Chapter 7

Assessment of the Kamchatka Flounder stock in the Bering Sea and Aleutian Islands

By

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Executive Summary

An age-structured assessment is presented for Kamchatka flounder and is a full update of the 2020 stock assessment. Structural changes were not made to the model. Differences between the 2020 assessment and the current assessment were due to changes in the data inputs (see summary below).

Summary of changes in assessment input

1) Estimates of catch were updated for all years. The 2022 catch was estimated using an expansion factor of 1.045 that was derived from the 5-yr average proportion of Kamchatka flounder caught as of October 1st.

2) The 2021 and 2022 fishery length composition data were added to the assessment.

3) The 2021 and 2022 EBS shelf bottom trawl survey biomass and length composition estimates were added to the assessment. All years were updated.

4) The 2022 Aleutian Island bottom trawl survey biomass and length composition estimated were added to the assessment.

The assessment methodology remained unchanged.

Summary of Results

	Tier 3 assessment model			
	As estimated last year for		As estimated this year for	
Quantity	2022	2023	2023	2024
M (natural mortality rate)	0.11	0.11	0.11	0.11
Tier	3a	3a	3a	3a
Projected total (age 2+) biomass (t)	143,983	142,762	121,977	118,713
Projected female spawning biomass	55,701	57,082	47,877	47,387
Projected				
$B_{100\%}$	101,376	101,376	94,370	94,370
$B_{40\%}$	40,550	40,550	37,748	37,748
$B_{35\%}$	35,482	35,482	33,029	33,029
F_{OFL}	0.108	0.108	0.103	0.103
$maxF_{ABC}$	0.09	0.09	0.086	0.086
F_{ABC}	0.09	0.09	0.086	0.086
OFL (t)	10,903	11,115	8,946	8,776
maxABC (t)	9,214	9,393	7,579	7,435
ABC (t)	9,214	9,393	7,579	7,435
	As determined *last* year for:		As determined *this* year for:	
Status	2020	2021	2021	2022
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	no
Approaching overfished	n/a	no	n/a	no

**Based on model 16.0b. The 2022 preliminary catch was set equal to the extrapolated end of 2022 catch (8661 t) in place of maximum ABC.*

Responses to SSC and Plan Team Comments on Assessments in General

Given the time constraints posed by this year's meeting schedule, the SSC co-chairs suggested that authors not feel obligated to respond to all of last year's SSC and Team comments in this year's assessments.

"The SSC requests that all authors fill out the risk table in 2019…" (SSC December 2018)

"…risk tables only need to be produced for groundfish assessments that are in 'full' year in the cycle." (SSC, June 2019)

"The SSC recommends the authors complete the risk table and note important concerns or issues associated with completing the table." (SSC, October 2019)

"The SSC requests the GPTs, as time allows, update the risk tables for the 2020 full assessments.

…..The SSC recommends dropping the overall risk scores in the tables.

…..The SSC requests that the table explanations be included in all the assessments which include a risk table for completeness.

….The SSC notes that the risk tables provide important information beyond ABC-setting which may be useful for both the AP and the Council and welcomes feedback to improve this tool going forward." (SSC December 2019)

A risk table is presented in the Harvest Recommendations section. After completing this exercise, we do not recommend ABC be reduced below maximum permissible ABC.

Responses to SSC and Plan Team Comments Specific to this Assessment

The SSC would encourage the examination of catchability and temperature.

A model run accounting for a relationship between bottom temperature anomalies and catchability was done after the September Plan Team meeting and the fit to survey biomass degraded. A more thorough examination of this relationship, as well as a relationship between catchability and cold-pool area will be done during the next full assessment. This will be done to determine whether time-varying catchability betters explains the observed EBS shelf survey biomass.

The SSC supports the PT recommendations that the age-length transition matrix be re-examined in the next full assessment and the re-examination of the assumptions made regarding historical species compositions between arrowtooth and Kamchatka flounders.

This will be addressed during the next full assessment

The methods used to inform the assumptions made about the species compositions between arrowtooth and Kamchatka flounders was explored during the 2020 full assessment. A summary is provided in Fishery catch and length composition section for the method used to derive these values.

The SSC suggest the author explore incorporating aging error into the assessment given the improvements seen in the arrowtooth flounder assessment.

This will be examined during the next full assessment.

Introduction

BSAI Kamchatka flounder has been classified as a Tier 3 stock since 2013. Prior to 2013, Kamchatka flounder was assessed using the Tier 5 methodology and relied on trawl survey biomass from the Bering Sea shelf, Bering Sea slope and the Aleutian Islands and an estimate of natural mortality. ABC and OFL were determined from a 7-year averaging technique of survey biomass.

Kamchatka flounder (*Atheresthes evermanni*) is a relatively large flatfish which is distributed from Northern Japan through the Sea of Okhotsk to the Western Bering Sea north to Anadyr Gulf (Wilimovsky et al. 1967) and east to the eastern Bering Sea shelf and south of the Alaska Peninsula (there is also a catch record from California). In U.S. waters, they are found in commercial concentrations in the Aleutian Islands where they generally decrease in abundance from west to east (Zimmerman and Goddard 1996). They are also present in Bering Sea slope waters but are absent in survey catches east of Chirikof Island.

In the eastern part of their range, Kamchatka flounder overlap with arrowtooth flounder (*Atheresthes stomias*), a species that is similar in appearance. The two were not routinely distinguished in the commercial catches until 2008 and not consistently separated in the trawl survey catches until 1991. Hence, Kamchatka flounder were included in the arrowtooth flounder stock assessment and managed as a species complex (Wilderbuer et al. 2009). Managing the two species as a complex became undesirable in 2010 due to the emergence of a directed fishery for Kamchatka flounder in the BSAI management area. Since the ABC was determined by the large amount of arrowtooth flounder relative to Kamchatka flounder (the complex was about 93% arrowtooth flounder), there was concern about overharvesting Kamchatka flounder. The *Atheresthes sp*., arrowtooth flounder and Kamchatka flounder, have been managed separately since 2011.

Fishery

Catch History

The catch of Kamchatka flounder was combined in catch records for arrowtooth flounder and Greenland turbot (*Reinhardtius hippoglossoides*) in the 1960s. The fisheries for Greenland turbot intensified during the 1970s and the bycatch of arrowtooth flounder and Kamchatka flounder is assumed to have also increased. Catches of these species decreased after implementation of the MFCMA and the Kamchatka flounder resource remained lightly exploited. The combined catches of Kamchatka flounder and arrowtooth flounder averaged 12,933 t from 1977-2008 (Table 7-1). It is estimated that only a small fraction (<10%) of this catch was Kamchatka flounder. The decline in catch resulted from catch restrictions placed on the fishery for Greenland turbot and phasing out of the foreign fishery in the U.S. EEZ. The total combined catch for arrowtooth and Kamchatka flounder, catches were not differentiated by species until 2011, reported by the Alaska Regional Office is a blend of vessel reported catch and observer at-sea sampling of the catch. However, the observer program has consistently identified the two species from catches aboard trawl vessels since 2008. Observer sampling has indicated that the proportion of Kamchatka flounder in the combined catch has steadily increased from 10% before 2008 to 54% in 2010 (see Fishery catch and length composition section for the method used to derive these values).

Year	Percent of combined catch
2008	34%
2009	42%
2010	54%

The increase in harvest was due to the development of a foreign market for Kamchatka flounder, which has now become a fishery target. Based on the above observer-derived percentages, the 2010 estimated catch of Kamchatka flounder was 20,960 t and represents the highest catch of the time series (Table 7-1, Figure 7-1). Catch declined between 2010 and 2018 and has been increasing since. Kamchatka flounder catch was 8,286 t as of October 1, 2022. Catch has generally been below TAC, except in 2020 when catch was 10% higher than TAC. Over the past 5 years, approximately 95.48% of the Kamchatka flounder catch has been captured by this time of the year. The catch as of October 1st was expanded by a factor of 1.045 to obtain a preliminary 2022 catch equal to 8,661 t (Table 7-1).

Figure 7-2 shows the monthly catch of Kamchatka flounder since 2011. Kamchatka flounder are mainly caught between May and August and caught to a lesser extent between September and November. A larger proportion of the catch has been from the Aleutian Islands (AI; mainly from area 541), except in years 2014 - 2017 and 2019 (Figure 7-3a and b).

Data

The data used in this assessment includes the following:

Fishery catch	1991-2022
Shelf survey biomass estimates and standard error	1991-2019, 2021-2022
Slope survey biomass estimates and standard error	2002, 2004, 2008, 2010, 2012, 2016
Aleutian Islands survey biomass and S.E.	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, 2022
Shelf survey length composition	1991-2019, 2021-2022
Slope survey length composition	2004, 2008, 2016
Aleutian Islands survey length composition	1991, 1994, 1997, 2000, 2002, 2004, 2006, 2012, 2014, 2022
Fishery length data	2008 – 2011, 2018-2022
Slope survey age data	2002, 2012
Aleutian Islands survey age data	2010, 2016, 2018

Fishery catch and length composition

Kamchatka flounder was not speciated in the Catch Accounting System until 2011 and was reported as part of the arrowtooth flounder and Kamchatka flounder species group. As such, the catch of the species group is split using proportions derived from the RACE bottom trawl surveys and the Fishery Monitoring Analysis (FMA) Division.

Catches from 1991-2007 were estimated assuming that Kamchatka flounder comprised 10% of the combined total catch during this time period. At this time, Kamchatka was not consistently identified by the observer program, but was consistently identified by the RACE bottom trawl surveys. As such, this ratio was derived from the survey data for 1991-2007 (Figure 7-4). Beginning in 2008, the species proportions were applied to the total combined Kamchatka-arrowtooth catch for 2008-2010 (i.e., 34%, 42%, and 54%) were derived from the extrapolated survey haul weights for Kamchatka and arrowtooth flounder from the NORPAC Catch Report Table on AKFIN. The ratio estimator is as follows:

$$P_y = \frac{\sum_h Kam_{h,y}}{\sum_h ATF_{h,y} + Kam_{h,y}},$$

Where, P_y is the proportion of Kamchatka in year y, $Kam_{h,y}$ is the extrapolated weight of Kamchatka flounder in haul h in year y, and ATF is the extrapolated weight of arrowtooth flounder. This estimator is in-line with the current speciation practices used by the AKRO.

Kamchatka catches as reported in the CAS from 2011 to 2022 were used in the assessment model. The end of year catch for 2022 was derived from the 5-year average proportion of Kamchatka captured by October 1st. Over the past 5 years, approximately 95.5% of the Kamchatka flounder catch has been captured by October 1st. For this assessment, the 2022 catch was extrapolated to the end of the year by an expansion factor of 1.045 and was set equal to 8661 t (Table 7-1, Figure 7-1).

A comparison of the catch estimates used in the 2020 assessment and this assessment is shown in Figure 7-2. The estimates were generally unchanged.

Length data from the fishery from years 2008-2011 and 2018-2022 are used in the assessment (Table 7-2, Figure 7-5). Sampling increased in years 2018-2022 and resulted in substantially more samples compared to 2008-2011. The sex-specific length frequency distributions are fairly consistent between 2018 and 2022 for both females and males.

Biomass and composition estimates from Trawl Surveys

Biomass estimates for Kamchatka flounder from the eastern Bering Sea shelf and slope bottom trawl surveys and the bottom trawl survey in the Aleutian Islands region are shown in Table 7-3. Reliable estimates of Kamchatka flounder in the Aleutian Islands survey start in 1991.

The survey biomass estimates were updated for this assessment. The EBS shelf bottom trawl survey biomass and CV estimates were similar to the values used in the 2020 assessment and include estimates for years 2021 and 2022 (Figure 7-6). Small differences (~1%) were due to changes made in 2021 to the stratum area table, which resulted in small changes to the biomass and abundance estimates for all survey years for all species. The changes that were made achieved the following objectives:

- The projection was transformed into a standard EPSG format
- 200m contour was made contiguous to the BS slope shapefiles
- EBS and NBS were made contiguous
- The boundary artifact polygon was removed

Shapefiles exclude landmass using the ARDEM dataset (downloaded on 12/29/2017) at 0.0 elevation settings for ARDEM transformation/conversion are not recorded. If depth limits are changed to 20m in the future, research into optimal settings is advised. NBS extent excludes station AA-10 which was dropped from sampling beginning in 2017. The southern border of the Chukchi Sea survey extent was altered for contiguity. These changes altered the area of extrapolation for each stratum from 0-1.9%, and increased the overall survey area (EBS + NBS) by 0.01%. Because we want to maintain consistency throughout the data series for trend analysis, these new stratum areas were applied to the entire data series this year.

Kamchatka flounder biomass on the EBS shelf has been declining since 2015. Biomass increased slightly in 2019, but this was followed by a 26% decrease in 2021 and a 10% decrease in 2022 (Figure 7-6). Although the biomass estimates are lower, lower biomass has been observed in the late 1990s and early 2000s. The EBS shelf BTS was cancelled in 2020 due to the COVID pandemic.

The Aleutian Islands BTS was conducted in 2022 after being cancelled in 2020 due to the COVID pandemic. Biomass declined by 42% in 2022 and is one of the lowest survey observations since 1991 (Figure 7-7). The EBS slope bottom trawl survey has not been conducted since 2016 and the biomass and CV estimates remain unchanged from the previous assessment (Figures 7-8). The slope biomass increased between 2004 and 2012 and then declined in 2016.

Population level length composition estimates for the three trawl surveys are shown by year and sex in Figures 7-9 – 7-11. The length composition from all three surveys were updated for this assessment. The lengths from the EBS shelf are generally smaller and represent younger Kamchatka than those observed on the slope (Figures 7-9, 7-10, and 7-12). The EBS shelf survey length composition estimates suggest several recruitment events prior to 1991, in the early 2000s, and 2010 (Figure 7-9). There is also evidence of the early 2000s cohort in the slope survey length composition estimates between 2008 and 2012 (Figure 7-10). The length distributions from the Aleutian Island bottom trawl survey have multiple modes compared to the length distributions from the EBS and reflect year classes moving through the population (Figure 7-11). There is some evidence of recruitment in 2004, 2010, and 2016.

Sex-specific age composition data from the EBS slope and Aleutian Islands bottom trawl surveys are included in the assessment (Figure 7-13). The age data from Aleutian Islands survey in years 2010, 2016, and 2018 and the age data from the EBS Slope survey in years 2002 and 2012 are used. Hence, the length composition estimates in these years are not used in the assessment. There is evidence of a higher proportion of younger fish from the AI bottom trawl survey than the EBS slope survey.

Biological data

The RACE bottom trawl surveys provide data on age and length composition of the population, growth rates, and length-weight relationships.

The length-at-age data are shown in Figures 7-13 - 7-15. The relationships derived for the 2020 assessment are used in this assessment. The oldest fish aged was a 58 year old male (Figure 7-14). The oldest female fish was 48 years old (Figure 7-15). The growth parameters values used in this assessment are as follows:

Sex	L_∞	k	t_0
Female	79.60	0.098	-0.802
Males	60.73	0.149	-0.452

The growth curves are shown Figure 7-16. The sex-specific, age-length transition matrices derived for the 2020 assessment were used for this assessment. Age was converted to length assuming that age-at-length is normally-distributed with sex-specific mean length-at-age given by the von Bertalanffy equation using the parameters given above. As was done in the previous assessments, a CV of 0.08 was applied to all ages to provide the uncertainty in growth for the transition matrices. The sex-specific transition matrices are shown in Figure 7-17.

The sex-specific length-weight relationships used in the assessment are as follows:

Males: $W = 3.912 \times 10^{-3} L^{3.22351}$

Females: $W = 3.185 \times 10^{-3} L^{3.28894}$,

where weight is in grams and length is in centimeters (Figure 7-18). Weight-at-age was derived from the length-weight and von Bertalanffy growth relationships derived from the RACE surveys' specimen data.

Maturity was determined in a study by Stark (2011) from a histological examination of ovary samples collected in the Bering Sea (Table 7-4).

Natural mortality is fixed in the assessment model and is set equal to 0.11 for females and males. The fixed estimate of natural mortality is based on the results of a likelihood profile analysis done in 2016.

Analytic Approach

Model Structure

This stock assessment uses the AD Model Builder software to model the population dynamics of Bering Sea and Aleutian Islands Kamchatka flounder starting in 1991. Population size in numbers at age a in year t was modeled as:

$$N_{a,t} = N_{a-1,t-1} e^{Z_{a-1,t-1}},\ 2 < a < A \text{ and } 1991 < t < T$$

where Z is the sum of instantaneous fishing mortality ($F_{a,t}$) and natural mortality (M), A is the maximum age modeled in the population, and T is the terminal year of the assessment (i.e., 2022). All derived parameters are sex-specific, but this subscript was dropped for simplicity.

Natural mortality, M, was fixed at 0.11 for both sexes in the assessment model, following the assumption made in the 2016 assessment. During the 2016 assessment, M was estimated as a free parameter but the model would not converge and likelihood profiling was conducted to identify the fixed value.

Fishing mortality is a function of fishery selectivity at age ($selex_a$), average fishing mortality (μ_f), and a year-specific random deviation (ε_t):

$$F_{a,t} = selex_a e^{\mu_f \varepsilon_t}.$$

Average fishing mortality and the annual deviations (30) are estimated model parameters. Sex-specific, age-based relationships were used to model fishery selectivity and assumed constant over all years. Fishery selectivity was assumed to be asymptotic and modeled using a logistic selectivity pattern. This assumption was made because the directed fishery for Kamchatka flounder presumably targets larger fish (Figure 7-5). The logistic slope parameter was fixed and the parameter describing the inflection of the curve was estimated for both female and male selectivity. The low sampling intensity for length measurements from the fishery may not provide sufficient information for the model to reliably estimate fishery selectivity. The input sample size for fitting this data was set at a low level (25).

The maximum age modeled in this assessment is 25 and represents a plus-group consisting of fish age 25 and older. The numbers at age for the plus group are modeled as:

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

The numbers at age in the first year are modeled as:

$$N_{a,syr} = e^{\ln \bar{R} - M(a-1) + \tau_{syr-a}},\ 2 < a < A$$

$$N_{A,syr} = \frac{e^{\ln \bar{R} - M(a-1) + \tau_{syr-a}}}{1 - e^{-M}},\ a = A$$

where $\bar{R}$ is the mean number of age-2 recruits and τ is an age specific random deviation assumed to be normally distributed with a mean of zero and a standard deviation equal to σ_r, the recruitment standard deviation.

Age-2 recruitment after the first year is modeled as:

$$N_{2,t} = e^{\ln \bar{R} + \tau_t},$$

where τ_t is a random deviation assumed to be normally distributed with a mean of zero and a standard deviation equal to σ_r. Hence, the estimated recruitment parameters include the 24 τ parameters in 1991 (ages 2-25), the 31 subsequent recruitment deviation (τ_t) estimates from 1992-2022 and the mean log recruitment.

Catch at age is modeled using the Baranov catch equation:

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

and converted to weight by multiplying by the weight-at-age, w_a, which was estimated outside of the model.

The predicted length composition data (fishery and survey) were calculated by multiplying the numbers at age by a transition matrix that gives the proportion of each age in each length bin. Predicted trawl survey biomass in year t was modeled as:

$$B_{t,surv} = q_{surv} \sum_a N_{a,t} selex_{a,surv} w_a,$$

Where q_{surv} is the survey specific catchability. It was assumed that the shelf, slope and Aleutian Islands surveys measure non-overlapping segments of the Kamchatka flounder stock. Catchability parameters were estimated for the EBS shelf and Aleutian Islands surveys. The slope survey catchability was fixed at 0.18, as was done in previous assessments.

Sex-specific, age-based relationships were used to model survey selectivity. Selectivity was assumed constant over all years. The survey length data indicate that fish less than about 4 years old (< 30 cm) are found mostly on the Bering Sea shelf and to some extent in the Aleutian Islands. Males and females from 30-50 cm are found on the shelf and in deeper waters of the Aleutian Islands and Bering Sea slope waters, and males and females > 50 cm are mainly found at depths below 200 meters. Sex-specific dome-shaped selectivity using a double logistic pattern was freely estimated for males and females in the shelf survey due to the lack of larger fish there. Selectivity for the slope and Aleutian Islands surveys were assumed to be asymptotic for both sexes and were modeled using a logistic pattern. The two parameters describing the slope and inflection of the logistic pattern were estimated for both sexes and surveys.

The assessment model used this year remains unchanged from the final 2020 stock assessment, model 16.0b.

Data weighting

Data weights in the model are not based on a formal data-weighting method. Instead the weights for the bottom trawl survey biomass estimates are set equal to the annual standard deviations. The multinomial input sample sizes reflect a down weighting of the fishery length composition estimates relative to the trawl surveys and the trawl surveys were equally weighted. The input sample sizes were 25 for the fishery composition data and 200 for the trawl surveys, respectively. The fishery length composition estimates were given less weight than the survey length composition estimates due to the limited sampling frequency and minimal number of samples collected from the fishery. A multinomial input sample size of 200 was used for the slope and Aleutian Islands age composition estimates. An emphasis factor of 300 was used to ensure the model fit the observed catch data with minimal observation error.

Parameters Estimated Outside of the Assessment Model

The parameters estimated outside of the model include the von Bertalanffy growth parameters, the age-length conversion matrix, the length-weight relationship, weight at age, and maturity.

Parameters Estimated Inside the Assessment Model

The suite of parameters estimated by the base model are classified by the following likelihood components:

Data Component	Distribution assumption
Trawl fishery length composition	Multinomial
Shelf survey population length composition	Multinomial
Slope survey population length composition	Multinomial
Slope survey age composition (2002 and 2012)	Multinomial
Aleutian Islands survey length composition	Multinomial
Aleutian Islands age composition (2010)	Multinomial
Trawl survey biomass estimates and S.E.	Log normal
Slope survey biomass estimates and S.E.	Log normal
Aleutian Islands biomass estimates and S.E.	Log normal

The total log likelihood is the sum of the likelihoods for each data component. The model allows for the individual likelihood components to be weighted by an emphasis factor. Equal emphasis was placed on fitting all data components for this assessment with the exception that a large emphasis was placed on fitting the fishery catch.

A summary of the number of parameters estimated in the model are:

Parameters	Number
Recruitment parameters	
Log(Mean recruitment)	1
Recruitment deviations (1991: ages 2-25, 1992-2022)	55
Fishing mortality parameters	
Log(mean F)	1
Annual deviations (1991 – 2022)	32
Selectivity parameters	
Fishery	2
Shelf survey	8
Slope survey	4
Aleutian Islands survey	4
Catchability parameters	
Shelf survey	1
Aleutian Islands survey	1

Results

Model Evaluation

The fit to the EBS shelf bottom trawl biomass estimates were similar among to the previous assessment for the majority of the time series, but deviates over the last 8 years of the time series (Figure 7-19, top panels). The fits to the shelf survey biomass predicted the cyclical trend between 1991 and 2013 in the data fairly well; however, there is some pattern in the residuals. The model consistently overestimates biomass between 1995 and 2004 then underestimates biomass for several years and overestimates the last 4years. Biomass on the shelf increased between 2012 and 2015. The model predicted an increase in biomass between 2012 and 2019 during the last assessment, underestimated the increase between 2012 and 2015,and missed the declining trend between 2015 and 2019. The 2021 biomass declined by 26% from 2019 and the 2022 biomass is 10% lower than 2021. The model estimates a relatively flat trend between 2013 and 2022, where the model still underestimates biomass in 2014-2016, better fits biomass between 2017 and 2019, and overestimates biomass in 2021and 2022.

The fits to the EBS slope survey biomass estimates were similar between the last and current assessment and relatively flat (Figure 7-19, middle panels). The model fits the 2008 and 2016 biomass estimates relatively well, while overestimating biomass in 2002 and 2004 and underestimating biomass in 2010 and 2012. The slope biomass increased between 2008 and 2012, which the model misses.

The model fit to the Aleutian Island survey biomass estimates are rather flat (Figure 7-19, bottom panels). The fit is similar to the fit from the 2021 assessment, with a slight downward scale. Biomass in 2022 is 42% lower than the biomass in 2018 and the uncertainty is lower than previous years. The model scales downward to estimate that point.

The fits to the sex-specific length composition estimates from the surveys are shown in Figures 7-20 through 7-28. Comparatively the model fit to the shelf length data is quite good compared to the data from the EBS slope survey and the Aleutian Islands survey. The fits to the slope survey length composition estimates seem to underestimate a cohort in the female data and consistently underestimate males between 40 cm and 57 cm and overestimate the limbs of the distribution (Figures 7-23 - 7-25). The length data from the Aleutian Islands survey had multiple modes, which were difficult to estimate (Figures 7-26 – 7-28). The model expected more 55 cm – 75 cm and females than observed in 2000 and more smaller females in 2022. The model expected fewer large males in 2012 and 2014 than observed and more 35 cm – 65 cm males in 2022.

Fits to the Aleutian Islands age composition estimates generally captured the shape of the data and underestimate the plus group (Figure 7-29). The model generally overestimates 6-9 year old females, especially in 2010 and 2016, and 8-16 year old males. The model expects more 16-17 year olds and more individuals in the plus group than observed by the EBS slope survey (Figure 7-29).

The estimated selectivity curves indicate that the shelf survey captures younger individuals than the slope and Aleutian Islands surveys and the fishery (Figure 7-30). Male and female peak selectivity for the EBS shelf survey were similar. Male selectivity was slightly higher on the youngest males than females and somewhat lower selectivity on 10-18 year old males. The selectivity curves for the slope survey shifted to the right, so lower selectivity on younger fish, in the current assessment Male selectivity was higher for younger Kamchatka than female selectivity and full selection is between 7 and 8 years of age. Full selection of females for the EBS slope survey is ~10 years old. Selectivity of males and females is somewhat linear and higher for males than females across all ages.

Fishery sampling for Kamchatka has been greater between 2018-2022 than in previous years. The model consistently underestimates the peak of the distribution (between 40cm and 60cm) and overestimates lengths larger than 60 cm (Figures 7-30 and 7-31). The model also consistently underestimated the distribution between 57 cm and 69 cm in 2006, 2008, 2010, and 2012 and the peak of the distribution between 44 cm and 54 cm in 2018-2020 and 2022. Fishery selectivity was similar for both sexes and among models.

Retrospective analyses were also conducted to evaluate inconsistencies in the model outcomes in the face of increasing data. The results are summarized in the Retrospective analysis section, but the results indicate that the retrospective pattern has become more pronounced than the 2020 assessment.

Time Series Results

The trends in SSB, total biomass, numbers, and age-2 recruitment from the current assessment are similar to the 2020 assessment; however, scaled downward. Spawning stock biomass and total biomass are ~3-4% lower between 1991 and 2010 and ~7-8% lower between 2014 and 2020 than the 2020 last assessment (Figure 7-34, left panels). This corresponds to a ~3% and 20% average difference in recruitment over these time periods, respectively. It is important to note that the SSB and total biomass confidence intervals from the 2020 assessment and current assessment overlap. Additionally the mean estimates of the current assessment are within the confidence intervals of the 2020 assessment.

A leave one out analysis was conducted to determine the individual impact of the new EBS shelf bottom trawl survey biomass and length data in 2021 and 2022 and the new AI bottom trawl survey biomass survey and length data in 2022. The analysis was conducted by removing all data from an individual survey for a single year were removed. The impact of removing any one source of data had a similar impact on SSB (Figure 7-35), where the cumulative impact of the three sources of new data led to lower SSB in the most recent time period than the previous assessment. The impact on age-2 recruits differed depending on the data source removed. Removing the AI BTS data resulted in lower recruitment than the current assessment model. Conversely when removing either the EBS BTS 2021 or 2022 data, recruitment was higher than the current assessment model. This indicates the AI BTS data informs the model of higher recruitment than the EBS BTS data.

The trend in SSB generally declines between 1991 and 2013, increases until 2020 where it then levels off (Table 7-7, Figure 7-34). Total biomass also has a declining trend between 1991 and 2003, increases until

2008, declines between 2009 and 2015, followed by an increase until 2020 and in 2021 and 2022 there has been a slight decline. The estimated numbers at age show that there was a strong cohort from 2002, which is shown as age-2 recruits in 2004 (Table 7-8). Other strong cohorts from 2008 through 2014 have matured or are maturing (age at 50% maturity is ~10 years old) and are either vulnerable or entering an age at which they are becoming more vulnerable to the fishery (age at 50% selectivity is ~7 years old). The increase in catch follows an increase in TAC in the last two years and may help explain the leveling off or decline in SSB and total biomass seen in 2021 and 2022.

Model estimates of fishing mortality indicate that the stock was lightly harvested from 1991 to 2007, with an average annual full selection F of 0.015 (Table 7-9, Figure 7-36). As the fishery developed for Kamchatka flounder in 2008 the fishing mortality was much higher peaking at 0.23 in 2010. Fishing mortality declined between 2011 and 2018 and ranged between 0.12 and 0.04. Fishing mortality has been increasing since and ranged between 0.05 in 2019 and 0.1 in 2022. The increase follows the increasing trend in TAC. For the last 5 years fishing mortality has averaged 0.069. This is below the $F_{40\%}$ value of 0.086.

Projections and Harvest Recommendations

The reference fishing mortality rate for Kamchatka flounder 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 $B_{40\%}$, $F_{40\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average age-2 recruitment from 1989-2020 estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{40\%}$ is calculated as the product of $SPR_{40\%}$ * equilibrium recruits. Since reliable estimates of 2022 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and B>$B_{40\%}$, the reference fishing mortality for Kamchatka flounder is defined in tier 3a of Amendment 56. For this tier, F_{ABC} is constrained to be ≤ $F_{40\%}$, and F_{OFL} is defined as $F_{35\%}$. The values of these quantities are:

2023 SSB estimate (B)	=	47,877 t
$B_{40\%}$	=	37,748 t
$F_{40\%}$	=	0.086
F_{ABC}	=	0.086
$F_{35\%}$	=	0.103
F_{OFL}	=	0.103

The estimated catch level for year 2023 associated with the overfishing level of F = 0.103 is 8,946 t. **The 2023 recommended ABC associated with F_{ABC} of 0.086 is 7,579 t.**

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

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. Over the last 5-years, the fishery has caught approximately 95.5% its total catch by the first week of October. The catch as of October 1, 2022 was expanded by 4.5% to estimate the end of the year catch, 8661 t. This value was also used as the 2022 catch level as a projection model input. 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 2023, are as follows ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)

Scenario 2: In all future years, F is set equal to a constant fraction (author's F) of max F_{ABC}.

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, the upper bound on F_{ABC} is set at $F_{60\%}$ (Rationale: This scenario provides a likely lower bound on FABC 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.)

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and projections of the mean Kamchatka flounder harvest and spawning stock biomass for the scenarios are shown in Table 7-10.

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

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 its MSY level in 2022 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 1) above its MSY level in 2024 or 2) above ½ of its MSY level in 2024 and expected to be above its MSY level in 2034 under this scenario, then the stock is not approaching an overfished condition.)

SSB in 2023 and 2024 are above MSY therefore this stock is not considered to be overfished and is not approaching overfishing.

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 BSAI Kamchatka flounder assessments is based on AFSC groundfish surveys dating back to 1991. Fits to the data are adequate for the majority of the time period, but with the addition of 2021 and 2022 EBS shelf and AI survey data the fit to the previous several years degraded. The trends in biomass and numbers were the same as the 2020 assessment, but were scaled downward. This was the result of the model trying to better fit the most recent two years of data that had declined by 26% in 2021 and another 10% in 2022 on the EBS shelf and 42% in the Aleutian Islands.

The BSAI Kamchatka flounder assessment does not show a strong retrospective pattern, but the pattern did become more pronounced in the current assessment as compared to the previous assessment. Mohn's rho for SSB is 0.116.

The degraded fit to the EBS shelf survey biomass and the increased retrospective pattern suggest that this is a Level 2 concern.

Population dynamics considerations

The Kamchatka flounder SSB exhibited a declining trend between 1998 and 2015. TAC was consistently set below ABC between 2013 and 2018 and SSB increased slightly between 2016 and 2020. TAC increased between 2020 and 2022 and in the recent two years was set to ABC. SSB has leveled off between 2020 and 2022. The EBS shelf and Aleutians Islands survey biomass showed relatively large declines in recent years. The EBS shelf declines 26% in 2021 and another 10% in 2022 from 2019 levels and in the Aleutian Islands the decline in 2022 was 42%.

Population numbers have been declining the past few years (Figure 7-34); however, there is evidence of a relatively large age-2 recruitment event in 2016 and fairly regular recruitment over time (Table 7-8. Figure 7-34).

Environmental/Ecosystem considerations

Environmental processes

The extended warm phase experienced in the eastern Bering Sea (EBS) that began in approximately 2014 has largely relaxed to normal conditions over the past year (August 2021 - August 2022). Sea surface temperature (SST) was within one standard deviation of the long term average and marine heatwaves were relatively weak and short-lived compared to recent years. Estimates of bottom temperature derived from the ROMS model suggest that bottom temperatures in the northern Bering Sea (NBS) over the past year were within normal ranges while the southeastern Bering Sea (SEBS) was significantly cooler than average. The Bering Sea ice extent was generally higher than average throughout much of the 2021-2022 winter. Ice advanced rapidly in November, though there was an abrupt springtime retreat beginning in mid-April. These cool-to-normal winter conditions were favorable to cold pool formation, though not to the areal extent in the years preceding 2014 (Hennon et al., 2022).

In the Aleutian Islands, the prevalence, duration, and intensity of marine heatwaves have continued to increase in 2022. Marine heatwave conditions persisted throughout the year in the western and central

Aleutian Islands while the eastern Aleutian Islands experienced marine heatwave conditions in the summer. Sustained above-average SSTs have occurred across the Aleutian Islands over the last 10-years (Ortiz and Zador, 2022).

Kamchatka flounder (KF) have similar distributions as Arrowtooth flounder within the BSAI. Adult KF tend to avoid the cold pool, with contractions in years with larger cold pool spatial extent over the shelf and expansions in years with smaller cold pool extent. Drastically reduced cold pool extents were observed in 2018, 2019, and 2021. The 2020 cold pool on the shelf was modeled (i.e., ROMS output) to be close to average in spatial extent and the 2022 cold pool (observed and modeled) was near the historical average and resembled other average-to-cool years, most similar to 2017 (Hennon et al., 2022).

Prey

Juvenile KF are zooplanktivores. Zooplankton abundances (copepods and euphausiids) over the southeastern Bering Sea shelf were surveyed in spring and late-summer 2022. Spring trends are likely more important for small life stages of KF, as by late-summer the fish have settled out of the pelagic environment. Relative to the last cold period which ended in 2012, large copepod abundances were reduced, though abundances were increased from 2021. Small copepod numbers remained elevated compared to abundances during the cold period from 2006-2012 and were also increased from 2021. Euphausiid estimates remained low, as is common during the spring, and were decreased from 2021 (Kimmel et al., 2022). In the Aleutian Islands, direct measurements of zooplankton are not available, therefore inferences are made from seabird reproductive success. Planktivorous auklets had above average reproductive success in 2021 and 2022), suggesting sufficient zooplankton prey availability. Data from the Continuous Plankton Recorders showed copepod community size was anonymously smaller from 2016–2018, but has been increasing since then with slightly above average size in 2021, which may indicate slightly larger zooplankton prey availability (Ortiz et al., 2022).

