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

by

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Executive Summary

The last full assessment for Pacific ocean perch (POP) was presented to the Plan Team in 2020. The following changes were made to POP assessment relative to the November 2020 SAFE:

Summary of Changes in Assessment Inputs

Changes in the Input Data

1) Catch data was updated through 2021, and total catch for 2022 was projected.

2) The 2022 AI survey biomass estimate and length composition were included in the assessment.

3) The 2020 and 2021 fishery age 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

There were no changes to the stock assessment methodology in the recommended model.

Summary of Results

A summary of the 2022 assessment recommended ABCs relative to the 2021 recommendations is shown below. BSAI Pacific ocean perch are not overfished or approaching an overfished condition. The recommended 2023 ABC and OFL are 42,038 t and 50,133 t, which are increases of 18% from the maximum ABC and OFL specified last year for 2022 of 35,688 t and 42,605 t. In recent assessments, the large biomass estimates from the Aleutian Islands trawl survey have resulted in large estimated stock sizes, and the biomass estimate from the 2022 survey is the largest on record. 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: 2022	2023	As estimated or recommended this year for: 2023*	2024*
M (natural mortality rate)	0.056	0.056	0.056	0.056
Tier	3a	3a	3a	3a
Projected total (age 3+) biomass	738,710	724,085	888,722	876,140
Female spawning biomass (t)				
Projected	299,232	288,437	359,074	352,616
$B_{100\%}$	584,747	584,747	652,626	652,626
$B_{40\%}$	233,899	233,899	261,050	261,050
$B_{35\%}$	204,661	204,661	228,419	228,419
F_{OFL}	0.089	0.089	0.089	0.089
$maxF_{ABC}$	0.073	0.073	0.074	0.074
F_{ABC}	0.073	0.073	0.074	0.074
OFL (t)	42,605	40,977	50,133	49,279
maxABC (t)	35,688	34,322	42,038	41,322
ABC (t)	35,688	34,322	42,038	41,322
Status	As determined last year for: 2020	2021	As determined this year for: 2021	2022
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 harvests of 33,616 t and 33,043 t in 2023 and 2024, respectively.

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
2022 smoothed biomass estimate	492,623	170,314	245,831	113,052	245,905
percentage	38.9%	13.4%	19.4%	8.9%	19.4%

The following table gives the projected OFLs and apportioned ABCs for 2023 and 2024, and the recent OFLs, ABCs, TACs, and catches.

Area	Year	Age 3 Bio (t)	OFL	ABC	TAC	Catch[1]
BSAI	2021	756,011	44,376	37,173	35,899	35,479
	2022	738,710	42,605	35,688	35,385	26,420
	2023	888,722	50,133	42,038	n/a	n/a
	2024	876,140	49,279	41,322	n/a	n/a
Eastern Bering Sea	2021			10,782	10,782	10,693
	2022			10,352	10,352	6,353
	2023			11,903	n/a	n/a
	2024			11,700	n/a	n/a
Eastern Aleutian Islands	2021			8,419	8,419	8,288
	2022			8,083	8.083	5,001
	2023			8,152	n/a	n/a
	2024			8,013	n/a	n/a
Central Aleutian Islands	2021			6,198	6,198	5,993
	2022			5,950	5,950	4,916
	2023			5,648	n/a	n/a
	2024			5,551	n/a	n/a
Western Aleutian Islands	2021			11,774	10,500	10,505
	2022			11,303	11,000	10,150
	2023			16,335	n/a	n/a
	2024			16,058	n/a	n/a

[1]Catch through September 25, 2022

Responses to SSC and Plan Team Comments on Assessments in General

(SSC, June 2021) The SSC developed *Preliminary Guidance and SSC Recommendations* regarding the use of risk tables, with 9 specific comments/recommendations.

Authors' response: We have attempted to follow this guidance when updating the risk table in this assessment.

(Joint Plan Team, September 2022) *The Teams recommended that stock assessment authors transition from the ADMB random-effects survey smoother to this package which implements the same model with several improvements.*

The *rema* package was used to estimate the smoothed survey biomass time series, which were used in the calculations of apportionments.

(SSC, October 2022) *Several assessment updates noted potential impacts of the recent lack of the EBS slope survey on abundance and size/ age composition data. The SSC acknowledges that these challenges result from ongoing survey resource limitations and that the 2018 SSC Sub-Committee on Trawl Survey Options and Priorities ranked the slope survey as the lowest priority. The SSC recommends that* *assessment authors continue to highlight instances where the lack of these data may degrade stock assessment performance.*

The BSAI POP stock assessment utilizes the EBS slope survey, which is the only fishery-independent data source for the portion of the stock in the EBS. The lack of recent EBS slope survey biomass estimates causes uncertainty in the BSAI POP assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

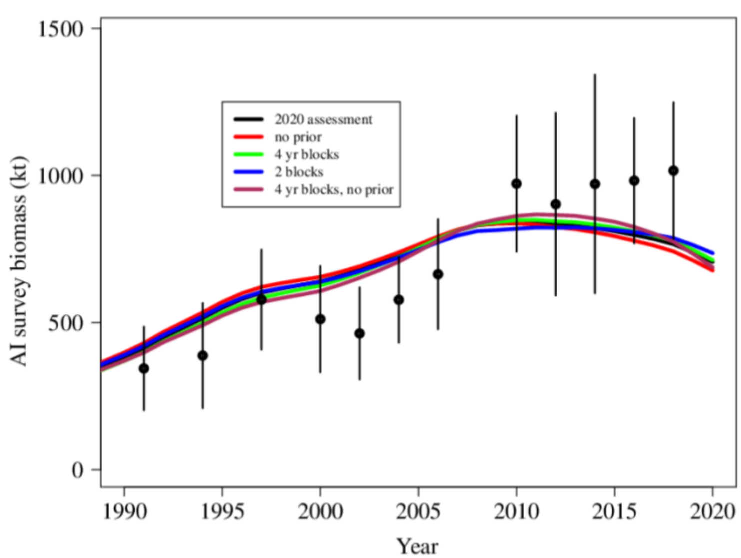
(BSAI Plan Team, November 2020) *The Team recommended investigating Francis weighting and trying different time blocks of natural mortality to help improve the fit to the Aleutian Islands survey index.*

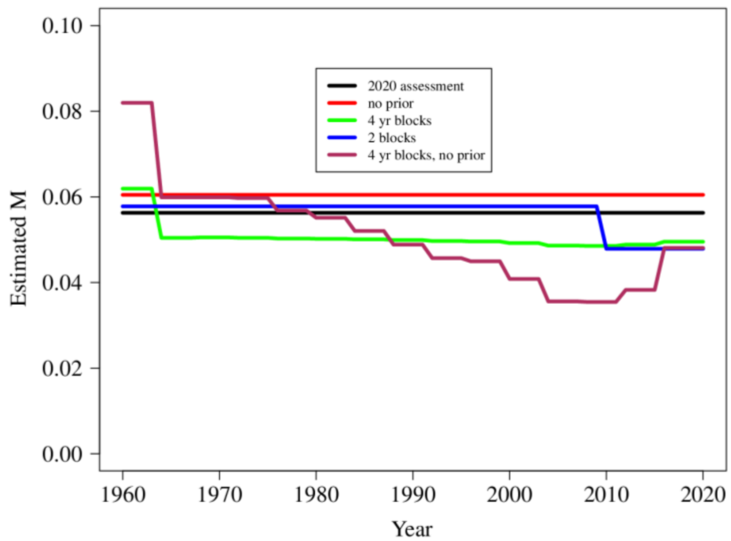
(SSC, December 2020) *The lack of fit in recent years is concerning and the SSC suggests that this should continue to be a focus of future work.*

(SSC, December 2020) *The SSC supports continued work on evaluating M, including examining the impact of loosening the prior on M and considering time blocks in M, as suggested by the BSAI GPT, if an appropriate rationale can be developed. The SSC also supports the BSAI GPT recommendation to investigate Francis weighting.*

The Terms of Reference for the 2022 CIE of BSAI Pacific ocean perch were tailored to reflect the SSC and Plan Team comments on natural mortality, data weighting, and the lack of fit in recent years to the Aleutian Islands trawl survey. The exploratory results we describe below were presented to the CIE panel and conducted with modifications to the model and data used in the 2020 assessment.

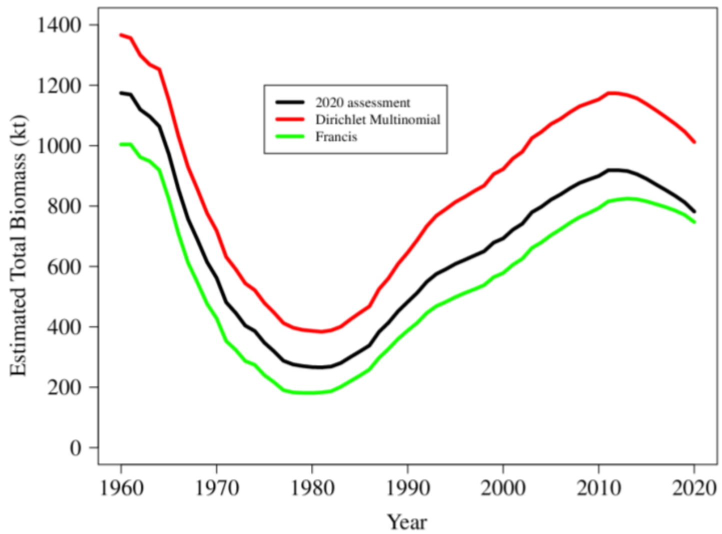
The CIE panel was supportive of the use of relatively recent studies on the estimation of natural mortality from statistical models applied to empirical data. We also considered recent research suggesting that implementing time-varying dynamics in processes such as natural mortality, when used to improve retrospective patterns, can cause misspecification in reference points if the “wrong” process is modeled as time-varying (Szuwalski et al. 2018). For the POP model, modeling M as time-varying can result in substantial changes in the estimates of M, but not substantial improvements to the fit the AI survey biomass:

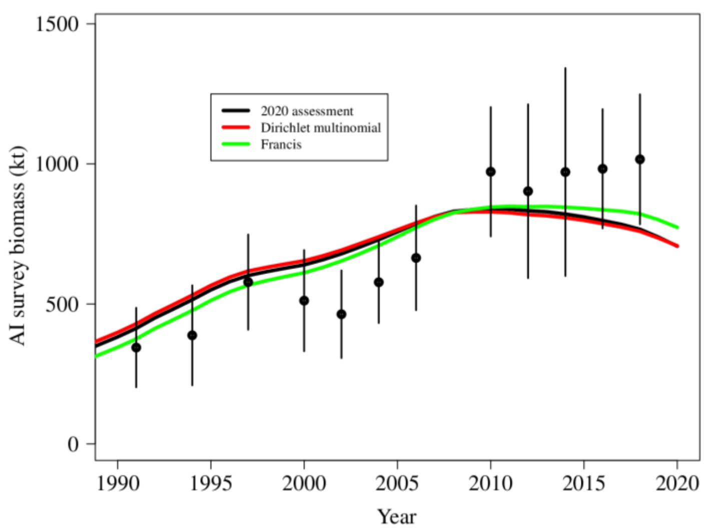




The CIE panel was split on the utility of further exploring time-varying natural mortality, and it was not pursued in the 2022 assessment. However, one useful result of these model runs was the indication that the estimates of natural mortality are not strongly influenced by the prior distribution, suggesting this prior could be relaxed or potentially removed in future assessments.

Several data-weighting procedures were evaluated in the CIE review, including McAlllister-Ianelli, Francis, and the Dirichlet-multinomial. The exploratory model runs indicated that the data-weighting procedures affected the scale of estimated biomass (via estimation of survey catchability), but did not substantially improve the fit to the AI survey biomass time series:





The CIE review panel did not find that alternative data-weighting procedures improved the model sufficiently to warrant departure from the McAllister-Iannelli weighting.

The lack of fit to the AI survey was a focal point of the CIE, motivating the analyses described above. No obvious solutions were identified during the CIE review. The CIE reviewers recommended that fitting the model to indices of survey abundance rather than survey biomass may improve the retrospective pattern, and we evaluated this model in this assessment.

(SSC, December 2020) *The SSC further suggests the author considers evaluating combining the two surveys biomass and age compositions through geo-spatial models.*

The CIE panel received a presentation from Dr. James Thorson on the utility of geo-spatial models to merge multiple survey indices. Dr. Thorson indicated that these approaches can work when there is sufficient spatial and temporal overlap of the survey indices that allows for the relative calibration to be estimated. In our case, there is no spatial overlap between the AI and EBS slope surveys, and the habitats between the areas differ substantially. Any differences in the survey observations between these areas could arise from either differences in sampling methods and gear, or from differences in the population densities. Because of this potential confounding, the spatio-temporal modeling group within the AFSC RACE division was not supportive of efforts to use spatio-temporal modeling to combine the surveys.

(BSAI Plan Team, September 2022) *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.*

We evaluated a model in which the estimated survey abundances, rather than the survey biomass estimates, were fit by the model. There was insufficient time to explore the other two modeling topics.

(BSAI Plan Team, September 2022) *The author noted that there may be variability in maturity over time, but we do not have the data to verify this. Therefore, it may be helpful to update the maturity study.*

We will consider the collection of updated maturity information as a potential field research topic.

(BSAI Plan Team, September 2022) *The Team noted the CIE request to explore estimating the age-length conversion matrix within the stock assessment model and mentioned the new work on the WHAM model that was presented in the Joint Plan Team. This stock could be a potential case study for testing the features of the new model.*

This modeling topic will be explored in future assessments.

Introduction

Pacific ocean perch (POP, *Sebastes alutus*) inhabit the outer continental shelf and upper slope regions of the North Pacific Ocean and Bering Sea. 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), and the BSAI

OFLs, ABCs, TACs, and catches from 2002 to 2022 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 from the fishery have been available since 1990 (Table 12.4). From 1990-2009, 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. From 2017 to 2022, the discard rates in the EBS area increased to an average of 16% and were 12% for 2022 (through September 25, 2022).

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 recent years, the AI catch is relatively evenly spread throughout the across the Aleutian Islands. 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 2011 to 2021 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 rockfish trips targeting rockfish, Atka mackerel, and walleye pollock (Table 12.8). Catch of prohibited species is low in trips targeting rockfish, with the catch of most prohibited species groups averaging less than 80 t or 6000 individuals from 2011-2021 (Table 12.9). Catch of non-FMP species by in BSAI trips targeting rockfish are largest for giant grenadier (*Albatrossia pectoralis*), miscellaneous fish, and unidentified sponge (Table 12.10).

Non-commercial catches are shown in Appendix 12.A.

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 aging 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).

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° W to 170° W), as the post-1991 coefficients of variation (CVs) range from 0.41 to 0.64 (Table 12.15), although the trend in the region appears to be increasing. From 2010-2022, 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 2022 survey biomass estimate of 1,063,030 t is a 5% increase from the 2018 estimate of 1,016,309 t (Table 12.15). The 2022 AI survey biomass was greater than 25% of the 2018 estimates for the WAI and CAI subareas, but the survey biomass in the EAI and SBS subareas decreased by 17% and 1%, 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 11,897 km^2 in 2022 (Figure 12.4), an increase by a factor of 2.

Examination of the AI survey abundance estimate by strata indicates that high abundance and rates of increase are widespread throughout the AI survey area. Of the 45 AI survey strata, 79% of the 2022 population estimate was contained in 10 strata, with at least one of these ten strata occurring in each of the 4 major strata regions (i.e., 4 each in the WAI and EAI, and 1 each in the CAI and SBS) (Table 12.16). In 9 of these strata, the average population estimate from the 2010-2022 surveys exceeded population estimate from the 1991-2006 surveys (Figure 12.5). The average value for this ratio of abundances was

3.0 in the top 3 strata for 2022 population abundance (Table 12.16).

Age composition data exists for each Aleutian Islands survey, and the numbers of length measurements taken and otoliths read are shown in Table 12.17. The survey age compositions from 1991-2000 indicate relatively strong year classes in 1977, 1984, and 1988 (Table 12.18, Figure 12.6). 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; however, these year classes appear to be weaker in the 2018 age composition (Figure 12.6).

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 72,665 t in 2002 to 357,369 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 12.7. 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 12.8, 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. 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 aging error matrix to produce the expected observed survey or fishery age compositions.

Aging 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.

Aleutian Islands survey data from 1991 through 2018 were used to estimate growth curves. The resulting von Bertalanffy growth parameters were L_{inf} = 41.51 cm, k = 0.14, and t_0 = -1.311. Growth information from the Aleutian Islands was used to convert estimated numbers-at-age within the model to estimated numbers-at-length.

A conversion matrix was created to convert modeled number at ages to modeled number at length bin, and consists of the proportion of each age that is expected in each length bin. This matrix was created by fitting a polynomial relationship to the observed CV in length at each age (obtained for each survey from 1991-2018 by the multiplying the estimated survey length distribution by the age-length key), and the predicted 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 x 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 following table summarizes the data available for the recommended BSAI POP model:

Component	BSAI
Fishery catch	1960-2022
Fishery age composition	1981-82, 1990, 1998, 2000-2009, 2011, 2013, 2015, 2017, 2019, 2020, 2021
Fishery size composition	1964-72, 1983-1984, 1987-1989, 1991-1997, 1999, 2010, 2012, 2014, 2016, 2018
AI Survey age composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018
AI Survey length composition	2022
AI Survey biomass estimates	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022
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. Population size in numbers at age a in year t was modeled as

$$N_{t,a} = N_{t-1,a-1} e^{-Z_{t-1,a-1}} \qquad 3 < a < A,\ 1960 < t \le T$$

where Z is the sum of the instantaneous fishing mortality rate ($F_{t,a}$) and the natural mortality rate (M), A is the maximum number of age groups modeled in the population, and T is the terminal year of the analysis (defined as 2022).

The numbers at age A are a “pooled” group consisting of fish of age A and older, and are estimated as

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

The plus group was set to 40+, following a sensitivity analysis conducted in the 2012 stock assessment (Spencer and Ianelli 2012).

The numbers at age in the first year of the model are estimated as

$$N_a = R_0 e^{-M(a-3)}$$

where R_0 is the number of age 3 recruits for an unfished population, thus producing an age structure in equilibrium with an unfished stock. It is generally thought that little fishing for rockfish occurred prior to

1960, so an equilibrium unfished age-structure seems reasonable.

The total numbers of age 3 fish (recruitment) from 1960 to 2019 are estimated as parameters in the model, and are modeled with a lognormal distribution

$$N_{t,3} = e^{\mu_R + \nu_t}$$

where ν_t is a time-variant deviation with a log-scale recruitment standard deviation of σ_r. Little information exists to determine the year-class strength for the three most recent cohorts (2020-2022), which were set to the estimated mean recruitment (based upon the log-scale mean, and the value of σ_r).

The fishing mortality rate for a specific age and time ($F_{t,a}$) is modeled as the product of fishing selectivity $s^f_{a,t}$ and a year-specific fully-selected fishing mortality rate f. The fully selected mortality rate is modeled as the product of a mean (μ_f) and a year-specific deviation (ε_t), thus $F_{t,a}$ is

$$F_{t,a} = s^f_{a,t} f_t = s^f_{a,t} e^{(\mu_f + \varepsilon_t)}$$

The mean number-at-age for each year was computed as

$$\overline{N}_{t,a} = N_{t,a}(1 - e^{-Z_{t,a}}) / Z_{t,a}$$

Catch biomass-at-age was computed as the product of mean numbers at age, instantaneous fishing mortality, and weight at age.

The predicted survey biomass for the AI trawl survey biomass $\hat{B}^{twl}_{AI,t}$ was computed as

$$\hat{B}^{twl}_{AI,t} = q^{twl}_{AI} \sum_a (\overline{N}_{t,a} s^{twl}_a W_a)$$

where W_a is the population weight-at-age, s^{twl}_a is the survey selectivity, and q^{twl} is the trawl survey catchability. The predicted survey biomass for the EBS trawl survey biomass $\hat{B}^{twl}_{EBS,t}$ is similar:

$$\hat{B}^{twl}_{EBS,t} = q^{twl}_{EBS} \sum_a (\overline{N}_{t,a} s^{twl}_a W_a)$$

Selectivity curves for the AI and EBS trawl surveys were modeled with logistic functions.

To facilitate parameter estimation, prior distributions the natural mortality rate M. A lognormal distribution was also used for the natural mortality rate M, with the mean set to 0.05 and the CV set to 0.05. The standard deviation of log recruits, σ_r, was fixed at 0.75.

Beginning in the 2014 assessment, fishery selectivity has been modeled with a bicubic spline. The number of age and year nodes are each set to 5 for a total of 25 selectivity parameters. Values at these nodes are the log-scale fishery selectivity and estimated as parameters, and fishery selectivity at ages and years between the nodes are interpolated with the bicubic spline. The smoothness of the surface is controlled by the number of nodes, and also by a series of penalties estimated within the model. Four types of penalties were used: 1) smoothness across the ages (modeled with the sum of second differences); 2) the slope of the rate of decline when selectivity decreases with age (modeled with the sum of first differences); 3) the inter-annual smoothness across years (modeled with the sum of second differences); and 4) the inter-annual variation across years (modeled with the first difference; this addresses situations in which the selectivity across years was relatively smooth but also non-constant, as would occur with a trend).

The weights for the age and length composition data were obtained from an iterative reweighting procedure. The multinomial sample size $N_{j,y}$ for data type *j* and year *y* is computed as

$$N_{j,y} = w_j \tilde{N}_{j,y}$$

where $\tilde{N}_{j,y}$ is the original "first stage" sample size (set to the square root of fish lengthed or aged), and w_j is a weight for data type *j,* computed as the harmonic mean of the ratio of effective sample size to first stage sample size (method TA1.1 in Francis (2011); often referred to as the "McAllister-Ianelli method"). The weights are a function of the fit of to the age and length composition data, and iterated in successive model runs until they converge. Note that this method preserves the relative weighting between years within a given data type.

Description of Alternative Models

In this assessment, we consider the accepted model from the 2020 assessment with data updated through 2022 (i.e., Model 16.3 (2022)), and an alternative model in which the estimated survey abundances (rather than the estimated survey biomass) were fit. The alternative model was motivated by CIE review recommendation that fitting survey abundances, rather than survey biomass, may improve the retrospective behavior. A plot of the time series of survey biomass and abundance, and their CVs, is shown in Figure 12.9. Although the two time series show similar trends, there are slight differences; for example, the rate of increase between the 2006 and 2010 survey is slightly large for the biomass estimates than the abundance estimates.

The two models considered are identical in model structure, with the only difference in the type of survey estimates being fit. Additionally, each of the two models iteratively re-estimates the McAllister-Iannelli weights.

Model	Description
Model 16.3 (2022)	The existing model, with data updated through 2022
Model 22	Fit the model to the survey abundance indices instead of the survey biomass indices.

Because the differences between the models pertains to the data being fit, standard model selection criteria such as AIC do not apply. 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.

