15. Assessment of the shortraker rockfish stock in the Bering Sea and Aleutian Islands

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Executive Summary

The Bering Sea and Aleutian Islands (BSAI) shortraker rockfish (*Sebastes borealis*) stock is currently managed in Tier 5 and is assessed on an even year schedule to coincide with new survey data from the Aleutian Islands (AI) bottom trawl survey.

Summary of Changes in Assessment Inputs

Changes in the input data:

1) Catch data have been revised and updated through October 15, 2022.
2) 2022 AI bottom trawl survey (BTS).
3) AFSC longline survey (LLS) relative population weights (RPWs) on the eastern Bering Sea (EBS) slope, 1997-2021. The EBS slope is sampled by the LLS in odd years.

Changes in the assessment methodology:

The random effects model was fit in Template Model Builder (TMB; Kristensen et al. 2016) using the new rema R library. The models presented as follows:

1) Model 18.9: The accepted model in the last full assessment as implemented in 2018 and 2020 using the univariate version of the random effects (RE) model (Shotwell et al., 2020). Model 18.9 was bridged from AD Model Builder (ADMB; Fournier et al. 2012) to TMB and to the multivariate version of the random effects (REM) model in Sullivan et al. (2022a, Appendix B). This bridging analysis was presented to and accepted by the BSAI Groundfish Plan Team in September 2022. In the bridged Model 18.9, three separate strata (AI, EBS slope, southern Bering Sea; SBS) are fit and share process error across strata (Sullivan et al., 2022a, Appendix B).
2) Model 22 (author-recommended): Same as the bridged Model 18.9 and also fits to the EBS slope LLS RPWs (Sullivan et al. 2022a, Appendix B).

Summary of Results

The summarized results of the risk table exercise for shortraker rockfish are in the table below. All scores of Level 1 suggest no need to set the ABC below the maximum permissible. Further details for each category of this risk table are provided in the *Harvest Recommendations* section.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 1: Normal	**Level 1:** Normal	**Level 1:** Normal	**Level 1:** Normal

Reference values for shortraker rockfish are summarized in the following table. The recommended 2023 acceptable biological catch (ABC) and overfishing limit (OFL) for BSAI shortraker rockfish are 530 t and 706 t, respectively. The stock is not being subjected to overfishing.

	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
Quantity	2022	2023	2023	2024
M (natural mortality rate)	0.03	0.03	0.03	0.03
Tier	5	5	5	5
Biomass (t)	24,055	24,055	23,547	23,547
F_{OFL}	0.03	0.03	0.03	0.03
$maxF_{ABC}$	0.0225	0.0225	0.0225	0.0225
F_{ABC}	0.0225	0.0225	0.0225	0.0225
OFL (t)	722	722	706	706
maxABC (t)	541	541	530	530
ABC (t)	541	541	530	530
	As determined *last* year for:		As determined *this* year for:	
Status	2020	2021	2021	2022
Overfishing		n/a		n/a

Summaries for the Plan Team

The following table gives the recent biomass estimates, catch, harvest specifications, and projected biomass, OFL and ABC for 2021-2024.

Year	Biomass	OFL	ABC	TAC	Catch
2021	24,055	722	541	500	496
2022	24,055	722	541	541	257[1]
2023	23,547	706	530		
2024	23,547	706	530		

[1] Catch as of October 15, 2022.

Responses to SSC and Plan Team Comments on Assessments in General

"*The Teams recommend that, for ESPs in general, when a fishery performance indicator may have ambiguous interpretations, no traffic light color coding should be assigned, but the scoring (which is indicative of a trend, but not the relationship of the indicator to stock health) should be maintained.*" (Joint Plan Team, November 2021)

An ecosystem and socioeconomic profile or ESP has not been created for this stock at this time. If an ESP is generated in the future we will use the standardized format which no longer includes a traffic light color coding for fishery performance indicators. This was instituted in the 2022 ESPs for several groundfish stocks and allows for the scoring to be maintained without the ambiguous color interpretations.

"*The Team recommends that the AFSC prioritize research on best practices for specifying the selectivity schedules used in projections for Tier 1-3 stocks in general.*" (BSAI Plan Team, November 2021)

This is a not a Tier 3 stock and so this comment does not apply to this stock.

"*The Team recommends all GOA authors evaluate any bottom trawl survey information used in their assessment prior to 1990 including the 1984 and 1987 surveys and conduct sensitivity analyses to evaluate their usefulness to the assessment. This may apply for Aleutian Islands surveys but this was only raised during GOA assessment considerations.*" (GOA Plan Team, November 2021)

This is not a GOA stock but we did consult the Groundfish Assessment Program (GAP) regarding the appropriate starting year for rockfish biomass estimates from the Aleutian Islands bottom trawl survey (AI BTS). The time series for the AI BTS began in 1980 but gear was not standardized until the 1991 survey when the Poly'Noreastern (PNE) bottom trawl was uniformly implemented. We start the AI BTS biomass time series in 1991 based on recommendations from the GAP program to use the standardized time series estimates.

