12. Assessment of the Pacific ocean perch stock in the Bering Sea/Aleutian Islands

by

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This report may be cited as:

Spencer, P.D and J.N. Ianelli. 2024. Assessment of the Pacific ocean perch stock in the Bering Sea/Aleutian Islands. North Pacific Fishery Management Council, Anchorage, AK. Available from https://www.npfmc.org/library/safe-reports/

Executive Summary

The last full assessment for Pacific ocean perch (POP) was presented to the Plan Team in 2022. The following changes were made to POP assessment relative to the November 2022 SAFE:

Summary of Changes in Assessment Inputs

Changes in the Input Data

1) Catch data was updated through 2023, and total catch for 2024 was projected.

2) The 2024 Aleutian Islands (AI) survey biomass estimate and length composition, and 2022 AI survey age composition, were included in the assessment.

3) The 2023 fishery age composition and 2022 fishery length compositions were included in the assessment.

4) The input multinomial sample sizes for the age and length composition data were reweighted using the McAllister-Ianelli iterative reweighting procedure.

Changes in the Assessment Methodology

1) A prior distribution is used for AI trawl survey catchability (lognormal distribution, mean = 1, CV = 0.15). This restores a catchability prior distribution used in earlier BSAI POP assessments.

2) The penalty parameter for dome-shapedness in the bicubic spline for fishery selectivity was increased from 10 to 30.

Summary of Results

A summary of the 2024 assessment recommended ABCs relative to the 2023 recommendations is shown below. BSAI Pacific ocean perch are not overfished or approaching an overfished condition. The recommended 2025 ABC and OFL are 37,375 t and 44,594 t, which are decreases of 7% from the maximum ABC and OFL specified last year for 2025 of 40,366 t and 48,139 t. In recent assessments, the large biomass estimates from the AI trawl survey have resulted in large estimated stock sizes. The biomass estimate from the 2022 survey is the largest on record (1.07 million tons), and the 2024 AI survey biomass estimate is slightly smaller (0.98 million tons). A summary of the recommended ABCs and OFLs from this assessment relative the ABC and OFL specified last year is shown below:

Quantity	As estimated or specified last year for: 2024	2025	As estimated or recommended this year for: 2025	2026
M (natural mortality rate)	0.056	0.056	0.051	0.051
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass (t)	871,892	858,751	847,803	832,388
Female spawning biomass (t)				
Projected	350,439	342,980	352,503	344,463
$B_{100\%}$	652,626	652,626	681,381	681,381
$B_{40\%}$	261,050	261,050	272,552	272,552
$B_{35\%}$	228,419	228,419	238,483	238,483
F_{OFL}	0.089	0.089	0.072	0.072
$maxF_{ABC}$	0.074	0.074	0.060	0.060
F_{ABC}	0.074	0.074	0.060	0.060
OFL (t)	49,010	48,139	44,594	43,084
maxABC (t)	41,096	40,366	37,375	36,578
ABC (t)	41,096	40,366	37,375	36,578
Status	As determined last year for: 2022	2023	As determined this year for: 2023	2024
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Projections are based on estimated catches of 34,894 t and 34,149 t used in place of maximum permissible ABC for 2025 and 2026. Fishing reference points (i.e., max F_{abc} and F_{ofl}) are based on estimated average fishery selectivity at age from 2020-2024 estimated in the 2024 assessment model.

Area Apportionment

The ABC for BSAI Pacific ocean perch is currently apportioned among four areas: the western, central, and eastern Aleutian Islands, and eastern Bering Sea. A random effects model was used to smooth the time series of subarea survey biomass and obtain the proportions, which are shown below.

ABC apportionments

	Area: WAI	CAI	EAI	SBS	EBS slope
2024 smoothed biomass estimate	506,358	182,590	206,200	86,457	245,954
percentage	41.2%	14.9%	16.8%	7.0%	20.0%

The following table gives the projected OFLs and apportioned ABCs for 2025 and 2026, and the recent OFLs, ABCs, TACs, and catches.

Area	Year	Age 3 Bio (t)	OFL	ABC	TAC	Catch[1]
BSAI	2023	888,722	50,133	42,038	37,703	35,951
	2024	871,892	49,010	41,096	37,626	26,124
	2025	847,803	44,594	37,375	n/a	n/a
	2026	832,388	43,084	36,578	n/a	n/a
Eastern Bering Sea	2023			11,903	11,903	10,892
	2024			11,636	11,636	6,946
	2025			10,121	n/a	n/a
	2026			9,905	n/a	n/a
Eastern Aleutian Islands	2023			8,152	8,152	7,791
	2024			7,969	7,969	6,969
	2025			6,278	n/a	n/a
	2026			6,144	n/a	n/a
Central Aleutian Islands	2023			5,648	5,648	5,461
	2024			5,521	5,521	3,724
	2025			5,559	n/a	n/a
	2026			5,441	n/a	n/a
Western Aleutian Islands	2023			16,335	12,000	11,807
	2024			15,970	12,500	8,485
	2025			15,417	n/a	n/a
	2026			16,058	n/a	n/a

[1]Catch through October 5, 2024

Responses to SSC and Plan Team Comments on Assessments in General

(SSC, October 2023). *When there are time-varying biological and fishery parameters in the model, the SSC requests that a table be included in the SAFE that documents how reference points are calculated.*

Time-varying fishery selectivity is estimated in this model, and an average of the estimated selectivity from the most recent 5 years (i.e., 2000 – 2024) is used to compute reference points. This is noted in the assessment in the section on Amendment 56 reference points, as required in the most recent guidelines for Alaska groundfish stock assessments.

(SSC, December 2023).*The SSC reiterates that only fishery performance indicators that provide some inference regarding biological status of the stock should be used . . . Examples of useful indicators include CPUE, fishery spatial and temporal patterns, and catches of thin or unhealthy fish (i.e., poor condition).*

Fishery CPUE is used in the risk table to draw inferences on the biological status of the stock.

(SSC, December 2023) *When risk scores are reported, the SSC requests that a brief justification for each* *score be provided, even when that score indicates no elevated risk.*

A brief justification is provided for each risk score.

Responses to SSC and Plan Team Comments Specific to this Assessment

(BSAI Plan Team, September 2022) *Of these CIE recommendations, the author recommended the following changes to be brought forward in November 1) fitting the model to survey abundance instead of biomass, 2) exploring stochastic initial age compositions, and 3) for equilibrium initial age composition, explore mortality rates other than that currently used in the model.*

Fitting the AI survey abundance estimates instead of the biomass estimates was evaluated in the 2022 assessment, and did not substantially improve the residual pattern in the fit the AI survey estimates.

A report describing modeling of stochastic initial age compositions, and initial age composition is equilibrium with mortality values other the estimated natural mortality, was presented to the BSAI Plan Team at the September, 2024 meeting and it attached as Appendix 12A. The fits to the AI survey index and the age/length composition data are not substantially improved from these modeling options.

(BSAI Plan Team, November 2022). *The Team discussed investigating the mortality rates by age particularly for the plus group as there were poor fits to this group in the eastern Bering Sea (EBS) slope survey. The Team noted that time blocks could be explored for the plus group or consider time-varying selectivity as there were younger fish in the AI BTS than the EBS slope survey.*

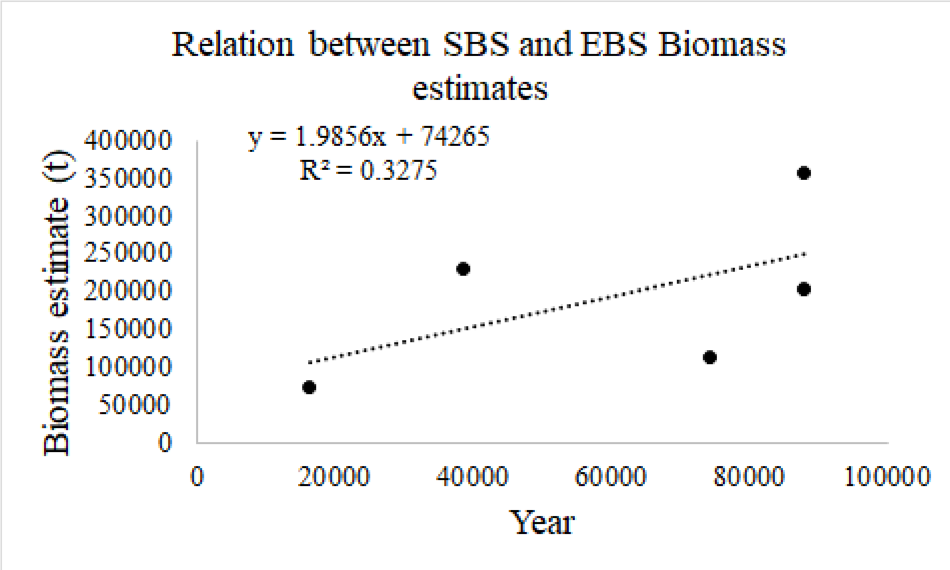
(SSC, December 2022). *The SSC concurs with the BSAI GPT suggestion to pursue time-varying survey selectivity for the AI bottom trawl survey and supports the BSAI GPT's other suggestions for model improvements*

A report describing modeling of time-varying survey selectivity was presented to the BSAI Plan Team at the September, 2024 meeting and it attached as Appendix 12A. The estimating time-varying AI and EBS selectivity curves show a sigmoidal shape rather than a dome-shaped pattern. The survey selectivity curve shows relatively little variation between years, and produces fits to the composition data that are similar to using time-invariant survey selectivity.

(BSAI Plan Team, November 2022). *The Team also discussed the relative proportion of the EBS slope survey information into the future and encouraged the author to look at alternatives for estimating the apportionment on the EBS slope and comparing where the different surveys match up in the past for determining what the proportion should be moving forward.*

The EBS slope survey has not been conducted since 2016, which impedes a data-based for comparing the relative abundance between the area and other subareas within the BSAI region.

Five surveys exists in which the EBS slope survey and the AI trawl survey were conducted in the same year. The relationship between the EBS slope survey biomass estimates and the nearest portion of the AI survey (the southern Bering Sea area) from these surveys is not strong (shown below).


Relation between SBS and EBS Biomass estimates
y = 1.9856x + 74265
R² = 0.3275
Biomass estimate (t)
400000
350000
300000
250000
200000
150000
100000
50000
0
0
20000
40000
60000
80000
100000
Year

Introduction

Pacific ocean perch (POP, *Sebastes alutus*) inhabit the outer continental shelf and upper slope regions of the North Pacific Ocean and Bering Sea. From 1982-1985 and from 1989-1990, Pacific ocean perch were occasionally managed within a species complex with four other associated rockfish species (northern rockfish, *S. polyspinis*; rougheye rockfish, *S. aleutianus*; shortraker rockfish, *S. borealis*; and sharpchin rockfish, *S. zacentrus*) in the eastern Bering Sea (EBS) and Aleutian Islands (AI) subareas from 1979 to 1990. Known as the POP complex, these five species were managed as a single entity with a single TAC (total allowable catch) for each of these two areas. In 1991, the North Pacific Fishery Management Council separated POP from the other red rockfish in order to provide protection from possible overfishing. Of the five species in the former POP complex, *S. alutus* has historically been the most abundant rockfish in this region and has contributed most to the commercial rockfish catch.

Information on Stock Structure

A variety of types of research can be used to infer stock structure of POP, including age and length compositions, growth patterns and other life-history information, and genetic studies. Spatial differences in age or length compositions can be used to infer differences in recruitment patterns that may correspond to population structure. In Queen Charlotte Sound, British Columbia, Gunderson (1972) found substantial differences in the mean lengths of POP in fishery hauls taken at similar depths which were related to differences in growth rates and concluded that POP likely form aggregations with distinct biological characteristics. In a subsequent study, Gunderson (1977) found differences in size and age composition between Moresby Gully and two other gullies in Queen Charlotte Sound. Westrheim (1970, 1973) recognized “British Columbia” and “Gulf of Alaska” POP stocks off the western coast of Canada based upon spatial differences in length frequencies, age frequencies, and growth patterns observed from a trawl survey. In a study that has influenced management off Alaska, Chikuni (1975) recognized distinct POP stocks in four areas – eastern Pacific (British Columbia), Gulf of Alaska, Aleutian Islands, and Bering Sea. However, Chikuni (1975) states that the eastern Bering Sea (EBS) stock likely receives larvae from both the Gulf of Alaska (GOA) and Aleutian Islands (AI) stock, and the AI stock likely receives larvae from the GOA stock.

An alternative approach to evaluating stock structure involves examination of rockfish life-history stages directly. Stock differentiation occurs from separation at key life-history stages. Because many rockfish species are not thought to exhibit large-scale movements as adults, movement to new areas and boundaries of discrete stocks may depend largely upon the pelagic larval and juvenile life-history stages. Simulation modeling of ocean currents in the Alaska region suggest that larval dispersal may occur over very broad areas, and may be dependent on month of parturition (Stockhausen and Hermann 2007).

Analysis of field samples of rockfish larvae are hindered by difficulties in identifying species. Analyses of archived *Sebastes* larvae was undertaken by Dr. Art Kendall revealed that species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfish species in the north Pacific have published descriptions of the complete larval developmental series. However, all of the larvae examined could be assigned to four morphs identified by Kendall (1991), where each morph is associated with one or more species. Rockfish identification can be aided by studies that combine genetic and morphometric techniques and information has been developed to identify individual species based on allozymes (Seeb and Kendall 1991) and mitochondrial DNA (Gharrett et al. 2001, Rocha-Olivares 1998). The Ocean Carrying Capacity (OCC) field program, conducted by the Auke Bay laboratory, uses surface trawls to collect juvenile salmon and incidentally collects juvenile rockfish. These juvenile rockfish are large enough (approximately 25 mm and larger) to allow extraction of a tissue sample for genetic analysis without impeding morphometric studies. In 2002, species identifications were made for an initial sample of 55 juveniles with both morphometric and genetic techniques. The two techniques showed initial agreement on 39 of the 55 specimens, and the genetic results motivated re-evaluation of some of the morphological species identifications. Forty of the specimens were identified as POP, and showed considerably more morphological variation for this species than previously documented.

Because stocks are, by definition, reproductively isolated population units, it is expected that different stocks would show differences in genetic material due to random drift or natural selection. Seeb and Gunderson (1988) used protein electrophoresis to infer genetic differences based upon differences in allozymes from POP collected from Washington to the Aleutian Islands. Discrete genetic stock groups were not observed, but instead gradual genetic variation occurred that was consistent with the isolation by distance model. The study included several samples in Queen Charlotte Sound where Gunderson (1972, 1977) found differences in size compositions and growth characteristics. Seeb and Gunderson (1988) concluded that the gene flow with Queen Charlotte Sound is sufficient to prevent genetic differentiation, but adult migrations were insufficient to prevent localized differences in length and age compositions. More recent studies of POP using microsatellite DNA revealed population structure at small spatial scales, consistent with the work of Gunderson (1972, 1977). These findings suggest that adult POP do not migrate far from their natal grounds and larvae are entrained by currents in localized retention areas (Withler et al. 2001).

Interpretations of stock structure are influenced by the technique used to assess genetic analysis differentiation, as illustrated by the differing conclusions produced from the POP allozyme work of Seeb and Gunderson (1988) and the microsatellite work of Withler et al. (2001). Note that these two techniques assess components of the genome that diverge on very different time scales and that, in this case, microsatellites are much more sensitive to genetic isolation. Protein electrophoresis examines DNA variation only indirectly via allozyme frequencies, and does not recognize situations where differences in DNA may result in identical allozymes (Park and Moran 1994). In addition, many microsatellite loci may be selectively neutral or near-neutral, whereas allozymes are central metabolic pathway enzymes and do not have quite the latitude to produce viable mutations. The mutation rate of microsatellite alleles can be orders of magnitude higher than allozyme locus mutation rates.

Most current studies on rockfish genetic population structure involve direct examination of either mitochondrial DNA (mtDNA) or microsatellite DNA. Palof et al. (2011) analyzed 14 microsatellite loci from Alaskan waters sampled from 1999-2005 and found significant spatial population structure and an isolation by distance pattern, with the scale of population structure about 400 km and possibly as small as 70 km. This suggests population structure on a relatively fine spatial scale consistent with the results in Gunderson (1972, 1977) and Withler et al. (2001).

Fishery

POP were highly sought by Japanese and Soviet fisheries and supported a major trawl fishery throughout the 1960s. Catches in the eastern Bering Sea peaked at 47,000 (metric tons, t) in 1961; the peak catch in the Aleutian Islands region occurred in 1965 at 109,100 t. These stocks were not productive enough to support such large removals. Catches continued to decline throughout the 1960s and 1970s, reaching their lowest levels in the mid-1980s. With the gradual phase-out of the foreign fishery in the 200-mile U.S. Exclusive Economic Zone (EEZ), a small joint-venture fishery developed but was soon replaced by a domestic fishery by 1990. In 1990 the domestic fishery recorded the highest POP removals since 1977. The OFLs, ABCs, TACs, and catches by management complex from 1977 to 2001 (when POP were managed as separate stocks in the EBS and AI) are shown in Table 12.1. Note that in some years, POP were managed in the "POP complex" management group, which also included rougheye rockfish, shortraker rockfish, northern rockfish, and sharpchin rockfish. Beginning in 2002, POP were managed as a single stock across the BSAI with the ABC subdivided between the EBS and AI subareas. The BSAI OFLs, ABCs, TACs, and catches from 2002 to 2024 are shown in Table 12.2. The catches of POP from 1977 by fishery type (i.e., foreign, joint venture, or domestic) is shown in Table 12.3.

Estimates of retained and discarded POP have been available since 1991 (Table 12.4). From 1991-2009, the eastern Bering Sea region generally showed a higher discard rate than in the Aleutian Islands region, with the average rates 33% and 14%, respectively. From 2010-2016, discard rates in the eastern Bering Sea and the Aleutian Islands were low, averaging 8% and 1% respectively. However, from 2017 to 2020 the discard rates in the EBS area increased to an average of 19%, and subsequently declined to an average of 7% from 202 to 2024. The discard rates for the EBS and AI in 2024 are 3% and 2%, respectively (through October 5, 2024).

Initial age-structured assessments for BSAI POP modeled separate selectivity curves for the foreign and domestic fisheries (Ianelli and Ito 1992), although examination of the distribution of observer catch reveals interannual changes in the depth and areas in which POP are observed to be caught within the foreign and domestic periods. For example, POP are predominately taken in depths between 200 m and 300 m, although during the late 1970s to early1980s and again in the mid-1990s, a relatively large portion of POP were observed to be captured at depths greater than 300 m (Table 12.5, Figure 12.1). Additionally, the proportion caught between 100 m and 200 m increased from ~ 20% in the early to mid-1990s to 27% from 2000-2010. The area of capture has changed as well; during the late 1970s Aleutian Islands POP were predominately captured in the western Aleutians (area 543), whereas from the early 1980s to the mid-1990s Aleutian Islands POP were captured predominately in the eastern Aleutians (area 541). Establishment of area-specific TACs in the mid-1990s redistributed the POP catch such that from 1996-2005 approximately 50% of the AI catch was taken in the western Aleutians (Table 12.6, Figure 12.1). In 2023, the proportion of the BSAI catch obtained in the eastern AI and eastern Bering Sea has increased to 66%. Note that the extent to which the patterns of observed catch can be used as a proxy for patterns in total catch is dependent upon the degree to which the observer sampling represents the true fishery. In particular, the proportions of total POP caught that were actually sampled by observers were very low in the foreign fishery, due to low sampling ratio prior to 1984 (Megrey and Wespestad 1990).

Catch by species from BSAI trips targeting rockfish from 2016 to 2023 indicate that the largest non-rockfish species caught are Atka mackerel, walleye pollock (*Gadus chalcogrammus*), Pacific cod (*G. microcephalus*), arrowtooth flounder (*Atheresthes stomas*), and Kamchatka flounder (*A. evermanni*) (Table 12.7). Pacific ocean perch are primarily caught in trips targeting rockfish, Atka mackerel, and walleye pollock (Table 12.8). Catch of prohibited species in trips targeting rockfish is shown in Table 12.9, with the catch of most prohibited species groups averaging less than 60 t or 4000 individuals from 2016-2024. Catch of non-FMP species by in BSAI trips targeting rockfish over this period are largest for giant grenadier (*Albatrossia pectoralis*), sculpin, squid, miscellaneous fish, and unidentified sponge (Table 12.10).

Non-commercial catches are shown in Appendix 12B.

Data

Fishery Data

Length measurements and otoliths read from the EBS and AI management areas (Tables 12.11 and 12.12) were combined to create fishery age and size compositions, with the length composition within management subareas weighted by the estimated catch numbers from observed tows. Age and/or length compositions were not included for several years due to low samples sizes of fish measured (years 1973-1976, 1985-1986), and/or otoliths read (years 1984-86). In 1982, the method for ageing otoliths at the Alaska Fisheries Science Center changed from surface reading to the break and burn method (Betty Goetz, Alaska Fisheries Science Center, pers. comm.), as the latter method is considered more accurate for older fish (Tagart 1984). The time at which the otoliths collected from 1977 to 1982 were read is not known for many vessels and cruises. However, the information available suggests that otoliths from 1977 to 1980 were read prior to 1981, whereas otoliths from 1981 and 1982 were read after 1982. Thus, fishery otoliths from 1977 to 1980 were not used because they were believed to be read by surface ageing and thought to be biased.

Beginning in 1998, samples of otoliths from the fishery catch have been read almost annually or biennially, and show relatively strong year classes from 1984-1988. The fishery length and age compositions used in the assessment are shown in Tables 12.13 and 12.14, respectively. Fishery age compositions from 2005-2017 indicate several strong recent year classes from 2003-2007 (Figure 12.2). The 2023 fishery age composition indicates relatively strong year classes from 2014-2016.

Survey Data

Cooperative U.S. – Japan trawl surveys were conducted in the AI 1980, 1983, and 1986, and have been used in previous BSAI POP assessments. However, differences exist in gear design and vessels used between these surveys and the NMFS surveys beginning in 1991 (Skip Zenger, National Marine Fisheries Service, personal communication). For example, the Japanese nets used in the 1980, 1983, and 1986 cooperative surveys varied between years and included large roller gear (Ronholt et al. 1994), in contrast to the poly-nor'eastern nets used in the current surveys (von Szalay et al. 2017), and similar variations in gear between surveys occurred in the cooperative EBS surveys. Given the difficulty of documenting the methodologies for these surveys, and standardizing these surveys with the NMFS surveys, this assessment model is conducted with only the NMFS surveys.

The Aleutian Islands survey biomass estimates were used as an index of abundance for the BSAI POP stock. Since 2000 the survey has occurred biennially, although the 2008 survey was canceled due to a lack of funding, and in 2020 the survey was canceled because of Covid-19. Note that there is wide variability among survey estimates from the southern Bering Sea portion of the survey (from 165 º W to 170 º W), as the post-1991 coefficients of variation (CVs) range from 0.41 to 0.68 (Table 12.15), although the trend in the region appears to be increasing. From 2010-2024, the total AI survey biomasses have exceeded 900,000 t for each survey, whereas the survey estimates prior to 2010 have not exceeded 665,000 t.

The 2024 survey biomass estimate of 983,636 t is a 7% decrease from the 2022 estimate of 1,063,030 t (Table 12.15). The 2024 AI survey biomass in the CAI increased by 25% relative to the 2022 estimate, but the survey biomass in the EAI and SBS subareas decreased by 17% and 39%, respectively. Maps of survey CPUE are shown in Figure 12.3, and indicate relatively high abundance throughout much of the Aleutian Islands.

The increase in the survey biomass has resulted in an increase in the minimum area occupied by the stock, as computed from the strata-specific survey population estimates. The minimum area covered by the stock was obtained from the computing the area associated with trawl tows contributing 95% ($D_{95\%}$) of abundance estimate, where the area for any given tow is the area of its strata divided by the strata sample size (Swain and Sinclair, 1994). This metric produces measure of area that is independent of the scale of population abundance, and reflects the spatial extent of a core portion of the population that excludes the area for tows with very small CPUE values. The $D_{95\%}$ values for POP increased from 5,934 km^2 in 1991 to 13,061 km^2 in 2024 (Figure 12.4), an increase by a factor of 2.2.

Age composition data exists for each Aleutian Islands survey, and the numbers of length measurements taken and otoliths read are shown in Table 12.16. The survey age compositions from 1991-2000 indicate relatively strong year classes in 1977, 1984, and 1988 (Table 12.17, Figure 12.5). Recent age composition data from 2004 -2012 indicate relatively strong year classes from 1996 to 2000. The 2014 and 2016 age compositions indicates relative strong 2004 and 2005 year classes (Figure 12.5). The 2022 AI survey age composition indicates a relatively strong 2014 year class. The AI survey length composition for 2024 is shown in Table 14.18.

The current EBS slope survey was initiated as a biennial survey in 2002. The most recent slope survey prior to 2002, excluding some preliminary tows in 2000 intended for evaluating survey gear, was in 1991. The biomass indices in the EBS slope survey have been increasing, ranging from 72,676 t in 2002 to 357,379 t in the 2016 survey, with CVs ranging from 0.68 in 2016 to 0.53 in 2002 (Table 12.15). EBS survey CPUE from the 2016, 2012, and 2010 surveys are shown in Figure 12.6. The slope survey was not conducted in 2006, 2014, and 2018 due to lack of funding or vessels, and this survey is unlikely to be conducted in future years. Age composition data for the EBS survey are available for all survey years (Figure 12.7, Table 12.19).

Biological data

A large number of samples are collected from the surveys for age determination, length-weight relationships, sex ratio information, and for estimating the length distribution of the population. The age compositions for inclusion in the model were estimated outside the model by constructing age-length keys for each year and using them to estimate the survey age distribution from the estimated survey length distribution from the same year. Because the survey length distributions are used to create the survey age distributions, the survey length distributions are removed from the model in years in which we have survey ages.

Ageing methods have improved since the start of the time series. Historically, POP age determinations were done using scales and surface readings from otoliths. These gave estimates of natural mortality of about 0.15 and longevity of about 30 years (Gunderson 1977). Based on the now accepted break and burn method of age determination using otoliths, Chilton and Beamish (1982) determined the maximum age of POP to be 90 years. Using similar information, Archibald et al. (1981) concluded that natural mortality for POP should be on the order of 0.05.

The following table summarizes the data available for the recommended BSAI POP model:

Component	BSAI
Fishery catch	1960-2024
Fishery age composition	1981-82, 1990, 1998, 2000-2009, 2011, 2013, 2015, 2017, 2019, 2020, 2021, 2023
Fishery size composition	1964-72, 1983-1984, 1987-1989, 1991-1997, 1999, 2010, 2012, 2014, 2016, 2018, 2022
AI Survey age composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022
AI Survey length composition	2024
AI Survey biomass estimates	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022, 2024
EBS Survey age composition	2002, 2004, 2008, 2010, 2012, 2016
EBS Survey biomass estimates	2002, 2004, 2008, 2010, 2012, 2016

Analytic Approach

Model Structure

An age-structured population dynamics model, implemented in the software program AD Model Builder, was used to obtain estimates of recruitment, numbers at age, and catch at age. McAllister-Ianelli (McAllister and Ianelli 1997) weighting is used for the composition data the natural mortality rate *M,* and the survey selectivity curve. The definitions of model parameters and quantities is shown in Table 12.20, and equations for population dynamics, estimated quantities, and likelihood components are shown in Tables 12.21 – 12.22 (for model 24, described below).

The root mean squared error (RMSE) was used to evaluate the relative size of residuals within data types:

$$RMSE = \sqrt{\frac{\sum_{n}(\ln(y) - \ln(\hat{y}))^2}{n}}$$

where y and $\hat{y}$ are the observed and estimated values, respectively, of a series length n.

Description of Alternative Models

In this assessment, we consider an alternative model that increases the penalty for “dome-shapedness” in the bicubic spline for fishery selectivity, and also uses a lognormal prior distribution for AI trawl survey selectivity (mean=1, CV=0.15). The model names and their relative differences are summarized below:

Model	Description
Model 16.3 (2024)	Accepted model from the 2022 assessment, which freely estimates the AI and EBS survey catchability coefficients without prior

	distributions
Model 24	Model 16.3, but with the penalty for the dome-shapedness in the bicubic spline used for fishery selectivity increased from 10 to 30, and a lognormal prior on the AI survey catchability (mean=1, CV=0.15)

The purpose of the proposed modeling change for the fishery selectivity curve is that in recent assessments the estimated time-varying fishery selectivity shows an unusual multimodal distribution across ages in recent years, which is difficult to explain. The extent to which selectivity decreases with age in dome-shaped patterns is controlled by a penalty applied to the rate of selectivity decrease (i.e., the first difference), which is set to 10 in the current model. In model 24, we increase this penalty to 30.

The use of a prior distribution for the survey catchability is supported from field work conducted by Jones et al. (2021) that compared rockfish densities in trawlable and untrawlable grounds in the Gulf of Alaska. Jones et al. (2021) found that the survey catchability for POP was 1.15, but this would be somewhat lower in this assessment because the portion of the population in the EBS is unavailable to the AI trawl survey. We also note that a prior distribution for AI trawl survey catchability was a feature in BSAI POP assessments prior to 2022, and preliminary runs made for the September 2024 BSAI Plan Team meeting indicated variability in estimated catchability and biomass without the constraining effect of a prior distribution.

Parameters Estimated Outside the Assessment Model

The parameters estimated independently include the age error matrix, the age-length conversion matrix, and individual weight at age.

The survey age data were based on the break and burn method of ageing POP, so they were treated as unbiased but measured with error. Kimura and Lyons (1991) reported that the percent agreement between readers varies from 60% for age 3 fish to 13% for age 25 fish data. The information on percent agreement was used to derive the variability of observed age around the "true" age, assuming a normal distribution. The mean number of fish at age available to the survey or fishery is multiplied by the ageing error matrix to produce the expected observed survey or fishery age compositions.

AI survey data from 1991 through 2022 were used to estimate growth curves. Von Bertalanffy growth curves were fit to estimates of mean length at age, which were obtained for each survey from 1991-2022 by the multiplying the estimated survey length distribution by the age-length key. The resulting von Bertalanffy growth parameters were L_{inf} = 41.43 cm, k = 0.14, and t_0 = -1.297, and these parameters were used to create a conversion matrix to convert the estimated numbers-at-age within the model to estimated numbers-at-length. The conversion matrix consists of the proportion of each age that is expected in each length bin, and was created by fitting a polynomial relationship to the observed CV in length at age from survey sampling. The estimated CV- length relationship was used to produce variation around the predicted size at age from the von Bertalanffy relationship. The resulting CVs of length at age of the transition matrix decrease from 0.15 at age 3 to 0.07 at age 40.

The estimated length(cm)-weight(g) relationship was estimated from data obtained in the AI trawl survey from the same years, with the length-weight parameters estimated as $a = 1.1 \times 10^{-5}$ and b = 3.07, where weight = a*(length)^b. The Aleutian Islands length-weight relationship was used to produce estimated weights at age.

The "observed" catch for 2024 is obtained by estimating the Oct-Dec catch (based on the remaining TAC available after October, and the average proportion in recent years of the remaining TAC caught from Oct-Dec) and adding this to the observed catch through October.

Parameters Estimated Inside the Assessment Model

Parameters estimated inside the assessment model include the mean and annual deviations for recruitment and fishing mortality, survey catchability, natural mortality, and the parameters associated with the curves for fishery selectivity, survey selectivity, and maturity-at-age.

Prior distributions were used for the natural mortality rate *M,* and the survey catchability coefficient (for model 24), the survey selectivity curve. A lognormal distribution was used for the natural mortality rate *M*, with the mean set to 0.05 (the value used in previous assessments, based upon expected relationships between *M* and longevity identified in Then et al. (2015), with the CV set to 0.05. The standard deviation of log recruits, σ_r, was fixed at 0.75.

Because the catch biomass is generally thought to be observed with higher precision that other variables, λ_3 is given a very high weight so as to fit the catch biomass nearly exactly.

A maturity ogive was fit within the assessment model to samples collected in 2010 from fishery and survey vessels (*n*=280; TenBrink and Spencer 2013) and in 2004 by fishery observers (*n*=165). The samples were analyzed using histological methods. Parameters of the logistic equation were estimated by maximizing the binomial likelihood within the assessment model. The number of fish sampled and number of mature fish by age for each collection were the input data, thus weighting the two collections by sample size. Due to the low number of young fish, high weights were applied to age 3 and 4 fish in order to preclude the logistic equation from predicting a high proportion of mature fish at age 0. The estimated age at 50% maturity is 9.1 years.

The number of estimated parameters is shown below:

Parameter type	Number
1) Fishing mortality mean	1
2) Fishing mortality deviations	65
3) Recruitment mean	1
4) Recruitment deviations	62
5) Unfished recruitment	1
6) Biomass survey catchabilities	2
7) Fishery selectivity parameters	25
8) Survey selectivity parameters	4
9) Natural mortality rate	1
10) Maturity parameters	2
Total parameters	164

Finally, a Monte Carlo Markov Chain (MCMC) algorithm was used to obtain estimates of parameter uncertainty (Gelman et al. 1995). One million MCMC simulations were conducted, with every 1,000th sample saved for the sample from the posterior distribution after excluding the first 50,000 simulations. Ninety percent credible intervals were produced as the values corresponding to the 5th and 95th percentiles of the MCMC evaluation. For this assessment, credible intervals on total biomass, spawning biomass, and recruitment strength are presented.

Results

Model Evaluation

A standard model evaluation would compare alternative models that represented different hypotheses regarding population dynamics and/or the mechanisms by which data is observed, and would be evaluated based on the best fits to the observed data. In this case, the two changes that separate model 24 from model 16.3 are relatively small model tweaks (i.e., restoring a prior distribution on AI survey catchability, and imposing less flexibility in the descending portions of dome-shaped fishery selectivity) rather than full-fledged alternative model specifications. Because these changes reduce the flexibility of the model in fitting survey catchability and fishery selectivity, it is expected that these would result in larger negative log-likelihoods. This is observed in Table 12.23, which shows that each of the composition data sets has a higher negative log-likelihood for model 24 relative to model 16.3. The fit the AI survey biomass time series is slightly improved in model 24 (Figure 12.8), which results from slightly better fits in the early part of the time series and worse fits to the composition data (illustrating the conflict between the composition data and the AI survey biomass index). The fishery selectivity curve for model 24 shows greater stability across ages relative to model 16 (Figure 12.9). The total biomass is larger for model 16.3 relative to model 24, which results from the differences in estimated AI survey catchability. The estimated AI survey catchability coefficients for model 16.3 and model 24 are 0.92 and 1.06, respectively, and the percent difference between these estimates (15%) is consistent with the difference between the estimates of total age 3+ biomass (Figure 12.10).

The data weights for model 16.3 and model 24 are similar to those estimated in the 2022 assessment (Figure 12.11). Model 24 has a reduction in the weight for the fishery lengths compared to model 16.3, but this change is relatively small in absolute terms. Model 24 also shows a higher weight for the AI survey length composition, but this data set includes only one year.

The plot of retrospective estimates of spawning biomass is shown in Figure 12.12. For each model, the 2022 model run shows the largest biomass than any of the retrospective runs, as new data in 2024 allows improved fit to the recent high AI trawl survey biomass or abundance index. Large changes in retrospective pattern also occur in 2016 and 2022, years coincident with high survey biomass estimates.

Mohn's rho can be used to evaluate the severity of any retrospective pattern, and compares an estimated quantity (in this case, spawning stock biomass) in the terminal year of each retrospective model run with the estimated quantity in the same year of the model using the full data set. The Mohn's rho for this set of retrospective runs was -0.36 and -0.25 for Models 16.3 (2024) and Model 24. The smaller (in absolute value) Mohn's rho of model 24 is expected because of the prior distribution on AI survey catchability.

The retrospective estimates of recruitment strength are shown in Figure 12.13. For each model, estimates of many of the post-2000 year classes have increased as more data has become available, which is related to the increase in the AI survey biomass estimates and abundance estimates over this period. The recruitment estimates for most recent year classes have increased with the addition of the 2022 data.

We recommend model 24 for the 2024 BSAI POP assessment. This model restores the prior distribution on the AI survey catchability (a feature that existed in historical BSAI POP assessments), and this prior distribution is consistent with field work conducted by Jones et al. (2021). Additionally, this model increases the penalty on domed-shapeness for fishery selectivity across ages, resulting in more stability in fishery selectivity across ages. Convergence was determined by successful inversion of the Hessian matrix and a maximum gradient component of less than 1e-4 (this value was 2.9e-5 for Model 24). A jitter analysis revealed that the proposed based model and all alternative models are insensitive to perturbations of parameter start values on the order of 15%. All parameters were estimated within their pre-specified bounds. Estimated values of model parameters and their standard deviations are shown in Table 12.24.

The lack of fit to the survey biomass estimates has been a longstanding issue with the BSAI POP assessment, and it is instructive to exclude age and length composition data sets to explore their influence on the model fits. A series of sensitivity model runs were conducted in which either all or all but one of the age/length composition data sets were excluded from the model. Excluding all the composition data (i.e., only fitting to the catch and survey biomass data) produces satisfactory fit to the AI survey biomass time series (Figure 12.14), and adding in only the fishery length composition produces a similar fit. Using only the fishery length composition results in slight underestimation of the survey biomass estimates from 2016-2018. However, the AI survey age compositions appear to be the most influential, as including only this composition data set resulted in overestimation of the biomass estimates from 2000-2006 and underestimation from 2018-2024.

Profiles on the natural mortality parameter (*M*) indicates that the fishery age composition and length composition data sets are informative, whereas the profiles of the survey biomass estimates and composition data indicate the lowest negative log-likelihoods at the lowest values of *M* considered (Figure 12.15). The fishery length composition data and the AI survey age composition data are informative for the estimates of AI survey catchability (Figure 12.16). The profiles for the AI and EBS survey biomass estimates showed the lowest negative log-likelihood at the lowest value of q considered, whereas the opposite pattern was observed for the fishery and EBS survey age compositions.

Time series results

In this assessment, spawning biomass is defined as the biomass estimate of mature females age 3 and older. Total biomass is defined as the biomass estimate of POP age 3 and older. Recruitment is defined as the number of age 3 POP.

Prior and Posterior Distributions

Posterior distributions for *M*, *q*, total 2024 biomass, and median recruitment, based upon the MCMC integrations, are shown in Figure 12.17. The estimate of *M* was 0.051, very close to the mean of the prior distribution for *M* of 0.05. The estimated Aleutian Islands survey catchability was 1.06. Because the Aleutian Islands does not cover the entire stock range (i.e., reduced availability), we would expect the catchability estimated by the model to be less than the catchability based solely on gear efficiency. Estimated catchabilities that do not account for the survey area being smaller than the stock area were larger than 1, which were hypothesized to result from the expansion of survey trawl estimates to untrawlable areas (Kreiger and Sigler 1996), and the catchability based on an acoustic-optic survey in the Gulf of Alaska was 1.15 (Jones et al. 2021). Similarly, the estimated catchability of the EBS trawl survey was 0.26, reflecting that the portion of the stock along the EBS slope is a relatively small fraction of the BSAI stock.

Biomass Trends

The estimated AI survey biomass index has increased from 381,534 t in 1991 to 906,927 t in 2016, and declined to 816,641 in 2021 (Figure 12.18). The addition of high AI survey biomass estimates has resulted in rescaling the population abundance (i.e., lowering survey catchability) relative to previous assessments in order to fit both the survey biomass time series and the composition data. The predicted EBS survey biomass generally matches the observed data, although the high biomass in 2016 is not fit well due to its high CV (Figure 12.19).

The total biomass showed a similar trend as the survey biomass, with the 2024 total biomass estimated as 864,800 t. The estimated time series of total biomass and spawning biomass, with 90% credibility bounds obtained from MCMC integration, are shown in Figure 12.20. Total biomass, spawning biomass, and recruitment (and their CVs from the Hessian approximation) are given in Table 12.25, and numbers at age are shown in Table 12.26.

Age/size compositions

The fits to the fishery age composition are shown in Figures 12.21, and the aggregate fits over all years and the Pearson residuals are shown in Figure 12.22. The aggregate fits indicate underfitting of ages 8 – 12 and overfitting of ages 15 – 18. Ages older than 25 are well fit by the model, although the Pearson residuals indicate that the plus group is being slightly overfit.

The fits to the fishery length compositions are shown in Figures 12.23, and the aggregate fits over all years and the Pearson residuals are shown in Figure 12.24. The observed proportion in the binned length group of 39+ cm for many of the years prior to 2000 was lower than the estimated proportion. The model was generally underfitting the plus group during these years, and the aggregate fit to the plus group shows a relatively strong underfitting. Some of the lack of fit in the mid- to late-1980s is attributable to the low sample size of lengths observed from a reduced fishery, and the model generally fits the data better in recent years which have larger number of samples.

The fits to the AI survey compositions are shown in Figures 12.25, and the aggregate fits over all years and the Pearson residuals are shown in Figure 12.26. The aggregate fits indicate that the peak of the age composition is the data and the model both occur at 10 years, although the observations at this age is underfit by the model. The model provides a reasonable fit to the 2022 length composition from the AI survey (Figure 12.27).