Parameters Estimated Outside the Assessment Model

The parameters estimated independently include the age error matrix, the age-length conversion matrix, individual weight at age, and the proportion of the stock available to the AI survey. The calculations for these quantities are described above.

Parameters Estimated Inside the Assessment Model

Parameter estimation is facilitated by comparing the model output to several observed quantities, such as the age and length composition of the survey and fishery catch, the survey biomass, and the catch biomass. The general approach is to assume that deviations between model estimates and observed quantities are attributable to observation error and can be described with statistical distributions. Each data component provides a contribution to a total log-likelihood function, and parameter values that minimize the negative log-likelihood are selected.

The likelihood of the initial recruitments were modeled with a lognormal distribution, yielding the following negative log-likelihood (excluding some constant terms)

$$\lambda_1 \left[\sum_{t=1}^{n} \frac{\left(\nu_t + \sigma_r^{\,2}/2\right)^2}{2\sigma_r^{\,2}} + n \ln(\sigma_r) \right]$$

where n is the number of years where recruitment is estimated. The adjustment of adding $\sigma^2/2$ to the deviation was made in order to produce deviations from the mean, rather than the median, recruitment. If σ_r is fixed, the term n ln (σ_r) adds a constant value to the negative log-likelihood.

The likelihoods of the fishery and survey age and length compositions were modeled with a multinomial distribution. The negative log of the multinomial function (excluding constant terms) for the fishery length composition data, with the addition of a term that scales the likelihood, is

$$-n_{f,t,l} \sum_{s,t,l} \left(p_{f,t,l} \ln(\hat{p}_{f,t,l}) - p_{f,t,l} \ln(p_{f,t,l}) \right)$$

where n is the reweighted sample size, and $p_{f,t,l.}$ and $\hat{p}_{f,t,l}$ are the observed and estimated proportion at length in the fishery by year and length. The likelihood for the age and length proportions in the survey, $p_{surv,t,a}$ and $p_{surv,t,l}$, respectively, follow similar equations.

The negative log-likelihood of the survey biomass was modeled with a lognormal distribution:

$$\lambda_2 \sum_t (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2 / 2cv_t^{\,2}$$

where obs_biom_t is the observed survey biomass at time t, cv_t is the coefficient of variation of the survey biomass in year t, and λ_2 is a weighting factor. The negative log-likelihood of the catch biomass was modeled with a lognormal distribution:

$$\lambda_3 \sum_t (\ln(obs\_cat_t) - \ln(pred\_cat_t))^2$$

where obs_cat_t and $pred\_cat_t$ are the observed and predicted catch. The “observed” catch for 2022 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. 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 overall negative log-likelihood function, excluding the priors on *M* and survey catchability, the penalties on time-varying fishery selectivity parameters, and the maturity ogive parameters, is

$$
\begin{aligned}
&\lambda_1\left[\sum_{t=1}^{n}\frac{\left(\nu_t+\sigma_r{}^2/2\right)^2}{2\sigma_r{}^2}+n\ln(\sigma_r)\right]+\\
&\lambda_2\sum_t\left(\ln(obs\_biom_t)-\ln(pred\_biom_t)\right)^2/2cv_t^2+\\
&-n_{f,t,l}\sum_{s,t,l}(p_{f,t,l}\ln(\hat{p}_{f,t,l})-p_{f,t,l}\ln(p_{f,t,l}))+\\
&-n_{f,t,a}\sum_{s,t,l}(p_{f,t,a}\ln(\hat{p}_{f,t,a})-p_{f,t,a}\ln(p_{f,t,a}))+\\
&-n_{surv,t,a}\sum_{s,t,a}(p_{surv,t,a}\ln(\hat{p}_{surv,t,a})-p_{surv,t,a}\ln(p_{surv,t,a}))+\\
&-n_{surv,t,l}\sum_{s,t,a}(p_{surv,t,l}\ln(\hat{p}_{surv,t,l})-p_{surv,t,l}\ln(p_{surv,t,l}))+\\
&\lambda_3\sum_t\left(\ln(obs\_cat_t)-\ln(pred\_cat_t)\right)^2
\end{aligned}
$$

For the models run in this analysis, λ_1, λ_2, and λ_3 were assigned weights of 1,1, and 50, reflecting a strong emphasis on fitting the catch data. The negative log-likelihood function was minimized by varying the following parameters:

Parameter type	Number
1) Fishing mortality mean	1
2) Fishing mortality deviations	63
3) Recruitment mean	1
4) Recruitment deviations	60
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	160

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 credibilty intervals were produced as the values corresponding to the 5th and 95th percentiles of the MCMC evaluation. For this assessment, credibility intervals on total biomass, spawning biomass, and recruitment strength are presented.

Results

Model Evaluation

Fitting the survey abundance indices rather than the survey biomass indices does not substantially change the estimation of stock dynamics. The likelihood components are shown in Table 12.20, and are very similar between the two models. In particular, the RMSE values for the survey and abundance indices are shown for each model; when the model was fit to the abundance index, the RMSE for the biomass index represents a “ghost” fit (i.e., how well the model matches a data component that is not included in the likelihood equation). The RMSE values for the AI and EBS survey indices are very similar to each regardless of whether survey biomass or survey abundance is being fit. This can also be seen in Figure 12.10, which show that the estimated Aleutian Islands survey biomass index, when fitting the survey abundance indices, is very similar to the estimated Aleutian Islands survey biomass index when fitting the biomass indices. The root mean squared error indicates better fits to the AI survey indices than the EBS survey indices (Table 12.20). The harmonic mean of effective *N* for the composition data components indicate better fits to the fishery age and length compositions than the survey composition data.

The plot of retrospective estimates of spawning biomass is shown in Figure 12.11. For each model, the 2022 model run shows the largest biomass than any of the retrospective runs, as new data in 2022 allows improved fit to the recent high AI trawl survey biomass or abundance index. Large changes in retrospective pattern also occur in 2016 and 2018, 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 -0.33 and -0.31 for Models 16.3 (2022) and Model 22, respectively, very similar to each other and higher in magnitude than the value of -0.24 obtained in the 2020 assessment.

The retrospective estimates of recruitment strength is shown in Figure 12.12. 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.

Given that Model 22 did not improve the retrospective pattern of the assessment, and is very similar to the existing Model 16.3 (2022), we recommend Model 16.2 (2022). The updated data weights are shown in Figure 12.13, and are similar to those from the 2020 assessment. Estimated values of model parameters and their standard deviations are shown in Table 12.21.

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 2022 biomass, and median recruitment, based upon the MCMC integrations, are shown in Figure 12.14. The estimate of *M* was 0.056, slightly above the mean of the prior distribution for *M* of 0.05. The estimated Aleutian Islands survey catchability was 1.0. 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. Similarly, the estimated catchability of the EBS trawl survey was 0.25, 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 413,681 t in 1991 to 883,897 t in 2013, and declined to 796,681 in 2020 (Figure 12.15). 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 12.16).

The total biomass showed a similar trend as the survey biomass, with the 2022 total biomass estimated as 902,537 t. The estimated time series of total biomass and spawning biomass, with 90% credibility bounds obtained from MCMC integration, are shown in Figure 12.17. Total biomass, spawning biomass, and recruitment (and their CVs from the Hessian approximation) are given in Table 12.22, and numbers at age are shown in Table 12.23.

Age/size compositions

The fits to the fishery age and length composition are shown in Figures 12.18-12.19. The observed proportion in the binned length group of 39+ cm for 1964 and 1965 was lower than the estimated proportion, reflecting the modeling of the initial numbers at age as an equilibrium population. However, by 1966 reasonable fits were observed for the binned length group in the fishery length composition (Figure 12.19). 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. Good fits are obtained for most age groups in the 1991-2018 AI surveys (Figure 12.20), although the 2004 and 2005 year classes are overestimated in the 2010 and 2012 composition data, and underestimated in the 2014 composition data. The model provides a reasonable fit to the 2022 length composition from the AI survey (Figure 12.21).

The model fit the 2002 EBS survey age composition data well, 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 (Figure 12.22).

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 6.33 and 10.99, respectively (Figure 12.23). The estimated fishery selectivity by age and year is shown in Figure 12.24, 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 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 – 23, and > 32, years old.

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 12.25). 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 0.41, whereas the average from 1981 to 2021 was 0.04.

The plot of estimated fishing mortality rates and spawning stock biomass relative to the harvest control rules (Figure 12.26) 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 12.27; Table 12.22). The relationship between spawning stock and recruitment also displays a high degree of variability (Figure 12.28). 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 12.18 and 12.20. 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 $F_{0.40}$, $F_{0.35}$, and $SPR_{0.40}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from the 1977-2016 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{0.40}$ is calculated as the product of $SPR_{0.40}$ * equilibrium recruits, and this quantity is 261,050 t. The estimated spawning stock biomass for 2023 is 359,074 t.

Specification of OFL and maximum permissible ABC

Since reliable estimates of the 2023 spawning biomass (*B*), $B_{0.40}$, $F_{0.40}$, and $F_{0.35}$ exist and $B>B_{0.40}$ (359,074 t > 261,050 t), POP reference fishing mortality have been classified in tier 3a. For this tier, F_{ABC} maximum permissible F_{ABC} is $F_{0.40}$, and F_{OFL} is equal to $F_{0.35}$. The values of $F_{0.40}$ and $F_{0.35}$ are 0.074 and 0.089, respectively.

The 2023 ABC associated with the $F_{0.40}$ level of 0.074 is 42,038 t.

The estimated catch level for year 2022 associated with the overfishing level of F = 0.089 is 50,133 t. A summary of these values is below.

2023 SSB estimate (B)	**=**	**359,074 t**
$B_{0.40}$	=	261,050 t
$F_{ABC} = F_{0.40}$	=	0.074
$F_{OFL} = F_{0.35}$	=	0.089
Max ABC	=	42,038 t
OFL	=	50,133 t

Projections

A standard set of projections is conducted for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2022 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2023 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2022. 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.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2021, 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 2023 recommended in the assessment to the *max* F_{ABC} for 2021. (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 2017-2021 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 2022 or 2) above ½ of its MSY level in 2022 and above its MSY level in 2032 under this scenario, then the stock is not overfished.)

Scenario 7: In 2023 and 2024, F is set equal to *max* F_{ABC}, and in all subsequent years F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2034 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 six scenarios are shown in Table 12.24.

Risk Table and ABC recommendation

Overview

The following template is used to complete the risk table:

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.

2. Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.

3. Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.

4. Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings."

Assessment considerations

The value of Mohn's rho for this assessment of -0.33 indicates a relatively strong retrospective pattern that is beyond the guidelines proposed by Hurtado-Ferro et al. (2015), and the magnitude of Mohn's rho increased from the value of -0.24 in the 2020 assessment. 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. We rank the assessment considerations as a 2 (*Substantially increased assessment uncertainty/ unresolved issues*).

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, and 2008) remain relatively strong. Overall, we rank the assessment considerations as a 1 (*Stock trends are typical for the stock; recent recruitment is within normal range*).

Environmental/ecosystem considerations

Environment: The average bottom temperature from the Aleutian Islands bottom trawl survey (AIBTS, (165°W – 172°E, 30-500 m) was ~4.4◦C, similar to 2018 and cooler than the highest observed in 2016 but still above the long term mean, as have the last four surveys (2014 onwards). Mid-depth (100-300m) and water column temperature (surface to bottom) from the longline survey (164°W to 180°W) and bottom trawl survey, respectively show a similar pattern, with warmer temperatures throughout the water column starting 2014. Surface temperature both from the AIBTS, as well as satellite, show an increasing trend in temperatures, during both summer and winter with 2022 being one of the warmest years in summer throughout the Aleutians and in wintertime for the western and central Aleutians. Most of the year through August has been under some level of heatwave in the central and western Aleutians, less so in the eastern Aleutians. This is in sharp contrast to the GOA where only a few days were under marine heatwave (Bond et al., 2022).

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. It is this larvae phase which is most vulnerable to the Marine heatwaves and the year-round increased temperatures. In 2022 the MHV in the western and central Aleutians were of severe intensity for a short period in spring and summer. 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.

Prey: Larger (>20 cm) POP diets include approximately 20% copepods, 30% euphausiids, and 20% myctophid fish. POP are also the dominant species within the pelagic foragers and along with northern rockfish comprise the larger portion of the guild once dominated by the combined biomass of Atka mackerel and walleye pollock. Data from continuous plankton recorders showed the copepod community was slightly larger in size, while planktivorous auklets that nest in the western Aleutians at Buldir Island had above average reproductive success in 2022 (as they did in 2021), suggesting that zooplankton were sufficiently abundant to support successful production of chicks and possibly indicative of abundant zooplankton prey in that area. The abundant prey might have contributed to the improvement in fish condition across the entire Aleutians. A biannual pattern, corresponding to that of the eastern Kamchatka pink salmon is evident in the estimated numbers at age 3 which carries over to the older ages. This biannual pattern starts in the late 1980s when pink salmon first decreased for a few years and subsequently increased about 50% in [odd] years of high abundance. Since then, high abundance of pink salmon has tripled. The biannual cycle and cascading effects of pink salmon predation on copepods has been documented before by Springer and van Vliet (2014), Batten et al., (2018), and Matta et al., (2020).

Competitors and predators: POP and northern rockfish are jointly the dominant pelagic foragers over Atka mackerel and pollock (Ortiz, 2022). Both Atka mackerel and Kamchatka pink salmon are primary consumers of copepods and both have shown biannual signals in their growth and abundance, respectively. However, the recent increases in Kamchatka pink salmon 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. 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 stable in the Aleutians from 2002 to 2018 (Sweeney and Gelatt, 20202) and harbor seals which are decreasing (London, et al., 2021). Sebastes spp. was also 25% of the tufted puffins diets at Buldir in 2021 (Rojek et al., 2022).

The indicator most relevant to reflecting habitat disturbance is the estimated area disturbed by trawls from the fishing effects model (Olson, 2021). Trends in potential habitat disturbance are likely more relevant for adult POP, rather than juveniles, which are more closely tied to the rocky habitat which is avoided by bottom trawls. Sponges and hydrocorals seemed to have decreased in the past few years in the western and central Aleutians based on data from the bottom trawl survey, coinciding with a decrease in bycatch of structural epifauna in the past two years, however these groups are poorly sampled by trawl nets and there does not seem to be an overall detrimental effect in rockfish, which overall are increasing or stable in the AI except for shortraker and shortspine thornyheads. Rooper et al (2019) concluded the removal of deep coral and sponges is likely to reduce the overall density of rockfishes. 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.

Taken together, these indicators suggest that the current level of concern is level 1— no apparent environmental/ ecosystem concerns for the POP stock aside from the recent stretch of increased temperatures. That being said, 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 – 2022 (Figure 12.29) . 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: Substantially increased concerns	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 42,038 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, which are shown below:

ABC apportionments

			Area		
	WAI	CAI	EAI	SBS	EBS slope
2022 smoothed biomass estimate	492,623	170,314	245,831	113,052	245,905
percentage	38.9%	13.4%	19.4%	8.9%	19.4%

The apportioned ABCs for 2023 and 2024 are as follows:

			Area		
	WAI	CAI	EAI	EBS	Total ABC
2023 ABC	16,335	5,648	8,152	11,903	42,038
2024 ABC	16,058	5,551	8,013	11,700	41,322

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 2023, it does not provide the best estimate of OFL for 2024, because the mean 2023 catch under Scenario 6 is predicated on the 2023 catch being equal to the 2023 OFL, whereas the actual 2023 catch will likely be less than the 2023 OFL. The executive summary contains the appropriate one- and two-year ahead projections for both ABC and OFL. Catches for 2023 and 2024 were obtained by setting the F rate for these years to estimated F for 2022 of 0.059.

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 (2021) is 35,479 t. This is less than the 2021 BSAI OFL of 44,376 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 2022:

a. If spawning biomass for 2022 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2022 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2022 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 12.24). If the mean spawning biomass for 2032 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 2024 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2024 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2024 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2034. If the mean spawning biomass for 2034 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 2022 of Scenario 6 is 1.6 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 2024 of Scenario 7 is 1.52 times the $B_{35\%}$ value.

Based on the recommended model, the F that would have produced a catch for 2021 equal to the 2021 OFL is 0.076.

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 September 25, 2022, 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	35479
2022	POP	42605	35688	35385	26420

Table 12.3. Foreign, Joint Vessel Program, and Domestic catch of POP by area from 1977 to 2022.

	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			24,786	35,479
2022			6,353			20,067	26,420

*Estimated removals through September 25, 2022.

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		
			Percent			Percent			Percent
Year	Retained	Discarded	Discarded	Retained	Discarded	Discarded	Retained	Discard	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	24,199	587	2	33,688	1,791	5
2022	5,613	740	12	19,751	316	2	25,364	1,056	4

[*]Estimated removals through September 25, 2022.
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	23,717

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	34056

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 11/15/2022.

Species Group Name	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Pacific Ocean Perch	18315	18671	25492	26071	23420	19589	20422	21091	27651	25802	23637	19347	22459
Atka Mackerel	1804	1447	2967	2175	5490	5255	5365	5513	8734	8527	6846	5390	4960
Northern Rockfish	1104	587	1253	864	2863	1338	1476	1768	4527	3512	2193	3050	2045
Pollock	536	667	1380	1104	947	875	1424	1524	2254	1995	2248	2332	1440
Pacific Cod	342	273	587	361	731	625	813	637	1217	975	899	572	669
Arrowtooth Flounder	512	483	1114	698	630	363	359	257	465	579	672	602	561
BSAI Kamchatka Flounder	355	245	1169	642	565	463	427	322	518	714	549	267	520
Other Rockfish	223	125	191	168	171	129	163	198	342	405	284	307	225
Sablefish	19	18	53	20	11	14	143	147	286	370	475	613	181
BSAI Skate and GOA Skate,	104	97	232	164	171	139	144	165	294	282	216	111	177
Rougheye Rockfish	90	104	162	113	92	70	65	116	246	288	248	152	146
BSAI Shortraker Rockfish	234	247	197	54	63	38	36	116	121	146	224	127	134
Sculpin	122	100	129	96	127	88	135	106	199	188			129
BSAI Other Flatfish	66	147	52	67	41	16	52	88	157	141	161	208	100
Flathead Sole	59	28	42	39	52	41	53	67	119	89	125	134	71
Greenland Turbot	29	20	59	42	34	28	37	53	119	165	115	75	65
Squid	37	33	60	56	66	26	31	50					45
Rock Sole	12	22	29	21	38	15	32	36	67	61	49	49	36
Shark	5	1	2		2	2		2	2	4	2	6	3
Octopus	4	4	2	3	1	1	3	3	4	2	2	3	3
Yellowfin Sole	1	1	4	0	1	1	0	4	1	1	5	0	2
BSAI Alaska Plaice								1		0			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 11/15/2022.

Fishery	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Rockfish	18315	18632	25492	26069	23267	19555	20422	20995	27561	25802	23327	19347	22399
Atka Mackerel	4350	4173	4127	4263	5112	7763	6945	9140	6871	6977	7816	7536	6256
Pollock - midwater	435	273	410	1088	1984	2082	3026	2675	4975	3371	1864	1062	1937
Pollock - bottom	223	433	209	212	544	1171	1412	1194	3039	2677	604	307	1002
Kamchatka Flounder - BSAI	332	148	154	105	81	97	80	130	233	1021	912	612	325
Arrowtooth Flounder	304	210	659	550	217	338	108	60	105	338	293	226	284
Flathead Sole	33	116	226	80	23		12		80	79	217	414	128
Greenland Turbot - BSAI						42	37	111	150	32	109	28	73
Other Flatfish - BSAI				3		47	70		44		17	53	39
Pacific Cod	8	47	7	8	15	50	48	5	20	15	6	1	19
Yellowfin Sole - BSAI		0	17	1	0	3	0	1	1	63	2	0	8
Rock Sole - BSAI	1		30			0							10
Sablefish								0		0		30	10
Halibut	1			0	0		0	0	0				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 11/15/2022.

Species Group Name	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Average
Bairdi Tanner Crab	0.70	7.66	0.25	0.62	0.84	0.10	0.07	0.05	0.10	0.61	0.10	0.43	0.96
Blue King Crab	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chinook Salmon	0.18	0.39	0.17	1.04	0.27	0.58	0.21	0.79	0.26	1.54	0.28	0.36	0.51
Golden (Brown) King Crab	3.25	3.30	3.66	6.30	4.95	3.02	5.29	5.59	7.67	15.22	7.72	5.68	5.97
Halibut	67.07	81.93	59.64	86.00	44.16	51.18	24.98	76.95	89.89	140.40	94.02	120.79	78.08
Herring	2.12	0.01	0.00	1.34	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Non-Chinook Salmon	0.91	0.77	0.41	1.28	0.76	0.12	0.19	0.27	0.33	0.00	0.08	0.00	0.43
Opilio Tanner (Snow) Crab	0.14	2.31	0.10	0.71	14.54	0.07	0.02	0.00	0.00	0.07	0.01	0.17	1.51
Red King Crab	0.00	0.21	0.06	0.33	0.48	0.63	0.06	0.10	0.13	0.41	0.12	0.14	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 11/15/2022.