Common prey items for adult KF are juvenile walleye pollock and benthic prey such as eel pouts and shrimp. The 2022 age-0 pollock relative biomass estimates from the BASIS survey in the northeastern and southeastern regions of the Bering Sea are less than estimates during the recent warm period (2014-2018), and are slightly greater than the cold period from 2007-2013 (Andrews et al., 2022). Benthic infauna and other non-targets are not sampled well by the bottom trawl survey. The 2022 relative CPUE estimate for eelpouts showed a modest increase from 2021 to just above the average of the estimates over the last 10 years. Eelpouts have important roles in the energy flow within benthic communities, but it is not known at present whether these changes in CPUE are related to changes in energy flow (Buser, 2022).

In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish such that, all else being equal, consumption must increase to maintain fish condition. Higher temperatures that increase consumption demands beyond what is available may impact body condition. Condition factor has not been regularly estimated for KF during the bottom trawl survey, although a recent study found that their condition was generally higher with warmer bottom temperature (Grüss et al., 2020). Taken together, indicators of prey availability for KF suggest sufficient prey is available over the southeastern Bering Sea shelf.

Competitors

Greenland turbot, arrowtooth flounder, and Pacific halibut can be considered competitors based on overlap in their ecological niches as large upper-trophic predatory flatfish. These species are included within the apex predator guild. The biomass of the apex predator guild over the southeastern Bering Sea shelf increased from 2021 to 2022 and is nearly equal to their long term mean. The trend in this guild is largely driven by Pacific cod and ATF, both of whom have increased from 2021 (Whitehouse, 2022).

Given that ATF biomass greatly exceeds the biomass of KF in the southeastern Bering Sea, an increase in competition for habitat or prey resources, driven by increases in ATF biomass, may impact KF.

Predators

Predators of juvenile KF are not well known, but likely include fur seals, Pacific cod, skates, and sleeper sharks. Predators of adult KF are also not well known, but likely include toothed whales. Fur seal abundance has been steadily declining, as measured by pup counts at St. Paul Island through 2021 (Siddon, 2022). Pacific cod abundance increased over the southern shelf from 2021 to 2022 (Whitehouse, 2022). Indirect evidence of killer whale presence in the Bering Sea is available based on depredation noted during the NOAA AFSC longline survey. While rates of depredation increased from 1997-2009, depredation interactions remained relatively consistent between 2009-2021 (Siwicke, pers. comm.). Taken together, trends in predator abundances would indicate no increased predation concern for KF in the southeastern Bering Sea.

Summary for *Environmental/Ecosystem considerations:*

- Environment: The extended warm phase experienced by the eastern Bering Sea (EBS) that began in approximately 2014 has largely relaxed to normal conditions over the past year (August 2021 - August 2022).
- Winds: Along-shelf winds were variable in 2022, but favored onshelf Ekman transport in April and June that supported transport to suitable nursery habitat.
- Indicators of prey availability for KF suggest sufficient prey is available over the southeastern Bering Sea shelf.
- An increase in competition for habitat or prey resources over the southeastern Bering Sea, driven by increases in ATF biomass, may impact KF.
- Trends in predator abundances would indicate no increased predation concern for KF in the southeastern Bering Sea.

Together, the most recent data available suggest an ecosystem risk of Level 1 – Normal: “No apparent environmental/ecosystem concerns”.

Fishery performance

Fishery performance has been relatively stable since 2011 when Kamchatka was no longer managed as part of the arrowtooth flounder/Kamchatka flounder complex. TAC was consistently specified below ABC between 2012 and 2020. In 2021 and 2022, TAC was set to the ABC. On average, 80% of the TAC and 59% of the ABC is caught by the fishery annually since 2011. In 2020, 110% of the TAC and 77% of the ABC was caught by the fishery. As of October 26, 2022, 92% of the TAC and ABC had been achieved.

Summary and ABC recommendation

Summarize the results of the previous subsections in a table.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 2- increased assessment uncertainty/unresolved concerns	Level 1 – No increased concerns	Level 1- no increased concerns	Level 1- no increased concerns

An additional reduction in ABC is not warranted for this stock.

Status Determination

The Kamchatka stock is neither overfished nor approaching an overfished condition. With regard to assessing the current stock level, the expected stock size in the year 2022 of scenario 6 is above $B_{35\%}$, 33,029 t. With regard to whether the stock is likely to be in an overfished condition in the near future, the expected stock size in the year 2035 of scenario 7 is also greater than $B_{35\%}$. Figure 7-37 shows the relationship between the estimated time-series of female spawning biomass and fishing mortality and the tier 3 control rule for Kamchatka flounder. The simulation results for the 7 harvest scenarios are shown in Table 7-10. Given the results, Kamchatka are not currently overfished or approaching overfishing.

The *F* that would have produced a catch for last year equal to last year's OFL was 0.126.

Retrospective analysis

A retrospective analysis was conducted by removing data for an entire year for 10 years. The model was then refit to the model for each annual removal. Retrospective patterns of female spawning biomass, total biomass, fishing mortality, and recruitment were evaluated.

Female spawning biomass was greater than the reference model for all years, but peel 10 was close to the reference model, Figure 7-38, top-left panel). Total biomass was consistently greater than the reference model. The Mohn's rho statistics computed for female spawning biomass and total biomass were 0.116 and 0.210, respectively and fall within the rule-of-thumb presented by Hurtado-Ferro et al. (2014). The estimates of age-2 recruits were also generally greater than the reference model. Fishing mortality exhibited little change given the strong emphasis on fitting the model to the observed catch. Compared to the 2020 assessment a stronger retrospective pattern is observed. This is likely due to the misfit of the EBS shelf biomass data. During the next full assessment issues with time varying catchability will be evaluated. Figure 7-39 shows spatial distribution of the EBS shelf bottom trawl survey catch per unit effort in weight per area relative to the cold-pool extent. We see some area constriction in years with a larger cold pool and expansion with a smaller cold pool. We will evaluate models accounting for a relationship between catchability and cold pool extent during the next full assessment.

Ecosystem Considerations

Predators of Kamchatka flounder

Kamchatka flounder have rarely been found in the stomachs of other groundfish species in samples collected by the Alaska Fisheries Science Center. Their presence has only been documented in 17 stomach samples from the BSAI where the predators included Pacific cod, pollock, Pacific halibut, arrowtooth flounder and two sculpin species.

Kamchatka flounder predation

The prey of Kamchatka flounder can be discerned from 152 stomachs collected in 1983 (Yang and Livingston 1986). The principle diet was composed of walleye pollock, shrimp (mostly Crangonidae) and euphausids. Pollock was the most important prey item for all sizes of fish, ranging from 56 to 86% of the total stomach content weight. An examination of diet overlap with arrowtooth flounder indicated that these two congeneric species basically consume the same resources. Therefore the following sections are from the arrowtooth flounder assessment but pertain to Kamchatka flounder.

Fishery Effects on the Ecosystem

The direct impact on the Kamchatka fishery on the ecosystem is through bycatch. Table 7-11 summarizes the non-target catch by the Kamchatka flounder fishery since 2011. The highest non-target catch is of giant grenadier and in 2019 and 2020 squid were caught in some abundance. The bycatch of prohibited species is summarized in Table 7-12. The main prohibited species co-occurring with Kamchatka catch is golden king crab followed by snow crab and tanner crab, but in few years.

Data Gaps and Research Priorities

Several improvements should be explored during future assessment cycles:

1. The current age-length transition matrix assumes the relationship between CV and age is constant and should be re-evaluated.
2. The EBS shelf bottom trawl length composition data is a consistent and numerous data source and the model may be overfitting to these data and creating patterns in the survey biomass residuals and other composition data. A formal data weighting method (e.g., Francis or McAllister-Ianelli) should be evaluated.
3. Ageing error is not accounted for in this assessment and should be considered during the next assessment and may help to resolve conflicts between the length and age data.
4. The growth relationship, weight-at-age, and the age-length matrix were updated using the available age-length and length-weight data from the RACE bottom trawl surveys (2010 – present). The data were aggregated given that there were no obvious qualitative differences between regions (Bering Sea and Aleutian Islands). There was some conflict between the length and age data and the data should be re-examined to ensure that regional differences in growth are not being obscured. Additionally several years of otoliths from the EBS slope and AI bottom trawl surveys have not been aged. An age request will be made to have them aged to better evaluate any differences in growth and to provide improved growth parameter estimates.
5. We will evaluate models accounting for a relationship between catchability and cold pool extent during the next full assessment.

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Tables

Table 7-1. Total combined catch (t) of arrowtooth and Kamchatka flounder in the eastern Bering Sea and Aleutian Islands region, 1977-2022. Kamchatka (Kam) catches from 1991to 2007 were assumed to be 10% of the total. Catches in 2008, 2009, and 2010 were assumed to be 31%, 45%, and 55% of the total, respectively. Catches from 2011 to 2018 are as reported for Kamchatka flounder. The 2022 Kamchatka catch is an estimate extrapolated to the year end. The Kamchatka specific OFL, ABC, and TAC since 2011 are also reported.

Year	Total	Kam	OFL	ABC	TAC	Percent Total	Percent ABC	Percent TAC
1970	12,872	-	-	-	-	-	-	-
1971	19,373	-	-	-	-	-	-	-
1972	14,446	-	-	-	-	-	-	-
1973	12,922	-	-	-	-	-	-	-
1974	24,668	-	-	-	-	-	-	-
1975	21,616	-	-	-	-	-	-	-
1976	19,176	-	-	-	-	-	-	-
1977	11,489	-	-	-	-	-	-	-
1978	10,140	-	-	-	-	-	-	-
1979	14,357	-	-	-	-	-	-	-
1980	18,364	-	-	-	-	-	-	-
1981	17,113	-	-	-	-	-	-	-
1982	11,518	-	-	-	-	-	-	-
1983	13,969	-	-	-	-	-	-	-
1984	9,452	-	-	-	-	-	-	-
1985	7,447	-	-	-	-	-	-	-
1986	7,181	-	-	-	-	-	-	-
1987	4,859	-	-	-	-	-	-	-
1988	19,990	-	-	-	-	-	-	-
1989	7,306	-	-	-	-	-	-	-
1990	13,058	-	-	-	-	-	-	-
1991	19,510	1,951	-	-	-	10	-	-
1992	11,897	1,190	-	-	-	10	-	-
1993	9,299	930	-	-	-	10	-	-
1994	14,338	1,434	-	-	-	10	-	-
1995	9,284	928	-	-	-	10	-	-
1996	14,654	1,465	-	-	-	10	-	-
1997	10,469	1,047	-	-	-	10	-	-
1998	15,237	1,524	-	-	-	10	-	-
1999	11,378	1,138	-	-	-	10	-	-

Table 7-1. Continued.

Year	Total	Kam	OFL	ABC	TAC	Percent Total	Percent ABC	Percent TAC
2000	13,230	1,323	-	-	-	10	-	-
2001	14,058	1,406	-	-	-	10	-	-
2002	11,855	1,185	-	-	-	10	-	-
2003	13,253	1,325	-	-	-	10	-	-
2004	18,185	1,818	-	-	-	10	-	-
2005	14,243	1,424	-	-	-	10	-	-
2006	13,442	1,344	-	-	-	10	-	-
2007	11,916	1,192	-	-	-	10	-	-
2008	21,370	7,266	-	-	-	34	-	-
2009	29,900	12,558	-	-	-	42	-	-
2010	38,815	20,960	-	-	-	54	-	-
2011	20,575	10,053	23,600	17,700	17,700	33	57	57
2012	22,641	9,594	24,800	18,600	17,700	30	51	54
2013	21,007	7,836	16,300	12,200	10,000	27	64	78
2014	19,626	6,568	8,270	7,100	7,100	25	91	91
2015	11,721	5,072	10,500	9,000	6,500	31	55	77
2016	11,485	4,924	11,100	9,500	5,000	30	51	97
2017	6,934	4,582	10,360	8,880	5,000	41	51	90
2018	7,243	3,166	11,347	9,737	5,000	31	32	62
2019	10,374	4,581	10,965	9,260	5,000	31	48	90
2020	10,874	7,478	11,495	9708	6,800	41	77	110
2021	9,014	6,667	10,630	8,982	8,982	43	74	74
2022	7,107	8,661	10,903	9,214	9,214	-	-	-

Table 7-2. Number of Kamchatka flounder fishery length (cm) observations.

Length (cm)	Females							Males						
	2008	2009	2010	2011	2018	2019	2020	2008	2009	2010	2011	2018	2019	2020
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	1	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	2	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	0	0	0	0	0	2	0	0	0	0	0	0	1
27	0	0	0	0	0	0	2	0	0	0	0	0	1	2
28	0	0	0	0	0	0	1	0	0	0	0	0	3	5
29	0	0	0	0	0	0	1	0	0	0	0	0	2	4
30	0	0	0	0	0	0	3	0	0	0	0	2	3	6
31	0	0	0	0	0	0	5	0	0	0	0	1	3	6
32	0	0	0	0	3	4	2	0	0	0	0	7	4	4
33	0	0	0	0	5	1	5	0	0	0	0	7	8	4
34	1	1	0	0	6	4	7	1	0	1	0	8	13	14
35	0	0	0	0	6	3	11	1	0	0	0	14	12	23
36	1	0	0	0	4	5	7	0	0	0	0	11	23	31
37	1	0	1	0	8	5	22	0	1	1	0	25	43	33
38	0	0	1	0	7	14	33	2	0	2	0	18	58	66
39	2	0	1	1	13	27	46	0	0	2	0	29	76	84
40	1	0	2	0	11	21	54	1	0	5	1	41	113	134
41	1	0	5	2	21	36	97	2	0	5	5	62	111	215
42	0	0	1	1	28	40	106	1	0	6	5	72	148	236
43	2	0	2	1	30	44	146	4	0	24	15	90	175	227
44	2	1	6	0	43	58	138	2	1	33	16	92	245	263
45	3	1	14	3	39	62	118	5	3	31	13	129	331	294
46	4	1	22	0	59	88	151	5	0	30	21	140	369	309
47	3	1	23	0	73	101	151	4	2	46	15	169	443	391
48	3	2	40	4	89	145	132	4	2	44	20	169	461	476
49	1	1	20	8	77	160	160	4	5	26	12	143	444	554
50	1	1	12	11	77	154	178	2	2	19	24	125	430	517

Table 7-2. Continued.

Length (cm)	Females 2008	2009	2010	2011	2018	2019	2020	Males 2008	2009	2010	2011	2018	2019	2020
51	2	1	15	9	84	171	181	4	1	19	14	114	358	477
52	2	0	12	3	87	164	200	6	2	13	4	97	242	415
53	3	0	5	3	73	169	214	5	2	17	6	86	216	360
54	1	1	16	2	73	172	187	4	2	9	6	76	168	275
55	0	2	8	8	77	151	196	5	2	7	3	76	139	243
56	4	0	8	3	58	156	183	7	1	13	4	53	139	190
57	2	1	7	5	63	96	167	6	4	15	6	52	100	181
58	1	0	8	9	42	112	132	11	1	11	4	43	66	139
59	1	1	7	4	48	105	109	9	4	7	7	37	63	117
60	1	1	7	4	35	112	132	7	2	17	10	28	48	82
61	2	2	11	2	61	87	115	7	1	17	7	25	42	106
62	1	1	5	5	38	80	106	6	9	24	6	30	23	91
63	2	0	7	3	29	62	88	5	3	25	11	19	25	82
64	0	0	2	5	15	66	67	8	3	20	6	16	23	68
65	2	5	5	3	20	42	60	2	4	17	4	16	15	52
66	0	2	12	1	14	43	44	2	0	11	1	9	8	49
67	1	1	6	5	17	30	32	2	2	11	3	6	8	33
68	3	1	11	3	18	22	32	0	0	3	0	3	5	22
69	1	1	12	3	10	26	23	1	0	1	0	3	2	8
70	0	3	4	2	2	24	23	0	0	4	0	0	3	6
71	2	1	11	0	5	14	17	0	0	0	0	0	2	1
72	0	2	11	1	4	7	12	0	0	0	1	0	1	1
73	1	3	7	0	1	13	17	0	0	0	0	0	0	0
74	0	1	8	2	4	8	14	0	0	0	0	2	0	0
75	0	0	6	0	5	8	10	0	0	0	0	0	1	0
76	2	0	3	3	6	12	8	0	0	0	0	1	0	0
77	0	3	3	0	3	2	12	0	0	0	0	0	0	0
78	0	2	6	1	5	11	7	0	0	0	0	0	0	1
79	0	0	4	0	2	2	4	0	0	0	0	0	0	0
80	0	0	5	2	5	4	3	0	0	0	0	0	0	0
81	0	0	3	0	2	4	1	0	0	0	0	0	0	0
82	0	1	1	0	2	2	2	0	0	0	0	0	1	0
83	0	1	1	0	3	3	2	0	0	0	0	0	0	0
84	0	0	1	0	3	0	2	0	0	0	0	0	0	0
85	0	0	0	1	0	0	0	0	0	0	0	0	0	0
86	1	0	1	0	0	0	1	0	0	0	0	0	0	0
87	0	0	1	0	0	1	0	0	0	0	0	0	0	0
88	0	0	0	0	1	0	1	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	1	0	0	1	0	0	0	0	0	0	0	0

Table 7-2. Continued.

Length (cm)	Females		Males	
	2021	2022	2021	2022
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
19	0	0	0	0
20	1	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	2	0
25	1	0	0	0
26	2	0	0	0
27	1	0	1	0
28	0	2	0	0
29	2	2	4	3
30	4	0	1	2
31	5	2	3	5
32	8	4	5	2
33	6	3	9	6
34	7	4	13	8
35	11	8	24	6
36	11	4	25	7
37	29	7	50	17
38	26	15	48	23
39	21	13	63	38
40	37	18	94	42
41	57	40	160	73
42	70	42	257	82
43	93	43	347	133
44	126	52	362	140
45	126	80	324	211
46	169	96	313	258
47	141	105	338	245
48	134	120	350	241
49	134	133	429	236
50	135	101	416	226

Table 7-2. Continued.

	Females		Males	
Length (cm)	2021	2022	2021	2022
51	127	103	454	198
52	115	108	461	193
53	119	107	317	151
54	163	104	313	142
55	172	107	275	109
56	144	91	250	106
57	147	89	250	84
58	120	62	195	66
59	105	62	157	57
60	89	63	112	49
61	118	51	130	34
62	88	53	83	28
63	82	48	99	22
64	73	45	85	30
65	52	31	78	23
66	50	20	61	21
67	31	17	35	12
68	26	13	28	3
69	20	6	13	1
70	11	9	8	5
71	23	6	2	1
72	19	7	1	1
73	16	5	0	1
74	13	6	0	1
75	15	1	1	0
76	10	3	0	2
77	9	4	0	0
78	7	3	0	0
79	7	2	0	0
80	3	0	0	0
81	4	0	0	0
82	1	2	1	0
83	4	0	0	0
84	3	0	0	0
85	1	2	0	0
86	0	0	0	0
87	1	0	0	0
88	0	0	0	0
89	0	0	0	0
90	0	1	0	0

Table 7-3. Estimated Kamchatka flounder biomass and coefficient of variation (CV) from the three BSAI bottom trawl surveys (shelf, slope, and Aleutian Islands). Reliable estimates of Kamchatka flounder biomass are available after 1991 when Kamchatka and arrowtooth flounder were consistently differentiated.

Year	Shelf biomass (t)	Shelf CV	Slope biomass (t)	Slope CV	AI biomass (t)	AI CV
1983	-	-	-	-	1130.7	0.18
1984	-	-	-	-	-	-
1985	-	-	-	-	-	-
1986	-	-	-	-	587.3	0.22
1987	40.1	1	-	-	-	-
1988	13677.1	0.23	-	-	-	-
1989	17009.58	0.17	-	-	-	-
1990	32703.14	0.14	-	-	-	-
1991	37511.2	0.11	-	-	16262.6	0.27
1992	44764.3	0.1	-	-	-	-
1993	40223.97	0.08	-	-	-	-
1994	52461.81	0.12	-	-	49197.4	0.38
1995	28371.65	0.1	-	-	-	-
1996	24942.55	0.09	-	-	-	-
1997	19497.7	0.1	-	-	37695.3	0.25
1998	23898.99	0.09	-	-	-	-
1999	18993.02	0.14	-	-	-	-
2000	21383.52	0.11	-	-	28534.9	0.23
2001	31081.49	0.09	-	-	-	-
2002	23485.84	0.12	18630.8	0.11	49107.4	0.28
2003	27575.06	0.11	-	-	-	-
2004	30114.53	0.09	14740.2	0.1	39276.4	0.23
2005	46214.62	0.07	-	-	-	-
2006	61352.13	0.08	-	-	45370.4	0.24
2007	65003.4	0.08	-	-	-	-
2008	58013.57	0.09	24822.4	0.19	-	-
2009	49299.6	0.1	-	-	-	-
2010	58102.3	0.07	27856.0	0.1	53961.9	0.38
2011	45960.77	0.09	-	-	-	-
2012	42716.94	0.08	32685.2	0.22	35099.8	0.4
2013	46115.71	0.08	-	-	-	-
2014	57785.5	0.09	-	-	45156.9	0.37
2015	60135.39	0.06	-	-	-	-
2016	55136.47	0.06	21368.6	0.1	27967.7	0.23
2017	47893.29	0.06	-	-	-	-
2018	43845.29	0.05	-	-	29308.3	0.29
2019	44636.46	0.08	-	-	-	-
2020	-	-	-	-	-	-
2021	32856.21	0.07	-	-	-	-
2022	29699.16	0.09	-	-	16864.1	0.26

Table 7-4. Estimated maturity at age for female Kamchatka flounder (Stark 2011).

age	proportion mature
2	0.00
3	0.01
4	0.01
5	0.02
6	0.05
7	0.10
8	0.18
9	0.31
10	0.48
11	0.66
12	0.80
13	0.89
14	0.94
15	0.97
16	0.99
17	0.99
18	1.00
19	1.00
20	1.00
21	1.00
22	1.00
23	1.00
24	1.00
25	1.00

Table 7-5. Key parameter estimates, standard deviations, and parameter correlation from a) Model 16.0b (2020) and b) current assessment.

a)

				Index																			
Index	Parameter	Value	St. Dev	1	2	3	57	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
1	q1	1.00	0.06	1																			
2	q3	0.57	0.06	0.15	1																		
3	mean_log_rec	15.67	0.11	-0.19	-0.15	1																	
57	log_avg_fmort	-3.65	0.05	0.42	0.50	-0.29	1																
90	srv1_slope_f1	1.01	0.20	-0.19	0.00	0.00	0.01	1															
91	srv1_sel50_f1	1.48	0.33	0.39	0.00	0.00	-0.01	-0.66	1														
92	srv1_slope_f2	0.37	0.05	-0.10	-0.03	0.00	-0.03	0.26	-0.65	1													
93	srv1_sel50_f2	7.05	1.24	-0.40	0.01	0.00	0.01	0.53	-0.89	0.84	1												
94	srv1_slope_m1	1.03	0.30	-0.24	0.00	0.00	0.00	0.18	-0.36	0.22	0.33	1											
95	srv1_sel50_m1	0.77	0.25	0.38	0.00	0.01	-0.01	-0.26	0.59	-0.36	-0.55	-0.30	1										
96	srv1_slope_m2	0.51	0.07	-0.21	-0.01	0.00	-0.02	0.15	-0.34	0.21	0.32	0.36	-0.65	1									
97	srv1_sel50_m2	7.69	0.64	-0.45	0.02	0.00	0.02	0.25	-0.55	0.33	0.53	0.60	-0.77	0.81	1								
98	srv2_slope_f	1.13	0.15	0.08	0.00	-0.01	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	1							
99	srv2_sel50_f	4.66	0.24	-0.10	0.03	0.01	0.00	0.00	0.01	-0.03	0.00	0.00	0.01	-0.01	0.01	-0.71	1						
100	srv2_slope_m	1.92	0.31	0.05	-0.02	0.00	-0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	-0.01	0.09	-0.14	1					
101	srv2_sel50_m	3.60	0.17	-0.07	0.04	0.00	0.03	0.00	0.00	-0.03	0.00	0.00	0.00	-0.01	0.01	-0.13	0.20	-0.67	1				
102	srv3_slope_f	0.08	0.01	-0.11	0.45	-0.06	0.32	0.00	0.02	-0.07	-0.01	-0.01	0.02	-0.03	0.01	-0.04	0.08	-0.04	0.08	1			
103	srv3_sel50_f	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1		
104	srv3_slope_m	0.12	0.01	-0.04	-0.07	-0.03	0.14	0.00	0.01	-0.04	0.00	0.00	0.01	-0.01	0.02	-0.02	0.04	-0.02	0.04	-0.07	0.00	1	
105	srv3_sel50_m	12.85	1.19	-0.07	0.42	-0.03	0.18	0.00	0.01	-0.04	0.00	0.00	0.01	-0.02	0.00	-0.02	0.04	-0.02	0.04	0.70	0.00	-0.55	1

Table 7-5. Continued.

b)

			St.	Index																				
Index	Parameter	Value	Dev	1	2	3	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
1	q1	1.04	0.05	1																				
2	q3	0.57	0.06	0.21	1																			
3	mean_log_rec	15.63	0.09	-0.24	-0.19	1																		
59	log_avg_fmort	-3.54	0.05	0.48	0.54	-0.35																		
92	fish_sel50_f	6.74	0.27	0.04	-0.01	-0.02	1																	
93	fish_sel50_m	7.41	0.29	-0.01	0.02	0.01	0.05	1																
94	srv1_slope_f1	1.08	0.20	-0.17	0.00	0.00	0.00	0.00	1															
95	srv1_sel50_f1	1.42	0.25	0.36	-0.01	0.01	0.02	0.01	-0.60	1														
96	srv1_slope_f2	0.38	0.05	-0.05	-0.02	-0.01	-0.02	-0.01	0.22	-0.61	1													
97	srv1_sel50_f2	7.23	0.96	-0.37	0.02	0.00	-0.06	-0.01	0.50	-0.85	0.82	1												
98	srv1_slope_m1	1.11	0.31	-0.23	0.00	0.00	0.00	-0.01	0.17	-0.35	0.18	0.31	1											
99	srv1_sel50_m1	0.78	0.21	0.34	0.00	0.01	0.00	0.03	-0.22	0.53	-0.29	-0.49	-0.21	1										
100	srv1_slope_m2	0.52	0.07	-0.18	-0.01	0.00	0.00	-0.01	0.13	-0.30	0.16	0.28	0.34	-0.63	1									
101	srv1_sel50_m2	7.54	0.57	-0.41	0.02	0.00	0.00	-0.06	0.22	-0.51	0.27	0.48	0.58	-0.73	0.82	1								
102	srv2_slope_f	1.17	0.16	0.07	0.02	-0.02	-0.04	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	1							
103	srv2_sel50_f	5.52	0.21	-0.10	0.01	0.02	0.02	-0.04	0.00	0.01	-0.02	0.00	0.00	0.00	-0.01	0.00	-0.56	1						
104	srv2_slope_m	1.80	0.26	0.04	-0.01	0.00	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.05	-0.11	1					
105	srv2_sel50_m	4.13	0.17	-0.06	0.04	0.00	-0.03	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	-0.01	0.01	-0.09	0.19	-0.53	1				
106	srv3_slope_f	0.09	0.01	-0.07	0.45	-0.08	0.00	0.02	0.00	0.01	-0.05	0.00	0.00	0.01	-0.02	0.02	-0.02	0.06	-0.03	0.07	1			
107	srv3_sel50_f	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1		
108	srv3_slope_m	0.13	0.01	-0.02	-0.06	-0.03	0.05	-0.09	0.00	0.01	-0.03	0.00	0.00	0.00	-0.01	0.02	-0.01	0.03	-0.01	0.03	-0.05	0.00	1	
109	srv3_sel50_m	12.42	1.03	-0.04	0.44	-0.06	-0.07	0.11	0.00	0.01	-0.03	0.00	0.00	0.01	-0.01	0.00	-0.01	0.03	-0.02	0.05	0.71	0.00	-0.48	1

Table 7-6. Key parameter estimates and standard deviations from Models 16.0b (2020) and current assessment.

Parameter	16.0b (2020)		16.0b (2022)		Parameter	16.0b (2020)		16.0b (2022)	
q1	1.00	0.06	1.04	0.05	mean_log_rec	15.67	0.11	15.63	0.09
q3	0.57	0.06	0.57	0.06	rec_dev	0.55	0.32	0.52	0.32
fish_sel50_f	7.12	0.29	6.74	0.27	rec_dev	-0.27	1.96	-0.29	1.95
fish_sel50_m	7.09	0.33	7.41	0.29	rec_dev	-0.49	1.80	-0.51	1.79
srv1_slope_f1	1.01	0.20	1.08	0.20	rec_dev	-0.67	1.70	-0.69	1.69
srv1_sel50_f1	1.48	0.33	1.42	0.25	rec_dev	-0.78	1.65	-0.79	1.64
srv1_slope_f2	0.37	0.05	0.38	0.05	rec_dev	-0.85	1.61	-0.86	1.61
srv1_sel50_f2	7.05	1.24	7.23	0.96	rec_dev	-0.88	1.60	-0.88	1.60
srv1_slope_m1	1.03	0.30	1.11	0.31	rec_dev	-0.86	1.60	-0.85	1.61
srv1_sel50_m1	0.77	0.25	0.78	0.21	rec_dev	-0.78	1.62	-0.74	1.64
srv1_slope_m2	0.51	0.07	0.52	0.07	rec_dev	-0.64	1.65	-0.54	1.69
srv1_sel50_m2	7.69	0.64	7.54	0.57	rec_dev	-0.57	1.65	-0.37	1.70
srv2_slope_f	1.13	0.15	1.17	0.16	rec_dev	-0.68	1.60	-0.40	1.65
srv2_sel50_f	4.66	0.24	5.52	0.21	rec_dev	0.88	0.49	0.76	0.51
srv2_slope_m	1.92	0.31	1.80	0.26	rec_dev	0.84	0.42	0.74	0.44
srv2_sel50_m	3.60	0.17	4.13	0.17	rec_dev	-1.00	0.96	-0.63	0.80
srv3_slope_f	0.08	0.01	0.09	0.01	rec_dev	0.06	0.48	0.16	0.45
srv3_sel50_f	20.00	0.00	20.00	0.00	rec_dev	0.01	0.44	0.06	0.43
srv3_slope_m	0.12	0.01	0.13	0.01	rec_dev	0.17	0.35	-0.01	0.40
srv3_sel50_m	12.85	1.19	12.42	1.03	rec_dev	0.15	0.35	0.31	0.32
log_avg_fmort	-3.65	0.05	-3.54	0.05	rec_dev	0.88	0.21	0.87	0.21
fmort_dev	-0.51	0.07	-0.57	0.07	rec_dev	0.71	0.19	0.72	0.17
fmort_dev	-1.00	0.06	-1.07	0.06	rec_dev	-0.05	0.21	-0.02	0.19
fmort_dev	-1.25	0.06	-1.33	0.06	rec_dev	-0.51	0.20	-0.49	0.19
fmort_dev	-0.83	0.05	-0.91	0.05	rec_dev	-0.60	0.19	-0.55	0.17
fmort_dev	-1.28	0.05	-1.36	0.05	rec_dev	0.00	0.14	0.01	0.13
fmort_dev	-0.82	0.05	-0.90	0.05	rec_dev	-0.58	0.17	-0.58	0.16
fmort_dev	-1.15	0.05	-1.23	0.05	rec_dev	-1.27	0.21	-1.14	0.19
fmort_dev	-0.75	0.05	-0.83	0.05	rec_dev	-0.83	0.18	-0.79	0.16
fmort_dev	-1.01	0.05	-1.09	0.05	rec_dev	-0.29	0.15	-0.27	0.14
fmort_dev	-0.83	0.04	-0.91	0.05	rec_dev	0.27	0.13	0.28	0.12
fmort_dev	-0.73	0.04	-0.82	0.05	rec_dev	0.15	0.13	0.13	0.13
fmort_dev	-0.87	0.04	-0.96	0.04	rec_dev	0.22	0.13	0.20	0.12
fmort_dev	-0.74	0.04	-0.82	0.04	rec_dev	-0.66	0.18	-0.60	0.17
fmort_dev	-0.41	0.04	-0.49	0.04	rec_dev	-0.20	0.16	-0.22	0.16
fmort_dev	-0.64	0.04	-0.72	0.04	rec_dev	0.55	0.13	0.62	0.12
fmort_dev	-0.69	0.04	-0.77	0.04	rec_dev	1.00	0.13	1.00	0.11
fmort_dev	-0.81	0.04	-0.89	0.04	rec_dev	1.48	0.12	1.55	0.10
fmort_dev	1.00	0.04	0.91	0.04	rec_dev	0.40	0.14	0.42	0.13
fmort_dev	1.56	0.04	1.47	0.04	rec_dev	-0.30	0.16	-0.31	0.15
fmort_dev	2.13	0.05	2.05	0.05	rec_dev	0.07	0.14	0.02	0.14
fmort_dev	1.46	0.05	1.38	0.05	rec_dev	0.00	0.15	-0.04	0.15
fmort_dev	1.44	0.05	1.36	0.05	rec_dev	0.09	0.15	0.08	0.15
fmort_dev	1.27	0.05	1.20	0.05	rec_dev	1.00	0.12	1.03	0.11
fmort_dev	1.12	0.05	1.06	0.05	rec_dev	0.57	0.14	0.57	0.13
fmort_dev	0.87	0.05	0.81	0.05	rec_dev	0.72	0.13	0.66	0.12
fmort_dev	0.82	0.05	0.77	0.05	rec_dev	0.36	0.14	0.04	0.14
fmort_dev	0.70	0.05	0.66	0.05	rec_dev	0.64	0.13	0.44	0.12
fmort_dev	0.27	0.05	0.24	0.05	rec_dev	0.80	0.14	0.63	0.12
fmort_dev	0.59	0.06	0.57	0.05	rec_dev	0.97	0.14	0.72	0.12
fmort_dev	1.06	0.06	1.06	0.05	rec_dev	0.45	0.17	0.11	0.15
fmort_dev	-	-	0.94	0.06	rec_dev	0.58	0.18	0.33	0.15
fmort_dev	-	-	1.20	0.06	rec_dev	-0.72	0.51	0.08	0.21
					rec_dev	-0.08	2.12	0.84	0.15
					rec_dev	-	-	-0.81	0.32
					rec_dev	-	-	-0.51	0.32

Table 7-7. Estimated total biomass (ages 2+), female spawning biomass, and age -2 recruitment.