"*With respect to Risk Tables, the SSC would like to highlight that "risk" is the risk of the ABC exceeding the true (but unknown) OFL, as noted in the October 2021 SSC Risk Table workshop report. Therefore, for all stocks with a risk table, assessment authors should evaluate the risk of the ABC exceeding the true (but unknown) OFL and whether a reduction from maximum ABC is warranted, even if past TACs or exploitation rates are low.*" (SSC, December 2021)

Since this is a full assessment year for BSAI shortraker rockfish, we provide a risk table with formatting as recommended by the SSC and the table ranking descriptions for completeness. We evaluated the four risk categories as they relate to the shortraker stock assessment, population dynamics and fishery performance as presented in this SAFE report and also consulted with the Ecosystem Status Report or ESR editors regarding the environmental/ecosystems considerations. Following the completion of this exercise, the highest score for this stock is a Level 1 and the authors do not recommend that the ABC be reduced below maximum permissible ABC. Please see the *Harvest Recommendations* section for further details for each category of this risk table.

"*The SSC recommends that groundfish, crab and scallop assessment authors do not change recommendations in documents between the Plan Team and the SSC meetings, because it makes it more difficult to understand the context of the Plan Team's rationale and seems counter to the public process without seeing a revision history of the document."*

"The SSC recommends a working group be formed to explore options for altering the timing of reviews of select crab and groundfish assessments to address this timing issue"

(SSC, December 2021)

We do not plan to change the recommendations in this SAFE document between the Plan Team and the SSC meetings and did not change the SAFE document from the last full assessment between meetings.

In reference to the lack of recent EBS slope survey information: "*The SSC recommends that assessment authors continue to highlight instances where the lack of these data may degrade stock assessment performance.*" (SSC, October 2022)

In the September Plan Team meeting we discussed the importance of the EBS slope survey information during several of the presentations to the BSAI Plan Team. We also have incorporated the longline survey data on the EBS slope within the random effects model to account for the lack of an EBS slope survey for shortraker rockfish in this assessment.

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

"*The SSC supports the JGPT's recommendation that stock assessment authors transition from the ADMB RE variants to the rema framework, which implements the same model variants in a single framework with several improvements.*" (SSC, October 2022)

In September Plan Team we provided a document using the *rema* R package for shortraker rockfish and provided a bridging exercise between the previous univariate version of the random effects model used in the 2020 shortraker stock assessment. We also now use the *rema* option in the *rema* R package to incorporate an additional relative population weight estimate from the longline survey.

Responses to SSC and Plan Team Comments Specific to this Assessment

"*The Team recommended the author communicate with the Groundfish Assessment Program (GAP) survey team to determine the appropriate starting year for the bottom trawl survey data for this species, and to document that decision in the assessment document.*" (BSAI Plan Team, September 2022)

Following the September Plan Team, we consulted with the Groundfish Assessment Program (GAP) regarding the appropriate starting year for rockfish biomass estimates from the Aleutian Islands bottom trawl survey (AI BTS). The time series for the AI BTS began in 1980 but gear was not standardized until the 1991 survey when the Poly'Noreastern (PNE) bottom trawl was uniformly implemented. We start the AI BTS biomass time series in 1991 based on recommendations from the GAP program to use the standardized time series estimates. We also continue to use the standardized EBS slope BTS data from 2002 to 2016 following recommendations from GAP. We included documentation of this decision within the Survey subsection of the Data section along with descriptions of each survey used in this assessment.

"*The Team recommended limiting the November analysis to the last approved model, Model 18, and the updated Model 22.*" (BSAI Plan Team, September 2022)

We provide a short description of the bridging exercise but do not include that as one of the alternative models in this assessment. The models for evaluation are now the bridged base model implemented in the rema r package using TMB and the multivariate version of the random effects model (*rem*) and the alternative model using the multivariate version with the additional survey (*rema*) as recommended by the BSAI Plan Team in September.

Introduction

The Bering Sea and Aleutian Islands shortraker rockfish complex is currently managed in Tier 5 and is assessed on a biennial basis to coincide with the Aleutian Islands groundfish bottom trawl survey.

Distribution

Shortraker rockfish (*Sebastes borealis*) are distributed along the continental slope in the north Pacific from Point Conception in southern California to Japan, and are commonly found between eastern Kamchatka and British Columbia (Love et al. 2002). Adults occur in a narrow range of depths on the continental slope centered at ~350 m (Rooper 2008), often in areas of steep slope (Rooper and Martin 2012). In bottom trawl survey data, shortraker rockfish are most common through the Aleutian Islands (AI) and the central Gulf of Alaska (GOA).

Life History Information

Shortraker rockfish are among the longest-lived animal species in the world, reaching ages > 150 years. The species is viviparous with spawning believed to occur throughout the spring and summer (Westerheim 1975, McDermott 2004). Little is known of shortraker rockfish early life history and habitat preferences, as immature fish are rarely observed. Love et al. (2002) indicates the species is found at shallower depths during early life history. Studies of habitat preferences in the GOA indicate shortraker rockfish may be more abundant in boulder patches with associated *Primnoa* coral (Krieger and Ito 1999, Krieger and Wing 2002). Shortraker rockfish consume large benthic or near-bottom prey, including myctophids, shrimp and squid (Yang et al. 2006).