Species Group Name	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Benthic urochordata	0.39	0.46	6.08	12.16	2.88	0.32	0.18	1.50	2.82	0.27	2.08	4.41
Birds - Auklets					Conf							
Birds - Black-footed Albatross	Conf											
Birds - Gull												
Birds - Laysan Albatross					Conf							
Birds - Northern Fulmar	Conf				Conf			Conf				
Birds - Shearwaters		Conf			Conf	Conf						
Birds - Storm Petrels		Conf			Conf							
Bivalves	0.07	0.17	0.03	0.15	0.05	0.02	0.05	0.14	0.03	0.09	0.02	0.02
Brittle star unidentified	1.06	3.27	6.08	3.21	5.02	0.14	0.12	1.61	0.17	0.22	0.17	0.39
Capelin										Conf		
Corals Bryozoans - Corals Bryozoans Unid	5.27	5.23	9.25	23.56	5.89	26.61	11.15	46.45	32.65	27.44	20.52	40.67
Corals Bryozoans - Red Tree Coral									Conf	0.41	Conf	Conf
Eelpouts	19.26	3.17	3.57	2.46	1.75	4.56	1.33	1.77	2.84	11.00	1.88	12.03
Giant Grenadier	240.85	321.44	181.68	95.36	121.74	29.33	108.63	69.95	161.34	286.15	42.02	288.00
Greenlings	2.44	0.46	0.79	0.67	Conf	Conf					Conf	Conf
Grenadier - Pacific Grenadier												Conf
Grenadier - Rattail Grenadier Unidentified	3.25	Conf		23.44	Conf			Conf	Conf	Conf	5.79	14.75
Gunnels										Conf		
Hermit crab unidentified	0.15	0.08	0.04	0.10	0.04	0.01	0.02	0.09	0.03	0.06	0.01	Conf
Invertebrate unidentified	0.32	8.62	1.69	4.86	0.16	0.13	1.86	Conf	0.34	128.04	55.21	1.36
Lanternfishes (myctophidae)	0.07	0.14	Conf	0.11	0.03	Conf	Conf	0.05	0.11	0.06	Conf	0.01
Misc crabs	5.11	0.35	0.30	1.00	0.28	0.24	0.40	0.24	0.30	0.70	0.20	0.22
Misc crustaceans	0.23	0.15	0.18	0.18	0.22	0.38	0.11	0.20	0.23	0.11	0.04	0.20
Misc deep fish	Conf	0.01	Conf	Conf	Conf		Conf	Conf	0.01	0.01		
Misc fish	49.93	55.68	78.92	104.32	74.95	107.35	58.93	61.48	43.00	67.48	55.44	66.46
Misc inverts (worms etc)	0.01	0.01	0.03	0.00	Conf		Conf	Conf	Conf	Conf	Conf	Conf
Other osmerids		0.01	Conf	Conf	Conf							Conf
Pacific Hake												Conf
Pacific Sand lance			Conf									
Pandalid shrimp	0.53	0.38	0.16	0.14	0.32	0.10	0.15	0.40	0.26	0.45	0.19	0.44
Polychaete unidentified	0.01	0.00	Conf	0.03	0.02		Conf		Conf			0.01
Saffron Cod					Conf							
Sculpin	139.34	96.57										
Scypho jellies	2.42	15.23	3.43	11.50	1.23	0.39	0.52	0.73	0.46	8.14	0.11	0.75
Sea anemone unidentified	2.46	4.41	0.36	1.22	0.49	0.25	0.19	0.29	0.22	0.78	0.36	1.59
Sea pens whips	0.04	0.15	0.20	0.14	0.46	Conf	0.06	0.07	0.14	0.11	0.01	0.02
Sea star	12.55	12.45	16.01	32.69	45.25	4.27	3.29	9.13	5.90	9.25	5.17	6.48
Smelt (Family Osmeridae)	Conf											
Snails	0.80	0.76	0.79	0.80	0.81	0.31	0.13	0.51	0.42	0.68	0.24	0.38
Sponge unidentified	51.26	72.86	92.48	96.75	77.81	71.48	48.31	149.37	127.84	211.09	51.04	67.87
Squid	78.86	75.80	56.42	23.41								
State-managed Rockfish	0.68	0.46	1.13	0.34	0.36	Conf	0.62	0.49	Conf	Conf		Conf
Stichaeidae			Conf		Conf		Conf	Conf	0.02			Conf
urchins dollars cucumbers	3.92	1.05	0.69	2.64	2.10	1.14	0.37	1.55	0.93	2.34	0.94	1.64

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	236	8,654	8,890			

*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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

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

Age	Year																				
	1981	1982	1990	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2011	2013	2015	2017	2019	2020	2021
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 12.15. Pacific ocean perch biomass estimates (t) and coefficients of variation (in parentheses) from the 1991-2022 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	208,465 (0.31)	78,776 (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	178,437 (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)	518,770 (0.18)	
2002	196,704 (0.26)	140,361 (0.41)	109,795 (0.14)	16,311 (0.41)	463,171 (0.17)	72,665 (0.53)
2004	212,639 (0.21)	153,477 (0.17)	137,112 (0.29)	74,208 (0.45)	577,436 (0.13)	112,273 (0.38)
2006	278,990 (0.16)	170,942 (0.23)	190,752 (0.37)	23,701 (0.47)	664,384 (0.14)	
2008						107,886 (0.41)
2010	395,944 (0.21)	221,700 (0.17)	266,607 (0.18)	87,794 (0.55)	972,046 (0.12)	203,421 (0.38)
2012	263,661 (0.23)	233,666 (0.17)	366,413 (0.37)	38,658 (0.63)	902,398 (0.17)	231,046 (0.33)
2014	338,455 (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)	284,909 (0.17)	87,952 (0.47)	982,503 (0.11)	357,369 (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)	146,998 (0.23)	232,021 (0.25)	113,739 (0.37)	1,063,030 (0.13)	

Table 12.16. Region, depth, estimated 2022 survey abundance, and ratio of average survey abundances between the 2010-2022 and 1991-2006 time periods for the 10 AI trawl survey strata with the largest abundance estimates in the 2022 survey.

Survey area	Depth (m)	Strata	2022 survey survey abudance (millions)	Cumulative proportion of 2022 total abundance estimate	Ratio of 2010-2022 abundance to 1991-2006 abundance
west	201-300	213	435.31	0.27	2.36
west	101-200	212	306.25	0.46	2.29
east	201-300	623	134.36	0.55	1.45
sbs	101-200	722	73.33	0.59	24.54
east	201-300	523	63.37	0.63	1.86
west	201-300	223	58.25	0.67	0.75
west	101-200	222	56.71	0.70	1.17
east	101-200	612	50.84	0.73	1.54
east	101-200	512	45.28	0.76	1.90
central	101-200	412	41.57	0.79	2.62

Table 12.17. 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			

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

	Year											
Age	1991	1994	1997	2000	2002	2004	2006	2010	2012	2014	2016	2018
3	0.027	0.003	0.018	0.017	0.020	0.006	0.005	0.004	0.003	0.002	0.002	0.001
4	0.025	0.009	0.010	0.050	0.064	0.027	0.006	0.005	0.014	0.008	0.007	0.011
5	0.049	0.029	0.015	0.047	0.040	0.019	0.020	0.017	0.011	0.017	0.009	0.005
6	0.052	0.062	0.031	0.064	0.055	0.052	0.097	0.028	0.015	0.053	0.013	0.011
7	0.212	0.082	0.054	0.028	0.066	0.049	0.074	0.010	0.050	0.033	0.034	0.024
8	0.095	0.100	0.104	0.050	0.062	0.111	0.078	0.029	0.053	0.064	0.107	0.020
9	0.074	0.099	0.148	0.027	0.043	0.084	0.094	0.056	0.026	0.115	0.051	0.041
10	0.109	0.166	0.117	0.068	0.052	0.095	0.073	0.144	0.055	0.132	0.074	0.098
11	0.046	0.060	0.117	0.079	0.027	0.049	0.059	0.100	0.077	0.065	0.110	0.038
12	0.055	0.074	0.063	0.136	0.023	0.031	0.067	0.086	0.107	0.037	0.074	0.067
13	0.040	0.060	0.085	0.052	0.087	0.027	0.030	0.032	0.057	0.056	0.030	0.060
14	0.036	0.029	0.033	0.052	0.067	0.033	0.008	0.073	0.038	0.063	0.020	0.044
15	0.013	0.034	0.026	0.040	0.026	0.021	0.016	0.035	0.048	0.048	0.032	0.027
16	0.002	0.038	0.020	0.047	0.036	0.046	0.030	0.045	0.049	0.023	0.030	0.025
17	0.002	0.025	0.026	0.029	0.044	0.036	0.021	0.013	0.039	0.017	0.027	0.033
18	0.003	0.019	0.012	0.019	0.070	0.043	0.041	0.008	0.025	0.031	0.036	0.027
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
20	0.003	0.010	0.015	0.021	0.034	0.045	0.018	0.020	0.009	0.015	0.035	0.037
21	0.001	0.004	0.012	0.011	0.000	0.016	0.028	0.031	0.011	0.008	0.034	0.038
22	0.000	0.003	0.007	0.011	0.019	0.014	0.015	0.025	0.012	0.007	0.018	0.039
23	0.002	0.006	0.004	0.015	0.011	0.021	0.025	0.022	0.032	0.010	0.012	0.030
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
25	0.004	0.002	0.001	0.006	0.006	0.010	0.014	0.024	0.013	0.013	0.018	0.017
26	0.000	0.005	0.007	0.003	0.005	0.006	0.006	0.036	0.022	0.017	0.009	0.007
27	0.004	0.005	0.004	0.002	0.001	0.007	0.011	0.021	0.042	0.009	0.017	0.009
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
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
30	0.000	0.001	0.003	0.009	0.007	0.001	0.001	0.007	0.010	0.015	0.019	0.024
31	0.004	0.002	0.004	0.001	0.000	0.002	0.002	0.003	0.013	0.011	0.021	0.026
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
33	0.001	0.003	0.001	0.002	0.006	0.007	0.008	0.006	0.008	0.005	0.009	0.027
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
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
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
37	0.002	0.001	0.003	0.004	0.001	0.001	0.001	0.000	0.005	0.003	0.005	0.006
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
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
40+	0.109	0.042	0.034	0.056	0.072	0.052	0.058	0.037	0.045	0.043	0.043	0.055

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. Negative log likelihoods, root mean squared errors, and estimates and CV for key model quantities, for BSAI POP models.

	Model 16.3a (2022)	Model 22
Negative log-likelihood		
Data components		
AI survey biomass	10.86	
EBS survey biomass	2.19	
AI survey abundance		10.37
EBS survey abundance		2.66
Catch biomass	0.00	0.00
Fishery age comp	282.57	282.50
Fishery length comp	248.68	248.96
AI survey age comp	157.96	158.56
AI survey length comp	6.61	7.39486
EBS survey age comp	74.40	74.50
Maturity	2.71	2.71
Priors and penalties		
Recruitment	11.71	11.89
Prior on M	2.70	2.74
Fishery selectivity	122.77	122.21
Total negative log-likelihood	930.70	932.01
Parameters	160	160
Root mean square error		
AI survey biomass	0.196	0.190
EBS survey biomass	0.437	0.445
AI survey abundance	0.199	0.189
EBS survey abundance	0.497	0.496
Recruitment	0.785	0.787
Fishery age comp	0.012	0.012
Fishery length comp	0.022	0.022
AI survey age comp	0.011	0.011
AI survey length comp	0.018	0.017
EBS survey age comp	0.016	0.016
Harmonic mean of effective N		
Fishery age comp	210.024	210.193
Fishery length comp	200.407	200.079
AI survey age comp	180.696	179.080
AI survey length comp	103.495	120.633
EBS survey age comp	106.426	107.038
Estimated key quantities		
M	0.056	0.056
CV	0.031	0.031
AI survey q	1.006	1.014
CV	0.139	0.140
EBS survey q	0.249	0.237
CV	0.219	0.225
2022 total biomass(t)	902,540	912,590
CV	0.171	0.175
2022 SSB(t)	365,390	366,930
CV	0.200	0.206

Table 12.21. Estimated parameter values and standard deviations for the BSAI POP assessment model.

Parameter	Estimate	Standard Deviation	Parameter	Estimate	Standard Deviation	Parameter	Estimate	Standard Deviation
sel_par	-3.0125	0.2282	fmort_dev	-2.1775	0.2875	rec_dev	-0.5505	0.3592
sel_par	-0.8927	0.1518	fmort_dev	-1.9801	0.2869	rec_dev	-0.7605	0.4110
sel_par	-2.6869	0.1491	fmort_dev	-3.2239	0.2865	rec_dev	-0.6012	0.3011
sel_par	-2.9129	0.1357	fmort_dev	-2.0633	0.2863	rec_dev	-1.2984	0.3973
sel_par	-2.0711	0.2581	fmort_dev	-1.3388	0.2863	rec_dev	-1.1291	0.3099
sel_par	2.0579	0.1242	fmort_dev	-1.0398	0.2864	rec_dev	-1.1872	0.3459
sel_par	1.1138	0.0805	fmort_dev	-0.6554	0.2865	rec_dev	-0.2350	0.2154
sel_par	0.9587	0.0757	fmort_dev	0.4569	0.2867	rec_dev	-0.3542	0.2846
sel_par	0.4452	0.0560	fmort_dev	-0.4836	0.2869	rec_dev	-0.7036	0.4410
sel_par	0.4152	0.1037	fmort_dev	-0.0501	0.2871	rec_dev	-0.1221	0.4336
sel_par	0.3699	0.1234	fmort_dev	0.0939	0.2872	rec_dev	0.2838	0.4034
sel_par	0.0561	0.0847	fmort_dev	-0.3045	0.2872	rec_dev	0.6004	0.3101
sel_par	0.2369	0.0793	fmort_dev	-0.4753	0.2871	rec_dev	0.0588	0.4185
sel_par	0.3751	0.0580	fmort_dev	-0.2328	0.2869	rec_dev	-0.2054	0.4558
sel_par	-0.1380	0.1087	fmort_dev	-0.4439	0.2867	rec_dev	1.4733	0.1206
sel_par	-0.6657	0.1375	fmort_dev	-0.7672	0.2864	rec_dev	-0.2190	0.4944
sel_par	-0.4085	0.0836	fmort_dev	-0.5337	0.2862	rec_dev	0.7013	0.2046
sel_par	0.0221	0.0888	fmort_dev	-0.8171	0.2860	rec_dev	-0.1309	0.4048
sel_par	0.4181	0.0724	fmort_dev	-0.8484	0.2859	rec_dev	1.0986	0.1523
sel_par	0.4910	0.1188	fmort_dev	-0.6647	0.2859	rec_dev	0.4699	0.2621
sel_par	-1.2996	0.2199	fmort_dev	-0.3731	0.2860	rec_dev	-0.0344	0.3057
sel_par	-1.0195	0.1206	fmort_dev	-0.5735	0.2861	rec_dev	-0.7801	0.4022
sel_par	-0.3020	0.1293	fmort_dev	-0.7059	0.2863	rec_dev	-0.3348	0.2666
sel_par	-0.0633	0.1160	fmort_dev	-0.5087	0.2865	rec_dev	-0.5283	0.3584
sel_par	0.0499	0.1947	fmort_dev	-0.1680	0.2867	rec_dev	0.6463	0.1714
sel_aslope_ai_srv	0.8453	0.0664	fmort_dev	-0.2479	0.2869	rec_dev	0.3985	0.2566
sel_aslope_ebs_srv	0.7131	0.0997	fmort_dev	-0.4035	0.2872	rec_dev	1.1759	0.1365
sel_a50_ai_srv	6.3305	0.1742	fmort_dev	-0.2787	0.2875	rec_dev	-0.3434	0.4263
sel_a50_ebs_srv	10.9940	0.4479	fmort_dev	-0.0002	0.2878	rec_dev	1.0432	0.1428
logM	-2.8808	0.0311	fmort_dev	-0.0006	0.2882	rec_dev	-0.1195	0.3965
log_avg_fmort	-3.9024	0.3015	fmort_dev	0.2648	0.2887	rec_dev	1.4707	0.1120
fmort_dev	-2.1747	0.3014	fmort_dev	0.3120	0.2894	rec_dev	-0.5476	0.4852
fmort_dev	-0.0792	0.3011	fmort_dev	0.3009	0.2902	rec_dev	0.4340	0.2147
fmort_dev	-0.8580	0.3008	fmort_dev	0.3130	0.2910	rec_dev	-0.4974	0.4708
fmort_dev	0.0170	0.3004	fmort_dev	0.3640	0.2920	rec_dev	0.7470	0.2115
fmort_dev	1.1381	0.2992	fmort_dev	0.4553	0.2933	rec_dev	0.8933	0.2139
fmort_dev	1.5771	0.2962	fmort_dev	0.7118	0.2949	rec_dev	0.2216	0.3532
fmort_dev	1.7564	0.2942	fmort_dev	0.6805	0.2970	rec_dev	0.1160	0.3564
fmort_dev	1.6755	0.2935	fmort_dev	0.5813	0.2992	rec_dev	1.0962	0.1702
fmort_dev	1.8732	0.2932	fmort_dev	0.5735	0.3015	rec_dev	-0.0827	0.4115
fmort_dev	1.6074	0.2927	rec_dev	1.0354	0.2480	rec_dev	0.0916	0.3551
fmort_dev	2.0471	0.2920	rec_dev	-0.5649	0.5872	rec_dev	0.5775	0.2743
fmort_dev	1.2100	0.2920	rec_dev	-0.6854	0.5617	rec_dev	0.5212	0.3067
fmort_dev	1.4469	0.2923	rec_dev	-0.4217	0.6271	rec_dev	0.0977	0.4145
fmort_dev	0.5714	0.2926	rec_dev	1.1405	0.4175	rec_dev	0.6112	0.3078
fmort_dev	1.5268	0.2922	rec_dev	1.3202	0.3402	rec_dev	-0.0477	0.4650
fmort_dev	1.3280	0.2916	rec_dev	-0.5208	0.6049	rec_dev	0.3285	0.3824
fmort_dev	1.6345	0.2913	rec_dev	-0.8390	0.5259	mean_log_rec	4.4136	0.0935
fmort_dev	0.7185	0.2915	rec_dev	-0.8371	0.4896	log_rinit	4.3072	0.0778
fmort_dev	0.4282	0.2910	rec_dev	-0.7511	0.4537	log_q_srv_AI	0.0060	0.1383
fmort_dev	0.3887	0.2904	rec_dev	-0.9503	0.4376	log_q_srv_EBS	-1.3888	0.2166
fmort_dev	-0.0008	0.2897	rec_dev	-1.2539	0.4480	mat_beta1	-6.6118	3.6559
fmort_dev	-0.0570	0.2890	rec_dev	-1.0159	0.4292	mat_beta2	0.7270	0.4473
fmort_dev	-1.5230	0.2883						

Table 12.22. Estimated time series of POP total biomass (t), spawning biomass (t), and recruitment (thousands).

	Total Biomass (ages 3+)				Spawner Biomass (ages 3+)				Recruitment (age 3)			
	Assessment Year				Assessment Year				Assessment Year			
	2022		2020		2022		2020		2022		2020	
Year	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV	Est	CV
1977	291,970	0.101	287,690	0.101	124,230	0.113	122,530	0.114	26,696	0.320	25,732	0.323
1978	280,050	0.104	275,600	0.104	118,510	0.117	116,790	0.118	25,190	0.357	24,379	0.361
1979	275,020	0.105	270,280	0.105	114,430	0.122	112,660	0.122	65,272	0.227	63,282	0.230
1980	271,720	0.106	266,730	0.106	111,330	0.126	109,500	0.126	57,938	0.295	57,031	0.297
1981	270,970	0.106	265,760	0.106	109,430	0.129	107,510	0.129	40,854	0.450	40,591	0.456
1982	274,100	0.106	268,750	0.106	108,330	0.130	106,300	0.130	73,075	0.439	73,435	0.436
1983	286,440	0.104	280,380	0.104	108,940	0.131	106,790	0.131	109,660	0.412	103,080	0.428
1984	306,540	0.101	300,000	0.101	110,540	0.135	108,260	0.135	150,510	0.318	149,310	0.314
1985	325,980	0.099	318,870	0.099	113,370	0.141	110,930	0.141	87,569	0.427	85,542	0.428
1986	346,310	0.097	338,480	0.097	117,790	0.149	115,200	0.149	67,233	0.468	64,083	0.474
1987	392,700	0.095	383,610	0.096	123,740	0.158	120,950	0.159	360,300	0.141	351,940	0.140
1988	424,420	0.094	414,120	0.095	131,280	0.170	128,240	0.170	66,331	0.510	61,922	0.513
1989	463,720	0.094	451,980	0.094	140,840	0.183	137,490	0.183	166,490	0.217	160,970	0.215
1990	495,620	0.094	482,670	0.095	151,090	0.195	147,320	0.195	72,438	0.421	70,959	0.414
1991	527,890	0.097	512,840	0.098	160,790	0.204	156,510	0.204	247,700	0.176	235,510	0.178
1992	566,160	0.097	549,280	0.099	175,490	0.211	170,620	0.212	132,090	0.281	127,170	0.278
1993	593,850	0.099	575,120	0.101	190,310	0.217	184,740	0.218	79,770	0.319	75,291	0.320
1994	611,390	0.102	591,020	0.103	205,630	0.215	199,260	0.216	37,844	0.417	35,735	0.414
1995	630,700	0.103	608,660	0.105	222,420	0.205	215,200	0.206	59,075	0.283	55,239	0.282
1996	645,930	0.105	622,280	0.107	238,280	0.195	230,170	0.195	48,682	0.376	44,733	0.376
1997	662,290	0.107	636,360	0.109	252,040	0.187	242,990	0.188	157,580	0.196	145,160	0.198
1998	678,460	0.108	650,290	0.111	265,130	0.178	255,140	0.179	122,990	0.280	114,290	0.278
1999	710,760	0.109	679,000	0.113	276,370	0.164	265,470	0.166	267,600	0.168	245,190	0.172
2000	727,330	0.111	692,960	0.114	283,570	0.151	271,840	0.152	58,570	0.445	55,130	0.436
2001	760,130	0.112	721,510	0.116	289,750	0.142	277,180	0.144	234,340	0.173	211,120	0.178
2002	783,390	0.113	741,380	0.117	295,360	0.141	281,850	0.143	73,263	0.416	67,066	0.411
2003	827,710	0.114	779,530	0.119	301,570	0.148	286,870	0.150	359,340	0.151	320,840	0.158
2004	850,140	0.115	797,690	0.121	309,490	0.158	293,310	0.159	47,753	0.504	44,574	0.496
2005	878,460	0.117	821,130	0.122	321,360	0.166	303,390	0.167	127,430	0.237	113,580	0.245
2006	900,030	0.118	838,560	0.124	335,300	0.170	315,270	0.172	50,210	0.488	45,252	0.485
2007	925,100	0.119	858,960	0.125	348,870	0.172	326,580	0.174	174,270	0.237	158,450	0.245
2008	947,070	0.121	876,570	0.128	361,140	0.174	336,410	0.176	201,730	0.242	189,320	0.247
2009	963,040	0.123	888,470	0.131	373,930	0.174	346,670	0.177	103,050	0.371	92,425	0.383
2010	977,490	0.124	899,560	0.133	385,690	0.170	356,000	0.174	92,722	0.377	87,086	0.378
2011	1,000,300	0.126	918,660	0.136	393,640	0.164	361,740	0.169	247,100	0.205	232,910	0.214
2012	1,005,000	0.129	918,830	0.139	397,210	0.161	363,420	0.168	76,013	0.431	50,736	0.474
2013	1,007,800	0.132	915,880	0.143	399,180	0.162	363,670	0.171	90,485	0.375	57,068	0.412
2014	1,005,200	0.136	905,440	0.148	398,490	0.167	361,380	0.177	147,100	0.300	97,807	0.339
2015	1,000,800	0.140	890,090	0.154	397,740	0.171	359,010	0.183	139,050	0.330	71,370	0.428
2016	992,710	0.143	871,350	0.159	397,000	0.174	356,510	0.188	91,039	0.435	51,273	0.514
2017	988,150	0.147	853,210	0.164	395,890	0.178	353,150	0.192	152,140	0.331	88,687	0.466
2018	976,520	0.151	833,870	0.170	393,390	0.181	347,610	0.196	78,718	0.485		
2019	963,440	0.156	812,140	0.175	388,110	0.184	338,180	0.200	114,680	0.405		
2020	940,150	0.162	781,735	0.183	379,290	0.189	324,062	0.207				
2021	919,070	0.167	756,011		371,620	0.195	310,036					
2022	902,540	0.171			365,390	0.200						
2023	888,872				359,074							
Mean recruitment of post-1976 year classes									126,618		113,997	

Table 12.23. Estimated numbers at age for POP (millions).