	16.0b (2020)					16.0b (2022)						
Year	Total biomass	SSB	SSB lb	SSB ub	Rec	Total biomass	SSB	SSB lb	SSB ub	Rec	Rec lb	Rec ub
1991	161,314	76,116	64,027	90,487	7.03	154,935	72,447	61,054	85,966	7.10	5.22	9.66
1992	159,854	75,009	63,809	88,175	12.72	153,775	71,516	60,941	83,926	12.39	10.07	15.24
1993	158,678	74,675	64,236	86,809	7.17	152,881	71,348	61,470	82,812	6.92	5.29	9.05
1994	157,037	74,998	65,226	86,234	3.59	151,536	71,816	62,547	82,458	3.96	2.81	5.56
1995	154,188	75,529	66,346	85,983	5.56	148,982	72,472	63,741	82,400	5.62	4.22	7.48
1996	151,370	76,521	67,848	86,304	9.5	146,458	73,573	65,303	82,890	9.42	7.50	11.82
1997	147,970	76,862	68,649	86,058	16.77	143,327	74,016	66,163	82,800	16.24	13.69	19.27
1998	145,093	76,738	68,950	85,407	14.88	140,668	74,001	66,534	82,305	13.97	11.49	17.00
1999	142,085	75,575	68,197	83,752	15.86	137,820	72,956	65,866	80,810	15.07	12.53	18.12
2000	139,496	74,054	67,070	81,766	6.62	135,371	71,561	64,835	78,985	6.73	4.92	9.20
2001	136,931	72,008	65,405	79,276	10.47	132,893	69,643	63,272	76,654	9.89	7.56	12.95
2002	134,999	69,675	63,438	76,525	22.06	131,070	67,436	61,409	74,054	22.80	19.10	27.22
2003	134,693	67,499	61,601	73,961	34.55	130,819	65,371	59,666	71,623	33.57	28.42	39.66
2004	136,828	65,466	59,885	71,567	55.92	133,145	63,443	58,035	69,354	58.00	51.52	65.32
2005	139,584	63,609	58,306	69,394	19.08	136,104	61,656	56,510	67,271	18.69	15.30	22.84
2006	143,565	62,581	57,495	68,117	9.44	140,287	60,645	55,706	66,022	9.07	6.98	11.80
2007	148,024	62,056	57,137	67,399	13.71	144,898	60,112	55,335	65,302	12.52	9.96	15.75
2008	152,443	62,088	57,288	67,291	12.72	149,415	60,143	55,483	65,195	11.85	9.26	15.17
2009	150,306	59,467	54,761	64,578	13.97	147,318	57,564	52,995	62,526	13.37	10.44	17.13
2010	143,463	55,373	50,712	60,463	34.58	140,451	53,515	48,988	58,461	34.65	29.84	40.24
2011	128,288	48,495	43,822	53,666	22.5	124,950	46,535	41,989	51,573	21.75	17.64	26.82
2012	124,851	47,782	42,928	53,185	26.14	121,172	45,678	40,954	50,947	23.78	19.82	28.55
2013	122,180	47,157	42,073	52,855	18.19	117,876	44,871	39,932	50,422	12.82	10.01	16.43
2014	121,882	46,728	41,430	52,704	24.23	116,675	44,247	39,113	50,054	19.15	15.72	23.33
2015	123,524	46,360	40,891	52,560	28.26	117,051	43,655	38,377	49,660	23.06	19.01	28.00
2016	127,525	46,647	41,034	53,027	33.55	119,316	43,713	38,318	49,869	25.18	20.85	30.44
2017	131,819	47,371	41,607	53,934	19.95	121,490	44,180	38,662	50,486	13.79	10.50	18.12
2018	136,687	48,908	42,949	55,694	22.77	123,906	45,380	39,702	51,871	17.20	13.22	22.38
2019	142,176	51,750	45,534	58,815	6.18	127,363	47,752	41,863	54,469	13.29	8.85	19.96
2020	145,368	54,191	47,690	61,579	11.74	129,522	49,480	43,375	56,443	28.60	21.75	37.64
2021	-	-	-	-	-	127,701	49,459	43,162	56,676	5.45	2.93	10.16
2022	-	-	-	-	-	126,067	49,667	43,171	57,141	7.38	3.97	13.72

Table 7-8. Estimated numbers (millions) of a) females and b) males from model 16.0b.

a)

	Age																							
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1991	3.5	3.4	4.8	9.1	9.5	4.8	3.2	3.0	3.0	1.2	4.3	3.9	1.1	1.0	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.4	0.4	7.9
1992	6.2	3.2	3.0	4.3	8.1	8.5	4.3	2.8	2.7	2.6	1.1	3.8	3.5	1.0	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	7.3
1993	3.5	5.5	2.8	2.7	3.9	7.3	7.6	3.8	2.5	2.4	2.4	1.0	3.4	3.1	0.9	0.8	0.6	0.4	0.4	0.3	0.3	0.3	0.3	6.8
1994	2.0	3.1	5.0	2.6	2.4	3.5	6.5	6.8	3.4	2.2	2.1	2.1	0.8	3.0	2.7	0.8	0.7	0.5	0.4	0.3	0.3	0.3	0.2	6.3
1995	2.8	1.8	2.8	4.5	2.3	2.2	3.1	5.8	6.0	3.0	2.0	1.9	1.9	0.8	2.7	2.4	0.7	0.6	0.5	0.3	0.3	0.2	0.2	5.8
1996	4.7	2.5	1.6	2.5	4.0	2.0	1.9	2.8	5.2	5.3	2.7	1.7	1.7	1.6	0.7	2.4	2.1	0.6	0.6	0.4	0.3	0.2	0.2	5.3
1997	8.1	4.2	2.3	1.4	2.2	3.6	1.8	1.7	2.4	4.6	4.7	2.4	1.5	1.5	1.5	0.6	2.1	1.9	0.5	0.5	0.4	0.3	0.2	4.9
1998	7.0	7.3	3.8	2.0	1.3	2.0	3.2	1.6	1.5	2.2	4.1	4.2	2.1	1.4	1.3	1.3	0.5	1.9	1.7	0.5	0.4	0.3	0.2	4.5
1999	7.5	6.3	6.5	3.4	1.8	1.1	1.8	2.8	1.4	1.4	1.9	3.6	3.7	1.9	1.2	1.2	1.1	0.5	1.6	1.5	0.4	0.4	0.3	4.2
2000	3.4	6.7	5.6	5.8	3.0	1.6	1.0	1.6	2.5	1.3	1.2	1.7	3.2	3.3	1.7	1.1	1.0	1.0	0.4	1.5	1.3	0.4	0.3	4.0
2001	4.9	3.0	6.0	5.0	5.2	2.7	1.4	0.9	1.4	2.2	1.1	1.1	1.5	2.8	2.9	1.5	1.0	0.9	0.9	0.4	1.3	1.2	0.3	3.9
2002	11.4	4.4	2.7	5.4	4.5	4.7	2.4	1.3	0.8	1.2	2.0	1.0	0.9	1.3	2.5	2.6	1.3	0.8	0.8	0.8	0.3	1.1	1.0	3.7
2003	16.8	10.2	4.0	2.4	4.8	4.0	4.2	2.2	1.1	0.7	1.1	1.7	0.9	0.8	1.2	2.2	2.3	1.2	0.7	0.7	0.7	0.3	1.0	4.2
2004	29.0	15.0	9.1	3.6	2.2	4.3	3.6	3.7	1.9	1.0	0.6	1.0	1.5	0.8	0.7	1.0	2.0	2.0	1.0	0.7	0.6	0.6	0.3	4.6
2005	9.3	26.0	13.5	8.2	3.2	1.9	3.9	3.2	3.3	1.7	0.9	0.6	0.9	1.4	0.7	0.7	0.9	1.7	1.8	0.9	0.6	0.6	0.5	4.3
2006	4.5	8.4	23.3	12.1	7.3	2.8	1.7	3.4	2.8	2.9	1.5	0.8	0.5	0.8	1.2	0.6	0.6	0.8	1.5	1.6	0.8	0.5	0.5	4.3
2007	6.3	4.1	7.5	20.8	10.8	6.6	2.5	1.5	3.0	2.5	2.6	1.3	0.7	0.4	0.7	1.1	0.5	0.5	0.7	1.3	1.4	0.7	0.5	4.2
2008	5.9	5.6	3.6	6.7	18.7	9.7	5.8	2.3	1.4	2.7	2.2	2.3	1.2	0.6	0.4	0.6	0.9	0.5	0.5	0.6	1.2	1.2	0.6	4.1
2009	6.7	5.3	5.0	3.3	6.0	16.5	8.4	5.0	1.9	1.1	2.3	1.8	1.9	1.0	0.5	0.3	0.5	0.8	0.4	0.4	0.5	1.0	1.0	4.0
2010	17.3	6.0	4.7	4.5	2.9	5.3	14.2	7.0	4.1	1.5	0.9	1.8	1.5	1.5	0.8	0.4	0.3	0.4	0.6	0.3	0.3	0.4	0.8	3.9
2011	10.9	15.5	5.4	4.2	4.0	2.5	4.4	11.2	5.3	3.0	1.1	0.6	1.3	1.0	1.1	0.5	0.3	0.2	0.3	0.4	0.2	0.2	0.3	3.4
2012	11.9	9.7	13.9	4.8	3.8	3.5	2.2	3.7	9.2	4.3	2.4	0.9	0.5	1.0	0.8	0.9	0.4	0.2	0.1	0.2	0.4	0.2	0.2	2.9
2013	6.4	10.6	8.7	12.4	4.3	3.3	3.0	1.8	3.0	7.4	3.4	1.9	0.7	0.4	0.8	0.7	0.7	0.3	0.2	0.1	0.2	0.3	0.1	2.5
2014	9.6	5.7	9.5	7.8	11.0	3.8	2.9	2.6	1.5	2.5	6.1	2.8	1.6	0.6	0.3	0.7	0.5	0.6	0.3	0.1	0.1	0.1	0.2	2.1
2015	11.5	8.6	5.1	8.5	6.9	9.8	3.3	2.5	2.1	1.3	2.0	5.0	2.3	1.3	0.5	0.3	0.5	0.4	0.5	0.2	0.1	0.1	0.1	1.9
2016	12.6	10.3	7.7	4.6	7.6	6.2	8.6	2.8	2.1	1.8	1.1	1.7	4.2	1.9	1.1	0.4	0.2	0.5	0.4	0.4	0.2	0.1	0.1	1.7
2017	6.9	11.3	9.2	6.9	4.1	6.7	5.4	7.4	2.4	1.8	1.5	0.9	1.4	3.5	1.6	0.9	0.3	0.2	0.4	0.3	0.3	0.2	0.1	1.5
2018	8.6	6.2	10.1	8.3	6.1	3.6	5.9	4.7	6.4	2.1	1.5	1.3	0.8	1.2	3.0	1.4	0.8	0.3	0.2	0.3	0.3	0.3	0.1	1.4
2019	6.6	7.7	5.5	9.0	7.4	5.5	3.2	5.2	4.1	5.5	1.8	1.3	1.1	0.6	1.1	2.6	1.2	0.7	0.2	0.1	0.3	0.2	0.2	1.3
2020	14.3	5.9	6.9	4.9	8.1	6.6	4.8	2.8	4.5	3.5	4.7	1.5	1.1	1.0	0.6	0.9	2.2	1.0	0.6	0.2	0.1	0.2	0.2	1.3
2021	2.7	12.8	5.3	6.2	4.4	7.1	5.7	4.1	2.4	3.7	2.9	3.9	1.2	0.9	0.8	0.5	0.7	1.8	0.8	0.5	0.2	0.1	0.2	1.2
2022	3.7	2.4	11.5	4.8	5.5	3.9	6.2	4.9	3.5	2.0	3.1	2.4	3.2	1.0	0.8	0.7	0.4	0.6	1.5	0.7	0.4	0.1	0.1	1.2

b)

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1991	3.5	3.4	4.8	9.1	9.5	4.8	3.2	3.0	3.0	1.2	4.3	3.9	1.1	1.0	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.4	0.4	7.9
1992	6.2	3.2	3.0	4.3	8.1	8.5	4.3	2.8	2.7	2.7	1.1	3.8	3.5	1.0	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3	7.3
1993	3.5	5.5	2.8	2.7	3.9	7.3	7.6	3.9	2.5	2.4	2.4	1.0	3.4	3.1	0.9	0.8	0.6	0.4	0.4	0.3	0.3	0.3	0.3	6.8
1994	2.0	3.1	5.0	2.6	2.4	3.5	6.5	6.8	3.4	2.2	2.1	2.1	0.8	3.0	2.7	0.8	0.7	0.5	0.4	0.3	0.3	0.3	0.2	6.3
1995	2.8	1.8	2.8	4.5	2.3	2.2	3.1	5.8	6.0	3.1	2.0	1.9	1.9	0.8	2.7	2.4	0.7	0.6	0.5	0.3	0.3	0.2	0.2	5.8
1996	4.7	2.5	1.6	2.5	4.0	2.0	1.9	2.8	5.2	5.4	2.7	1.8	1.7	1.6	0.7	2.4	2.1	0.6	0.6	0.4	0.3	0.2	0.2	5.3
1997	8.1	4.2	2.3	1.4	2.2	3.6	1.8	1.7	2.5	4.6	4.8	2.4	1.6	1.5	1.5	0.6	2.1	1.9	0.5	0.5	0.4	0.3	0.2	4.9
1998	7.0	7.3	3.8	2.0	1.3	2.0	3.2	1.6	1.5	2.2	4.1	4.2	2.1	1.4	1.3	1.3	0.5	1.9	1.7	0.5	0.4	0.3	0.2	4.5
1999	7.5	6.3	6.5	3.4	1.8	1.1	1.8	2.8	1.5	1.4	1.9	3.6	3.7	1.9	1.2	1.2	1.1	0.5	1.6	1.5	0.4	0.4	0.3	4.2
2000	3.4	6.7	5.6	5.8	3.0	1.6	1.0	1.6	2.5	1.3	1.2	1.7	3.2	3.3	1.7	1.1	1.0	1.0	0.4	1.5	1.3	0.4	0.3	4.0
2001	4.9	3.0	6.0	5.0	5.2	2.7	1.4	0.9	1.4	2.2	1.1	1.1	1.5	2.8	2.9	1.5	1.0	0.9	0.9	0.4	1.3	1.2	0.3	3.9
2002	11.4	4.4	2.7	5.4	4.5	4.7	2.4	1.3	0.8	1.3	2.0	1.0	1.0	1.3	2.5	2.6	1.3	0.8	0.8	0.8	0.3	1.1	1.0	3.7
2003	16.8	10.2	4.0	2.4	4.8	4.0	4.2	2.2	1.1	0.7	1.1	1.8	0.9	0.8	1.2	2.2	2.3	1.2	0.8	0.7	0.7	0.3	1.0	4.2
2004	29.0	15.0	9.1	3.6	2.2	4.3	3.6	3.7	1.9	1.0	0.6	1.0	1.6	0.8	0.7	1.1	2.0	2.0	1.0	0.7	0.6	0.6	0.3	4.6
2005	9.3	26.0	13.5	8.2	3.2	1.9	3.9	3.2	3.3	1.7	0.9	0.6	0.9	1.4	0.7	0.7	0.9	1.7	1.8	0.9	0.6	0.6	0.5	4.3
2006	4.5	8.4	23.3	12.1	7.3	2.8	1.7	3.5	2.8	2.9	1.5	0.8	0.5	0.8	1.2	0.6	0.6	0.8	1.5	1.6	0.8	0.5	0.5	4.3
2007	6.3	4.1	7.5	20.8	10.8	6.6	2.5	1.5	3.1	2.5	2.6	1.3	0.7	0.4	0.7	1.1	0.5	0.5	0.7	1.4	1.4	0.7	0.5	4.2
2008	5.9	5.6	3.6	6.7	18.7	9.7	5.9	2.3	1.4	2.7	2.2	2.3	1.2	0.6	0.4	0.6	0.9	0.5	0.5	0.6	1.2	1.2	0.6	4.1
2009	6.7	5.3	5.0	3.3	6.0	16.6	8.5	5.1	1.9	1.2	2.3	1.9	1.9	1.0	0.5	0.3	0.5	0.8	0.4	0.4	0.5	1.0	1.0	4.0
2010	17.3	6.0	4.8	4.5	2.9	5.3	14.5	7.3	4.2	1.6	0.9	1.8	1.5	1.5	0.8	0.4	0.3	0.4	0.6	0.3	0.3	0.4	0.8	3.9
2011	10.9	15.5	5.4	4.2	4.0	2.6	4.6	11.9	5.6	3.1	1.1	0.7	1.3	1.1	1.1	0.6	0.3	0.2	0.3	0.4	0.2	0.2	0.3	3.4
2012	11.9	9.7	13.9	4.8	3.8	3.5	2.2	3.9	9.9	4.6	2.5	0.9	0.5	1.0	0.8	0.9	0.4	0.2	0.1	0.2	0.4	0.2	0.2	2.9
2013	6.4	10.7	8.7	12.4	4.3	3.4	3.1	1.9	3.2	8.1	3.7	2.0	0.7	0.4	0.8	0.7	0.7	0.4	0.2	0.1	0.2	0.3	0.1	2.5
2014	9.6	5.7	9.5	7.8	11.1	3.8	3.0	2.7	1.6	2.7	6.6	3.0	1.6	0.6	0.3	0.7	0.5	0.6	0.3	0.2	0.1	0.1	0.2	2.1
2015	11.5	8.6	5.1	8.5	7.0	9.9	3.4	2.6	2.3	1.3	2.2	5.5	2.5	1.4	0.5	0.3	0.6	0.4	0.5	0.2	0.1	0.1	0.1	2.0
2016	12.6	10.3	7.7	4.6	7.6	6.2	8.7	2.9	2.2	1.9	1.1	1.9	4.6	2.1	1.1	0.4	0.2	0.5	0.4	0.4	0.2	0.1	0.1	1.7
2017	6.9	11.3	9.3	6.9	4.1	6.8	5.5	7.6	2.5	1.9	1.6	1.0	1.6	3.9	1.8	1.0	0.3	0.2	0.4	0.3	0.3	0.2	0.1	1.5
2018	8.6	6.2	10.1	8.3	6.1	3.7	6.0	4.8	6.6	2.2	1.6	1.4	0.8	1.3	3.3	1.5	0.8	0.3	0.2	0.3	0.3	0.3	0.1	1.4
2019	6.6	7.7	5.5	9.0	7.4	5.5	3.3	5.3	4.2	5.7	1.9	1.4	1.2	0.7	1.2	2.8	1.3	0.7	0.3	0.1	0.3	0.2	0.2	1.3
2020	14.3	6.0	6.9	5.0	8.1	6.6	4.9	2.9	4.6	3.6	4.9	1.6	1.2	1.0	0.6	1.0	2.4	1.1	0.6	0.2	0.1	0.2	0.2	1.3
2021	2.7	12.8	5.3	6.2	4.4	7.2	5.8	4.2	2.4	3.9	3.0	4.0	1.3	1.0	0.8	0.5	0.8	2.0	0.9	0.5	0.2	0.1	0.2	1.2
2022	3.7	2.4	11.5	4.8	5.5	3.9	6.4	5.1	3.6	2.0	3.2	2.5	3.4	1.1	0.8	0.7	0.4	0.7	1.6	0.7	0.4	0.1	0.1	1.2

Table 7-9. Annual fishing mortality at full selection and exploitation rates for Kamchatka flounder.

	16.0b		16.0b (2022)	
Year	F	Exploitation	F	Exploitation
1991	0.02	0.01	0.02	0.01
1992	0.01	0.01	0.01	0.01
1993	0.01	0.01	0.01	0.01
1994	0.01	0.01	0.01	0.01
1995	0.01	0.01	0.01	0.01
1996	0.01	0.01	0.01	0.01
1997	0.01	0.01	0.01	0.01
1998	0.01	0.01	0.01	0.01
1999	0.01	0.01	0.01	0.01
2000	0.01	0.01	0.01	0.01
2001	0.01	0.01	0.01	0.01
2002	0.01	0.01	0.01	0.01
2003	0.01	0.01	0.01	0.01
2004	0.02	0.01	0.02	0.01
2005	0.01	0.01	0.01	0.01
2006	0.01	0.05	0.01	0.01
2007	0.01	0.08	0.01	0.01
2008	0.07	0.14	0.07	0.05
2009	0.12	0.08	0.13	0.09
2010	0.22	0.08	0.23	0.15
2011	0.11	0.06	0.12	0.08
2012	0.11	0.05	0.11	0.08
2013	0.09	0.04	0.10	0.07
2014	0.08	0.04	0.08	0.06
2015	0.06	0.03	0.07	0.04
2016	0.06	0.02	0.06	0.04
2017	0.05	0.03	0.06	0.04
2018	0.03	0.05	0.04	0.03
2019	0.05	0.07	0.05	0.04
2020	0.08	0.09	0.08	0.06
2021	-	-	0.07	0.05
2022	-	-	0.10	0.07

Table 7.10. Projections of catch (t), total biomass (t), spawning biomass (t), and fishing mortality rate for each of the seven management scenarios and for the preferred assessment model (model 16.b). The value of $B_{40\%}$ and $B_{35\%}$ are 37,748 t and 33,029 t, respectively. The 2022 estimates of OFL and ABC are different that the specified values for 2022 and reflect changes in the model.

Year	Catch	Total biomass	SSB	F	OFL	ABC
			Alternative 1			
2022	8,661	126,067	48,830	0.10	9,151	7,753
2023	7,579	121,977	47,927	0.09	8,946	7,579
2024	7,435	118,713	47,387	0.09	8,776	7,435
2025	7,270	115,454	46,674	0.09	8,581	7,270
2026	7,096	112,337	45,756	0.09	8,375	7,096
2027	6,878	109,580	44,667	0.09	8,117	6,878
2028	6,607	107,207	43,402	0.09	7,797	6,607
2029	6,352	105,385	41,991	0.09	7,496	6,352
2030	6,169	104,189	40,529	0.09	7,282	6,169
2031	6,049	103,376	39,222	0.09	7,138	6,049
2032	5,901	102,938	38,247	0.08	6,962	5,901
2033	5,800	102,784	37,663	0.08	6,843	5,800
2034	5,755	102,873	37,370	0.08	6,791	5,755
2035	5,745	103,047	37,286	0.08	6,779	5,745
2036	5,759	103,252	37,324	0.08	6,796	5,759
			Alternative 2			
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	7,753
2023	7,579	121,977	47,927	0.09	8,946	7,579
2024	7,435	118,713	47,387	0.09	8,776	7,435
2025	7,270	115,454	46,674	0.09	8,581	7,270
2026	7,096	112,337	45,756	0.09	8,375	7,096
2027	6,878	109,580	44,667	0.09	8,117	6,878
2028	6,607	107,207	43,402	0.09	7,797	6,607
2029	6,352	105,385	41,991	0.09	7,496	6,352
2030	6,169	104,189	40,529	0.09	7,282	6,169
2031	6,049	103,376	39,222	0.09	7,138	6,049
2032	5,901	102,938	38,247	0.08	6,962	5,901
2033	5,800	102,784	37,663	0.08	6,843	5,800
2034	5,755	102,873	37,370	0.08	6,791	5,755
2035	5,745	103,047	37,286	0.08	6,779	5,745
2036	5,759	103,252	37,324	0.08	6,796	5,759

Table 7-10. Continued. Projections of catch (t), total biomass (t), spawning biomass (t), and fishing mortality rate for each of the seven management scenarios and for the preferred assessment model (model 16.b). The value of $B_{40\%}$ and $B_{35\%}$ are 37,748 t and 33,029 t, respectively. The 2022 estimates of OFL and ABC are different that the specified values for 2022 and reflect changes in the model.

Alternative 3						
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	6,214
2023	6,075	121,977	47,996	0.07	8,946	6,075
2024	6,054	120,270	48,256	0.07	8,914	6,054
2025	6,007	118,398	48,308	0.07	8,844	6,007
2026	5,942	116,494	48,096	0.07	8,749	5,942
2027	5,833	114,778	47,642	0.07	8,588	5,833
2028	5,671	113,271	46,930	0.07	8,348	5,671
2029	5,511	112,147	45,988	0.07	8,113	5,511
2030	5,398	111,503	44,902	0.07	7,948	5,398
2031	5,337	111,129	43,884	0.07	7,858	5,337
2032	5,310	111,038	43,126	0.07	7,819	5,310
2033	5,305	111,079	42,671	0.07	7,812	5,305
2034	5,312	111,241	42,438	0.07	7,808	5,312
2035	5,325	111,422	42,377	0.07	7,810	5,325
2036	5,341	111,604	42,418	0.07	7,818	5,341
Alternative 4						
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	3,945
2023	3,857	121,977	48,095	0.04	8,946	3,857
2024	3,932	122,567	49,542	0.04	9,117	3,932
2025	3,985	122,827	50,775	0.04	9,240	3,985
2026	4,021	122,867	51,703	0.04	9,322	4,021
2027	4,022	122,898	52,317	0.04	9,323	4,022
2028	3,981	122,919	52,582	0.04	9,227	3,981
2029	3,931	123,098	52,509	0.04	9,112	3,931
2030	3,903	123,552	52,165	0.04	9,049	3,903
2031	3,900	124,107	51,764	0.04	9,043	3,900
2032	3,915	124,812	51,523	0.04	9,077	3,915
2033	3,939	125,547	51,515	0.04	9,134	3,939
2034	3,967	126,309	51,670	0.04	9,199	3,967
2035	3,997	127,022	51,955	0.04	9,267	3,997
2036	4,026	127,674	52,307	0.04	9,335	4,026

Table 7-10. Continued. Projections of catch (t), total biomass (t), spawning biomass (t), and fishing mortality rate for each of the seven management scenarios and for the preferred assessment model (model 16.b). The value of $B_{40\%}$ and $B_{35\%}$ are 37,748 t and 33,029 t, respectively. The 2022 estimates of OFL and ABC are different that the specified values for 2022 and reflect changes in the model.

Alternative 5						
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	0
2023	0	121,977	48,263	0.00	8,946	0
2024	0	126,563	51,791	0.00	9,470	0
2025	0	130,776	55,232	0.00	9,951	0
2026	0	134,665	58,432	0.00	10,386	0
2027	0	138,387	61,321	0.00	10,729	0
2028	0	141,873	63,804	0.00	10,955	0
2029	0	145,245	65,848	0.00	11,137	0
2030	0	148,613	67,465	0.00	11,342	0
2031	0	151,830	68,840	0.00	11,581	0
2032	0	154,985	70,215	0.00	11,840	0
2033	0	157,985	71,700	0.00	12,106	0
2034	0	160,826	73,231	0.00	12,363	0
2035	0	163,465	74,802	0.00	12,609	0
2036	0	165,902	76,354	0.00	12,842	0
Alternative 6						
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	9,151
2023	8,946	121,977	47,864	0.10	8,946	8,946
2024	8,651	117,298	46,598	0.10	8,651	8,651
2025	8,346	112,820	45,217	0.10	8,346	8,346
2026	8,046	108,673	43,702	0.10	8,046	8,046
2027	7,709	105,064	42,096	0.10	7,709	7,709
2028	7,325	102,012	40,396	0.10	7,325	7,325
2029	6,976	99,670	38,635	0.10	6,976	6,976
2030	6,556	98,088	36,916	0.10	6,556	6,556
2031	6,194	97,161	35,521	0.10	6,194	6,194
2032	5,987	96,875	34,607	0.09	5,987	5,987
2033	5,901	96,938	34,125	0.09	5,901	5,901
2034	5,886	97,232	33,936	0.09	5,886	5,886
2035	5,914	97,575	33,944	0.09	5,914	5,914
2036	5,962	97,907	34,057	0.09	5,962	5,962

Table 7-10. Continued. Projections of catch (t), total biomass (t), spawning biomass (t), and fishing mortality rate for each of the seven management scenarios and for the preferred assessment model (model 16.b). The value of $B_{40\%}$ and $B_{35\%}$ are 37,748 t and 33,029 t, respectively. The 2022 estimates of OFL and ABC are different that the specified values for 2022 and reflect changes in the model.

		Alternative 7				
Year	Catch	Total biomass	SSB	F	OFL	ABC
2022	8,661	126,067	48,830	0.10	9,151	9,151
2023	7,579	121,977	47,927	0.09	8,946	8,946
2024	7,435	118,713	47,387	0.09	8,776	8,776
2025	8,581	115,454	46,612	0.10	8,581	8,581
2026	8,255	110,983	44,992	0.10	8,255	8,255
2027	7,893	107,070	43,267	0.10	7,893	7,893
2028	7,484	103,737	41,440	0.10	7,484	7,484
2029	7,112	101,143	39,551	0.10	7,112	7,112
2030	6,771	99,338	37,705	0.10	6,771	6,771
2031	6,371	98,114	36,143	0.10	6,371	6,371
2032	6,120	97,580	35,086	0.09	6,120	6,120
2033	5,997	97,450	34,489	0.09	5,997	5,997
2034	5,956	97,597	34,207	0.09	5,956	5,956
2035	5,964	97,831	34,141	0.09	5,964	5,964
2036	5,996	98,080	34,197	0.09	5,996	5,996

Table 7-11. Non-target catch (t) when Kamchatka flounder were fishery targets, 2011-2020.

Species Group Name	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Benthic urochordata	0.04		0.04	0.07	0.25				0.01	0.00	0.00	
Bivalves			0.01		0.00	0.00				0.00	0.00	0.01
Bristlemouths		0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brittle star unidentified	0.01	0.01	0.22	0.93		0.05				0.00		
Capelin	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corals Bryozoans - Corals Bryozoans Unidentified	1.57	0.67	0.14	0.35		0.14	1.34	0.37	0.93	0.14		0.20
Eelpouts	6.79	4.53	4.74	2.58	0.62	2.71	2.52	1.49	4.04	10.98	23.65	15.58
Eulachon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Giant Grenadier	605.8	700.	995.	189.7	124.	301.	76.	171.	305.	419.	2179.	969.
Greenlings		0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grenadier - Rattail Grenadier Unidentified	272.			118.			2.14	0.41	0.00		392.38	
Hermit crab unidentified	0.02		0.03	0.01	0.00		0.00		0.00	0.00		
Invertebrate unidentified					0.00						0.55	5.64
Lanternfishes (myctophidae)	0.52	0.44	0.06	0.00		0.00		0.30	0.02	0.04		0.11
Misc crabs	0.07	0.01	1.39	1.00	0.03	0.05	0.12	0.03	0.02	0.02	0.28	0.24
Misc crustaceans	0.03			0.00	0.00		0.00	0.27		0.00		0.00
Misc deep fish	0.30	0.10	0.00	0.00	0.00	0.00				0.00		
Misc fish	9.43	7.29	4.32	2.97	0.56	0.36	1.45	0.32	0.16	0.20	1.78	0.87
Misc inverts (worms etc)	0.01	0.01	0.01							0.00	0.01	0.01

Table 7-11. Continued.

Species Group Name	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Other osmerids		0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Pacific Sand lance		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pandalid shrimp	0.18	0.16	0.28	0.48	0.04	0.04	0.28	0.13	0.16	0.07	0.04	0.36
Polychaete unidentified		0.00		0.01		0.00			0.00	0.00		
Saffron Cod	0.00	0.00				0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sculpin	42.09	13.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scypho jellies	0.18	1.31	1.17	0.78	0.03	0.00	0.68		0.22	0.04	0.02	
Sea anemone unidentified	0.45	0.11	2.82	2.82	0.87	0.47		0.14	0.08		0.69	1.18
Sea pens whips			0.07				0.00			0.00	0.00	
Sea star	1.83	0.55	4.18	6.33	2.42	0.40	0.83	1.70	0.63	0.69	0.81	3.05
Snails	0.05	0.02	0.13	0.13	0.03						0.08	0.14
Sponge unidentified	6.46	2.57	2.73	4.04	0.46	1.57	6.55	11.54	1.78	1.23	0.46	18.69
Squid	92.29	146.64	82.65	36.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
State-managed Rockfish			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stichaeidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
urchins dollars cucumbers	0.34	0.05	0.16	0.26	0.07	0.16		0.12	0.32	0.23	0.59	0.54

Table 7-12. Prohibited species catch when Kamchatka flounder were fishery targets, 2011-2020. Catch of halibut is in tons and crab, herring, and salmon are in number of fish.

