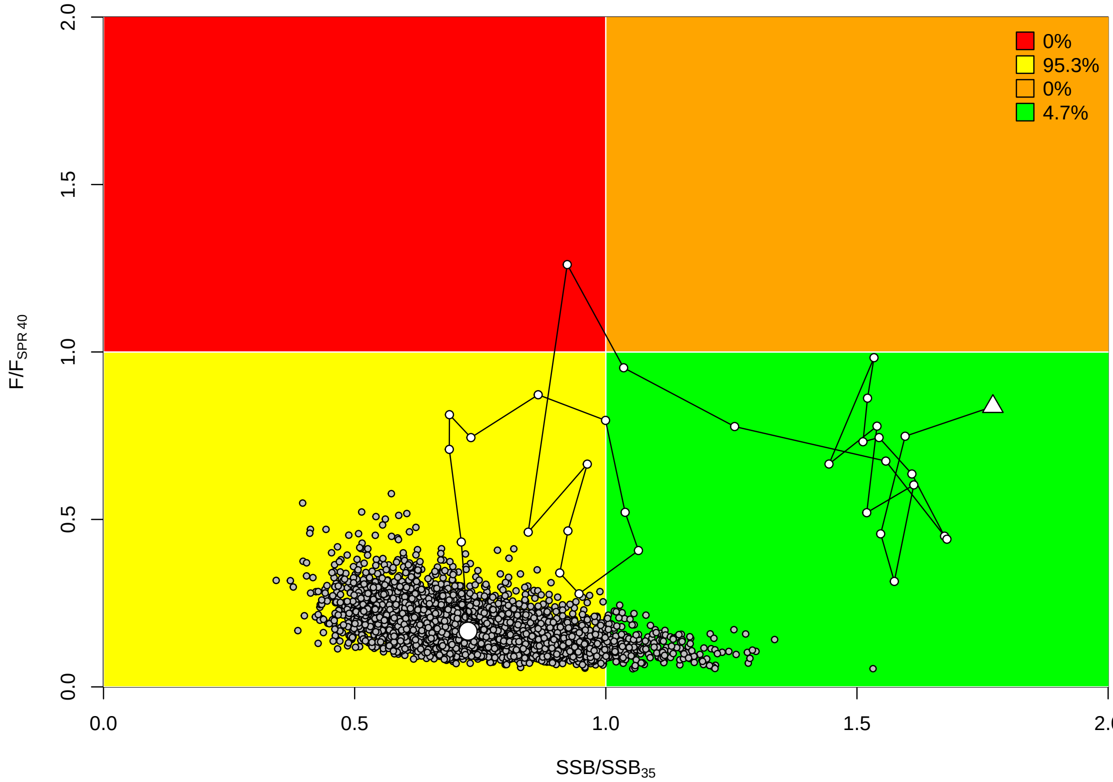


Figure 2A.36: A Kobe plot demonstrating the stock status uncertainty over SSB/SSBmsy and F/Fmsy, indicates a 95.3% probability that the stock status is between SSB8% and SSB35%, and that the fishing mortality rate is below F40%. The triangle represents the first year (1991) and the large circle the final year (2024). Grey dots provide uncertainty among Model 24.1a runs for the stock status in the final year.