The fits to the EBS survey compositions are shown in Figures 12.28, and the aggregate fits over all years and the Pearson residuals are shown in Figure 12.29. The model fit the 2002 EBS survey age composition data well (notwithstanding the plus group), with worse fits to other years of EBS survey age composition data. In particular, the 2004 and 2005 year classes, which appear strong in the AI survey composition data, are consistently overestimated for the EBS survey composition data. The aggregated fits show consistent underfitting for the AI and EBS survey age plus groups and overfitting of the fishery age and length composition data, indicating the tension between these data sets.

Fishing and Survey Selectivity

Younger fish show higher survey selection in the AI survey than in the EBS survey, with the ages at 50% selection estimated as 6.39 and 10.94, respectively (Figure 12.30). The estimated fishery selectivity by age and year is shown in Figure 12.31, and shows a pattern consistent with the empirical data in fishery catch examined above. Strong dome-shaped selectivity is estimated in the early 1960s to allow fish of age

20 and older from this period to survive the large fully-selected fishing rates in the 1960s and early 1970s and be available for capture in the fishery and survey in the early 1980s (by which time they have entered the 40+ group). The model estimates that dome-shaped selectivity has gradually become less peaked over time. The average selectivity from the most recent 5 years shows a bimodal pattern with reductions in selectivity for fish between 14 – 22 years, and > 33 years.

Fishing Mortality

The estimates of instantaneous fishing mortality for POP range from highs during the 1970's to low levels in the 1980's (Figure 12.32). Fishing mortality rates since the early 1980's, however, have moderated considerably due to the phase out of the foreign fleets and quota limitations imposed by the North Pacific Fishery Management Council. Note that because of the change in the fishery selectivity over time, the fully-selected rates are not completely comparable over time with respect to the degree to which the stock has been harvested. Nonetheless, the average fully-selected fishing mortality from 1965 to 1980 was 0.27, whereas the average from 1981 to 2023 was 0.04.

The plot of estimated fishing mortality rates and spawning stock biomass relative to the harvest control rules (Figure 12.33) indicate that BSAI POP would be considered overfished (using current definitions) during much of the period from the mid-1960s to the mid-1980s, although it should be noted the current definitions of $B_{35\%}$ are based on the estimated recruitment of the post-1977 year classes and the average fishery selectivity from the most recent 5 years.

Recruitment

Year-class strength varies widely for BSAI POP (Figure 12.34; Table 12.25). The relationship between spawning stock and recruitment also displays a high degree of variability (Figure 12.35). The 1961-62 year classes are particularly large and sustained the heavy fishing in the 1960s. The rebuilding of the stock in the 1980s and 1990s was based upon recruitments for the 1981, 1984, 1986, and 1988-89 year classes. Recruitment appears to be lower in early 1990s, but several cohorts from 1994 to 2008 generally show relatively strong recruitment (with the exception the 1997 and 1999 year classes), which is consistent with the increasing trend of biomass and the fishery and AI survey age compositions shown in Figures 12.21 and 12.25. The recent year classes of 2011-2012, 2014, and 2016 appear to be relatively strong, but the retrospective analyses suggests that recruitment estimates for these year classes may not have stabilized.

Harvest recommendations

Amendment 56 reference points

The reference fishing mortality rate for Pacific ocean perch is determined by the amount of reliable population information available (Amendment 56 of the Fishery Management Plan for the groundfish fishery of the Bering Sea/Aleutian Islands). Estimates of $F_{40\%}$, $F_{35\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from the 1977-2018 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{40\%}$ is calculated as the product of $SPR_{40\%}$ * equilibrium recruits, and this quantity is 272,552 t. The estimated spawning stock biomass for 2025 is 352,503 t. Estimated fishery selectivity varies annually in the assessment, and an average of fishery selectivity from the most recent 5 years (i.e., 2000-2004) was used to compute the reference points.

Specification of OFL and maximum permissible ABC

Since reliable estimates of the 2025 spawning biomass (*B*), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B > B_{40\%}$ (352,503 t > 272,552 t), POP reference fishing mortality have been classified in tier 3a. For this tier, F_{ABC} maximum permissible F_{ABC} is $F_{40\%}$, and F_{OFL} is equal to $F_{35\%}$. The values of $F_{40\%}$ and $F_{35\%}$ are 0.060 and 0.072, respectively.

The 2025 ABC associated with the $F_{40\%}$ level of 0.060 is 37,375 t.

The estimated catch level for year 2025 associated with the overfishing level of F = 0.072 is 44,594 t. A summary of these values is below.

2025 SSB estimate (B)	**=**	**352,503 t**
$B_{40\%}$	=	272,552 t
$F_{ABC} = F_{40\%}$	=	0.060
$F_{OFL} = F_{35\%}$	=	0.072
Max ABC	=	37,375 t
OFL	=	44,594 t

Projections

A standard set of projections were conducted for each stock managed under Tiers 1, 2, or 3 of Amendment 56. For each scenario, the projections begin with the vector of 2024 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2025 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2024. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

The first five scenarios are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2025, are as follow ("*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 2025 recommended in the assessment to the *max* F_{ABC} for 2025. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to the 2019-2023 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 4: In all future years, F is set equal to $F_{75\%}$. (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 the Pacific ocean perch 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 expected to be above 1) above its MSY level in 2024 or 2) above ½ of its MSY level in 2024 and above its MSY level in 2034 under this scenario, then the stock is not overfished.)

Scenario 7: In 2025 and 2026, F is set equal to max FABC, 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 assessment 2026 and expected to be above its MSY level in assessment 2036 under this scenario, then the stock is not approaching an overfished condition.).

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and projections of the mean harvest and spawning stock biomass for the remaining five scenarios are shown in Table 12.27.

Risk Table and ABC recommendation

The risk table and definitions of the risk level (i.e., normal, increased concern, and extreme concern) by risk category is in the Introduction to the BSAI SAFE document. Application of the risk table is described below for each risk category.

Assessment considerations

The value of Mohn's rho for this assessment of -0.25 indicates a relatively strong retrospective pattern that is beyond the guidelines proposed by Hurtado-Ferro et al. (2015). This retrospective pattern arises due to an increase in several recent AI survey biomass estimates beginning in 2010 that are larger than the modeled survey biomass. The retrospective pattern and the residuals to the AI survey biomass time series could represent misspecification in either the modeled population dynamics or observational processes, but specific mechanisms have not been identified.

The aggregated (across years) fits to the age and length compositions indicate generally poor fits to these data. This may be because of the strong variability in the composition data, both within and between data sets, that impedes clear signals of year-class strength that are easily tracked through time.

We rank the assessment considerations as a 2 (*Increased concern; Substantially increased assessment uncertainty/ unresolved issues, such as residual patterns and substantial retrospective patterns, especially positive ones*.)

Population dynamics considerations

The rapid increase in the AI survey biomass estimates between 2006 and 2010 appears unusual for a long-lived stock, although several surveys since 2010 have consistently shown a relatively high level of biomass. Recruitment estimates for some recent year classes (i.e., 2000, 2004-05, 2008, 2014, 2016) remain relatively strong. Overall, we rank the population dynamics considerations as a 1 (*Normal; Stock population dynamics (e.g., recruitment, growth, natural mortality) are typical for the stock and recent trends are within normal range.*).

Environmental/ecosystem considerations

The average bottom temperature from the Aleutian Islands bottom trawl survey (AIBTS, (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. In the Bering Sea slope, temperature from the longline survey in 2023 also had a step increase in 2015 from average temperatures around 3.5°C to temperatures above 4°C; in 2023 the temperature was 4.4°C. Temperature profiles of depths between 100-300 in the eastern Aleutians show temperature at 150 to 250 m around 5.5°C in 2023.

Pacific ocean perch (POP) are typically found at temperatures between 3.6 - 4.7°C in the AI and 3.3 - 4.3°C in the eastern Bering Sea. Larvae are released in April – May and they stay in surface waters until the shift to deeper areas around age 3. In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish such that, all else being equal, consumption must increase to maintain fish condition. Thus, the persistent higher temperatures may be considered a negative indicator for POP. The higher temperatures increasing consumption demands beyond what is available, along with higher competition, high biomass of POP and potential density dependent mechanisms, may have jointly contributed to the below average body condition observed since 2012 (Howard et al. 2024).

Larger (>20 cm) POP diets include approximately 20% copepods, 30% euphausiids, and 20% myctophid fish. Data for 2023 from the Continuous Plankton Recorders that sample near the Aleutian chain suggests a real increase in the relative abundance of smaller species, potentially because of warmer than normal conditions. The meso-zooplankton biomass was positive (for the first time since 2017) (Ostle and Batten, 2024). Reproductive success of planktivorous seabirds was above the long term mean in Aiktak island (eastern Aleutians) and below the long term mean at Buldir (western Aleutians), suggesting a gradient of foraging conditions with improved conditions toward the east. Despite the positive indicators for prey in the eastern Aleutians, fish condition of POP was below the long-term mean across the chain (Howard et al 2024).

Recent increases in Kamchatka pink salmon (a predator of copepods, along with POP) has coincided with high abundance in POP, so we can assume that they have not been exhibiting limiting competitive impacts to date. Other groundfish consuming myctophids include walleye pollock, arrowtooth flounder and Pacific cod. Potential spatial dynamics in competitive forcing cannot currently be assessed.

POP are not commonly observed in field samples of stomach contents, although previous studies have identified sablefish, Pacific halibut, and sperm whales as predators (Major and Shippen 1970), as well as occasionally Pacific cod, bigmouth sculpin, yellow Irish lord, Alaska skate and Greenland turbot (AFSC groundfish food habits database). The consumption trends of these species on POP within the Aleutian Islands is not well known, but population trends of these predators do not pose any obvious concerns for changes in predation pressure on POP. Other predators include Steller sea lions, which have been decreasing in the western Aleutians and most of the central Aleutians (Sweeney and Gelatt, 2024) and harbor seals which are decreasing throughout the Aleutians (London, et al., 2021). Steller sea lions are increasing in the eastern Aleutians.

The indicator most relevant to reflecting habitat disturbance is the estimated area disturbed by trawls from the fishing effects model (Olson, 2021). Although only available through 2021, the fishing effects model has not indicated large changes in habitat disturbance trends, and has remained below 3% for the Aleutian Islands (EAI, CAI and WAI) since 2009, so we assume that the level of habitat disturbance that may impact POP has been stable. Sponges and corals seemed to have decreased in the past few years in the western and central Aleutians based on data from the bottom trawl survey (Conrath et al. 2024) although there was no decrease in bycatch of the combined structural epifauna in 2023 (Whitehouse 2024). These groups are poorly sampled by trawl nets and there does not seem to be an overall detrimental effect although Rooper et al (2019) concluded the removal of deep coral and sponges is likely to reduce the overall density of rockfishes.

Overall, we rank the environmental/ecosystem considerations as a 1 (*Normal; No apparent ecosystem concerns related to biological status (e.g., environment, prey, competition, predation), or minor concerns with uncertain impacts on the stock*). The recent stretch of increased temperatures could potentially have negative effects, but the recent increasing trend in the POP stock suggests that the temperature impacts have not been limiting.

Fishery performance

The growth of the BSAI POP stock since the early 1990s has led increased catch, particularly since 2010 with the large AI survey trawl biomass estimates, and the current catches are largest since the mid-1970s. The catch per unit effort (CPUE; t/hr) from Observer data on tows in which rockfish are the largest species group component and POP are the most dominant rockfish indicate relatively stable CPUE from 2004 – 2016, and a reduction in CPUE during 2017 – 2024 (Figure 12.36) . This decline may represent changes in fishing practices in order to avoid bycatch species rather than difficultly in targeting POP. We rank the fishery performance as a 1 (*No apparent fishery/resource-use performance and/or behavior concerns*).

Summary and ABC recommendation

Considerations			
Assessment-related	*Population dynamics*	*Environmental/ ecosystem*	*Fishery Performance*
Level 2: Increased concern	Level 1: Normal	Level 1: Normal	Level 1: Normal

Notwithstanding the concerns over the retrospective pattern and other issues identified in the *Assessment-related considerations* section, the AI trawl survey indicates that BSAI POP remain at high abundances. We recommend the maximum ABC of 37,375 t.

Area Allocation of Harvests

The ABC of BSAI POP is currently partitioned into subarea ABCs based on estimates of relative biomass across BSAI subareas, which are obtained from research surveys. A random effects model is used to smooth the subarea survey biomass estimates to obtain the proportional biomass across the subareas (Figure 12.37), and the smoothed estimates for 2024 are shown below:

ABC apportionments

	Area				
	WAI	CAI	EAI	SBS	EBS slope
2024 smoothed biomass estimate	506,358	182,590	206,200	86,457	245,954
percentage	41.2%	14.9%	16.8%	7.0%	20.0%

The apportioned ABCs for 2025 and 2026 are as follows:

	Area				
					Total
	WAI	CAI	EAI	EBS	ABC
2025 ABC	15,417	5,559	6,278	10,121	37,375
2026 ABC	16,058	5,441	6,144	9,905	36,578

Status Determination

In addition to the seven standard harvest scenarios, Amendments 48/48 to the BSAI and GOA Groundfish Fishery Management Plans require projections of the likely OFL two years into the future. While Scenario 6 gives the best estimate of OFL for 2025, it does not provide the best estimate of OFL for 2026, because the mean 2025 catch under Scenario 6 is predicated on the 2025 catch being equal to the 2025 OFL, whereas the actual 2025 catch will likely be less than the 2025 OFL. The executive summary contains the appropriate one- and two-year ahead projections for both ABC and OFL. Catches for 2025 and 2026 were obtained by setting the F rate for these years to estimated F for 2024 of 0.056.

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?

Is the stock being subjected to overfishing? The official BSAI catch estimate for the most recent complete year (2023) is 35,951 t. This is less than the 2023 BSAI OFL of 50,133 t. Therefore, the stock is not being subjected to overfishing.

Harvest Scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be *overfished*. Any stock that is expected to fall below its MSST in the next two years is defined to be *approaching* an overfished condition. Harvest Scenarios #6 and #7 are used in these determinations as follows:

Is the stock currently overfished? This depends on the stock's estimated spawning biomass in 2024:

a. If spawning biomass for 2024 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2024 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2024 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest Scenario #6 (Table 12.27). If the mean spawning biomass for 2034 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an overfished condition? This is determined by referring to harvest Scenario #7:

a. If the mean spawning biomass for 2026 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2026 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2026 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2036. If the mean spawning biomass for 2036 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

The results of these two scenarios indicate that the BSAI POP stock is neither overfished nor approaching an overfished condition. With regard whether the stock is currently overfished, the expected stock size in the year 2024 is 1.5 times its $B_{35\%}$ value of 228,419 t. With regard to whether the BSAI POP stock is likely to be overfished in the future, the expected stock size in 2026 of Scenario 7 is 1.4 times the $B_{35\%}$ value.

Based on the recommended model, the F that would have produced a catch for 2023 equal to the 2023 OFL is 0.080.

Ecosystem Considerations

Ecosystem Effects on the stock

1) Prey availability/abundance trends

POP feed upon calanoid copepods, euphausids, myctophids, and other miscellaneous prey (Yang 2003). From a sample of 292 Aleutian Island specimens collected in 1997, calanoid copepods, euphausids, and myctophids contributed 70% of the total diet by weight. The diet of small POP was composed primarily of calanoid copepods (89% by weight), with euphausids and myctophids contributing approximately 35% and 10% of the diet, respectively, of larger POP. The diet data obtained from the AI trawl survey since 2000 has shown a similar pattern, with small POP (≤ 20 cm) feeding on copepods and euphausids, and larger POP feeding on these prey group and also myctophids. The availability and abundance trends of these prey species are unknown.

2) Predator population trends

POP are not commonly observed in field samples of stomach contents, although previous studies have identified sablefish, Pacific halibut, and sperm whales as predators (Major and Shippen 1970). The population trends of these predators can be found in separate chapters within this SAFE document.

3) Changes in habitat quality

POP appear to exhibit ontogenetic shifts in habitat use. Carlson and Straty (1981) used a submersible off southeast Alaska to observe juvenile red rockfish they believed to be POP at approximately 90-100 m in rugged habitat including boulder fields and rocky pinnacles. Kreiger (1993) also used a submersible to observe that the highest densities of small red rockfish in untrawlable rough habitat. As POP mature, they move into deeper and less rough habitats. Length frequencies of the Aleutian Islands survey data indicate that large POP (> 25 cm) are generally found at depths greater than 150 m. Brodeur (2001) also found that POP was associated with epibenthic sea pens and sea whips along the Bering Sea slope. There has been little information identifying how rockfish habitat quality has changed over time.

Fishery Effects on the ecosystem

Catch of prohibited species from 2003-2008 by fishery are available from the NMFS Regional Office. The rockfish fishery in the BSAI area, which consists only of the AI POP target fishery, contributed approximately 2% of the gold/brown king crab catch and approximately 1% of the halibut bycatch. For other prohibited species, the BSAI rockfish fisheries contributed much lower that 1% of the bycatch.

Estimates of non-target catches in the rockfish fishery are also available from the Catch Accounting System database maintained by the NMFS Regional Office. BSAI rockfish fisheries contribute mostly to the bycatch of coral, sponge, and polychaetes. From 2003 to 2008, the BSAI rockfish fisheries contributed 31% of the coral and bryozoan bycatch, 18% of the sponge bycatch, 8% of the red tree coral bycatch, and 7% of the polychaete bycatch. The relative contribution was variable between years; for example, the annual relative contribution corals and bryozoans ranged from 5% in 2004 to 53% in 2003, and the other groups listed above show similar levels of variability.

The POP fishery is not likely to diminish the amount of POP available as prey due to its low selectivity for fish less than 27 cm. Additionally, the fishery is not suspected of affecting the size-structure of the population due to the relatively light fishing mortality, averaging 0.05 over the last 5 years. It is not known what effects the fishery may have on the maturity-at-age of POP.

Data Gaps and Research Priorities

Although Pacific ocean perch may be considered a “data-rich” species relative to other rockfish, little information is known regarding most aspects of their biology, including reproductive biology and the distribution, duration, and habitat requirements of various life-history stages. Given the relatively unusual reproductive biology of rockfish and its importance in establishing management reference points, data on reproductive capacity should be collected on a periodic basis.

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Tables

Table 12.1. Total allowable catch (TAC), acceptable biological catch (ABC), and catch of the species groups used to manage Pacific ocean perch from 1977 to 2001 in the Aleutian Islands and the eastern Bering Sea. The "POP complex" includes the other red rockfish species (shortraker rockfish, rougheye rockfish, northern rockfish, and sharpchin rockfish) plus POP.

	Aleutian Islands					Eastern Bering Sea				
Year	Management Group	OFL (t)	ABC (t)	TAC (t)	Catch (t)	Management Group	OFL (t)	ABC (t)	TAC (t)	Catch (t)
1977	POP				7927	POP				2406
1978	POP				5286	POP				2230
1979	POP				5486	POP				1722
1980	POP				4010	POP				959
1981	POP				3668	POP				1186
1982	POP complex				979	POP complex				205
1983	POP complex				471	POP complex				192
1984	POP complex				564	POP complex				315
1985	POP complex				216	POP complex				61
1986	POP			6800	302	POP			825	670
1987	POP			8175	1055	POP			2850	1178
1988	POP		16600	6000	2024	POP		6000	5000	1326
1989	POP complex		16600	6000	2963	POP complex		6000	5000	2533
1990	POP complex		16600	6000	11826	POP complex		6300	6300	6499
1991	POP		10775	10775	2785	POP		4570	4570	5099
1992	POP	11700	11700	11700	10280	POP	3540	3540	3540	3255
1993	POP	16800	13900	13900	13376	POP	3750	3330	3330	3764
1994	POP	16600	10900	10900	10866	POP	2920	1910	1910	1688
1995	POP	15900	10500	10500	10304	POP	2910	1850	1850	1208
1996	POP	25200	12100	12100	12827	POP	2860	1800	1800	2855
1997	POP	25300	12800	12800	12648	POP	5400	2800	2800	681
1998	POP	20700	12100	12100	9047	POP	3300	1400	1400	956
1999	POP	19100	13500	13500	12484	POP	3600	1900	1400	421
2000	POP	14400	12300	12300	9328	POP	3100	2600	2600	452
2001	POP	11800	10200	10200	8557	POP	2040	1730	1730	896

Table 12.2. Overfishing level (OFL), total allowable catch (TAC), acceptable biological catch (ABC), and catch for BSAI POP from 2002 to present. Catch data is through week-end-date of October 5, 2024, from NMFS Alaska Regional Office.

		Bering Sea/Aleutian Islands			
Year	Management Group	OFL (t)	ABC (t)	TAC (t)	Catch (t)
2002	POP	17500	14800	14800	11215
2003	POP	18000	15100	14100	14744
2004	POP	15800	13300	12580	11896
2005	POP	17300	14600	12600	10427
2006	POP	17600	14800	12600	12867
2007	POP	26100	21900	19900	18451
2008	POP	25700	21700	21700	17436
2009	POP	22300	18800	18800	15347
2010	POP	22400	18860	18860	17851
2011	POP	36300	24700	24700	24003
2012	POP	35000	24700	24700	24154
2013	POP	41900	35100	35100	31362
2014	POP	39585	33122	33122	32381
2015	POP	42588	34988	32021	31432
2016	POP	40529	33320	31900	31187
2017	POP	53152	43723	34900	32164
2018	POP	51675	42509	37361	34431
2019	POP	61067	50594	44069	43171
2020	POP	58956	48846	42875	40417
2021	POP	44376	37173	35899	35480
2022	POP	42605	35688	35385	34782
2023	POP	50133	42038	37703	35951
2024*	POP	49010	41096	37626	26124

Table 12.3. Foreign, Joint Vessel Program, and Domestic catch of POP by area from 1977 to 2024.

	Eastern Bering Sea			Aleutian Islands			BSAI
Year	Foreign	JVP	Domestic	Foreign	JVP	Domestic	Total catch
1977	2,406	0		7,927	0		10,333
1978	2,230	0		5,286	0		7,516
1979	1,722	0		5,486	0		7,208
1980	907	52		4,010	0		4,969
1981	1,185	1		3,668	0		4,854
1982	186	19		977	2		1,183
1983	99	93		463	8		663
1984	172	142		324	241		879
1985	30	31		0	216		277
1986	18	103	549	0	163	139	972
1987	5	49	1,123	0	502	554	2,233
1988	0	46	1,280	0	1,512	512	3,350
1989	0	26	2,507	0	0	2,963	5,496
1990			6,499			11,826	18,324
1991			5,099			2,785	7,884
1992			3,255			10,280	13,534
1993			3,764			13,376	17,139
1994			1,688			10,866	12,554
1995			1,208			10,304	11,511
1996			2,855			12,827	15,681
1997			681			12,648	13,329
1998			956			9,047	10,003
1999			421			12,484	12,905
2000			451			9,328	9,780
2001			896			8,557	9,453
2002			639			10,575	11,215
2003			1,145			13,600	14,744
2004			731			11,165	11,896
2005			879			9,548	10,427
2006			1,041			11,826	12,867
2007			870			17,581	18,451
2008			513			16,923	17,436
2009			623			14,725	15,347
2010			3,547			14,304	17,851
2011			5,600			18,403	24,003
2012			5,584			18,570	24,154
2013			5,051			26,311	31,362
2014			7,437			24,944	32,381
2015			7,925			23,507	31,432
2016			8,090			23,097	31,187
2017			8,607			23,557	32,164
2018			9,317			25,114	34,431
2019			14,074			29,097	43,171
2020			11,944			28,473	40,417
2021			10,693			24,787	35,480
2022			10,066			24,716	34,782
2023			10,892			25,059	35,951
2024*			6,946			19,178	26,124

*Estimated removals through October 5, 2024.

Table 12.4. Estimated retained and discarded catch (t), and percent discarded, of Pacific ocean perch from the eastern Bering Sea (EBS) and Aleutian Islands (AI) regions.

	EBS			AI			BSAI		
Year	Retained	Discarded	Percent Discarded	Retained	Discarded	Percent Discarded	Retained	Discard	Percent Discarded
1991	4,126	972	19	1,815	970	35	5,942	1,942	25
1992	2,732	522	16	8,666	1,614	16	11,398	2,136	16
1993	2,601	1,163	31	11,479	1,896	14	14,080	3,059	18
1994	1,187	501	30	9,491	1,375	13	10,678	1,876	15
1995	839	368	30	8,603	1,701	17	9,442	2,069	18
1996	2,522	333	12	9,831	2,995	23	12,353	3,328	21
1997	420	261	38	10,854	1,794	14	11,274	2,055	15
1998	813	143	15	8,041	1,006	11	8,854	1,149	11
1999	277	144	34	10,985	1,499	12	11,261	1,644	13
2000	230	221	49	8,586	743	8	8,816	964	10
2001	399	497	55	7,195	1,362	16	7,594	1,859	20
2002	286	354	55	9,315	1,260	12	9,601	1,614	14
2003	564	581	51	11,558	2,042	15	12,122	2,622	18
2004	536	196	27	9,286	1,879	17	9,822	2,074	17
2005	627	253	29	8,100	1,448	15	8,727	1,700	16
2006	751	290	28	9,869	1,957	17	10,620	2,246	17
2007	508	363	42	15,051	2,530	14	15,558	2,893	16
2008	318	195	38	16,640	283	2	16,959	477	3
2009	463	160	26	14,011	713	5	14,474	873	6
2010	3,347	200	6	13,988	316	2	17,335	516	3
2011	5,249	351	6	18,021	382	2	23,270	733	3
2012	5,178	406	7	18,169	401	2	23,348	807	3
2013	4,746	304	6	26,063	248	1	30,809	553	2
2014	6,614	823	11	24,770	174	1	31,384	997	3
2015	6,749	1,176	15	23,267	240	1	30,016	1,416	5
2016	7,419	671	8	22,899	199	1	30,317	870	3
2017	6,986	1,621	19	23,293	264	1	30,279	1,885	6
2018	7,828	1,488	16	24,617	497	2	32,446	1,985	6
2019	11,259	2,815	20	28592	505	2	39852	3,320	8
2020	9,610	2,334	20	27,946	526	2	37,556	2,860	7
2021	9,489	1,204	11	24,200	587	2	33,689	1,791	5
2022	9,290	777	8	24,343	372	2	33,633	1,149	3
2023	10,299	593	5	24,624	435	2	34,924	1,028	3
2024*	6,760	186	3	18,884	294	2	25,644	480	2

*Estimated removals through October 5, 2024.
Source: NMFS Alaska Regional Office

Table 12.5. Percentage catch (by weight) of Aleutians Islands POP in the foreign/joint venture fisheries and the domestic fishery by depth.

	Depth Zone (m)							
Year	0	100	200	300	400	500	501	Observed catch (t)
1977	25	23	39	11	2	1	0	173
1978	0	40	36	19	3	1	1	145
1979	0	13	60	23	4	0	0	311
1980	0	7	45	49	0	0	0	108
1981	0	9	67	23	0	0	0	138
1982	0	34	56	5	2	1	2	115
1983	0	11	85	0	1	1	1	54
1984	0	53	42	5	0	1	0	85
1985	0	87	13	0	0	0	0	109
1986	0	74	25	2	0	0	0	66
1987	0	39	61	0	0	0	0	258
1988	0	78	21	1	0	0	0	76
1989								
1990	2	23	58	14	2	1	0	7,726
1991	0	23	70	5	1	1	0	1,588
1992	0	21	71	8	0	0	0	6,785
1993	0	20	77	3	0	0	0	8,867
1994	0	20	69	11	0	0	0	7,562
1995	0	15	68	14	2	0	0	6,154
1996	0	17	54	26	2	1	0	8,547
1997	0	13	66	21	0	0	0	9,320
1998	0	21	72	7	0	0	0	7,380
1999	0	30	63	7	0	0	0	10,369
2000	0	21	63	15	0	0	0	7,456
2001	0	29	61	10	0	0	0	5,679
2002	2	36	57	5	1	0	0	8,124
2003	0	26	70	3	0	0	0	11,266
2004	1	26	65	7	1	0	0	10,083
2005	2	36	55	6	1	0	0	7,403
2006	1	33	61	5	0	0	0	9,895
2007	0	23	68	7	1	0	0	15,551
2008	1	20	74	5	0	0	0	16,685
2009	1	26	65	8	1	0	1	14,495
2010	1	21	71	7	1	0	0	14,299
2011	0	13	78	7	1	0	0	18,391
2012	0	22	67	11	1	0	0	18,569
2013	0	12	76	11	1	0	0	26,297
2014	0	12	79	8	0	0	0	24,882
2015	1	21	73	4	0	0	0	23,421
2016	1	27	68	4	0	0	0	23,002
2017	0	27	71	2	0	0	0	23,536
2018	1	33	63	3	0	0	0	25,032
2019	1	29	68	2	0	0	0	29,050
2020	0	29	68	3	0	0	0	28,495
2021	0	31	65	4	0	0	0	23,718
2022	0	28	68	3	0	0	0	24,626
2023	0	32	65	3	0	0	0	25,002

Table 12.6. Percentage catch (by weight) of BSAI POP in the foreign and joint venture fisheries and the domestic fishery by management area.

	Area				
	541	542	543	EBS	Observed catch (t)
1977	7	10	27	56	391
1978	17	20	20	43	256
1979	17	20	44	18	381
1980	8	28	32	32	159
1981	24	23	10	43	241
1982	29	26	13	32	170
1983	35	3	3	59	148
1984	44	6	1	49	434
1985	36	17	0	47	230
1986	52	0	0	48	188
1987	86	5	0	9	333
1988	4	89	0	7	316
1989					
1990	43	11	14	31	11273
1991	10	21	6	63	4284
1992	64	12	3	22	8677
1993	54	18	9	19	10976
1994	58	28	4	10	8437
1995	63	22	5	9	6793
1996	22	16	44	19	10549
1997	19	22	54	5	9843
1998	19	24	47	11	8288
1999	21	22	54	3	10678
2000	21	23	52	4	7762
2001	24	22	42	12	6471
2002	22	26	45	7	8769
2003	28	20	44	8	12273
2004	23	26	46	5	10577
2005	21	22	47	10	8233
2006	22	25	44	8	10805
2007	28	25	43	4	16193
2008	27	27	43	3	17233
2009	26	27	42	4	15117
2010	23	23	35	20	17848
2011	23	20	34	23	24033
2012	23	20	34	24	24288
2013	30	21	32	17	31494
2014	28	20	29	23	32504
2015	25	22	28	26	31587
2016	23	22	28	27	31419
2017	24	21	27	28	32486
2018	26	21	25	28	34778
2019	25	19	23	34	43780
2020	26	20	24	30	40460
2021	23	17	29	30	34057
2022	23	17	31	29	34484
2023	22	15	33	30	35515

Table 12.7. Catch (t) of FMP groundfish species caught in BSAI trips targeting rockfish. "Conf" indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 09/30/2024.

Species Group Name	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average
Pacific Ocean Perch	19589	20422	21091	27651	25802	23637	23415	25374	15198	22464
Atka Mackerel	5255	5365	5513	8734	8527	6846	6173	8895	5954	6807
Northern Rockfish	1338	1476	1768	4527	3512	2193	3133	5217	3348	2946
Pollock	875	1424	1524	2254	1995	2248	2779	3626	2664	2154
Pacific Cod	625	813	637	1217	975	899	721	810	633	814
Arrowtooth Flounder	363	359	257	465	579	672	708	738	759	544
BSAI Kamchatka Flounder	463	427	322	518	714	549	305	554	743	511
Sablefish	14	143	147	286	370	475	707	681	667	388
Other Rockfish	129	163	198	342	405	284	355	424	311	290
BSAI Skate and GOA Skate, Oth	139	144	165	294	282	216	174	183	181	198
Rougheye Rockfish	70	65	116	246	288	248	219	332	191	197
Sculpin	88	135	106	199	188					143
BSAI Other Flatfish	16	52	88	157	141	161	248	244	174	142
Flathead Sole	41	53	67	119	89	125	172	245	239	128
BSAI Shortraker Rockfish	38	36	116	121	146	224	152	152	50	115
Greenland Turbot	28	37	53	119	165	115	91	169	168	105
Rock Sole	15	32	36	67	61	49	59	50	57	47
Squid	26	31	50							35
Shark	2	Conf	2	2	4	2	6	3	10	4
Octopus	1	3	3	4	2	2	3	3	3	3
Yellowfin Sole	1	0	4	1	1	5	0	0		1
BSAI Alaska Plaice	Conf		1		0	Conf	Conf			0

Table 12.8. Catch (t) of BSAI POP by trip target fishery. “Conf” indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 09/30/2024.

Fishery	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average
Rockfish	19589	20422	21091	27651	25802	23637	23415	25374	15198	22464
Atka Mackerel	7763	6945	9140	6871	6977	7816	8519	7866	8104	7778
Pollock - midwater	2082	3026	2675	4975	3371	1864	1062	913	1170	2349
Pollock - bottom	1171	1412	1194	3039	2677	604	405	432	621	1284
Kamchatka Flounder - BSAI	97	80	130	233	1021	912	612	677	186	439
Arrowtooth Flounder	338	108	60	105	338	293	238	121	515	235
Flathead Sole	Conf	12	Conf	80	79	217	414	200	Conf	167
Other Flatfish - BSAI	47	70	Conf	44	Conf	17	53	249	33	74
Greenland Turbot - BSAI	42	37	111	150	32	109	28	Conf	Conf	73
Sablefish	Conf	Conf	0	Conf	0	Conf	30	112	131	55
Pacific Cod	50	48	5	20	15	6	3	4	116	30
Yellowfin Sole - BSAI	3	0	1	1	63	2	1	1	Conf	9
Halibut		0	0	0	Conf		Conf	Conf	Conf	0
Rock Sole - BSAI	0	Conf			Conf	Conf		Conf		0

Table 12.9. Bycatch (t) of PSC species by BSAI trip targeting rockfish, in tons for halibut and herring and 1000s of individuals for crab and salmon. "Source: Alaska Regional Office, via AKFIN 09/30/2024.

Species	2024	2023	2022	2021	2020	2019	2018	2017	2016	Average
Bairdi Tanner Crab	8.01	4.64	0.70	7.66	0.25	0.62	0.84	0.10	0.07	2.54
Blue King Crab	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chinook Salmon	0.08	0.11	0.21	0.39	0.17	1.04	0.27	0.58	0.21	0.34
Golden (Brown) King Crab	2.01	3.11	3.32	3.30	3.66	6.30	4.95	3.02	5.29	3.88
Halibut	36.29	72.32	73.87	81.93	59.64	86.00	44.16	51.18	24.98	58.93
Herring	0.44	2.08	2.12	0.01	0.00	1.34	0.04	0.01	0.00	0.67
Non-Chinook Salmon	0.74	1.09	0.95	0.77	0.41	1.28	0.76	0.12	0.19	0.70
Opilio Tanner (Snow) Crab	1.34	0.58	0.14	2.31	0.10	0.71	14.54	0.07	0.02	2.20
Red King Crab	0.00	0.18	0.00	0.21	0.06	0.33	0.48	0.63	0.06	0.22

Table 12.10. Bycatch (t) of non-FMP species by BSAI trip targeting rockfish. “Conf” indicates confidential records with less than three vessels or processors. Source: Alaska Regional Office, via AKFIN 9/30/2024.

Species Group Name	2024	2023	2022	2021	2020	2019	2018	2017	2016
Benthic urochordata	0.18	2.70	0.40	0.46	6.08	12.16	2.88	0.32	0.18
Birds - Auklets							Conf		
Birds - Black-footed Albatross			Conf				Conf		
Birds - Laysan Albatross							Conf		
Birds - Northern Fulmar	Conf	Conf	Conf				Conf		
Birds - Shearwaters	Conf			Conf			Conf	Conf	
Birds - Storm Petrels		Conf		Conf			Conf		
Bivalves	0.20	0.23	0.07	0.17	0.03	0.15	0.05	0.02	0.05
Brittle star unidentified	0.72	3.63	1.13	3.27	6.08	3.21	5.02	0.14	0.12
Corals Bryozoans - Corals Bryozoans Uniden	3.61	10.48	9.45	5.23	9.25	23.56	5.89	26.61	11.15
Eelpouts	40.24	20.72	19.26	3.17	3.57	2.46	1.75	4.56	1.33
Giant Grenadier	233.51	284.93	240.85	321.44	181.68	95.36	121.74	29.33	108.63
Greenlings	1.07	2.38	2.43	0.46	0.79	0.67	Conf	Conf	
Grenadier - Rattail Grenadier Unidentified	Conf	3.84	3.25	Conf		23.44	Conf		
Hermit crab unidentified	0.11	0.14	0.15	0.08	0.04	0.10	0.04	0.01	0.02
Invertebrate unidentified	0.14	0.47	0.32	8.62	1.69	4.86	0.16	0.13	1.86
Lanternfishes (myctophidae)	0.03	0.04	0.08	0.14	Conf	0.11	0.03	Conf	Conf
Misc crabs	2.31	2.68	5.11	0.35	0.30	1.00	0.28	0.24	0.40
Misc crustaceans	0.01	0.18	0.23	0.15	0.18	0.18	0.22	0.38	0.11
Misc deep fish	Conf	Conf	Conf	0.01	Conf	Conf	Conf		Conf
Misc fish	36.91	65.24	51.04	55.68	78.92	104.32	74.95	107.35	58.93
Misc inverts (worms etc)	0.14	0.01	0.01	0.01	0.03	0.00	Conf		0.00
Other osmerids	Conf			0.01	0.04	Conf	Conf		
Pacific Hake			Conf						
Pacific Sand lance		Conf			Conf				
Pandalid shrimp	0.27	0.36	0.53	0.38	0.16	0.14	0.32	0.10	0.15
Polychaete unidentified	0.01	0.43	0.01	0.00	Conf	0.03	0.02		Conf
Saffron Cod							Conf		
Sculpin	120.60	184.75	145.76	96.57					
Scypho jellies	1.05	5.53	2.49	15.23	3.43	11.50	1.23	0.39	0.52
Sea anemone unidentified	9.07	13.10	2.51	4.41	0.36	1.22	0.49	0.25	0.19
Sea pens whips	0.09	0.14	0.04	0.15	0.20	0.14	0.46	Conf	0.06
Sea star	18.33	20.56	12.78	12.45	16.01	32.69	45.25	4.27	3.29
Smelt (Family Osmeridae)			Conf						
Snails	0.95	1.50	0.80	0.76	0.79	0.80	0.81	0.31	0.13
Sponge unidentified	34.56	81.58	53.41	72.86	92.48	96.75	77.81	71.48	48.31
Squid	126.93	122.51	79.23	75.80	56.42	23.41			
State-managed Rockfish	1.17	2.75	0.58	0.46	1.13	0.34	0.36	Conf	0.62
Stichaeidae	Conf	Conf			Conf		Conf		Conf
urchins dollars cucumbers	6.26	6.27	3.94	1.05	0.69	2.64	2.10	1.14	0.37

Table 12.11. Number of length measurements from the EBS and AI POP fisheries during 1964-1972, from Chikuni (1975).

Year	EBS	AI	Total
1964	24,150	55,599	79,749
1965	14,935	66,120	81,055
1966	26,458	25,502	51,960
1967	48,027	59,576	107,603
1968	38,370	36,734	75,104
1969	28,774	27,206	55,980
1970	11,299	27,508	38,807
1971	14,045	18,926	32,971
1972	10,996	18,926	29,922

Table 12.12. Number of length measurements and otoliths read from the EBS and AI POP fisheries, from the NORPAC Observer database.

	Fish lengths			Otoliths read		
Year	EBS	AI	Total	EBS	AI	Total
1973	1		1**			
1974	84		84**	84		84**
1975	271		271**	125		125**
1976	633		633**	114	19	133**
1977	1,059	9,318	10,377*	139	404	543
1978	7,926	7,283	15,209*	583	641	1,224
1979	1,045	10,921	11,966*	248	353	601
1980		3,995	3,995*		398	398
1981	1,502	7,167	8,669*	78	432	510
1982		4,902	4,902*		222	222
1983	232	441	673			
1984	1,194	1,210	2,404	72		72**
1985	300		300**	160		160**
1986		100	100**		99	99**
1987	11	384	395			
1988	306	1,366	1,672			
1989	957	91	1,048			
1990	22,228	47,198	69,426	144	184	328
1991	8,247	8,221	16,468			
1992	13,077	24,932	38,009			
1993	8,379	26,433	34,812			
1994	2,654	11,546	14,200			
1995	272	11,452	11,724			
1996	2,967	13,146	16,113			
1997	143	10,402	10,545			
1998	989	11,106	12,095		823	823
1999	289	3,839	4,128			
2000	284	3,382	3,666*		487	487
2001	327	2,388	2,715*		524	524
2002	78	3,671	3,749*	11	455	466
2003	247	4,681	4,928*	11	386	397
2004	135	3,270	3,405*	30	754	784
2005	237	2,243	2,480*	42	539	581
2006	274	3,757	4,031*	25	424	449
2007	74	5,629	5,703*	11	664	675
2008	250	7,001	7,251*	17	555	572
2009	460	5,593	6,053*	49	670	719
2010	2,584	5,384	7,968			
2011	4,144	7,965	12,109*	316	616	932
2012	5,686	7,896	13,582			
2013	3,897	13,082	16,979*	233	810	1,043
2014	4,044	12,125	16,169			
2015	4,117	12,213	16,330*	243	773	1,016
2016	3,707	12,209	15,916			
2017	4,772	16,702	21,474*	239	841	1,080
2018	5,841	18,661	24,502			
2019	7,408	20,146	27,554*	277	816	1,093
2020	6,149	23,631	29,780*	230	920	1,150
2021	6,199	16,996	23,195*	277	780	1,057
2022	7,810	16,983	24,793			
2023	7,446	16,425	23,871*	347	755	1,102
2024	1,010	8,305	9,315			

*Used to create age composition. **Not used.