Evidence of Stock Structure

Several types of research can be used to infer stock structure of shortraker rockfish, including larval distribution patterns and genetic studies. In 2002, an analysis of archived *Sebastes* larvae was undertaken by Dr. Art Kendall using data collected in 1990 off southeast Alaska (650 larvae) and the AFSC ichthyoplankton database (16,895 *Sebastes* larvae, collected on 58 cruises from 1972 to 1999, primarily in the GOA). The southeast Alaska larvae all showed the same morph, and were too small to have characteristics that would allow species identification. A preliminary examination of the AFSC ichthyoplankton database indicated that most larvae were collected in the spring, the larvae were widespread in the areas sampled, and most were small (5-7 mm). The larvae were organized into three size classes for analysis: <7.9 mm, 8.0-13.9 mm, and >14.0 mm. A subset of the abundant small larvae was examined, as were all larvae in the medium and large groups. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfish species in the north Pacific have published descriptions of the complete larval developmental series. However, all of the larvae examined could be assigned to four morphs identified by Kendall (1991), where each morph is associated with one or more species. Most of the small larvae examined belong to a single morph, which contains the species *S. alutus* (Pacific ocean perch), *S. polyspinus* (northern rockfish), and *S. ciliatus* (dusky rockfish). Some larvae (18) belonged to a second morph which has been identified as *S. borealis* (shortraker rockfish) in the Bering Sea. The locations of these larvae were near Kodiak Island, the Semidi Islands, Chirkof Island, the Shumagin Islands, and near the eastern end of the AI.

Population structure for shortraker rockfish has been observed in microsatellite data (Matala et al. 2004), with the geographic scale consistent with current management regions (i.e., GOA, AI, and EBS). The most efficient partitioning of the genetic variation into non-overlapping sets of populations identified three groups: a southeast Alaska group, a group extending from southeast Alaska to Kodiak Island, and a group extending from Kodiak Island to the central AI (the western limit of the samples). The available data are consistent with a neighborhood genetic model, suggesting that the expected dispersal of a particular specimen is much smaller than the species range. A parallel study with mtDNA revealed weaker stock structure than that observed with the microsatellite data. It is not known how shortraker in the EBS or western AI relate to the large population groups identified by Matala et al. (2004) due to a lack of samples in these areas.

Spatial differences in life-history characteristics, such as growth rates and age at maturity, could also provide information on stock structure. However, little data are available on these processes, in part because of the difficulty of aging shortraker rockfish. Production aging of shortraker rockfish is currently impeded by the lack of consistent age criteria. Recent, ^{14}C age validation studies appeared promising, but additional testing regarding the accuracy of ages may be needed before initiating production aging.

Fishery

Catches of shortraker rockfish have been reported in a variety of species groups in the foreign and domestic Alaskan fisheries. Foreign catch records did not report shortraker rockfish by species, but in categories such as "other species" (1977, 1978), "POP complex" (1979-1985, 1989), and "rockfish without POP" (1986-1988). Shortraker rockfish were managed in the domestic fishery as part of the "other red rockfish" from 1991-2000 and the "shortraker/rougheye" complex from 2001-2003. The ABCs, TACs, and catches by management complex from 1988-2022 are shown in Table 15.1a and 15.1b. Since 2003, the catch accounting system (CAS) has reported catch of shortraker rockfish by species and area. From 1991-2002, shortraker rockfish catch was reconstructed by computing the harvest proportions within management groups from the North Pacific Foreign Observer Program database, and applying these proportions to the estimated total catch obtained from the NOAA Fisheries Alaska Regional Office "blend" database. This reconstruction was conducted by estimating the shortraker catch for each area (i.e., the EBS and each of the three Aleutian Island areas, the central (CAI), Western (WAI), and Eastern Aleutian Islands (EAI)) and gear type (trawl and longline) from 1994-2002. For 1991-1993, the Regional Office blend catch data for the AI was not reported by AI subarea, and the AI catch was obtained using the observer harvest proportions by gear type for the entire AI area. Similar procedures were used to reconstruct the estimates of catch from the 1977-1989 foreign and joint venture fisheries. Estimated domestic catches in 1990 were obtained from Guttormsen et al. 1992. Catches from the domestic fishery prior to the domestic observer program were obtained from PACFIN records. Catches of shortraker rockfish since 1977 are shown in Table 15.2. Catches were relatively high during the late 1970s, declined during the late 1980s as the foreign fishery was reduced, increased in the early 1990s, declined in the mid-1990s and have been relatively stable with a slight increase in early 2000s and again since 2019. Catches since 2003 have ranged between approximately 120-500 t (Table 15.2).

The catches by area from 1994-2022 have been variable, with the largest catches occurring in the EBS in 1978 and 1979 (Table 15.2). From 2003 to 2022, 50% of the shortraker catch occurred in the EBS, with 18%, 20%, and 13% in the WAI, CAI, and EAI areas respectively. Catches in the WAI averaged 34 t from 2003-2010, then increased in 2011-2013 to an average of 164 t, and decreased to an average of 27 t from 2014-2021. Catch as of October 15, 2022 was 31 t in the Western AI (Table 15.3).

Estimates of discarding by species complex are shown in Table 15.4. Estimates of discarding of the other red rockfish complex in the EBS were generally above 55% from 1993 to 2000, with the exception of 1993 and 1995 when discarding rates were less than 26%. The variation in discard rates may reflect different species compositions of the other red rockfish catch. Discard rates of EBS shortraker/rougheye (SR/RE) complex from 2001 to 2003 were below 52%, and discard rates of AI SR/RE complex from 1993-2003 were below 41%. In general, the discard rates of EBS SR/RE are less than the discard rates of EBS other red rockfish in most years, likely reflecting the relatively higher value of rougheye and shortraker rockfishes over other members of the complex. Discard rates of BSAI shortraker rockfish from 2004-2021 have ranged from 12% to less than 54%, and were 31.1% in 2021 and 17.8% for 2022 (catch taken through October 15, 2022).