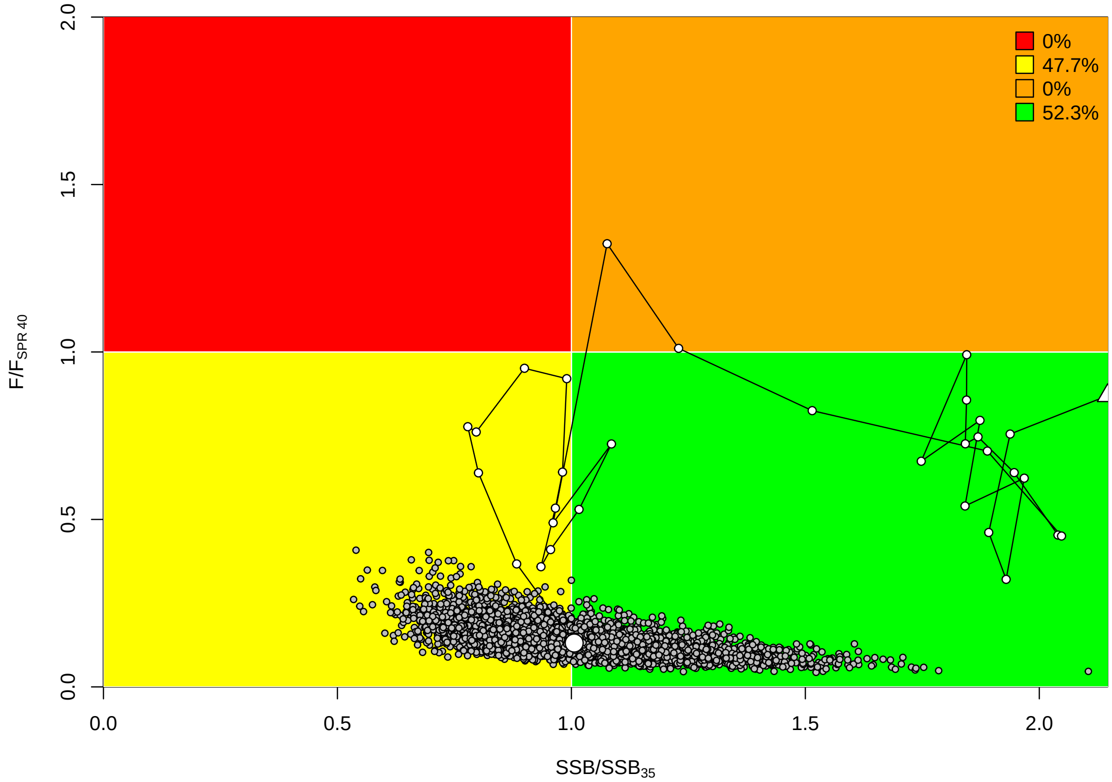


Figure 2A.37: A Kobe plot demonstrating the stock status uncertainty over SSB/SSBmsy and F/Fmsy, indicates a 47.7% probability that the stock status is between SSB17.5% and SSB35%, 52.3% probability that the stock status is greater than SSB35%. The triangle represents the first year (1991) and the large circle the final year (2024). Grey dots provide uncertainty among Model 24.0 runs for the stock status in the final year.