Table 12.13. Fishery length compositions used in the model, from Chikuni (1975) (for years 1964-1972) and the NORPAC foreign and domestic Observer databases.

	Year																	
Length (cm)	1964	1965	1966	1967	1968	1969	1970	1971	1972	1977	1978	1979	1980	1983	1984	1987	1988	1989
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	0.002	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.004	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.001	0.000	0.000	0.002	0.005	0.001
20	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.005	0.003	0.001	0.001	0.005	0.009	0.000
21	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.004	0.000	0.003	0.004	0.003	0.006	0.001	0.003	0.000	0.020	0.000
22	0.001	0.000	0.002	0.002	0.002	0.003	0.001	0.011	0.000	0.009	0.009	0.007	0.014	0.003	0.007	0.007	0.047	0.001
23	0.002	0.002	0.006	0.004	0.008	0.005	0.006	0.012	0.000	0.017	0.018	0.010	0.018	0.001	0.005	0.002	0.058	0.000
24	0.001	0.009	0.010	0.010	0.024	0.018	0.011	0.014	0.006	0.022	0.031	0.012	0.021	0.007	0.014	0.007	0.040	0.001
25	0.003	0.011	0.014	0.012	0.046	0.044	0.017	0.013	0.028	0.028	0.061	0.023	0.020	0.031	0.023	0.022	0.036	0.006
26	0.004	0.021	0.022	0.020	0.069	0.085	0.031	0.019	0.049	0.042	0.066	0.034	0.041	0.028	0.035	0.058	0.050	0.005
27	0.006	0.030	0.028	0.024	0.075	0.129	0.039	0.037	0.057	0.046	0.051	0.057	0.047	0.032	0.054	0.097	0.097	0.012
28	0.008	0.036	0.040	0.029	0.078	0.146	0.082	0.051	0.068	0.054	0.055	0.063	0.072	0.024	0.070	0.118	0.120	0.016
29	0.016	0.040	0.043	0.038	0.064	0.132	0.097	0.073	0.085	0.055	0.084	0.077	0.066	0.064	0.086	0.101	0.137	0.049
30	0.026	0.061	0.058	0.039	0.057	0.094	0.102	0.115	0.100	0.057	0.088	0.090	0.076	0.087	0.108	0.087	0.102	0.051
31	0.050	0.072	0.065	0.060	0.053	0.059	0.102	0.135	0.123	0.060	0.061	0.096	0.066	0.092	0.121	0.106	0.081	0.038
32	0.067	0.094	0.079	0.060	0.048	0.041	0.089	0.107	0.096	0.064	0.046	0.088	0.078	0.083	0.104	0.133	0.040	0.035
33	0.080	0.078	0.068	0.070	0.051	0.026	0.063	0.079	0.074	0.061	0.045	0.073	0.067	0.051	0.065	0.108	0.026	0.066
34	0.096	0.097	0.076	0.079	0.057	0.030	0.052	0.059	0.057	0.051	0.038	0.066	0.051	0.046	0.042	0.056	0.015	0.058
35	0.136	0.115	0.087	0.085	0.060	0.035	0.054	0.048	0.052	0.059	0.038	0.055	0.055	0.011	0.033	0.012	0.006	0.069
36	0.130	0.097	0.079	0.096	0.064	0.042	0.060	0.050	0.050	0.057	0.043	0.046	0.048	0.039	0.032	0.007	0.009	0.086
37	0.128	0.083	0.078	0.094	0.062	0.039	0.051	0.044	0.046	0.065	0.054	0.045	0.044	0.040	0.035	0.005	0.017	0.089
38	0.097	0.057	0.063	0.088	0.052	0.027	0.054	0.044	0.039	0.069	0.052	0.044	0.051	0.052	0.047	0.000	0.030	0.113
39+	0.149	0.099	0.178	0.188	0.130	0.045	0.089	0.085	0.071	0.179	0.150	0.102	0.153	0.305	0.114	0.064	0.047	0.303

Table 12.13 (cont).

	Year													
Length (cm)	1991	1992	1993	1994	1995	1996	1997	1999	2010	2012	2014	2016	2018	2022
15	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
16	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.002	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001
19	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001
20	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.001	0.001
21	0.001	0.001	0.002	0.000	0.001	0.000	0.000	0.001	0.001	0.003	0.001	0.001	0.001	0.002
22	0.003	0.001	0.003	0.001	0.003	0.001	0.000	0.003	0.001	0.002	0.001	0.002	0.002	0.004
23	0.004	0.003	0.006	0.001	0.006	0.001	0.000	0.002	0.002	0.001	0.002	0.002	0.004	0.003
24	0.006	0.005	0.008	0.004	0.005	0.001	0.000	0.004	0.003	0.002	0.002	0.002	0.005	0.004
25	0.008	0.010	0.012	0.008	0.005	0.001	0.000	0.006	0.003	0.002	0.003	0.002	0.004	0.006
26	0.014	0.020	0.014	0.015	0.005	0.003	0.001	0.006	0.003	0.004	0.005	0.002	0.004	0.008
27	0.022	0.029	0.022	0.025	0.011	0.008	0.002	0.005	0.005	0.006	0.006	0.004	0.006	0.011
28	0.021	0.034	0.041	0.036	0.016	0.014	0.006	0.004	0.004	0.008	0.008	0.009	0.009	0.017
29	0.033	0.044	0.062	0.042	0.027	0.023	0.011	0.013	0.006	0.008	0.010	0.014	0.013	0.019
30	0.037	0.060	0.072	0.063	0.031	0.036	0.025	0.013	0.010	0.012	0.014	0.024	0.017	0.023
31	0.043	0.094	0.084	0.087	0.055	0.048	0.055	0.026	0.022	0.020	0.025	0.039	0.029	0.033
32	0.054	0.111	0.102	0.101	0.082	0.069	0.088	0.049	0.042	0.027	0.037	0.053	0.053	0.046
33	0.076	0.103	0.111	0.108	0.122	0.094	0.120	0.075	0.068	0.044	0.051	0.066	0.078	0.057
34	0.100	0.089	0.104	0.105	0.151	0.111	0.122	0.098	0.088	0.061	0.071	0.077	0.092	0.067
35	0.118	0.076	0.088	0.096	0.130	0.112	0.127	0.124	0.097	0.083	0.092	0.095	0.098	0.083
36	0.116	0.069	0.074	0.077	0.113	0.107	0.111	0.133	0.100	0.096	0.101	0.104	0.101	0.095
37	0.094	0.065	0.058	0.066	0.079	0.102	0.093	0.128	0.096	0.111	0.117	0.101	0.106	0.099
38	0.073	0.053	0.044	0.051	0.053	0.088	0.073	0.102	0.091	0.105	0.115	0.093	0.092	0.095
39+	0.169	0.130	0.092	0.114	0.099	0.180	0.167	0.207	0.356	0.400	0.336	0.309	0.285	0.324

Table 12.14. Fishery age compositions used in the model, the NORPAC foreign and domestic Observer databases.

	Year																					
Age	1981	1982	1990	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2011	2013	2015	2017	2019	2020	2021	2023
3	0.003	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.009	0.003	0.001	0.003
4	0.044	0.010	0.003	0.002	0.008	0.001	0.008	0.009	0.010	0.004	0.001	0.000	0.002	0.002	0.000	0.000	0.005	0.002	0.002	0.014	0.005	0.010
5	0.159	0.066	0.009	0.002	0.007	0.008	0.010	0.015	0.003	0.022	0.003	0.000	0.001	0.003	0.005	0.010	0.001	0.010	0.021	0.010	0.028	0.013
6	0.067	0.049	0.072	0.003	0.012	0.006	0.034	0.004	0.020	0.006	0.051	0.001	0.004	0.001	0.008	0.009	0.006	0.023	0.018	0.032	0.041	0.027
7	0.082	0.077	0.092	0.006	0.012	0.023	0.026	0.036	0.027	0.038	0.026	0.050	0.019	0.019	0.016	0.012	0.031	0.017	0.043	0.048	0.041	0.081
8	0.060	0.075	0.081	0.037	0.022	0.030	0.074	0.065	0.075	0.014	0.058	0.046	0.100	0.043	0.015	0.030	0.036	0.023	0.053	0.071	0.039	0.069
9	0.105	0.057	0.137	0.084	0.025	0.038	0.043	0.052	0.062	0.081	0.045	0.107	0.077	0.123	0.058	0.052	0.036	0.084	0.052	0.055	0.057	0.075
10	0.075	0.103	0.168	0.195	0.067	0.018	0.027	0.040	0.072	0.065	0.092	0.057	0.088	0.076	0.047	0.046	0.072	0.085	0.078	0.075	0.078	0.063
11	0.055	0.060	0.082	0.095	0.076	0.033	0.037	0.042	0.039	0.065	0.093	0.102	0.076	0.087	0.143	0.054	0.073	0.081	0.082	0.085	0.054	0.043
12	0.048	0.093	0.123	0.091	0.138	0.087	0.059	0.031	0.017	0.050	0.063	0.088	0.099	0.077	0.068	0.061	0.044	0.090	0.065	0.062	0.058	0.048
13	0.014	0.069	0.071	0.103	0.078	0.140	0.091	0.042	0.023	0.016	0.032	0.055	0.086	0.095	0.056	0.103	0.045	0.074	0.053	0.055	0.054	0.038
14	0.035	0.034	0.037	0.130	0.071	0.077	0.085	0.091	0.032	0.017	0.014	0.026	0.041	0.061	0.056	0.068	0.020	0.034	0.052	0.051	0.036	0.041
15	0.020	0.047	0.019	0.050	0.100	0.082	0.052	0.078	0.078	0.044	0.013	0.022	0.018	0.039	0.058	0.053	0.046	0.029	0.056	0.044	0.038	0.040
16	0.007	0.028	0.012	0.029	0.109	0.086	0.072	0.048	0.078	0.086	0.055	0.015	0.013	0.021	0.065	0.041	0.028	0.036	0.031	0.031	0.037	0.032
17	0.000	0.032	0.007	0.065	0.053	0.078	0.085	0.061	0.046	0.068	0.053	0.031	0.017	0.018	0.032	0.060	0.050	0.033	0.019	0.026	0.033	0.031
18	0.005	0.012	0.007	0.026	0.048	0.073	0.070	0.077	0.064	0.051	0.064	0.033	0.024	0.023	0.020	0.055	0.063	0.036	0.023	0.018	0.025	0.026
19	0.003	0.003	0.006	0.015	0.044	0.051	0.035	0.085	0.049	0.049	0.035	0.048	0.038	0.028	0.016	0.033	0.056	0.043	0.034	0.028	0.033	0.023
20	0.003	0.006	0.000	0.014	0.020	0.027	0.041	0.048	0.076	0.062	0.052	0.029	0.044	0.043	0.023	0.025	0.044	0.029	0.033	0.032	0.023	0.020
21	0.006	0.010	0.006	0.015	0.027	0.034	0.024	0.030	0.054	0.063	0.052	0.048	0.039	0.031	0.026	0.013	0.041	0.038	0.024	0.038	0.022	0.023
22	0.009	0.024	0.003	0.005	0.025	0.012	0.013	0.028	0.029	0.040	0.059	0.046	0.021	0.023	0.032	0.013	0.018	0.023	0.030	0.015	0.027	0.017
23	0.010	0.006	0.002	0.006	0.009	0.021	0.015	0.040	0.021	0.030	0.022	0.054	0.039	0.022	0.031	0.015	0.010	0.013	0.020	0.016	0.025	0.024
24	0.003	0.016	0.000	0.003	0.005	0.009	0.018	0.018	0.020	0.029	0.019	0.023	0.037	0.032	0.027	0.024	0.012	0.011	0.016	0.012	0.027	0.032
25	0.004	0.000	0.000	0.003	0.005	0.009	0.012	0.014	0.020	0.023	0.026	0.023	0.034	0.035	0.027	0.034	0.024	0.013	0.020	0.020	0.022	0.019
26	0.000	0.008	0.005	0.001	0.002	0.004	0.005	0.003	0.012	0.008	0.021	0.018	0.019	0.016	0.027	0.014	0.030	0.018	0.012	0.012	0.020	0.024
27	0.005	0.000	0.004	0.002	0.000	0.003	0.007	0.002	0.016	0.014	0.006	0.023	0.019	0.016	0.037	0.029	0.032	0.020	0.021	0.023	0.014	0.011
28	0.000	0.002	0.000	0.000	0.003	0.008	0.005	0.001	0.003	0.009	0.006	0.017	0.007	0.014	0.021	0.028	0.023	0.017	0.012	0.020	0.013	0.023
29	0.003	0.000	0.000	0.003	0.001	0.000	0.007	0.006	0.003	0.003	0.001	0.006	0.005	0.011	0.012	0.020	0.029	0.010	0.013	0.013	0.011	0.012
30	0.002	0.000	0.000	0.002	0.002	0.007	0.002	0.003	0.004	0.003	0.005	0.006	0.006	0.008	0.016	0.017	0.025	0.012	0.014	0.011	0.006	0.011
31	0.007	0.000	0.002	0.001	0.000	0.000	0.003	0.005	0.004	0.003	0.003	0.007	0.001	0.008	0.009	0.008	0.026	0.014	0.010	0.011	0.013	0.011
32	0.009	0.003	0.006	0.000	0.004	0.002	0.006	0.000	0.002	0.000	0.006	0.003	0.001	0.001	0.006	0.012	0.019	0.018	0.015	0.010	0.014	0.013
33	0.004	0.000	0.000	0.000	0.000	0.004	0.002	0.000	0.004	0.003	0.003	0.000	0.003	0.004	0.007	0.010	0.012	0.015	0.018	0.011	0.009	0.007
34	0.012	0.000	0.000	0.000	0.000	0.002	0.004	0.002	0.002	0.005	0.002	0.002	0.003	0.000	0.006	0.009	0.015	0.009	0.010	0.012	0.019	0.012
35	0.005	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.003	0.000	0.004	0.005	0.007	0.009	0.010	0.009	0.012	0.015
36	0.011	0.005	0.001	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001	0.000	0.001	0.001	0.007	0.006	0.002	0.002	0.004	0.010	0.010
37	0.013	0.017	0.006	0.000	0.002	0.000	0.000	0.006	0.000	0.005	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.001	0.004	0.004	0.013	0.006
38	0.008	0.005	0.002	0.000	0.000	0.002	0.002	0.000	0.001	0.003	0.000	0.000	0.001	0.003	0.001	0.003	0.004	0.003	0.005	0.002	0.005	0.006
39	0.014	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.000	0.000	0.000	0.000	0.002	0.004	0.003	0.003	0.003	0.004	0.002	0.003
40+	0.089	0.069	0.038	0.009	0.024	0.021	0.027	0.017	0.025	0.016	0.016	0.011	0.013	0.014	0.019	0.020	0.010	0.019	0.014	0.011	0.034	0.040

Table 12.15. Pacific ocean perch biomass estimates (t) and coefficients of variation (in parentheses) from the 1991-2024 triennial trawl surveys for the three management sub-areas in the Aleutian Islands region, and the 2002-2016 EBS slope surveys.

	Aleutian Islands Survey					
Year	Western	Central	Eastern	southern BS	Total AI survey	EBS slope survey
1991	208,464 (0.31)	78,775 (0.25)	55,545 (0.40)	1,501 (0.51)	344,286 (0.21)	
1994	184,703 (0.39)	84,411 (0.33)	100,585 (0.42)	18,217 (0.64)	387,916 (0.23)	
1997	178,436 (0.19)	166,816 (0.28)	220,633 (0.28)	12,099 (0.58)	577,984 (0.15)	
2000	222,632 (0.32)	129,740 (0.32)	140,528 (0.25)	18,870 (0.54)	511,770 (0.18)	
2002	196,704 (0.26)	140,361 (0.41)	109,795 (0.14)	16,311 (0.41)	463,171 (0.17)	72,676 (0.53)
2004	212,639 (0.21)	153,477 (0.17)	137,112 (0.29)	74,208 (0.45)	577,436 (0.13)	112,582 (0.38)
2006	278,990 (0.16)	170,942 (0.23)	190,752 (0.37)	23,701 (0.47)	664,384 (0.14)	
2008						107,891 (0.41)
2010	395,944 (0.21)	221,700 (0.17)	266,607 (0.18)	87,795 (0.55)	972,046 (0.12)	203,460 (0.38)
2012	263,661 (0.23)	233,666 (0.17)	366,414 (0.37)	38,657 (0.63)	902,398 (0.17)	231,220 (0.33)
2014	338,456 (0.21)	315,544 (0.49)	233,560 (0.28)	83,409 (0.50)	970,968 (0.19)	
2016	403,049 (0.19)	206,593 (0.19)	284,908 (0.17)	87,952 (0.47)	982,503 (0.11)	357,379 (0.68)
2018	427,440 (0.20)	195,497 (0.19)	278,326 (0.21)	115,046 (0.29)	1,016,309 (0.11)	
2022	570,272 (0.20)	153,147 (0.23)	232,021 (0.25)	113,738 (0.37)	1,063,030 (0.13)	
2024	529,334 (0.26)	191,364 (0.24)	193,387 (0.18)	69,550 (0.62)	983,636 (0.16)	

Table 12.16. Number of length measurements and otoliths read from the Aleutian Islands and eastern Bering Sea slope surveys.

	Aleutian Islands survey		Eastern Bering Sea slope survey	
Year	Length	Otoliths read	Length	Otoliths read
1980	20,796	890		
1983	22,873	2,495		
1986	14,804	1,860		
1991	14,262	1,015		
1994	18,922	849		
1997	22,823	1,224		
2000	21,972	1,238		
2002	20,284	337	2,040	299
2004	24,949	1,031	4,084	425
2006	19,737	462		
2008			2,818	413
2010	22,725	951	3,348	415
2012	31,450	1,140	3,459	472
2014	30,204	1,078		
2016	36,277	1,062	3,398	400
2018	30,980	918		
2022	23,912	1,204		
2024	16,448			

Table 12.17. AI survey age compositions used in the model.

	Year												
Age	1991	1994	1997	2000	2002	2004	2006	2010	2012	2014	2016	2018	2022
3	0.027	0.003	0.020	0.017	0.021	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.000
4	0.024	0.009	0.011	0.050	0.067	0.027	0.006	0.005	0.014	0.008	0.007	0.011	0.003
5	0.046	0.029	0.014	0.047	0.041	0.019	0.020	0.017	0.011	0.017	0.009	0.005	0.007
6	0.050	0.062	0.028	0.064	0.056	0.052	0.097	0.028	0.015	0.053	0.013	0.011	0.052
7	0.209	0.082	0.048	0.028	0.064	0.049	0.074	0.010	0.050	0.033	0.034	0.024	0.031
8	0.095	0.100	0.095	0.050	0.060	0.111	0.078	0.029	0.053	0.064	0.107	0.020	0.071
9	0.076	0.100	0.139	0.027	0.041	0.084	0.094	0.056	0.026	0.115	0.051	0.041	0.051
10	0.111	0.166	0.116	0.068	0.049	0.095	0.073	0.144	0.055	0.132	0.074	0.098	0.055
11	0.047	0.061	0.119	0.079	0.027	0.049	0.059	0.100	0.077	0.065	0.110	0.038	0.051
12	0.056	0.074	0.065	0.136	0.022	0.031	0.067	0.086	0.107	0.037	0.074	0.067	0.028
13	0.041	0.060	0.090	0.052	0.085	0.027	0.030	0.032	0.057	0.056	0.030	0.060	0.046
14	0.037	0.030	0.035	0.052	0.065	0.033	0.008	0.073	0.038	0.063	0.020	0.044	0.050
15	0.013	0.034	0.027	0.040	0.026	0.021	0.016	0.035	0.048	0.048	0.032	0.027	0.031
16	0.002	0.038	0.021	0.047	0.037	0.046	0.030	0.045	0.049	0.023	0.030	0.025	0.045
17	0.002	0.025	0.028	0.029	0.045	0.036	0.021	0.013	0.039	0.017	0.027	0.033	0.048
18	0.003	0.019	0.013	0.019	0.071	0.043	0.041	0.008	0.025	0.031	0.036	0.027	0.033
19	0.003	0.004	0.009	0.022	0.027	0.041	0.033	0.008	0.008	0.018	0.028	0.031	0.013
20	0.003	0.010	0.016	0.021	0.035	0.045	0.018	0.020	0.009	0.015	0.035	0.037	0.007
21	0.001	0.004	0.013	0.011	0.000	0.016	0.028	0.031	0.011	0.008	0.034	0.038	0.016
22	0.000	0.003	0.008	0.011	0.019	0.014	0.015	0.025	0.012	0.007	0.018	0.039	0.020
23	0.003	0.006	0.005	0.015	0.012	0.021	0.025	0.022	0.032	0.010	0.012	0.030	0.015
24	0.007	0.003	0.002	0.006	0.006	0.019	0.028	0.027	0.024	0.006	0.006	0.019	0.022
25	0.004	0.002	0.002	0.006	0.006	0.010	0.014	0.024	0.013	0.013	0.018	0.017	0.021
26	0.000	0.005	0.008	0.003	0.005	0.006	0.006	0.036	0.022	0.017	0.009	0.007	0.022
27	0.005	0.005	0.004	0.002	0.001	0.007	0.011	0.021	0.042	0.009	0.017	0.009	0.016
28	0.002	0.003	0.001	0.003	0.005	0.008	0.006	0.012	0.020	0.019	0.008	0.013	0.013
29	0.003	0.005	0.003	0.004	0.006	0.005	0.013	0.014	0.015	0.009	0.014	0.025	0.007
30	0.000	0.001	0.003	0.009	0.008	0.001	0.001	0.007	0.010	0.015	0.019	0.024	0.012
31	0.004	0.002	0.005	0.001	0.000	0.002	0.002	0.003	0.013	0.011	0.021	0.026	0.008
32	0.005	0.003	0.005	0.002	0.002	0.001	0.005	0.004	0.012	0.007	0.012	0.022	0.013
33	0.002	0.003	0.001	0.002	0.006	0.007	0.008	0.006	0.008	0.005	0.009	0.027	0.019
34	0.002	0.001	0.002	0.005	0.000	0.000	0.003	0.003	0.017	0.007	0.009	0.014	0.016
35	0.000	0.001	0.001	0.005	0.006	0.006	0.001	0.003	0.004	0.008	0.009	0.006	0.015
36	0.001	0.002	0.002	0.005	0.005	0.003	0.002	0.002	0.003	0.005	0.008	0.013	0.013
37	0.003	0.001	0.003	0.004	0.001	0.001	0.001	0.000	0.005	0.003	0.005	0.006	0.027
38	0.003	0.002	0.001	0.000	0.000	0.002	0.002	0.003	0.003	0.003	0.009	0.005	0.012
39	0.001	0.001	0.000	0.002	0.000	0.004	0.000	0.005	0.003	0.003	0.001	0.003	0.012
40+	0.111	0.042	0.038	0.056	0.074	0.052	0.058	0.037	0.045	0.043	0.043	0.055	0.075

Table 12.18. AI survey length compositions used in the model.

Length (cm)	2024
15	0.000
16	0.000
17	0.000
18	0.000
19	0.001
20	0.001
21	0.002
22	0.003
23	0.004
24	0.005
25	0.007
26	0.007
27	0.008
28	0.012
29	0.016
30	0.025
31	0.036
32	0.037
33	0.054
34	0.075
35	0.096
36	0.114
37	0.102
38	0.092
39+	0.302

Table 12.19. EBS survey age compositions used in the model.

	Year					
Age	2002	2004	2008	2010	2012	2016
3	0.001	0.000	0.000	0.000	0.001	0.001
4	0.001	0.001	0.000	0.000	0.001	0.001
5	0.002	0.002	0.001	0.000	0.003	0.001
6	0.004	0.008	0.005	0.001	0.002	0.000
7	0.013	0.007	0.006	0.003	0.009	0.006
8	0.010	0.026	0.015	0.004	0.016	0.010
9	0.022	0.038	0.032	0.011	0.042	0.044
10	0.021	0.019	0.013	0.040	0.089	0.042
11	0.040	0.035	0.030	0.029	0.076	0.063
12	0.060	0.027	0.085	0.065	0.069	0.029
13	0.074	0.024	0.069	0.050	0.048	0.076
14	0.093	0.079	0.045	0.086	0.067	0.105
15	0.091	0.096	0.039	0.055	0.046	0.053
16	0.069	0.051	0.024	0.040	0.065	0.040
17	0.041	0.050	0.032	0.021	0.043	0.022
18	0.076	0.030	0.065	0.039	0.027	0.051
19	0.055	0.049	0.102	0.040	0.020	0.022
20	0.052	0.054	0.031	0.087	0.038	0.026
21	0.036	0.060	0.026	0.071	0.052	0.018
22	0.017	0.020	0.047	0.045	0.044	0.041
23	0.046	0.021	0.025	0.034	0.022	0.019
24	0.023	0.057	0.046	0.035	0.030	0.009
25	0.021	0.017	0.020	0.032	0.018	0.022
26	0.016	0.018	0.018	0.016	0.008	0.031
27	0.004	0.034	0.021	0.018	0.022	0.044
28	0.000	0.022	0.019	0.016	0.030	0.026
29	0.000	0.000	0.009	0.030	0.018	0.023
30	0.000	0.006	0.013	0.015	0.008	0.020
31	0.002	0.000	0.012	0.024	0.019	0.016
32	0.002	0.005	0.006	0.020	0.006	0.036
33	0.002	0.000	0.004	0.003	0.012	0.020
34	0.008	0.004	0.003	0.001	0.008	0.011
35	0.000	0.005	0.000	0.004	0.008	0.014
36	0.000	0.000	0.002	0.000	0.005	0.001
37	0.000	0.000	0.000	0.000	0.000	0.002
38	0.000	0.000	0.000	0.000	0.004	0.007
39	0.010	0.000	0.009	0.000	0.003	0.006
40+	0.086	0.135	0.124	0.065	0.020	0.043

Table 12.20. Parameters and quantities for the BSAI Pacific ocean perch model, with values where fixed or specified.

Parameter	Description	Value(s)
Y	Year	1960, . . . , 2024
N	Population abundance	
a	Age classes	
a_r	Age of recruitment	3
A	Plus-group age	40
l	Length classes	15, . . ., 39+
$w^p_{y,a}$	Vector of population weight-at-age by year (kg)	
$w^f_{y,a}$	Vector of fishery weight-at-age by year (kg)	
m_a	Vector of maturity-at-age	
μ_r	Average annual recruitment, log-scale	
μ_{init}	Recruitment, log-scale, cohorts in initial year	
μ_f	Average fishing mortality	
ε_y	Annual fishing mortality deviation, log-scale	
τ_y	Annual recruitment deviation	
γ_y	Annual recruitment deviation, cohorts in first year	
σ_R	Recruitment variability	0.75
s^f_a	Vector of selectivity-at-age for fishery	
s^f_a	Vector of selectivity-at-age for survey	
M	Natural mortality	
$F_{y,a}$	Fishing mortality for year *y* and age class *a*	
$Z_{y,a}$	Total mortality for year *y* and age class *a*	
SB_frac	Spawning month as fraction of year	0.25

Table 12.20 (continued). Parameters and quantities for the BSAI northern rockfish model, with values where fixed or specified.

Parameter	Description	Value(s)
$T_{a\rightarrow a'}$	Ageing error matrix	
$T_{a\rightarrow l}$	Age to length conversion matrix	
q	Trawl survey catchability	
SSB_y	Spawning biomass in year y ($=m_a\, w_a\, N_{y,a}$)	
M_{prior}	Prior mean for natural mortality	0.05
q_{prior}	Prior mean for trawl survey catchability	1.0
σ_M	Prior log-scale standard deviation for natural mortality	0.05
σ_q	Prior log-scale standard deviation for trawl survey catchability	0.15
$n_y^{f,a}, n_y^{f,l}, n_y^{t,a}$	First-stage input sample sizes for fishery length and age compositions, and survey age compositions (square root of fish lengthed or aged)	
$\lambda_{\hat{p}_a^f}, \lambda_{\hat{p}_l^f}, \lambda_{\hat{p}_a^t}$	Second-stage weights for fishery length and age compositions, and survey age compositions (from McAllister-Ianelli weighting)	
$\lambda_{\hat{C}}$,	Weight for catch likelihood	500
$\lambda_{\hat{I}}$	Weight for survey index	1
λ_f	Weight for F fishing mortality deviations	0.1

Table 12.21. Equations for modeling the population dynamics and observed data for BSAI Pacific ocean perch, see Table 12.12 for definitions.

Equations describing population dynamics

$N_{y,3} = \begin{cases} e^{\mu_r + \tau_y} & 1960 \le y \le 2021 \\ e^{\mu_r + \sigma_r^2/2} & 2022 \le y \le 2024 \end{cases}$	Number at age of recruitment
$N_{styr,a} = \begin{cases} e^{\mu_{init} - M(a-a_r)} & a_r < a < A \\ \frac{e^{\mu_{init} - M(A-a_r)}}{(1-e^{-M})} & a = A \end{cases}$	Numbers at age, start year
$N_{y,a} = \begin{cases} N_{y-1,a-1} e^{-Z_{y-1,a-1}} & a_r < a < A \\ N_{y-1,a-1} e^{-Z_{y-1,a-1}} + N_{y-1,a} e^{-Z_{y-1,a}} & a = A \end{cases}$	Numbers at age, subsequent years
$s_a^f = bicubic\_spline(5\ age\ nodes, 5\ year\ nodes)$	Fishery selectivity
$F_{y,a} = s_a^f e^{\mu_f + \epsilon_y}$	Fishing mortality
$Z_{y,a} = F_{y,a} + M$	Total mortality
$SSB_{y,a} = 0.5 N_{y,a} m_a w_{y,a}^p e^{-SB_{frac} * Z_{y,a}}$	Spawning biomass

Equations describing the observed data

$\bar{N}_{y,a} = N_{y,a}(1 - e^{-Z_{y,a}})/Z_{y,a}$	Mean numbers at age
$\hat{C}_{y,a} = F_{y,a} \bar{N}_{y,a}$	Estimated catch numbers at age
$\hat{Y}_t = \sum_{a=a_r}^{A} w_a \hat{C}_{y,a}$	Estimated catch biomass
$s_a^t = \left(1 + e^{-\delta^t (a - a_{50\%}^t)}\right)^{-1}$	Trawl survey selectivity (AI and EBS)
$\hat{I}_{t,y} = q \sum_{a=a_r}^{A} w_a s_a^t \bar{N}_{y,a}$	Estimated trawl survey biomass (AI and EB
$\hat{p}_{y,a}^t = T_{a \to a'} \frac{s_a^t \bar{N}_{y,a}}{\sum_{a=a_r}^{A} s_a^t \bar{N}_{y,a}}$	Estimated trawl survey age compositon (AI
$\hat{p}_{y,l}^f = T_{a \to l} \frac{\hat{C}_{y,a}}{\sum_{a=a_r}^{A} \hat{C}_{y,a}}$	Estimated fishery length compositon (AI and
$\hat{p}_{y,a}^f = T_{a \to a'} \frac{\hat{C}_{y,a}}{\sum_{a=a_r}^{A} \hat{C}_{y,a}}$	Estimated fishery age compositon
$\hat{m}_a = \left(1 + e^{-\delta^m (a - a_{50\%}^m)}\right)^{-1}$	Estimated maturity at age

Table 12.22. Equations for likelihood components for the BSAI northern rockfish model, see Tables 12.20 – 12.21 for definitions.

Negative log likelihood, data components	
$L_{\hat{c}} = \lambda_{\hat{c}} \sum_{Y} ln\left(\frac{Y_y + 0.001}{\hat{Y}_y + 0.001}\right)^2$	Catch likelihood
$L_{\hat{I}} = \lambda_{\hat{I}} \sum_{Y} \frac{1}{2(\sigma_{I,y}/I_y)} ln\left(\frac{I_y}{\hat{I}_y}\right)^2$	Trawl survey biomass likelihood
$L_{\hat{p}_a^f} = \lambda_{\hat{p}_a^f}\left(\sum_{Y} -n_y^{f,a} \sum_{a=a_r}^{A} \left(p_{y,a}^f + 0.00001\right) ln\left(\hat{p}_{y,a}^f + 0.00001\right)\right)$	Fishery age compostion likelihood
$L_{\hat{p}_l^f} = \lambda_{\hat{p}_l^f}\left(\sum_{Y} -n_y^{f,l} \sum_{L} \left(p_{y,l}^f + 0.00001\right) ln\left(\hat{p}_{y,l}^f + 0.00001\right)\right)$	Fishery length compostion likelihood
$L_{\hat{p}_a^t} = \lambda_{\hat{p}_a^t}\left(\sum_{Y} -n_y^{t,a} \sum_{a=a_r}^{A} \left(p_{y,a}^t + 0.00001\right) ln\left(\hat{p}_{y,a}^t + 0.00001\right)\right)$	Trawl survey age compostion likelihood
$L_m = \sum_{D} \sum_{a=a_r}^{A} -\lambda_{D,a} \ln\left(Binom\left(n_{a,D}, \widehat{m}_a\right)\right)$	Maturity likelihood
Negative log likelihoods, prior distributions and penalties	
$L_r = \frac{1}{2\sigma_r^2} \sum_{Y} \left(\tau_y + \sigma_r^2/2\right)^2 + Y \ln \sigma_r$	Recruitment deviations
$L_M = \frac{1}{2\sigma_M^2}\left(\ln\theta - \ln M_{prior} + \sigma_M^2/2\right)^2$	Prior distribution for natural mortality
$L_q = \frac{1}{2\sigma_q^2}\left(\ln\theta - \ln q_{prior} + \sigma_q^2/2\right)^2$	Prior distribution for AI survey catchability
$L_f = \lambda_f \sum_{Y} \epsilon_y^2$	F deviation penalty

Table 12.23. Negative log likelihoods, root mean squared errors, and estimates and CV for key model quantities, for BSAI POP models. Model 24 is the recommended model.

	Model 16.3 (2024)	Model 24
Negative log-likelihood		
Data components		
AI survey biomass	9.30	8.77
EBS survey biomass	2.08	2.05
Catch biomass	0.00	0.00
Fishery age comp	276.50	298.19
Fishery length comp	166.05	213.05
AI survey age comp	160.25	176.07
AI survey length comp	8.01	7.50
EBS survey age comp	67.29	73.91
Maturity	2.71	2.71
Priors and penalties		
Recruitment	12.15	11.98
Prior on AI survey q	0.00	0.11
Prior on M	0.47	0.03
Fishery selectivity	97.07	108.12
Total negative log-likelihood	809.57	910.07
Parameters	164	164
Root mean square error		
AI survey biomass	0.177	0.169
EBS survey biomass	0.425	0.422
Recruitment	0.792	0.785
Fishery age comp	0.012	0.012
Fishery length comp	0.023	0.026
AI survey age comp	0.011	0.012
AI survey length comp	0.014	0.012
EBS survey age comp	0.016	0.016
Harmonic mean of effective N		
Fishery age comp	212.079	205.662
Fishery length comp	184.760	155.640
AI survey age comp	186.675	173.565
AI survey length comp	182.042	223.607
EBS survey age comp	107.199	91.415
Estimated key quantities		
M	0.052	0.051
CV	0.036	0.040
AI survey q	0.917	1.061
CV	0.051	0.099
EBS survey q	0.221	0.259
CV	0.218	0.198
2024 total biomass(t)	998,000	864,800
CV	0.173	0.132
2024 SSB(t)	417,420	359,280
CV	0.197	0.160

Table 12.24. Estimated parameter values and standard deviations for the BSAI POP assessment model (model 24).

Parameter	Estimate	Standard Deviation	Parameter	Estimate	Standard Deviation	Parameter	Estimate	Standard Deviation
fsh_sel_par	-2.4147	0.2129	fmort_dev	-1.9880	0.2817	rec_dev	-0.6898	0.4310
fsh_sel_par	-0.7006	0.1485	fmort_dev	-3.2202	0.2813	rec_dev	-0.5147	0.3094
fsh_sel_par	-2.5145	0.1477	fmort_dev	-2.0466	0.2810	rec_dev	-1.2217	0.4053
fsh_sel_par	-2.7313	0.1297	fmort_dev	-1.3139	0.2808	rec_dev	-1.0818	0.3149
fsh_sel_par	-1.4736	0.2279	fmort_dev	-1.0017	0.2807	rec_dev	-1.1763	0.3526
fsh_sel_par	1.1776	0.1013	fmort_dev	-0.6052	0.2807	rec_dev	-0.2649	0.2211
fsh_sel_par	0.5679	0.0661	fmort_dev	0.5179	0.2808	rec_dev	-0.4018	0.2838
fsh_sel_par	0.5723	0.0606	fmort_dev	-0.4151	0.2810	rec_dev	-0.8913	0.4456
fsh_sel_par	0.3842	0.0502	fmort_dev	0.0228	0.2812	rec_dev	-0.2414	0.4449
fsh_sel_par	0.2548	0.0913	fmort_dev	0.1668	0.2813	rec_dev	0.3456	0.3759
fsh_sel_par	0.3684	0.0925	fmort_dev	-0.2376	0.2815	rec_dev	0.5141	0.3264
fsh_sel_par	0.0659	0.0571	fmort_dev	-0.4195	0.2816	rec_dev	-0.0017	0.4190
fsh_sel_par	0.3192	0.0556	fmort_dev	-0.1937	0.2816	rec_dev	-0.2581	0.4582
fsh_sel_par	0.3428	0.0519	fmort_dev	-0.4264	0.2815	rec_dev	1.4335	0.1229
fsh_sel_par	-0.0678	0.1000	fmort_dev	-0.7752	0.2813	rec_dev	-0.2366	0.4993
fsh_sel_par	-0.2553	0.0926	fmort_dev	-0.5689	0.2811	rec_dev	0.6924	0.2076
fsh_sel_par	-0.1684	0.0587	fmort_dev	-0.8800	0.2810	rec_dev	-0.1578	0.4187
fsh_sel_par	0.1537	0.0597	fmort_dev	-0.9382	0.2808	rec_dev	1.1113	0.1543
fsh_sel_par	0.3492	0.0578	fmort_dev	-0.7791	0.2808	rec_dev	0.4607	0.2730
fsh_sel_par	0.3052	0.1016	fmort_dev	-0.5081	0.2808	rec_dev	-0.0450	0.3164
fsh_sel_par	-0.6974	0.1484	fmort_dev	-0.7246	0.2808	rec_dev	-0.7762	0.4087
fsh_sel_par	-0.4533	0.0943	fmort_dev	-0.8682	0.2809	rec_dev	-0.3432	0.2726
fsh_sel_par	0.0038	0.0945	fmort_dev	-0.6788	0.2809	rec_dev	-0.5271	0.3627
fsh_sel_par	0.1527	0.0925	fmort_dev	-0.3428	0.2811	rec_dev	0.6482	0.1720
fsh_sel_par	0.1884	0.1542	fmort_dev	-0.4262	0.2812	rec_dev	0.3689	0.2658
sel_aslope_srv[1]	0.8279	0.0657	fmort_dev	-0.5842	0.2814	rec_dev	1.1689	0.1361
sel_aslope_srv[2]	0.7159	0.1058	fmort_dev	-0.4615	0.2816	rec_dev	-0.3549	0.4318
sel_a50_srv[1]	6.3878	0.1730	fmort_dev	-0.1847	0.2818	rec_dev	1.0281	0.1427
sel_a50_srv[2]	10.9430	0.4622	fmort_dev	-0.1873	0.2820	rec_dev	-0.1169	0.3994
log_avg_M	-2.9843	0.0396	fmort_dev	0.0757	0.2822	rec_dev	1.4538	0.1101
log_avg_fmort	-3.6644	0.2882	fmort_dev	0.1193	0.2826	rec_dev	-0.5410	0.4881
fmort_dev	-1.6952	0.2895	fmort_dev	0.1042	0.2830	rec_dev	0.4090	0.2193
fmort_dev	0.3890	0.2891	fmort_dev	0.1114	0.2834	rec_dev	-0.4822	0.4756
fmort_dev	-0.4057	0.2887	fmort_dev	0.1577	0.2839	rec_dev	0.7543	0.2156
fmort_dev	0.4538	0.2883	fmort_dev	0.2444	0.2846	rec_dev	0.9441	0.2130
fmort_dev	1.5287	0.2872	fmort_dev	0.4957	0.2855	rec_dev	0.2744	0.3574
fmort_dev	1.8489	0.2860	fmort_dev	0.4602	0.2866	rec_dev	0.1382	0.3690
fmort_dev	1.9029	0.2857	fmort_dev	0.3579	0.2878	rec_dev	1.1427	0.1658
fmort_dev	1.7222	0.2857	fmort_dev	0.3639	0.2892	rec_dev	0.0146	0.4041
fmort_dev	1.8542	0.2854	fmort_dev	0.4245	0.2907	rec_dev	0.0887	0.3643
fmort_dev	1.5815	0.2850	fmort_dev	0.4448	0.2924	rec_dev	0.6100	0.2580
fmort_dev	2.0539	0.2843	rec_dev	1.3195	0.2383	rec_dev	0.5047	0.2910
fmort_dev	1.2602	0.2842	rec_dev	-0.4084	0.6302	rec_dev	0.1841	0.3688
fmort_dev	1.5281	0.2841	rec_dev	-0.4649	0.6092	rec_dev	0.7932	0.2345
fmort_dev	0.6604	0.2841	rec_dev	-0.1940	0.6849	rec_dev	0.0147	0.4051
fmort_dev	1.5948	0.2839	rec_dev	0.8678	0.6860	rec_dev	0.7715	0.2260
fmort_dev	1.3499	0.2839	rec_dev	1.3365	0.4020	rec_dev	-0.7775	0.4802
fmort_dev	1.6113	0.2841	rec_dev	-0.5001	0.6142	rec_dev	-0.7813	0.4716
fmort_dev	0.6674	0.2845	rec_dev	-0.8850	0.5274	mean_log_rec	4.3129	0.0814
fmort_dev	0.3707	0.2843	rec_dev	-0.9264	0.4950	log_rinit	3.9641	0.0845
fmort_dev	0.3307	0.2840	rec_dev	-0.7665	0.4643	log_q_srv_AI	0.0590	0.0983
fmort_dev	-0.0535	0.2836	rec_dev	-0.8501	0.4450	log_q_srv_EBS	-1.3492	0.1962
fmort_dev	-0.0987	0.2832	rec_dev	-1.1527	0.4625	mat_beta1	-6.6118	3.6559
fmort_dev	-1.5518	0.2827	rec_dev	-0.9159	0.4461	mat_beta2	0.7270	0.4473
fmort_dev	-2.1954	0.2822	rec_dev	-0.4464	0.3739			

Table 12.25. Estimated time series of POP total biomass (t), spawning biomass (t), and recruitment (thousands) for the 2022 assessment (model 16.s) and model 24 in this assessment.