Species Group Name	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Bairdi Tanner Crab	128	5	620	306	8	101	0	0	0	0	19	158
Blue King Crab	0	0	0	0	0	0	0	0	0	0	0	0
Chinook Salmon	0	0	0	0	0	0	0	0	0	0	0	0
Golden (Brown) King Crab	3,014	1,010	1,998	2,670	631	3,259	4,000	3,052	8,348	2,927	6,215	10,622
Halibut	71	81	72	55	9	33	22	58	19	52	128	120
Herring	0	0	0	0	0	0	0	0	0	0	0	0
Non-Chinook Salmon	71	0	0	0	0	0	0	85	0	0	0	0
Opilio Tanner (Snow) Crab	0	0	190	1,188	457	0	0	0	45	0	0	14
Red King Crab	0	0	0	37	0	0	378	0	0	140	122	0

Table 7-13. Noncommercial catch of Kamchatka flounder in a) number and b) weight, 2010-2019.
a)

Number Collection program	Year										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
AFSC Annual Longline Survey									4	2	4
Aleutian Island Bottom Trawl Survey		5		5		5		5			
Atka Tagging Survey	2										
Bering Sea Slope Survey		6				6					
Eastern Bering Sea Bottom Trawl Survey	9	8	8	9	9	10	9	9	8		9
IPHC Annual Longline Survey	2	3	24	2					4	1	
Northern Bering Sea Bottom Trawl Survey							1	1	1		1
Pollock EFP 11-01		2									
St. Matthews Crab Survey							1				
Summer EBS Survey with Russia		1									

Table 7-13. Continued.
b)

Weight Collection program	Year 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
AFSC Annual Longline Survey									564	1,014	1,095
Aleutian Island Bottom Trawl Survey		5,277		4,750		3,095		5,016			
Atka Tagging Survey	5,853										
Bering Sea Slope Survey		6,702				4,196					
Eastern Bering Sea Bottom Trawl Survey	1,783	1,657	1,767	2,130	2,222	2,069	1,869	1,603	1,638		1,218
IPHC Annual Longline Survey	342	196	245	61	94	38	451	235	215	9	
Northern Bering Sea Bottom Trawl Survey							3	11	2		1
Pollock EFP 11-01		4,961									
St. Matthews Crab Survey							3				
Summer EBS Survey with Russia		0									

Figures

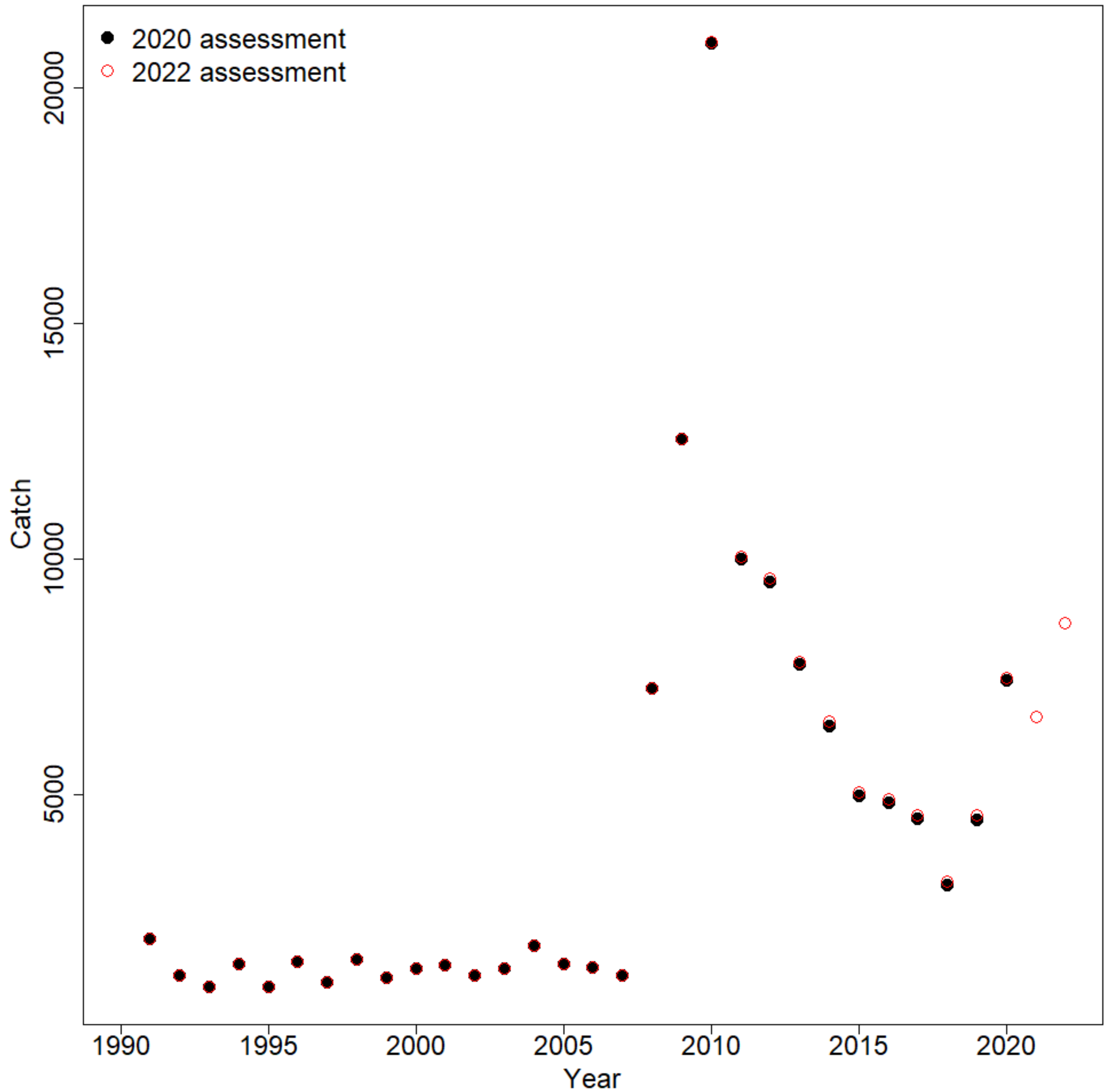


Figure 7-1. Catch in metric tons from the 2020 assessment and the updated data for the 2022 (current) assessment.

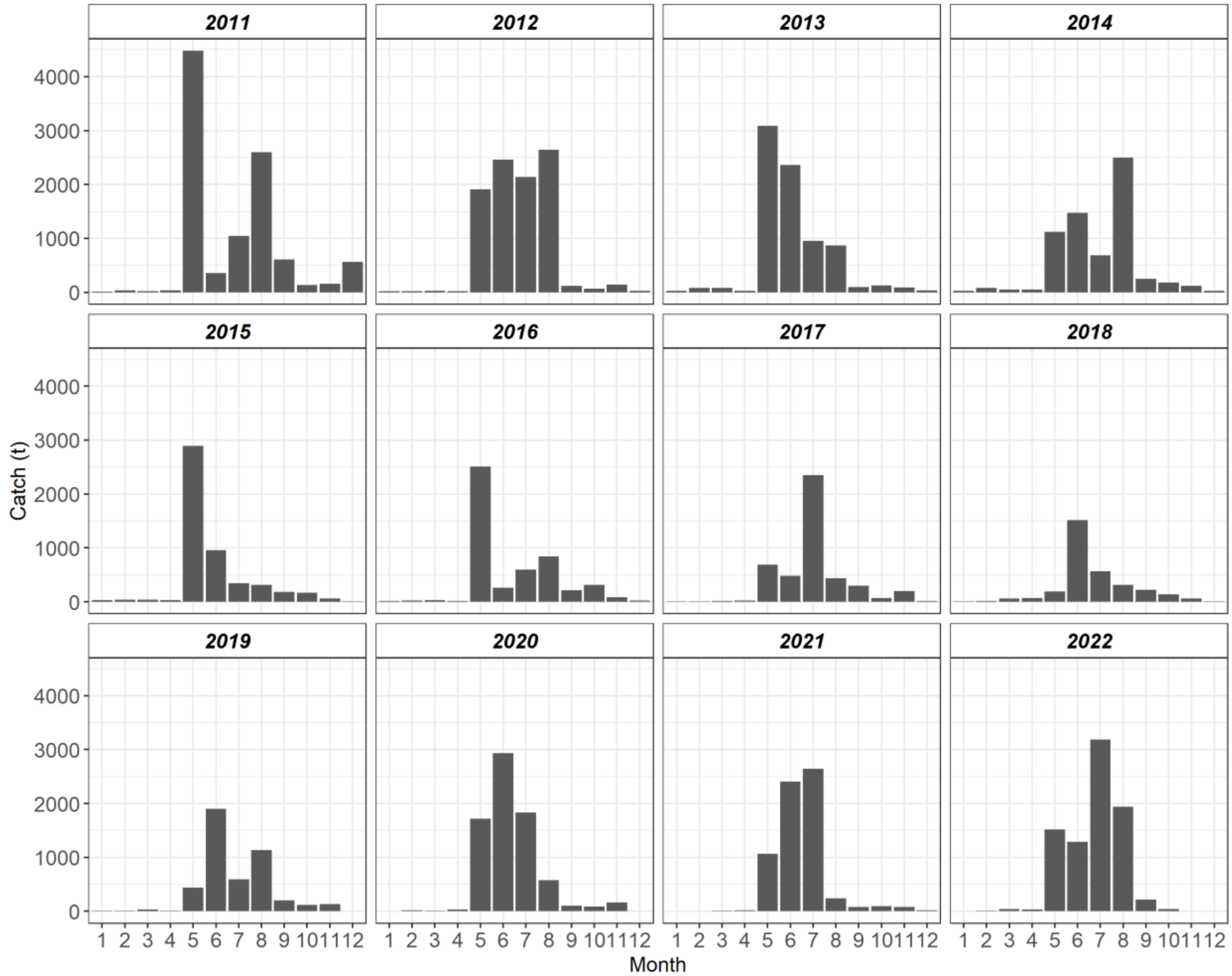
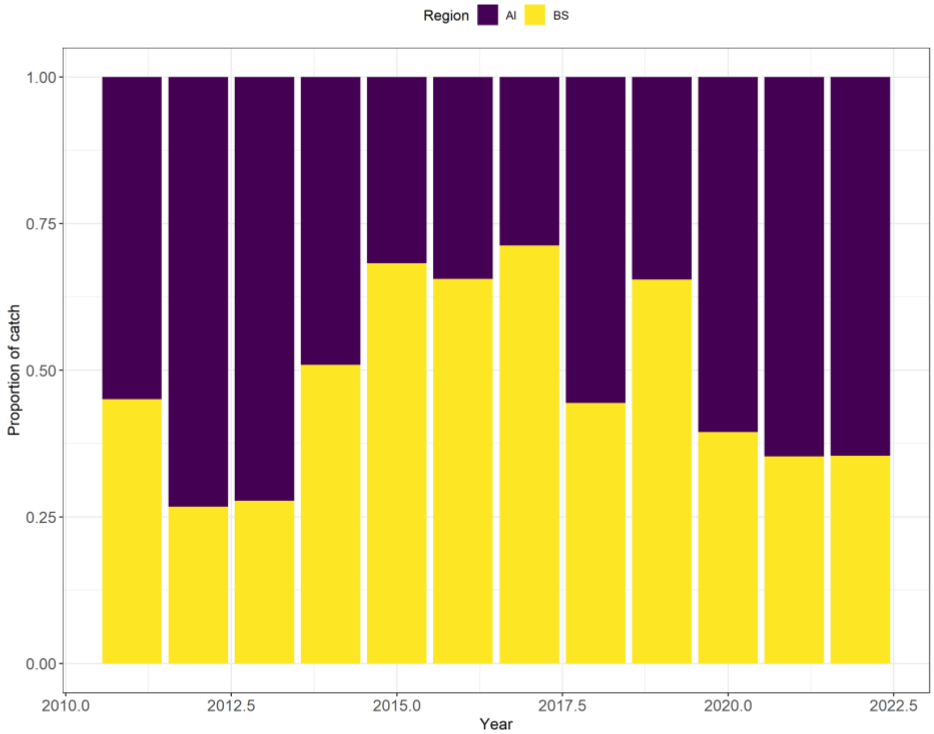


Figure 7-2. Kamchatka flounder catch (t) by month from Alaska Regional Office catch reports for years 2011- 2022. The 2022 data are through October 24, 2022.

a)



b)

Figure 7-3. Proportion of Kamchatka catch by a) region and b) NMFS area. Color scale defines area.

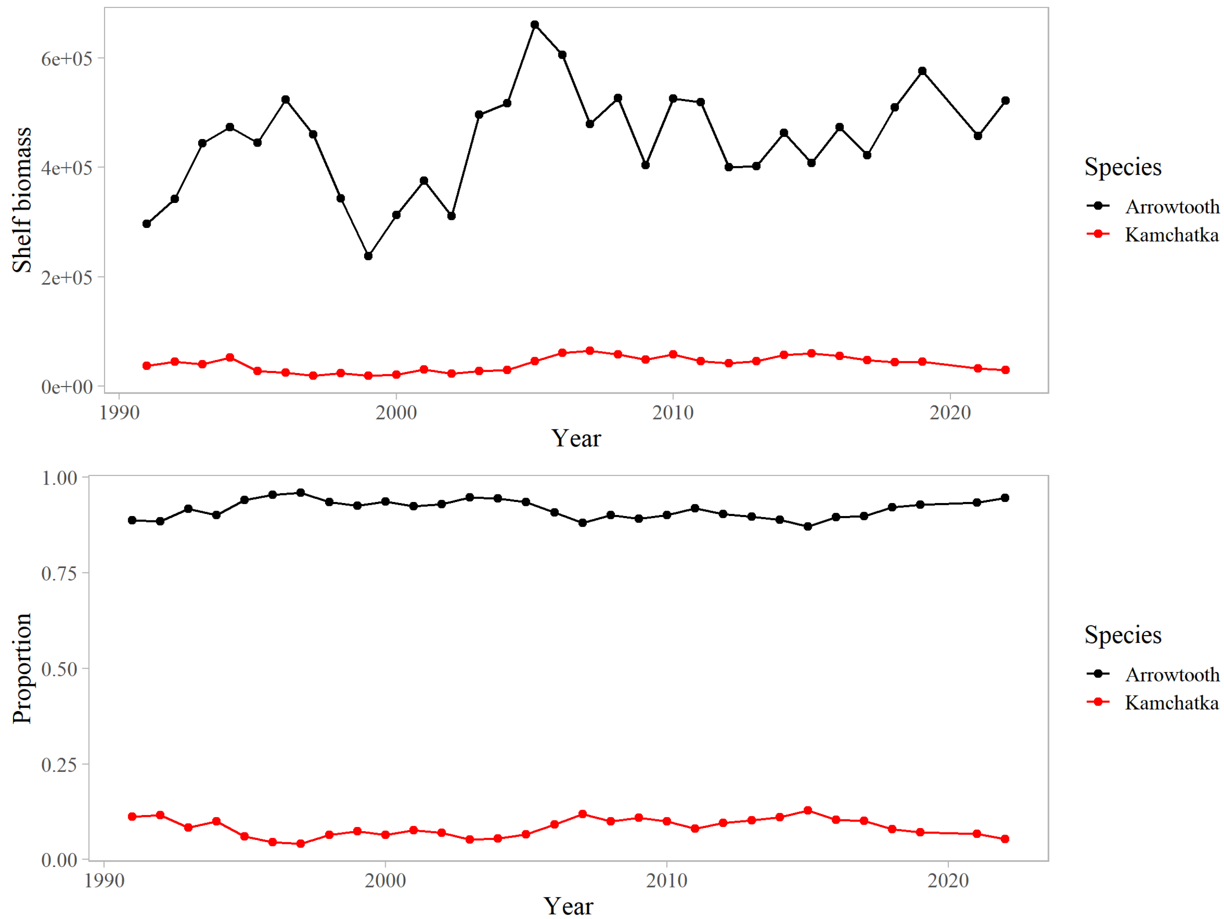


Figure 7-4. RACE EBS trawl survey biomass estimates for arrowtooth flounder and Kamchatka flounder (top panel) and their annual proportions (bottom panel).

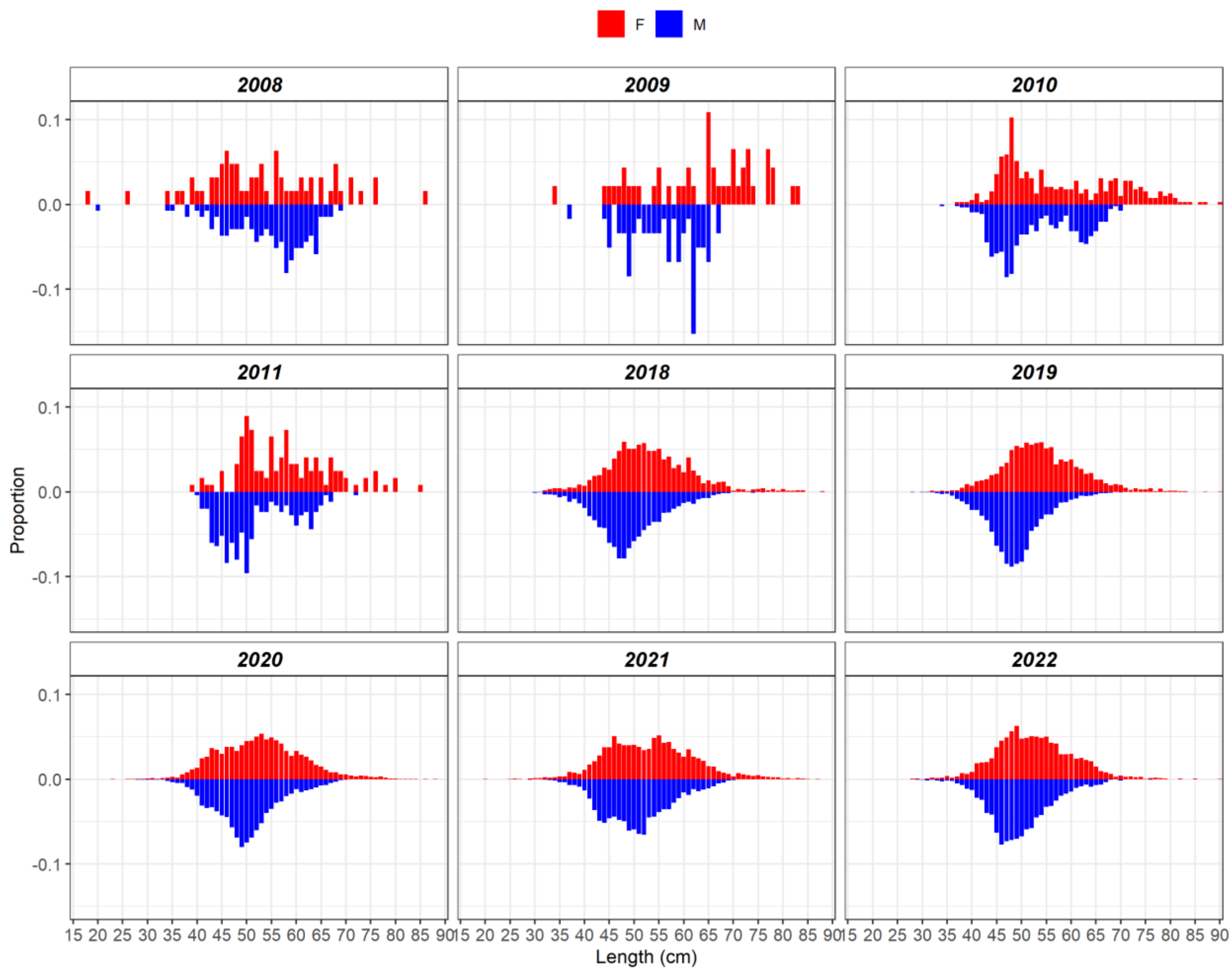


Figure 7-5. Fishery length composition data. Proportions sum to one for each sex. An annual input sample size of 25 per year is used for the fishery length composition data.

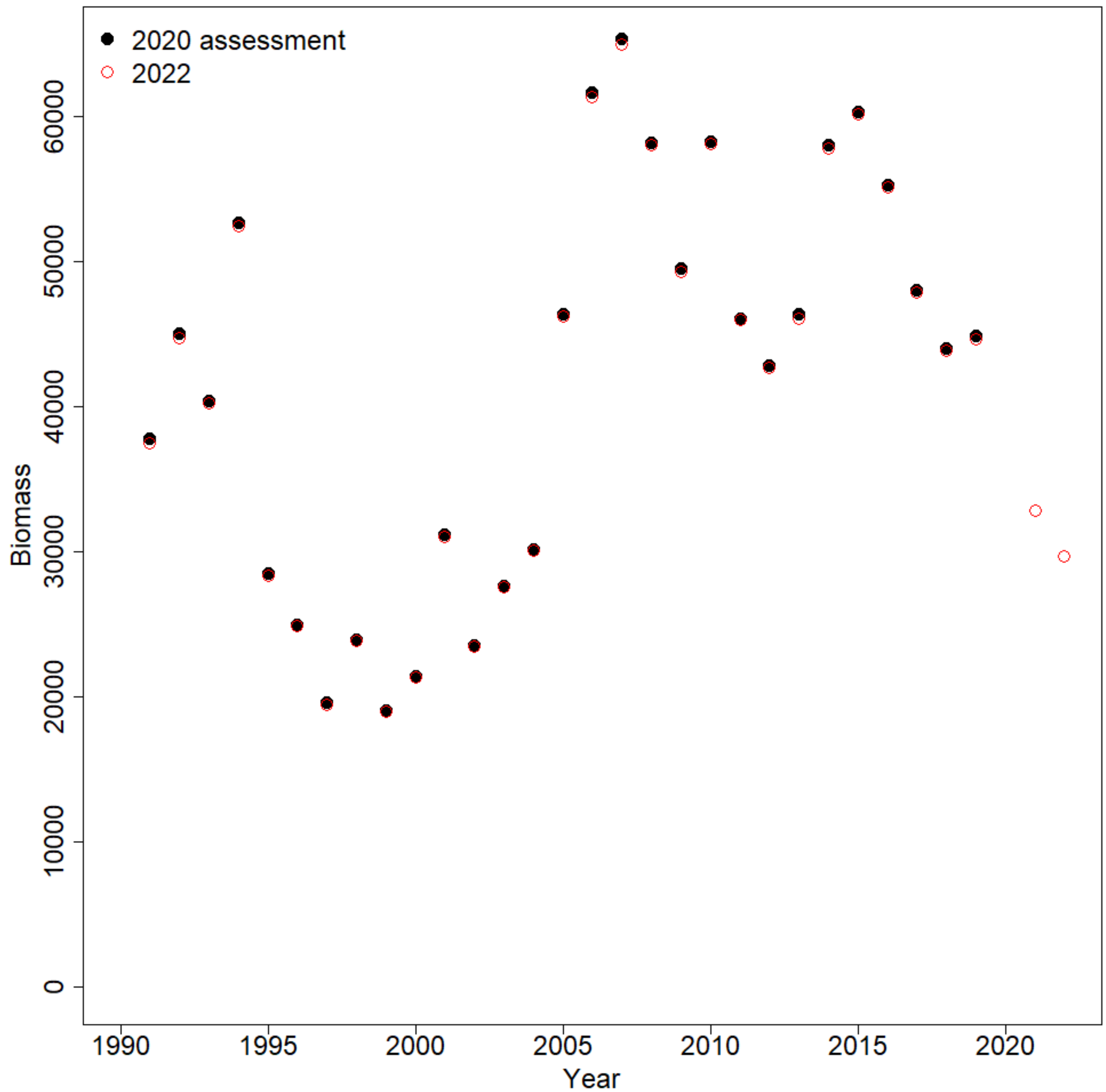


Figure 7-6. The EBS Shelf Bottom Trawl Survey biomass estimates used in the 2020 assessment and the 2022 (current) assessment. The 2020 survey was cancelled.

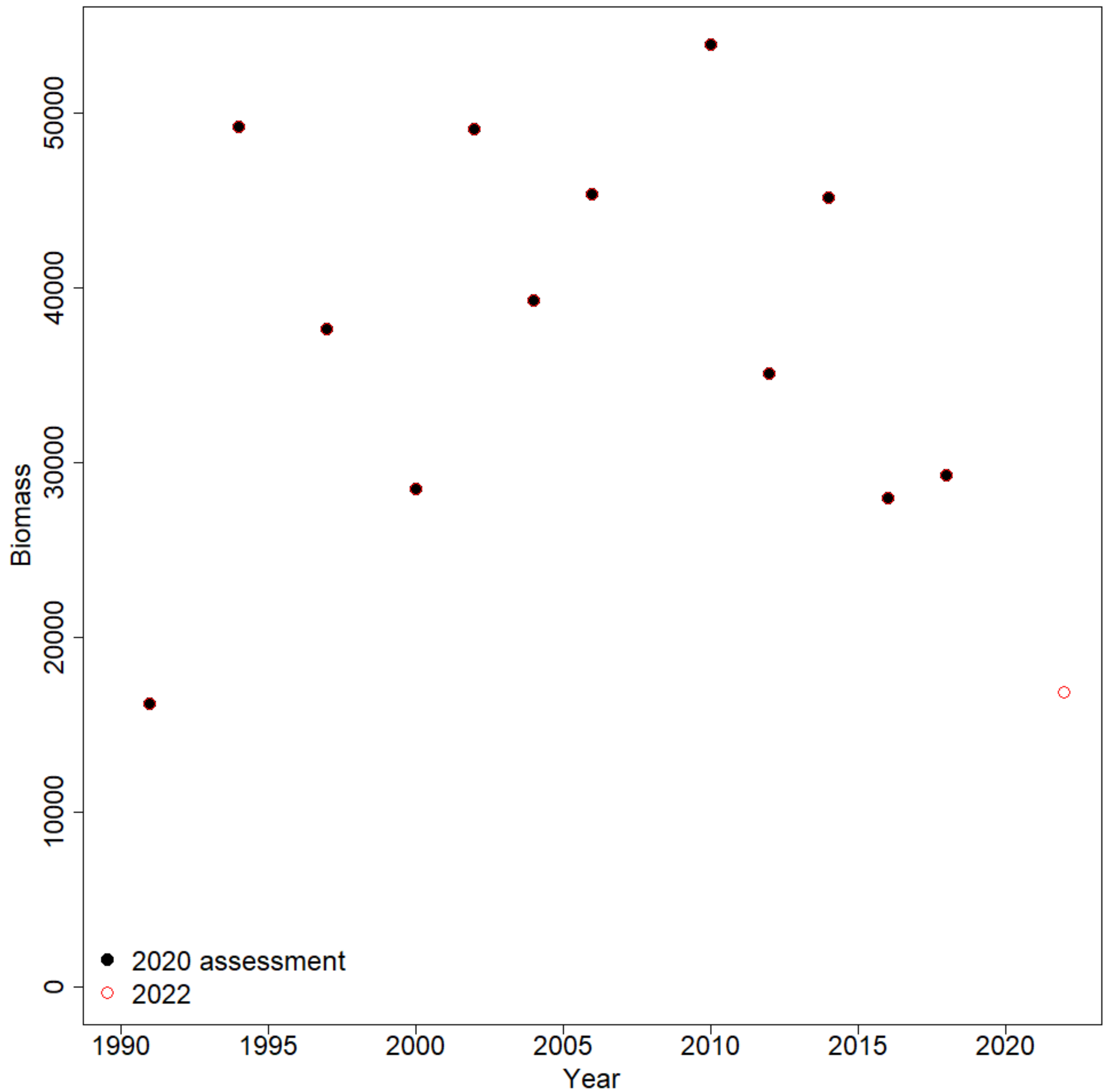


Figure 7-7. The Aleutian Islands Bottom Trawl Survey biomass estimates used in the 2020 assessment and the 2022 (current) assessment. The 2020 survey was cancelled.

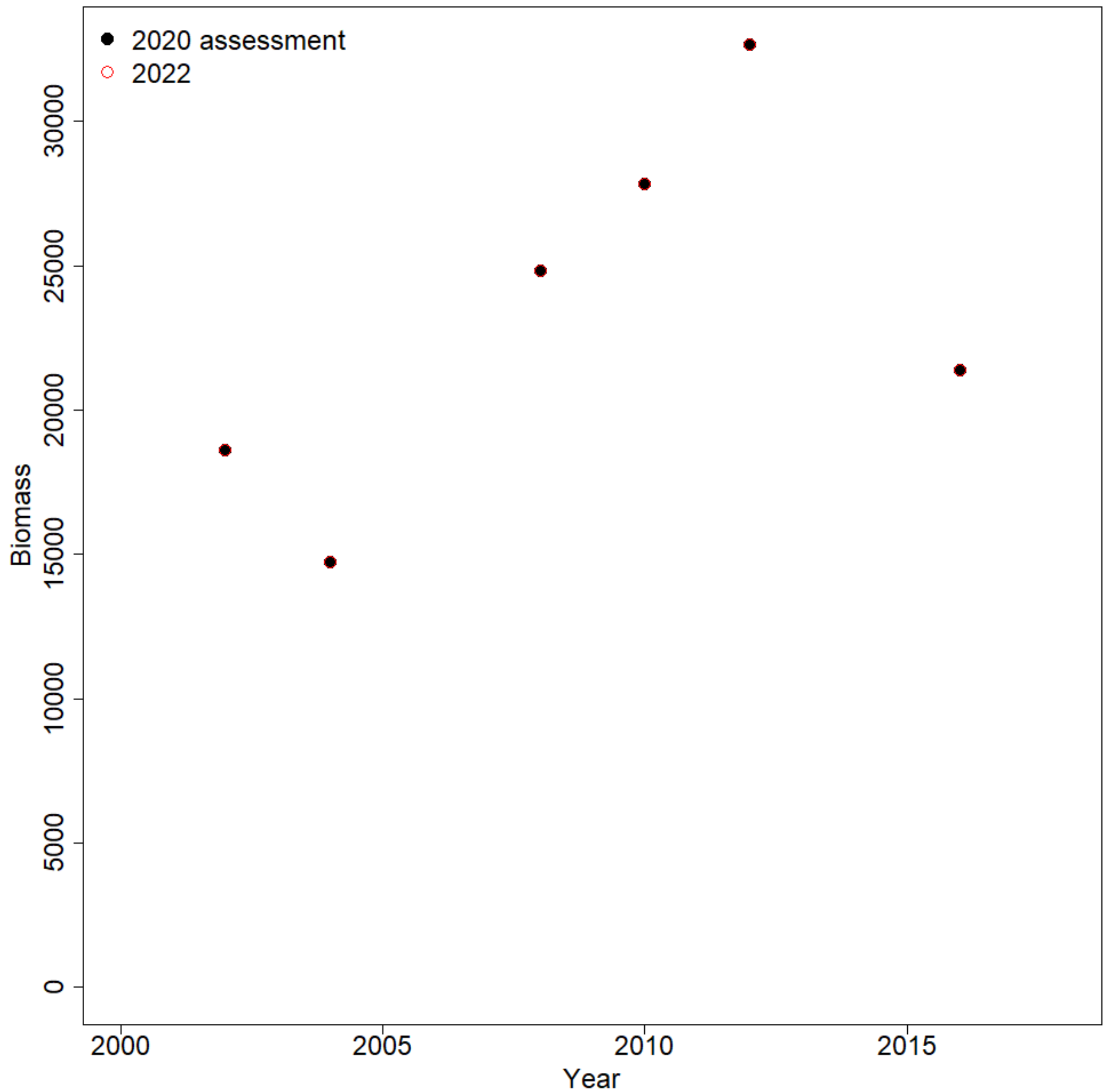


Figure 7-8. The EBS Slope Bottom Trawl Survey biomass estimates used in the 2020 assessment and the 2022 (current) assessment. The slope survey has not been conducted since 2016.

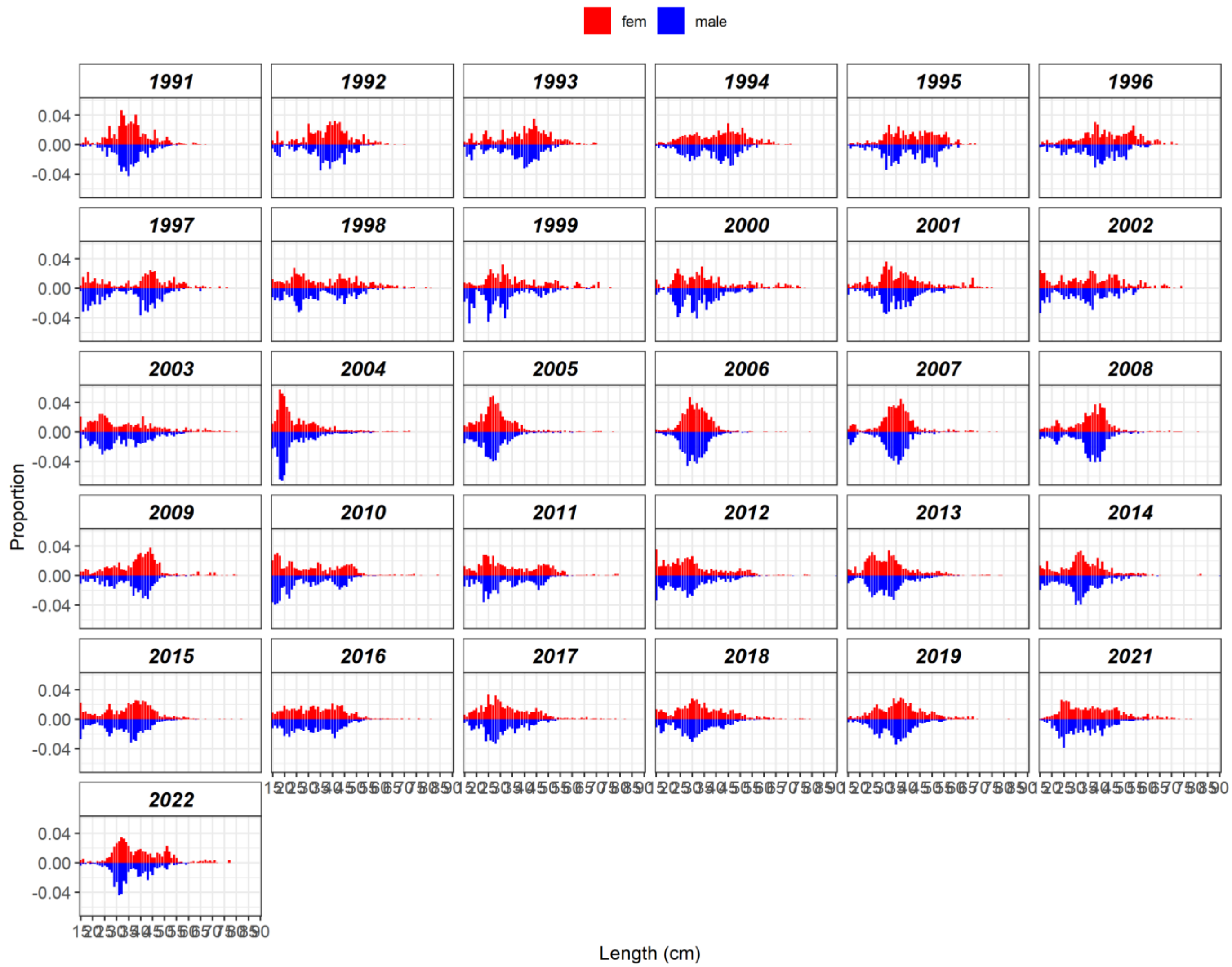


Figure 7-9. The EBS Shelf Bottom trawl survey length composition data normalized to one across sexes.