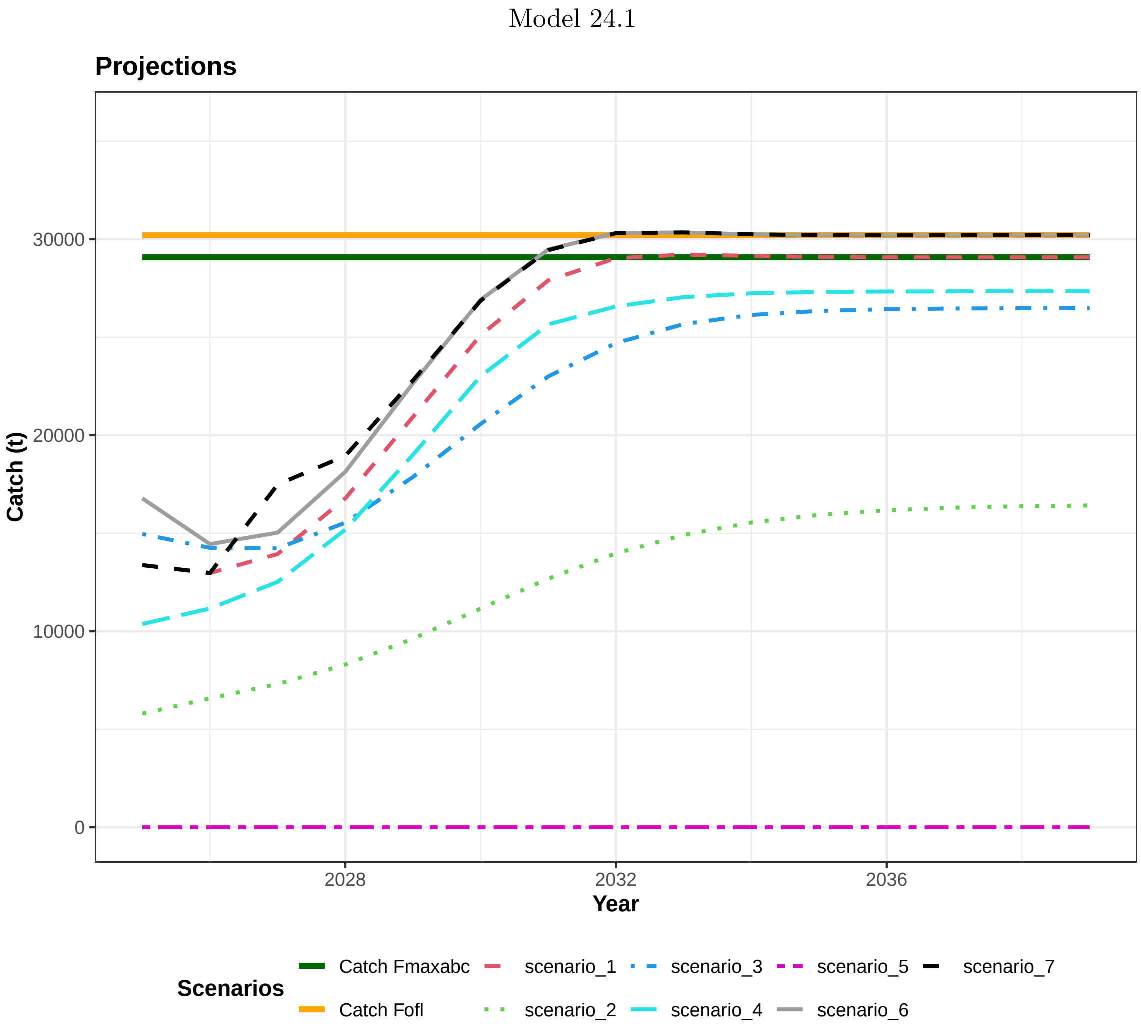


Figure 2A.38: Catch under seven NPFMC projection scenarios for Model 24.1.