Shortraker rockfish in the AI have been primarily taken in the rockfish trawl fishery (53%), and the Atka mackerel fishery (11%), as well as the flatfish (8%) and sablefish (8%) longline fisheries, with lesser catches from the halibut (7%) and Pacific cod (7%) fisheries (Table 15.5). Catches of shortraker rockfish from 2004-2020 in the EBS were caught largely in the flatfish trawl fishery (26%), rockfish bottom trawl (25%), midwater pollock trawl fishery (17%), Pacific cod longline (12%), and the halibut (10%) and flatfish (5%) longline fisheries (Table 15.6). Catches of shortraker rockfish in the EBS management area were concentrated in areas 517 and 521, the areas occupying much of the EBS slope (Table 15.6).

Shortraker rockfish and four other species of rockfish (Pacific ocean perch, northern rockfish, rougheye rockfish, *S. aleutianus*; and sharpchin rockfish, *S. zacentrus*) were managed as a complex in the EBS and AI management areas from 1979 to 1990. Known as the POP complex, these five species were managed as a single entity with a single TAC (total allowable catch) within each management area. In 1991, the North Pacific Fishery Management Council enacted new regulations that changed the species composition of the POP complex. For the EBS slope region, the POP complex was divided into two subgroups: 1) Pacific ocean perch, and 2) shortraker, rougheye, sharpchin, and northern rockfishes combined, also known as "other red rockfish" (ORR). For the AI region, the POP complex was divided into three subgroups: 1) Pacific ocean perch, 2) shortraker/rougheye rockfishes, and 3) sharpchin/northern rockfishes. In 2001, the other red rockfish complex in the EBS was split into two groups, shortraker/rougheye and sharpchin/northern, matching the complexes used in the AI. These subgroups were established to protect Pacific ocean perch, shortraker rockfish, and rougheye rockfish (the three most valuable commercial species in the assemblage) from possible overfishing. Additionally, separate TACs were established for the EBS and AI management areas, but the overfishing level (OFL) pertained to the entire BSAI area. In 2002, sharpchin rockfish were assigned to the "other rockfish" category, leaving only northern rockfish and the shortraker/rougheye complex as members of other red rockfish. In 2004, rougheye and shortraker rockfishes were managed by species in the BSAI area. Shortraker rockfish has been assessed separately since 2008.

Data

Fishery

The length composition from observer sampling of the domestic fishery (Figure 15.1a,b), indicate relatively consistent length distributions with the bulk of the sampled fish generally between 33 and 77 cm. There are no apparent trends in the size distribution. The number of length observations taken by fishery observers in the BSAI is shown in the following table.

Year	Number of fishery length observations	Year	Number of fishery length observations
1990	373	2009	1,346
1991	576	2010	2,156
1992	413	2011	1,158
1993	736	2012	709
1994	125	2013	835
1999	306	2014	1,137
2000	114	2015	1,260
2001	138	2016	493
2002	226	2017	234
2003	2,000	2018	434
2004	1,630	2019	600
2005	1,352	2020	238
2006	1,464	2021	523
2007	1,730	2022*	239
2008	702		

*Length samples as of October 15, 2022

The catch data are the estimates of single species catch described above and shown in Table 15.2. Removals from sources other than those that are included in the Alaska Region's official estimate of catch are presented in Appendix 1. Non-commercial removals averaged 2.4 t between 2005 and 2020.

Survey

AFSC Bottom Trawl Surveys

Biomass estimates for other red rockfish were produced from cooperative U.S.-Japan bottom trawl surveys (BTS) from 1979-1985 on the EBS slope, and from 1980-1986 in the AI. U.S domestic bottom trawl surveys were conducted in 1988, 1991, 2002, 2004, 2008, 2010, 2012, and 2016 on the EBS slope, and in 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, 2018, and 2022 in the AI and southern Bering Sea (SBS), which is defined by the International North Pacific Fisheries Commission (INPFC) and sampled in the AI BTS (Table 15.7). The 2008 AI survey and 2006, 2010, and 2018 EBS slope surveys were canceled. The 2020 AI survey and EBS slope survey were cancelled due to the COVID-19 pandemic. The spatial distribution of the BTS stratum are provided in Figure 15.2.

The AI BTS is a multi-species survey and biomass estimates are based on a stratified random design of habitat stratified by management area, sub-region, and depth zones (0-100 m, 101-200 m, 201-300 m and 301-500 m). However, the AI BTS is based on a stratified random design of previously successful stations and is therefore an index survey. Design-based biomass estimates may be more appropriately viewed as weighted mean catch-per-unit-effort expanded by strata over the survey area. The AI BTS time series began in 1980 but gear was not standardized until the 1991 survey when the Poly'Noreastern (PNE) bottom trawl was uniformly implemented. Before then, a mix of large, fortified nets and a similar net to the PNE were used. Also haul duration was generally 30 minutes prior to 1997 when haul duration was reduced to 15 minutes. Based on recommendations from the Groundfish Assessment Program (GAP), we start the AI BTS biomass time series in 1991 for shortraker rockfish. The spatial distribution of shortraker catch-per-unit-effort from 1991 to present is provided in Figure 15.3 and shows the patchy distribution of catches over time with some particularly large catches in single tows in the western and central AI.