	Total Biomass (ages 3+)				Spawner Biomass (ages 3+)				Recruitment (age 3)			
	Assessment Year				Assessment Year				Assessment Year			
	2024		2022		2024		2022		2024		2022	
Year	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
1977	211,600	0.092	291,970	0.101	84,760	0.116	124,230	0.113	25,307	0.322	26,696	0.320
1978	205,390	0.095	280,050	0.104	81,920	0.121	118,510	0.117	23,026	0.362	25,190	0.357
1979	205,250	0.095	275,020	0.105	80,504	0.127	114,430	0.122	57,280	0.229	65,272	0.227
1980	206,240	0.096	271,720	0.106	79,892	0.133	111,330	0.126	49,950	0.291	57,938	0.295
1981	208,870	0.096	270,970	0.106	80,304	0.136	109,430	0.129	30,618	0.453	40,854	0.450
1982	214,550	0.095	274,100	0.106	81,341	0.136	108,330	0.130	58,642	0.449	73,075	0.439
1983	229,830	0.092	286,440	0.104	83,871	0.135	108,940	0.131	105,470	0.381	109,660	0.412
1984	250,880	0.088	306,540	0.101	87,116	0.137	110,540	0.135	124,840	0.332	150,510	0.318
1985	271,120	0.085	325,980	0.099	91,238	0.142	113,370	0.141	74,524	0.425	87,569	0.427
1986	292,070	0.083	346,310	0.097	96,618	0.148	117,790	0.149	57,674	0.469	67,233	0.468
1987	336,830	0.080	392,700	0.095	103,170	0.157	123,740	0.158	313,060	0.134	360,300	0.141
1988	367,790	0.079	424,420	0.094	111,020	0.168	131,280	0.170	58,927	0.513	66,331	0.510
1989	405,800	0.078	463,720	0.094	120,650	0.182	140,840	0.183	149,200	0.214	166,490	0.217
1990	436,940	0.077	495,620	0.094	130,730	0.194	151,090	0.195	63,758	0.431	72,438	0.421
1991	468,240	0.079	527,890	0.097	140,040	0.202	160,790	0.204	226,810	0.168	247,700	0.176
1992	505,780	0.079	566,160	0.097	154,170	0.208	175,490	0.211	118,340	0.285	132,090	0.281
1993	532,940	0.080	593,850	0.099	168,250	0.213	190,310	0.217	71,368	0.324	79,770	0.319
1994	550,950	0.081	611,390	0.102	182,890	0.210	205,630	0.215	34,352	0.419	37,844	0.417
1995	570,890	0.082	630,700	0.103	199,150	0.199	222,420	0.205	52,967	0.282	59,075	0.283
1996	587,560	0.082	645,930	0.105	214,840	0.188	238,280	0.195	44,070	0.375	48,682	0.376
1997	605,270	0.083	662,290	0.107	228,680	0.179	252,040	0.187	142,750	0.186	157,580	0.196
1998	622,820	0.084	678,460	0.108	242,150	0.167	265,130	0.178	107,960	0.281	122,990	0.280
1999	655,770	0.084	710,760	0.109	253,950	0.151	276,370	0.164	240,260	0.153	267,600	0.168
2000	673,920	0.085	727,330	0.111	262,120	0.133	283,570	0.151	52,348	0.446	58,570	0.445
2001	707,300	0.085	760,130	0.112	269,350	0.122	289,750	0.142	208,700	0.159	234,340	0.173
2002	732,010	0.085	783,390	0.113	276,070	0.120	295,360	0.141	66,420	0.414	73,263	0.416
2003	775,950	0.085	827,710	0.114	283,170	0.126	301,570	0.148	319,480	0.132	359,340	0.151
2004	799,410	0.086	850,140	0.115	291,880	0.136	309,490	0.158	43,462	0.502	47,753	0.504
2005	828,000	0.086	878,460	0.117	304,240	0.144	321,360	0.166	112,380	0.230	127,430	0.237
2006	851,140	0.086	900,030	0.118	318,640	0.148	335,300	0.170	46,094	0.488	50,210	0.488
2007	877,350	0.087	925,100	0.119	332,530	0.149	348,870	0.172	158,720	0.229	174,270	0.237
2008	901,630	0.088	947,070	0.121	345,170	0.150	361,140	0.174	191,890	0.229	201,730	0.242
2009	919,850	0.089	963,040	0.123	358,260	0.148	373,930	0.174	98,225	0.368	103,050	0.371
2010	937,110	0.089	977,490	0.124	370,550	0.143	385,690	0.170	85,716	0.382	92,722	0.377
2011	963,040	0.090	1,000,300	0.126	379,180	0.135	393,640	0.164	234,060	0.185	247,100	0.205
2012	971,660	0.092	1,005,000	0.129	383,820	0.130	397,210	0.161	75,755	0.417	76,013	0.431
2013	977,660	0.094	1,007,800	0.132	386,980	0.130	399,180	0.162	81,578	0.376	90,485	0.375
2014	978,910	0.096	1,005,200	0.136	387,800	0.134	398,490	0.167	137,390	0.274	147,100	0.300
2015	977,460	0.099	1,000,800	0.140	388,620	0.137	397,740	0.171	123,660	0.306	139,050	0.330
2016	973,270	0.102	992,710	0.143	389,710	0.139	397,000	0.174	89,740	0.384	91,039	0.435
2017	974,250	0.105	988,150	0.147	390,390	0.141	395,890	0.178	165,020	0.252	152,140	0.331
2018	967,470	0.108	976,520	0.151	389,790	0.142	393,390	0.181	75,759	0.421	78,718	0.485
2019	963,890	0.111	963,440	0.156	386,320	0.142	388,110	0.184	161,470	0.246	114,680	0.405
2020	941,090	0.116	940,150	0.162	379,350	0.145	379,290	0.189	34,306	0.496		
2021	917,110	0.120	919,070	0.167	373,530	0.149	371,620	0.195	34,177	0.489		
2022	900,430	0.124	902,540	0.171	369,270	0.153	365,390	0.200				
2023	883,370	0.128	888,872		364,770	0.157	359,074					
2024	864,800	0.132			359,280	0.160						
2025	847,803				352,503							
Mean recruitment of post-1976 year classes									112,426		126,618	

Table 12.26. Estimated numbers at age for POP (millions) from model 24.

	Age																	
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1960	279.3	66.3	63.1	60.0	57.0	54.2	51.5	49.0	46.6	44.3	42.1	40.0	38.0	36.2	34.4	32.7	31.1	29.5
1961	49.6	265.4	63.0	59.9	56.9	54.0	51.3	48.6	46.1	43.7	41.5	39.4	37.4	35.6	33.8	32.2	30.7	29.2
1962	46.9	47.0	250.9	59.4	56.1	52.8	49.5	46.2	42.9	39.8	36.9	34.5	32.6	31.1	29.9	28.8	27.9	26.9
1963	61.5	44.5	44.6	237.5	56.0	52.7	49.3	45.9	42.4	39.0	35.8	33.1	30.9	29.2	28.0	27.0	26.2	25.5
1964	177.8	58.2	42.1	42.0	222.2	51.9	48.2	44.3	40.3	36.3	32.7	29.6	27.2	25.4	24.3	23.6	23.2	22.9
1965	284.1	167.3	54.4	38.8	38.0	195.8	43.9	38.6	33.3	28.2	23.9	20.5	18.3	17.0	16.4	16.4	16.7	17.1
1966	45.3	265.4	154.6	49.4	34.4	32.4	157.9	33.0	26.7	21.1	16.5	13.3	11.2	10.2	9.8	10.0	10.6	11.4
1967	30.8	42.1	243.7	139.2	43.3	28.9	25.7	117.0	22.6	16.8	12.3	9.2	7.3	6.3	5.9	6.0	6.4	7.2
1968	29.6	28.7	38.7	220.3	122.8	36.9	23.5	19.9	84.8	15.4	10.8	7.7	5.7	4.6	4.0	3.9	4.2	4.7
1969	34.7	27.3	26.1	34.5	190.9	102.4	29.3	17.6	13.9	55.8	9.6	6.5	4.6	3.5	2.9	2.6	2.7	3.0
1970	31.9	32.1	25.0	23.5	30.4	163.4	84.6	23.2	13.3	10.1	39.1	6.6	4.5	3.2	2.4	2.1	2.0	2.1
1971	23.6	28.8	28.5	21.5	19.6	24.2	123.3	60.0	15.4	8.3	6.0	22.6	3.8	2.6	1.9	1.5	1.4	1.4
1972	29.9	21.8	26.5	25.8	19.2	17.1	20.7	102.7	48.6	12.2	6.5	4.6	17.3	2.9	2.1	1.5	1.3	1.1
1973	47.8	27.3	19.7	23.5	22.5	16.3	14.1	16.6	79.6	36.6	9.0	4.7	3.4	12.8	2.2	1.6	1.2	1.0
1974	37.5	44.6	25.4	18.2	21.5	20.3	14.6	12.5	14.5	68.8	31.4	7.7	4.0	2.9	11.0	1.9	1.4	1.1
1975	44.6	33.8	39.7	22.2	15.6	18.0	16.6	11.6	9.6	10.9	50.8	23.0	5.6	3.0	2.2	8.4	1.5	1.1
1976	22.0	40.6	30.4	35.2	19.4	13.4	15.1	13.6	9.4	7.6	8.5	39.7	18.0	4.4	2.4	1.8	6.9	1.2
1977	25.3	19.7	35.8	26.4	30.0	16.1	10.9	12.0	10.6	7.1	5.7	6.3	29.6	13.5	3.4	1.8	1.4	5.5
1978	23.0	23.5	18.2	32.8	24.0	27.0	14.4	9.6	10.5	9.2	6.2	4.9	5.5	25.7	11.8	3.0	1.6	1.2
1979	57.3	21.5	21.8	16.8	30.2	22.0	24.6	13.0	8.6	9.4	8.2	5.5	4.4	4.9	23.0	10.6	2.7	1.5
1980	49.9	53.5	20.0	20.2	15.5	27.7	20.0	22.3	11.7	7.7	8.4	7.3	4.9	3.9	4.4	20.7	9.6	2.4
1981	30.6	46.9	50.2	18.7	18.8	14.4	25.6	18.4	20.4	10.7	7.1	7.6	6.7	4.4	3.6	4.0	19.0	8.9
1982	58.6	28.8	44.1	46.9	17.4	17.5	13.3	23.6	16.9	18.7	9.8	6.4	7.0	6.1	4.1	3.3	3.7	17.6
1983	105.5	55.6	27.3	41.7	44.4	16.5	16.5	12.6	22.3	16.0	17.6	9.2	6.1	6.6	5.7	3.8	3.1	3.5
1984	124.8	100.2	52.8	25.9	39.6	42.1	15.6	15.7	11.9	21.1	15.1	16.7	8.7	5.7	6.2	5.4	3.6	2.9
1985	74.5	118.5	95.1	50.1	24.6	37.5	39.9	14.8	14.8	11.3	19.9	14.3	15.7	8.2	5.4	5.9	5.1	3.4
1986	57.7	70.8	112.7	90.3	47.6	23.4	35.7	37.9	14.1	14.1	10.7	18.9	13.5	14.9	7.8	5.1	5.6	4.9
1987	313.1	54.8	67.3	106.9	85.7	45.2	22.1	33.8	35.9	13.3	13.3	10.1	17.9	12.8	14.1	7.4	4.9	5.3
1988	58.9	297.2	52.0	63.8	101.3	81.1	42.7	20.9	31.8	33.8	12.5	12.5	9.5	16.8	12.0	13.3	7.0	4.6
1989	149.2	55.9	281.8	49.3	60.4	95.7	76.5	40.2	19.6	29.8	31.6	11.7	11.7	8.8	15.7	11.2	12.4	6.5
1990	63.8	141.5	53.0	266.8	46.5	56.9	90.0	71.7	37.5	18.3	27.7	29.3	10.8	10.8	8.2	14.5	10.4	11.6
1991	226.8	60.3	133.4	49.8	249.3	43.2	52.4	82.1	64.7	33.5	16.1	24.3	25.6	9.4	9.5	7.2	12.9	9.3
1992	118.3	215.2	57.1	126.3	47.0	235.0	40.6	49.1	76.5	60.0	30.9	14.9	22.3	23.5	8.7	8.7	6.7	11.9
1993	71.4	112.2	203.8	54.0	119.0	44.2	219.6	37.7	45.2	70.0	54.6	28.0	13.4	20.1	21.2	7.9	7.9	6.1
1994	34.4	67.7	106.2	192.5	50.8	111.6	41.2	203.3	34.6	41.2	63.2	48.9	25.0	12.0	18.0	19.0	7.1	7.2
1995	53.0	32.6	64.2	100.6	181.9	47.9	104.8	38.5	189.0	32.0	37.8	57.8	44.6	22.8	10.9	16.4	17.4	6.5
1996	44.1	50.3	30.9	60.8	95.2	171.8	45.1	98.3	35.9	175.5	29.6	34.8	53.1	40.9	20.9	10.0	15.1	16.1
1997	142.7	41.8	47.7	29.3	57.5	89.8	161.4	42.2	91.4	33.2	161.0	27.0	31.7	48.2	37.2	19.0	9.2	13.9
1998	108.0	135.6	39.7	45.2	27.8	54.3	84.6	151.5	39.4	84.9	30.7	148.2	24.8	29.0	44.2	34.2	17.5	8.5
1999	240.3	102.6	128.7	37.7	42.9	26.3	51.3	79.7	142.3	36.9	79.1	28.5	137.5	23.0	26.9	41.1	31.8	16.3
2000	52.3	228.2	97.4	122.1	35.7	40.6	24.8	48.3	74.7	132.7	34.2	73.2	26.3	126.7	21.2	24.8	38.0	29.5
2001	208.7	49.7	216.8	92.4	115.8	33.8	38.4	23.4	45.4	70.0	124.0	31.9	68.1	24.4	117.8	19.7	23.1	35.4
2002	66.4	198.3	47.2	205.8	87.7	109.8	32.0	36.2	22.0	42.6	65.5	115.7	29.7	63.4	22.8	109.7	18.4	21.6
2003	319.5	63.1	188.3	44.8	195.2	83.0	103.8	30.2	34.0	20.6	39.8	60.9	107.4	27.6	58.8	21.1	102.0	17.1
2004	43.5	303.5	59.9	178.7	42.5	184.6	78.4	97.6	28.3	31.7	19.1	36.8	56.2	99.0	25.4	54.2	19.5	94.4
2005	112.4	41.3	288.2	56.9	169.4	40.2	174.5	73.9	91.7	26.5	29.6	17.8	34.1	52.1	91.8	23.6	50.4	18.2
2006	46.1	106.8	39.2	273.6	53.9	160.5	38.1	164.6	69.5	86.0	24.8	27.6	16.6	31.8	48.5	85.4	22.0	47.0
2007	158.7	43.8	101.4	37.2	259.4	51.1	151.6	35.9	154.7	65.1	80.2	23.0	25.6	15.4	29.5	45.0	79.3	20.4
2008	191.9	150.7	41.6	96.1	35.2	245.1	48.1	142.4	33.5	143.9	60.3	74.0	21.2	23.5	14.1	27.1	41.4	73.2
2009	98.2	182.2	143.1	39.4	91.1	33.3	231.1	45.2	133.3	31.3	133.6	55.7	68.3	19.5	21.7	13.0	25.0	38.3
2010	85.7	93.3	173.0	135.7	37.3	86.1	31.5	217.6	42.4	124.7	29.1	124.1	51.7	63.2	18.1	20.1	12.1	23.2
2011	234.1	81.4	88.5	164.0	128.5	35.3	81.2	29.6	203.9	39.6	115.9	27.0	114.7	47.7	58.4	16.7	18.6	11.2
2012	75.8	222.2	77.2	83.9	155.1	121.3	33.2	76.1	27.6	189.2	36.6	106.6	24.7	105.0	43.7	53.5	15.3	17.1
2013	81.6	71.9	210.7	73.1	79.3	146.4	114.1	31.1	71.0	25.6	174.7	33.6	97.8	22.7	96.3	40.1	49.2	14.1
2014	137.4	77.4	68.1	199.3	69.0	74.6	137.2	106.3	28.8	65.4	23.4	159.2	30.6	88.7	20.6	87.5	36.5	44.9
2015	123.7	130.3	73.3	64.4	188.0	64.9	69.9	127.7	98.5	26.5	59.8	21.3	144.5	27.7	80.5	18.7	79.6	33.3
2016	89.7	117.2	123.3	69.3	60.7	176.7	60.7	65.1	118.3	90.6	24.3	54.5	19.4	131.3	25.2	73.2	17.0	72.8
2017	165.0	85.1	111.0	116.5	65.3	57.0	165.3	56.5	60.2	108.9	83.0	22.1	49.6	17.6	119.3	22.9	66.8	15.6
2018	75.8	156.3	80.5	104.8	109.7	61.2	53.3	153.6	52.2	55.3	99.5	75.5	20.1	45.0	16.0	108.6	20.9	61.1
2019	161.5	71.7	147.7	75.9	98.5	102.8	57.1	49.4	141.5	47.8	50.4	90.3	68.4	18.2	40.8	14.5	98.8	19.1
2020	34.3	152.6	67.6	138.9	71.1	91.8	95.2	52.5	45.1	128.3	43.1	45.2	80.7	61.1	16.3	36.6	13.1	89.2
2021	34.2	32.4	143.8	63.6	130.0	66.2	85.0	87.6	48.0	40.9	115.7	38.7	40.5	72.4	54.9	14.7	33.0	11.8
2022	98.9	32.3	30.6	135.2	59.5	121.3	61.4	78.4	80.3	43.7	37.1	104.6	34.9	36.6	65.4	49.7	13.3	30.1
2023	98.9	93.4	30.4	28.7	126.6	55.5	112.4	56.6	71.9	73.2	39.7	33.6	94.5	31.6	33.1	59.4	45.3	12.2
2024	98.9	93.3	87.8	28.5	26.8	117.7	51.3	103.3	51.7	65.3	66.2	35.8	30.2	85.2	28.5	30.0	54.0	41.3

Table 12.26 (continued). Estimated numbers at age for POP (millions) from model 24.

	Age																			
Year	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40+
1960	28.1	26.7	25.4	24.1	22.9	21.8	20.7	19.7	18.7	17.8	16.9	16.1	15.3	14.5	13.8	13.1	12.5	11.9	11.3	217.8
1961	27.8	26.5	25.2	24.0	22.8	21.7	20.6	19.6	18.7	17.7	16.9	16.0	15.2	14.5	13.8	13.1	12.5	11.9	11.3	217.3
1962	25.9	25.0	23.9	22.9	21.9	20.9	19.9	19.0	18.1	17.2	16.4	15.6	14.8	14.1	13.4	12.8	12.2	11.6	11.0	213.2
1963	24.8	24.0	23.2	22.3	21.4	20.4	19.5	18.6	17.8	16.9	16.1	15.4	14.6	13.9	13.3	12.6	12.0	11.5	10.9	211.4
1964	22.6	22.1	21.6	21.0	20.3	19.5	18.7	17.9	17.1	16.3	15.6	14.9	14.2	13.5	12.9	12.3	11.7	11.2	10.7	207.1
1965	17.5	17.8	17.9	17.8	17.5	17.1	16.6	16.0	15.4	14.8	14.1	13.5	13.0	12.4	11.9	11.4	10.9	10.4	10.0	195.2
1966	12.2	13.1	13.7	14.1	14.2	14.2	14.0	13.6	13.2	12.8	12.3	11.9	11.4	11.0	10.6	10.2	9.8	9.4	9.0	179.6
1967	8.1	9.1	10.0	10.7	11.2	11.4	11.5	11.4	11.2	10.9	10.6	10.3	9.9	9.6	9.3	9.0	8.7	8.4	8.1	164.3
1968	5.4	6.3	7.2	8.1	8.7	9.2	9.5	9.6	9.6	9.5	9.3	9.0	8.8	8.5	8.3	8.0	7.8	7.6	7.3	152.2
1969	3.5	4.1	4.9	5.7	6.5	7.1	7.6	7.8	8.0	8.0	7.9	7.8	7.6	7.4	7.2	7.1	6.9	6.7	6.5	139.2
1970	2.4	2.8	3.4	4.1	4.8	5.5	6.0	6.4	6.7	6.8	6.9	6.8	6.7	6.6	6.5	6.3	6.2	6.1	5.9	129.8
1971	1.5	1.7	2.1	2.6	3.2	3.8	4.3	4.8	5.2	5.4	5.5	5.6	5.6	5.5	5.4	5.4	5.3	5.2	5.1	115.9
1972	1.1	1.3	1.5	1.8	2.3	2.8	3.3	3.8	4.2	4.6	4.8	4.9	5.0	5.0	4.9	4.9	4.8	4.8	4.7	109.6
1973	0.9	0.9	1.0	1.3	1.5	1.9	2.4	2.8	3.3	3.7	3.9	4.1	4.3	4.3	4.3	4.3	4.3	4.2	4.2	101.8
1974	0.9	0.8	0.8	0.9	1.1	1.4	1.8	2.2	2.6	3.0	3.3	3.6	3.8	3.9	4.0	4.0	4.0	3.9	3.9	98.0
1975	0.9	0.7	0.7	0.7	0.8	1.0	1.2	1.5	1.8	2.2	2.6	2.9	3.1	3.3	3.4	3.4	3.5	3.5	3.5	90.1
1976	0.9	0.7	0.6	0.6	0.6	0.7	0.8	1.0	1.3	1.6	1.9	2.3	2.5	2.7	2.9	3.0	3.1	3.1	3.1	84.0
1977	1.0	0.8	0.6	0.5	0.5	0.5	0.6	0.7	0.9	1.1	1.4	1.7	1.9	2.2	2.4	2.5	2.6	2.7	2.7	76.8
1978	5.0	0.9	0.7	0.5	0.5	0.4	0.5	0.5	0.6	0.8	1.0	1.3	1.5	1.8	2.0	2.2	2.3	2.4	2.5	73.3
1979	1.1	4.5	0.8	0.6	0.5	0.4	0.4	0.4	0.5	0.6	0.7	0.9	1.2	1.4	1.6	1.8	2.0	2.1	2.2	70.4
1980	1.3	1.0	4.1	0.8	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.0	67.5
1981	2.3	1.2	0.9	3.8	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.7	65.0
1982	8.2	2.1	1.2	0.9	3.6	0.7	0.5	0.4	0.3	0.3	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.5	62.5
1983	16.6	7.7	2.0	1.1	0.8	3.4	0.6	0.5	0.4	0.3	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	60.6
1984	3.3	15.7	7.3	1.9	1.0	0.8	3.2	0.6	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.7	0.8	1.0	58.7
1985	2.8	3.1	14.9	6.9	1.8	1.0	0.7	3.0	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	0.8	56.6
1986	3.3	2.7	3.0	14.1	6.6	1.7	0.9	0.7	2.9	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6	54.5
1987	4.6	3.1	2.5	2.8	13.4	6.3	1.6	0.9	0.7	2.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.5	52.3
1988	5.0	4.3	2.9	2.4	2.7	12.6	5.9	1.5	0.8	0.6	2.6	0.5	0.4	0.3	0.3	0.2	0.3	0.3	0.3	49.8
1989	4.3	4.7	4.1	2.7	2.2	2.5	11.9	5.6	1.4	0.8	0.6	2.4	0.4	0.3	0.3	0.2	0.2	0.2	0.3	47.3
1990	6.1	4.0	4.4	3.8	2.6	2.1	2.4	11.2	5.2	1.3	0.7	0.6	2.3	0.4	0.3	0.3	0.2	0.2	0.2	44.7
1991	10.3	5.5	3.6	4.0	3.5	2.3	1.9	2.1	10.1	4.7	1.2	0.7	0.5	2.1	0.4	0.3	0.2	0.2	0.2	41.1
1992	8.6	9.6	5.1	3.4	3.7	3.2	2.2	1.8	2.0	9.4	4.4	1.1	0.6	0.5	1.9	0.4	0.3	0.2	0.2	38.6
1993	10.9	7.9	8.8	4.7	3.1	3.4	3.0	2.0	1.6	1.8	8.7	4.1	1.0	0.6	0.4	1.8	0.3	0.3	0.2	36.0
1994	5.5	9.9	7.2	8.1	4.3	2.9	3.1	2.7	1.8	1.5	1.7	8.0	3.7	1.0	0.5	0.4	1.6	0.3	0.2	33.4
1995	6.6	5.1	9.2	6.7	7.5	4.0	2.6	2.9	2.5	1.7	1.4	1.6	7.4	3.5	0.9	0.5	0.4	1.5	0.3	31.3
1996	6.0	6.1	4.7	8.5	6.2	7.0	3.7	2.5	2.7	2.4	1.6	1.3	1.5	6.9	3.2	0.8	0.5	0.4	1.4	29.5
1997	14.8	5.5	5.6	4.4	7.9	5.8	6.5	3.4	2.3	2.5	2.2	1.5	1.2	1.4	6.4	3.0	0.8	0.4	0.3	28.8
1998	12.8	13.7	5.1	5.3	4.1	7.4	5.4	6.0	3.2	2.1	2.3	2.0	1.4	1.1	1.3	6.0	2.8	0.7	0.4	27.2
1999	7.9	12.0	12.8	4.8	4.9	3.8	6.9	5.0	5.6	3.0	2.0	2.2	1.9	1.3	1.0	1.2	5.6	2.6	0.7	25.9
2000	15.2	7.3	11.2	12.0	4.5	4.6	3.6	6.4	4.7	5.3	2.8	1.9	2.0	1.8	1.2	1.0	1.1	5.3	2.5	24.9
2001	27.5	14.2	6.9	10.5	11.2	4.2	4.3	3.3	6.0	4.4	4.9	2.6	1.7	1.9	1.7	1.1	0.9	1.0	4.9	25.7
2002	33.1	25.8	13.3	6.4	9.8	10.5	4.0	4.0	3.1	5.7	4.1	4.6	2.5	1.6	1.8	1.6	1.1	0.9	1.0	28.8
2003	20.2	30.9	24.1	12.4	6.0	9.2	9.8	3.7	3.8	2.9	5.3	3.9	4.3	2.3	1.5	1.7	1.5	1.0	0.8	27.9
2004	15.8	18.7	28.7	22.4	11.6	5.6	8.6	9.2	3.4	3.5	2.7	4.9	3.6	4.0	2.1	1.4	1.6	1.4	0.9	26.8
2005	87.9	14.8	17.5	26.9	20.9	10.8	5.2	8.0	8.6	3.2	3.3	2.5	4.6	3.4	3.8	2.0	1.3	1.5	1.3	26.0
2006	17.0	82.2	13.8	16.4	25.2	19.6	10.1	4.9	7.5	8.0	3.0	3.1	2.4	4.3	3.2	3.5	1.9	1.3	1.4	25.6
2007	43.8	15.8	76.8	12.9	15.3	23.5	18.3	9.5	4.6	7.0	7.5	2.8	2.9	2.2	4.0	2.9	3.3	1.8	1.2	25.3
2008	18.9	40.5	14.7	71.2	12.0	14.2	21.8	17.0	8.8	4.3	6.5	6.9	2.6	2.7	2.1	3.7	2.7	3.1	1.6	24.6
2009	67.8	17.5	37.6	13.6	66.2	11.1	13.2	20.3	15.8	8.2	4.0	6.0	6.4	2.4	2.5	1.9	3.5	2.5	2.9	24.5
2010	35.6	63.1	16.3	35.1	12.7	61.7	10.4	12.3	18.9	14.7	7.6	3.7	5.6	6.0	2.3	2.3	1.8	3.2	2.4	25.6
2011	21.5	33.1	58.7	15.2	32.6	11.8	57.4	9.7	11.4	17.6	13.7	7.1	3.4	5.2	5.6	2.1	2.1	1.7	3.0	26.1
2012	10.3	19.9	30.6	54.3	14.0	30.2	10.9	53.0	8.9	10.6	16.2	12.6	6.5	3.2	4.8	5.2	1.9	2.0	1.5	27.0
2013	15.8	9.5	18.4	28.3	50.2	13.0	27.9	10.1	49.0	8.2	9.7	14.9	11.6	6.0	2.9	4.4	4.8	1.8	1.8	26.5
2014	12.9	14.5	8.7	16.9	26.0	46.1	11.9	25.6	9.2	44.8	7.5	8.9	13.7	10.6	5.5	2.7	4.1	4.4	1.6	26.0
2015	41.0	11.8	13.3	8.0	15.5	23.8	42.2	10.9	23.4	8.4	40.9	6.9	8.1	12.5	9.7	5.0	2.4	3.7	4.0	25.4
2016	30.5	37.6	10.9	12.2	7.4	14.2	21.8	38.7	10.0	21.4	7.7	37.4	6.3	7.4	11.4	8.9	4.6	2.2	3.4	27.1
2017	66.7	28.0	34.6	10.0	11.2	6.8	13.0	20.0	35.4	9.1	19.5	7.0	34.1	5.7	6.8	10.4	8.1	4.2	2.0	28.0
2018	14.3	61.2	25.7	31.8	9.2	10.3	6.2	11.9	18.3	32.3	8.3	17.8	6.4	31.0	5.2	6.2	9.5	7.4	3.8	27.6
2019	55.8	13.1	56.1	23.6	29.1	8.4	9.4	5.7	10.9	16.7	29.4	7.6	16.2	5.8	28.2	4.7	5.6	8.6	6.8	28.7
2020	17.3	50.6	11.9	50.9	21.4	26.4	7.6	8.5	5.1	9.8	14.9	26.3	6.8	14.5	5.2	25.3	4.3	5.0	7.8	32.1
2021	81.0	15.7	46.1	10.8	46.3	19.4	23.9	6.9	7.7	4.6	8.8	13.4	23.6	6.1	13.0	4.7	22.7	3.8	4.5	36.1
2022	10.8	74.1	14.4	42.2	9.9	42.4	17.7	21.8	6.2	6.9	4.2	8.0	12.1	21.3	5.5	11.7	4.2	20.6	3.5	36.9
2023	27.5	9.9	67.9	13.2	38.7	9.0	38.7	16.2	19.8	5.7	6.3	3.8	7.2	10.9	19.2	4.9	10.6	3.8	18.7	36.8
2024	11.1	25.2	9.1	62.2	12.1	35.3	8.2	35.2	14.7	17.9	5.1	5.7	3.4	6.5	9.8	17.3	4.5	9.6	3.5	50.2

Table 12.27. Projections of BSAI spawning biomass (t), catch (t), and fishing mortality rate for each of the several scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 272,552 t and 238,483 t, respectively.

Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2024	35,603	35,603	35,603	35,603	35,603	35,603	35,603
2025	37,360	37,360	35,133	9,629	0	44,576	37,360
2026	36,431	36,431	34,360	9,735	0	43,051	36,431
2027	35,496	35,496	33,575	9,826	0	41,556	42,351
2028	34,563	34,563	32,782	9,899	0	40,102	40,844
2029	33,715	33,715	32,061	9,972	0	38,791	39,477
2030	32,976	32,976	31,437	10,053	0	37,644	38,275
2031	32,396	32,396	30,953	10,155	0	36,706	37,289
2032	31,928	31,928	30,566	10,268	0	35,955	36,488
2033	31,645	31,645	30,350	10,415	0	35,175	35,870
2034	31,441	31,441	30,204	10,576	0	34,293	35,138
2035	31,352	31,352	30,159	10,761	0	33,632	34,385
2036	31,307	31,307	30,158	10,947	0	33,124	33,784
2037	31,243	31,243	30,163	11,147	0	32,832	33,408
Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2024	359,243	359,243	359,243	359,243	359,243	359,243	359,243
2025	352,193	352,193	352,461	355,483	356,605	351,323	352,193
2026	342,991	342,991	344,284	359,164	364,819	338,811	342,991
2027	332,831	332,831	335,077	361,417	371,665	325,617	332,003
2028	322,682	322,682	325,800	363,058	377,892	312,732	318,732
2029	313,511	313,511	317,419	365,015	384,396	301,115	306,722
2030	305,784	305,784	310,406	367,754	391,619	291,203	296,423
2031	299,539	299,539	304,825	371,374	399,676	282,995	287,825
2032	294,625	294,625	300,485	375,855	408,610	276,308	280,778
2033	290,778	290,778	297,223	380,928	417,924	270,882	274,966
2034	287,901	287,901	294,830	386,697	428,142	266,778	270,401
2035	285,982	285,982	293,448	392,966	438,590	263,779	266,908
2036	283,997	283,997	291,870	398,427	448,408	261,165	263,694
2037	282,506	282,506	290,667	404,321	458,399	259,361	261,630
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2024	0.056	0.056	0.056	0.056	0.056	0.056	0.056
2025	0.060	0.060	0.056	0.015	0	0.072	0.060
2026	0.060	0.060	0.056	0.015	0	0.072	0.060
2027	0.060	0.060	0.056	0.015	0	0.072	0.072
2028	0.060	0.060	0.056	0.015	0	0.072	0.072
2029	0.060	0.060	0.056	0.015	0	0.072	0.072
2030	0.060	0.060	0.056	0.015	0	0.072	0.072
2031	0.060	0.060	0.056	0.015	0	0.072	0.072
2032	0.060	0.060	0.056	0.015	0	0.072	0.072
2033	0.060	0.060	0.056	0.015	0	0.071	0.072
2034	0.060	0.060	0.056	0.015	0	0.070	0.071
2035	0.060	0.060	0.056	0.015	0	0.069	0.070
2036	0.060	0.060	0.056	0.015	0	0.068	0.069
2037	0.060	0.060	0.056	0.015	0	0.068	0.069

Figures

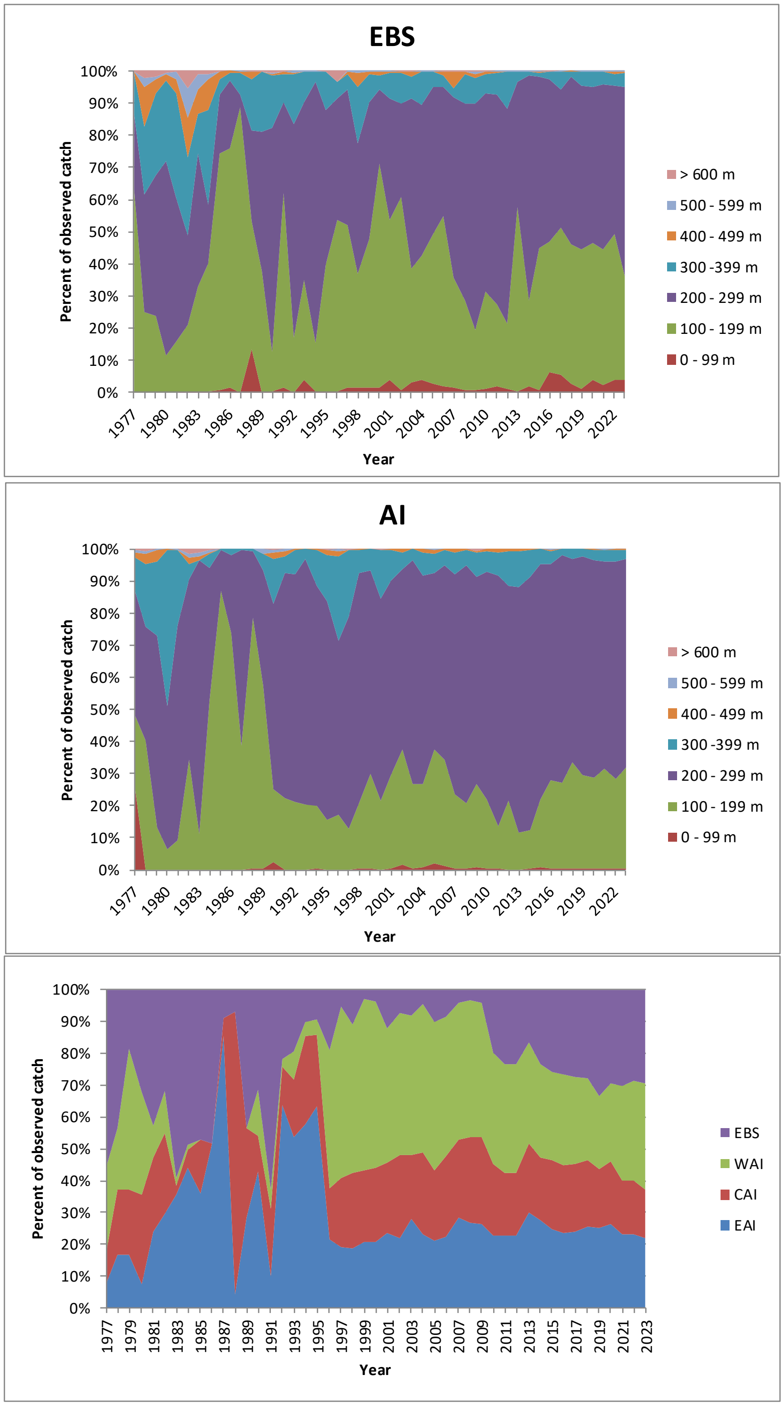


Figure 12.1. Distribution of observed BSAI Pacific ocean perch catch (from North Pacific Groundfish Observer Program) by depth zone for the EBS (top panel) and AI (middle panel), and BSAI subarea (bottom panel) from 1977 to 2023.