Model 24.1a

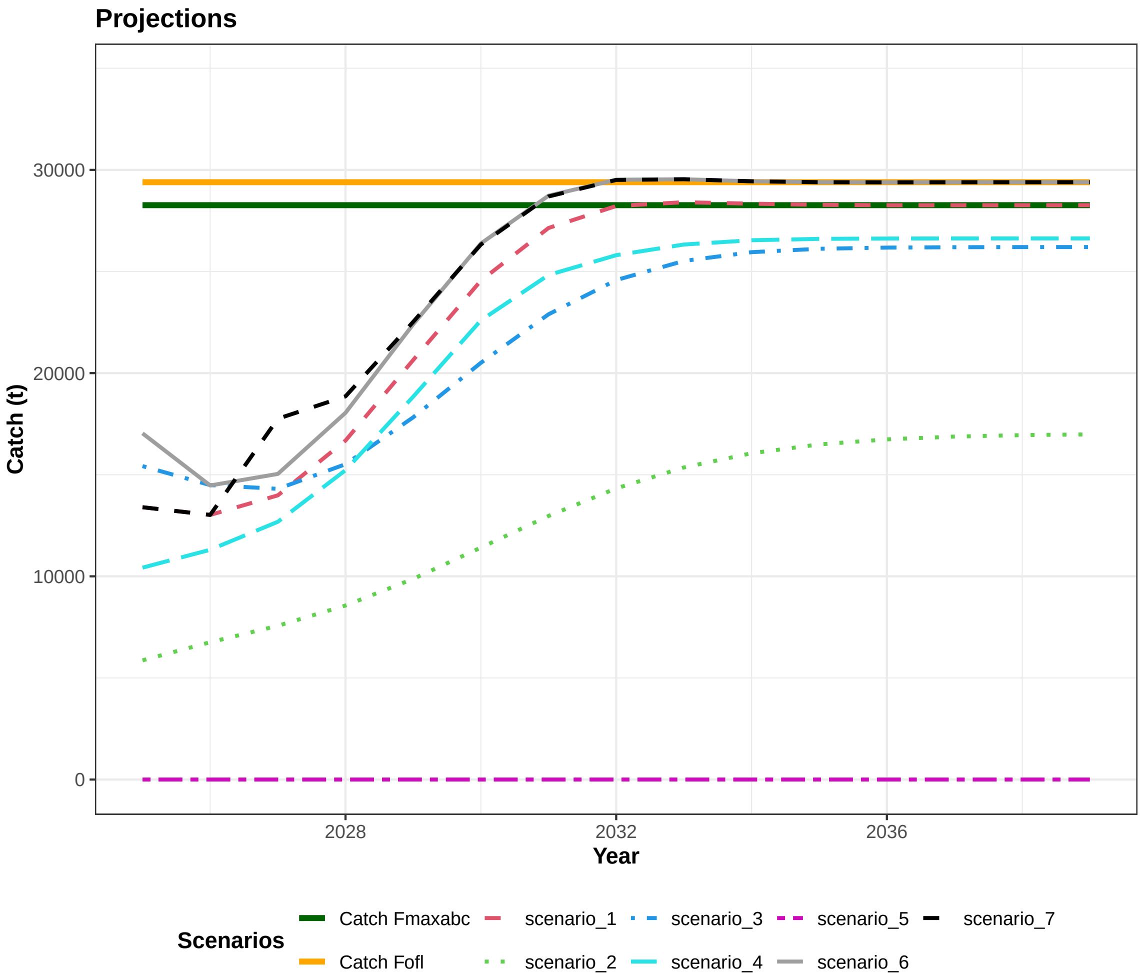


Figure 2A.39: Catch under seven NPFMC projection scenarios for Model 24.1a.