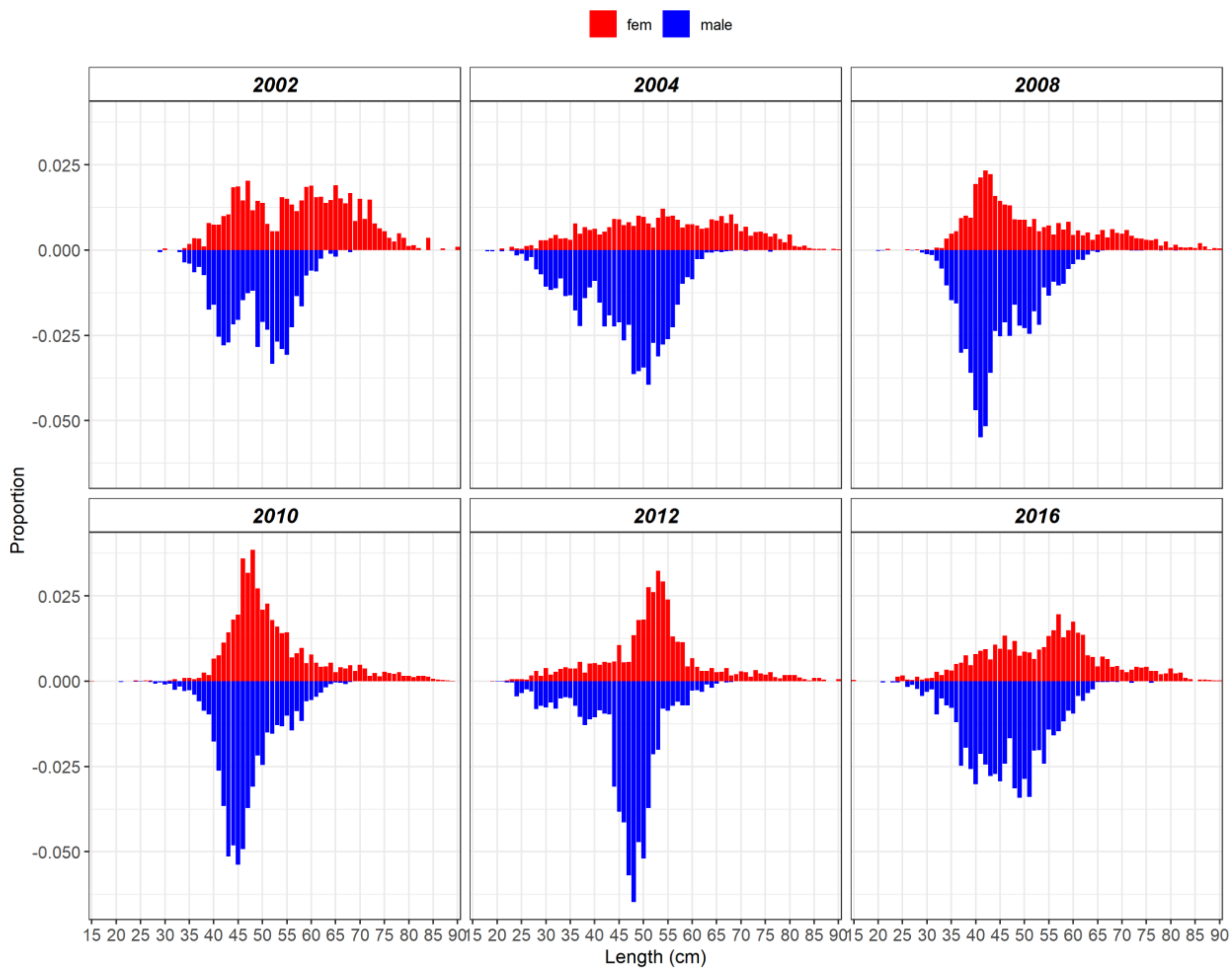


Figure 7-10. The EBS Slope Bottom Trawl Survey length composition data normalized to one across sexes.

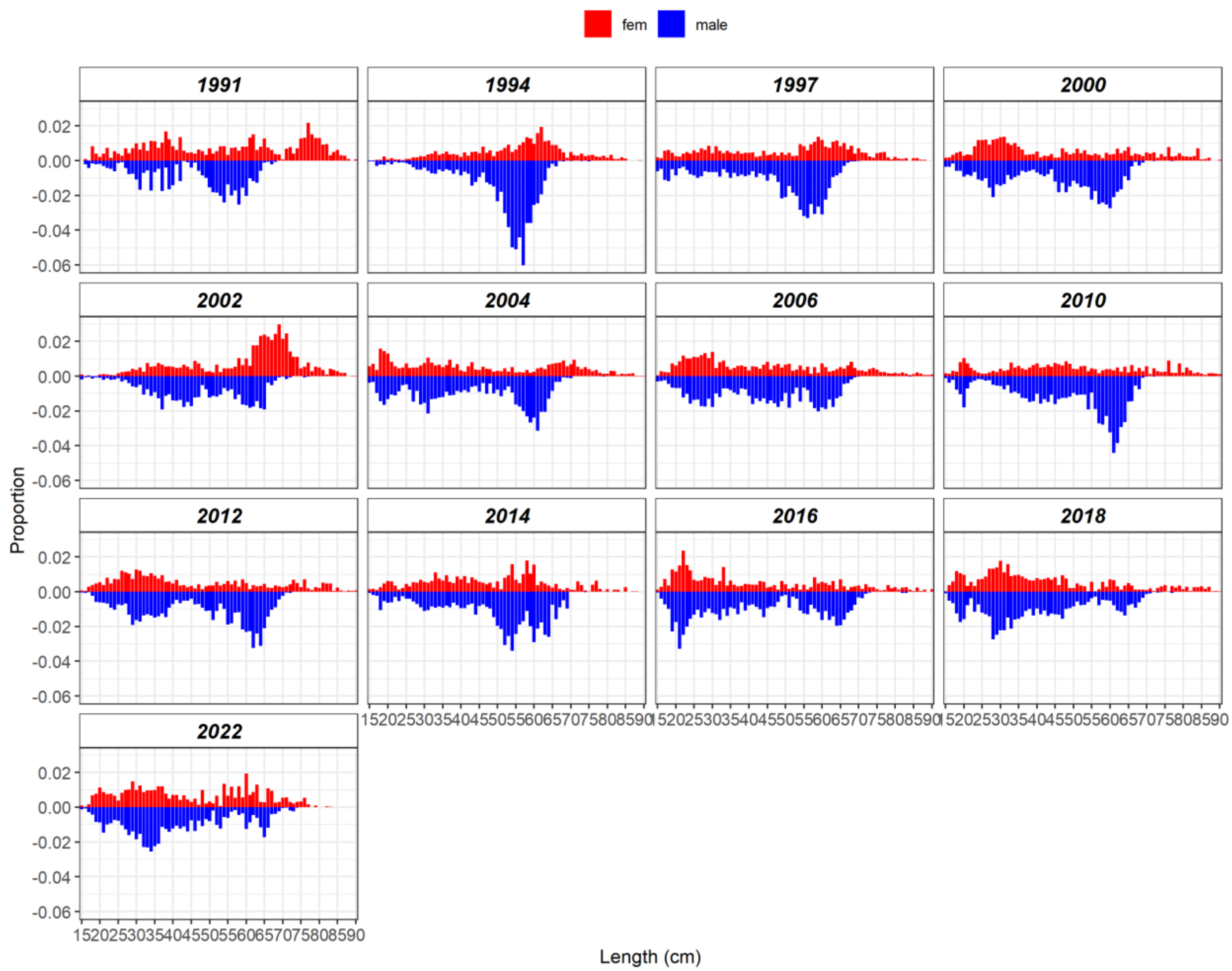


Figure 7-11. The Aleutian Islands Bottom Trawl Survey length composition data normalized to one across sexes.

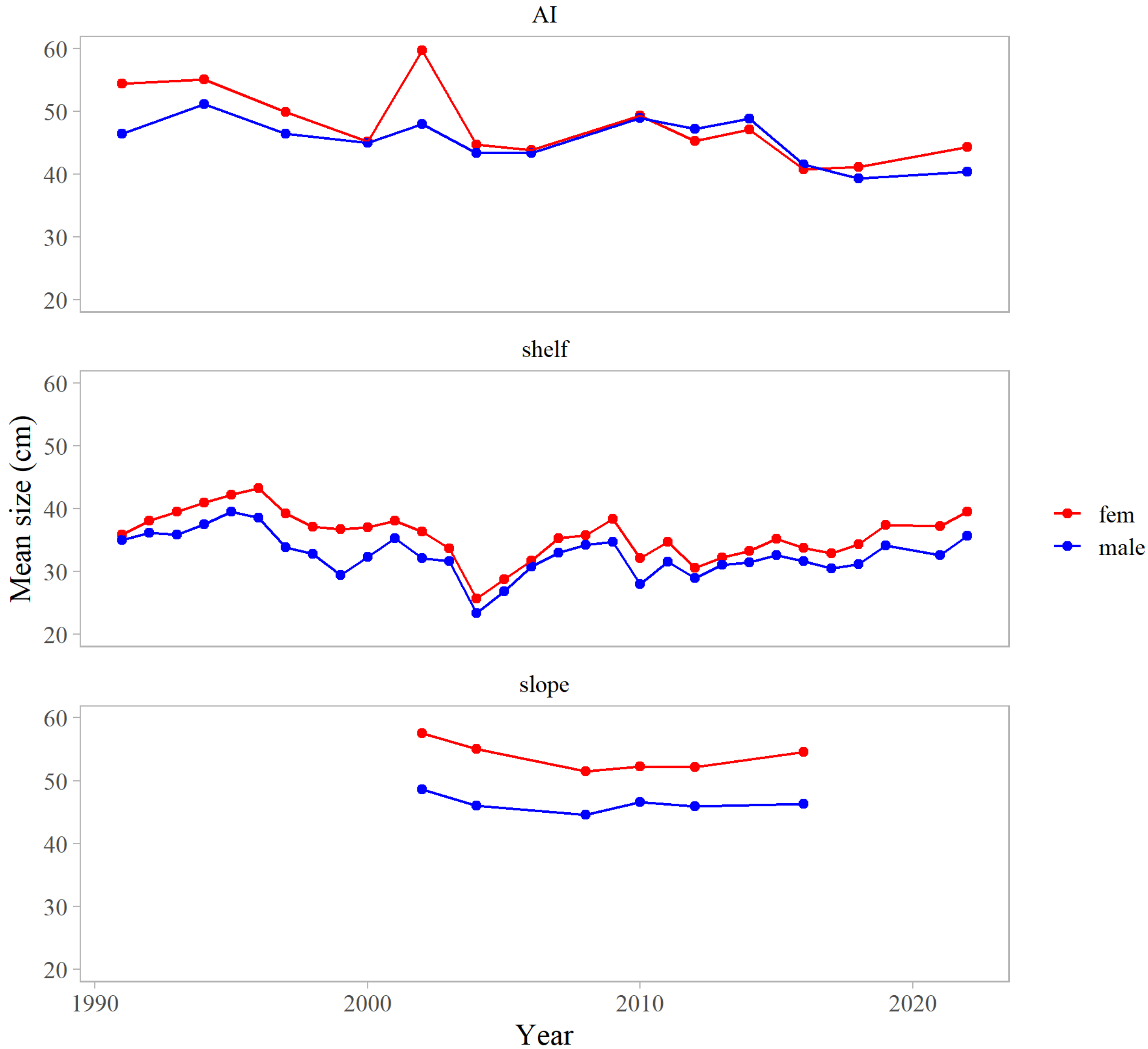


Figure 7-12. Mean length by survey: a) Aleutian Islands bottom trawl survey, b) EBS bottom trawl survey, and c) EBS slope bottom trawl survey.

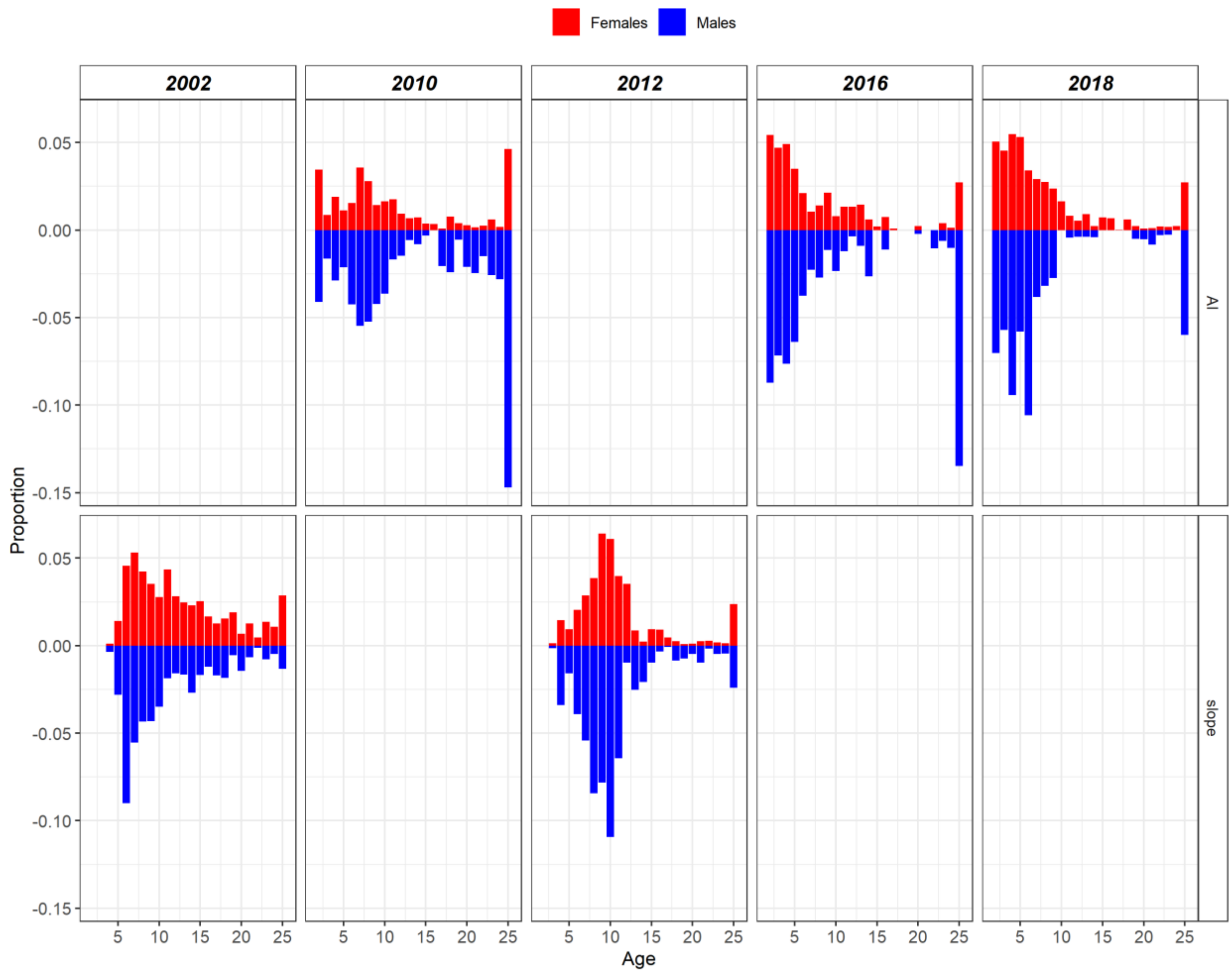


Figure 7-13. Normalized age compositions from the Aleutian Islands bottom trawl survey (top panels) and the EBS slope bottom trawl survey (bottom panels) by sex and year.

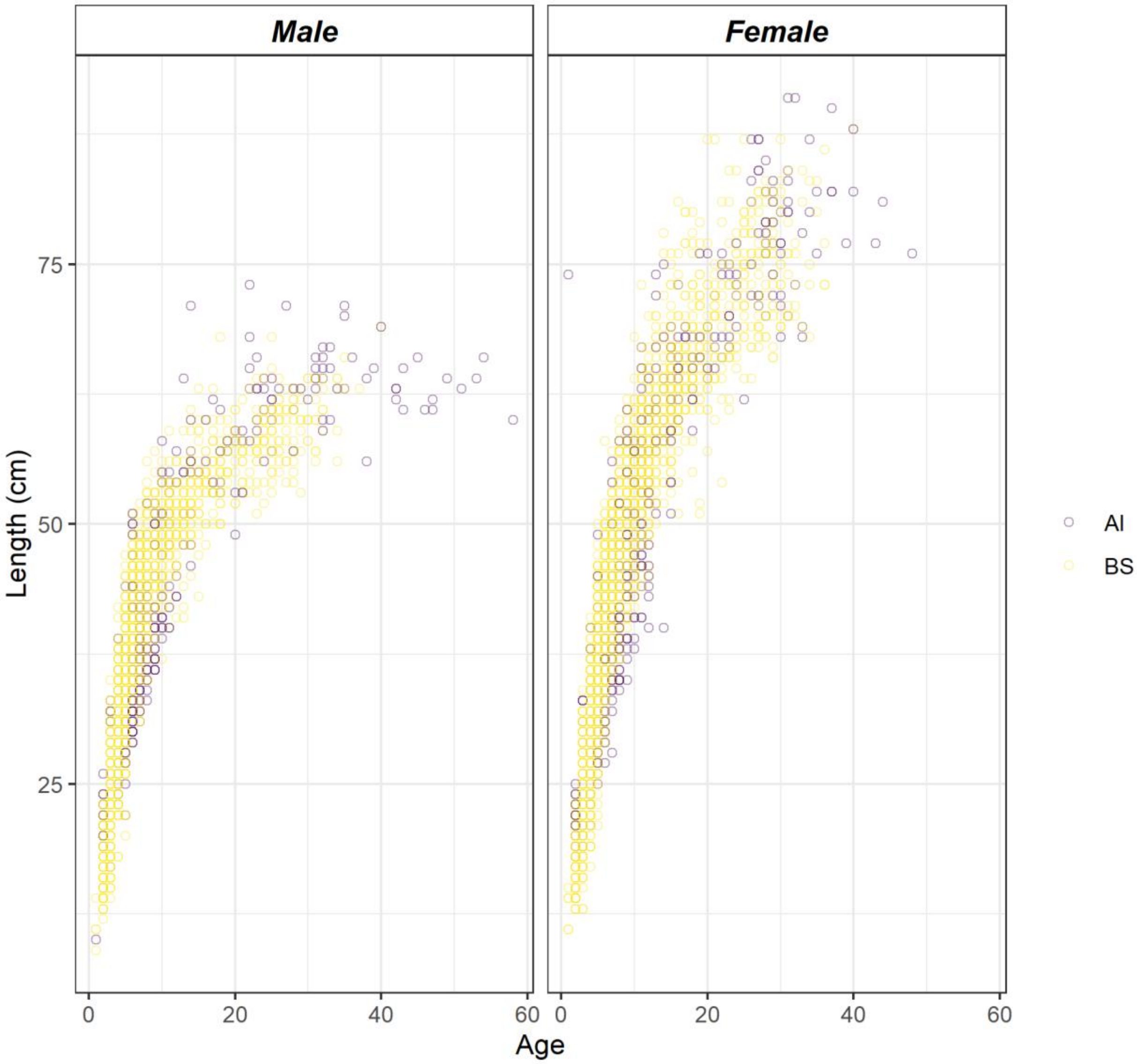


Figure 7-13. Sex and region specific age-length data from the EBS and Aleutian Islands bottom trawl survey (2010-2021).

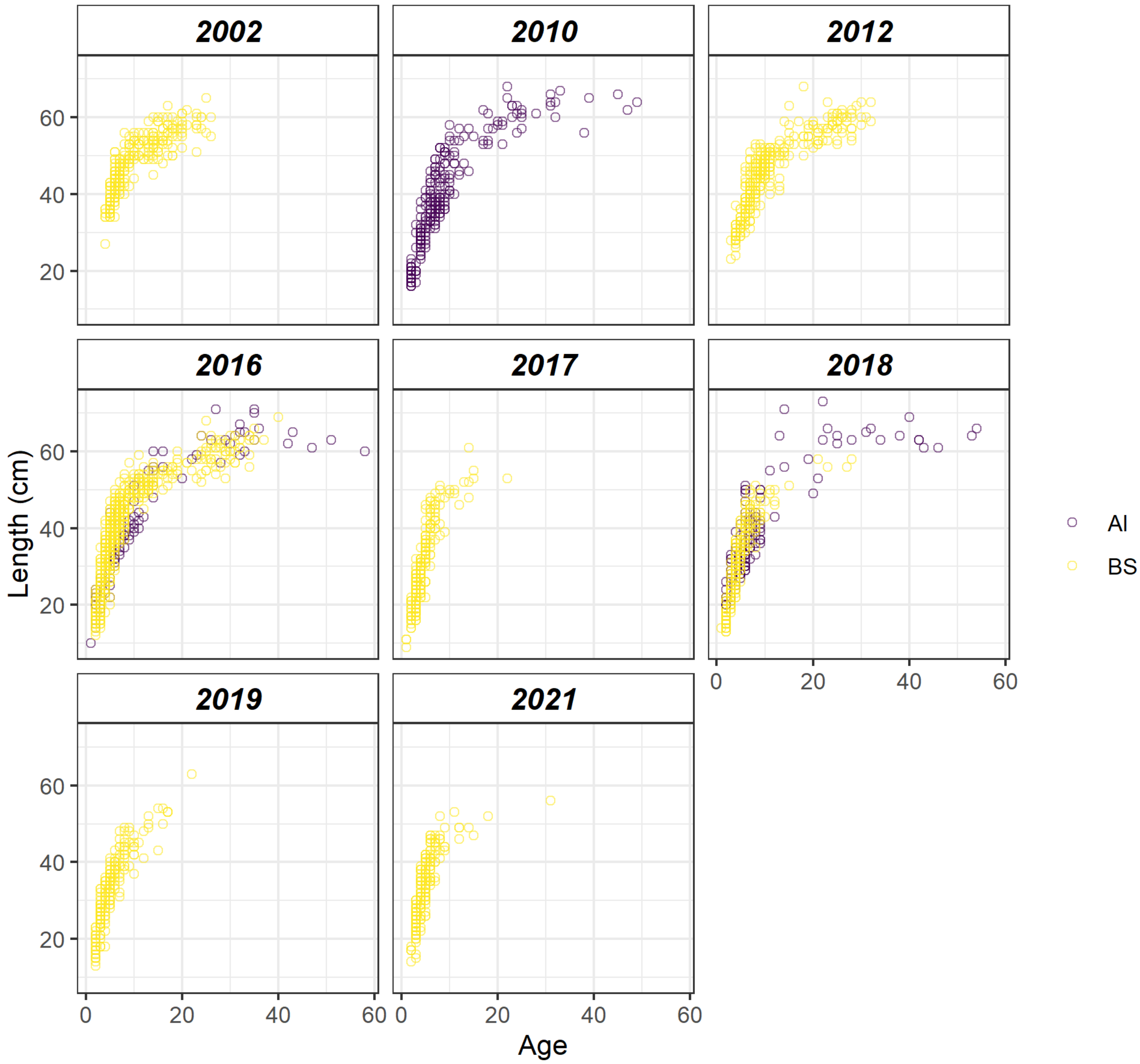


Figure 7-14. Region and year specific, male age-length data from the EBS and Aleutian Islands bottom trawl survey.

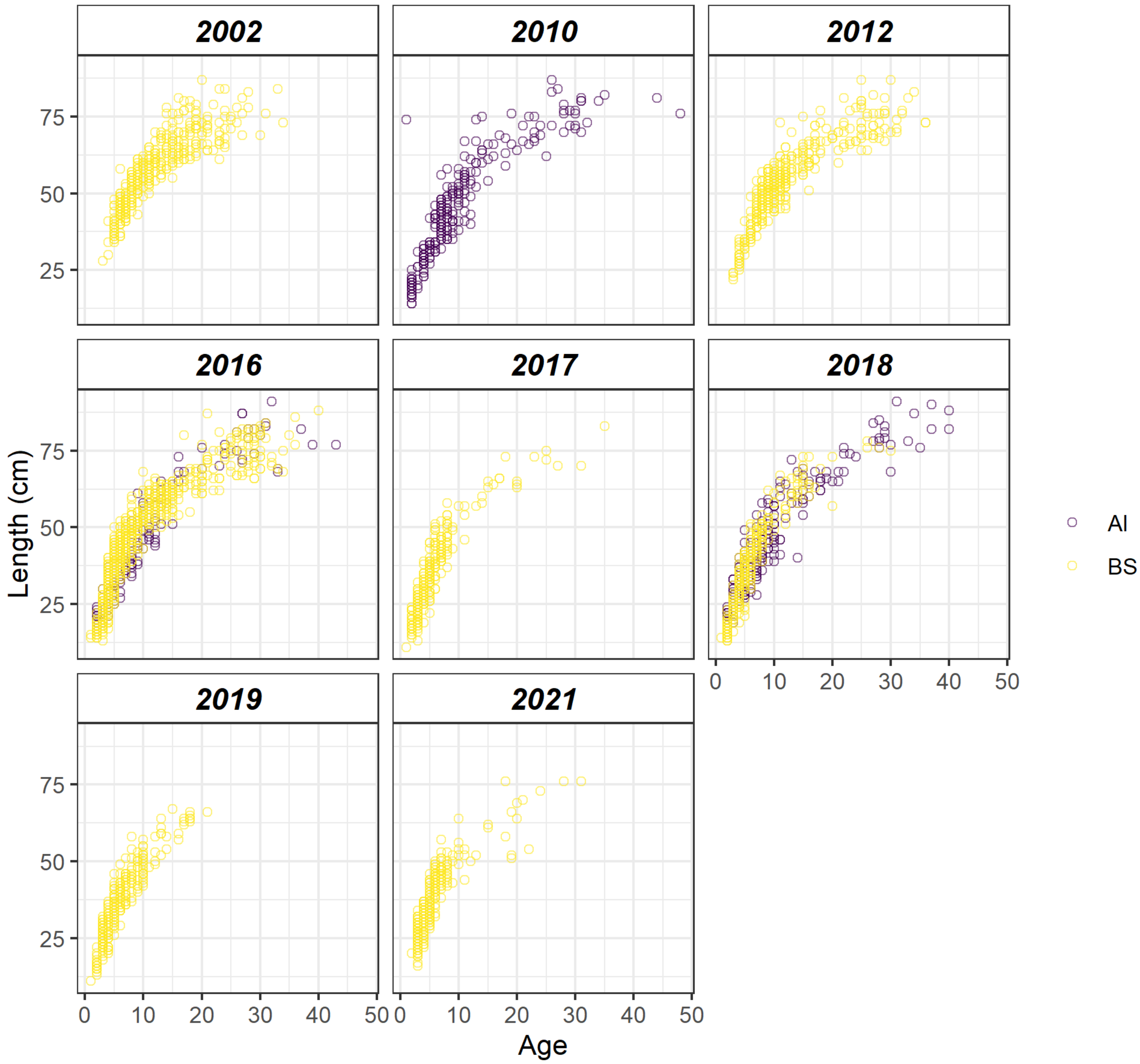


Figure 7-15. Region and year specific, female age-length data from the EBS and Aleutian Islands bottom trawl survey.

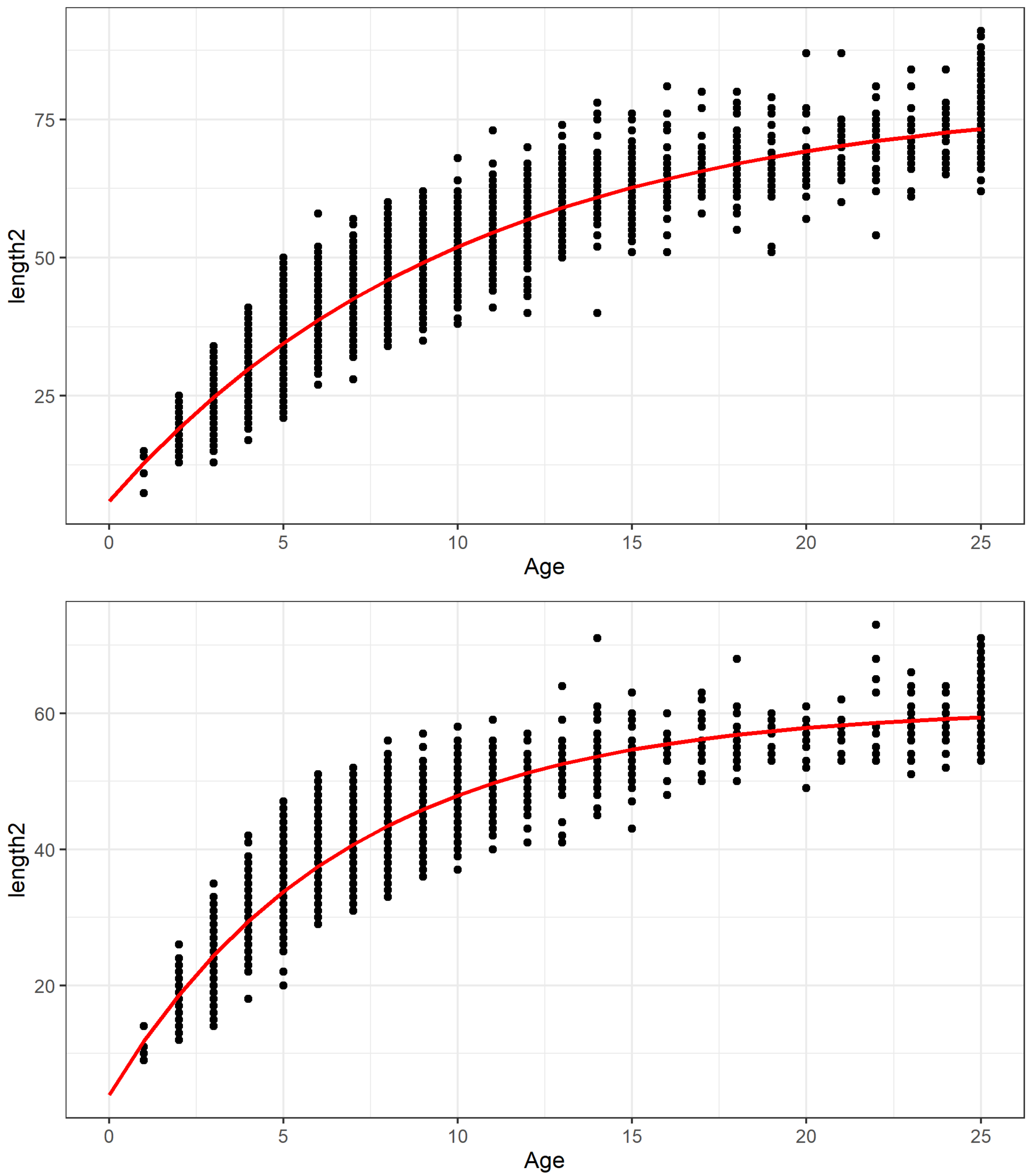
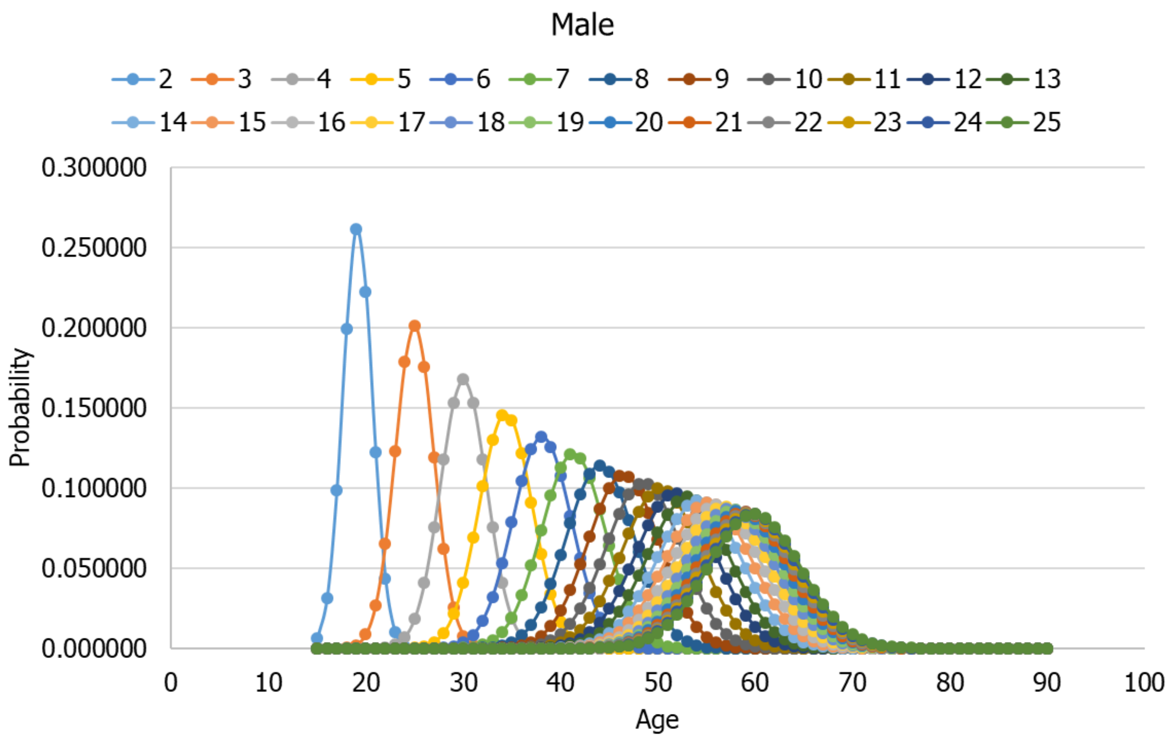


Figure 7-16. von Bertalanffy growth model fits (red points) to a) female and b) male age-length data.

a)



b)

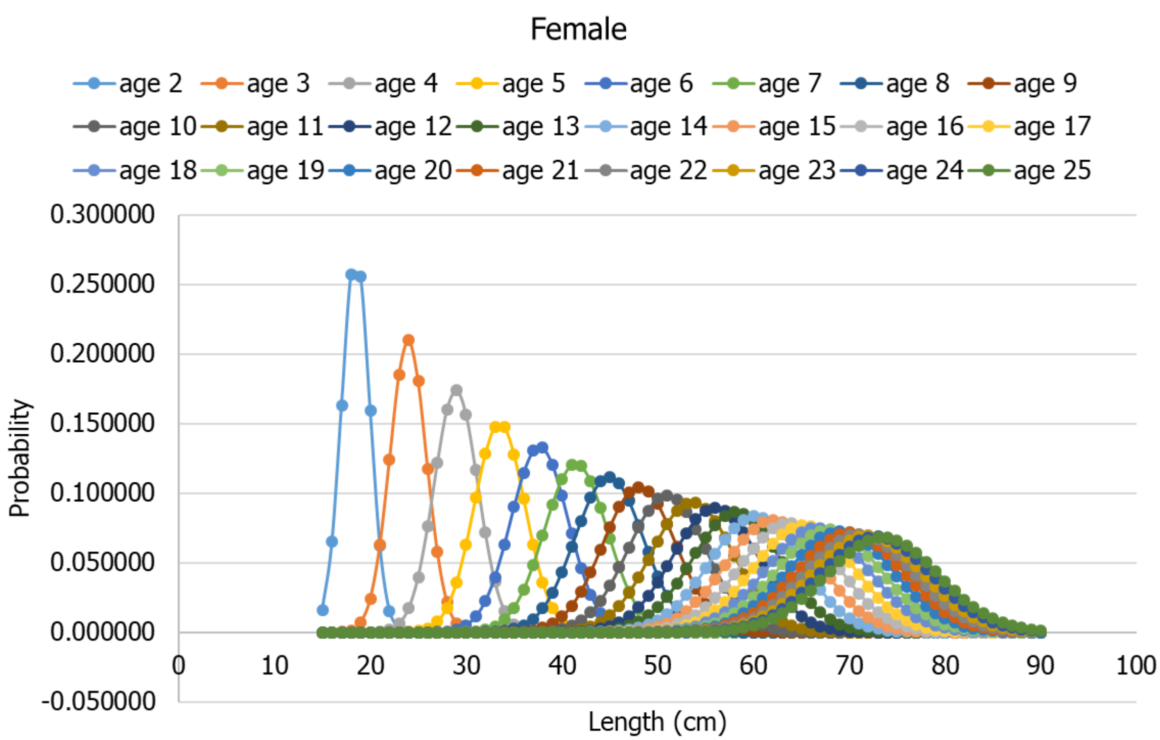


Figure 7-17. Age-length transition matrices assuming an 8% CV for all ages for a) males and b) females.