The EBS slope BTS is a multi-species survey with sampling effort distributed in proportion to the survey surface area by sub-region and depth (200-400 m, 400-600 m, 600-800 m, 800-1000 m, and 1000-1200 m; Hoff 2013). The biennial EBS slope survey was initiated in 2002. The most recent slope survey prior to 2002, excluding some preliminary tows in 2000 intended for evaluating survey gear, was in 1991. The survey used a standardized PNE with a tow duration of 30 minutes and towing speed of 2.5 knots. Although the EBS slope BTS only occurred six times and ended in 2016, it is likely our best depiction of deepwater rockfish species (e.g., shortaker rockfish, shortspine thornyhead) in this region.

EBS shelf BTS is conducted annually using fixed stations at the center of a 20 x 20 nautical mile grid (Lauth and Nichol 2013). Design-based estimates of EBS shelf BTS biomass are based on 12 strata that include four sub-regions and 3 depth strata (<50 m, 50-100 m, and 101-200 m). The survey design has been standardized since 1982 and uses a tow duration of 30 minutes and a 3 knot towing speed. The EBS shelf BTS uses a standard 83-112 Eastern otter trawl employing a 25.3 m head rope and 34.1 m footrope. Although the standard sampling trawl for the EBS shelf started in 1982, the survey was expanded in 1987 to include two more strata in the northwest area and the expanded survey area has been the standard sampling area to present.

The largest survey biomass for shortraker is found on the AI BTS, and there was a decreasing trend over the survey time period from 2000-2016 (Table 15.7, Figure 15.4) with an increase in the 2018 estimate back to near average levels and then a decrease in the 2022 estimate. The SBS, an area defined by the INPFC northeast of Samalga Pass that is sampled in the AI BTS, has the smallest survey biomass of any of the areas (Table 15.7, Figure 15.4). Biomass in the SBS has shown a consistent decline in biomass estimated by the survey since 1983, although there was an increase in 2022 from the previous survey. Shortraker rockfish are primarily caught in the 301-500 m stratum in the AI BTS, which is the deepest stratum in that survey. Estimates of deep-water species such as shortraker rockfish are likely underestimated in the AI BTS, because it does not sample <500 m. AI surveys from 1980 to 2018 indicated higher abundances in the western (543) and central (542) than in the eastern AI (541) (Table 15.7), with the SBS area having the lowest abundance (Figure 15.4). However, the 2022 survey shows higher abundances in the eastern AI and very low abundance in the western AI. The survey biomass estimates of shortraker rockfish from the 2002-2016 EBS slope surveys have ranged between 2570 t (2004) and 9,284 t (2012), with CVs between 0.22 and 0.57. There are no shortraker rockfish on the EBS shelf survey.

In contrast to the fishery length compositions, the survey length compositions reveal fewer large fish (Figure 15.1a,b), with the exception of the more recent EBS slope surveys of 2012 and 2016. In surveys from 1994 to 2018, fish lengths from survey samples generally occurred between 30 cm and 65 cm.

AFSC Longline Survey

The domestic longline survey is conducted annually by the AFSC over the continental slope region of the BS/AI and the GOA. The GOA stations are sampled each year while the Bering Sea is sampled on odd years and the Aleutian Islands in even years. This survey provides data on the relative abundance of shortraker rockfish and computes relative population numbers (RPNs) and relative population weights (RPWs) for fish on the continental slope as indices of stock abundance. Relative population abundance indices are computed annually using survey catch per unit of effort (CPUE) rates that are multiplied by the area size of the stratum within each geographic area. These relative population indices are available by numbers (RPN) and weights (RPW) for a given species (Rodgveller et al. 2011). The survey is primarily directed at sablefish, but also catch considerable numbers of shortraker rockfish. Results for this survey concerning rockfish, however, should be viewed with some caution, as the RPNs and RPWs do not take into account possible effects of competition for hooks with other species caught on the longline, especially sablefish. An analysis of the survey data indicated there was a negative correlation between catch rates of sablefish and shortraker rockfish in the GOA, and that there was likely competition for hooks between species in the surveys (Rodgveller et al. 2008). The study concluded that further research and experiments are needed to better quantify the effects of hook competition and to compute adjustment factors for the survey catch rates. Recently, another study compared catch rates of shortraker and rougheye rockfish on survey longline gear with observed densities of these fish around the longline from a manned submersible also in the GOA (Rodgveller et al. 2011). Results for shortraker and rougheye combined showed a catchability coefficient (q) of 0.91. There was a tendency for longline catch rates of the two species to be related to the observed densities, but this relationship was not significant. Again, this study concluded that additional research is needed on the longline catching process for shortraker rockfish to better determine the suitability of using longline survey results for assessment of this species.

The AFSC longline survey has been conducted annually since 1988, and RPNs and RPWs have been computed for each year and are available since 1997 for shortraker rockfish (Table 15.8). RPNs in the Aleutian Islands have ranged from a low of ~9,800 t in 2022 to a high of ~35,700 t in 2006 and in the Bering Sea from a low of ~4,100 t in 2009 to a high of ~28,700 t in 2003. The Aleutian Islands time series appears to exhibit a strong saw tooth pattern up until about 2016 when the series seems to stabilize somewhat (Table 15.8) and has decreased in recent years. The Bering Sea time series seems to be somewhat stable after about 2005. Definite trends in these data over the years are difficult to discern, and the BSAI values of RPN fluctuate considerably between adjacent years. This same pattern is evident in the GOA time series for shortraker rockfish. Some of the fluctuations may be related to changes in the abundance of sablefish, as discussed in the previous paragraph regarding competition for hooks among species. The 2022 longline survey RPN value for shortraker rockfish is down about 33% from 2020. Longline survey results show that the abundance of shortraker rockfish was generally higher in the Aleutians than the Bering Sea until about 2016 when they are similar in magnitude (Table 15.8).