Model 24.0

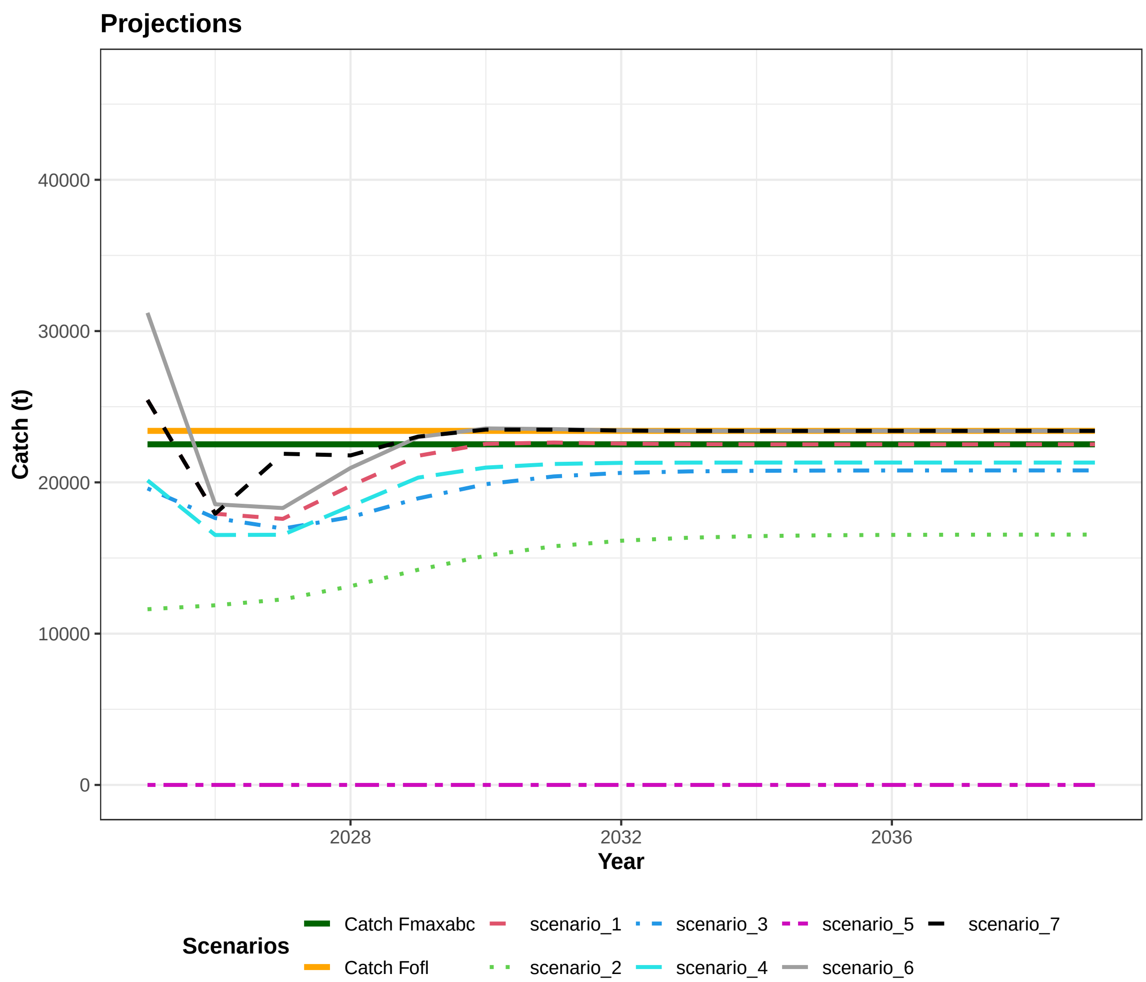


Figure 2A.40: Catch under seven NPFMC projection scenarios for Model 24.0.