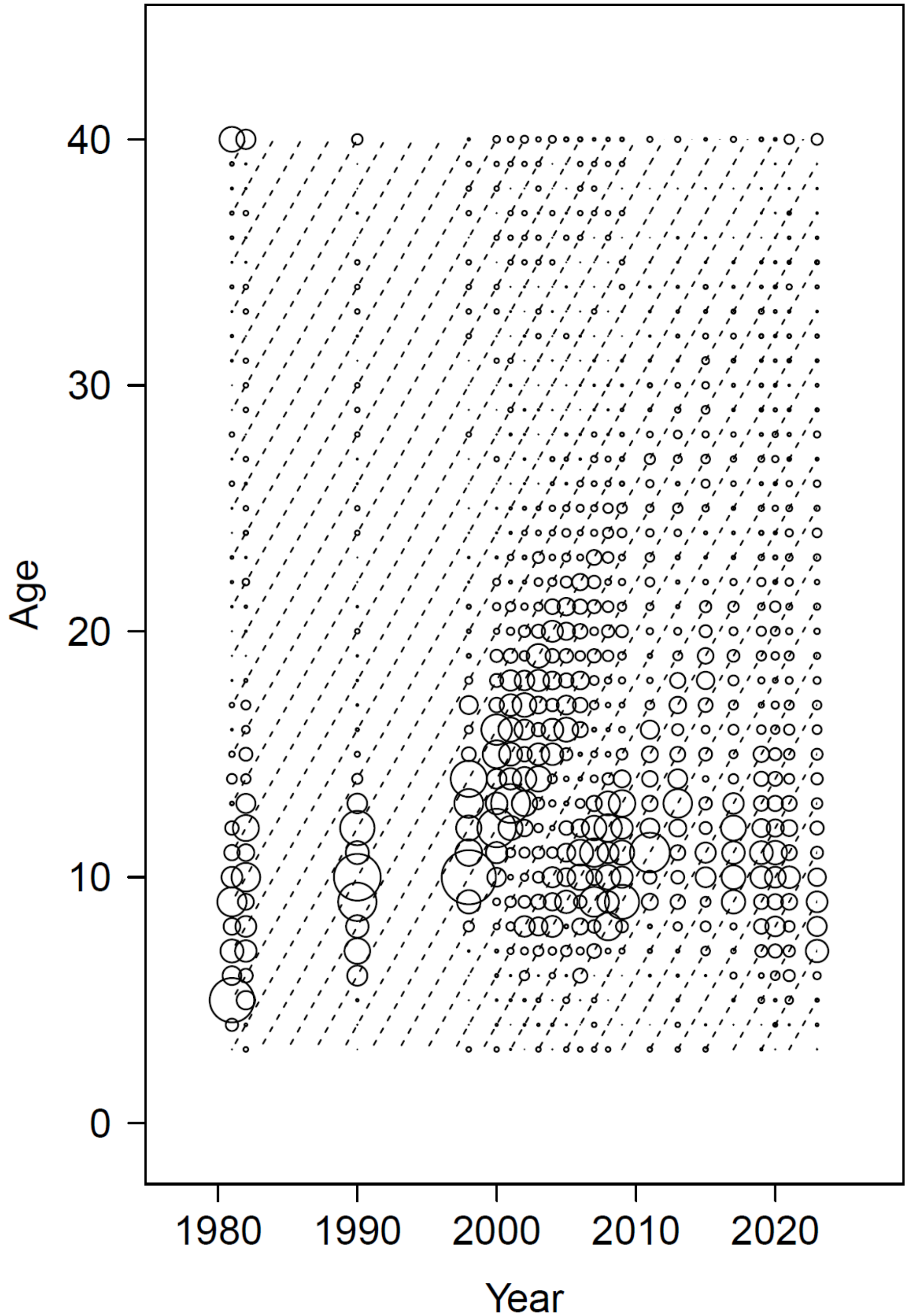


Figure 12.2. Fishery age composition data for the BSAI POP; The diameter of the circles are scaled within each year of samples, and dashed lines denote cohorts.

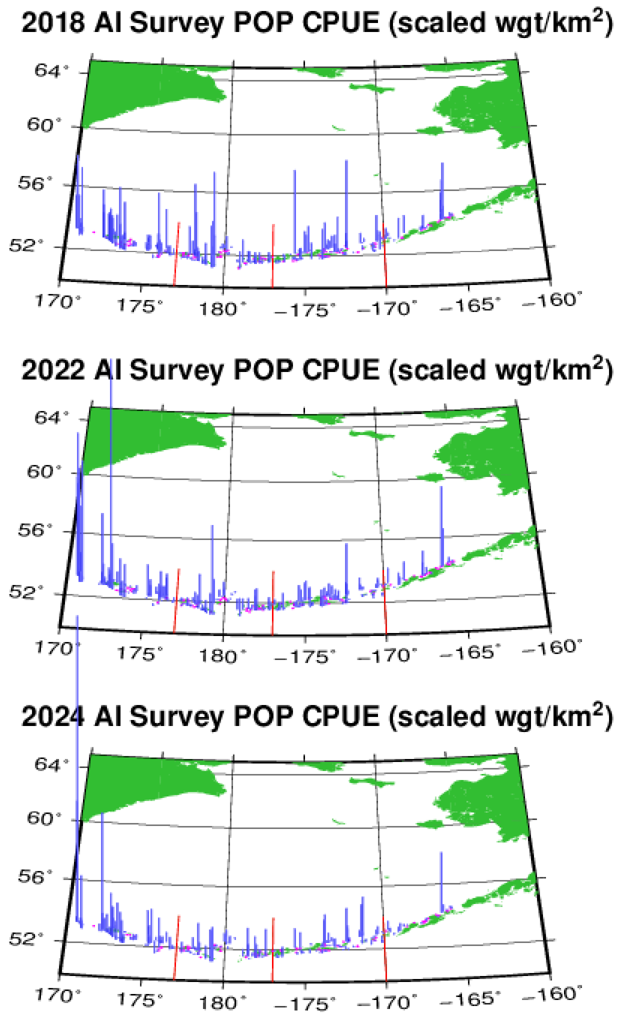


Figure 12.3. AI survey POP CPUE (kg/km^2) from 2016-2024; the symbol × denotes tows with no catch. The red lines indicate boundaries between the WAI, CAI, EAI, and EBS areas.

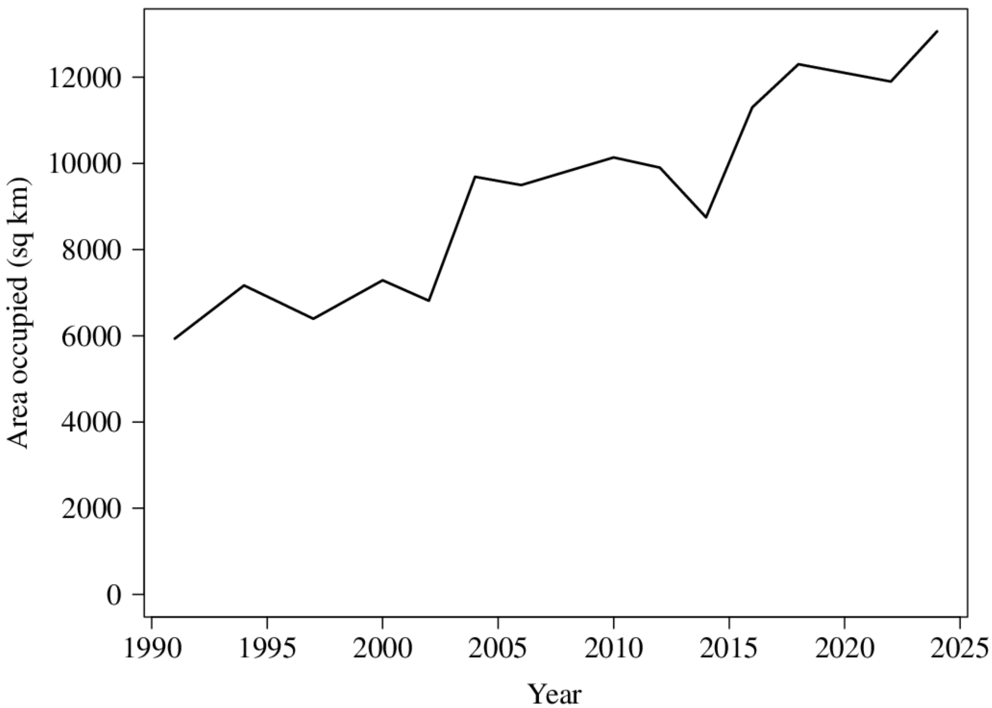


Figure 12.4. The minimum area occupied for 95% of the AI trawl survey abundance estimate for POP from 1991 to 2024.

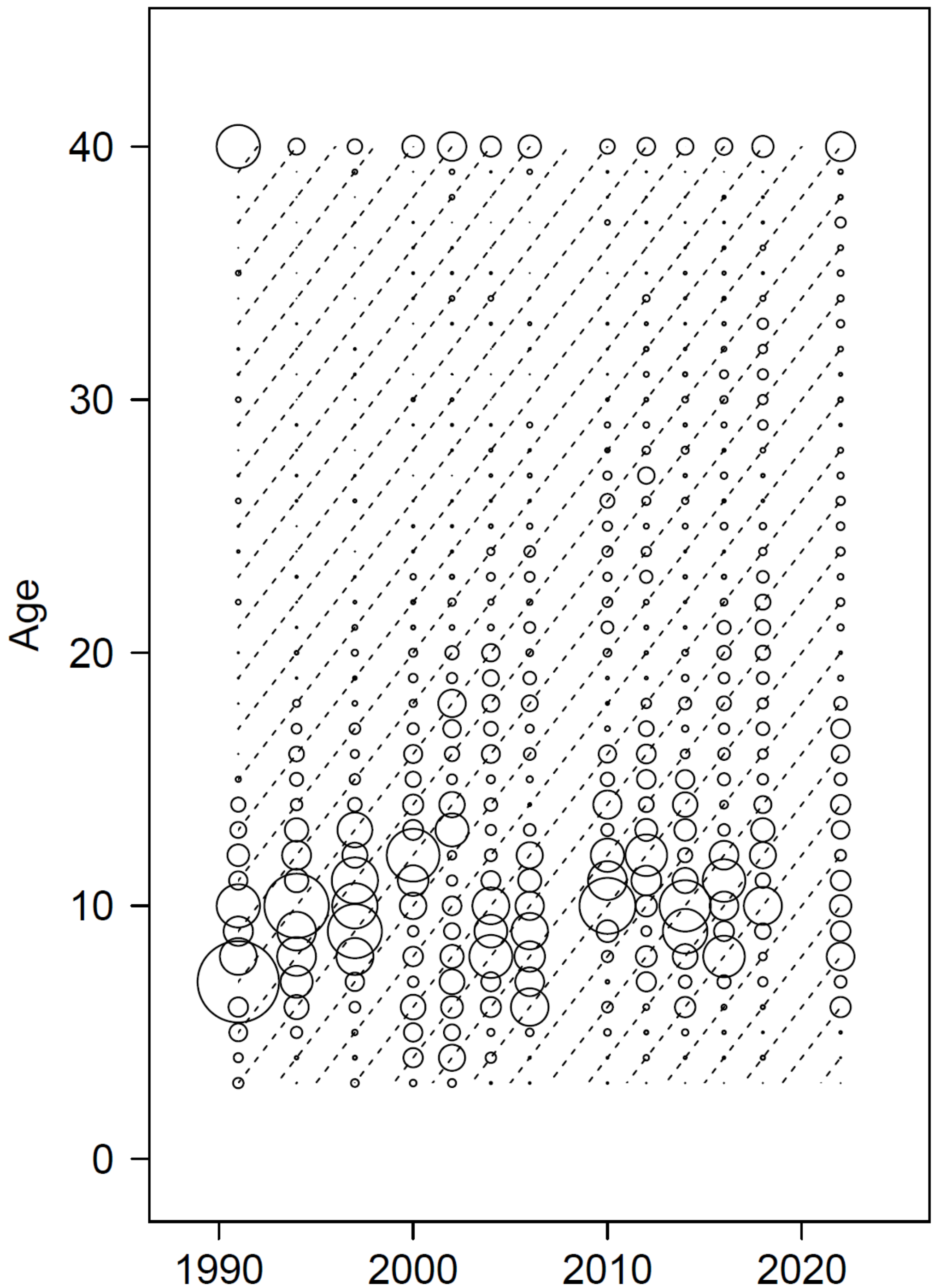


Figure 12.5. Age composition data from the Aleutian Islands trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

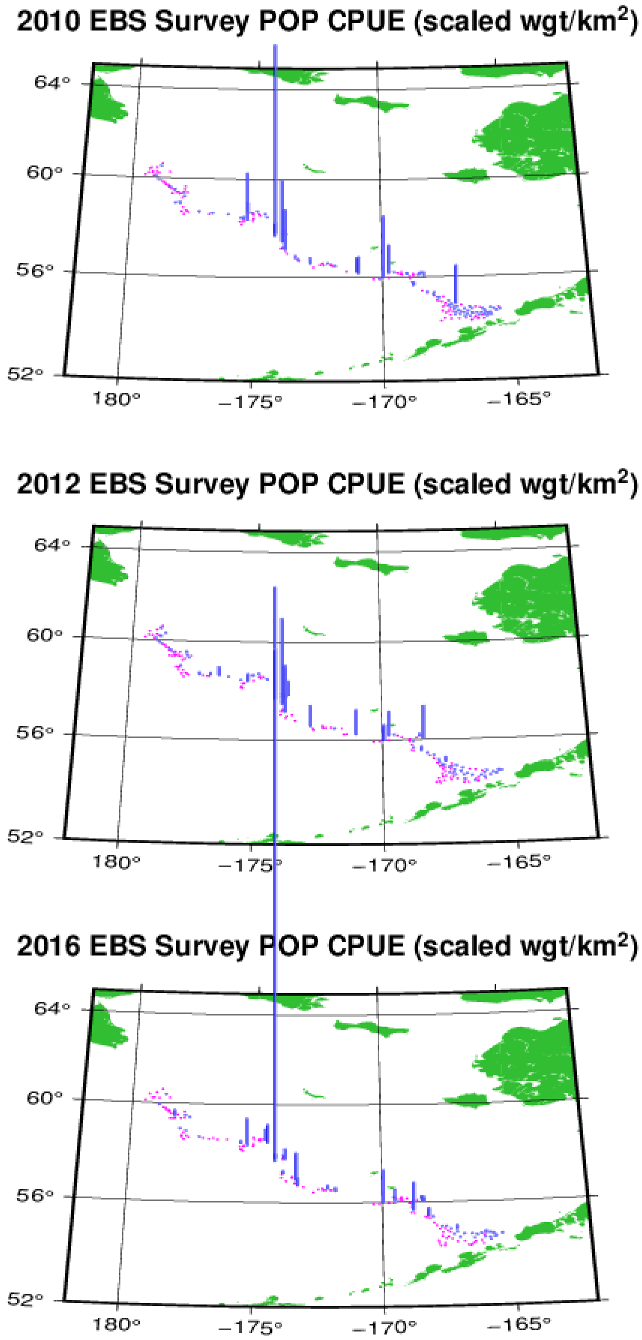


Figure 12.6. EBS slope survey POP CPUE (kg/km^2) from 2010-2016; the symbol × denotes tows with no catch.

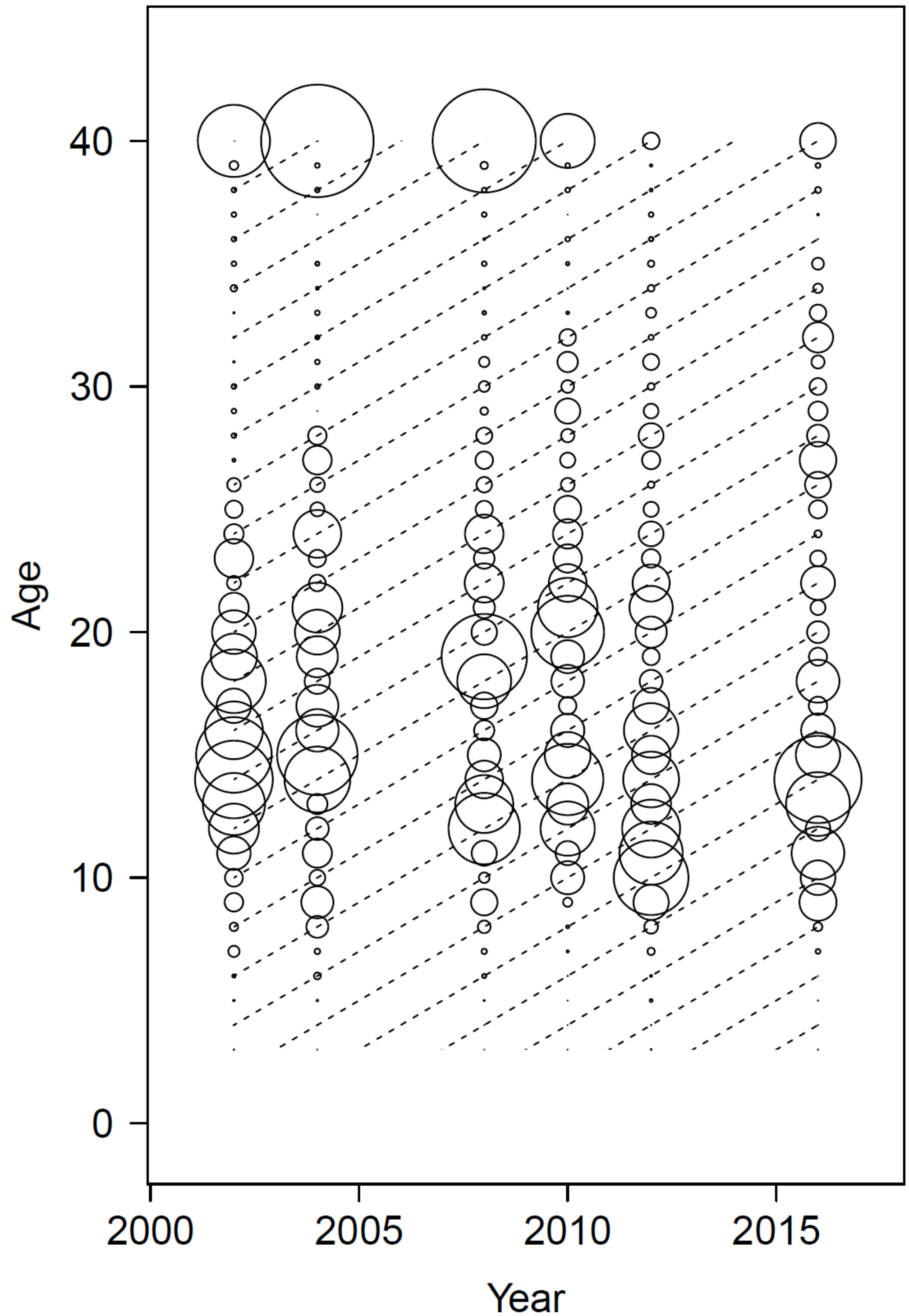


Figure 12.7. Age composition data from the eastern Bering Sea trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

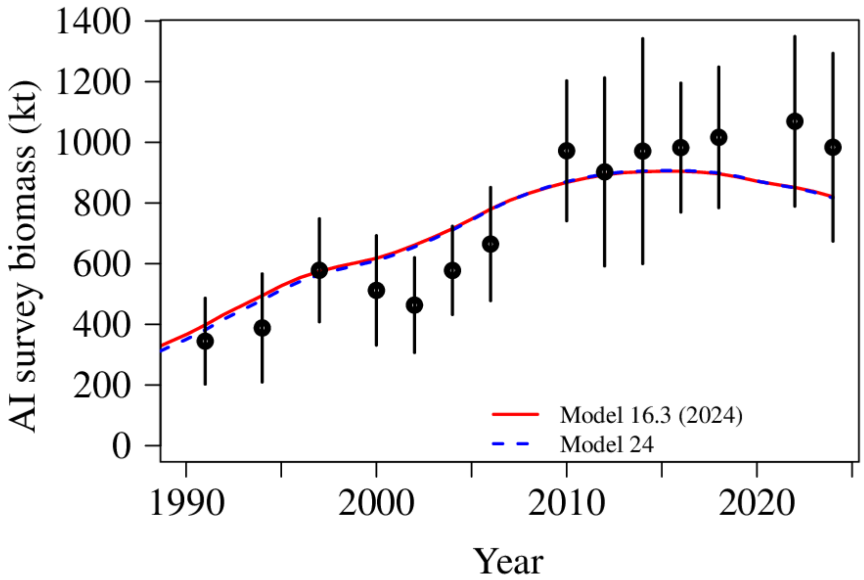


Figure 12.8. Fit to estimates of Aleutian Island survey biomass from Model 16.3 (2024) and Model 24.

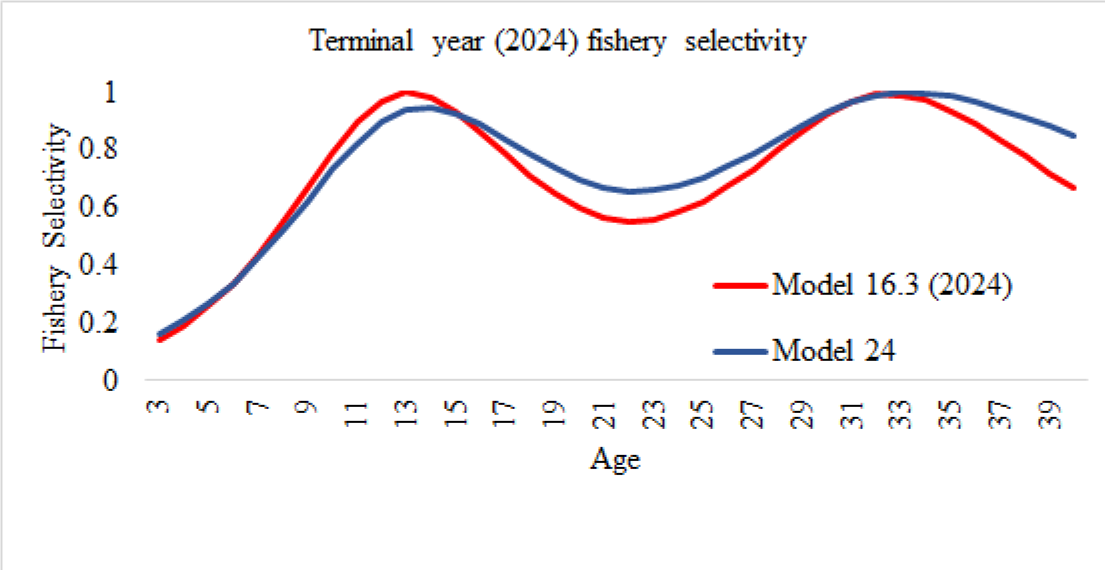


Figure 12.9. Estimated terminal-year fishery selectivity from Model 16.3 (2024) and Model 24.

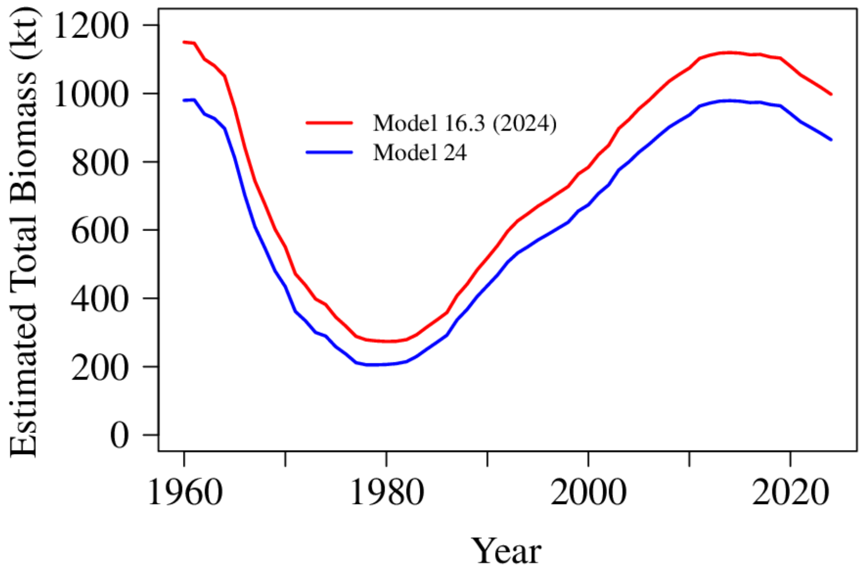


Figure 12.10. Estimated total biomass from Model 16.3 (2024) and Model 24.

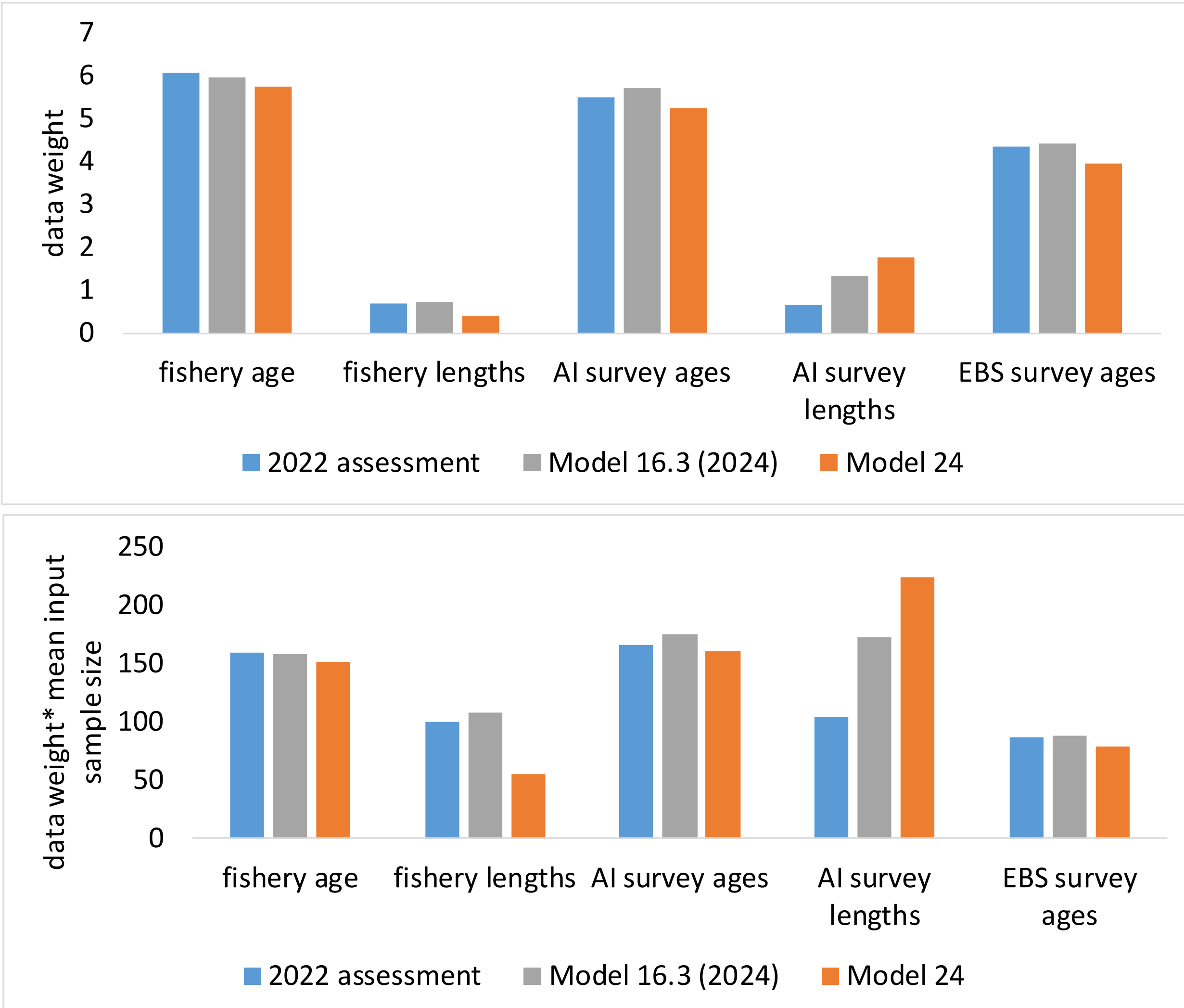
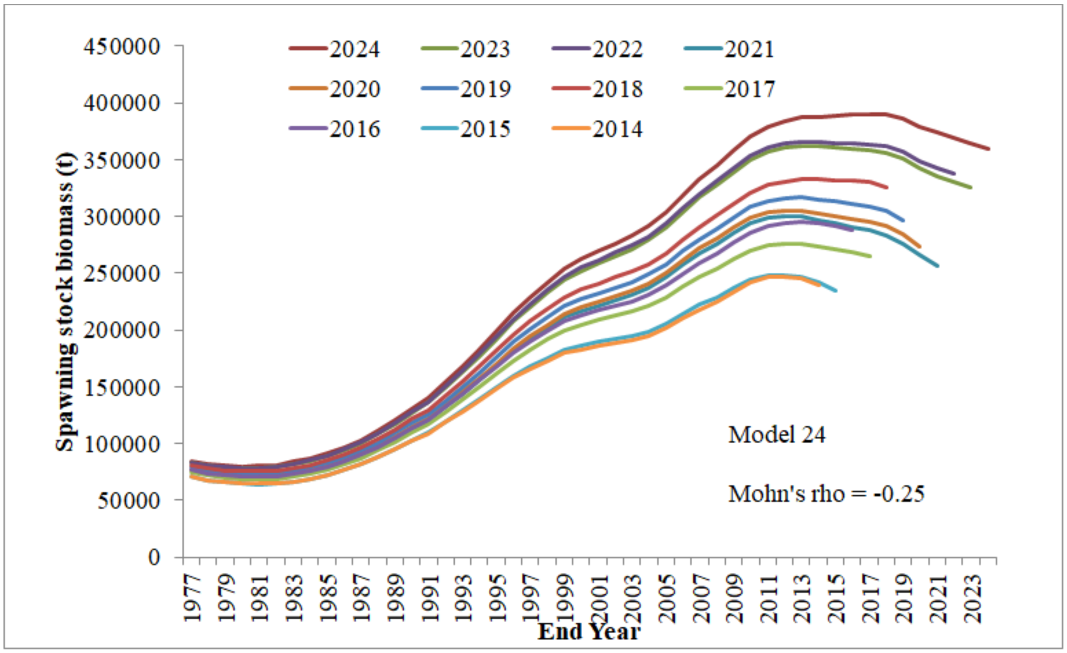


Figure 12.11. Data weights for the age and length composition data for the 2022 assessment, model 16.3 (2024) and model 24.



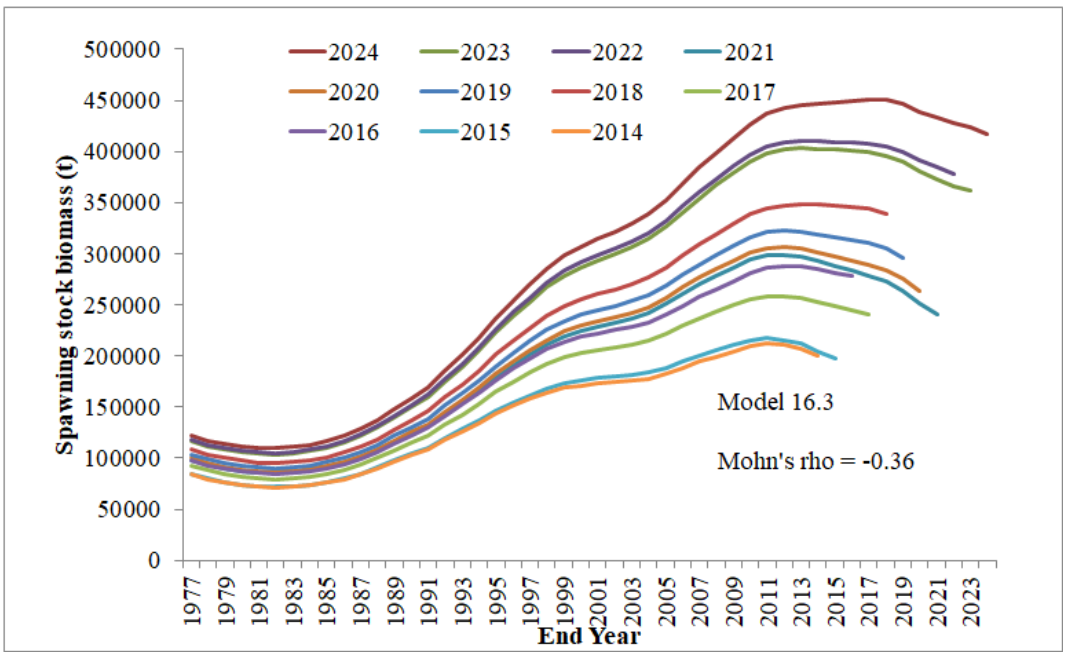


Figure 12.12. Retrospective estimates of spawning stock biomass for Model 16.3 (2024) and Model 24.

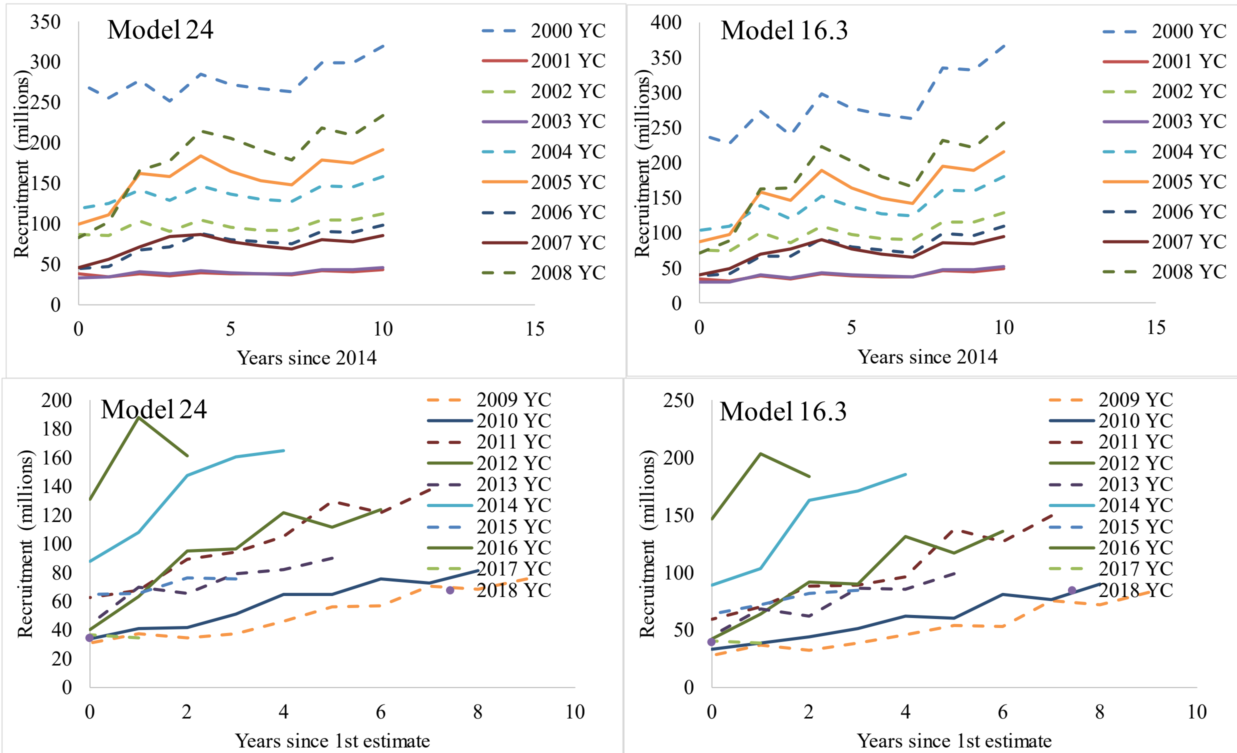


Figure 12.13. Retrospective estimates of recruitment from Model 16.3 (2024) and Model 24 for the 2000 – 2018 year classes, as a function of the years since either the first estimate or 2014 (whichever is later).

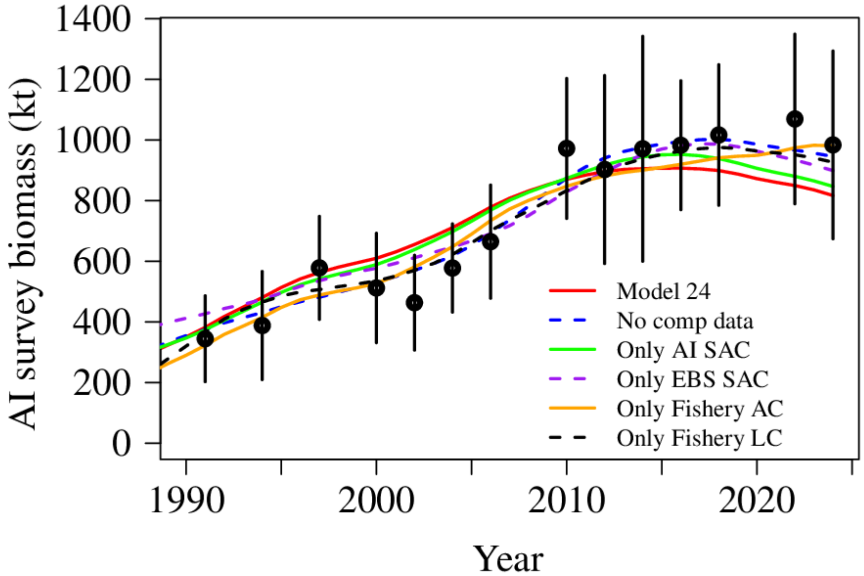


Figure 12.14. Fit to the AI survey biomass time series from model 24, and from sensitivity runs in which either all or all but one composition data is removed.

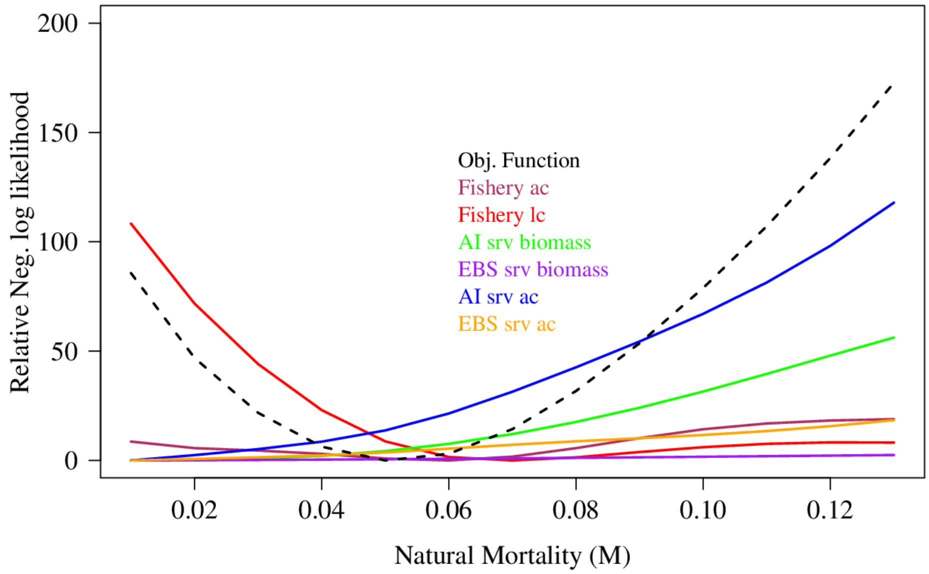


Figure 12.15. Likelihood profile for the estimated natural mortality parameter (*M*) using model 24.

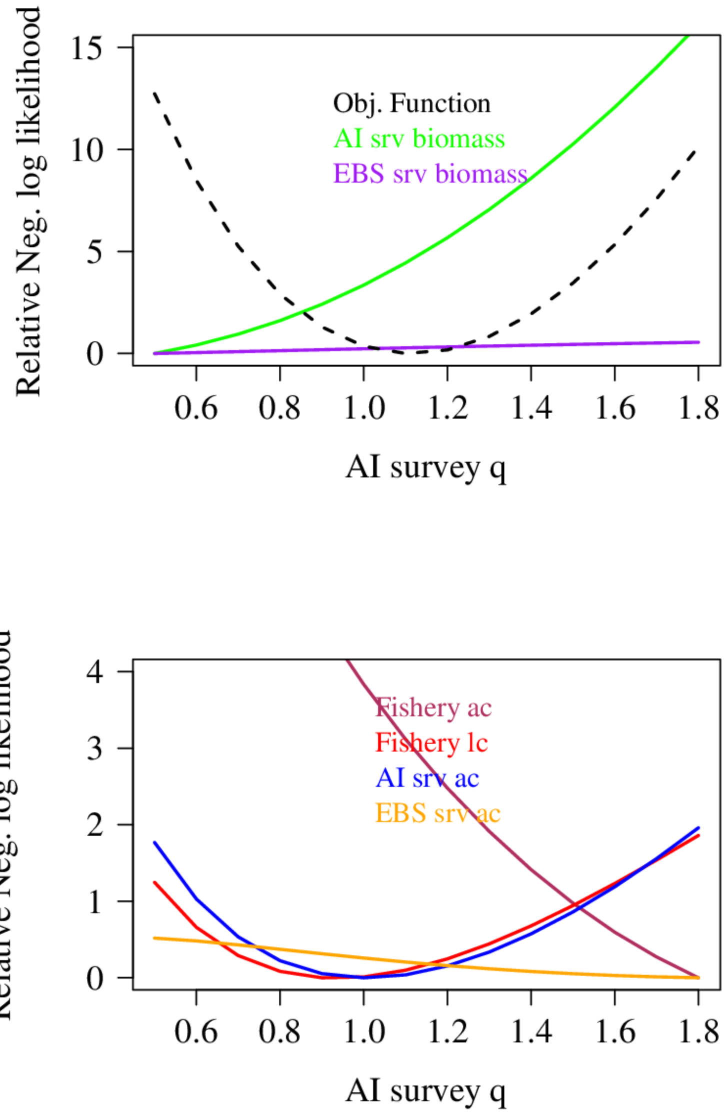


Figure 12.16. Likelihood profile for the estimated catchability of the AI trawl survey using model 24.