Length data are also collected for shortraker rockfish during longline surveys and compositions are available since 1997. A clear difference in size between the Aleutian Islands (sampled in even years) and the Bering Sea (sampled in odd years) exists with larger fish sampled in the Bering Sea. In surveys from 1996 to 2022, fish lengths from the Bering Sea were similar to the fishery samples and generally occurred between 50 cm and 80 cm, while fish lengths from the Aleutian Islands were similar to survey samples and generally occurred between 30 cm and 65 cm. The habitat between the two regions is quite different and the biomass estimates on the bottom trawl survey and the RPNs on the longline survey are larger for the Aleutian Islands than the Bering Sea.

The inclusion of LLS relative population weights (RPWs) for shortraker in the EBS slope region in the 2022 assessment was prompted by concerns over the cessation of the EBS slope BTS in 2016. We recommend including the EBS slope LLS RPWs to inform abundance trend information in recent years, thus reducing reliance on the 2016 estimate of biomass in that region. The potential use of LLS RPWs in the AI was explored; however, we do not recommend using the AI RPWs at this time due to a mismatch in the spatial extent and resolution of the AI BTS and LLS (Figure 15.2). The LLS only samples the eastern AI, and the LLS area boundaries would need to be manually redefined in order to make them comparable with the BTS strata (Figure 15.2).

International Pacific Halibut Commission Survey

The International Pacific Halibut Commission (IPHC) conducts a longline survey each year to assess Pacific halibut. This survey differs from the AFSC longline survey in gear configuration and sampling design, but also catches shortraker rockfish. More information on this survey can be found in Soderlund et al. (2009). A major difference between the two surveys is that the IPHC survey samples the shelf consistently from 1-500 meters, whereas the AFSC longline survey samples the slope and select gullies from 200 to 1000 meters. Because the majority of effort occurs on the shelf in shallower depths, the IPHC survey may catch smaller and younger shortraker rockfish than the AFSC longline survey and similar to the AFSC bottom trawl surveys; however, lengths of shortraker rockfish are not taken on the IPHC survey.

RPNs have been computed for each year of the IPHC survey and are available since 1998 to 2019 for shortraker rockfish (Table 15.9). RPNs in the Aleutian Islands have ranged from a low RPN in 2018 to a high in 2011 and in the Bering Sea from a low in 2006 to a high in 2009. RPNs increased in 2019 compared to 2018 for both the Bering Sea and Aleutian Islands regions. The Bering Sea estimate is now 68% above the long-term average for the time series, but the Aleutian Islands estimate was 43% below the long-term average for that time series. Both the Aleutian Islands and Bering Sea time series appear to exhibit some fluctuation over the time period, possibly due to hook competition, but the pattern is not as clear as saw tooth pattern on the AFSC longline survey (Figure 15.5).

There have been recent changes to the sampling protocol and coverage of the IPHC longline survey. As such, we do not recommend using this survey as these changes will limit the survey utility moving forward.

Analytic Approach

Exploitable biomass is estimated using a state-space random walk model, referred to broadly as the random effects (RE) model. The RE model is fit to design-based estimates of survey biomass and observation error. Population biomass is modeled as a series of random effects, and the overall smoothness of the population relative to survey biomass is governed by the process error variance, the only fixed effect parameter estimated in the model. There are two extensions to the RE model, a multivariate version that can be used to fit to multiple strata simultaneously and share process error across one or more strata (REM), and another version that can fit to an additional relative abundance index (REMA; Hulson et al. 2021). Equations for the RE, REM, and REMA models, and a guide to fitting these models in TMB using the rema R package is provided in Sullivan et al. (2022a).

Model 18.9

The accepted model in the last full assessment (Shotwell et al. 2020) as implemented in 2018 and 2020 used the univariate version of the RE model fit separately to the AI, southern Bering Sea (SBS, sampled by the AI BTS), and EBS slope. In September 2022, a bridging exercise was completed to bring this model to TMB using the rema R package. This model was further bridged from the univariate version to the multivariate version of the random effects (REM) model, where the three regions are fit simultaneously with a separate process error parameter in each region. The BSAI Plan Team endorsed this bridging exercise and recommended the bridged multivariate version be used for further model comparisons.

Model 22

In recent years, concerns have been raised about the lack of abundance information for shortraker rockfish and other species in the eastern Bering Sea (EBS) slope region following the cessation of the EBS slope

BTS in 2016 (Shotwell et al. 2020, Sullivan et al. 2020). In response, we developed an alternative model that addresses these concerns through the inclusion of the NMFS longline survey (LLS) relative population weights (RPWs) in the eastern Bering Sea (EBS) slope region. This model is the multi-survey (AI BTS, EBS slope BTS, and LLS) version of the REMA model, which has the same configuration as the bridged Model 18.9 but also fits to the LLS RPWs in the EBS slope region.