	Age																	
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1960	232.5	93.0	87.9	83.1	78.6	74.3	70.2	66.4	62.8	59.4	56.1	53.1	50.2	47.4	44.8	42.4	40.1	37.9
1961	46.9	219.8	87.9	83.1	78.5	74.1	70.0	66.0	62.2	58.6	55.2	52.0	49.2	46.6	44.2	41.9	39.7	37.6
1962	41.6	44.3	207.4	82.8	77.9	73.1	68.1	63.0	57.8	52.7	48.1	44.5	42.0	40.3	39.0	38.0	36.8	35.6
1963	54.2	39.3	41.9	195.8	77.9	73.1	68.2	63.0	57.5	51.9	46.7	42.3	39.2	37.2	36.0	35.3	34.7	34.0
1964	258.3	51.2	37.1	39.4	183.4	72.4	67.0	61.0	54.7	48.1	42.1	37.1	33.6	31.6	30.8	30.7	30.8	30.9
1965	309.1	243.5	48.0	34.6	36.3	164.4	62.1	53.6	44.4	35.6	28.3	23.4	20.6	19.6	19.9	21.1	22.7	24.2
1966	49.0	290.5	227.4	44.3	31.2	31.4	133.2	45.5	34.3	24.4	17.1	12.6	10.4	9.8	10.4	11.8	13.9	16.4
1967	35.7	46.0	269.9	208.0	39.4	26.4	24.6	93.1	27.4	17.6	10.9	7.1	5.2	4.7	4.9	5.9	7.5	9.7
1968	35.7	33.4	42.6	246.4	184.7	33.4	20.9	17.6	59.0	15.3	8.8	5.1	3.4	2.6	2.6	3.0	4.0	5.5
1969	39.0	33.3	30.7	38.4	214.3	152.0	25.3	14.2	10.4	30.4	7.0	3.8	2.2	1.6	1.4	1.5	1.9	2.8
1970	31.9	36.3	30.7	27.8	33.9	181.1	120.9	18.6	9.5	6.4	17.1	3.8	2.1	1.3	1.0	0.9	1.1	1.5
1971	23.6	29.4	32.8	27.0	23.4	26.7	130.5	77.7	10.5	4.7	2.9	7.4	1.7	1.0	0.7	0.6	0.6	0.7
1972	29.9	22.0	27.1	29.9	24.1	20.4	22.4	104.6	59.2	7.6	3.3	2.0	5.1	1.2	0.7	0.5	0.4	0.5
1973	47.6	27.7	20.1	24.4	26.3	20.5	16.5	17.2	76.0	40.7	5.0	2.1	1.3	3.5	0.8	0.5	0.4	0.4
1974	38.6	44.6	25.8	18.6	22.4	23.7	18.2	14.4	14.6	63.3	33.5	4.1	1.8	1.1	3.0	0.7	0.5	0.4
1975	45.3	35.4	40.3	22.9	16.1	18.7	19.0	13.8	10.4	10.1	42.5	22.3	2.8	1.2	0.8	2.2	0.6	0.4
1976	22.5	41.6	32.2	36.1	20.1	13.7	15.4	15.1	10.6	7.7	7.3	30.6	16.2	2.1	0.9	0.6	1.8	0.5
1977	26.7	20.5	37.3	28.2	30.8	16.5	10.8	11.6	10.8	7.3	5.2	4.9	20.7	11.2	1.5	0.7	0.5	1.4
1978	25.2	24.8	18.9	34.1	25.6	27.5	14.5	9.3	9.8	9.1	6.0	4.3	4.1	17.4	9.6	1.3	0.6	0.4
1979	65.3	23.5	23.1	17.5	31.3	23.2	24.6	12.8	8.2	8.5	7.8	5.2	3.7	3.5	15.2	8.5	1.1	0.6
1980	57.9	61.0	21.9	21.3	16.0	28.4	20.9	21.9	11.3	7.1	7.4	6.7	4.5	3.2	3.1	13.5	7.6	1.0
1981	40.9	54.3	57.0	20.4	19.8	14.8	26.0	19.0	19.8	10.1	6.3	6.6	6.0	4.0	2.9	2.8	12.3	7.0
1982	73.1	38.4	50.9	53.2	18.9	18.3	13.6	23.7	17.2	17.8	9.1	5.7	5.9	5.4	3.6	2.6	2.6	11.3
1983	109.7	69.0	36.2	48.0	50.1	17.8	17.2	12.7	22.2	16.0	16.6	8.5	5.3	5.5	5.1	3.4	2.5	2.4
1984	150.5	103.6	65.2	34.2	45.3	47.3	16.8	16.2	12.0	20.9	15.1	15.6	7.9	5.0	5.2	4.8	3.2	2.3
1985	87.6	142.2	97.9	61.5	32.2	42.7	44.5	15.8	15.2	11.2	19.6	14.1	14.6	7.5	4.7	4.9	4.5	3.0
1986	67.2	82.8	134.4	92.5	58.1	30.5	40.3	42.1	14.9	14.3	10.6	18.5	13.3	13.8	7.0	4.4	4.6	4.2
1987	360.3	63.5	78.2	126.9	87.3	54.8	28.7	38.0	39.6	14.0	13.5	10.0	17.3	12.5	13.0	6.6	4.2	4.3
1988	66.3	340.4	60.0	73.8	119.7	82.2	51.5	26.9	35.5	36.9	13.1	12.5	9.3	16.2	11.7	12.1	6.2	3.9
1989	166.5	62.6	321.3	56.6	69.5	112.5	77.1	48.2	25.1	33.0	34.3	12.1	11.6	8.6	15.0	10.9	11.3	5.8
1990	72.4	157.2	59.1	302.8	53.2	65.3	105.3	71.9	44.7	23.2	30.4	31.4	11.1	10.7	7.9	13.9	10.1	10.5
1991	247.7	68.3	147.9	55.4	282.6	49.3	59.9	95.5	64.2	39.4	20.2	26.2	27.1	9.6	9.3	7.0	12.3	9.0
1992	132.1	233.9	64.4	139.4	52.2	265.2	46.1	55.7	88.4	59.1	36.0	18.4	23.9	24.7	8.8	8.5	6.4	11.4
1993	79.8	124.7	220.6	60.7	130.9	48.8	246.8	42.6	51.1	80.2	53.2	32.3	16.4	21.4	22.2	7.9	7.8	5.9
1994	37.8	75.3	117.6	207.7	57.0	122.4	45.4	227.5	38.9	46.1	71.7	47.2	28.6	14.6	19.1	19.9	7.2	7.0
1995	59.1	35.7	71.1	110.9	195.5	53.5	114.5	42.2	210.3	35.7	42.0	65.0	42.8	25.9	13.3	17.4	18.3	6.6
1996	48.7	55.8	33.8	67.1	104.5	183.8	50.1	106.8	39.2	194.0	32.8	38.4	59.3	39.0	23.7	12.2	16.0	16.9
1997	157.6	46.0	52.7	31.8	63.2	98.1	172.0	46.6	98.8	35.9	176.8	29.7	34.7	53.7	35.4	21.6	11.1	14.7
1998	123.0	148.9	43.4	49.7	30.0	59.4	92.0	160.6	43.3	91.2	33.0	161.7	27.1	31.7	49.1	32.5	19.9	10.3
1999	267.6	116.2	140.7	41.0	46.9	28.3	55.8	86.3	150.0	40.3	84.5	30.5	149.2	25.0	29.3	45.4	30.1	18.4
2000	58.6	252.9	109.8	132.8	38.7	44.2	26.5	52.3	80.4	139.1	37.2	77.7	28.0	136.8	23.0	26.9	41.9	27.8
2001	234.3	55.4	238.9	103.7	125.3	36.4	41.5	24.9	48.9	74.9	129.2	34.5	71.9	25.9	126.6	21.3	25.0	39.0
2002	73.3	221.5	52.3	225.6	97.8	118.1	34.3	39.0	23.3	45.6	69.7	119.9	31.9	66.6	24.0	117.4	19.8	23.3
2003	359.3	69.2	209.2	49.4	212.8	92.2	111.1	32.2	36.5	21.7	42.3	64.5	110.7	29.5	61.4	22.2	108.7	18.3
2004	47.8	339.5	65.4	197.5	46.6	200.3	86.5	103.9	30.0	33.8	20.0	38.9	59.1	101.4	27.0	56.4	20.4	100.2
2005	127.4	45.1	320.7	61.7	186.3	43.9	188.3	81.2	97.1	27.9	31.4	18.5	35.9	54.5	93.6	24.9	52.2	18.9
2006	50.2	120.4	42.6	302.8	58.2	175.5	41.3	176.8	76.0	90.6	26.0	29.1	17.2	33.2	50.5	86.7	23.1	48.5
2007	174.3	47.4	113.7	40.2	285.6	54.9	165.0	38.7	165.2	70.7	84.1	24.0	26.9	15.8	30.7	46.6	80.1	21.4
2008	201.7	164.6	44.8	107.3	37.9	268.5	51.4	154.2	36.0	153.0	65.2	77.2	22.0	24.6	14.5	28.1	42.7	73.6
2009	103.0	190.6	155.4	42.3	101.1	35.7	252.0	48.1	143.7	33.4	141.3	60.0	70.8	20.2	22.5	13.3	25.8	39.3
2010	92.7	97.4	179.9	146.7	39.8	95.2	33.5	236.1	44.9	133.7	31.0	130.6	55.3	65.3	18.6	20.8	12.3	23.9
2011	247.1	87.6	91.9	169.7	138.2	37.5	89.3	31.3	220.1	41.7	123.6	28.5	120.2	50.9	60.0	17.1	19.1	11.3
2012	76.0	233.3	82.6	86.6	159.7	129.8	35.1	83.3	29.1	203.2	38.3	113.2	26.1	109.6	46.4	54.8	15.6	17.5
2013	90.5	71.8	220.1	77.9	81.5	150.0	121.5	32.7	77.3	26.9	186.8	35.1	103.4	23.8	100.1	42.4	50.2	14.3
2014	147.1	85.4	67.7	207.2	73.2	76.3	139.9	112.7	30.2	70.9	24.5	169.4	31.8	93.4	21.5	90.6	38.5	45.7
2015	139.1	138.8	80.5	63.7	194.5	68.5	71.1	129.7	103.9	27.6	64.5	22.2	153.0	28.7	84.4	19.5	82.2	35.0
2016	91.0	131.2	130.8	75.7	59.8	182.0	63.8	65.9	119.5	95.1	25.1	58.4	20.0	138.3	25.9	76.5	17.7	74.9
2017	152.1	85.9	123.6	123.0	71.0	55.9	169.5	59.1	60.7	109.3	86.5	22.8	52.8	18.1	125.2	23.5	69.6	16.1
2018	78.7	143.5	80.9	116.2	115.3	66.4	52.0	156.7	54.3	55.4	99.2	78.2	20.5	47.7	16.4	113.4	21.4	63.4
2019	114.7	74.2	135.0	75.9	108.8	107.5	61.6	47.9	143.5	49.3	50.1	89.3	70.2	18.5	42.9	14.8	102.9	19.5
2020	109.4	108.0	69.7	126.5	70.9	101.0	99.1	56.3	43.4	128.9	44.0	44.4	79.0	62.3	16.4	38.4	13.3	92.8
2021	109.4	103.0	101.4	65.3	118.0	65.8	93.1	90.7	51.0	39.0	115.0	39.1	39.4	70.3	55.6	14.7	34.5	12.0
2022	109.4	103.0	96.7	95.0	61.0	109.6	60.7	85.3	82.4	46.0	35.0	102.7	34.9	35.3	63.1	50.1	13.3	31.4

Table 12.23 (continued). Estimated numbers at age for POP (millions).

	Age																			
Year	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40+
1960	35.8	33.9	32.0	30.3	28.6	27.1	25.6	24.2	22.9	21.6	20.4	19.3	18.3	17.3	16.3	15.4	14.6	13.8	13.1	226.3
1961	35.7	33.7	31.9	30.2	28.6	27.0	25.6	24.2	22.8	21.6	20.4	19.3	18.3	17.3	16.3	15.4	14.6	13.8	13.0	226.2
1962	34.2	32.7	31.2	29.6	28.1	26.6	25.2	23.9	22.6	21.4	20.2	19.1	18.1	17.1	16.2	15.3	14.5	13.7	13.0	225.0
1963	33.0	31.9	30.6	29.2	27.8	26.4	25.0	23.7	22.5	21.3	20.1	19.0	18.0	17.0	16.1	15.3	14.4	13.7	12.9	224.5
1964	30.7	30.2	29.3	28.3	27.1	25.8	24.6	23.3	22.1	21.0	19.9	18.8	17.8	16.9	16.0	15.1	14.3	13.6	12.8	223.2
1965	25.5	26.2	26.3	26.0	25.3	24.4	23.4	22.3	21.3	20.2	19.2	18.2	17.3	16.4	15.5	14.7	14.0	13.3	12.6	219.3
1966	18.7	20.6	21.9	22.5	22.5	22.1	21.5	20.7	19.9	19.0	18.1	17.2	16.4	15.6	14.9	14.1	13.4	12.8	12.1	213.4
1967	12.3	14.8	16.9	18.4	19.2	19.4	19.3	18.9	18.3	17.6	16.8	16.1	15.4	14.7	14.0	13.4	12.8	12.2	11.6	206.4
1968	7.5	9.9	12.3	14.3	15.8	16.7	17.0	17.0	16.7	16.2	15.6	15.0	14.4	13.8	13.2	12.7	12.2	11.6	11.1	200.0
1969	4.1	5.9	8.0	10.2	12.1	13.5	14.4	14.7	14.8	14.6	14.2	13.8	13.3	12.8	12.3	11.9	11.4	11.0	10.5	192.2
1970	2.2	3.4	5.0	6.9	8.9	10.6	11.9	12.7	13.1	13.2	13.0	12.7	12.4	12.0	11.6	11.2	10.8	10.4	10.0	186.2
1971	1.1	1.7	2.7	4.0	5.7	7.4	8.9	10.1	10.9	11.2	11.3	11.3	11.1	10.8	10.5	10.2	9.9	9.6	9.3	177.2
1972	0.6	0.9	1.5	2.4	3.6	5.1	6.7	8.1	9.1	9.8	10.2	10.3	10.3	10.1	9.9	9.7	9.4	9.1	8.9	172.9
1973	0.4	0.5	0.8	1.3	2.1	3.2	4.5	6.0	7.2	8.2	8.8	9.2	9.3	9.3	9.2	9.0	8.8	8.6	8.4	167.4
1974	0.3	0.4	0.5	0.7	1.2	1.9	2.9	4.2	5.5	6.7	7.6	8.2	8.5	8.6	8.6	8.5	8.4	8.2	8.0	164.4
1975	0.3	0.3	0.3	0.4	0.6	1.0	1.7	2.6	3.7	4.9	5.9	6.8	7.3	7.7	7.8	7.8	7.8	7.6	7.5	158.3
1976	0.3	0.3	0.2	0.3	0.4	0.6	0.9	1.5	2.3	3.3	4.4	5.4	6.1	6.7	7.0	7.1	7.1	7.1	7.0	153.0
1977	0.4	0.3	0.2	0.2	0.2	0.3	0.5	0.8	1.3	2.1	3.0	3.9	4.8	5.5	6.0	6.3	6.4	6.5	6.5	146.2
1978	1.3	0.4	0.2	0.2	0.2	0.2	0.3	0.5	0.8	1.2	1.9	2.7	3.6	4.4	5.1	5.5	5.8	6.0	6.0	142.3
1979	0.4	1.2	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.7	1.1	1.8	2.5	3.3	4.1	4.7	5.1	5.4	5.6	138.7
1980	0.5	0.4	1.1	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	1.0	1.6	2.3	3.1	3.8	4.4	4.8	5.0	134.9
1981	1.0	0.5	0.3	1.0	0.3	0.2	0.2	0.1	0.2	0.2	0.4	0.6	1.0	1.5	2.2	2.9	3.6	4.1	4.5	131.2
1982	6.4	0.9	0.4	0.3	0.9	0.3	0.2	0.1	0.1	0.2	0.2	0.3	0.6	0.9	1.4	2.0	2.7	3.3	3.8	127.3
1983	10.6	6.0	0.8	0.4	0.3	0.9	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.5	0.9	1.3	1.9	2.6	3.1	123.8
1984	2.3	10.0	5.7	0.8	0.4	0.3	0.8	0.2	0.2	0.1	0.1	0.1	0.2	0.3	0.5	0.8	1.3	1.8	2.4	119.9
1985	2.2	2.2	9.5	5.4	0.7	0.4	0.3	0.8	0.2	0.2	0.1	0.1	0.1	0.2	0.3	0.5	0.8	1.2	1.7	115.5
1986	2.9	2.1	2.0	8.9	5.1	0.7	0.3	0.2	0.7	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.7	1.1	110.8
1987	4.0	2.7	2.0	1.9	8.4	4.8	0.7	0.3	0.2	0.7	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.7	105.7
1988	4.1	3.7	2.5	1.8	1.8	7.9	4.5	0.6	0.3	0.2	0.7	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.4	100.3
1989	3.6	3.8	3.5	2.4	1.7	1.7	7.5	4.2	0.6	0.3	0.2	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.2	94.8
1990	5.4	3.4	3.6	3.3	2.2	1.6	1.6	7.0	4.0	0.5	0.3	0.2	0.6	0.2	0.1	0.1	0.1	0.1	0.1	89.2
1991	9.5	4.9	3.1	3.2	3.0	2.0	1.5	1.5	6.4	3.6	0.5	0.2	0.2	0.5	0.1	0.1	0.1	0.1	0.1	82.8
1992	8.4	8.8	4.6	2.9	3.0	2.8	1.9	1.4	1.4	6.0	3.4	0.5	0.2	0.2	0.5	0.1	0.1	0.1	0.1	77.7
1993	10.5	7.7	8.2	4.2	2.7	2.8	2.6	1.8	1.3	1.3	5.6	3.2	0.4	0.2	0.1	0.5	0.1	0.1	0.1	72.5
1994	5.4	9.6	7.1	7.5	3.9	2.5	2.6	2.4	1.6	1.2	1.2	5.1	2.9	0.4	0.2	0.1	0.4	0.1	0.1	67.5
1995	6.5	5.0	8.9	6.6	7.0	3.6	2.3	2.4	2.2	1.5	1.1	1.1	4.8	2.7	0.4	0.2	0.1	0.4	0.1	63.2
1996	6.1	6.0	4.6	8.3	6.2	6.5	3.4	2.2	2.3	2.1	1.4	1.0	1.0	4.5	2.5	0.3	0.2	0.1	0.4	59.2
1997	15.5	5.6	5.6	4.3	7.7	5.7	6.1	3.1	2.0	2.1	1.9	1.3	1.0	0.9	4.1	2.4	0.3	0.2	0.1	55.6
1998	13.6	14.4	5.2	5.2	4.0	7.2	5.3	5.6	2.9	1.9	2.0	1.8	1.2	0.9	0.9	3.9	2.2	0.3	0.1	52.1
1999	9.6	12.7	13.5	4.9	4.9	3.7	6.7	5.0	5.3	2.7	1.7	1.8	1.7	1.1	0.8	0.8	3.6	2.1	0.3	49.0
2000	17.1	8.9	11.8	12.5	4.6	4.5	3.5	6.3	4.6	4.9	2.6	1.6	1.7	1.6	1.1	0.8	0.8	3.4	1.9	46.2
2001	25.9	16.0	8.3	11.0	11.7	4.3	4.2	3.2	5.8	4.3	4.6	2.4	1.5	1.6	1.5	1.0	0.7	0.7	3.2	45.1
2002	36.3	24.2	14.9	7.7	10.3	11.0	4.0	4.0	3.0	5.5	4.1	4.3	2.2	1.4	1.5	1.4	0.9	0.7	0.7	45.3
2003	21.6	33.8	22.5	13.9	7.2	9.6	10.2	3.7	3.7	2.8	5.1	3.8	4.0	2.1	1.3	1.4	1.3	0.9	0.6	43.1
2004	16.9	20.0	31.3	20.9	12.9	6.7	8.9	9.5	3.5	3.4	2.6	4.7	3.5	3.7	1.9	1.2	1.3	1.2	0.8	40.8
2005	93.0	15.7	18.6	29.1	19.5	12.0	6.2	8.3	8.8	3.2	3.2	2.4	4.4	3.3	3.5	1.8	1.1	1.2	1.1	38.9
2006	17.6	86.6	14.7	17.4	27.2	18.2	11.2	5.8	7.7	8.2	3.0	3.0	2.3	4.1	3.0	3.2	1.7	1.1	1.1	37.5
2007	44.9	16.3	80.5	13.6	16.1	25.3	16.9	10.4	5.4	7.2	7.6	2.8	2.8	2.1	3.8	2.8	3.0	1.6	1.0	36.1
2008	19.7	41.4	15.0	74.3	12.6	14.9	23.3	15.6	9.6	5.0	6.6	7.0	2.6	2.6	2.0	3.5	2.6	2.8	1.5	34.6
2009	67.9	18.2	38.3	13.9	68.7	11.6	13.8	21.5	14.4	8.8	4.6	6.1	6.5	2.4	2.4	1.8	3.3	2.4	2.6	33.5
2010	36.4	62.9	16.9	35.5	12.9	63.7	10.8	12.8	20.0	13.3	8.2	4.3	5.7	6.0	2.2	2.2	1.7	3.0	2.3	33.7
2011	22.1	33.7	58.3	15.6	32.9	11.9	59.0	10.0	11.8	18.4	12.3	7.6	3.9	5.2	5.6	2.0	2.0	1.6	2.8	33.5
2012	10.4	20.3	31.0	53.6	14.4	30.3	11.0	54.1	9.2	10.8	16.9	11.2	6.9	3.6	4.8	5.1	1.9	1.9	1.4	33.7
2013	16.1	9.6	18.7	28.6	49.4	13.2	27.8	10.1	49.6	8.4	9.9	15.4	10.3	6.3	3.3	4.4	4.7	1.7	1.7	32.6
2014	13.1	14.7	8.8	17.1	26.1	45.1	12.1	25.3	9.2	45.1	7.6	9.0	14.0	9.3	5.8	3.0	4.0	4.3	1.6	31.6
2015	41.7	12.0	13.5	8.0	15.6	23.8	41.1	11.0	23.0	8.3	40.8	6.9	8.1	12.7	8.5	5.2	2.7	3.7	3.9	30.6
2016	32.0	38.1	10.9	12.3	7.3	14.3	21.7	37.4	10.0	20.8	7.5	36.9	6.2	7.3	11.5	7.7	4.8	2.5	3.4	31.7
2017	68.5	29.3	34.9	10.0	11.3	6.7	13.0	19.8	34.0	9.0	18.8	6.8	33.3	5.6	6.6	10.4	7.0	4.4	2.3	32.3
2018	14.7	62.7	26.8	32.0	9.2	10.3	6.1	11.8	17.9	30.7	8.2	17.0	6.1	30.0	5.1	6.0	9.5	6.4	4.0	31.7
2019	57.9	13.5	57.4	24.6	29.2	8.4	9.4	5.5	10.7	16.2	27.6	7.3	15.2	5.5	27.0	4.6	5.4	8.6	5.8	32.7
2020	17.6	52.5	12.2	52.1	22.2	26.4	7.5	8.4	4.9	9.5	14.3	24.4	6.5	13.5	4.9	24.0	4.1	4.9	7.7	34.9
2021	84.2	16.0	47.8	11.1	47.3	20.1	23.8	6.8	7.5	4.4	8.4	12.7	21.6	5.7	11.9	4.3	21.4	3.7	4.4	38.6
2022	11.0	77.0	14.6	43.7	10.2	43.1	18.3	21.6	6.1	6.7	3.9	7.5	11.3	19.2	5.1	10.7	3.9	19.3	3.3	39.1

Table 12.24. Projections of BSAI spawning biomass (t), catch (t), and fishing mortality rate for each of the several scenarios. The values of $B_{35\%}$ and $B_{40\%}$ are 228,419 t and 261,050 t, respectively.