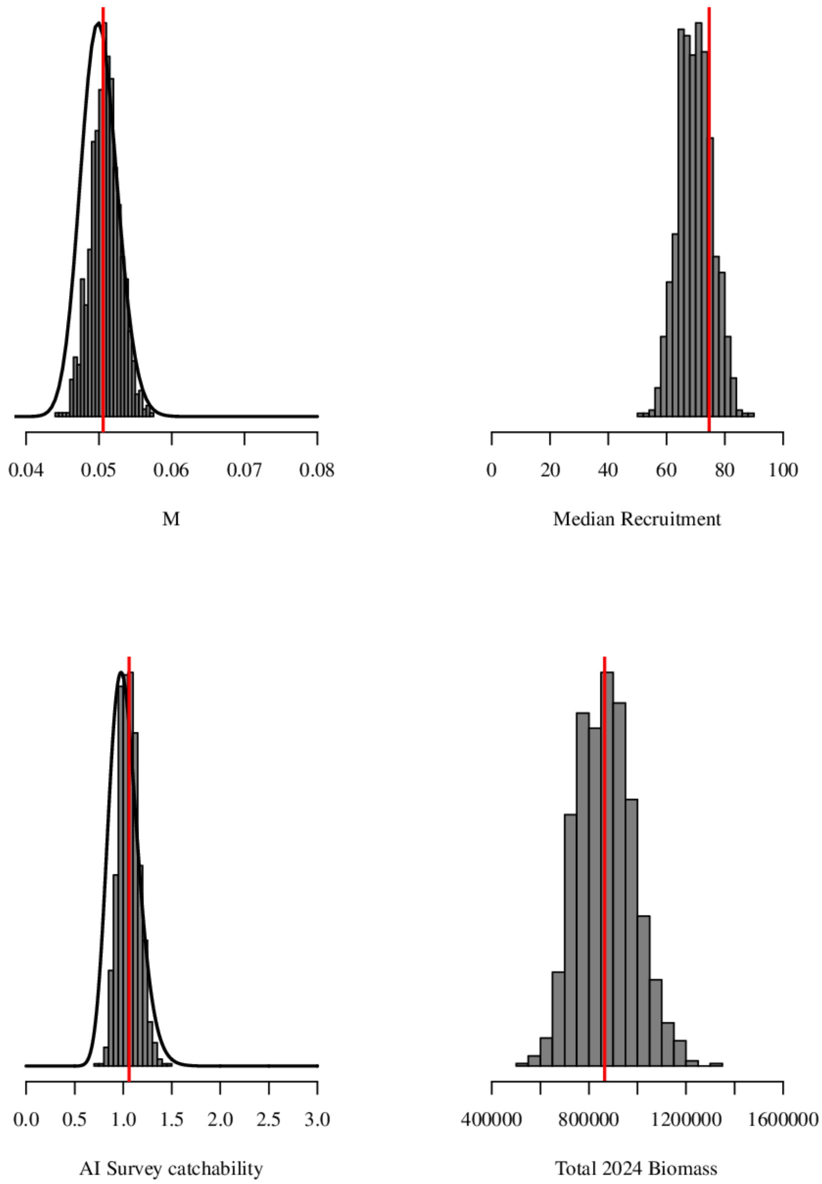


Figure 12.17. Posterior distributions from model 24 for key model quantities natural mortality (*M*), survey catchability, median recruitment, and 2024 total biomass. For *M* and survey catchability, the prior distributions are also shown with the solid black lines. The MLE estimates are indicated by the vertical red lines.

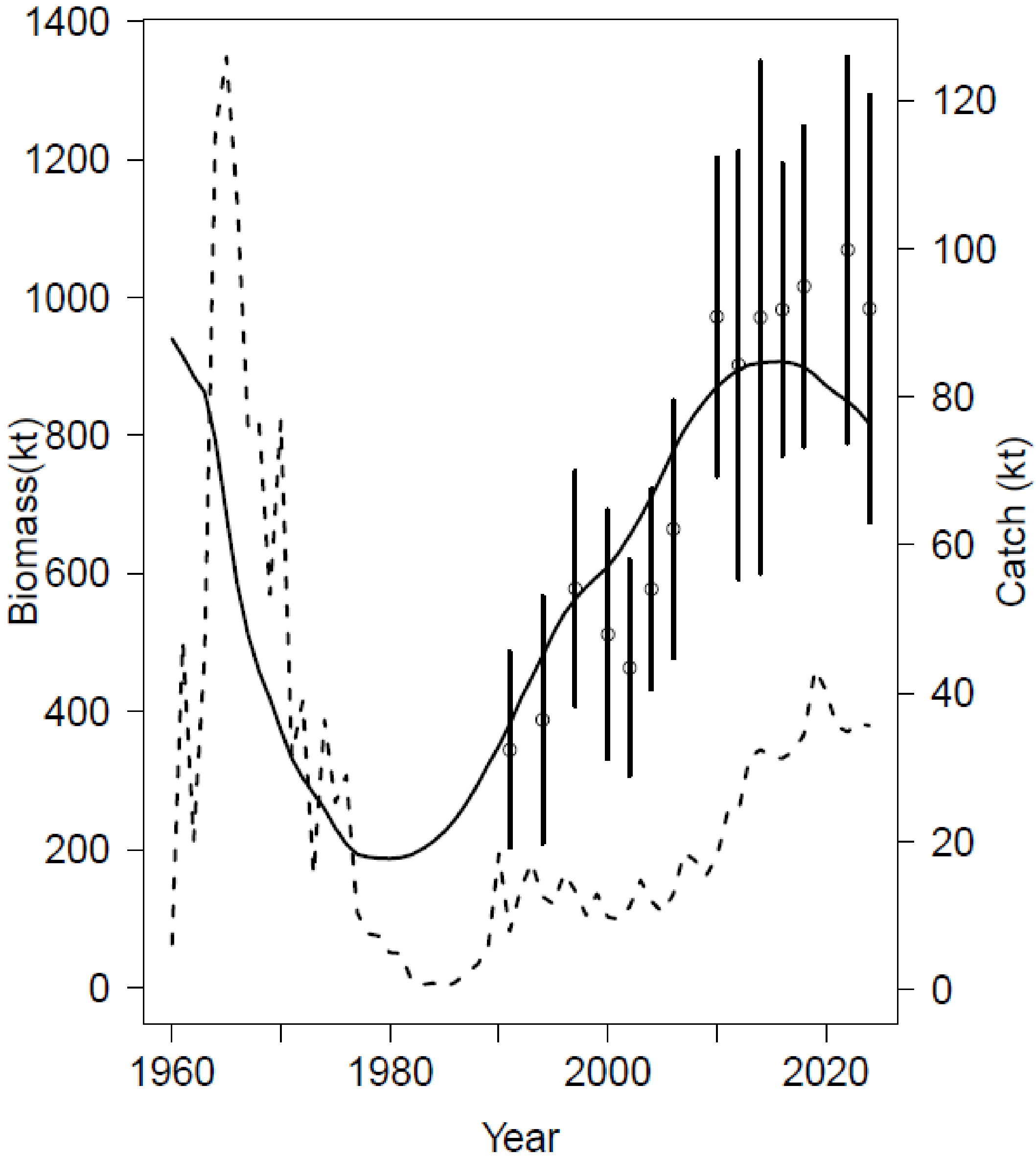


Figure 12.18. Observed AI survey biomass (data points, +/- 2 standard deviations), estimated survey biomass (solid line), and BSAI harvest (dashed line).

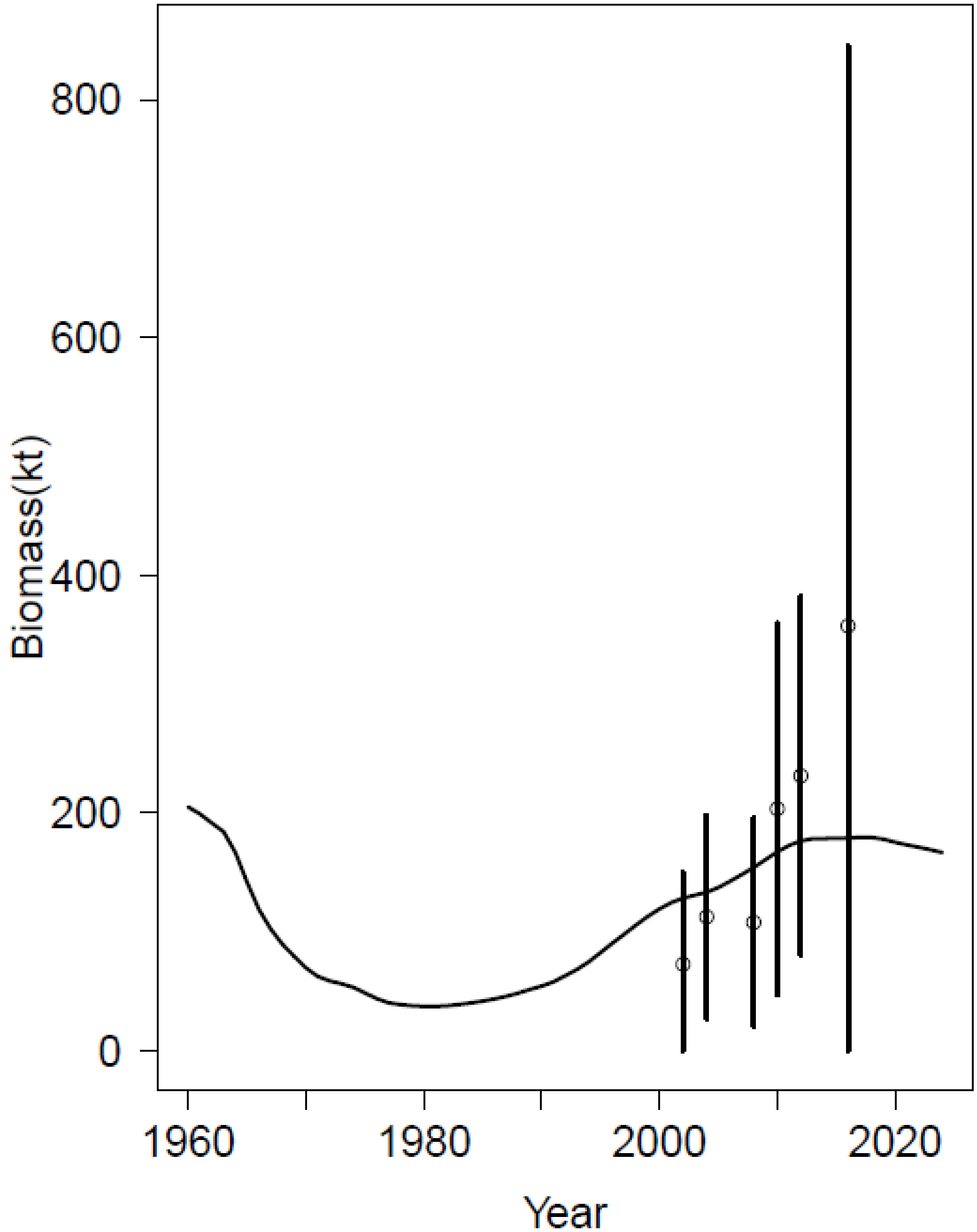


Figure 12.19. Observed EBS survey biomass (data points, +/- 2 standard deviations) and estimated survey biomass (solid line).

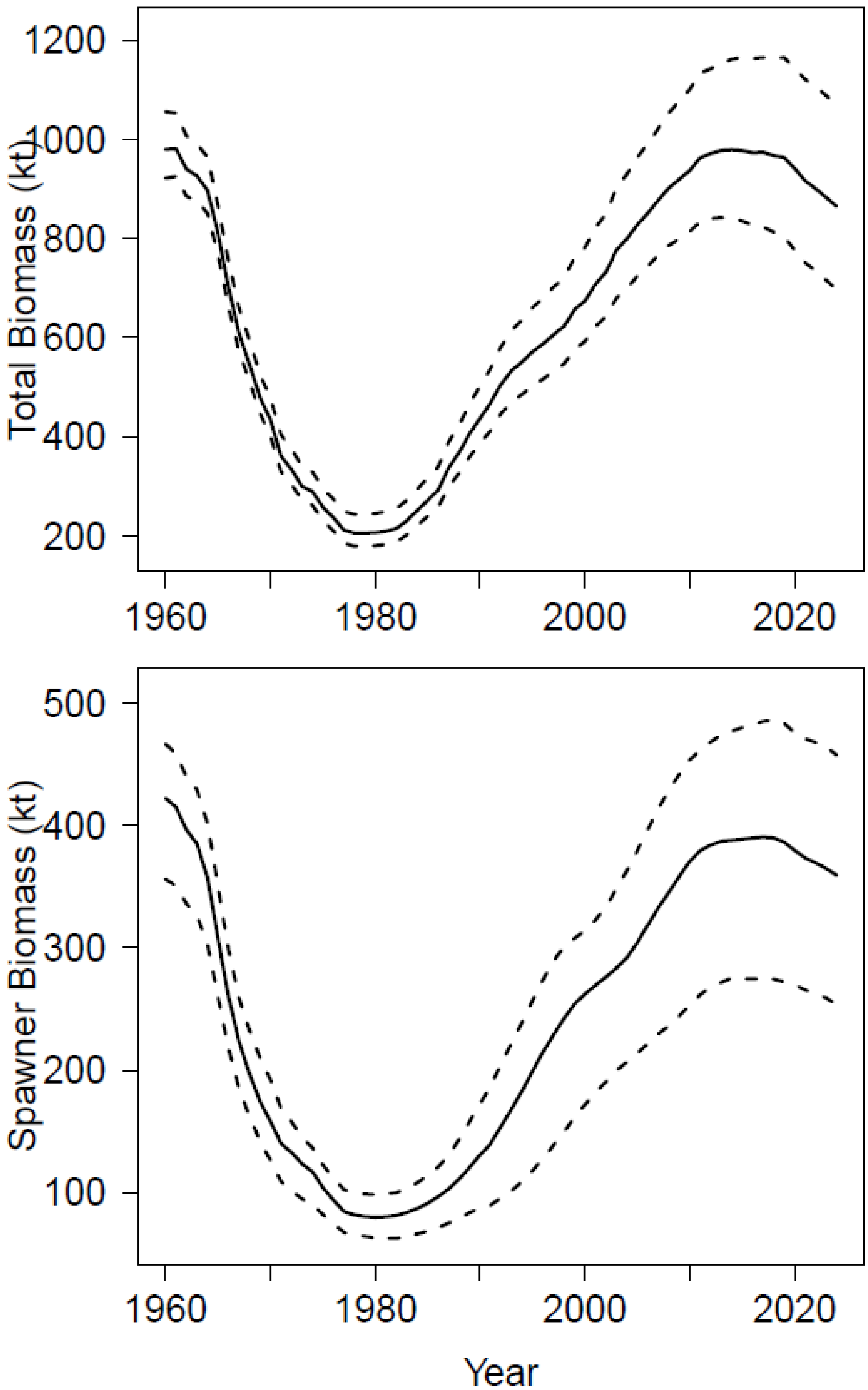


Figure 12.20. Total and spawner biomass for BSAI Pacific ocean perch, with 90% credible intervals from MCMC integration.

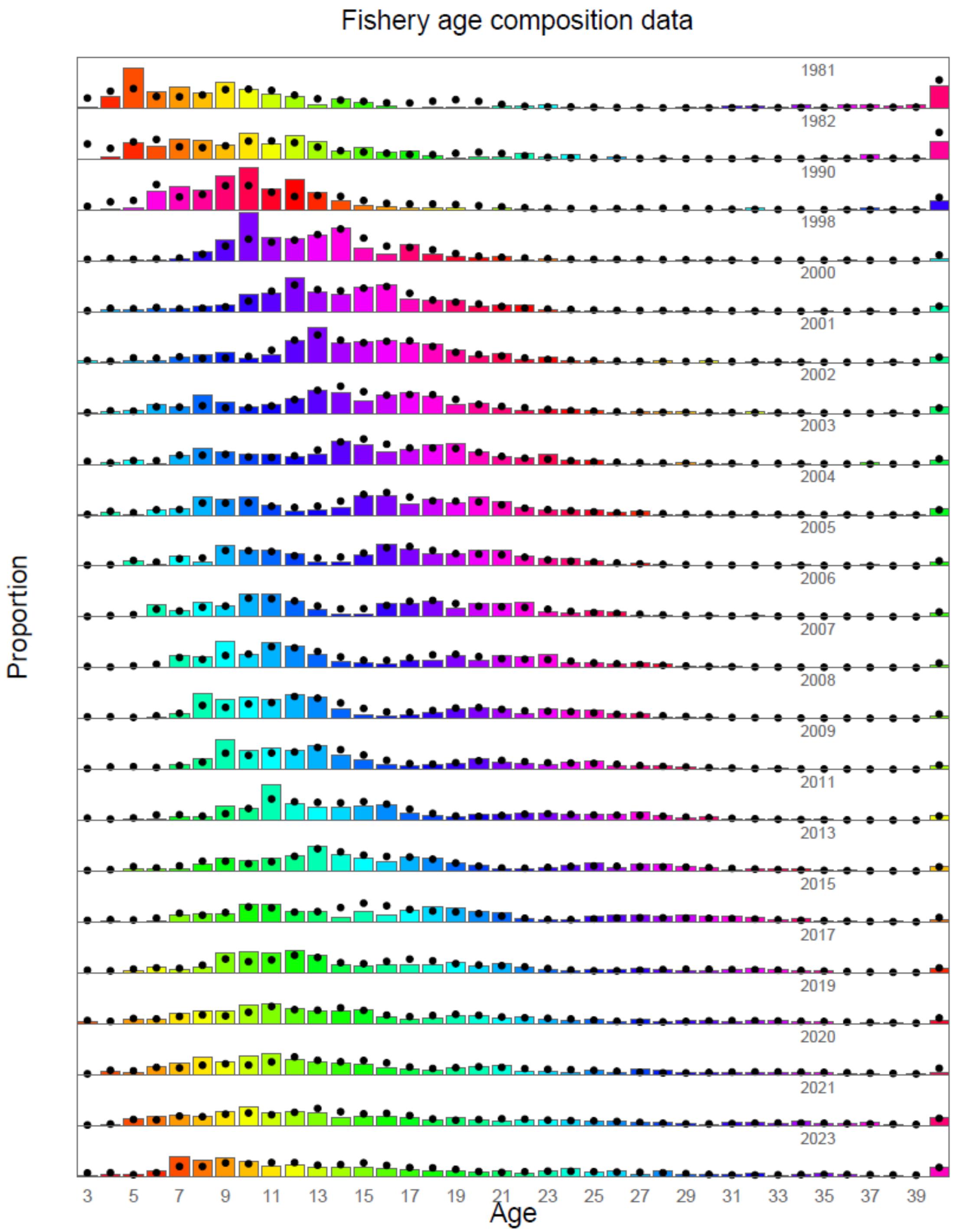


Figure 12.21. Model fits (dots) to fishery age composition data (columns) for BSAI Pacific ocean perch, 1981-2023. Colors correspond to cohorts (except for the 40+ group).

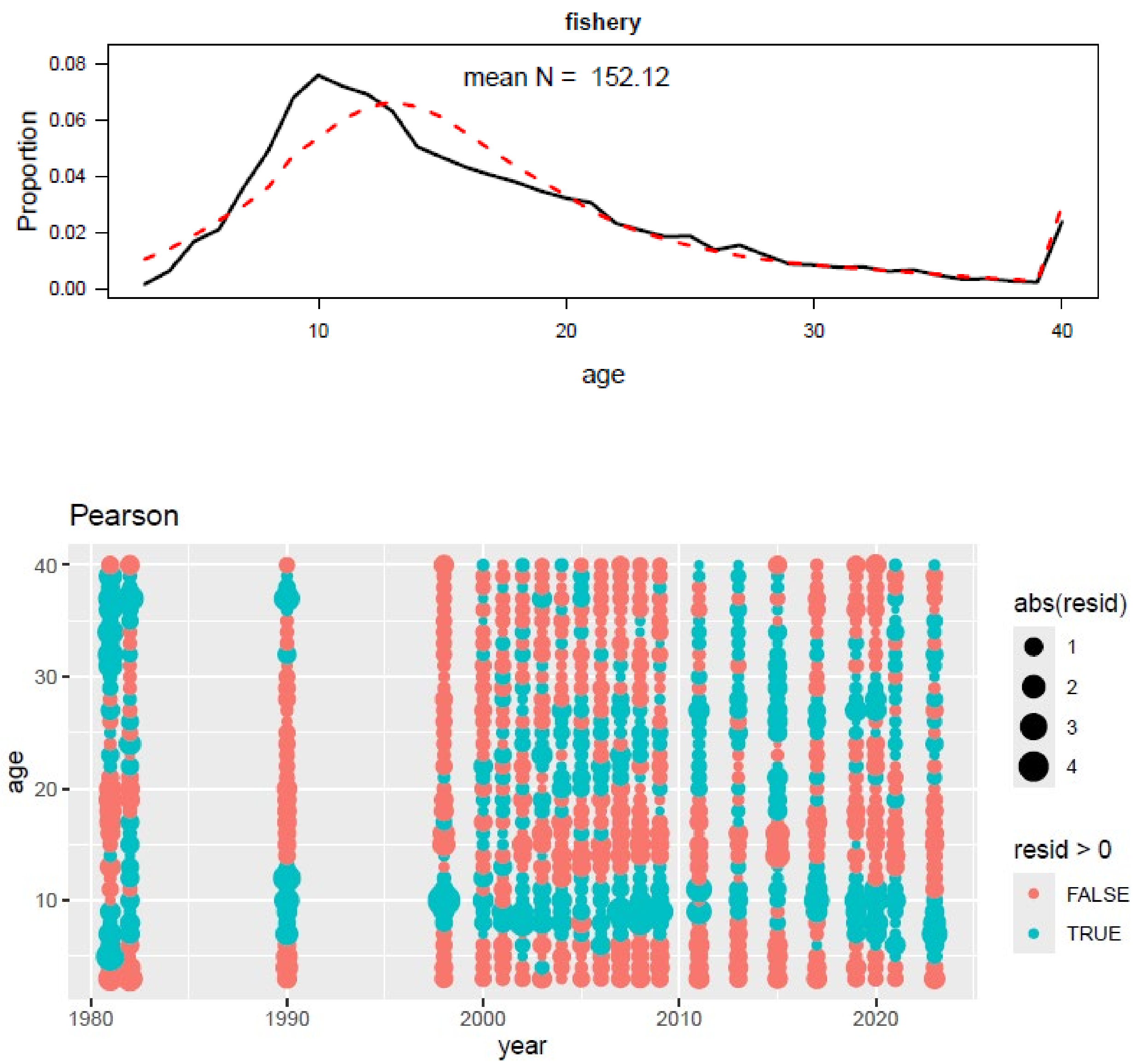


Figure 12.22. Aggregated observed (black) and estimated (red) fishery age compositions (top panel) and Pearson residuals (bottom panel).

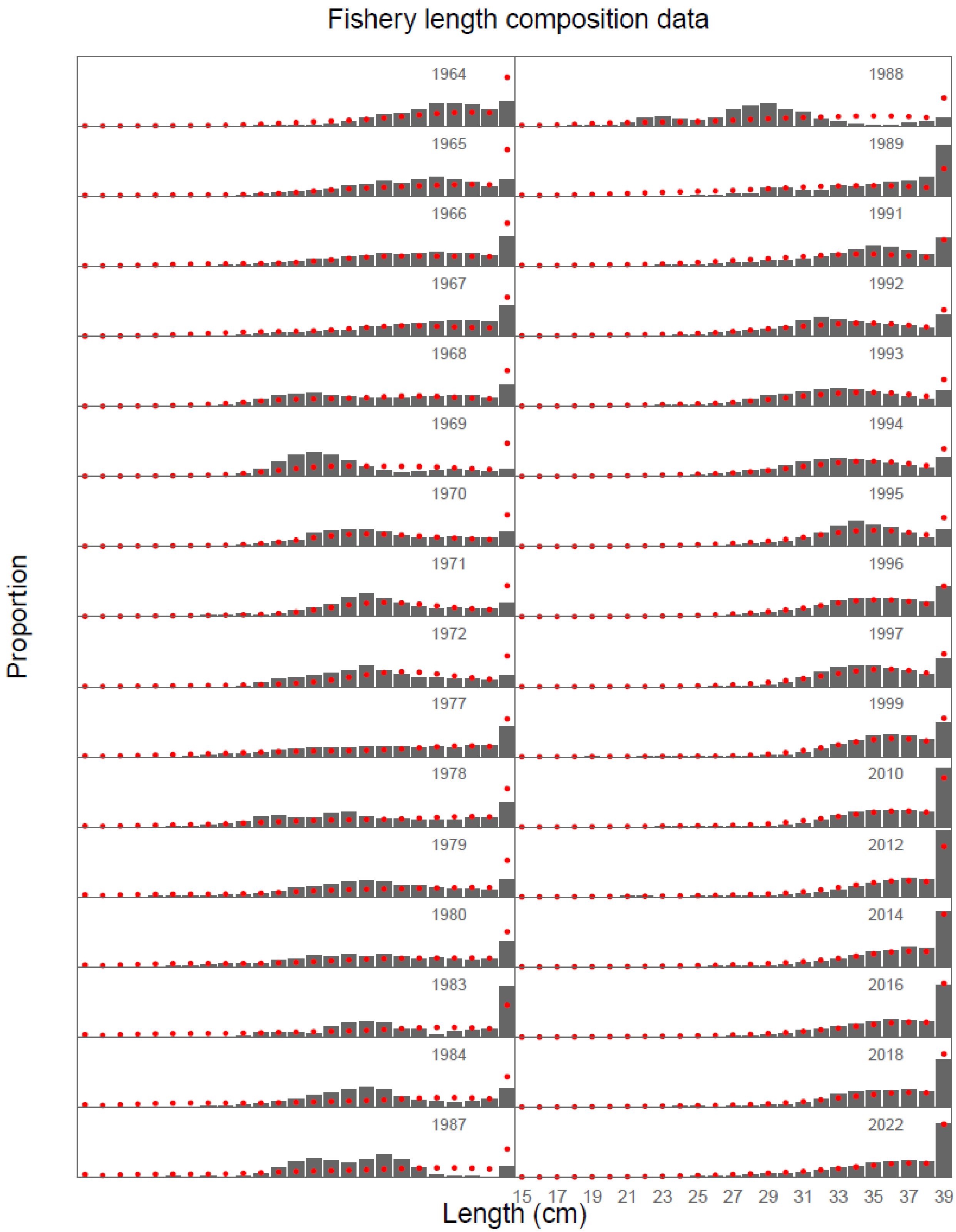


Figure 12.23. Model fits (dots) to fishery length composition data (columns) for BSAI Pacific

ocean perch, 1964-2022.

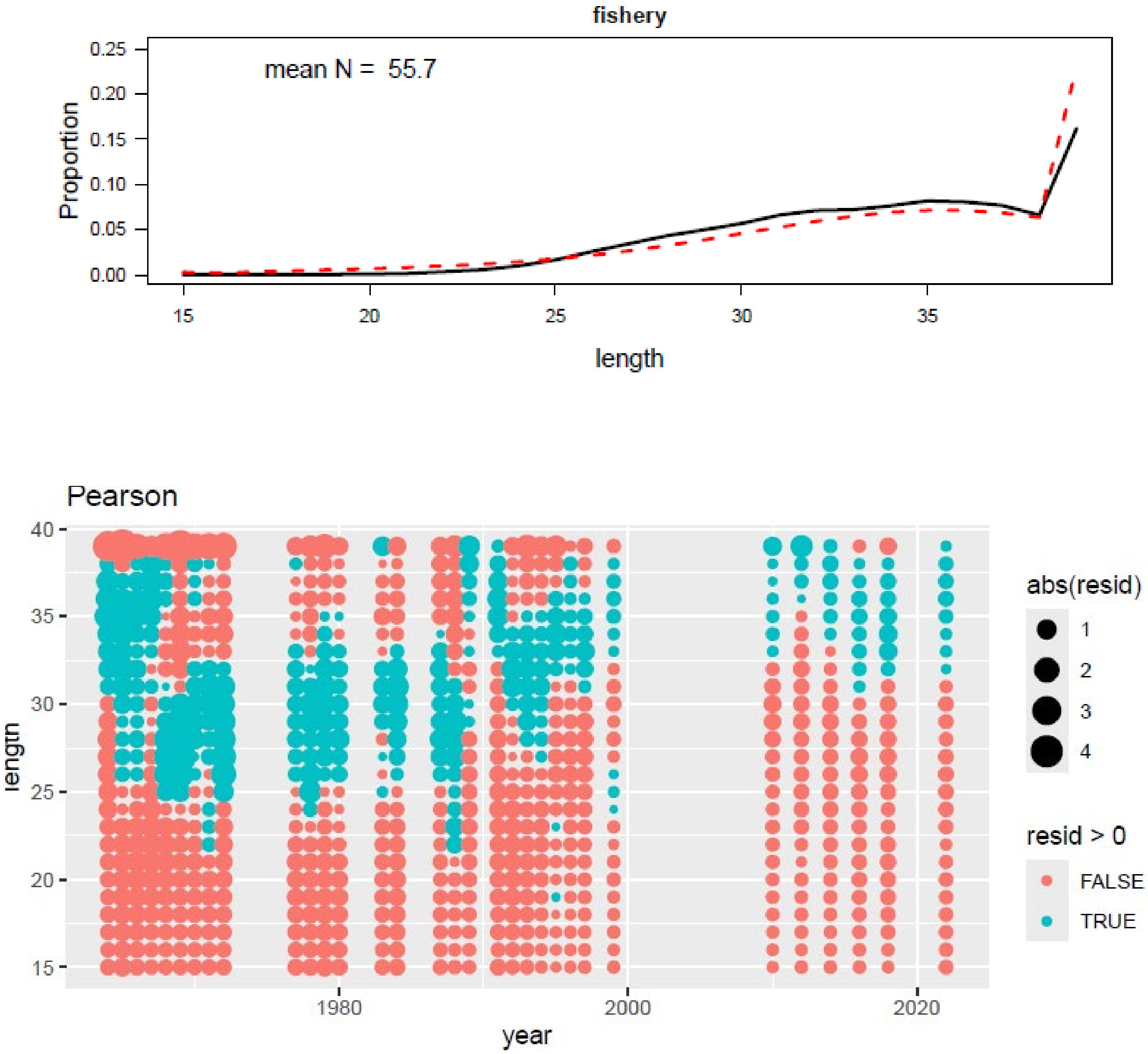


Figure 12.24. Aggregated observed (black) and estimated (red) fishery length compositions (top panel) and Pearson residuals (bottom panel).

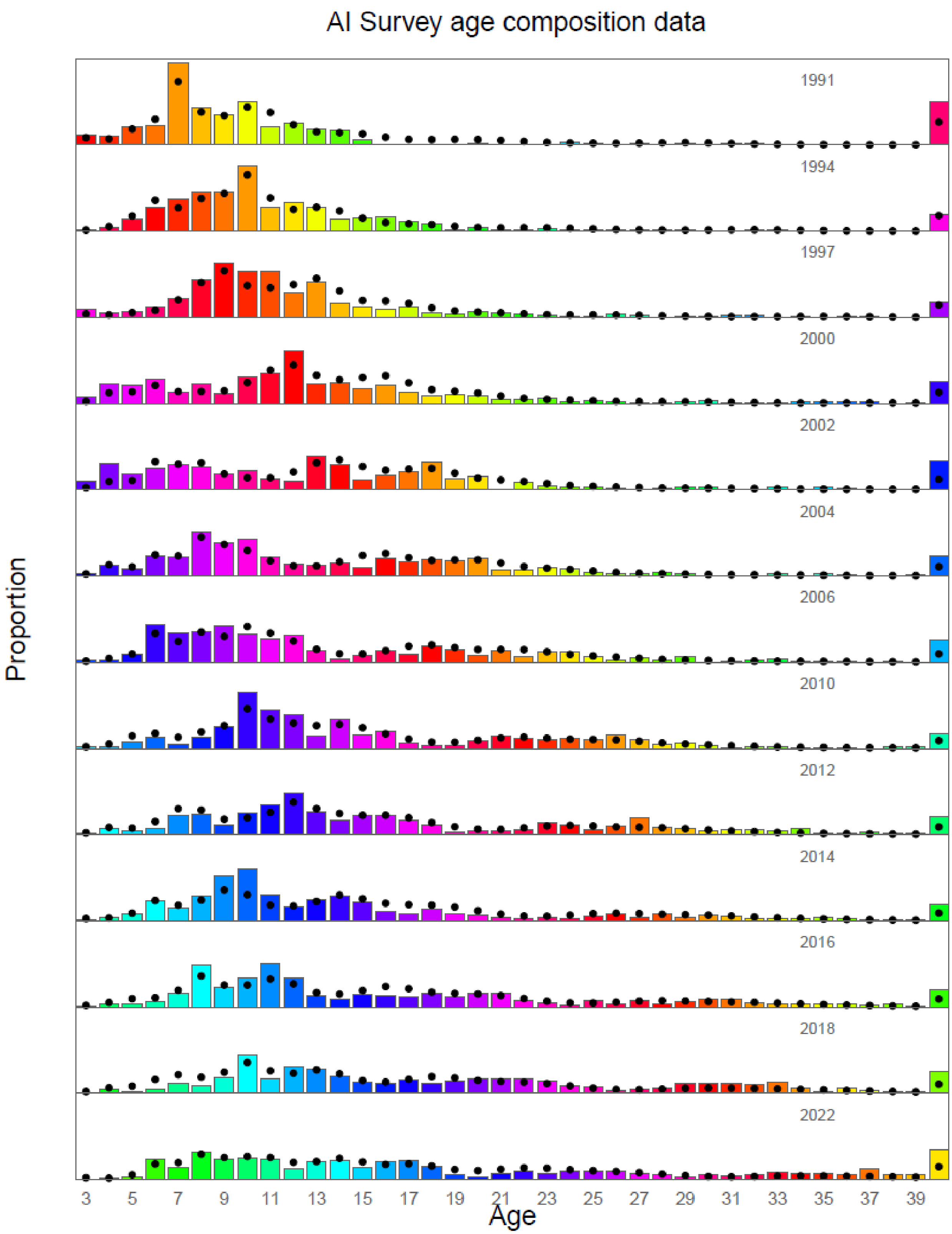


Figure 12.25. Model fits (dots) to survey age composition data (columns) for Aleutian Islands

Pacific ocean perch, 1991-2022. Colors correspond to cohorts (except for the 40+ group).

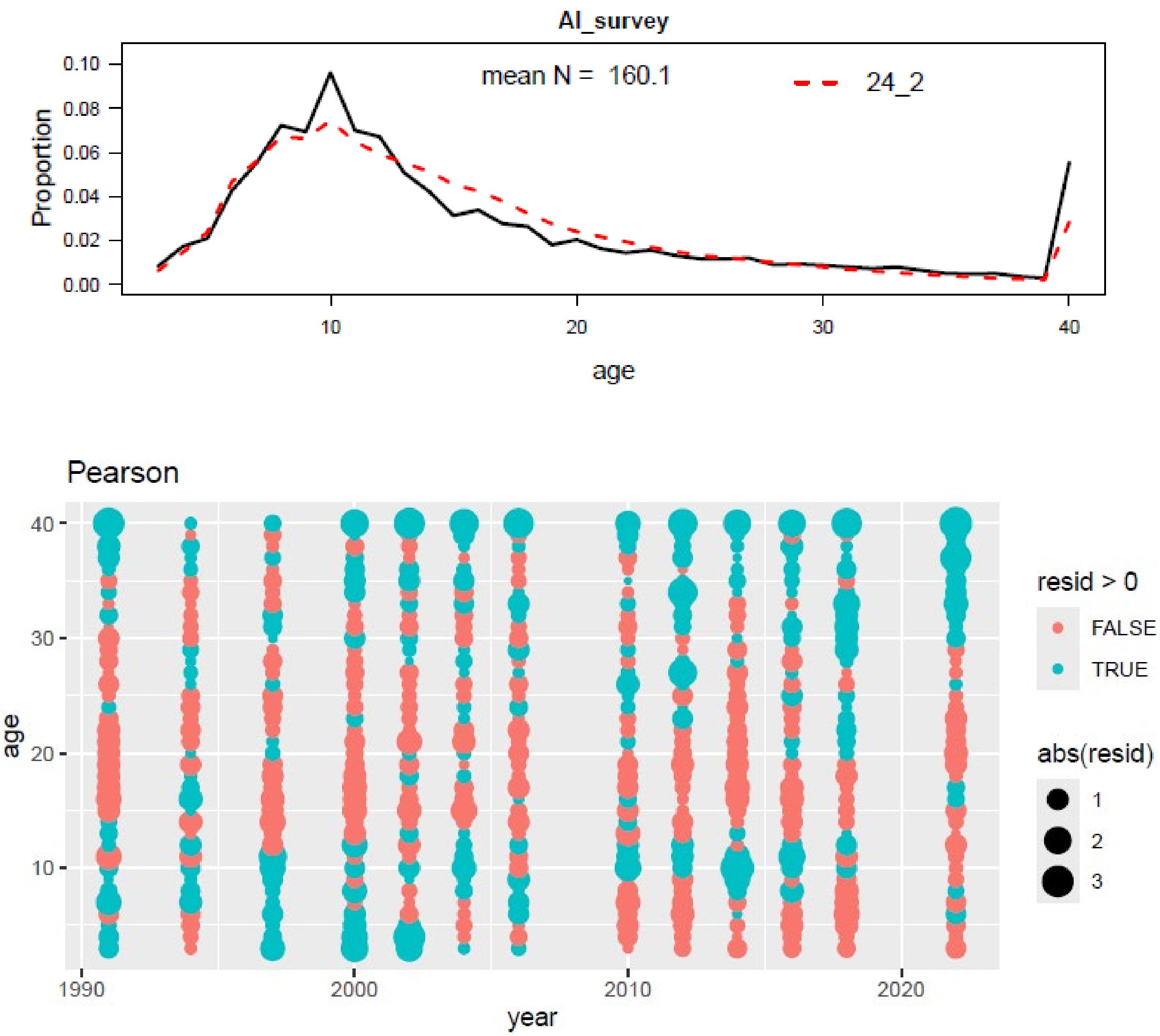


Figure 12.26. Aggregated observed (black) and estimated (red) AI survey age compositions (top panel) and Pearson residuals (bottom panel).

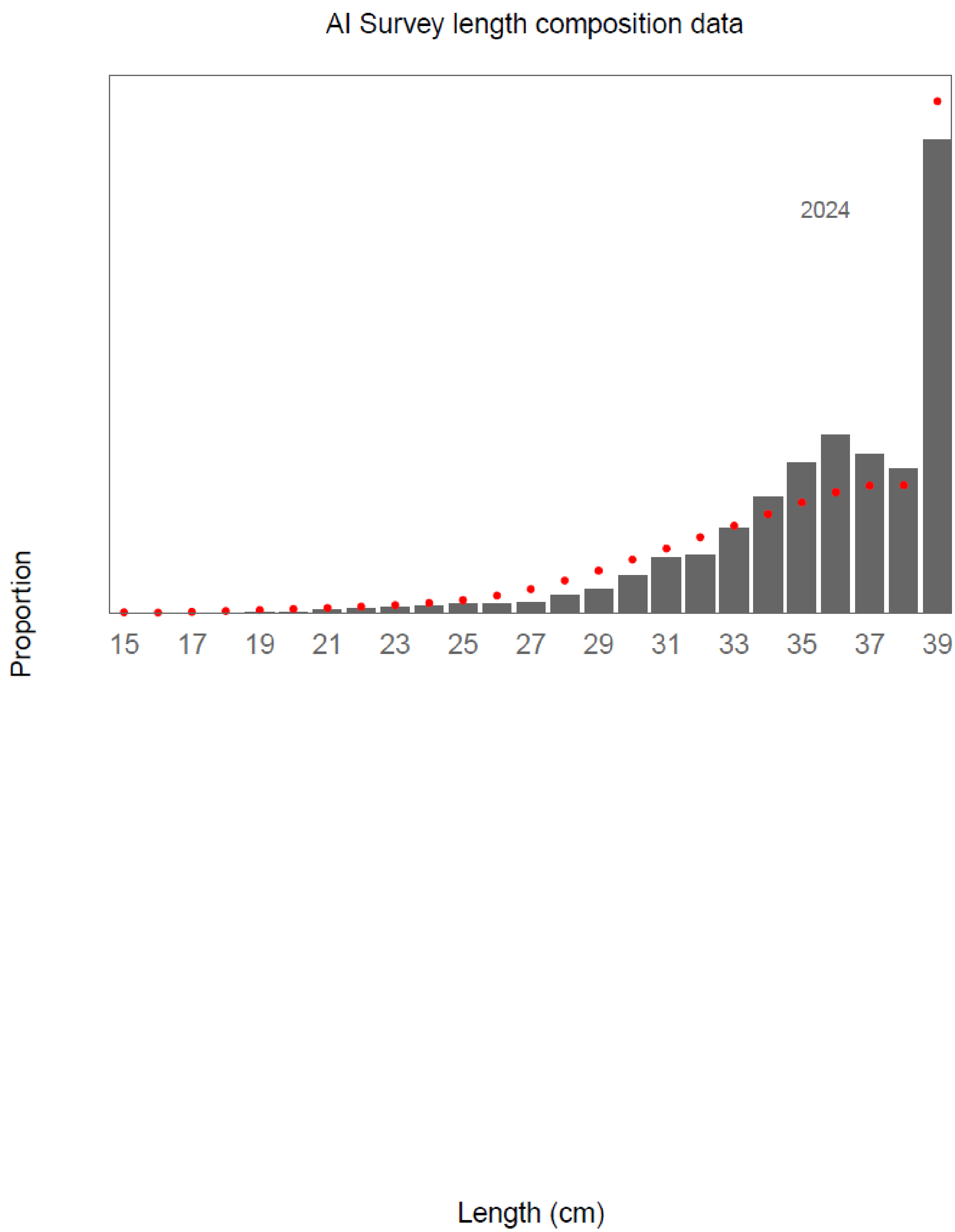


Figure 12.27. Model fits (dots) to 2024 AI survey length composition data (columns) for Pacific ocean perch.