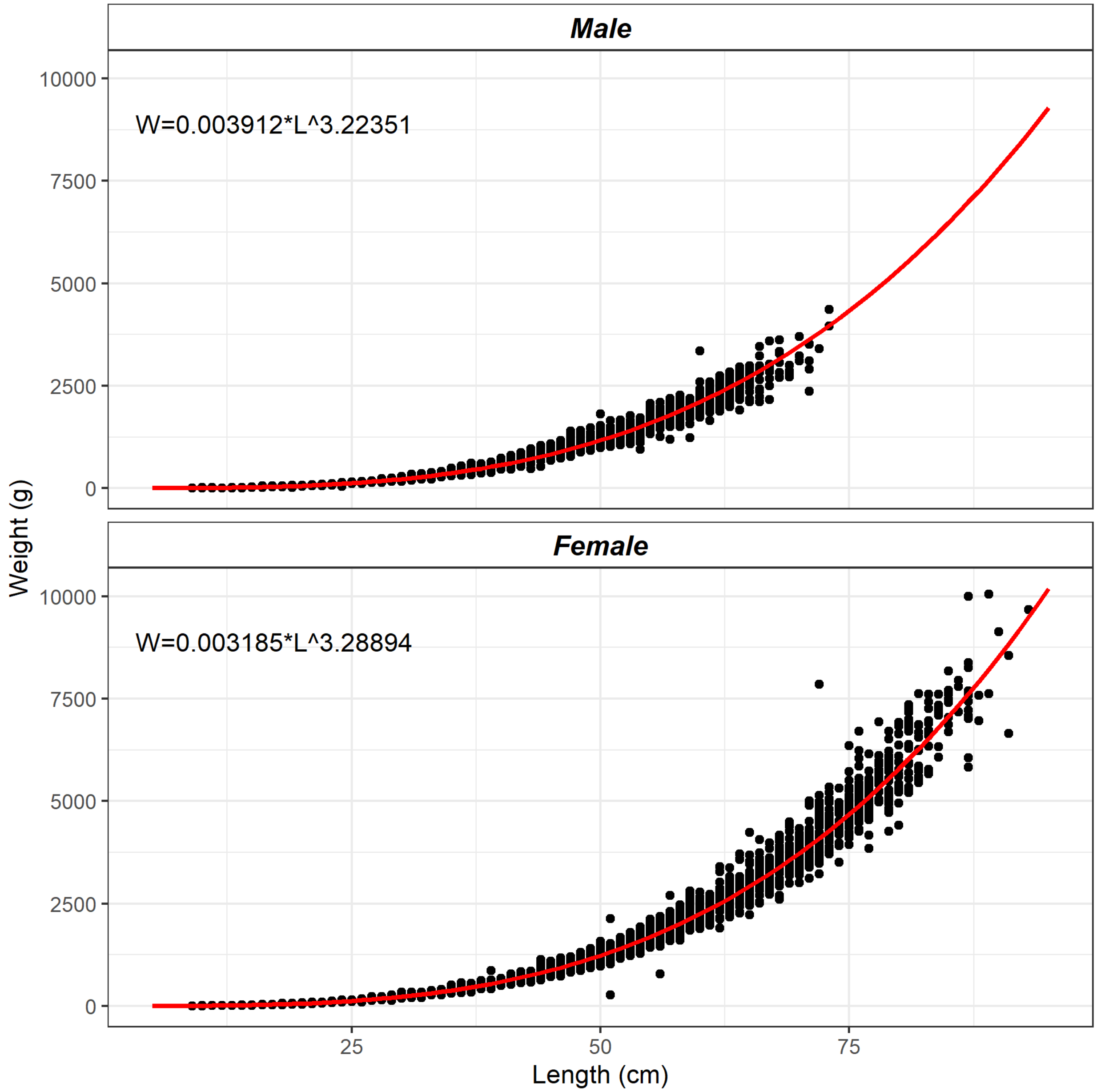


Figure 7-18. Sex-specific Kamchatka flounder length-weight relationships.

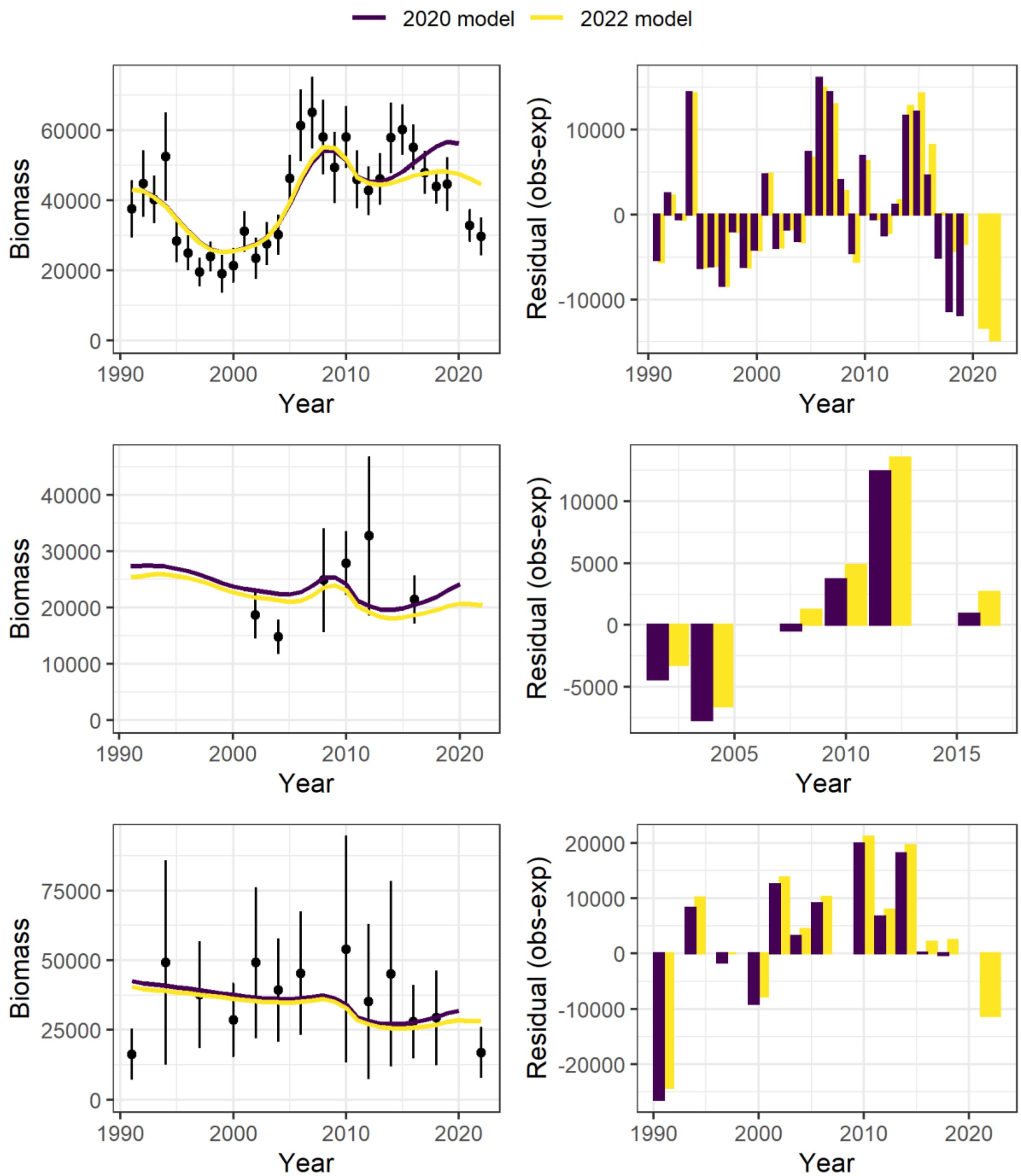


Figure 7-19. Model fit to the EBS shelf (top panels), EBS slope (middle panels), and the Aleutian Islands (bottom panels) bottom trawl survey biomass estimates and corresponding residuals for models and the 2020 assessment and current assessment. Root mean square error values are reported in Table 7-8.

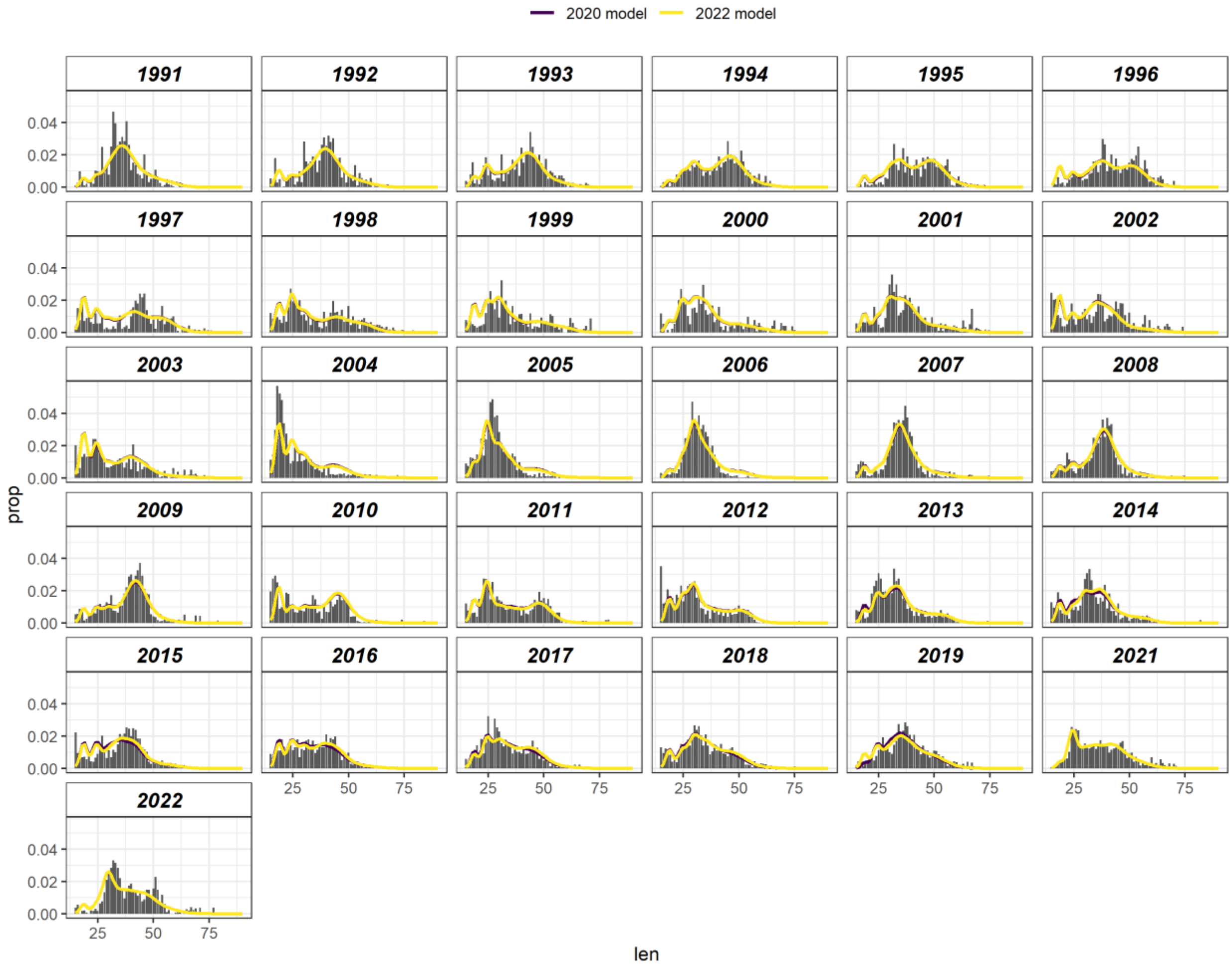


Figure 7-20. Fits to the shelf survey, female length composition data for the 2020 assessment and current assessment by year.

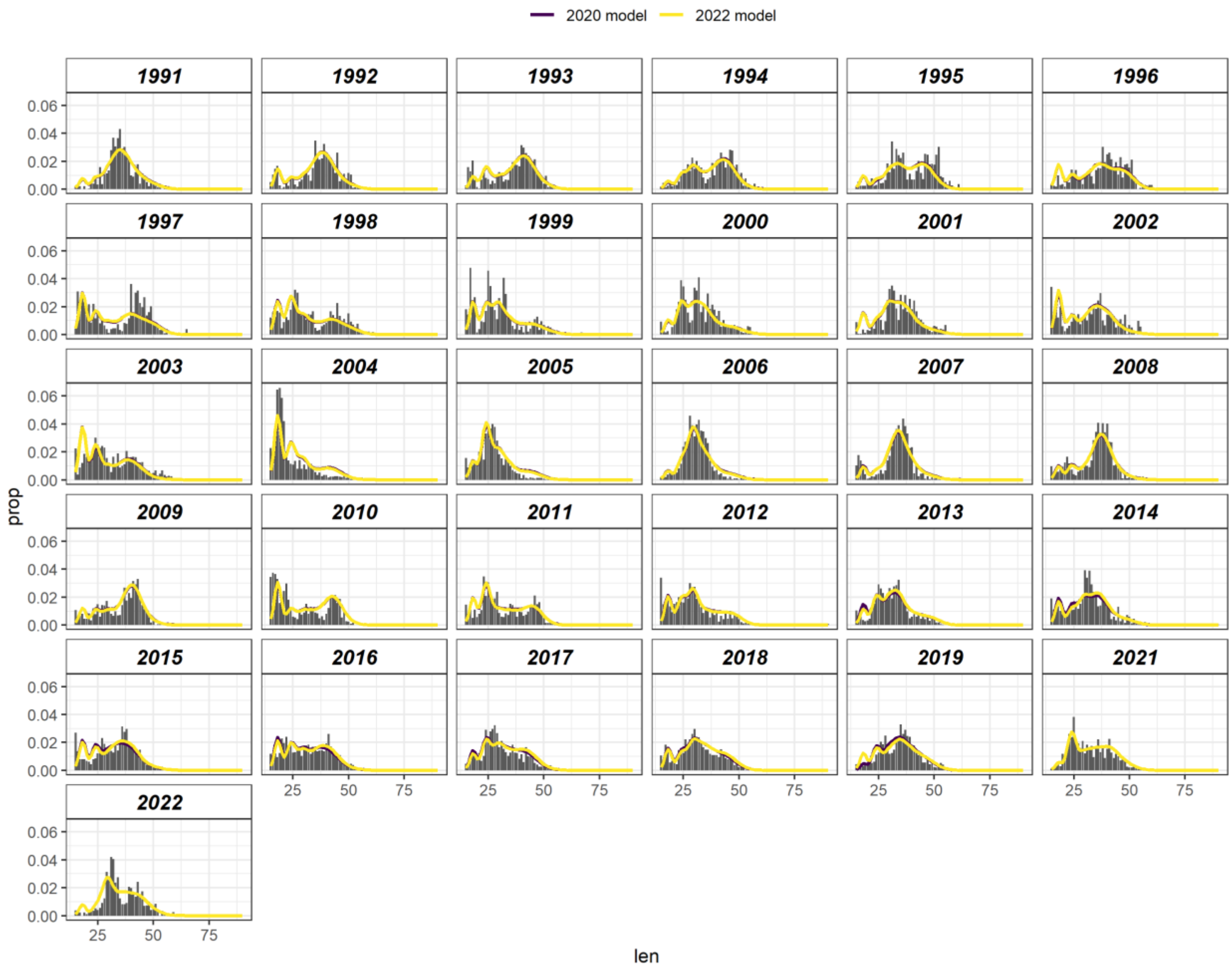


Figure 7-21. Fits to the shelf survey, male length composition data for the 2020 assessment and current assessment by year.

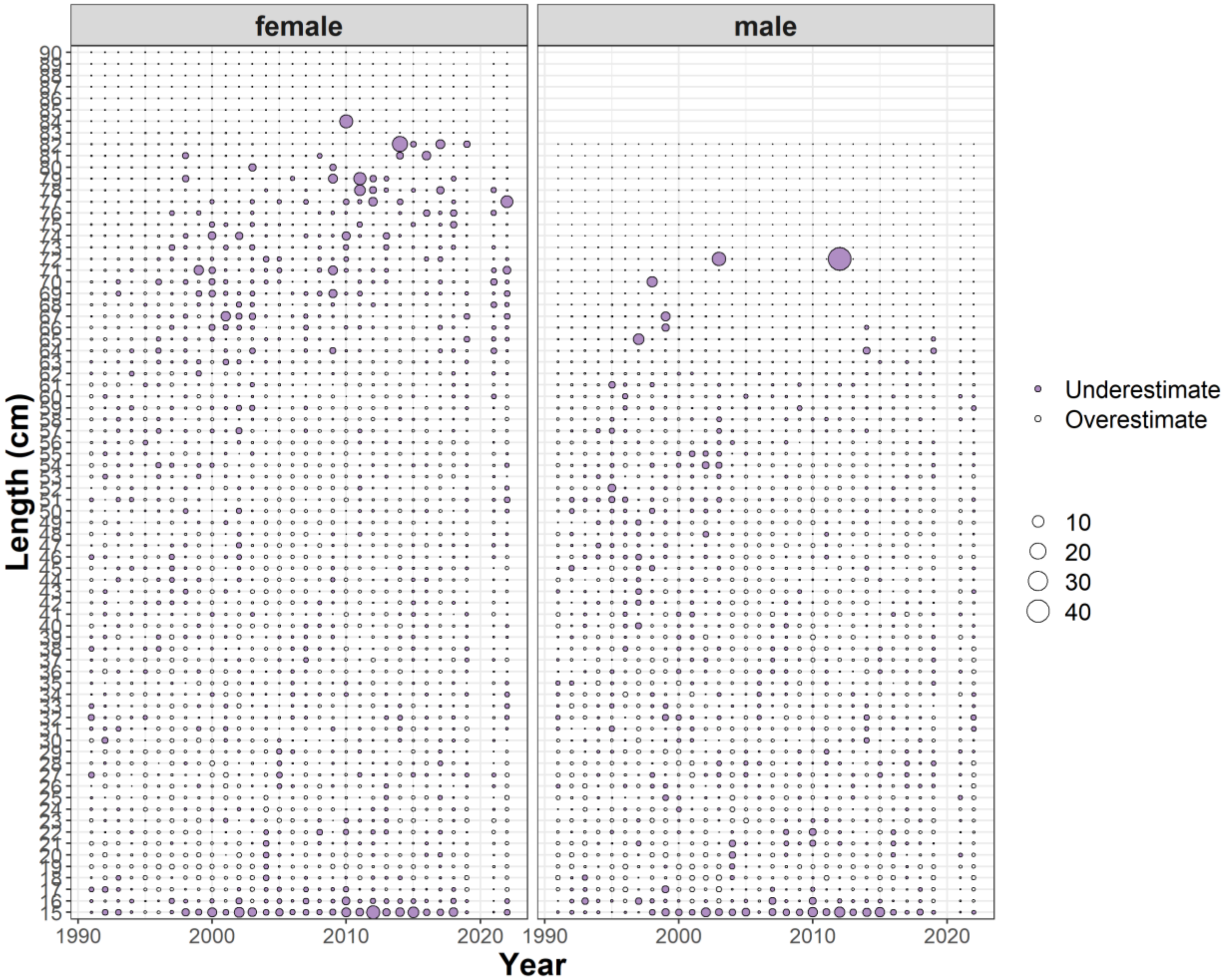


Figure 7-22. Shelf survey, length estimate standardized residuals for model 16.0b, current assessment. The size of the bubble is indicative of the residual value, the purple color indicates an overestimation, and the white color indicates underestimation.

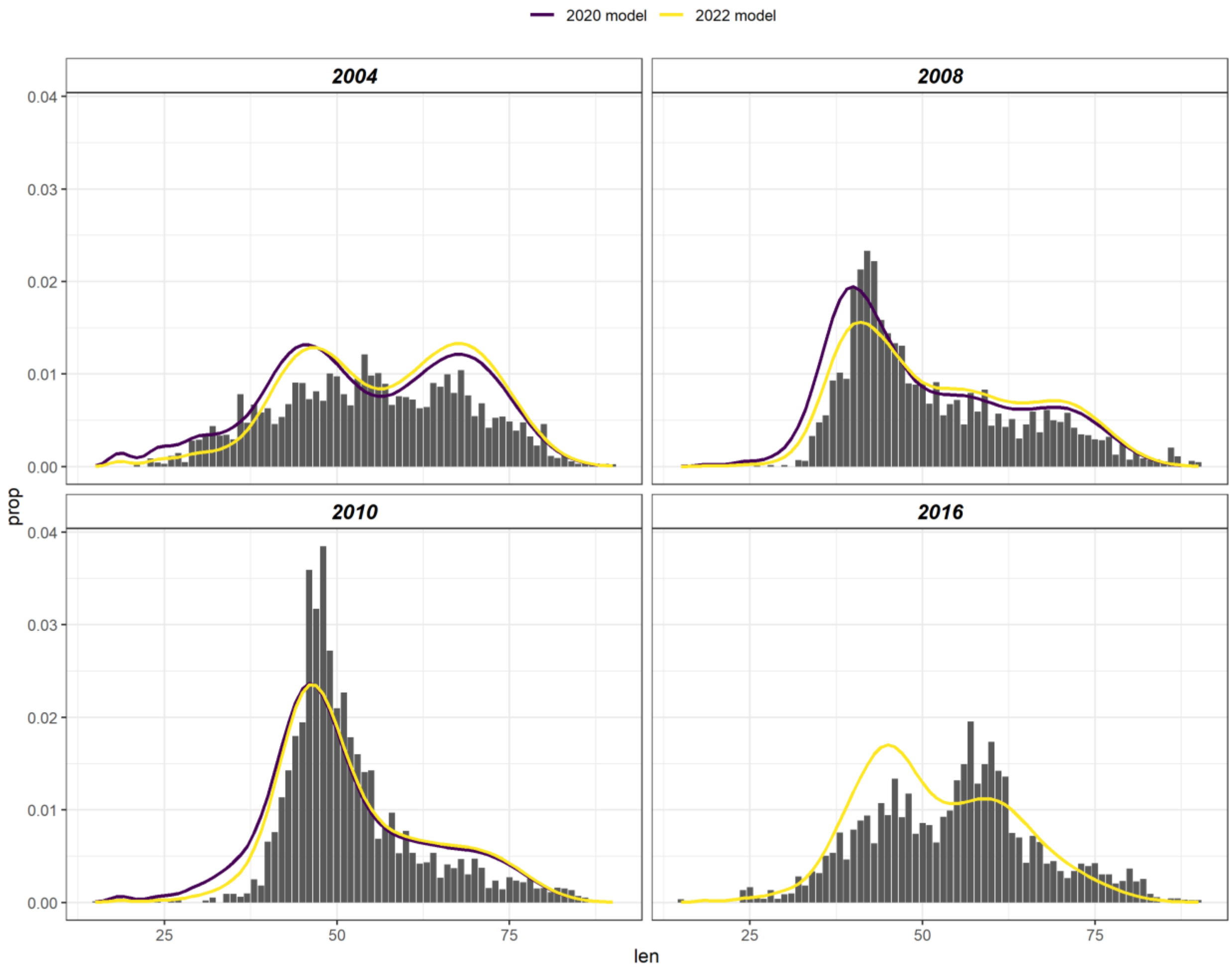


Figure 7-23. Fits to the slope survey, female length composition data for the 2020 assessment and current assessment by year.

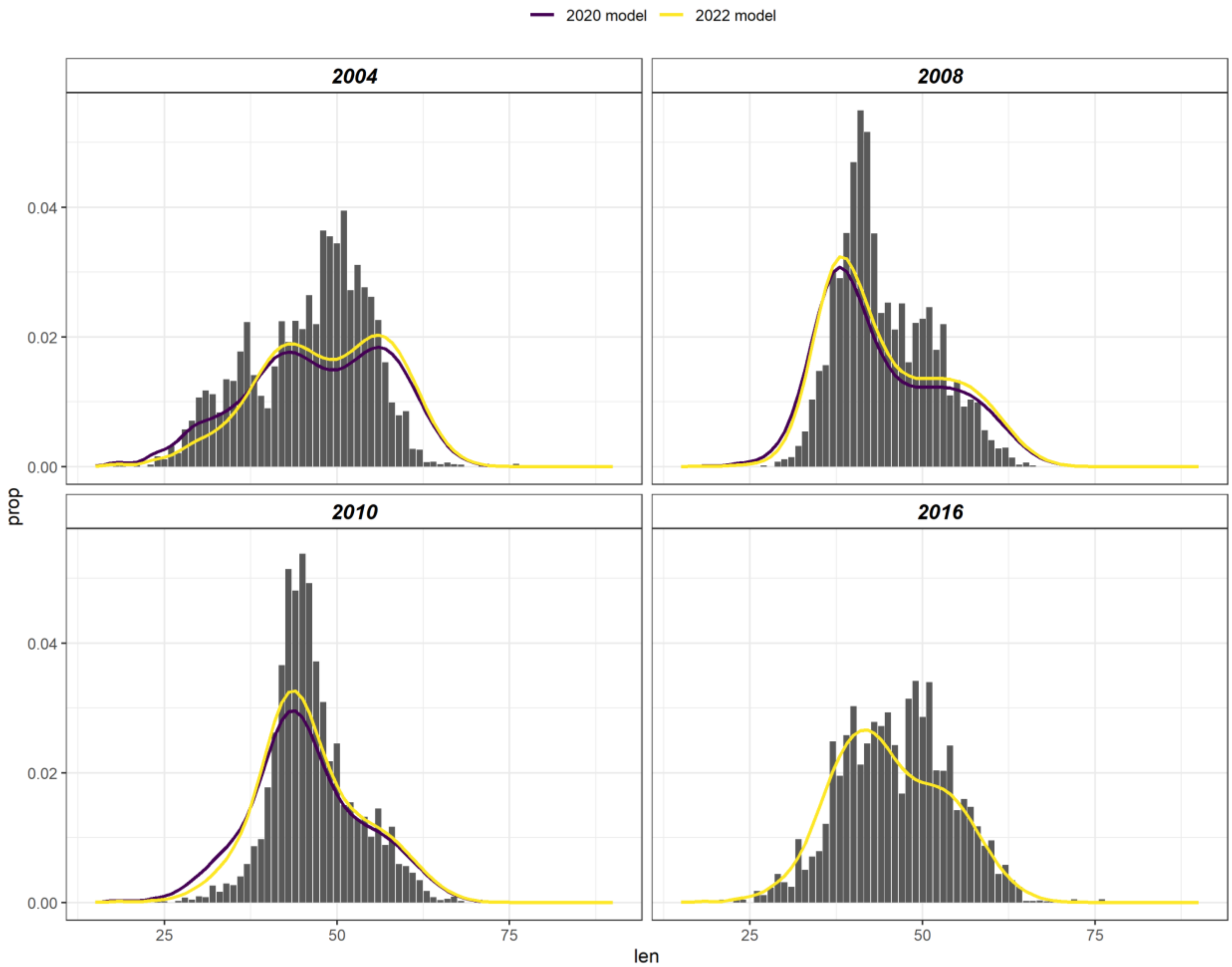


Figure 7-24. Fits to the slope survey, male length composition data for the 2020 assessment and current assessment by year.

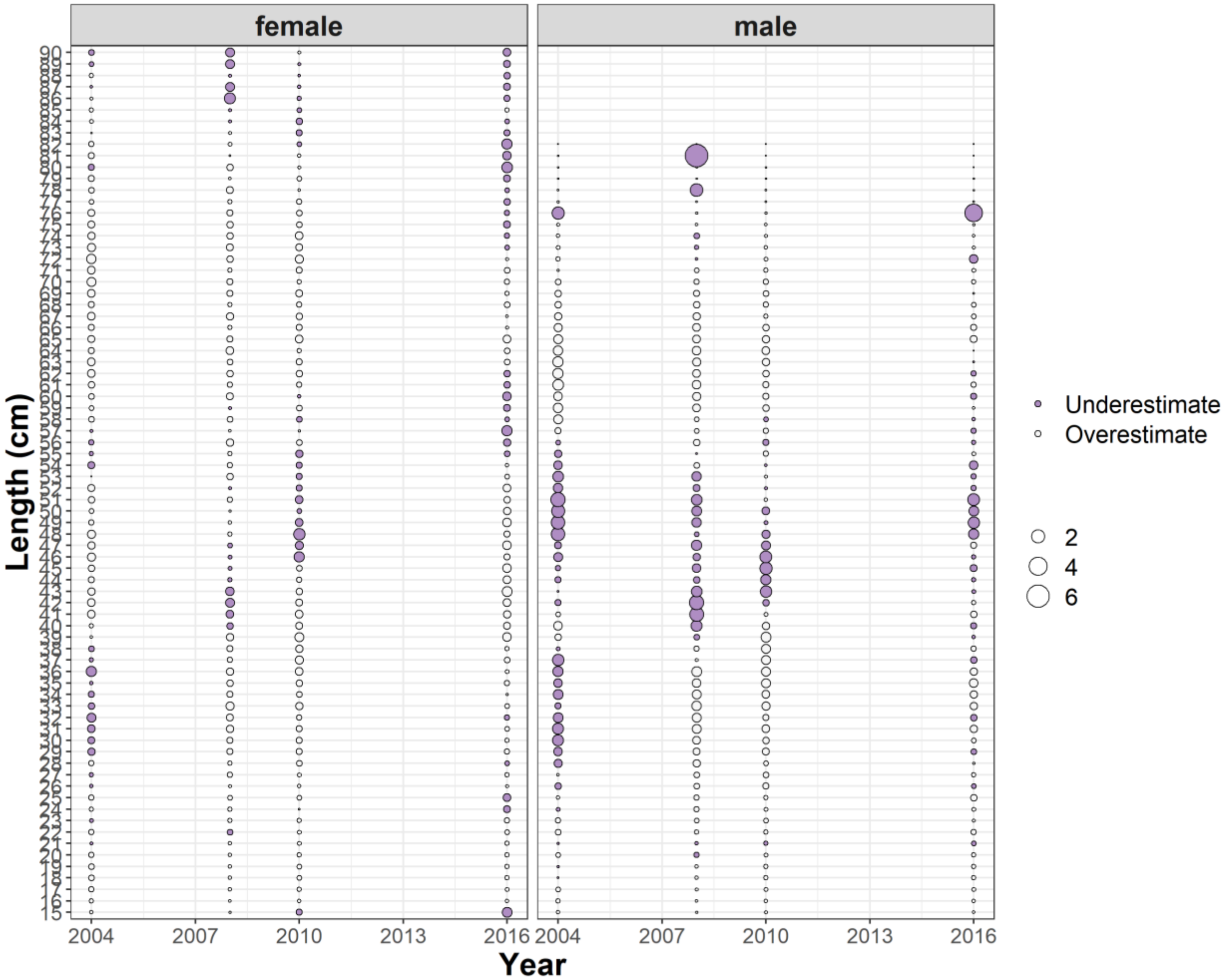


Figure 7-25. Slope survey, length estimate standardized residuals for model 16.0b, current assessment. The size of the bubble is indicative of the residual value, the purple color indicates an overestimation, and the white indicates underestimation.

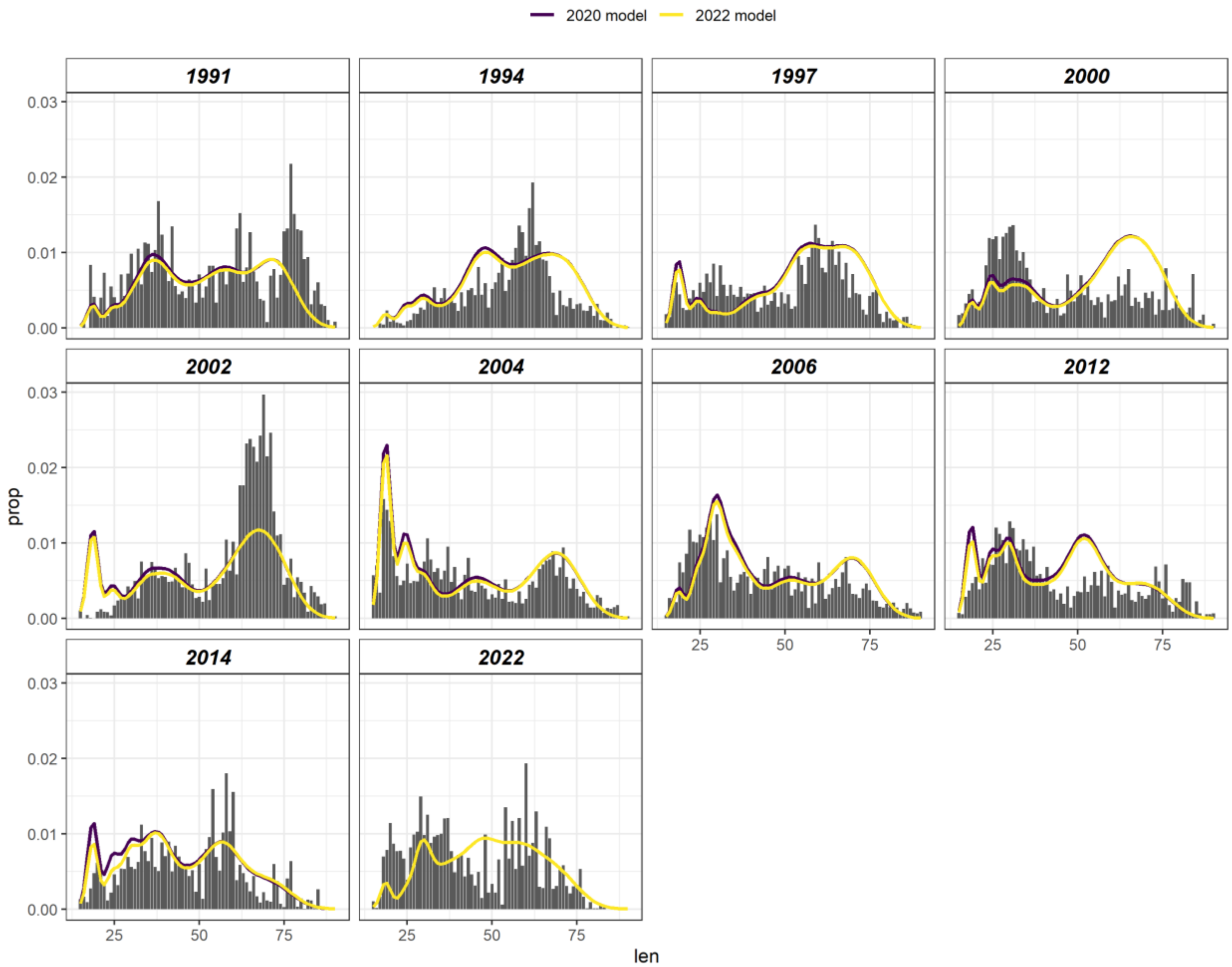


Figure 7-26. Fits to the Aleutian Islands survey, female length composition data for models 16.0b (2020 assessment) and current assessment by year.