Catch	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2022	34,234	34,234	34,234	34,234	34,234	34,234	34,234
2023	42,038	42,038	33,789	10,956	0	50,133	42,038
2024	40,868	40,868	33,206	11,089	0	48,218	40,868
2025	39,819	39,819	32,692	11,232	0	46,499	47,486
2026	38,844	38,844	32,209	11,370	0	44,920	45,829
2027	37,968	37,968	31,775	11,508	0	43,508	44,337
2028	37,191	37,191	31,394	11,644	0	42,263	43,014
2029	36,555	36,555	31,098	11,791	0	41,226	41,902
2030	36,035	36,035	30,873	11,944	0	40,364	40,970
2031	35,615	35,615	30,707	12,100	0	39,549	40,167
2032	35,267	35,267	30,584	12,255	0	38,636	39,280
2033	34,955	34,955	30,491	12,408	0	37,779	38,402
2034	34,636	34,636	30,410	12,554	0	37,027	37,601
2035	34,320	34,320	30,335	12,693	0	36,384	36,895
Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2022	365,390	365,390	365,390	365,390	365,390	365,390	365,390
2023	358,064	358,064	359,053	361,751	363,024	357,085	358,064
2024	347,753	347,753	352,516	365,777	372,182	343,095	347,753
2025	337,577	337,577	345,840	369,335	380,939	329,585	336,652
2026	327,898	327,898	339,380	372,712	389,540	316,914	323,497
2027	318,958	318,958	333,374	376,085	398,116	305,313	311,405
2028	311,056	311,056	328,136	379,752	406,938	295,057	300,663
2029	304,318	304,318	323,810	383,858	416,130	286,243	291,376
2030	298,714	298,714	320,389	388,415	425,691	278,807	283,485
2031	294,107	294,107	317,763	393,343	435,538	272,591	276,828
2032	290,286	290,286	315,742	398,479	445,502	267,418	271,205
2033	287,027	287,027	314,116	403,625	455,373	263,116	266,449
2034	284,167	284,167	312,721	408,634	465,000	259,495	262,395
2035	281,603	281,603	311,454	413,405	474,270	256,405	258,903
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2022	0.059	0.059	0.059	0.059	0.059	0.059	0.059
2023	0.074	0.074	0.059	0.019	0	0.089	0.074
2024	0.074	0.074	0.059	0.019	0	0.089	0.074
2025	0.074	0.074	0.059	0.019	0	0.089	0.089
2026	0.074	0.074	0.059	0.019	0	0.089	0.089
2027	0.074	0.074	0.059	0.019	0	0.089	0.089
2028	0.074	0.074	0.059	0.019	0	0.089	0.089
2029	0.074	0.074	0.059	0.019	0	0.089	0.089
2030	0.074	0.074	0.059	0.019	0	0.089	0.089
2031	0.074	0.074	0.059	0.019	0	0.089	0.089
2032	0.074	0.074	0.059	0.019	0	0.088	0.088
2033	0.074	0.074	0.059	0.019	0	0.087	0.087
2034	0.074	0.074	0.059	0.019	0	0.086	0.087
2035	0.074	0.074	0.059	0.019	0	0.085	0.086

Figures

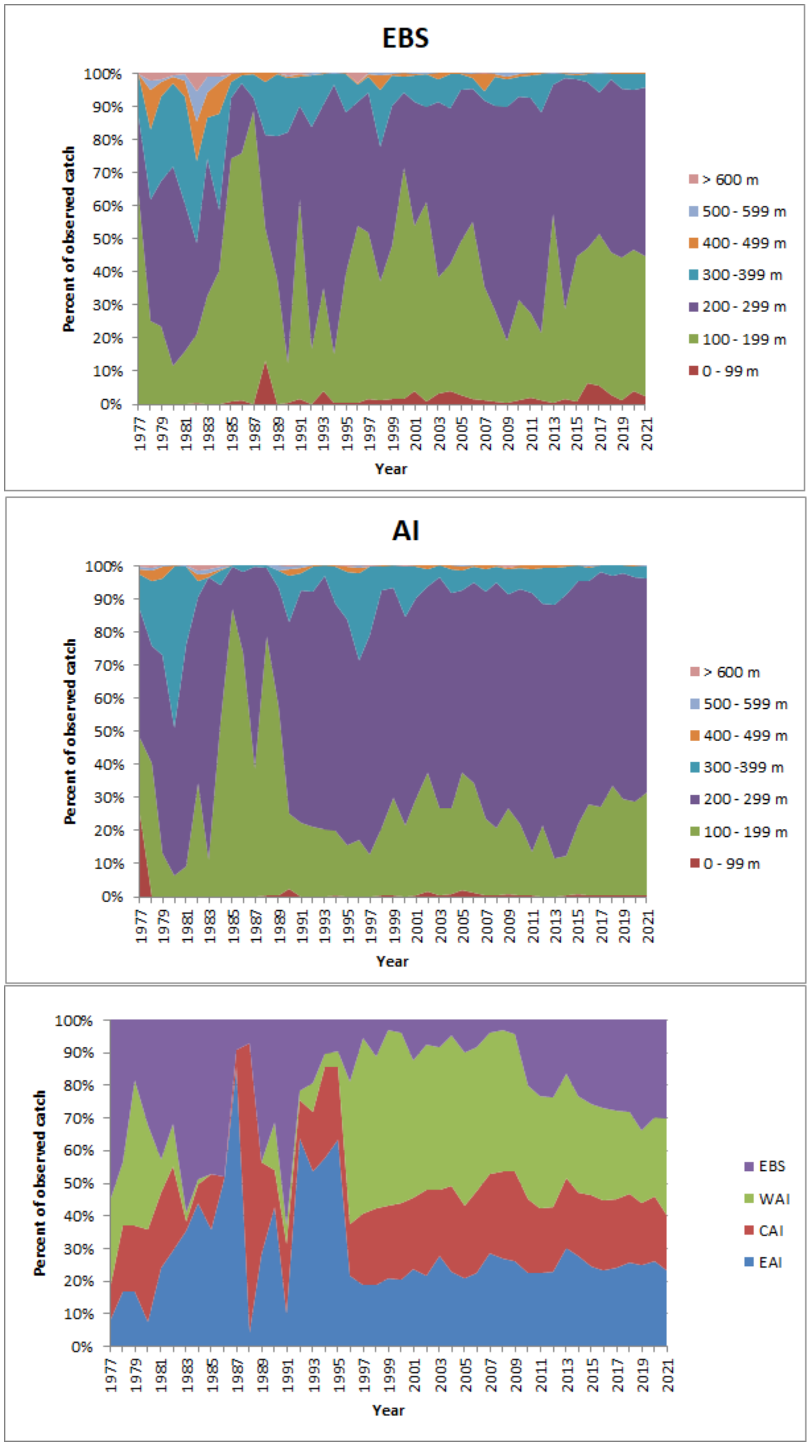

Figure 12.1. Distribution of observed BSAI Pacific ocean perch catch (from North Pacific Groundfish Observer Program) by depth zone for the EBS (top panel) and AI (middle panel), and BSAI subarea (bottom panel) from 1977 to 2021.

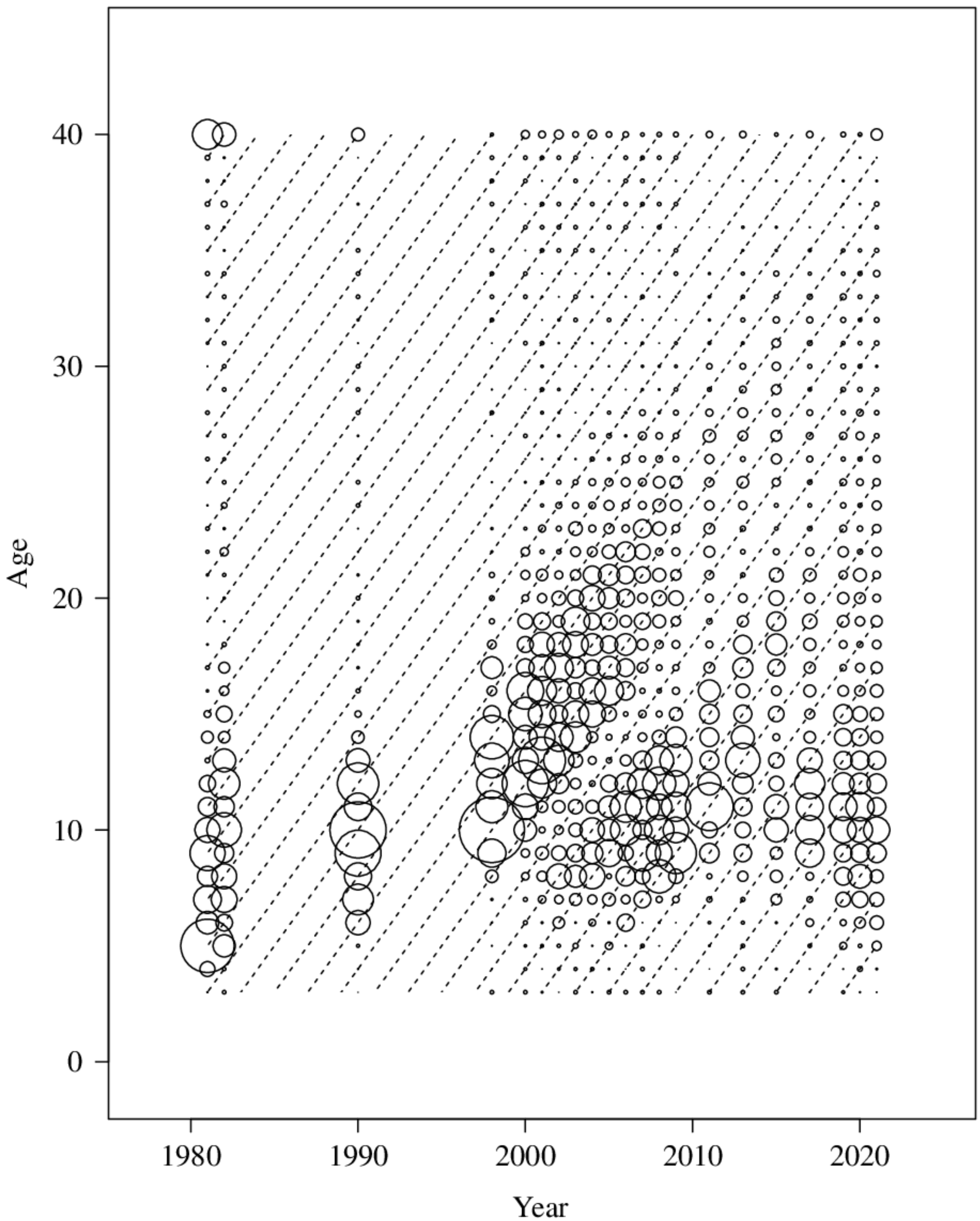

Figure 12.2. Fishery age composition data for the BSAI POP; The diameter of the circles are scaled within each year of samples, and dashed lines denote cohorts.

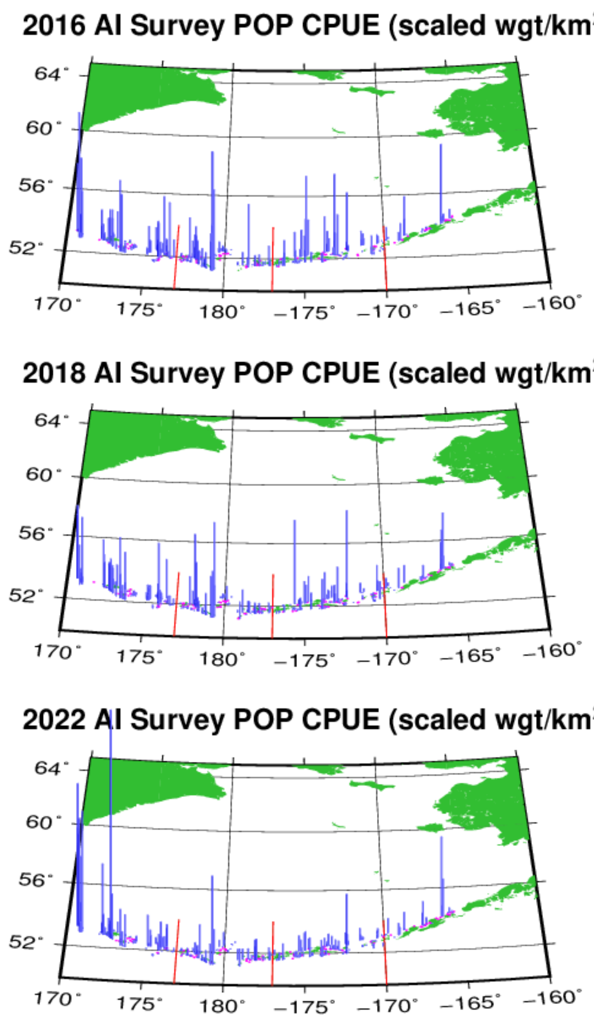

Figure 12.3. AI survey POP CPUE (kg/km^2) from 2016-2022; the symbol × denotes tows with no catch. The red lines indicate boundaries between the WAI, CAI, EAI, and EBS areas.

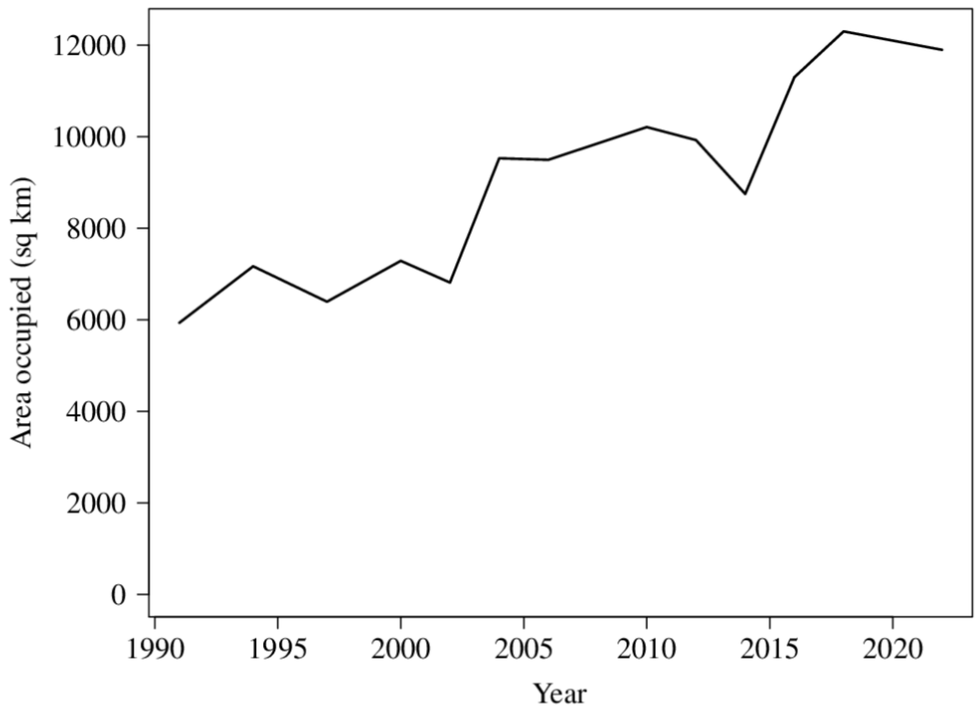

Figure 12.4. The minimum area occupied for 95% of the AI trawl survey abundance estimate for POP from 1991 to 2022.

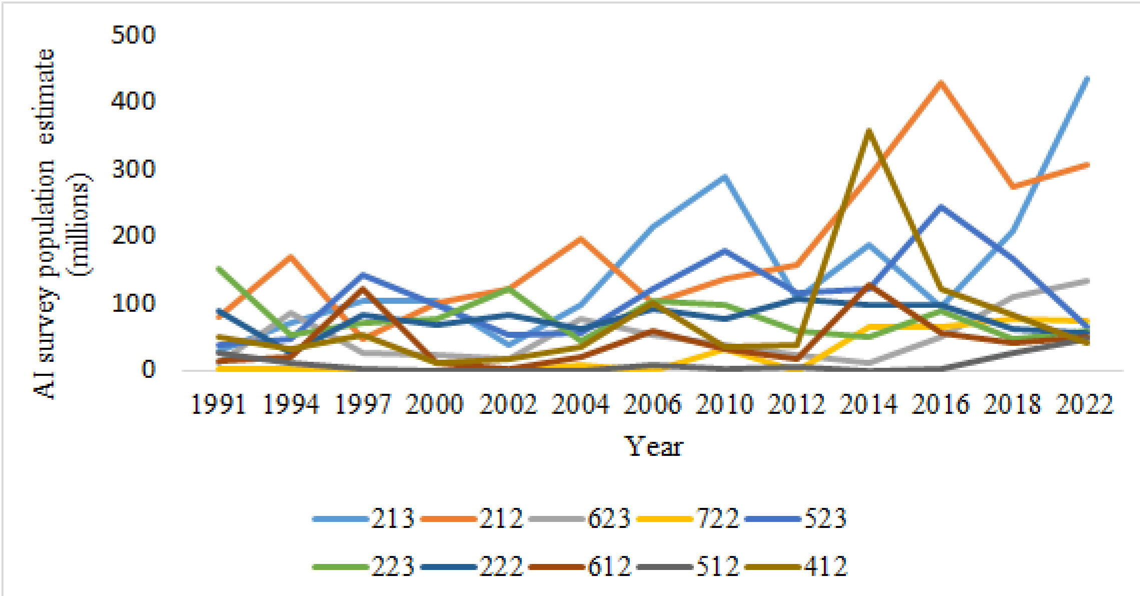

Figure 12.5. AI trawl survey abundance estimates for 10 strata with the largest abundance estimates for 2022. See Table 12.12 for the depth and region of the strata.

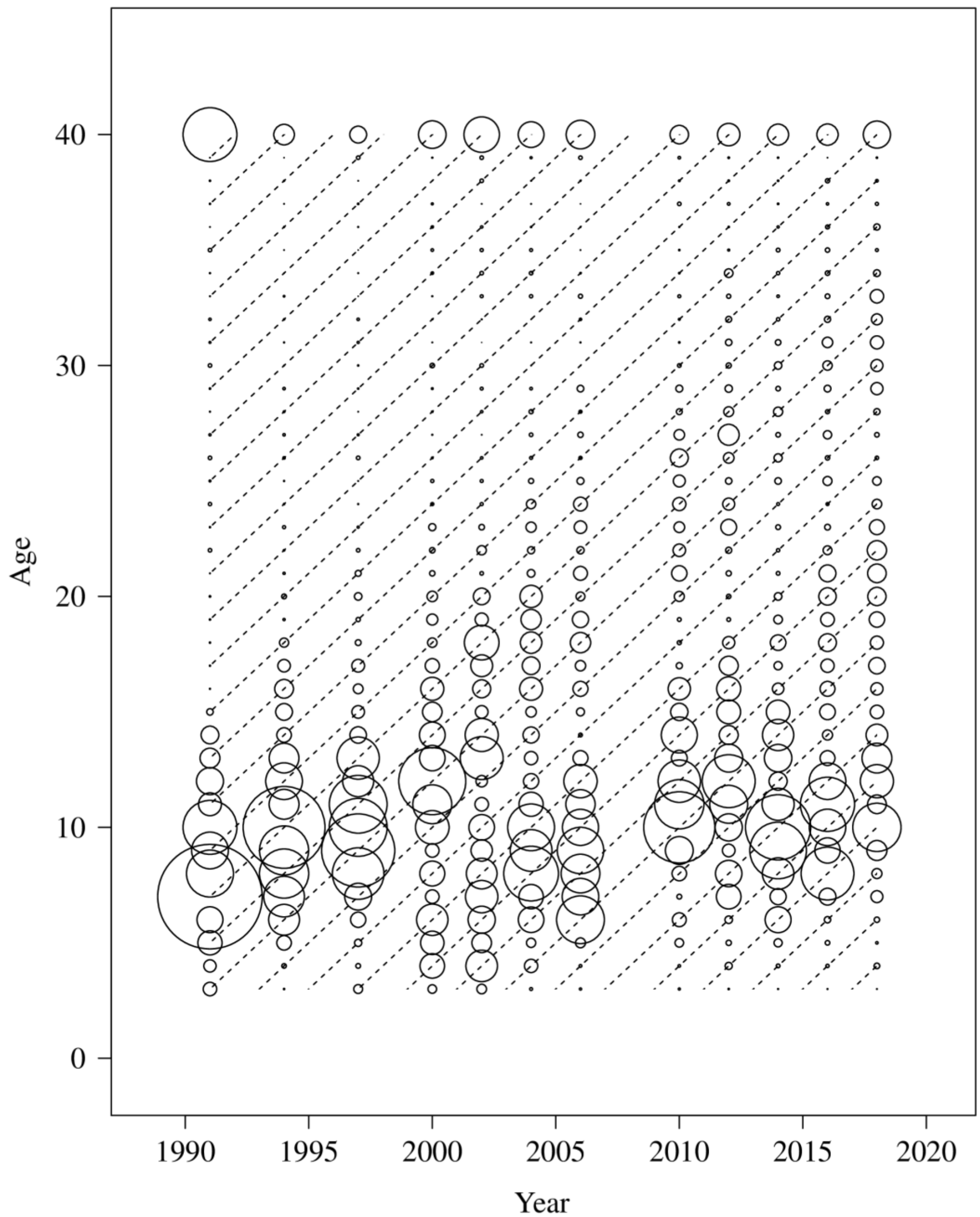

Figure 12.6. Age composition data from the Aleutian Islands trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

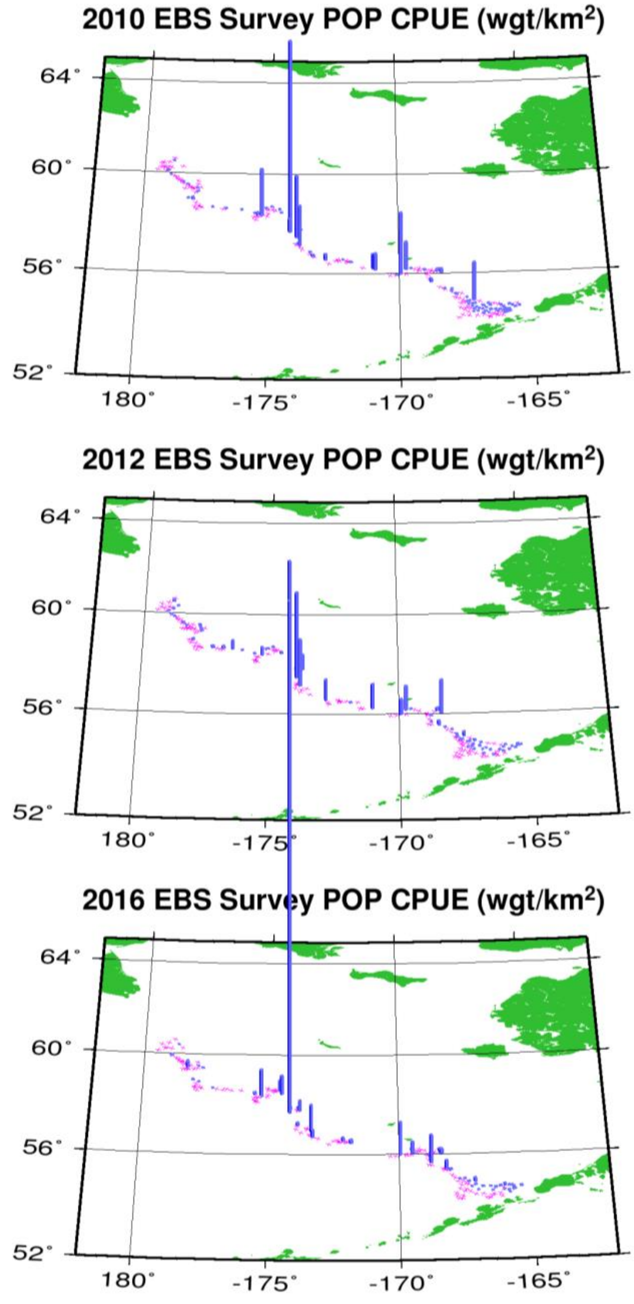

Figure 12.7. EBS slope survey POP CPUE (kg/km^2) from 2010-2016; the symbol × denotes tows with no catch.