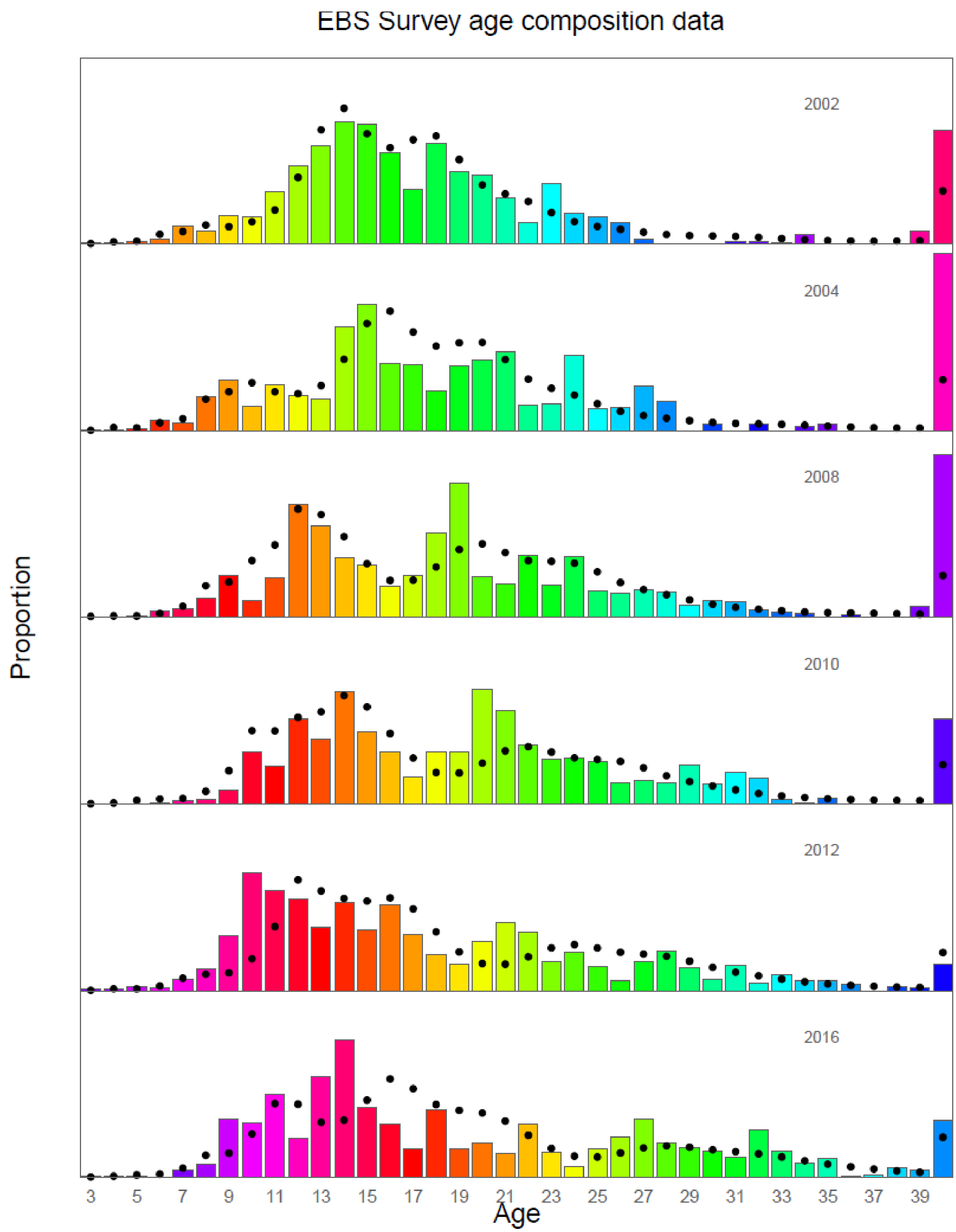


Figure 12.28. Model fits (dots) to EBS slope survey age composition data (columns) for Pacific ocean perch, 2002-2016. Colors correspond to cohorts (except for the 40+ group).

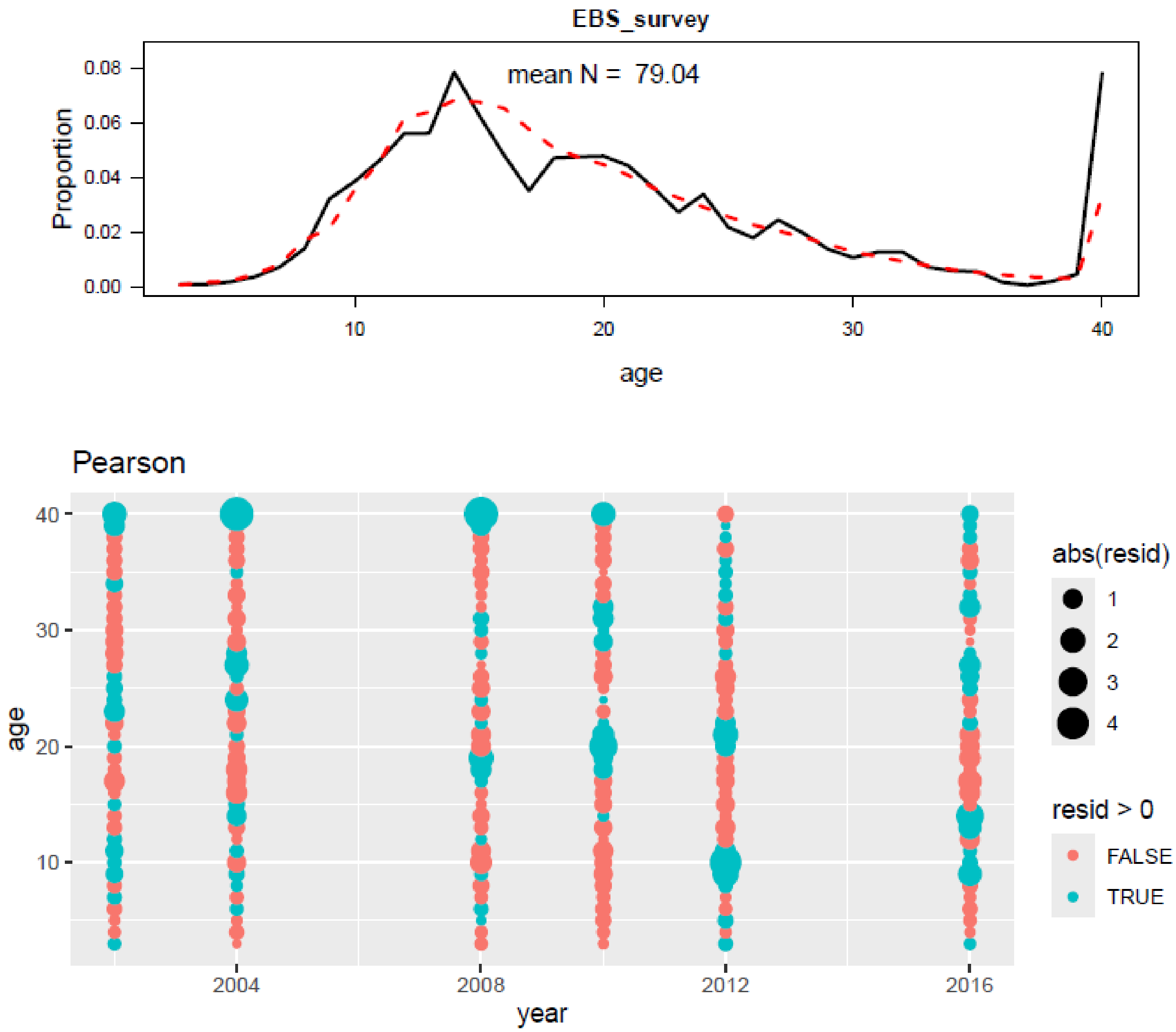


Figure 12.29. Aggregated observed (black) and estimated (red) EBS survey age compositions (top panel) and Pearson residuals (bottom panel).

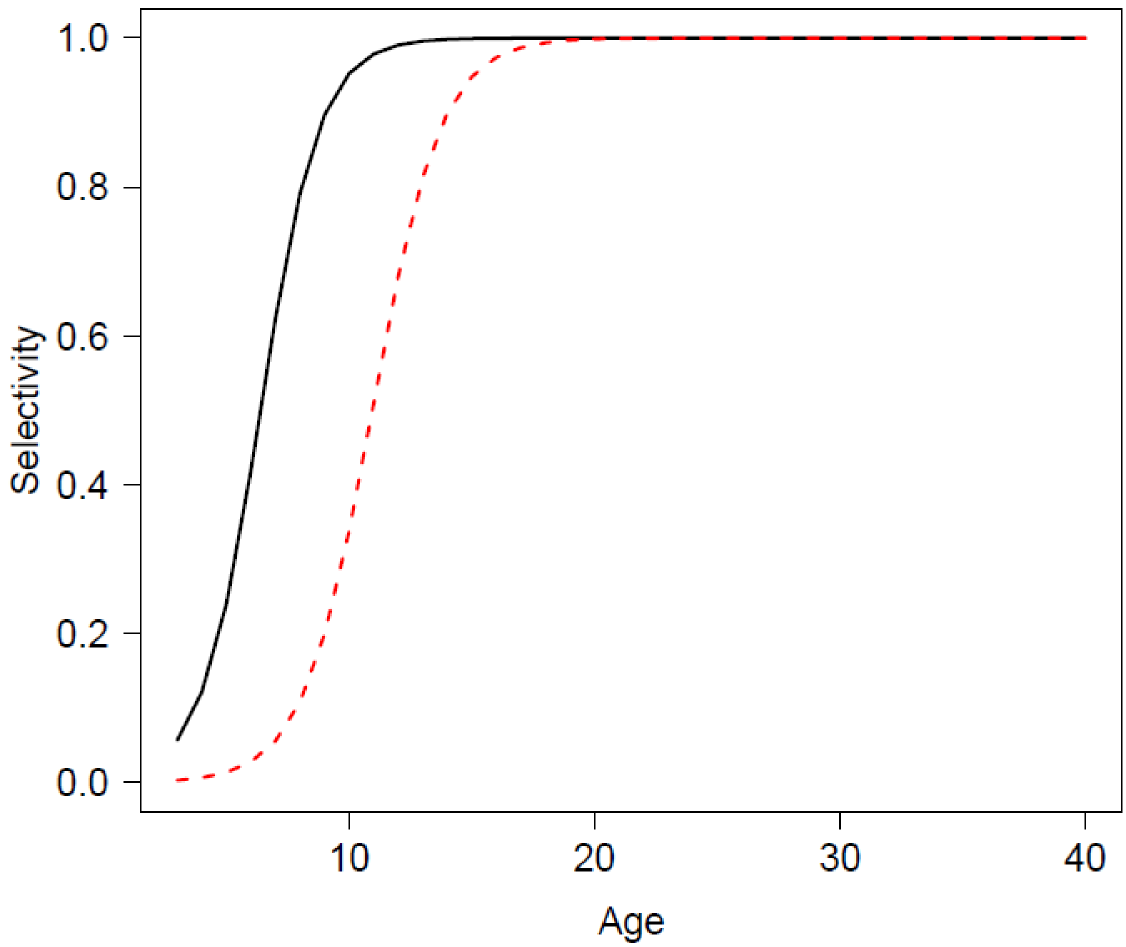


Figure 12.30. Estimated AI (black line) and EBS (red line) survey selectivity curve for BSAI POP.

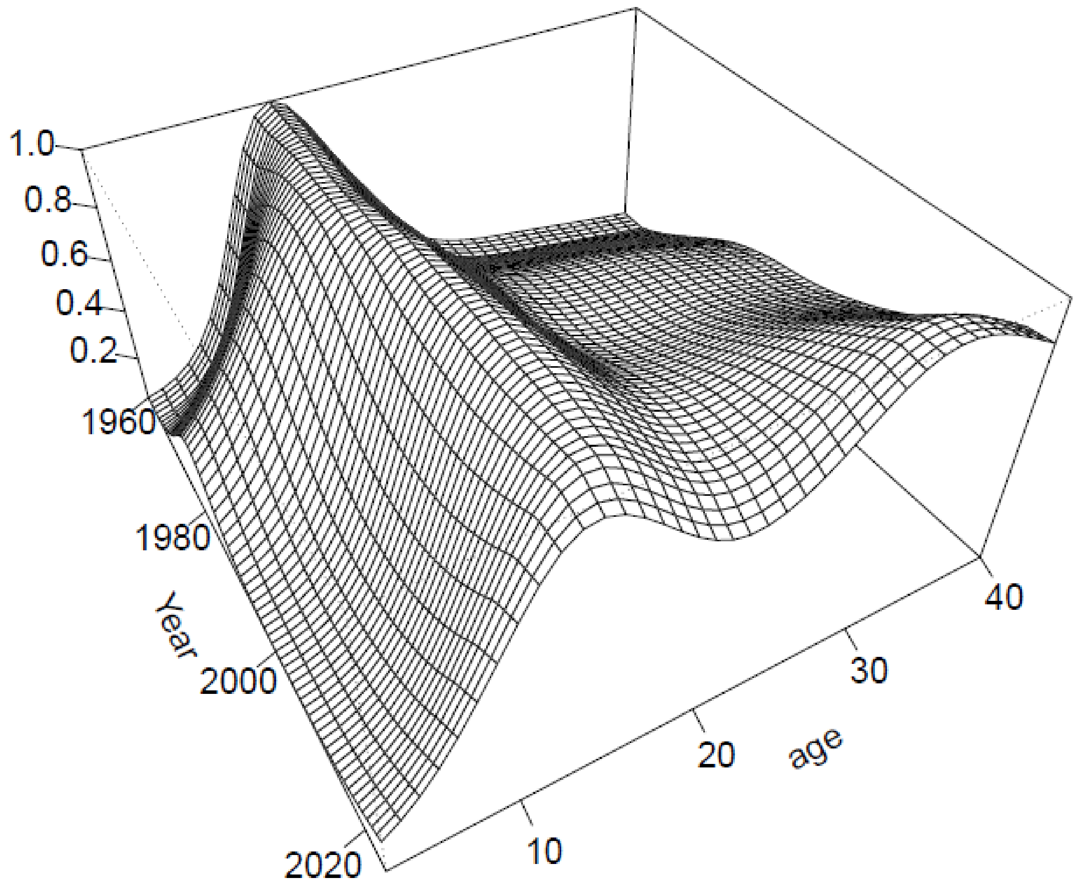


Figure 12.31. Estimated fishery selectivity from 1960-2024.

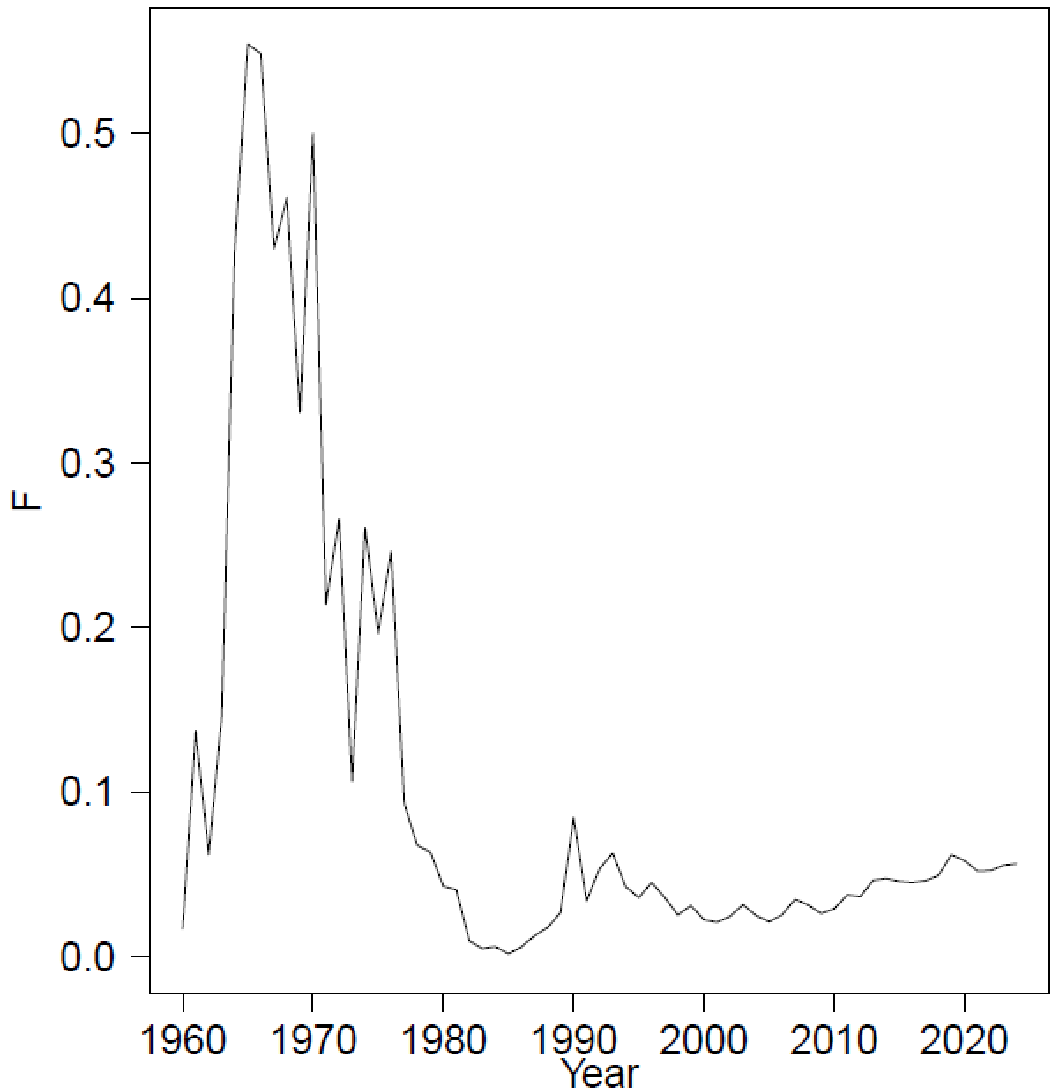
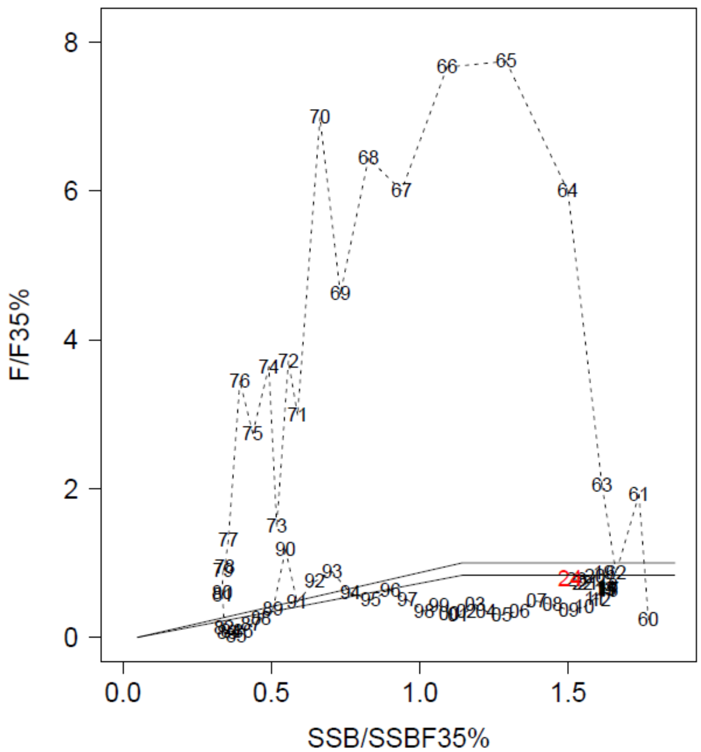


Figure 12.32. Estimated fully selected fishing mortality for BSAI POP.



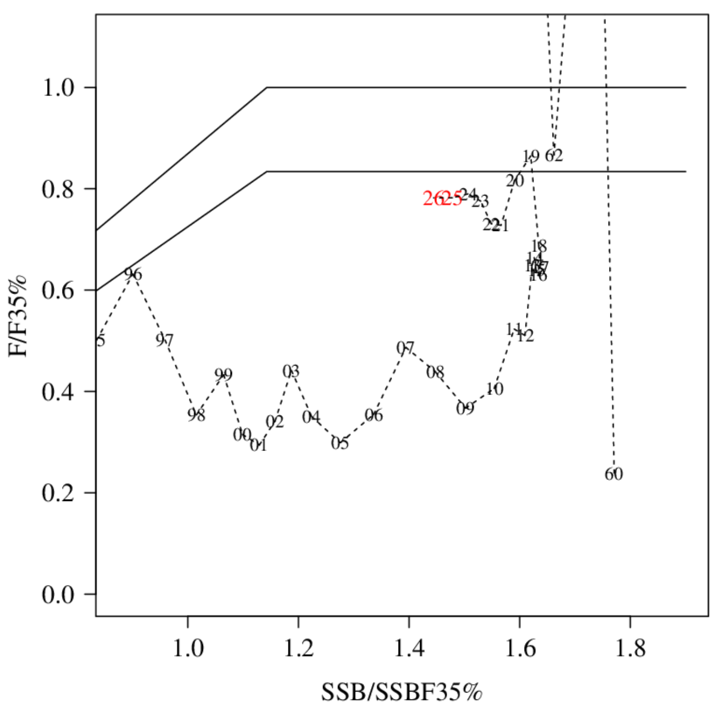


Figure 12.33. (Top panel) Estimated fishing mortality and SSB in reference to OFL (upper line) and ABC (lower line) harvest control rules, with 2024 shown in red. The bottom panel shows a

reduced vertical and horizontal scale, and the projected F and stock size for 2025 and 2026.

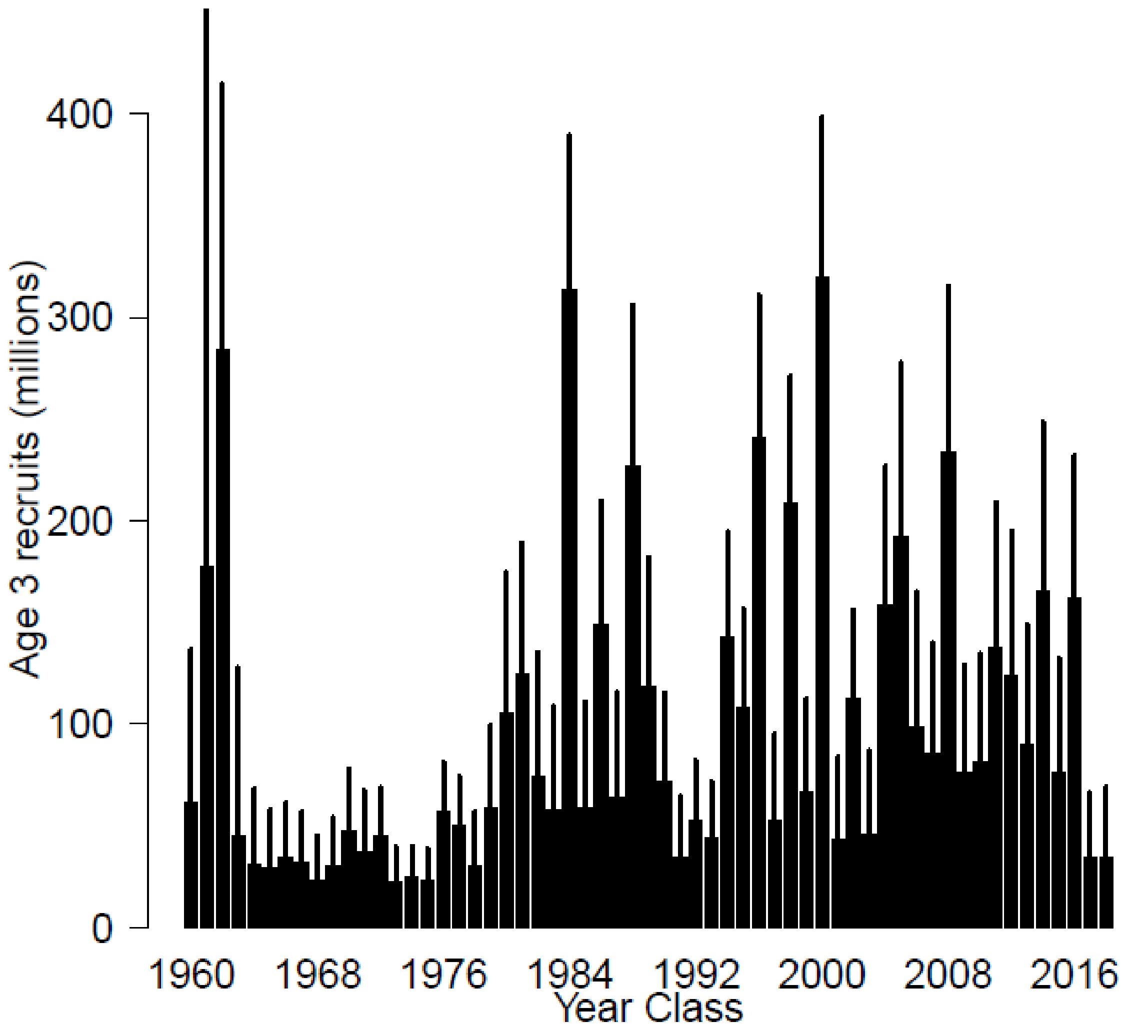


Figure 12.34. Estimated recruitment (age 3) of BSAI POP, with 90% credibility intervals obtained from MCMC integration.

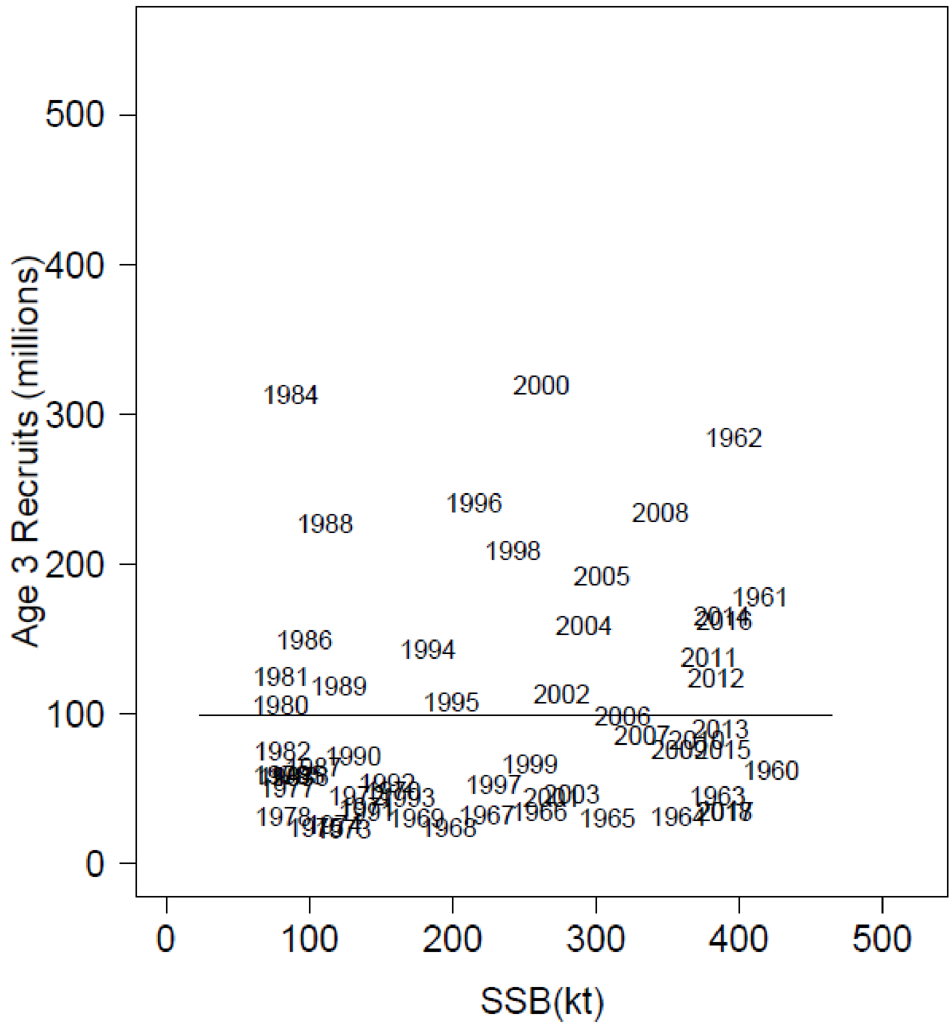


Figure 12.35. Scatterplot of BSAI POP spawner-recruit data; label is year class.

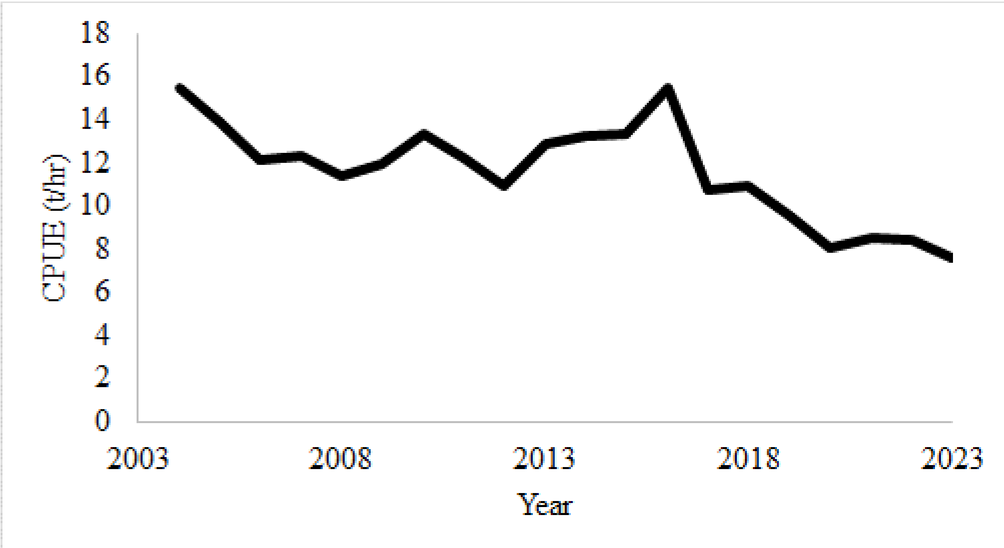


Figure 12.36. Catch per unit effort of POP in tows targeting POP from 2004 to 2024, from Observer data through October 10, 2024).

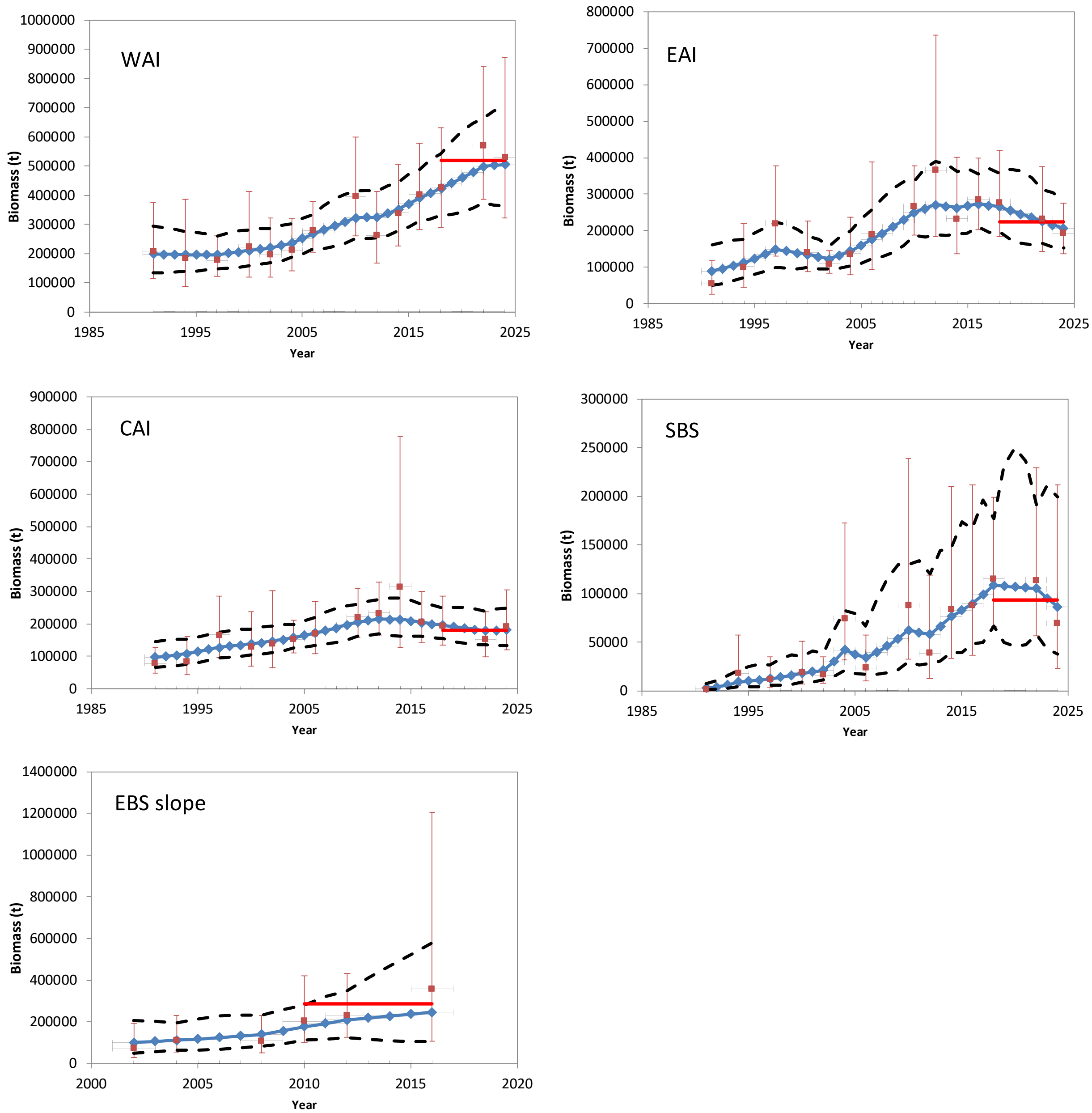


Figure 12.37. Estimated biomass from the AI and EBS slope trawl survey, with fits from a random effects model smoother. The horizontal red lines are a weighted average of the 3 most recent surveys.

Appendix 12A. Update on Plan Team and SSC requests for the BSAI Pacific ocean perch stock assessment, with preliminary model runs

Introduction

In the 2022, the Bering Sea/Aleutian Islands Plan Team and the Statistical and Scientific Committee of the North Pacific Fisheries Management Council made several recommendations regarding the BSAI Pacific ocean perch (POP) assessment model:

(BSAI Plan Team, September 2022) *Of these CIE recommendations, the author recommended the following changes to be brought forward in November 1) fitting the model to survey abundance instead of biomass, 2) exploring stochastic initial age compositions, and 3) for equilibrium initial age composition, explore mortality rates other than that currently used in the model.*

(BSAI Plan Team, November 2022). *The Team discussed investigating the mortality rates by age particularly for the plus group as there were poor fits to this group in the eastern Bering Sea (EBS) slope survey. The Team noted that time blocks could be explored for the plus group or consider time-varying selectivity as there were younger fish in the AI BTS than the EBS slope survey.*

(BSAI Plan Team, November 2022). *The Team also discussed the relative proportion of the EBS slope survey information into the future and encouraged the author to look at alternatives for estimating the apportionment on the EBS slope and comparing where the different surveys match up in the past for determining what the proportion should be moving forward.*

(SSC, December 2022). *The SSC concurs with the BSAI GPT suggestion to pursue time-varying survey selectivity for the AI bottom trawl survey and supports the BSAI GPT's other suggestions for model improvements*

The purpose of this report is to address the items above that concern the BSAI POP stock assessment and its input data, and present potential options for the 2024 assessment. Given that the fit to the AI survey has been a concern in this assessment (and other Alaska rockfish assessment), this fit is used as a criterion in evaluating potential modeling options.

The models considered in this report are:

Model	Description
Model 16.3	Accepted model from the 2022 assessment, which freely estimates the AI and EBS survey catchability coefficients without prior distributions
Model 24.1	Model 16.3, but with estimation of the recruitment for the initial numbers at age as stochastic variables

Model 24.2	Model 16.3, but with the penalty for the dome-shapedness in the bicubic spline used for fishery selectivity increased from 10 to 30, and a lognormal prior on the AI survey catchability (mean=1, CV=0.15)
Model 24.3	Model 24.2 but with selectivity for the AI and EBS trawl survey modeled with time-varying double normal curves

1) CIE recommendations for fitting survey abundance, and initial numbers at age

Fitting the AI survey abundance estimates instead of the biomass estimates was evaluated in the 2022 assessment, and did not substantially improve the residual pattern in the fit the AI survey estimates.

Estimated initial numbers at age for the 2022 model (16.3) and a model with stochastic initial numbers at age (24.1) are shown in Figure 12A.1. The start year of the model is 1960, and the estimated age-3 recruits in 1960 is estimated as a stochastic recruitment estimate. In model 16.3, the ages 4 to 40+ are estimated as from an equilibrium unfished population, and show a gradual decline in number at age with an accumulation of fish in the plus group. In contrast, estimation of stochastic numbers at age results in a strong estimated year class for 9 year old fish (1954 year class), and a lower number at age for the plus group, relative to model 16.3. Additionally, the estimates of age 3 fish in 1960 is smaller in model 24.1 relative to model 16.3, but the estimated number of age 4 fish is larger.

The aggregated age and length composition fits are nearly identical between models 16.3 and 24.1, for both the age (Figure 12A.2) and the length (Figure 12A.3) compositions. The fits to the AI survey index between these two models are also relatively similar, with very minor improvements in the fit to the 2010 – 2016 survey biomass indices (Figure 12A.4).

The estimated total biomass is smaller in model 24.1 than in model 16.3 (Figure 12A.5). This is largely due to survey catchability coefficients being larger in model 24.1, and the estimated natural mortality being smaller (Table 12A.1).

In models 16.3 and 24.1, the survey catchability coefficients are estimated freely without prior distributions, whereas the natural mortality parameter was estimated with normal distribution prior distribution, with both the mean and CV set at 0.05.

Model 16.3 estimates the initial numbers at age as being in equilibrium with an unfished population at the estimated natural mortality. Mortality estimates ranging from 0.5 to 1.5 the estimated natural mortality were also considered to estimate the equilibrium initial age composition, and resulted in changes in the number of the initial population in the plus group. As expected, with lower mortality rates the proportion of the initial population in the plus group increased (Figure 12A.1). The fits to the composition data, and the AI survey biomass index, are relatively unchanged with these alternative values of mortality (not shown). However, the AI survey catchability coefficient does change substantially to account for the change in the number of plus group fish, from 0.58 with equilibrium mortality at 0.5M to 1.25 with 1.5M. These exploratory models runs that alter the mortality rate for the initial year equilibrium population are not considered further in the assessment.

Model 24.1 does provides estimates of recruitment strength for the cohorts in the initial year that differ from those obtained with the equilibrium assumption in the current model. However, this appears to have little effect on the fit the composition data (based on the aggregated plots) and the fit to the AI survey index, which are two of the main problematic issues for this assessment. Additionally, model 24.1 estimates a large AI survey catchability coefficient of 1.51, suggesting that the AI trawl survey biomass substantially overestimates the true biomass, which seems unlikely (in part, because the AI survey does not account for the fish in the EBS portion of the stock area). Finally, we hypothesize that one reason the various modeling options for the initial year has little effect on the aggregated fits to the composition data is the long period between the initial year (1960) and the start of the fishery and AI survey age compositions (1981 and 1991, respectively). Given these issues, we recommend continuing to use the equilibrium population assumption for estimating the initial numbers at age.