Model 24.1

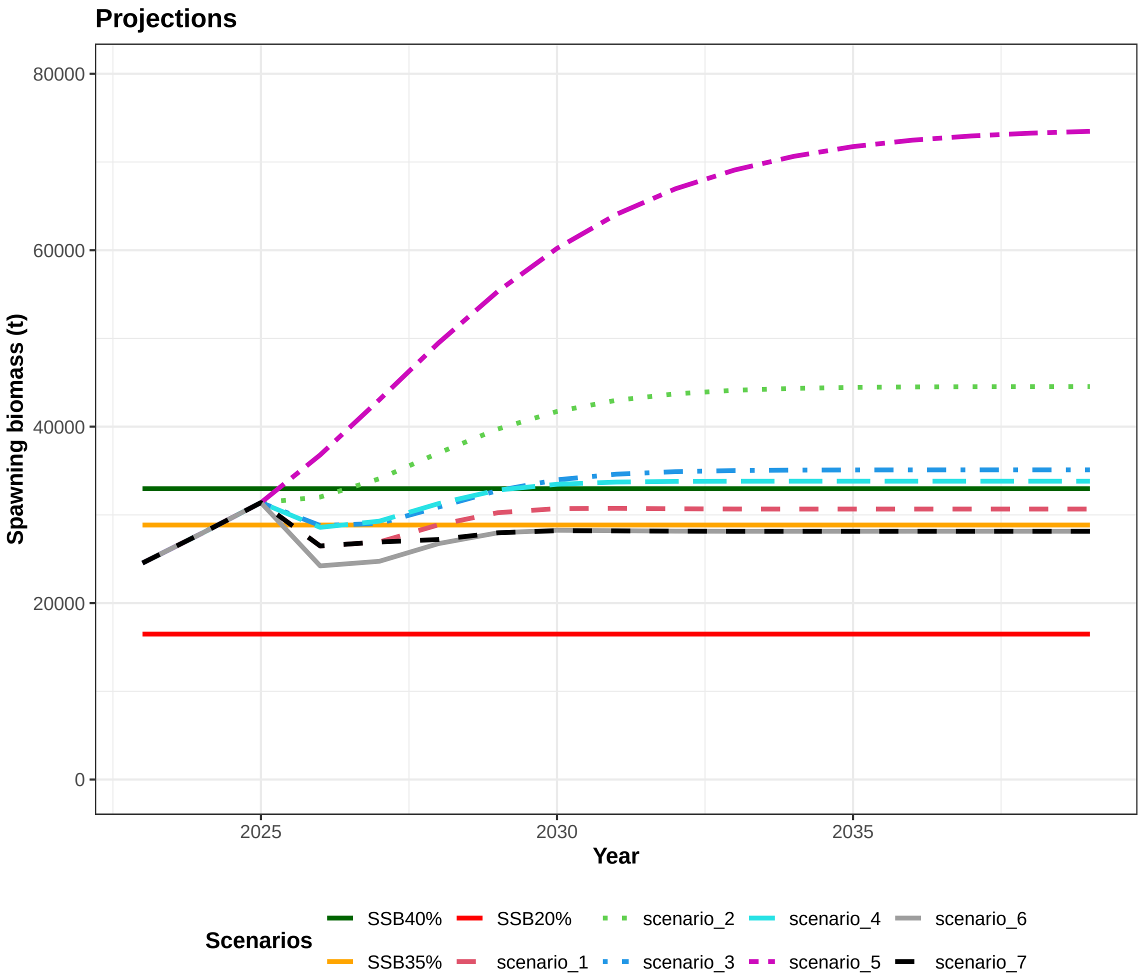


Figure 2A.41: Projected spawning stock biomass under seven NPFMC projection scenarios for Model 24.1.

Model 24.1a

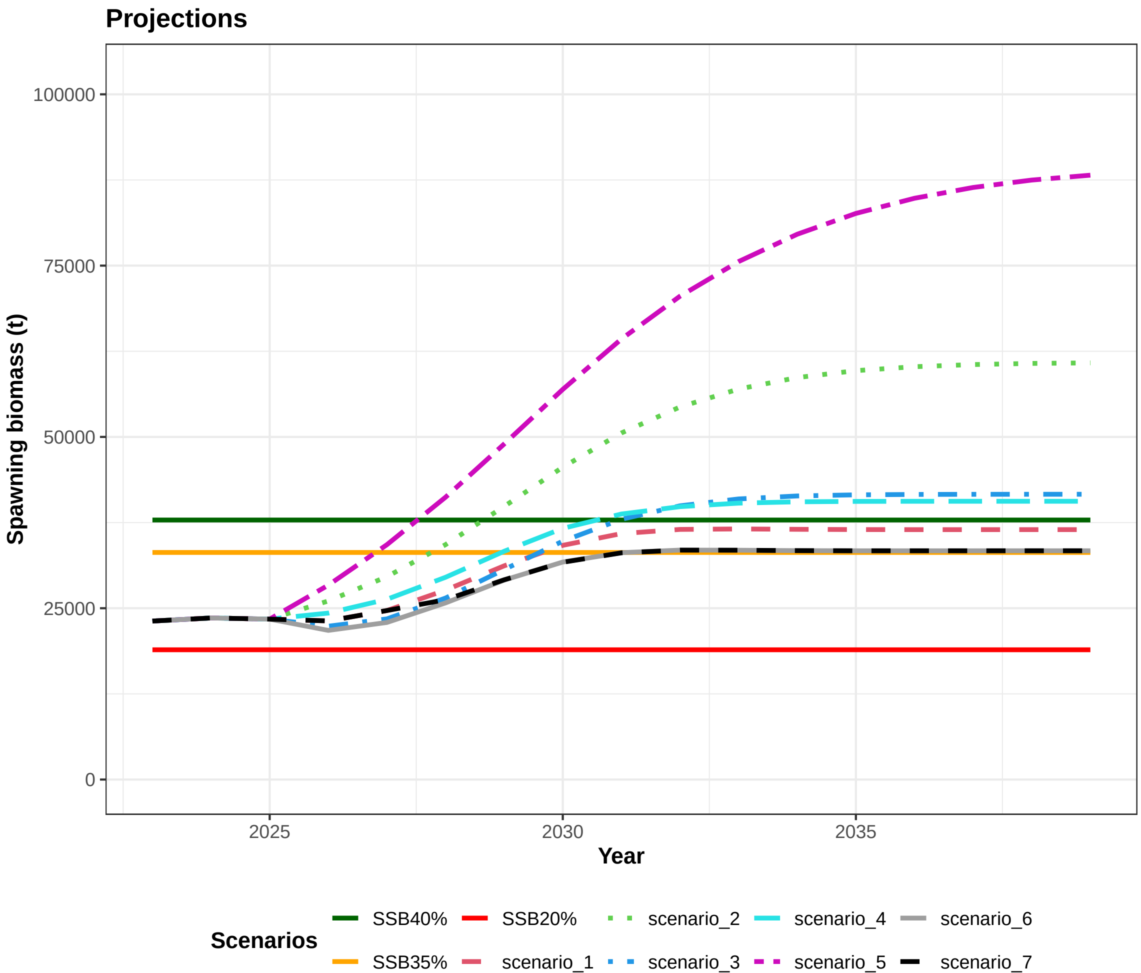


Figure 2A.42: Projected spawning stock biomass under seven NPFMC projection scenarios for Model 24.1a.