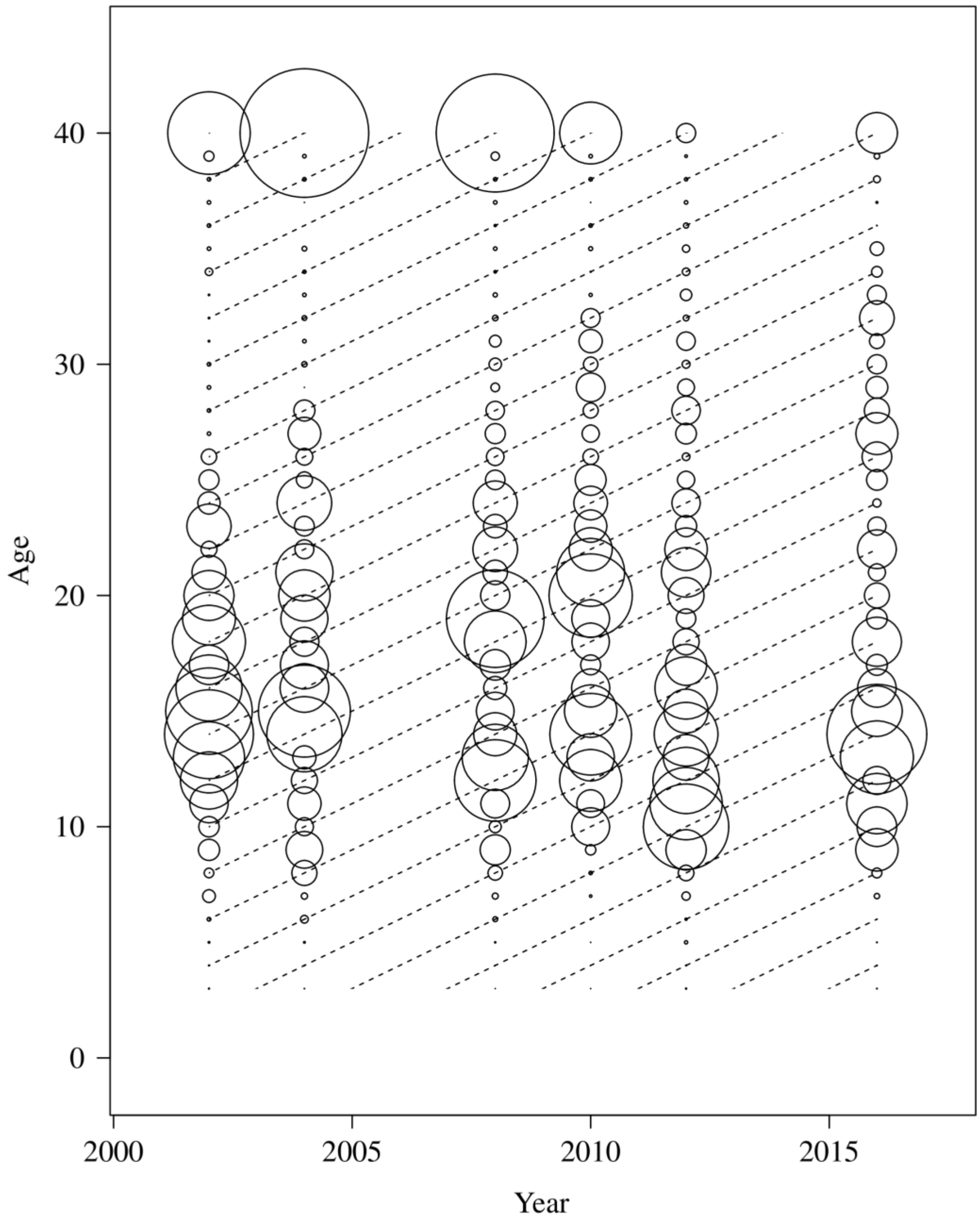

Figure 12.8. Age composition data from the eastern Bering Sea trawl survey; bubbles are scaled within each year of samples; and dashed lines denote cohorts.

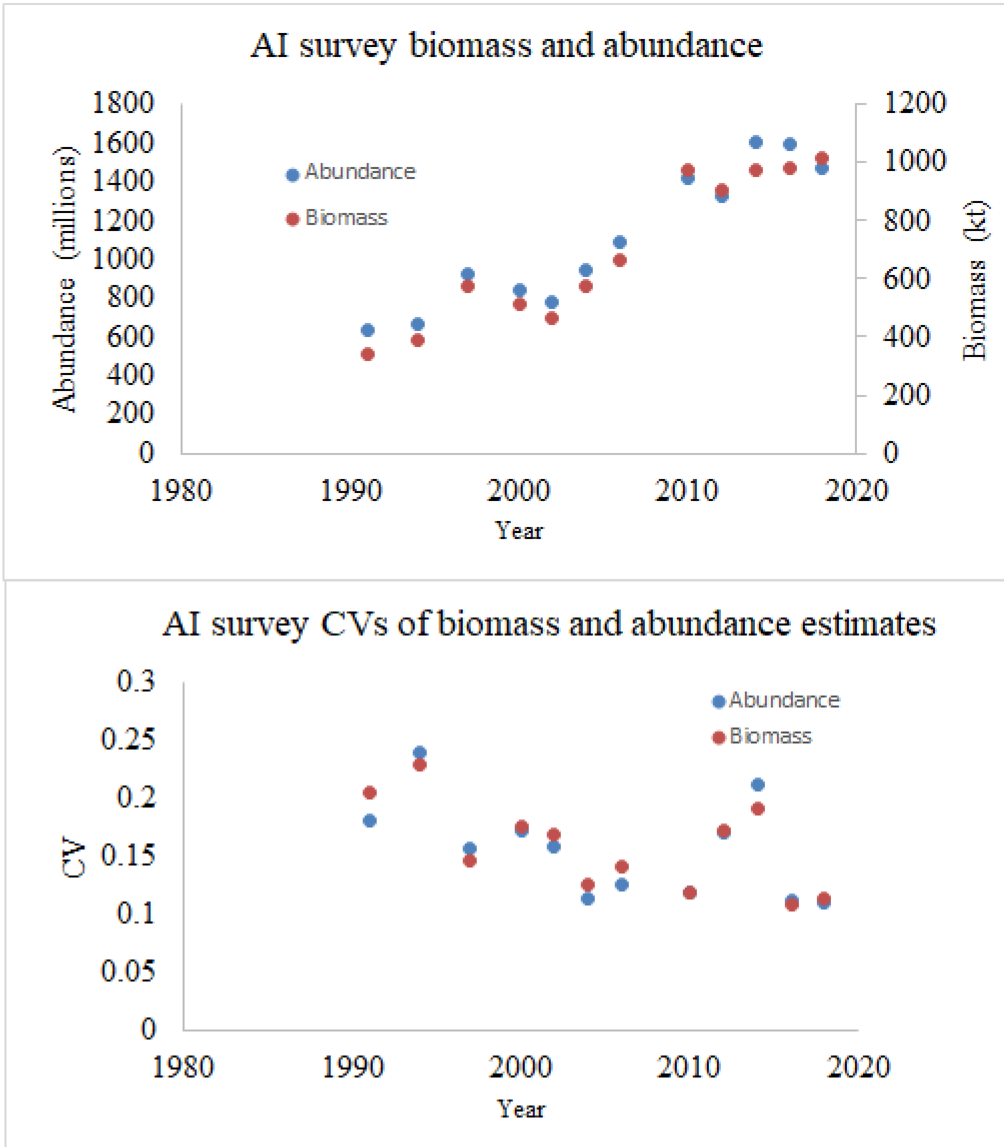

Figure 12.9 Time series of biomass and abundance estimates from the Aleutian Islands trawl survey, and their coefficients of variation.

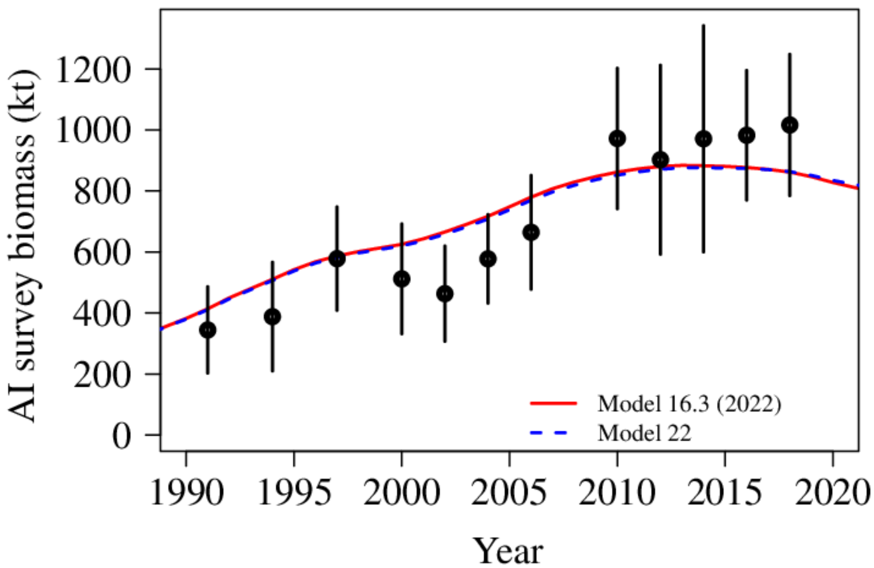

Figure 12.10. Fit to estimates of Aleutian Island survey biomass from Model 16.3 (2022) and Model 22.

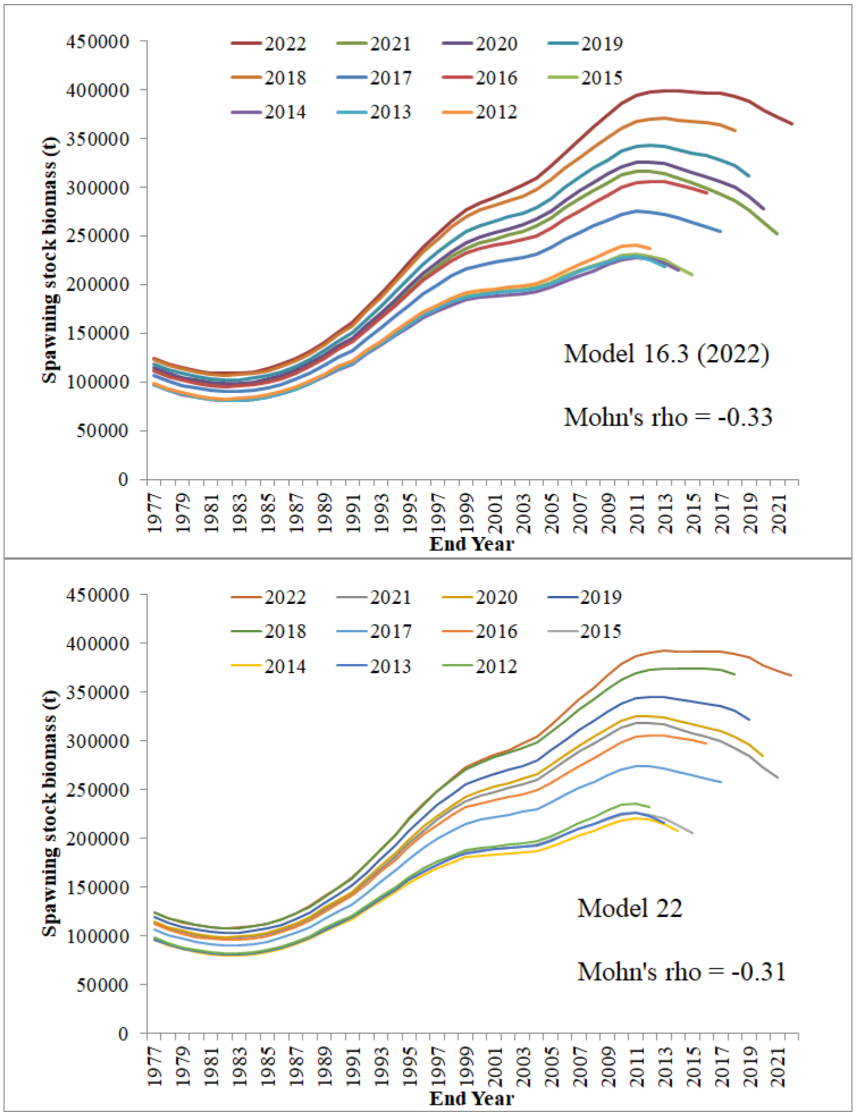

Figure 12.11. Retrospective estimates of spawning stock biomass for Model 16.3 (2022) and Model 22.

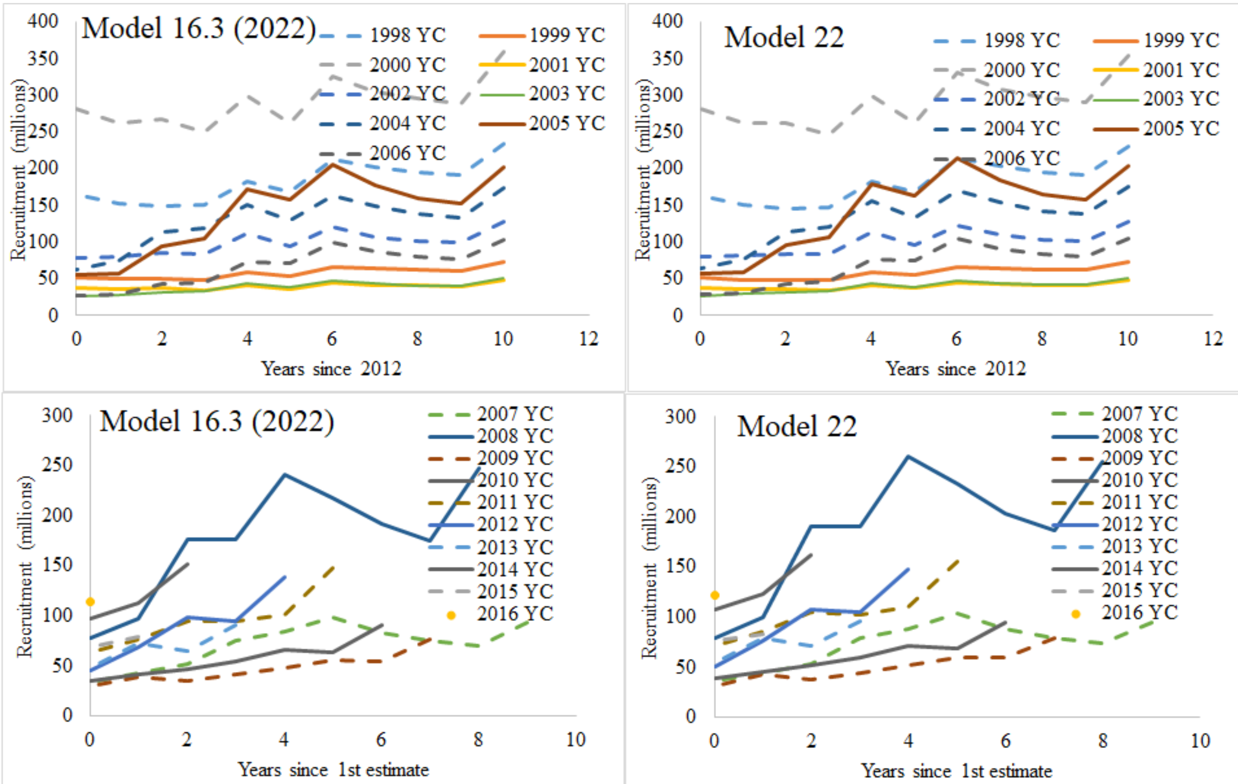

Figure 12.12. Retrospective estimates of recruitment from Model 16.3 (2022) and Model 22 for the 1998 – 2016 year classes, as a function of the years since either the first estimate or 2012 (whichever is later).

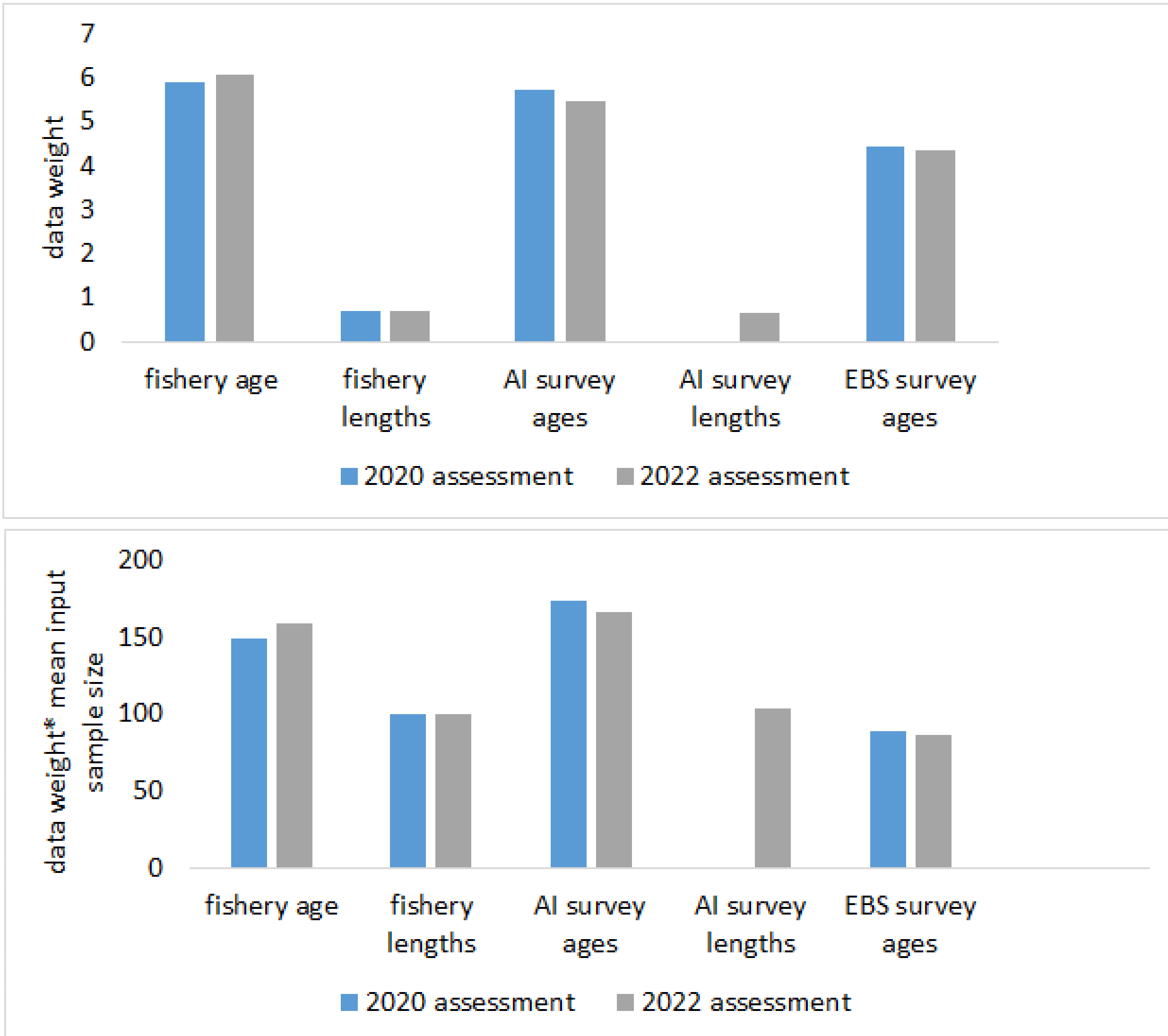

Figure 12.13. Data weights for the age and length composition data for this assessment and the 2020 assessment.