Finally, in recent assessments the estimated time-varying fishery selectivity (estimated from a bicubic spline) shows an unusual multimodal distribution across ages in recent years, which is difficult to explain (Figure 12A.6). The extent to which selectivity decreases with age in dome-shaped patters is controlled by penalty applied to the rate of selectivity decrease (i.e., the first difference), which is set to 10 in the current model. In model 24.2, we increase this penalty to 30. Additionally, this model also restores the use of a prior distribution (used in historical POP assessments) for AI survey catchability, with a mean of 1 and a CV of 0.15. The use of a prior distribution for the survey catchability is supported from field work conducted by Jones et al. (2021) that compared rockfish densities in trawlable and untrawlable grounds in the Gulf of Alaska. Jones et al. (2021) found that the survey catchability for POP was 1.15, but this would be somewhat lower in this assessment because the portion of the population in the EBS is unavailable to the AI trawl survey.

The estimated fishery selectivity for 2022 from models 16.3 and 24.2 are shown in Figure 12A.7. Model *24.2* still has a bimodal pattern across ages for recent fishery selectivity, but the pattern is less pronounced than in model *16.3*, particularly for ages ≥ 35 years.

2) Fits to the plus group, and time-varying survey selectivity

The Pearson residuals give an indication of the temporal pattern in the fits to the age compositions, and are shown in Figures 12A.8 – 12A.10 for the model 16.3. This model consistently underfits the plus group for the AI survey (10 of 12 surveys) and the EBS survey (5 of 6 surveys), but overfits the plus group for the fishery age compositions (16 of 21 years).

The BSAI Plan Team noted the poor fits to the EBS survey age composition plus group in their November 2022 comment, and suggested evaluating time-varying selectivity. The SSC further suggested that time-varying survey selectivity be explored for the AI survey selectivity.

Model 24.3 has the features of model 24.2, and additionally has time-varying selectivity for both the AI and EBS trawl surveys that is modeled in time blocks. We modeled survey selectivity with the double normal equation, which can take on a wide variety of sigmoidal and dome-shaped patterns. The double normal equation for selectivity is incorporated into BSAI rockfish assessment modeling code, but has not been operationally used. The equation for the double normal equation is

$$
s_a = \begin{cases} e^{\frac{-(a-\mu)^2}{2\sigma_1^2}} & for\ a < \mu \\ 1 & for\ \mu < a < \mu + d \\ e^{\frac{-(a-(\mu+d)^2}{2\sigma_2^2}} & for\ a > \mu + d \end{cases}
$$

The double normal joins two normal distributions, with the means of the two distributions defined by μ and $\mu + d$, respectively. The slopes of the ascending and descending portions of the survey are controlled by σ_1 and σ_2, respectively, and selectivity for ages between the two means is set to the maximum value (i.e., 1 for this application). Sigmoidal shapes can be obtained by setting the parameter d (the distance between the two means) to a value larger than the maximum age, which results in maintaining the selectivity for older ages at 1.

Blocks of 4 years were used for each of the AI and EBS surveys, which begin in 1991 and 2002, respectively. After the model start year of 1960, new selectivity time blocks are initiated in 1996, 2000, 2004, 2008, 2012, 2014, and 2020. For the EBS survey, new time blocks are initiated in 2004, 2008, and 2012 (the last year for the EBS survey was 2016). Between the blocks, each of the 4 parameters (μ, σ_1, σ_2, and d) are allowed to change, subject to penalties. Specifically, the deviations from the average parameter value was modeled with a normal distribution with a mean of 0 and a standard deviation of 0.8.

The estimated time-varying AI and EBS show sigmoidal rather than dome-shaped patterns, with slight variations between the blocks with respect to the slope and location of the ascending portion of the curve (Figures 12A.11 and 12A.12, respectively). The Pearson residual plots for model 24.3 largely shows the same pattern in fitting to the plus group as model 16.3, namely underfitting the plus group in the survey age compositions but overfitting the fishery age composition plus group (Figures 12A.13 – 12A.15). Fits to the aggregated composition data sets and the AI survey index show similar properties to those from model 24.2, and seem to be little affected by allowance of time-varying survey selectivity (Figures 12A.2 – 12A.3).

The total biomass for 2022 was similar between models 24.2 and 24.3, but throughout most of the time series model 24.3 estimated a lower biomass than model 24.2. The use of a prior distribution for AI survey catchability results in lower estimates for this parameter in models 24.2 and 24.3 than in model 24.2.

Conclusions and recommendations for fall, 2024 assessment

Exploratory models that investigated options for modeling the initial numbers at age, and time-varying survey selectivity, have not resolved the poor residual patterns with the fits to the AI survey biomass time series, or the age and length compositions. However, these exploratory models often differ in the scale of total biomass, as the current model does not use a prior distribution on AI survey catchability.

We recommend model 24.2 be considered in the fall 2024 assessment. This model restores the prior distribution on the AI survey catchability (a feature that existed in historical BSAI POP assessments), and this prior distribution is consistent with field work conducted by Jones et al. (2021). Additionally, this model increases the penalty on domed-shapeness for fishery selectivity across ages, resulting in more stability in fishery selectivity across ages.

References

Jones, D.T., C.N. Rooper, C.D. Wilson, P.D. Spencer, D.H. Hanselman, and R. Wilborn. 2021. Estimates of availability to bottom trawls for select rockfish species from acoustic-optic surveys in the Gulf of Alaska. Fisheries Research 236:105848

Table 12A1. Estimates of natural mortality and survey catchability coefficients for the models considered in this report.

Parameter	Model 16.3	Model 24.1	Model 24.2	Model 24.3
Natural morality (M)	0.056	0.044	0.054	0.054
AI survey catchability	1.00	1.51	1.16	1.21
EBS survey catchability	0.25	0.37	0.30	0.31

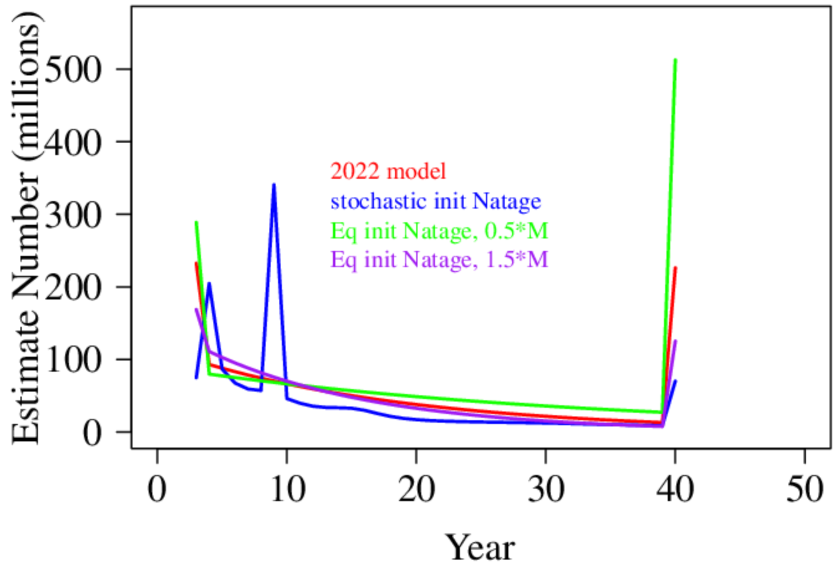


Figure 12A.1. Estimated numbers at age from models 16.3 and 24.1, and two alternative models that estimate an equilibrium initial number at age at different mortality rates.

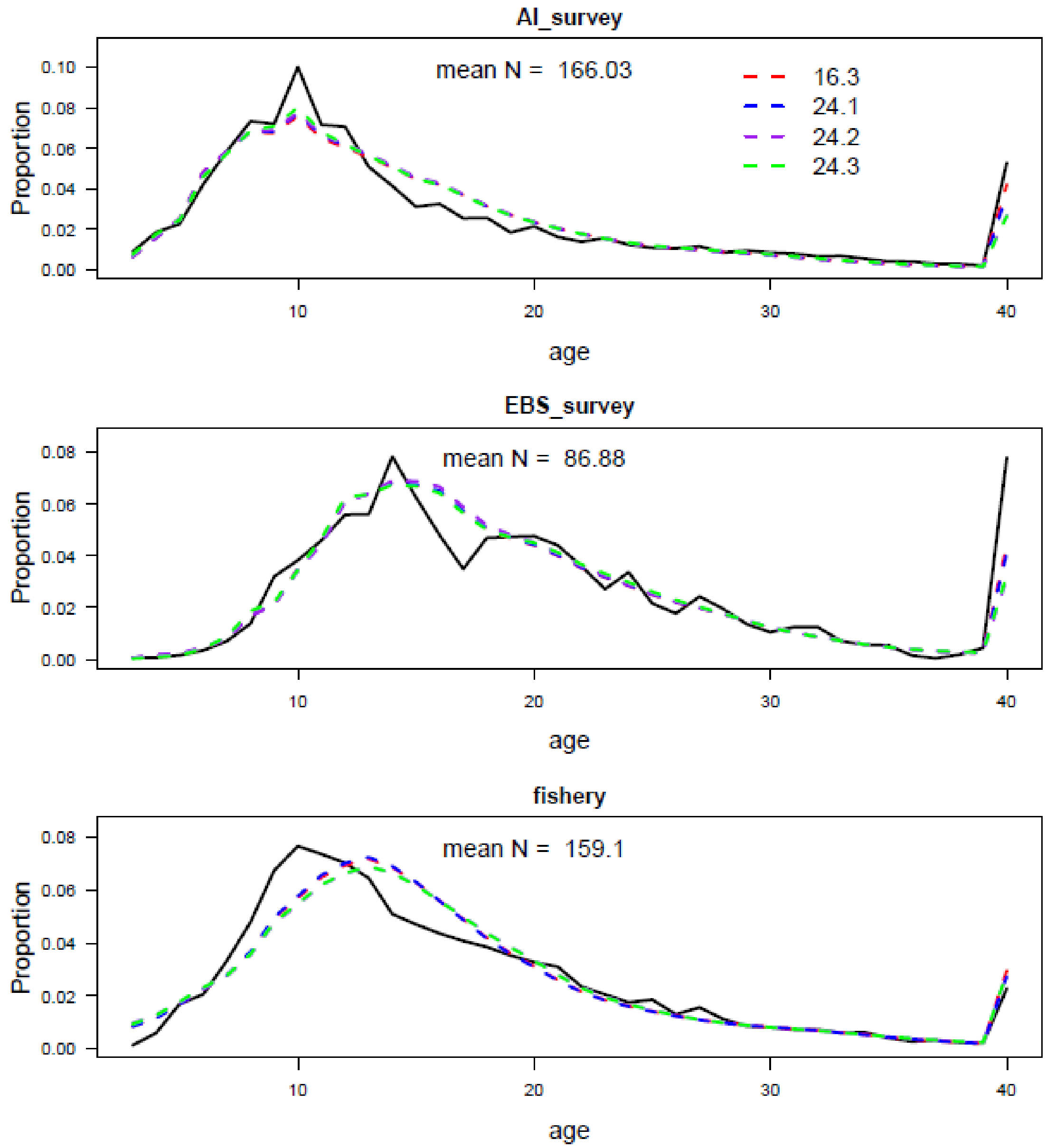


Figure 12A.2. Aggregated age composition data and fits from the 4 models considered in this report. Years within a data type were weighted by the year-specific sample size.

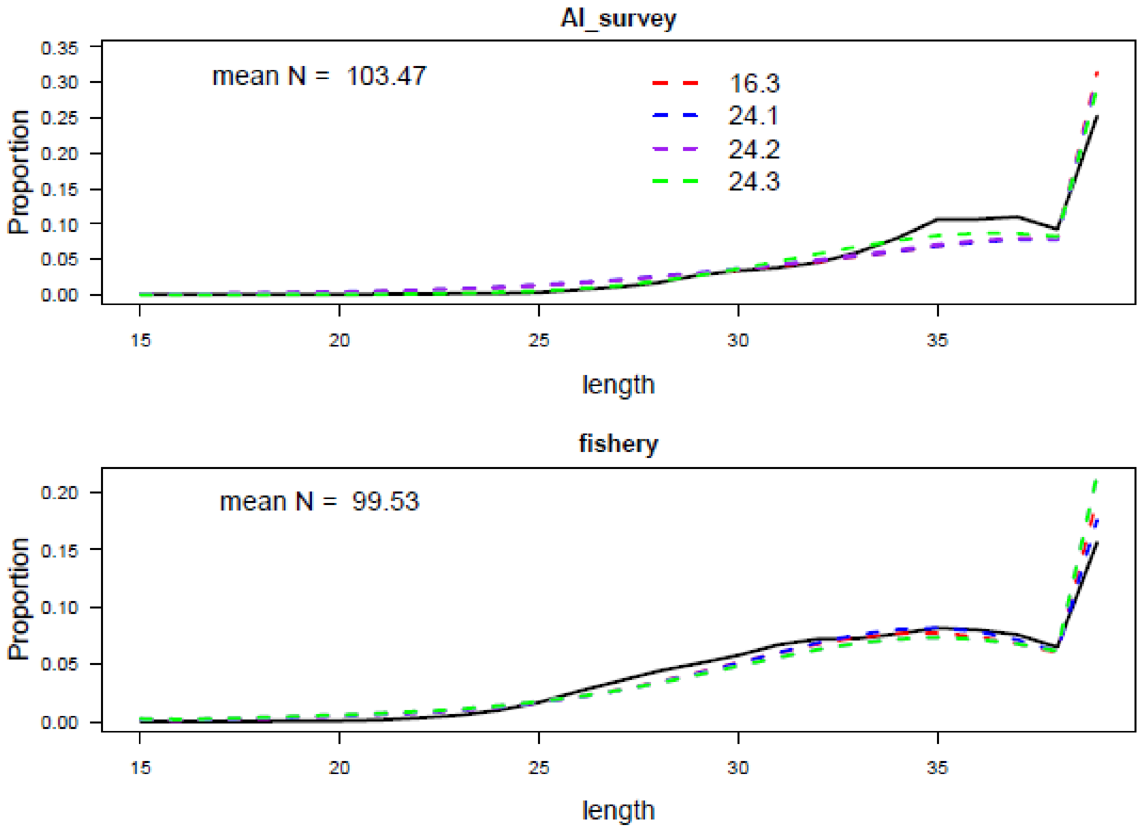


Figure 12A.3. Aggregated length composition data and fits from the 4 models considered in this report. Years within a data type were weighted by the year-specific sample size.

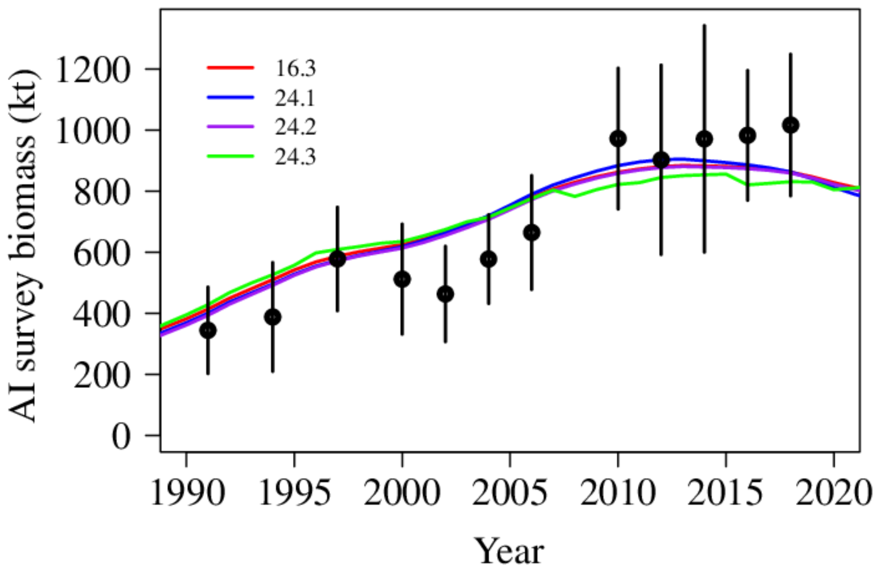


Figure 12A.4. Fit to the AI survey biomass index from the 4 models considered in this report.

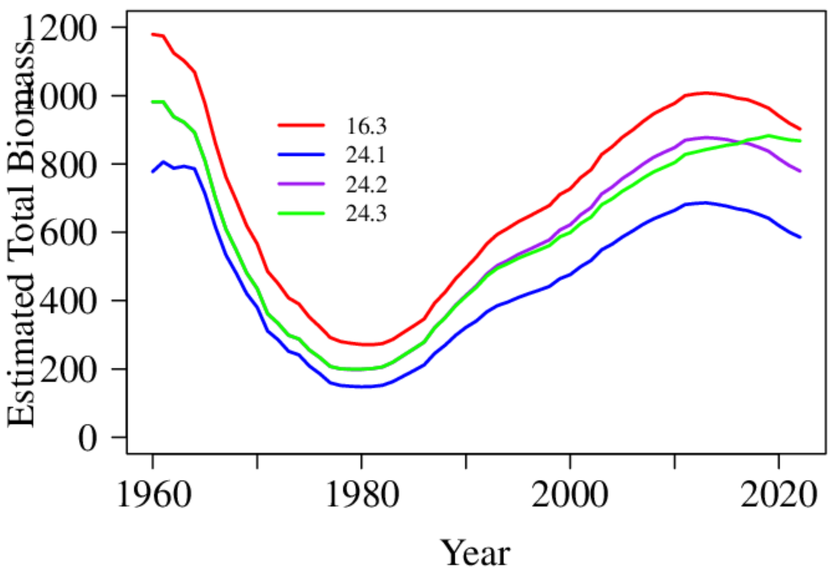


Figure 12A.5. Estimated total biomass from the 4 models considered in this report.

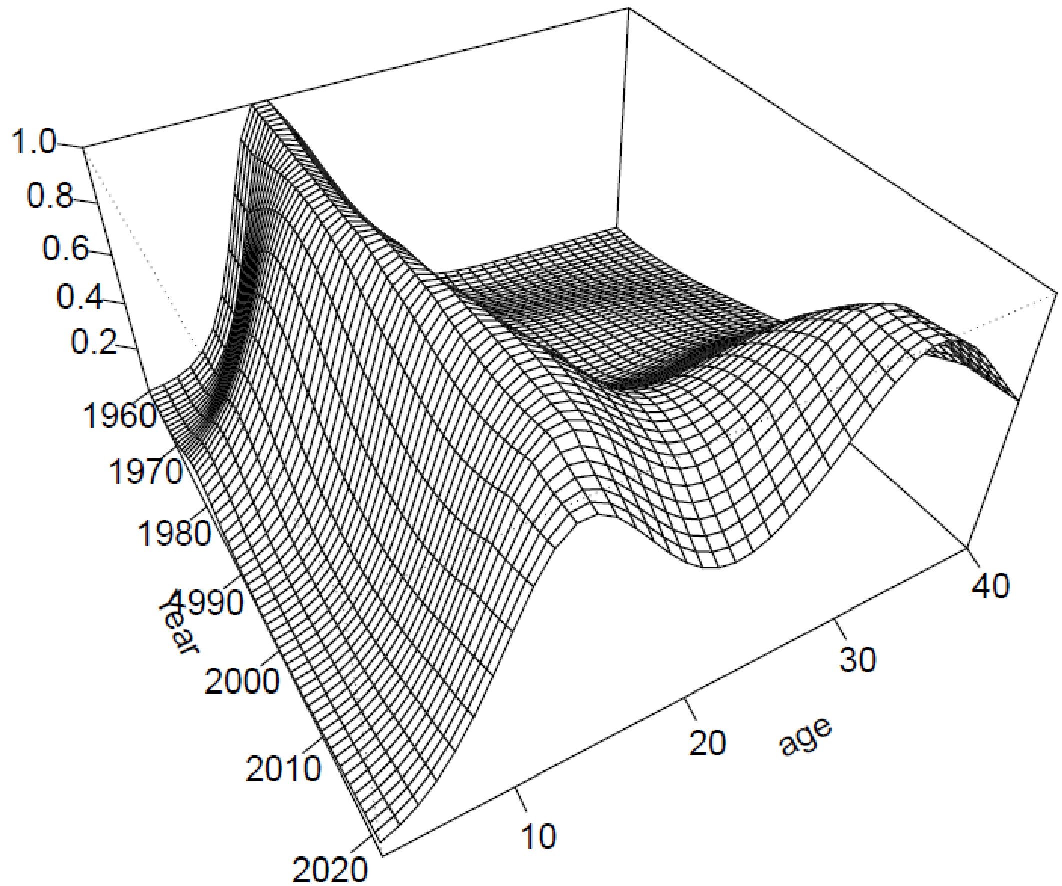


Figure 12A.6. Estimated fishery selectivity from the 2022 model (16.3); note the bimodal selectivity in recent years.

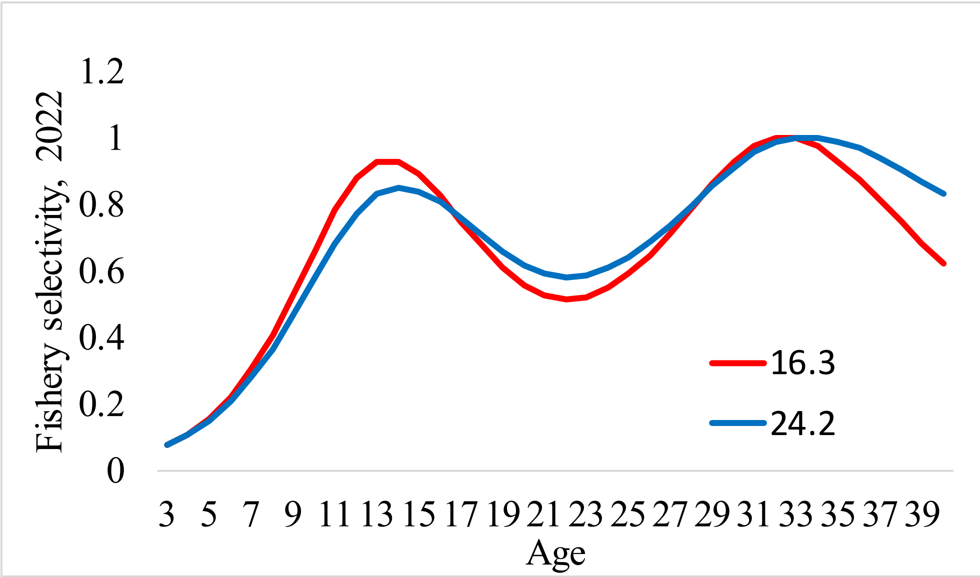


Figure 12A.7. Estimated fishery selectivity for 2022 from models 16.3 and 24.2.

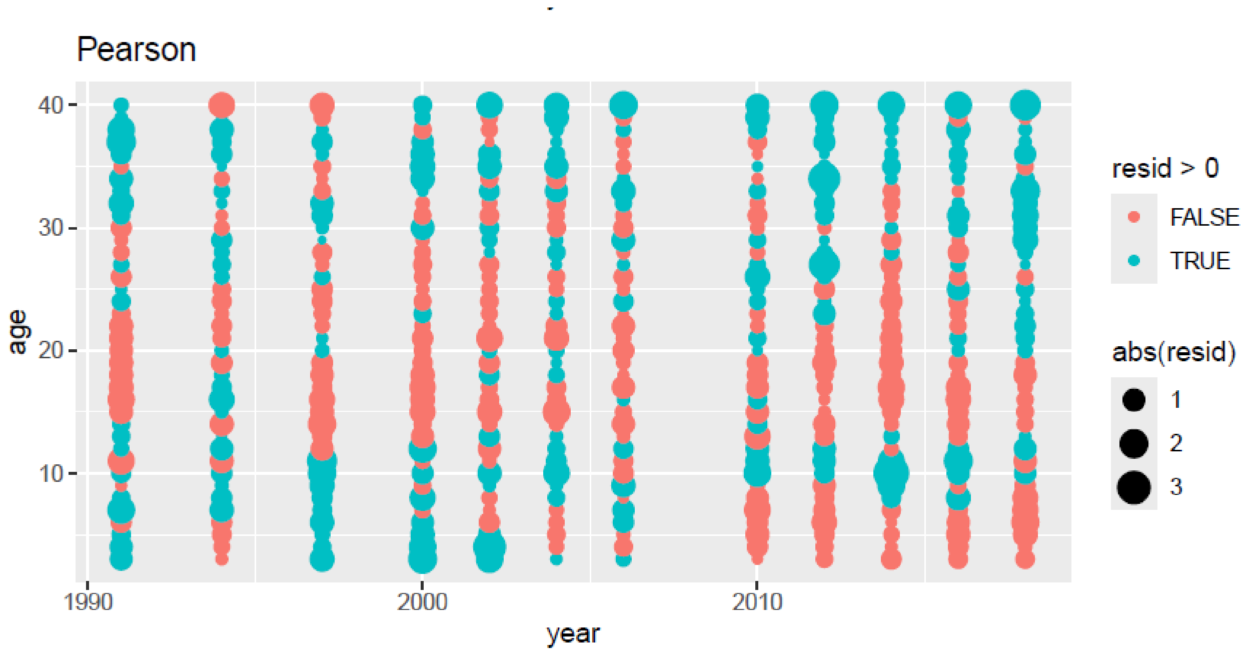


Figure 12A.8. Pearson residuals for the AI survey age composition data, model 16.3.

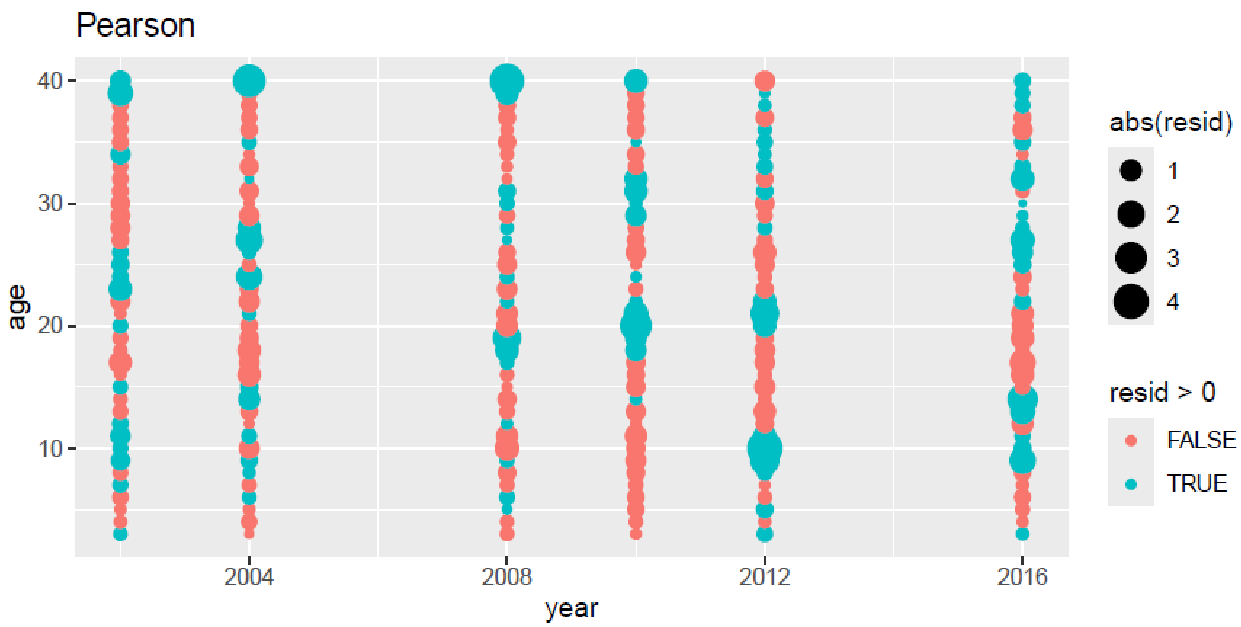


Figure 12A.9. Pearson residuals for the EBS survey age composition data, model 16.3.

Figure 12A.10. Pearson residuals for the fishery age composition data, model 16.3.

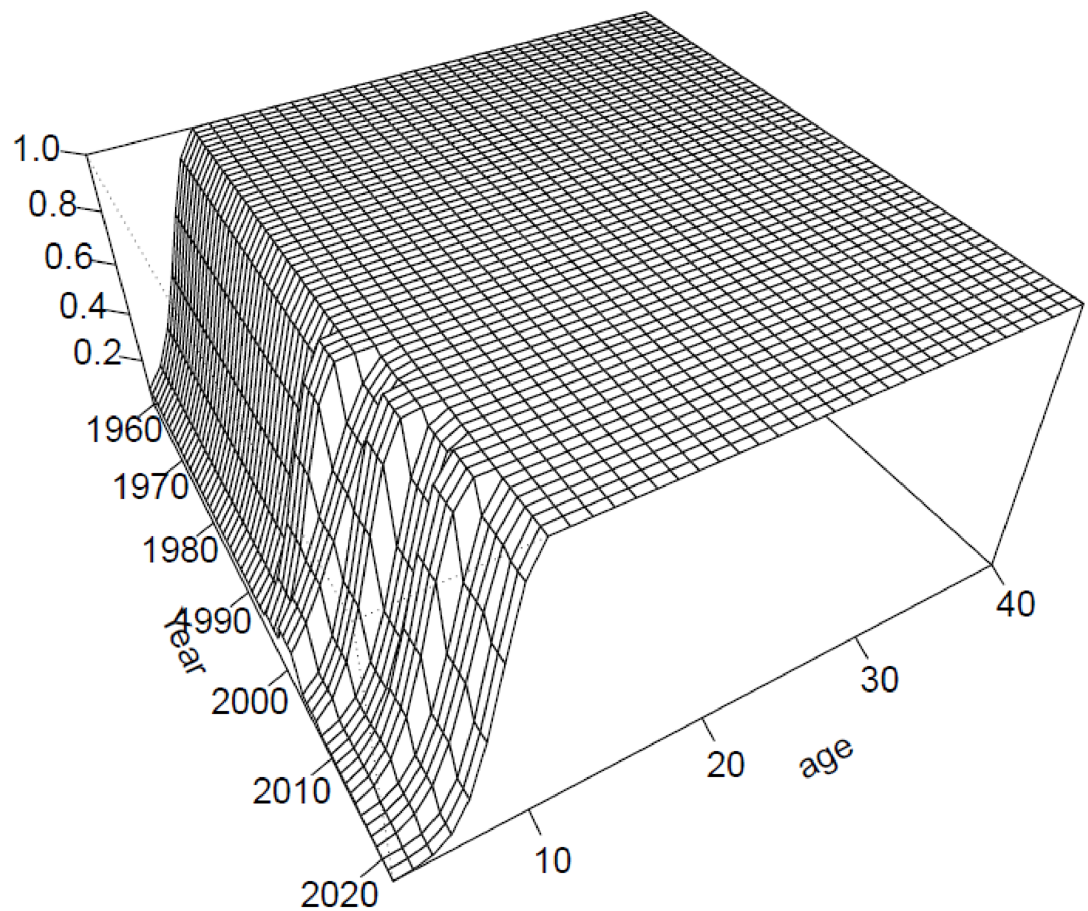


Figure 12A.11. Estimated time-varying AI survey selectivity, model 24.3.

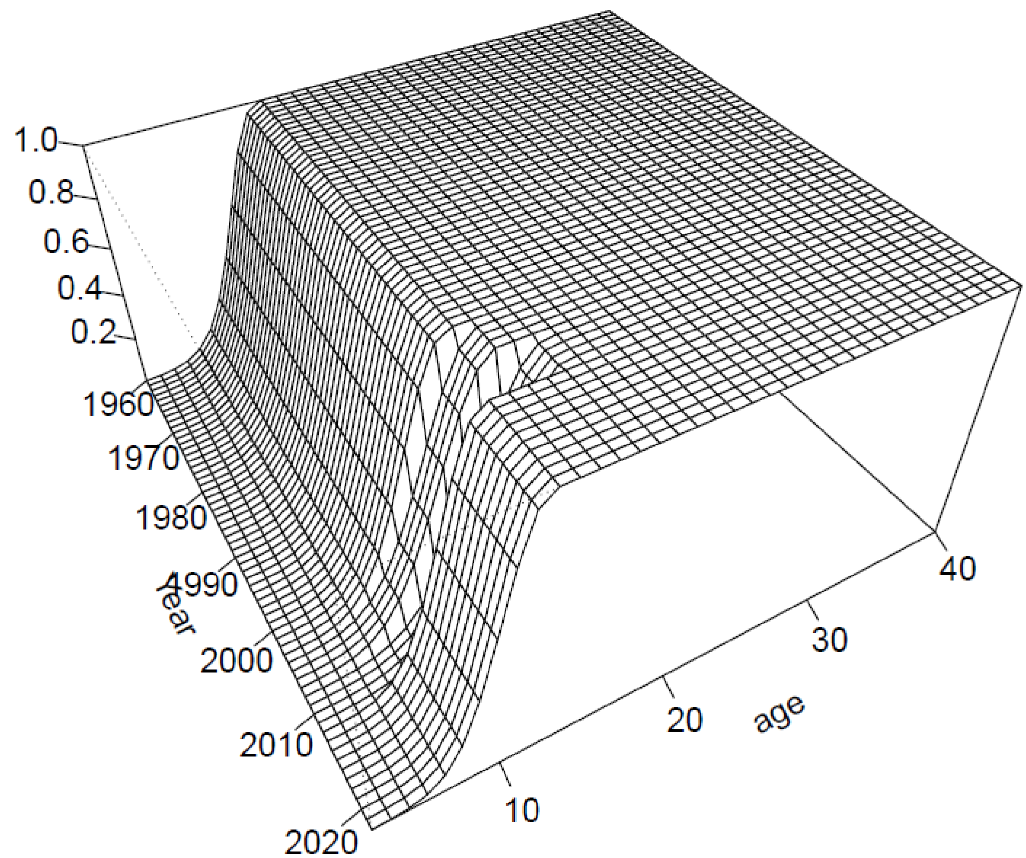


Figure 12A.12. Estimated time-varying EBS survey selectivity, model 24.3.

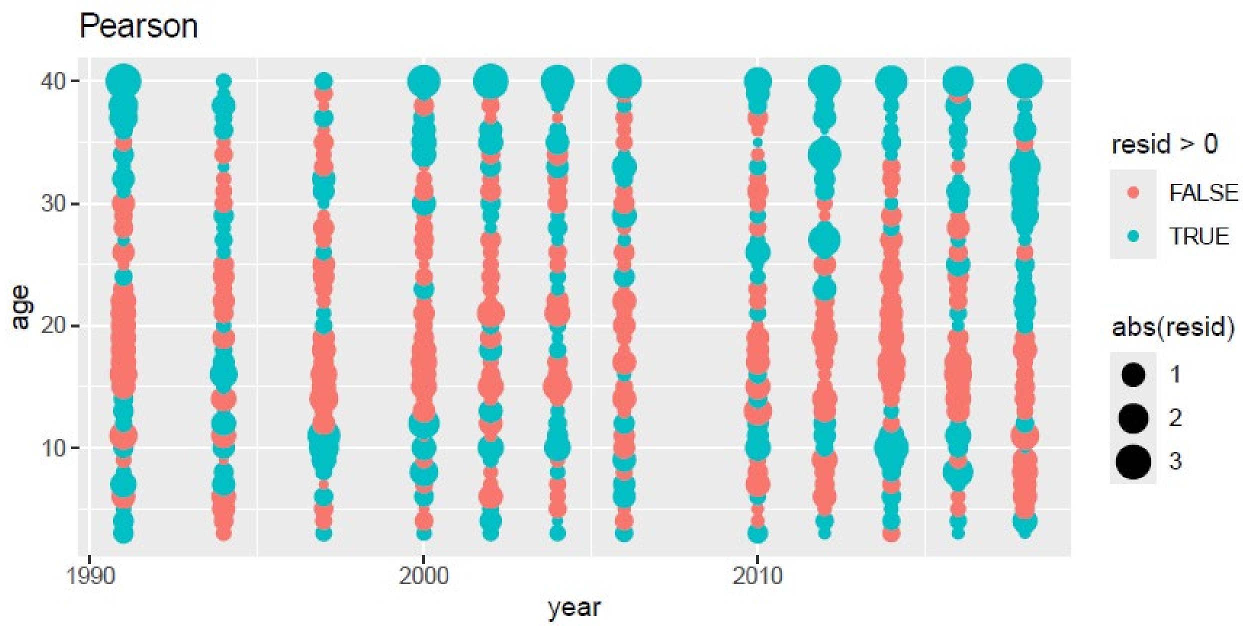


Figure 12A.13. Pearson residuals for the AI survey age composition data, model 24.3.

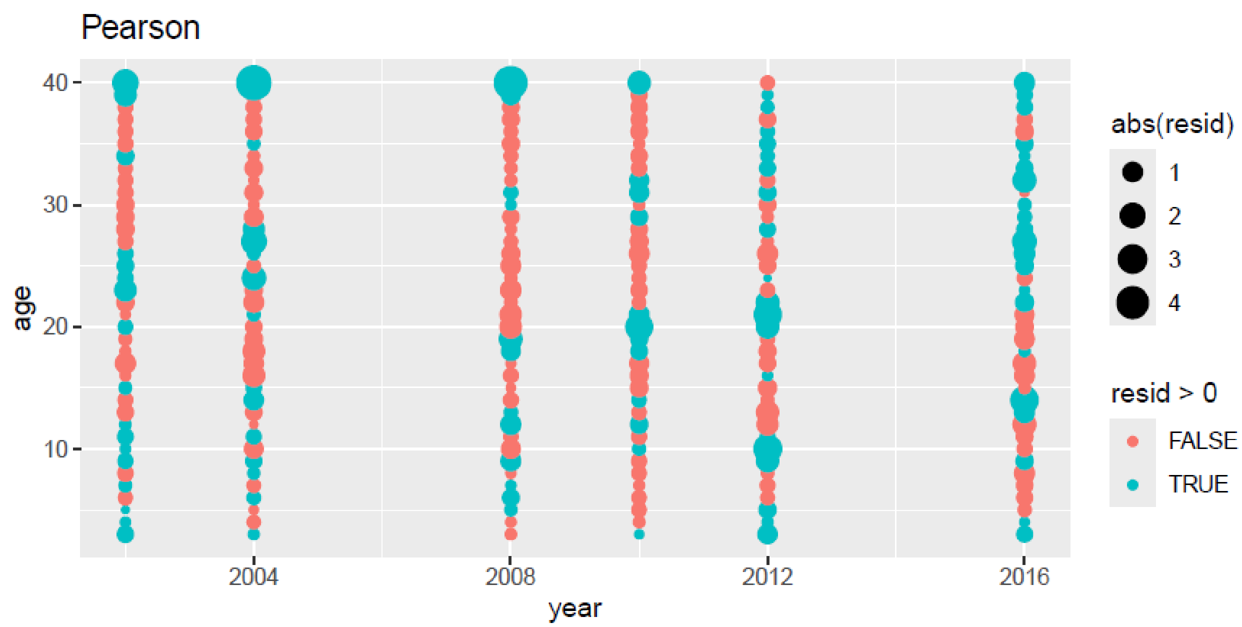


Figure 12A.14. Pearson residuals for the EBS survey age composition data, model 24.3.

Figure 12A.15. Pearson residuals for the fishery age composition data, model 24.3.

Appendix 12B. Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals that do not occur during directed groundfish fishing activities are reported (Table B1). This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For BSAI POP, these estimates can be compared to the trawl research removals reported in previous assessments. POP research removals are small relative to the fishery catch. The majority of removals are taken by the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey which is the primary research survey used for assessing the population status of BSAI POP. The amount of POP captured in research longline gear has typically been less than 0.2 t. Total removals of POP ranged between 0.15 t and 316 t between 2010 and 2023.

Appendix Table 12B.1. Removals of BSAI POP from activities other than groundfish fishing (t). Trawl and longline include research survey and occasional short-term projects.

Year	Source	Trawl	Longline	Other
1977	NMFS-AFSC survey databases	0.008		
1978		0.144		
1979		3.083		
1980		71.474		
1981		13.982		
1982		14.250		
1983		133.461		
1984		0.000		
1985		98.567		
1986		164.541		
1987		0.014		
1988		10.428		
1989		0.003		
1990		0.031		
1991		76.327		
1992		0.383		
1993		0.011		
1994		112.815		
1995		0.023		
1996		1.179	0.015	
1997		178.820		
1998		0.006	0.003	
1999		0.192	0.014	
2000		164.166	0.019	
2001		0.114	0.015	
2002		143.795	0.026	
2003		7.595	0.012	
2004		180.928	0.029	
2005		10.682	0.019	
2006		168.609	0.043	
2007		0.063	0.036	
2008		21.087	0.037	
2009		1.436	0.139	
2010	AKFIN database	266.674	0.097	
2011		104.409	0.011	
2012		285.773	0.046	
2013		8.496	0.057	
2014		247.868	0.056	
2015		2.872	0.196	
2016		316.299	0.029	
2017		1.437	0.065	
2018		248.408	0.036	
2019		0.239	0.128	
2020		0.077	0.070	
2021		0.830	0.000	
2022		225.530	0.000	
2023		0.691	0.000	