Model 24.0

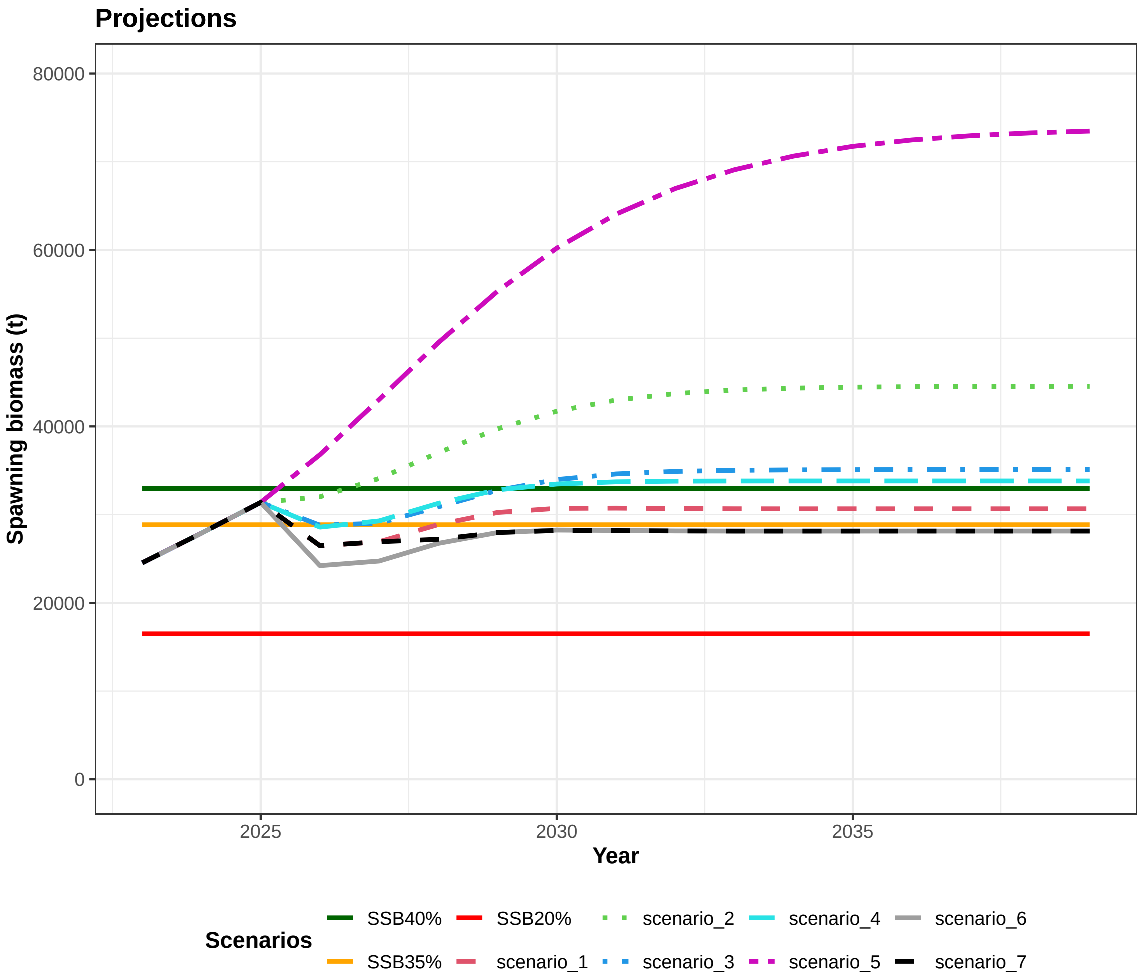


Figure 2A.43: Projected spawning stock biomass under seven NPFMC projection scenarios for Model 24.0.