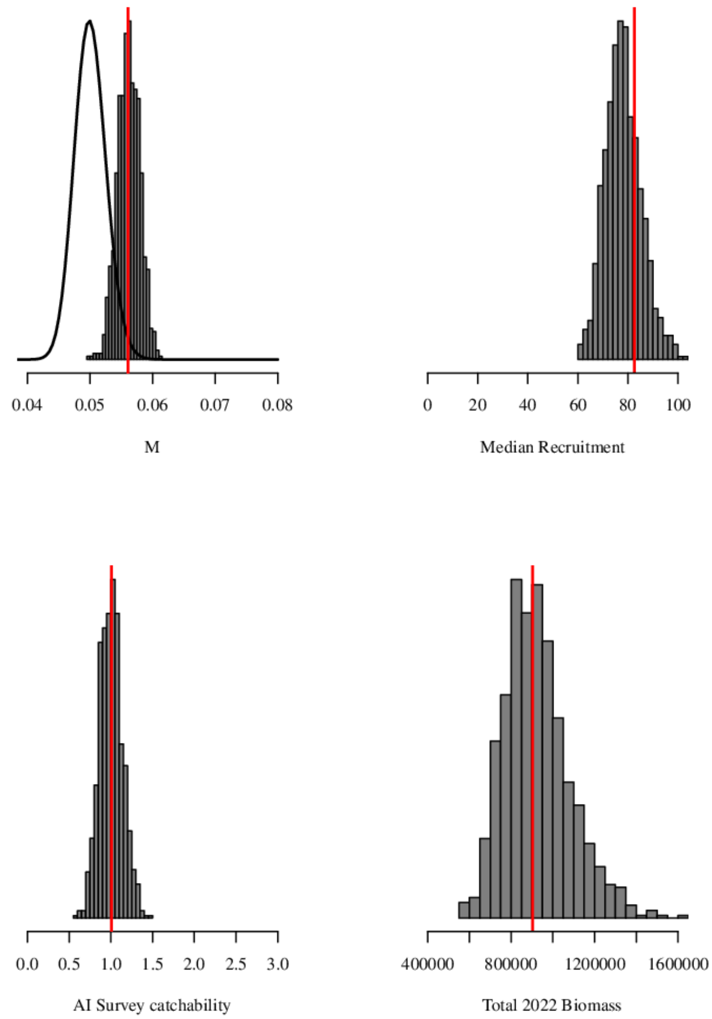

Figure 12.14. Posterior distributions for key model quantities *M*, survey catchability, median recruitment, and 2022 total biomass. For *M*, the prior distribution is also shown with the solid line. The MLE estimates are indicated by the vertical red lines.

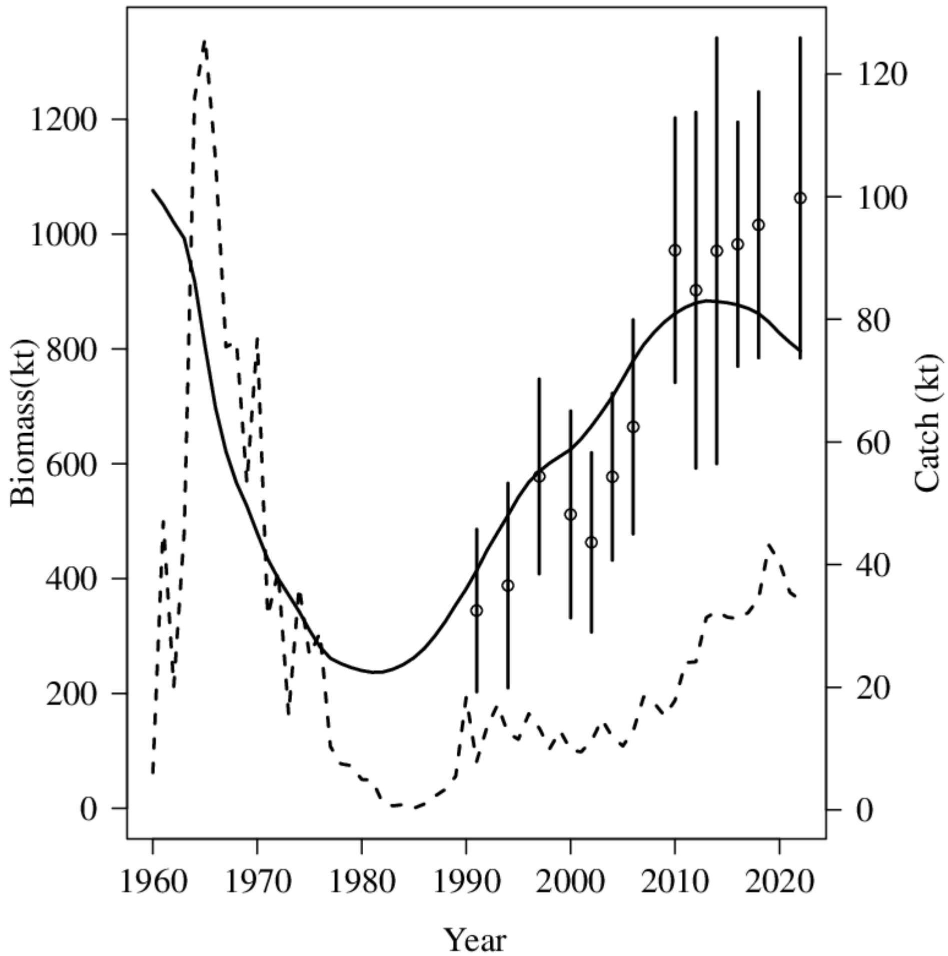

Figure 12.15. Observed AI survey biomass (data points, +/- 2 standard deviations), estimated survey biomass (solid line), and BSAI harvest (dashed line).

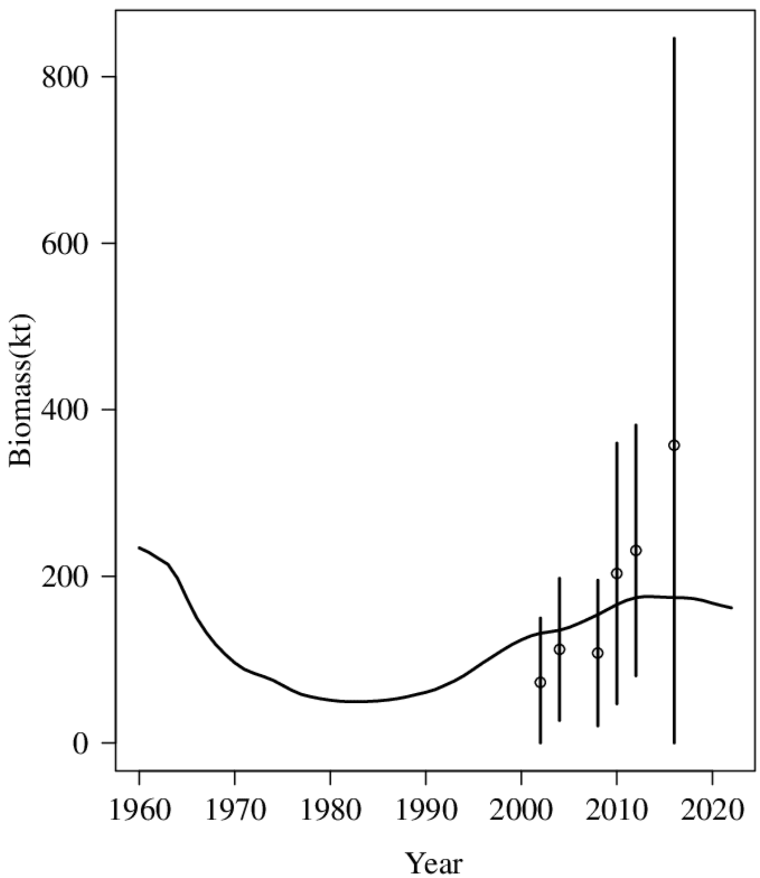

Figure 12.16. Observed EBS survey biomass (data points, +/- 2 standard deviations) and estimated survey biomass (solid line).

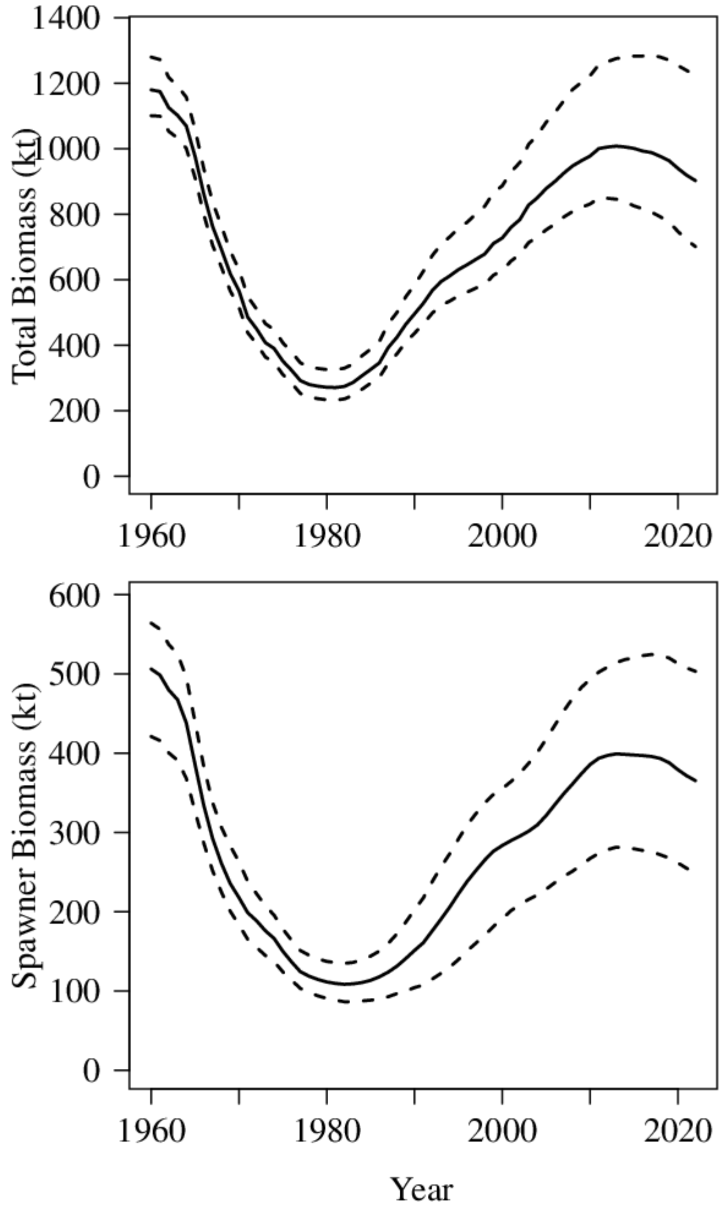

Figure 12.17. Total and spawner biomass for BSAI Pacific ocean perch, with 90% credibility intervals from MCMC integration.

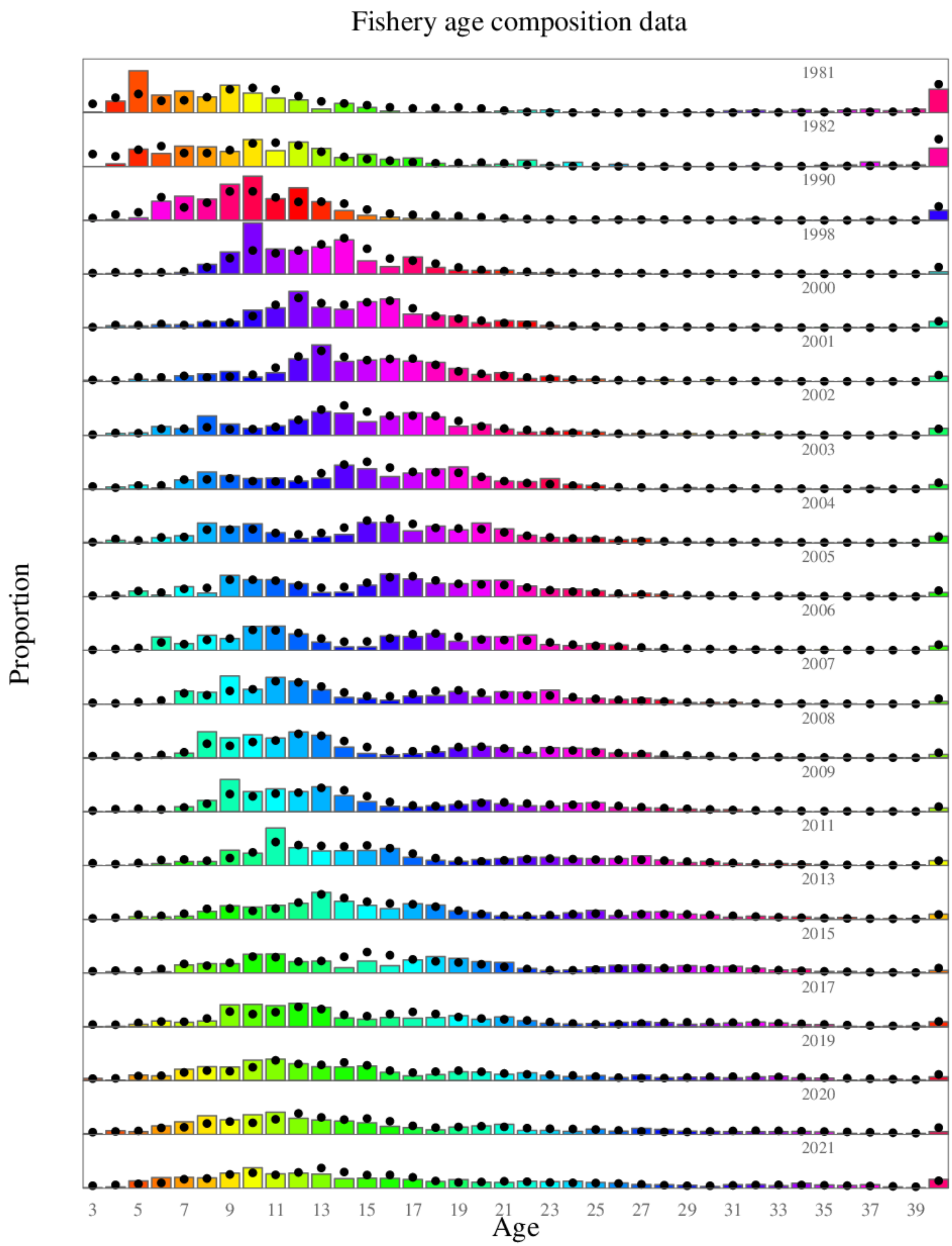

Figure 12.18. Model fits (dots) to fishery age composition data (columns) for BSAI Pacific ocean perch, 1981-2021. Colors correspond to cohorts (except for the 40+ group).

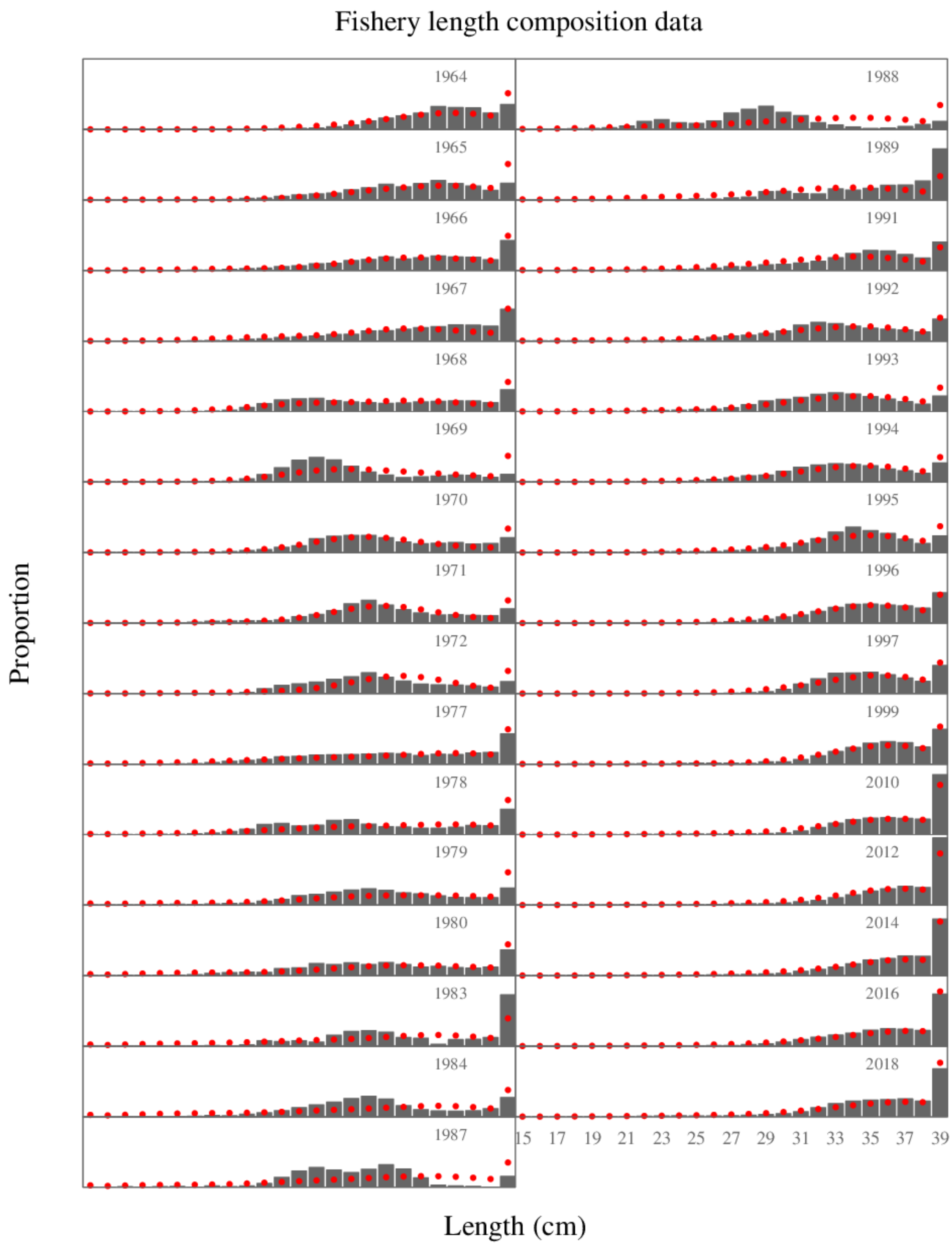

Figure 12.19. Model fits (dots) to fishery length composition data (columns) for BSAI Pacific ocean perch, 1964-2018.

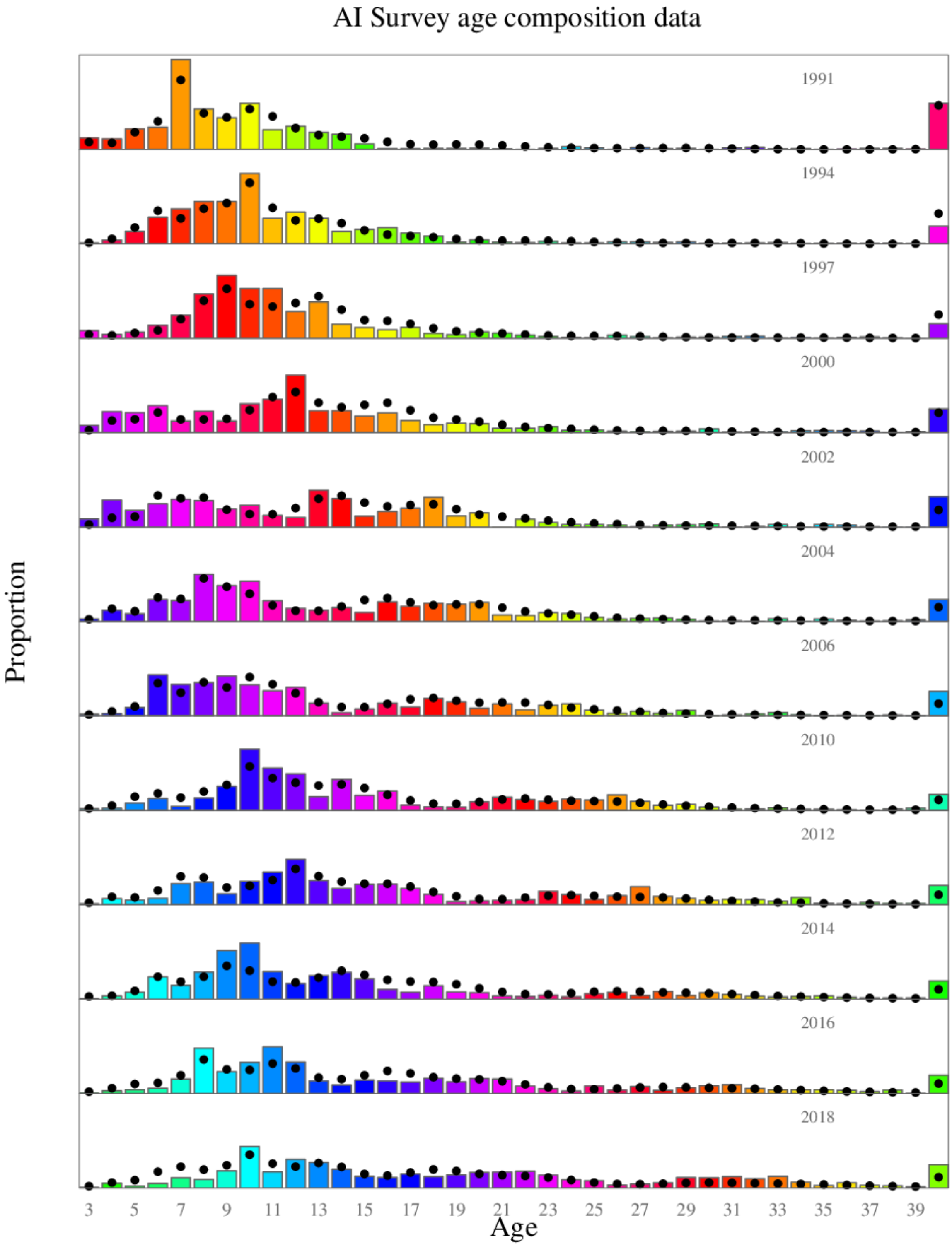

Figure 12.20. Model fits (dots) to survey age composition data (columns) for Aleutian Islands Pacific ocean perch, 1991-2018. Colors correspond to cohorts (except for the 40+ group).