Reference points

Shortraker rockfish in the BSAI are managed under Tier 5, where OFL = *M* * average survey biomass, where *M* represents natural mortality, and F_{ABC} is estimated by 0.75 * *M*. The acceptable biological catch (ABC) is obtained by multiplying F_{ABC} by the estimated biomass, ABC ≤ 0.75 * *M* * biomass.

Parameter Estimates

Shortraker rockfish are assumed to have a natural mortality rate (*M*) of 0.03. This estimate of natural mortality is consistent with estimates for north Pacific shortraker rockfish using the gonad somatic index, which ranged from 0.027 to 0.042 (McDermott 1994). Recently, a group of stock assessment authors collaborated on a tech memo to revisit available life history data and M for several rockfish species in Alaska (Sullivan et al. 2022b). This manuscript was only recently published and will be used to reevaluate M for BSAI shortraker rockfish in future years.

Results

Shortraker biomass is greatest in the AI (78% on average), followed by the EBS slope (21% on average) and then the SBS portion of the AI survey (1% on average). Both Model 18.9 and 22 perform well for shortraker rockfish in all survey regions (Figure 15.4) with very few estimates falling outside the confidence bounds. The fit to shortraker survey biomass shows a decrease from 1997-2006, then stable until 2016 and a slight increase to present in the AI, a slight increase in the EBS slope from 2002-2016, a decrease in the southern Bering Sea since 1997.

The LLS RPWs and BTS biomass estimates of shortraker on the EBS slope follow a similar trend where estimates overlap, therefore long-term predicted biomass trajectories are similar between Models 18.9 and 22 (Figure 15.4). Also, the estimate of process error is lower in Model 22, resulting in slightly less inter-annual variability in biomass in Model 22 (Table 15.10). The inclusion of the LLS RPW index uses the most current data on shortraker rockfish abundance in the EBS slope region, and therefore, Model 22 is the author-preferred model. Although adding this new data source does not change our current understanding of shortraker abundance on the EBS slope, the 2022 decline in the RPWs and AI BTS survey, and the decrease in GOA shortraker stock in 2022 RPWs suggest there may be continued changes to the dynamics of this stock (K. Siwicke, *pers. commun.*).

The BSAI biomass estimates of shortraker rockfish from both models are very similar and are provided in Table 15.11 and Figure 15.6. The 2022 biomass estimate differs by only 3.6% between the two models. More shortraker rockfish are present in the AI than the EBS. The random effects model results estimated 5,349 t in the EBS and 18,198 t in the AI in 2022. These were calculated by combining the Southern Bering Sea area (517+518) that was surveyed on the Aleutian Islands survey with the Bering Sea slope data estimates of biomass.

Given the history of previously managing EBS rockfish as separate stock complexes, and recent information on genetic population structure for other BSAI rockfish species, it is prudent to examine how area-specific exploitation rates compare to F_{ABC} and F_{OFL} reference points. Area-specific exploitation rates for a given year were obtained by dividing the yearly catch by the estimate of biomass for the strata. The subareas considered here are the AI subareas, the southern Bering Sea (i.e., areas 517 and 518) and the EBS slope (i.e., the remainder of the EBS management area minus the southern Bering Sea).

Exploitation rates in the AI have been below *M* and generally low from 2004-2021 (Figure 15.7). Increases in the catch in the western AI in 2011-2013 resulted in the exploitation rates in this area exceeding area-specific F_{ABC} and F_{OFL} (Table 15.3). Catch of shortraker rockfish in the SBS is variable, generally ranging from 0-50 t, but increased to the highest in the time series in 2019, dropped in 2020, and then increased again in 2021 to 112 t. As of October 15, 2022 the catch was lower than 2021 but these rapid fluctuations are interesting (Table 15.3). Biomass in the SBS region appears to be decreasing, and the 2018-2022 estimates are fairly low for the time series (Figure 15.7); however, the 2022 SBS biomass estimate has increased from last year. The exploitation rate has exceeded 1 in the SBS since 2018, indicating that catch was greater than the estimated biomass in this region from the model. However, the biomass estimates from the survey in this region are very clustered and sporadic and may not be representative of the shortraker population in this area (Figure 15.3). Little is known about shortraker rockfish preferred habitat but they often co-occur with rougheye and blackspotted rockfish (*Sebastes aleutianus* and *S. melanostictus*, respectively) that inhabit steep, rocky areas along the continental slope. Much of this habitat is considered untrawlable by survey gear and so the AI BTS may underestimate their abundance in this habitat. It should be noted that the SBS survey estimates have very high CVs and are based on very small catches of shortraker. For example, the 2022 SBS biomass estimate has a CV of 60% and comes from the catch of 4 fish in 2 hauls. The majority of the catch in the SBS region occurs in the rockfish, flatfish, and pollock fisheries. The rockfish fishery commonly uses "rockhopper" trawl gear that can move around rocks and boulders that are common to shortraker habitat. Additionally, the catch that is recorded in the SBS defined area (517 and 518) may not overlap consistently with the location of the sampled area on the AI BTS. Due to the differences in gear and the potential spatial mismatch between the fishery and the survey, it is not clear what the exploitation rate at this small of an area size means for the shortraker population as a whole.