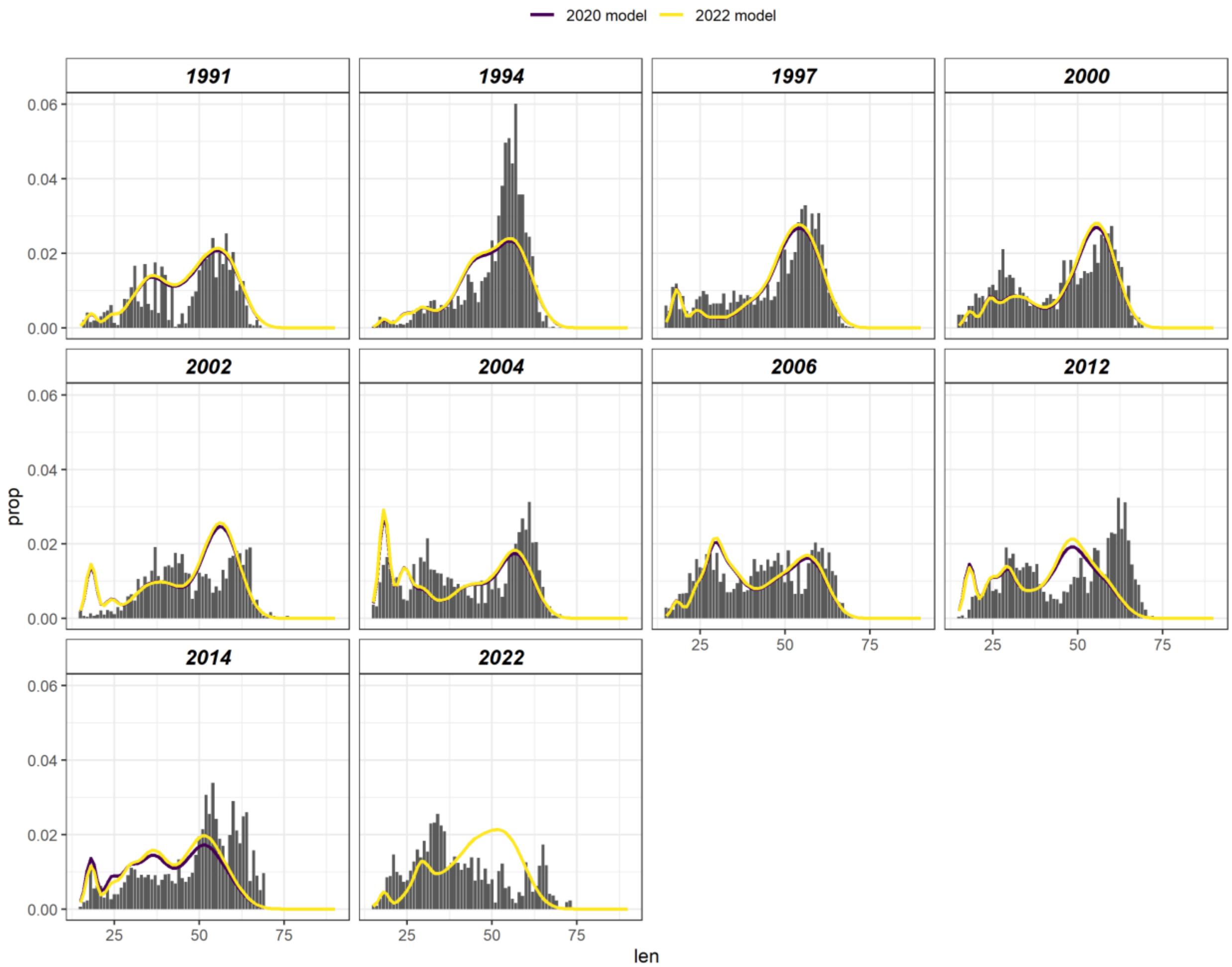


Figure 7-27. Fits to the Aleutian Islands survey, male length composition data for 2020 assessment and current assessment by year.

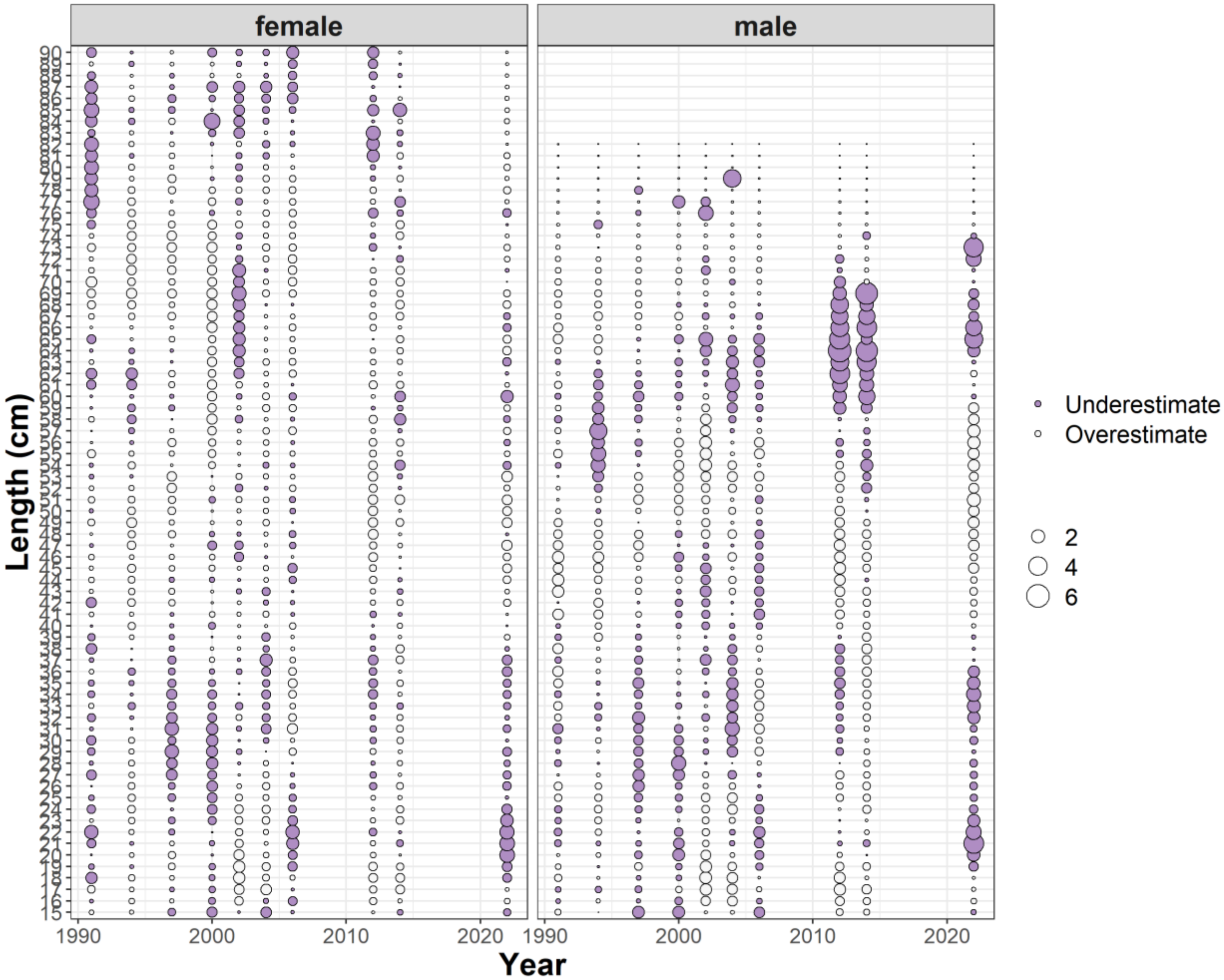


Figure 7-28. Aleutian Islands survey, length estimate standardized residuals for models 16.0b. The size of the bubble is indicative of the residual value, purple indicates an overestimation, and white indicates underestimation.

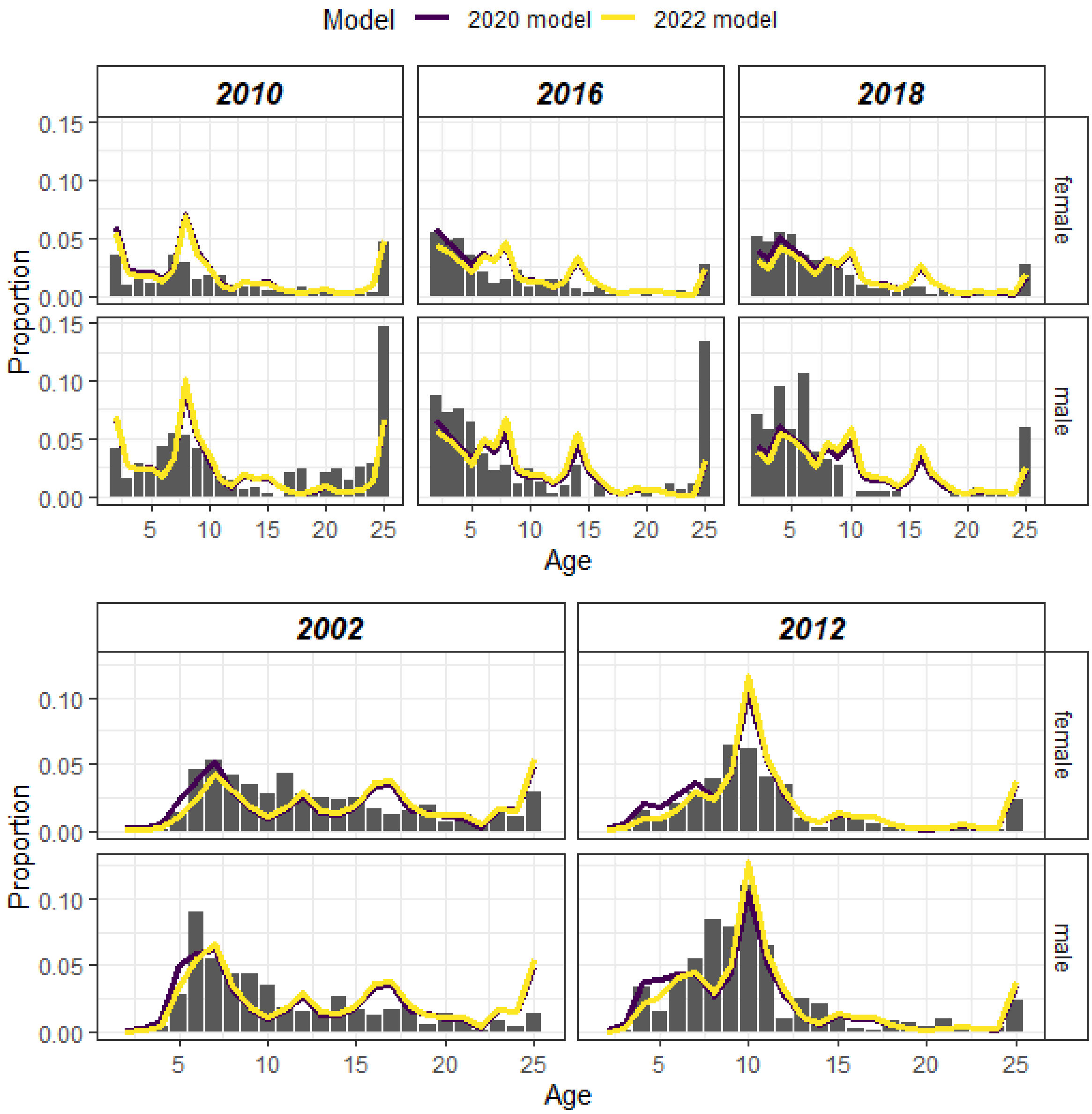


Figure 7-29. Model fit to the age composition data for the Aleutian Islands survey (top panels) and EBS slope survey (bottom panel) for the 2020 assessment and current assessment.

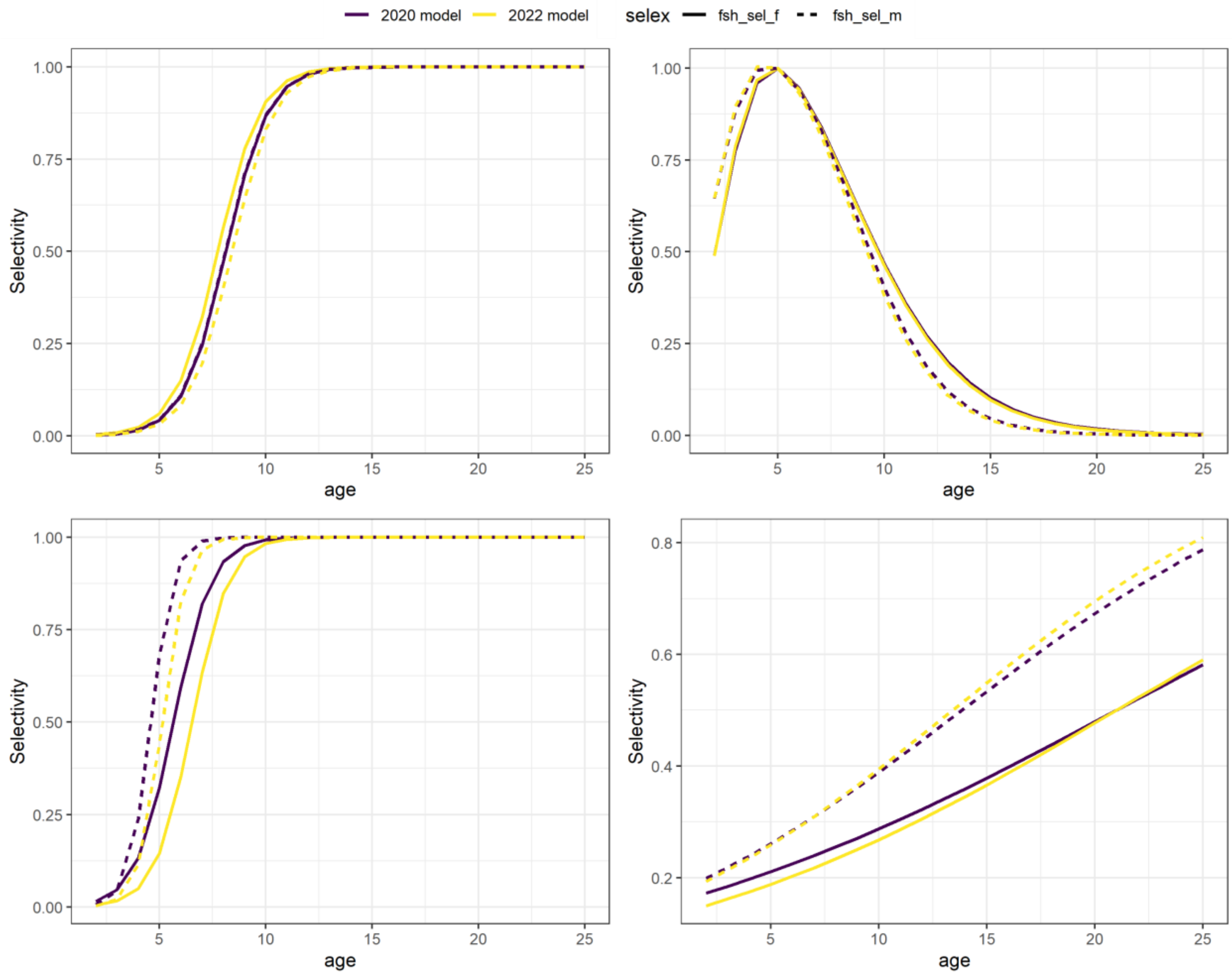


Figure 7-30. Estimated sex-specific selectivity from 2020 assessment (purple) and current assesment (yellow). Fishery (top left panel), EBS shelf survey (top right panel), EBS slope survey (bottom left panel), and Aleutian Islands (bottom right panel). Dashed lines are male selectivity curves and sold lines are female selectivity curves.

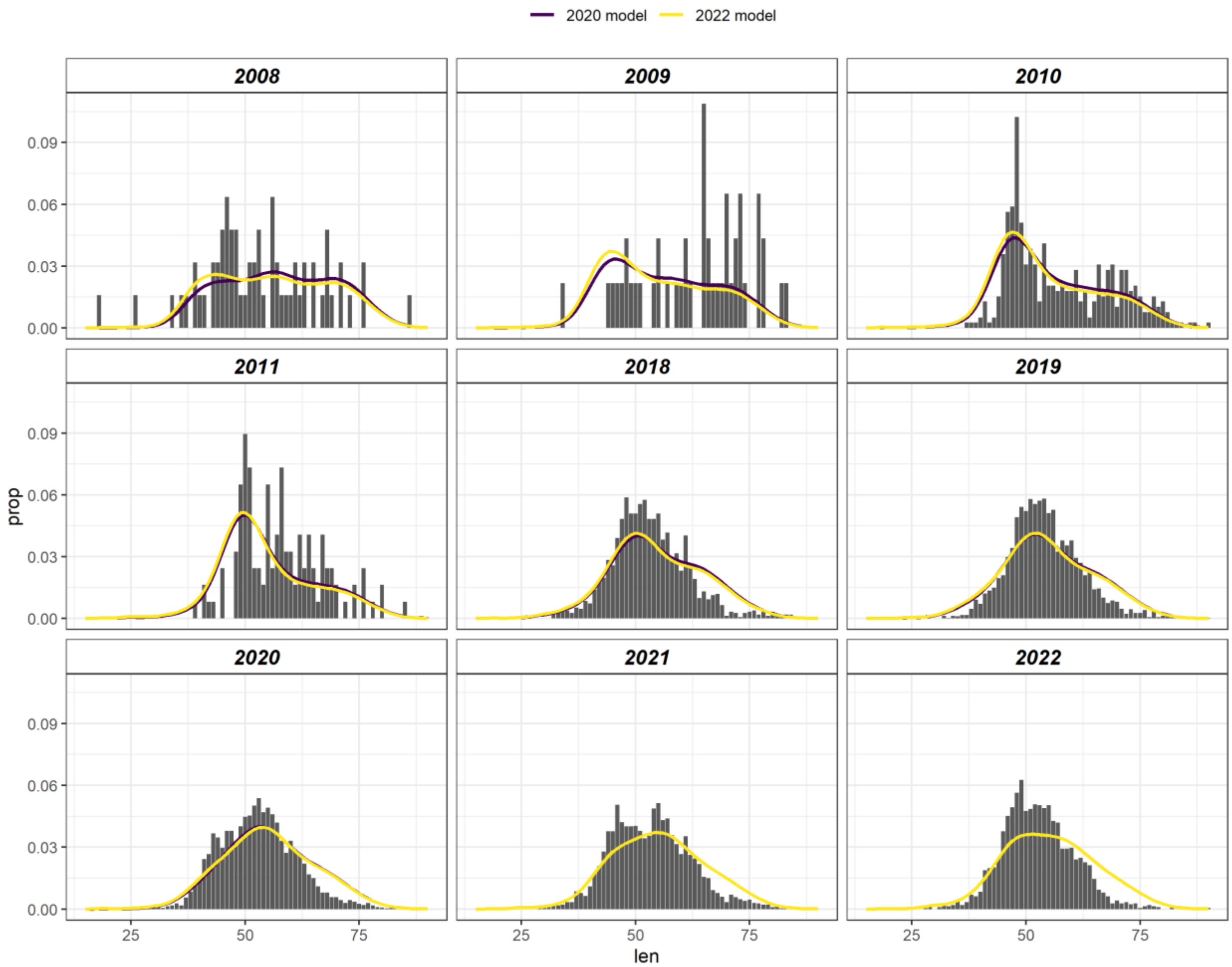


Figure 7-31. Fits to the fishery, female length composition data by year for models 2020 assessment and 2022 assessment.

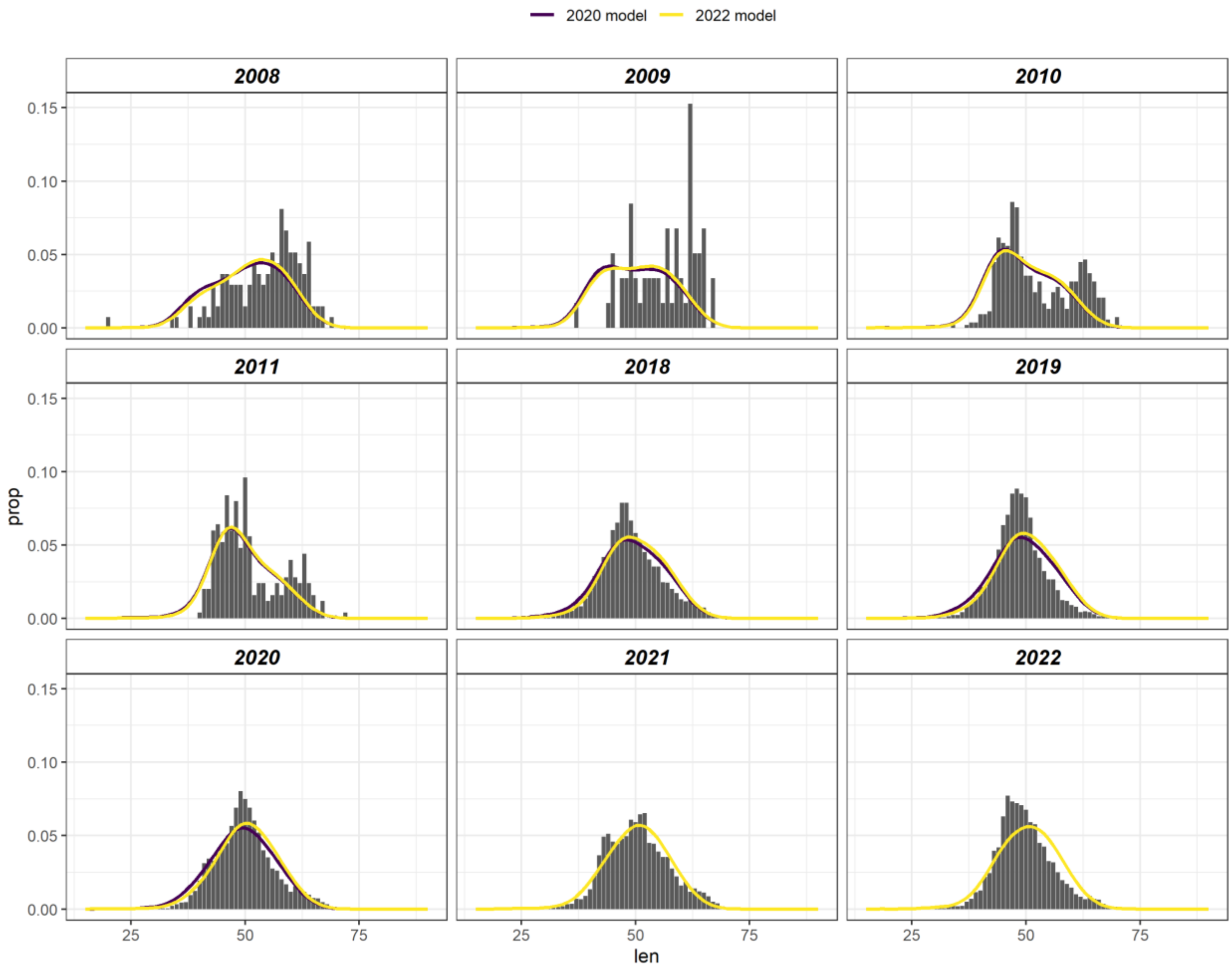


Figure 7-32. Fits to the fishery, male length composition data by year for the 2020 assessment and current assessment.

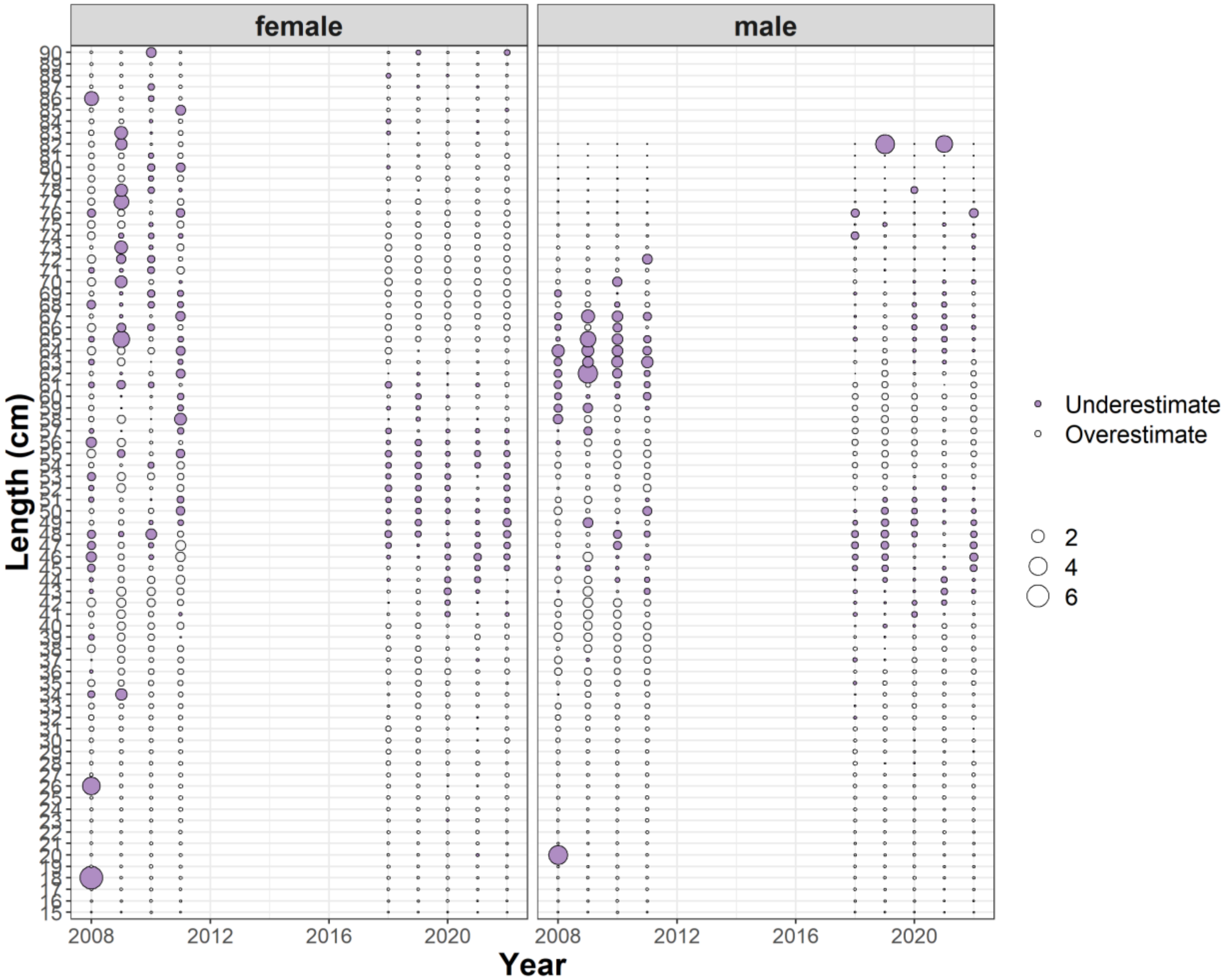


Figure 7-33. Fishery length estimate standardized residuals for models 16.0b, current assessment. The size of the bubble is indicative of the residual value, purple indicates an underestimation, and white indicates overestimation.

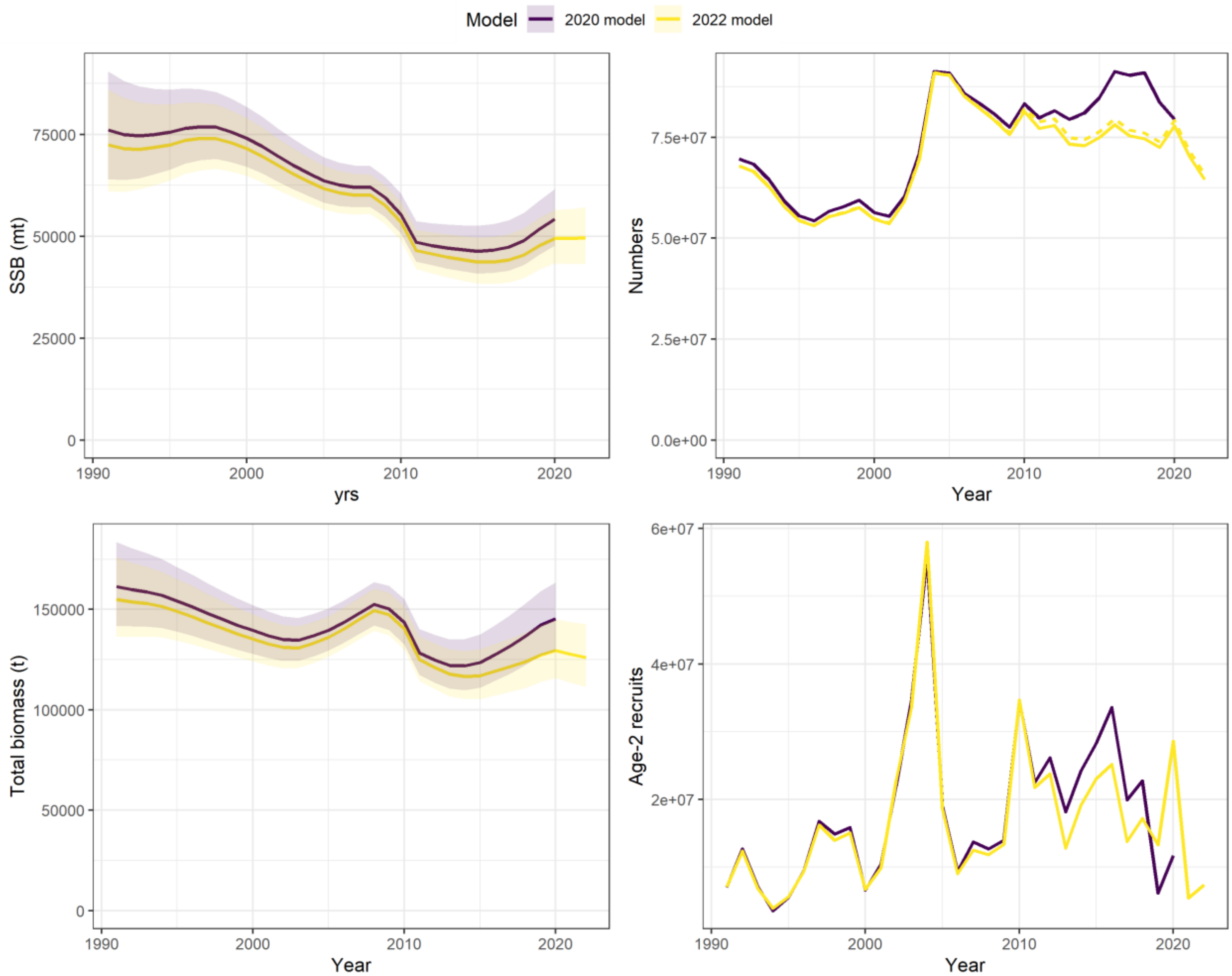


Figure 7-34. Estimates of female spawning biomass, sex-specific numbers, total biomass, and age-2 recruits, and total biomass from the 2020 assement (purple) and the current assessment (yellow).The shaded regions represent the 95% confidence interval.

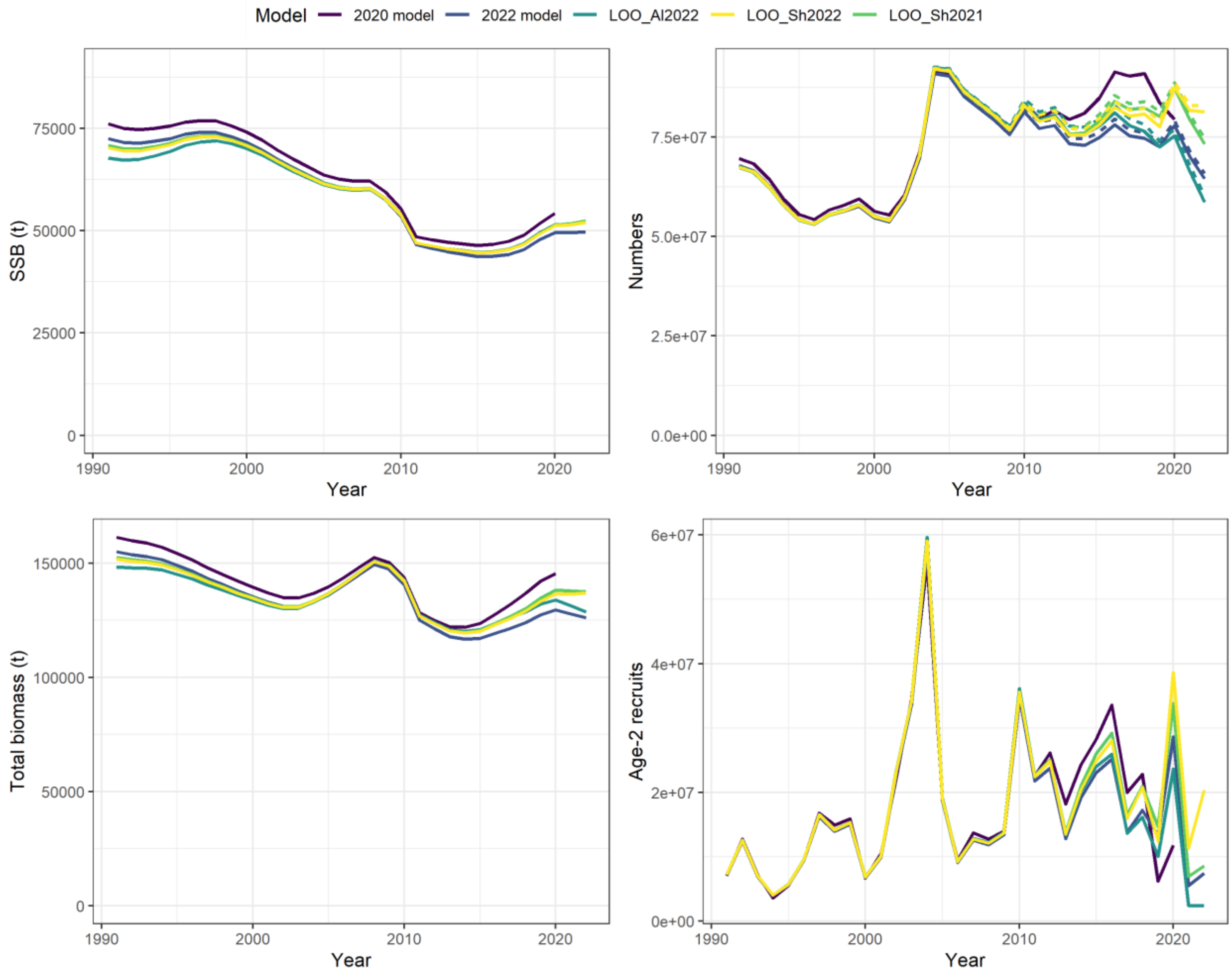


Figure 7-35. Estimates of female spawning biomass, sex-specific numbers, total biomass, and age-2 recruits, and total biomass from the 2020 assement, the current assessment, the leave-one-out analysis (LOO_AI2022: remove AI BTS 2022 data, LOO_SH2022: remove EBS Shelf BTS 2022 data, and LOO_SH2021: remove the EBS shelf BTS 2021 data).