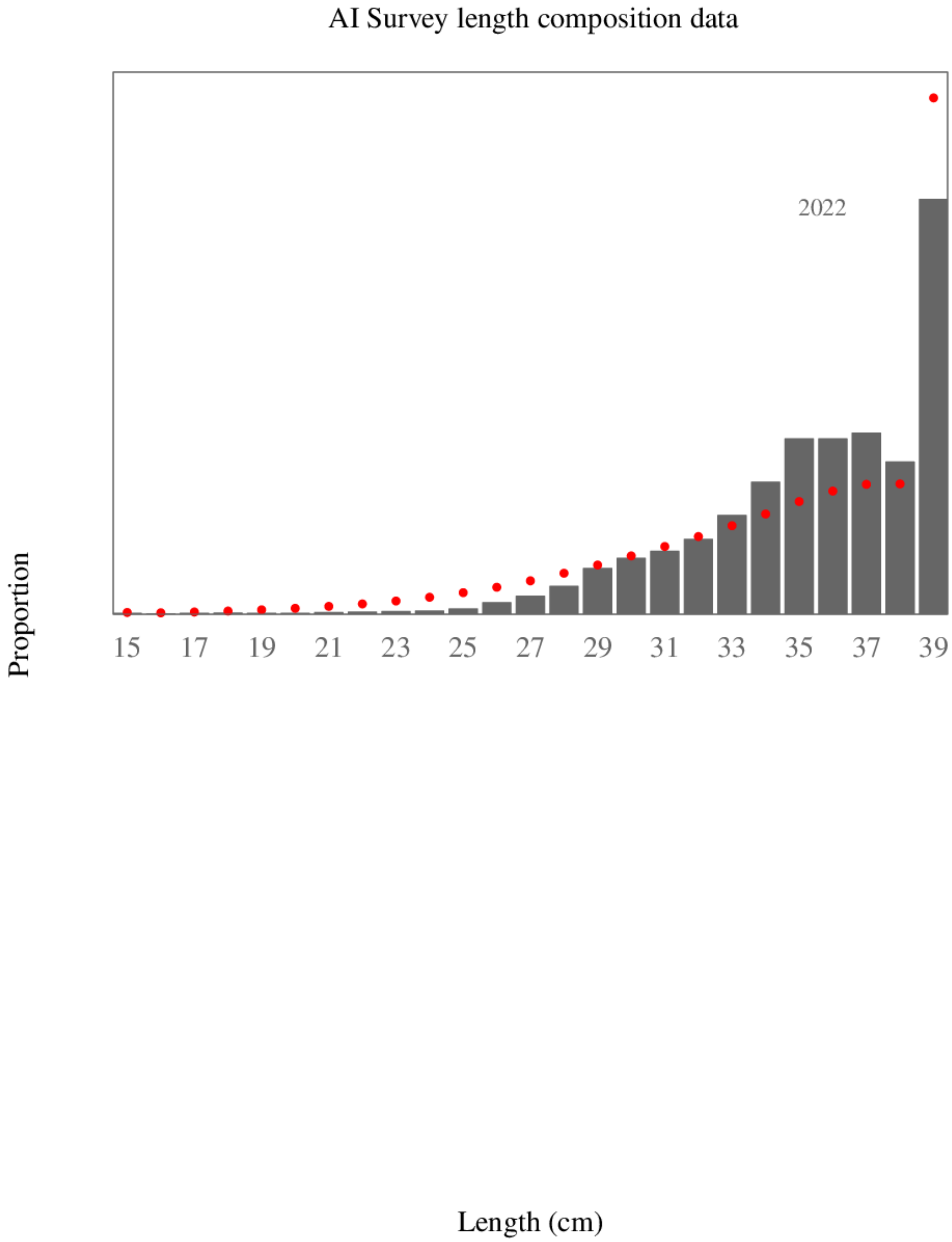

Figure 12.21. Model fits (dots) to 2022 AI survey length composition data (columns) for Pacific ocean perch.

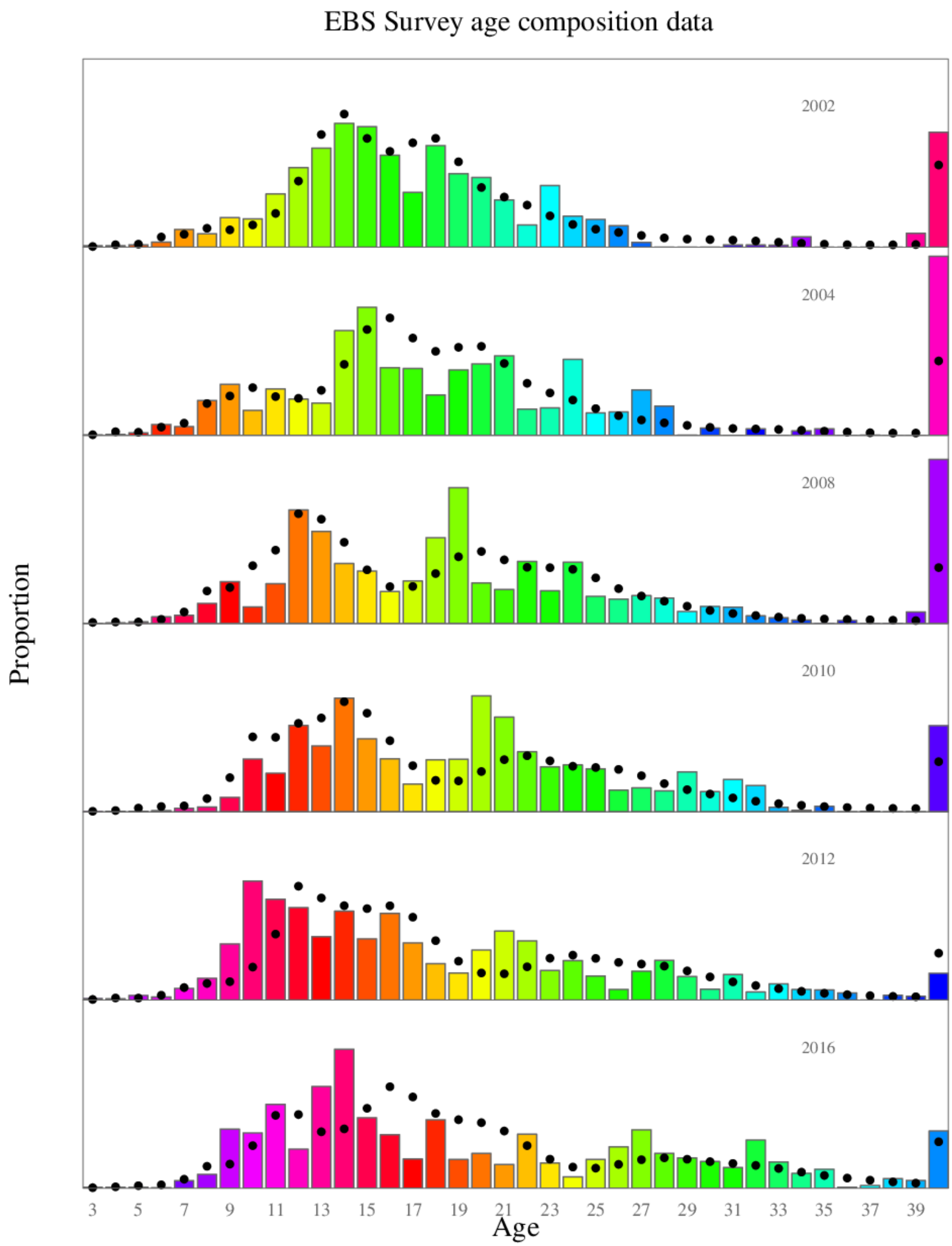

Figure 12.22. Model fits (dots) to EBS slope survey age composition data (columns) for Pacific ocean perch, 2002-2016. Colors correspond to cohorts (except for the 40+ group).

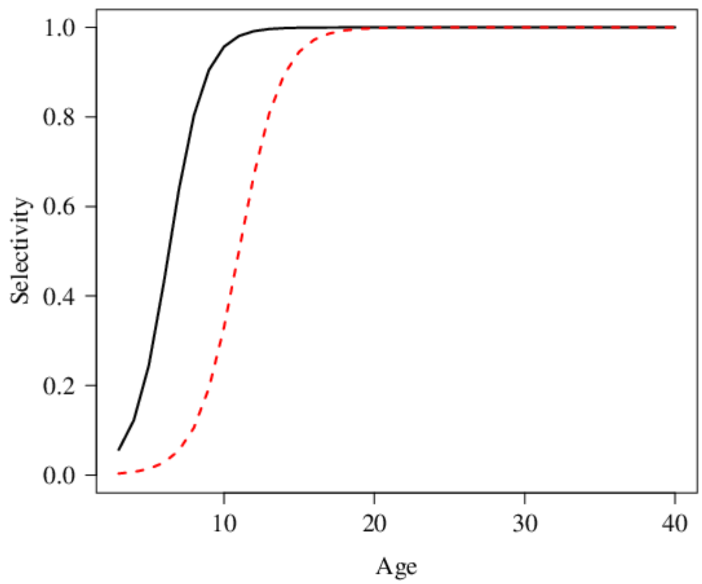

Figure 12.23. Estimated AI (black line) and EBS (red line) survey selectivity curve for BSAI POP.

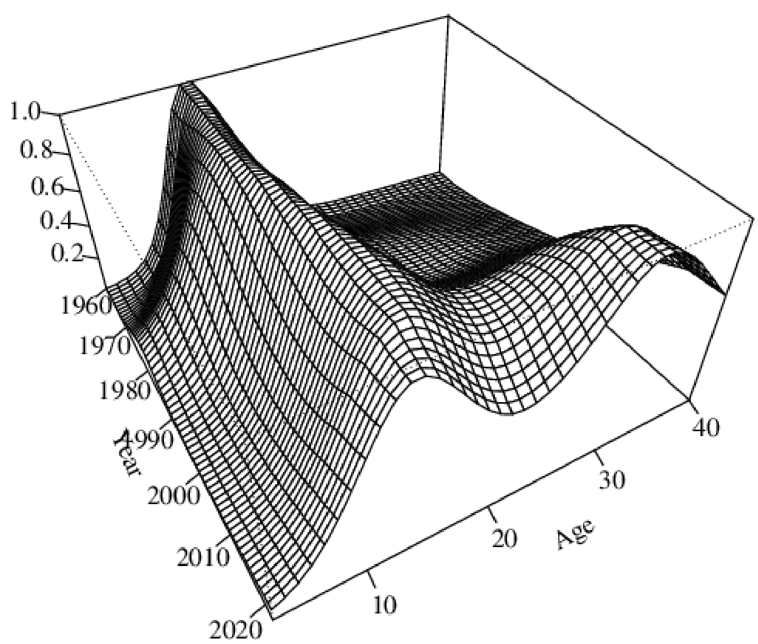

Figure 12.24. Estimated fishery selectivity from 1960-2022.

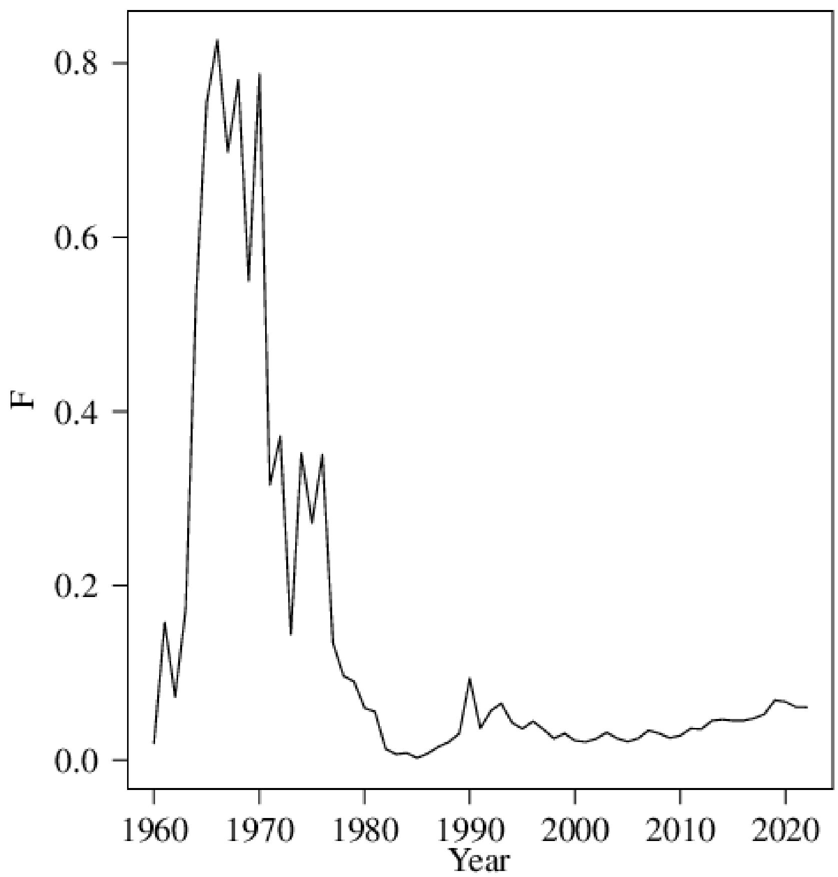

Figure 12.25. Estimated fully selected fishing mortality for BSAI POP.

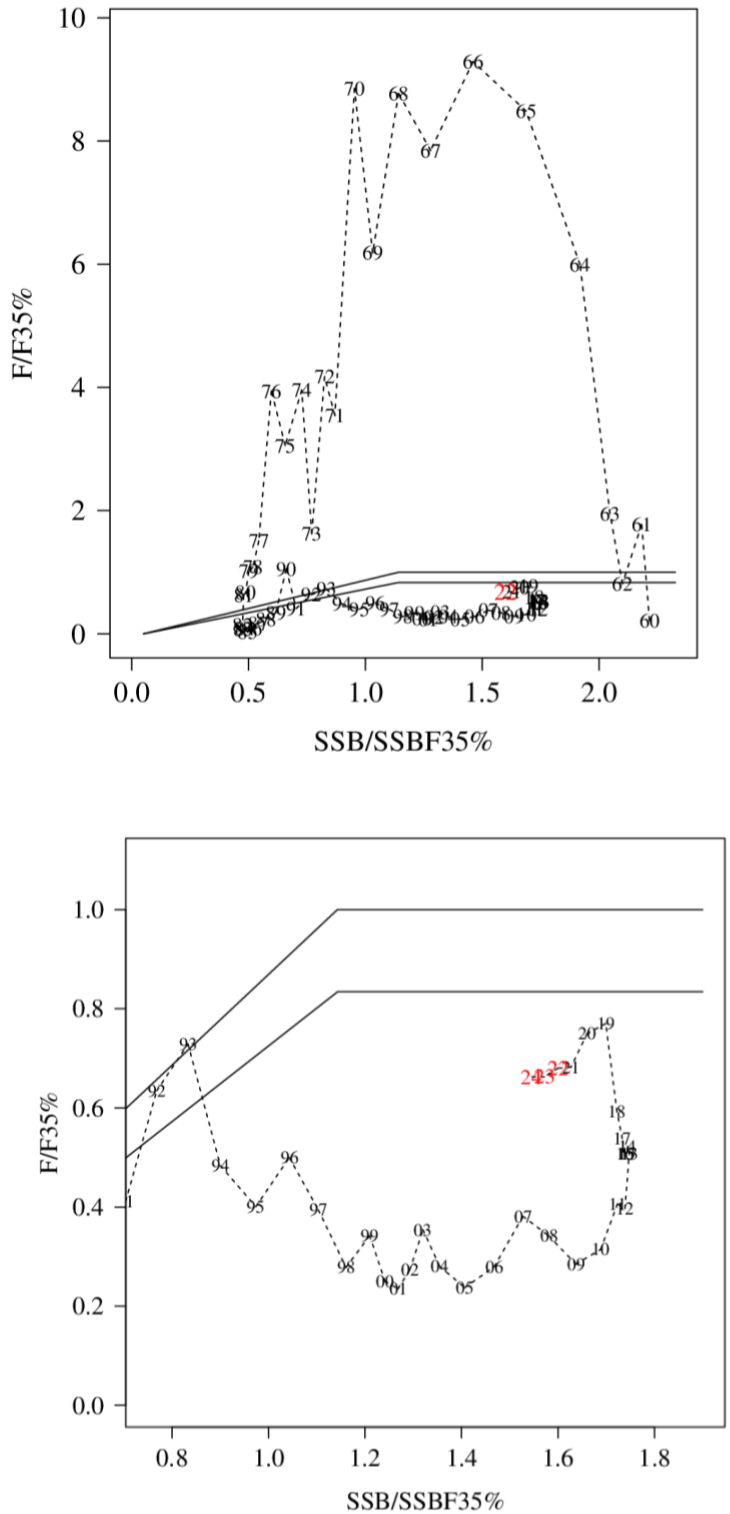

Figure 12.26. (Top panel) Estimated fishing mortality and SSB in reference to OFL (upper line) and ABC (lower line) harvest control rules, with 2022 shown in red. The bottom panel shows a reduced vertical scale, and the projected F and stock size for 2023 and 2024.

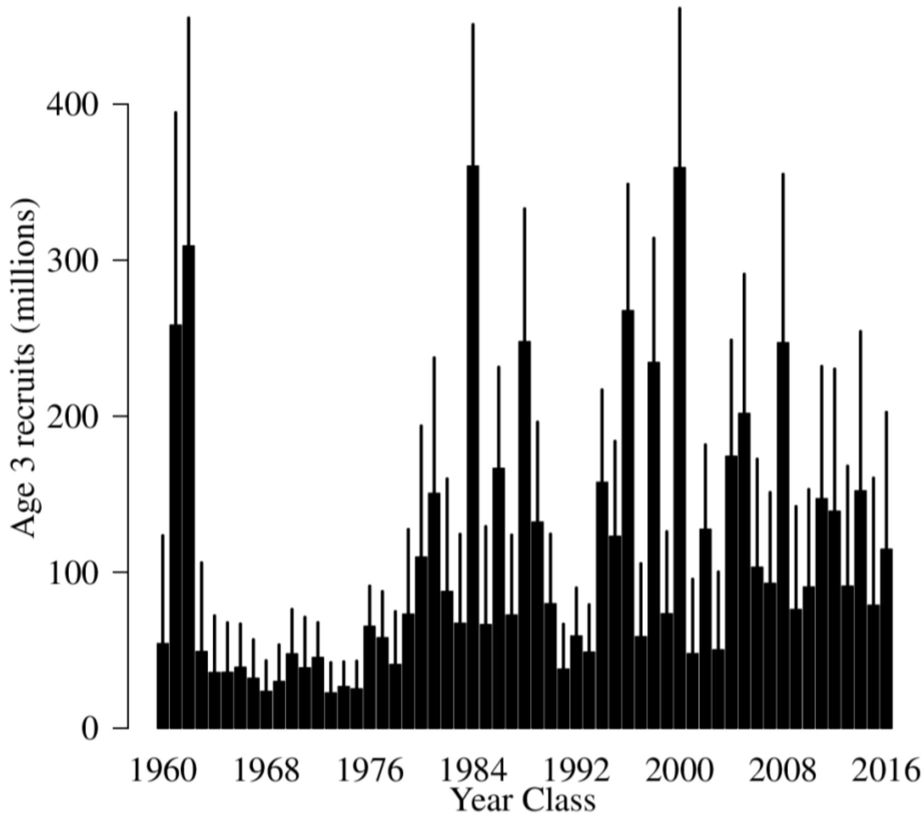

Figure 12.27. Estimated recruitment (age 3) of BSAI POP, with 90% credibility intervals obtained from MCMC integration.

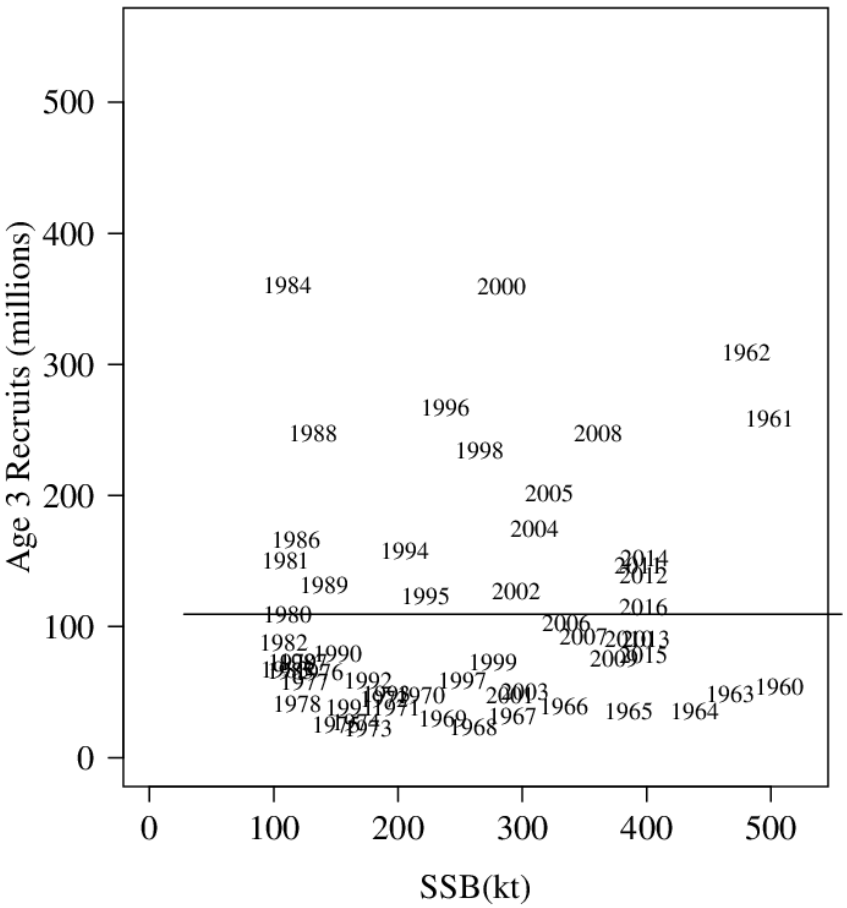

Figure 12.28. Scatterplot of BSAI POP spawner-recruit data; label is year class.

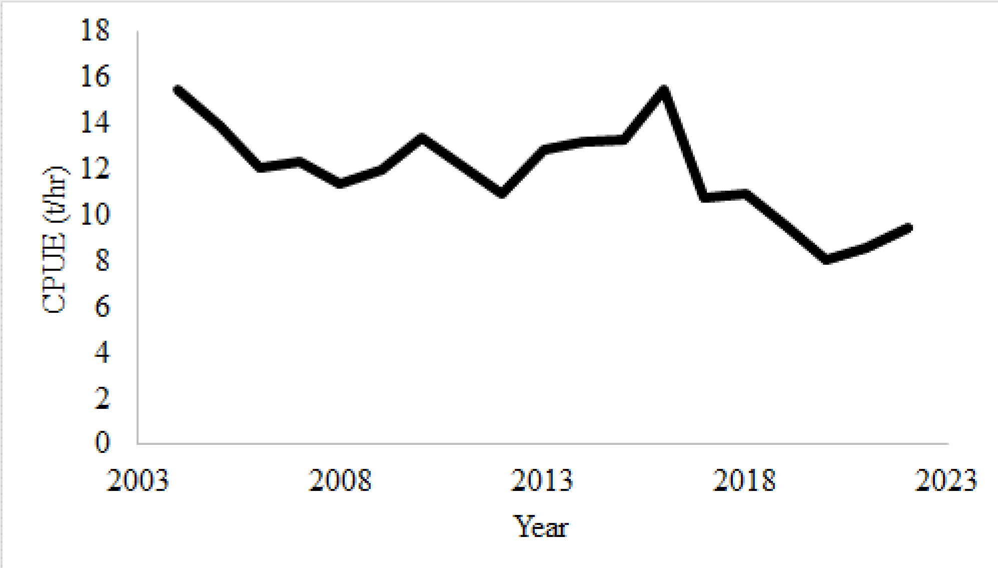

Figure 12.29. Catch per unit effort of POP in tows targeting POP from 2004 to 2022, from Observer data through Sep 25, 2022).

Appendix 12A. 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 A1). 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 0.15 t. Total removals of POP ranged between 0.15 t and 316 t between 2010 and 2021, and did not exceed 1.4 % of the ABC for these years.

Appendix Table 12A.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	0.058	
2015		2.940	0.139	
2016		316.299	0.029	
2017		1.437	0.065	
2018		248.408	0.037	
2019		0.239	0.128	
2020		0.077	0.070	
2021		0.830	0.057	