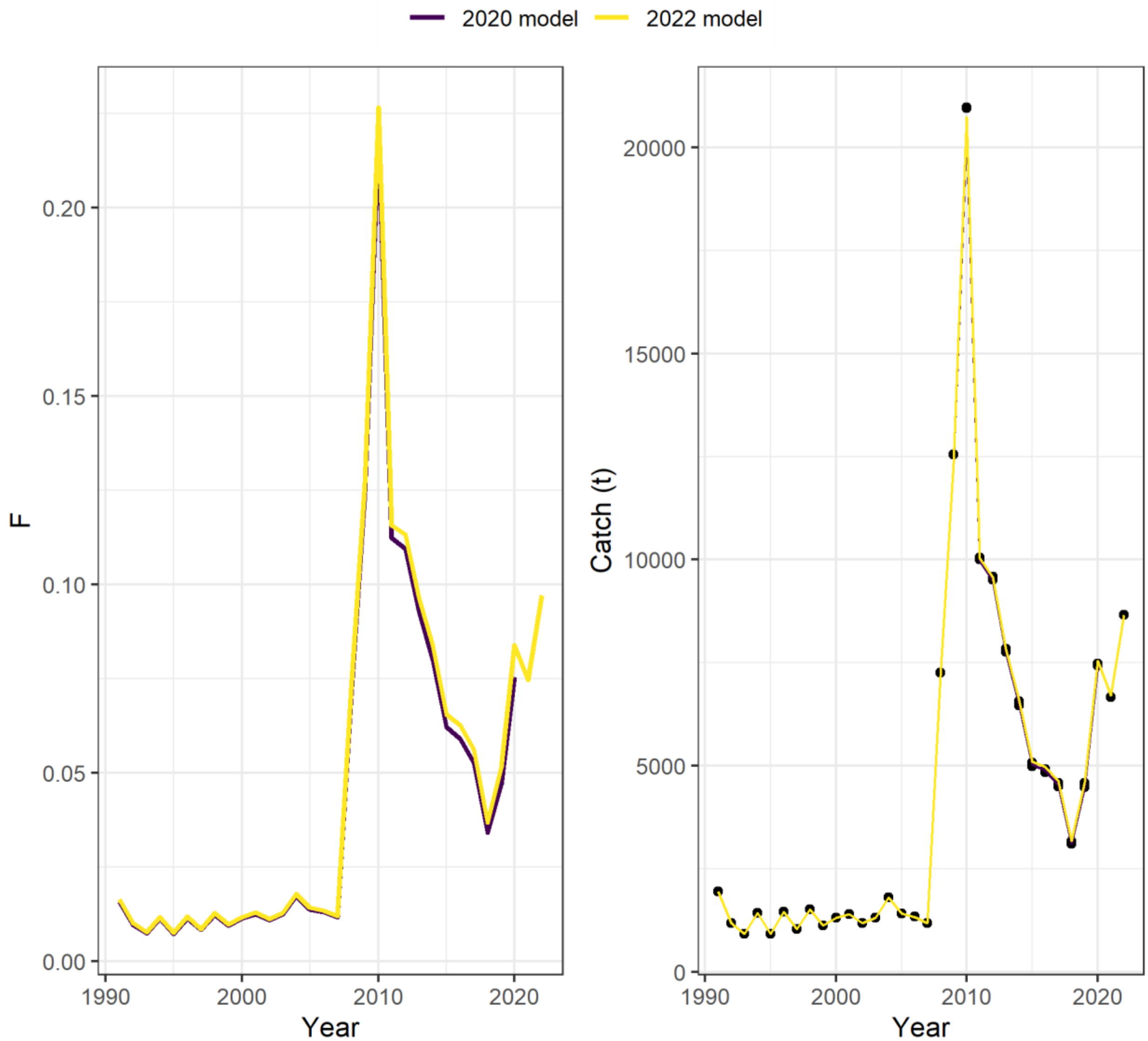


Figure 7-36. Estimate of fishing mortality and model fit to the catch data for the 2020 assessment and current assessment.

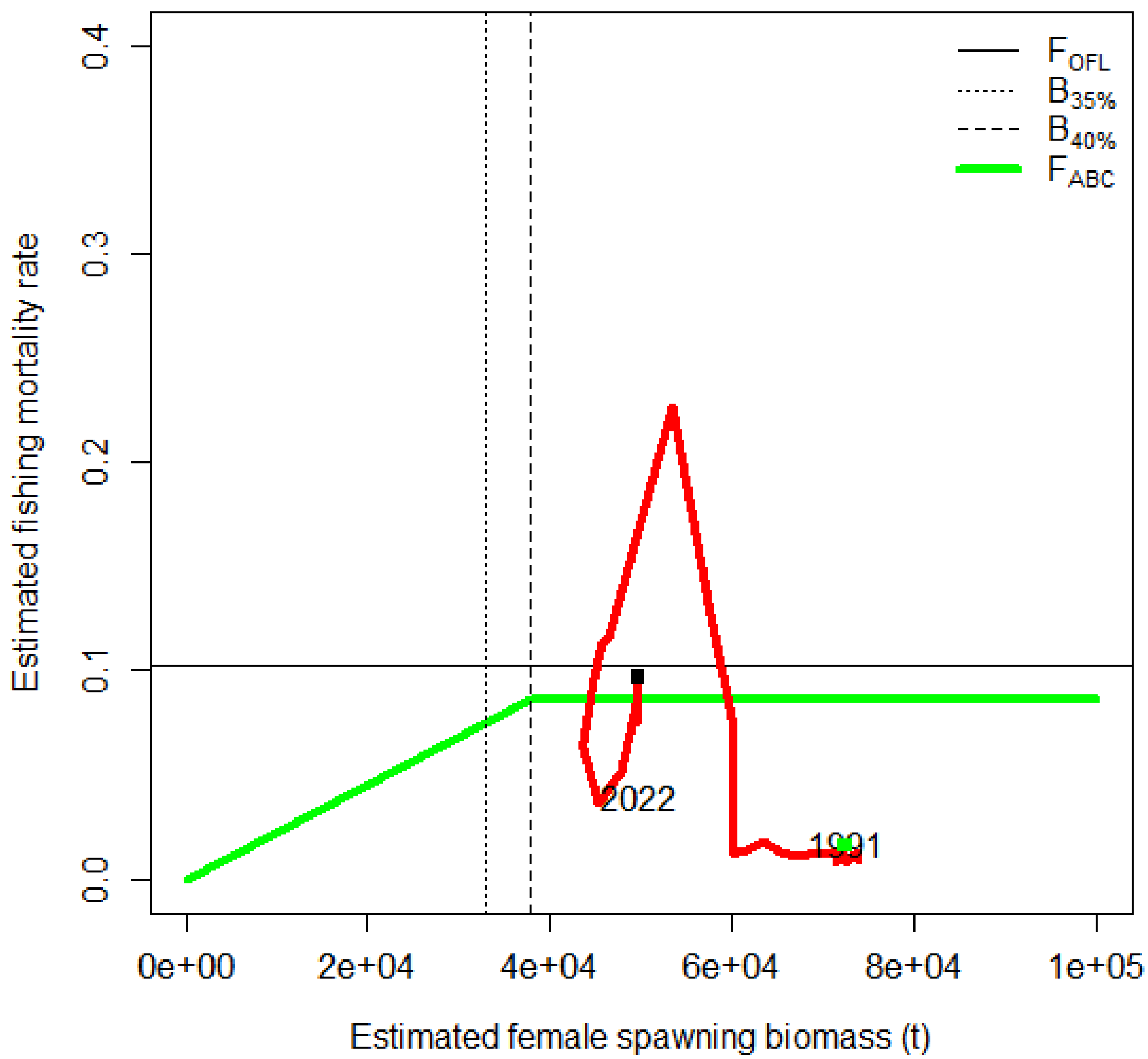
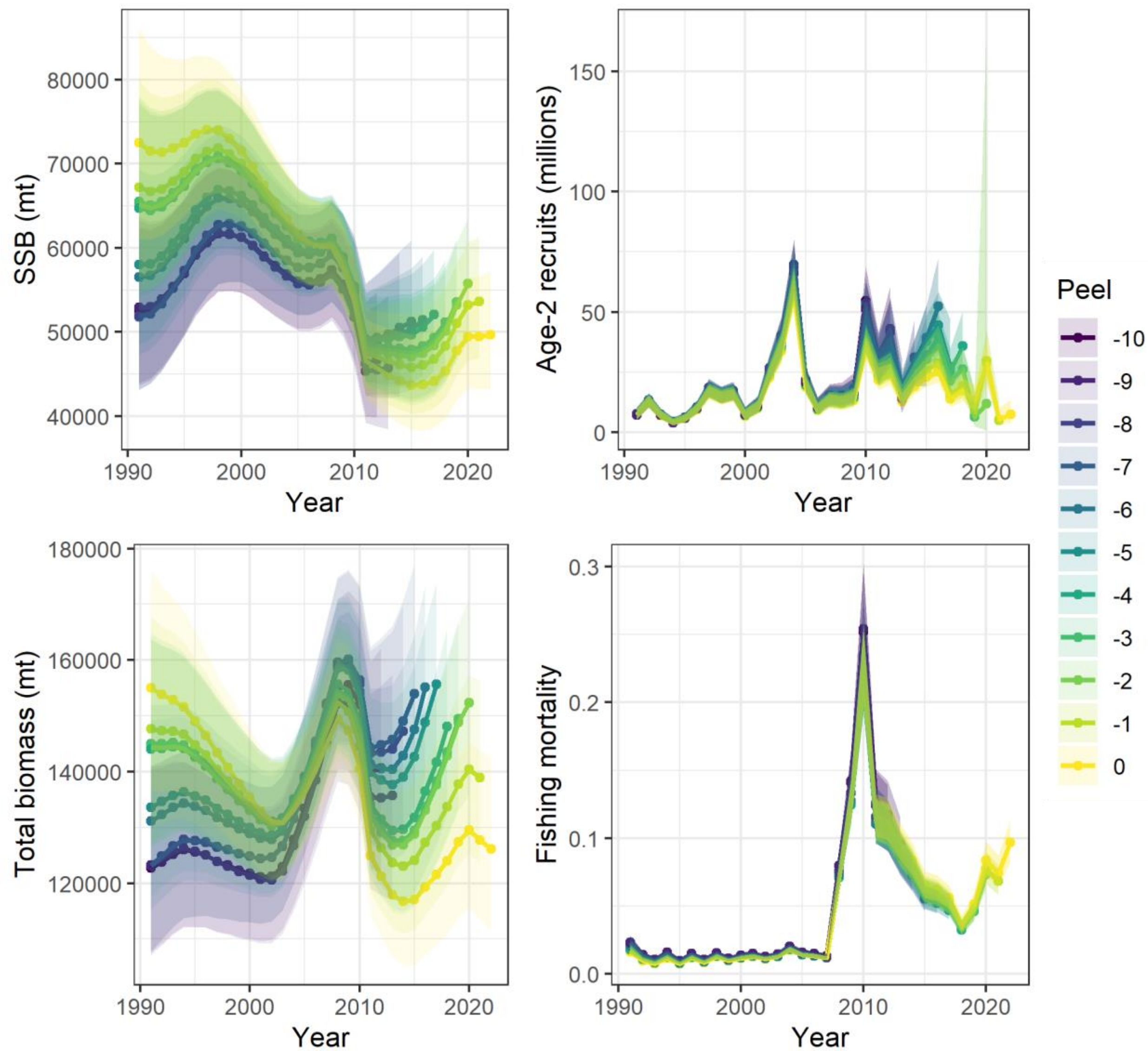


Figure 7-37. Phase plane plot of Kamchatka flounder female spawning stock biomass (t) and fishing mortality from Model 16.0b, current assessment.



	Mohn's rho			
Model	SSB	Total biomass	Recruitment	F
16.0b (2020)	0.020	0.111	0.262	0.034
16.0b (2022)	0.116	0.210	0.383	-0.102

Figure 7-38. Retrospective patterns in total biomass, female spawning biomass, average full selection fishing mortality, and age-2 recruits for model 16.0b, current assessment. Mohn’s rho is reported for Models 16.0b (2020) and 16.0b (2022).

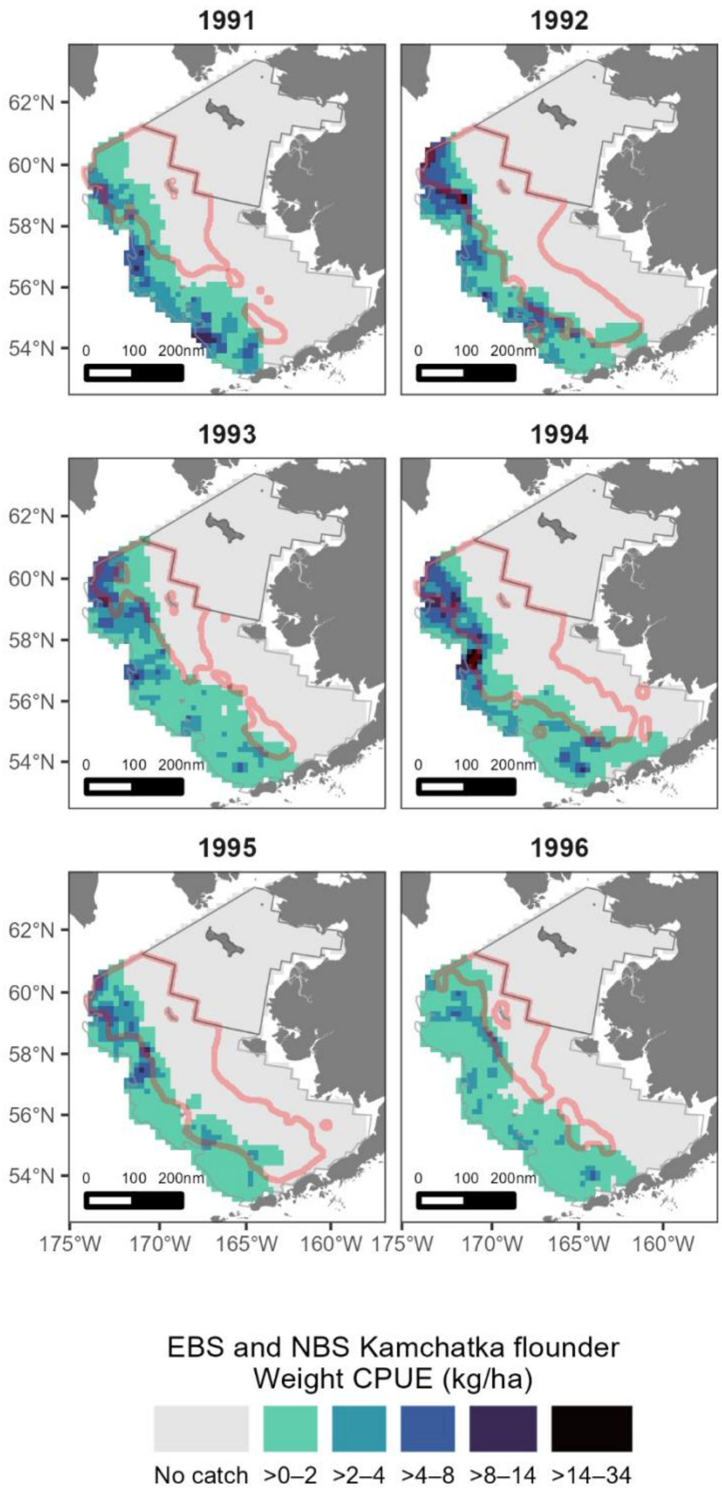


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.

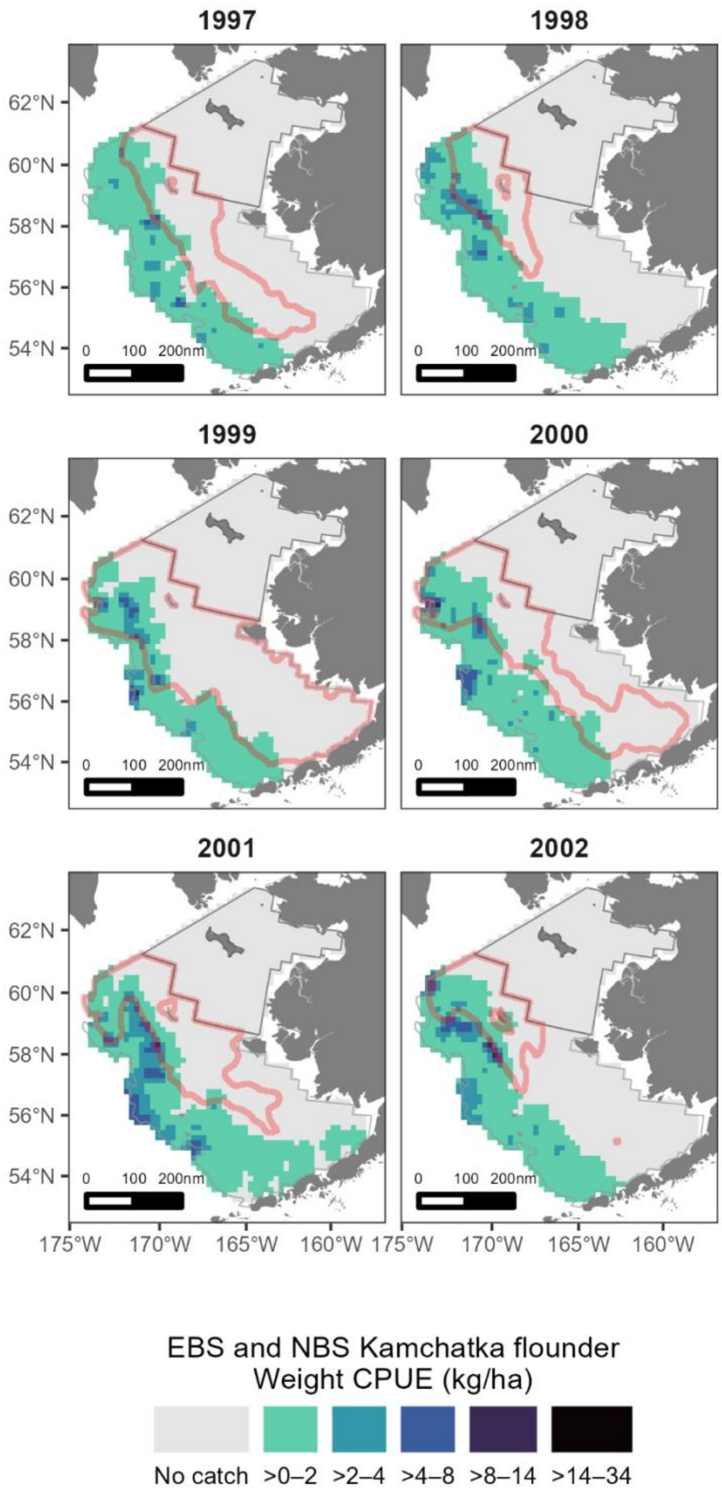


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.

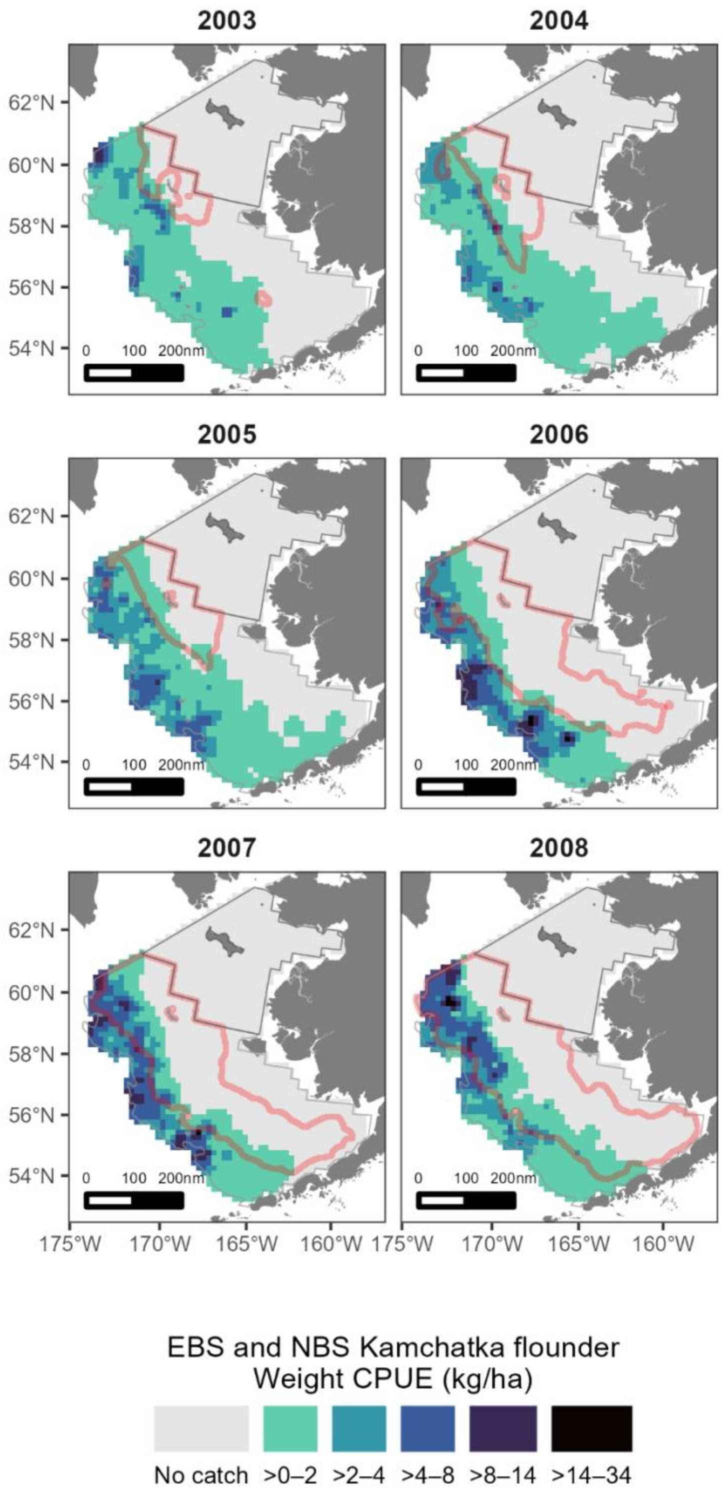


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.

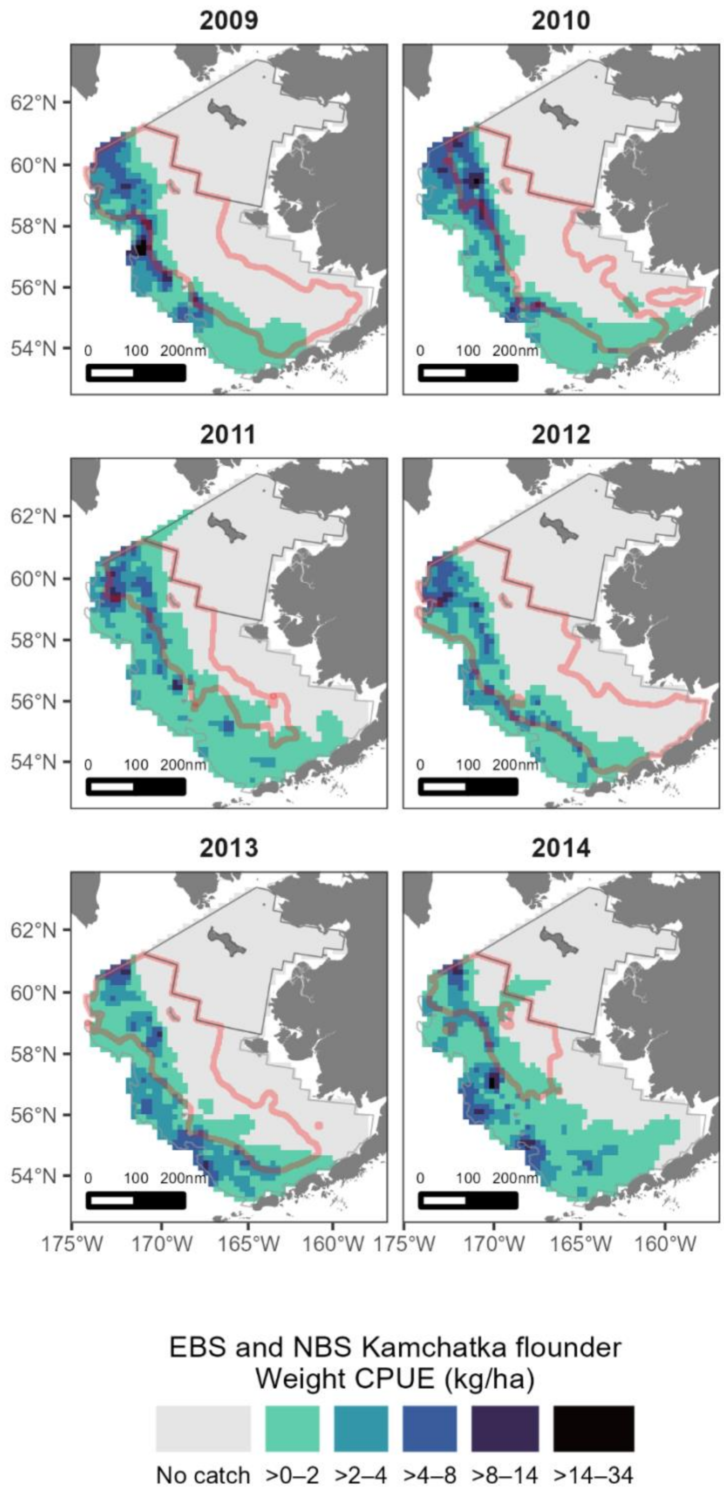


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.

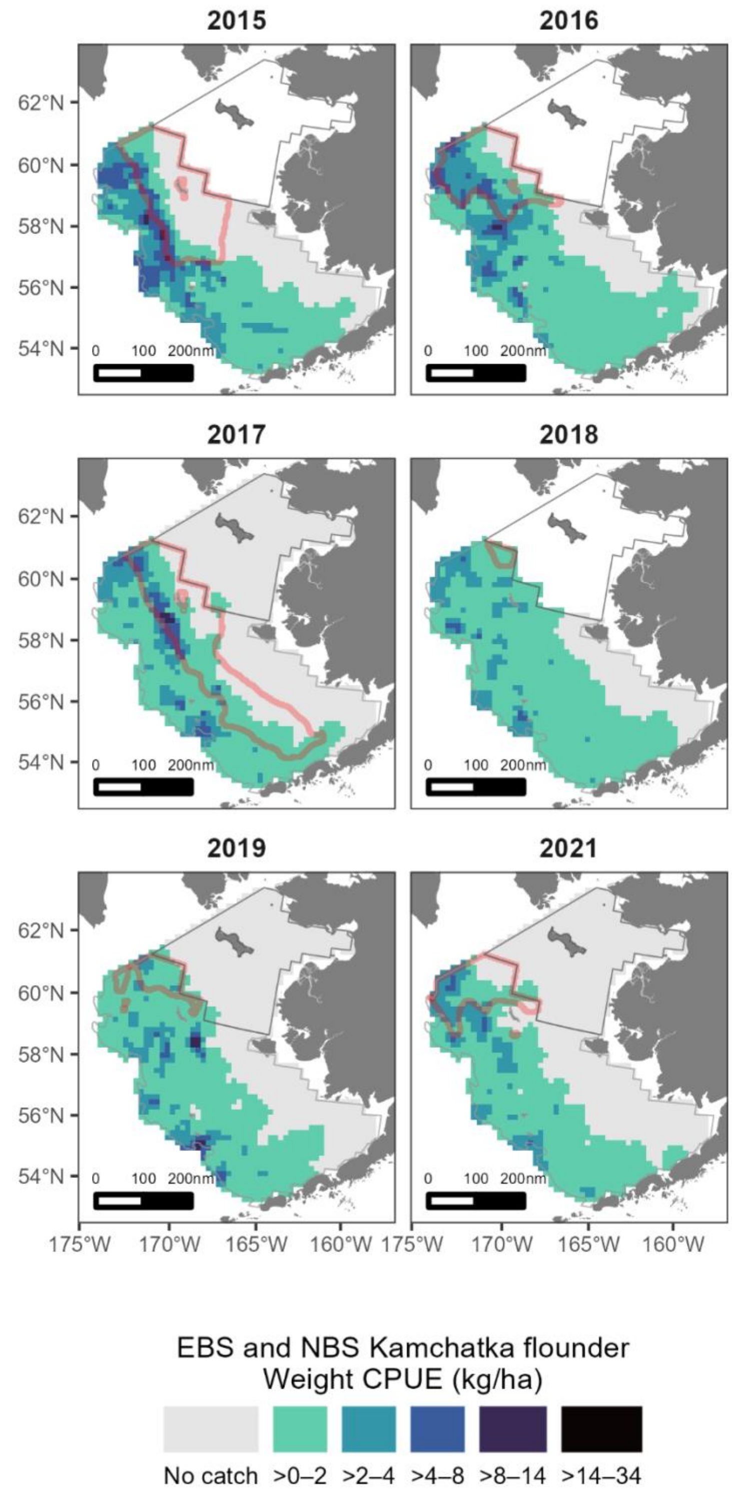
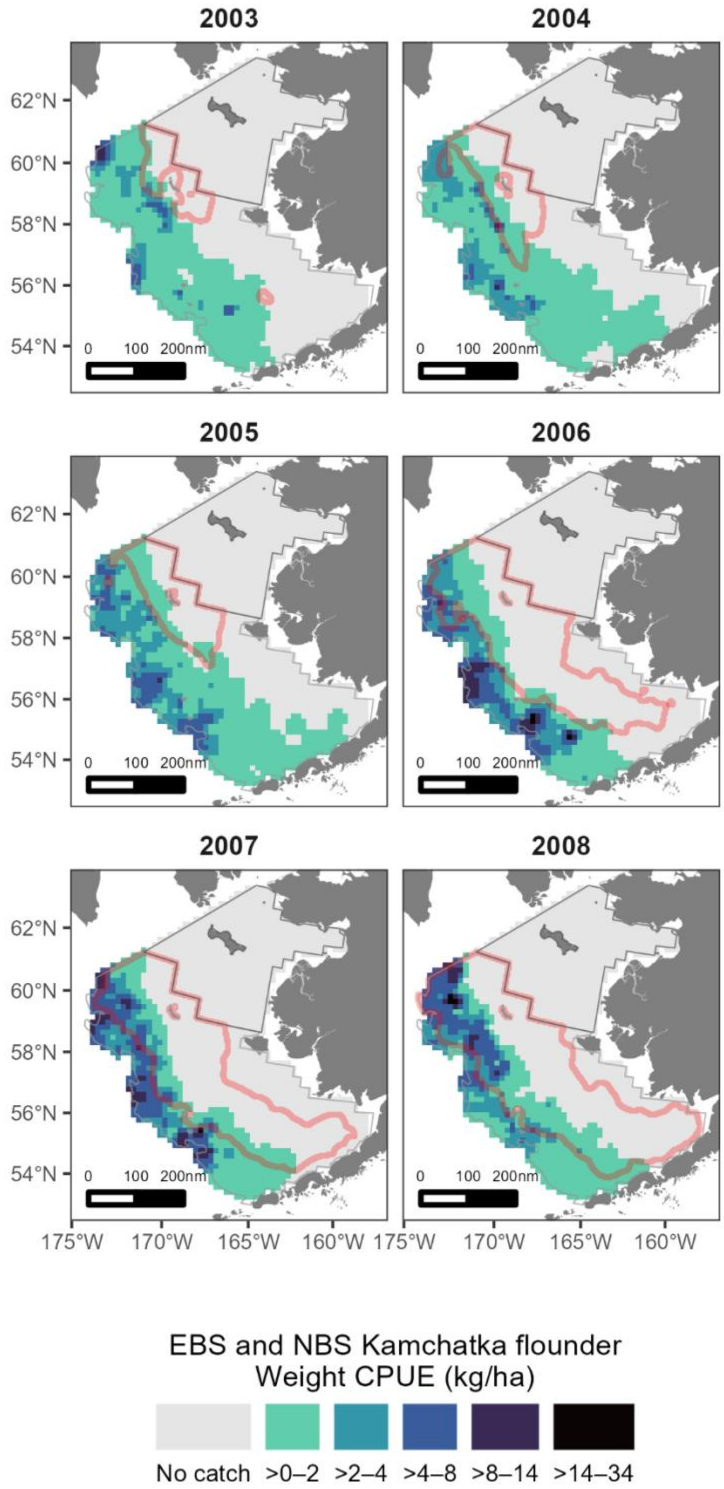


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.


2003
2004
2005
2006
2007
2008
62°N
60°N
58°N
56°N
54°N
0 100 200nm
175°W 170°W 165°W 160°W
EBS and NBS Kamchatka flounder
Weight CPUE (kg/ha)
No catch >0–2 >2–4 >4–8 >8–14 >14–34

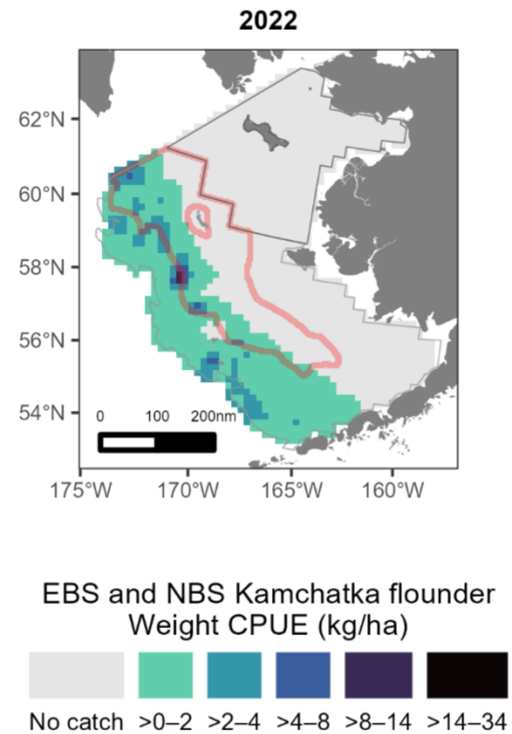


Figure 7-39. Kamchatka catch per unit effort (CPUE) in kg/hectare.