More notably, since we do not apportion the stock at the subarea level, the exploitation rate for the entire BSAI has remained below F_{ABC} and F_{OFL} since 2004 (Figure 15.7). The exploitation rate trend at the BSAI level appears to be somewhat cyclic with an increase from 2009-2013, followed by a decrease until 2016 and then an increase to current levels in 2022, which is the highest of the BSAI area-wide level time series (Figure 15.7). The cyclical nature may be related to the opening of directed fishing for Pacific ocean perch (POP) since 2010. Most of the BSAI shortraker catch is taken as incidental catch in the BSAI POP fishery, so any increase in POP catch in the POP target could contribute to the increases in incidental catch for shortraker rockfish (M. Furuness, *pers. commun.*).

Harvest Recommendations

Shortraker rockfish are currently managed under Tier 5 of Amendment 56 of the NPFMC BSAI Groundfish FMP, which requires a reliable estimate of stock biomass and natural mortality rate. The estimate of *M* for shortraker rockfish was obtained from Heifetz and Clausen (1991), and for Tier 5 stocks, F_{OFL} and F_{ABC} are defined as *M* and 0.75*M*, respectively:

2022	Shortraker Rockfish
M	0.03
Biomass	23,547
F_{OFL}	0.03
maxF_{ABC}	0.0225
F_{ABC}	0.0225
OFL	706
maxABC	530
ABC	530

Should the ABC be reduced below the maximum permissible ABC?

The SSC in its December 2018 minutes recommended that all assessment authors use the risk table when determining whether to recommend an ABC lower than the maximum permissible. The SSC also requested the addition of a fourth column on fishery performance, which has been included in the table below.

	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 an 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:	Severe problems	Stock trends are	Extreme anomalies in	Extreme

Extreme concern	with the stock assessment; severe retrospective bias. Assessment considered unreliable.	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.	multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	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 shortraker stock is a Tier 5 species, meaning only reliable biomass estimates are available to calculate ABCs. The BSAI shortraker assessment is one of few Tier 5 assessments in Alaska that is fit to multiple abundance indices (AI bottom trawl survey, EBS slope survey biomass estimates, LLS relative population weights). While these three surveys have different trends and years sampled, the inclusion of these three data sources has allowed for increased stability of biomass estimates across time. Generally, the biomass estimates for shortraker rockfish have shown relatively moderate confidence intervals and low CVs. The RE model performs well for shortraker rockfish as few survey data points fall outside the confidence intervals, but there is very little contrast in the data for all surveys; however, there are no concerning residual patterns, and the survey biomass trend is consistent in all areas (Figure 15.4).

The exploitation rate (catch/biomass ratio) has been consistently high for the shortraker rockfish in some areas, such as the SBS (Figure 15.7) where the estimate of catch/biomass has exceeded 1.0 for the past four years, indicating catch was greater than the estimated biomass. However, the spatial distribution of tows is patchy for shortraker rockfish particularly in the eastern AI and SBS region (Figure 15.3) and shortraker rockfish reside in steep rocky slope areas where the survey gear does not sample well. The survey may underestimate shortraker rockfish in these untrawlable areas. Alternatively, the fishery uses "rockhopper" gear that may allow catch of shortraker rockfish where the survey cannot sample. There may also be a spatial mismatch between the surveyed area and where the fishery catches shortraker rockfish. Also, only 1% of the total estimated shortraker biomass is in the SBS on average, with 21% in the EBS slope and 78% in the AI (minus the SBS portion of the survey). There is no information on the habitat quality of the SBS area versus the EBS slope or AI region with respect to shortraker habitat preferences. The exploitation rate for all areas has been below F_{OFL} and F_{ABC} over the last 20 years (Figure 15.7) with a somewhat cyclic pattern that could be related to the opening of the POP directed fishery since 2010. The EBS slope region has also exceeded the F_{ABC} in a few years and exceeded the F_{OFL} in 2021. However, the NMFS areas along the slope are even larger than those near the SBS surveyed area and there is likely a spatial mismatch as with the SBS. We do not manage at the sub-area level for this stock, but intend to monitor the sub-area exploitation rates into the future. We rated the assessment-related concern as level 1, normal.

Population dynamics considerations

In general, very little is known regarding the life history of shortraker rockfish, and current techniques do not produce reliable age estimates for the species. We are unable to estimate recruitment, and very few specimens of shortraker rockfish <35 cm have ever been caught in the BSAI. Any data collected during larval cruises lump all rockfish species together. Even with large annual variability in the individual bottom trawl surveys, biomass has been slowly trending upward. Exploration of the longline data suggests that there were increases in both the AFSC and IPHC longline surveys from the 2019 and 2020 estimates, suggesting the stock is increasing recently. Also, the length compositions show a slight increase in fish <35 cm in the 2021 fishery and 2022 LLS AI samples which suggests a potential increase in recruitment in the Aleutian Islands where the biomass is highest. Overall we rated the population-dynamic concern as level 1, normal, due to the fact that little to no information exists on the population dynamics of this species but that biomass has been trending upward and has shown normal variability for this species.

Environmental/Ecosystem considerations

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

Shortraker are typically found in the Aleutians at temperatures between 3.6 - 4.6°C, at depths between 200 and 450 m. They hatch internally and their larvae remain pelagic before settling in deeper water. This period is potentially when they are most vulnerable to marine heatwaves. Shortraker depth distribution has become shallower over time in the AI bottom trawl survey (Laman et al., 2022a), but there does not seem to have a trend in its temperature distribution. It is unclear whether the shift is due to inter/intra specific dynamics (e.g. spatial competition with Pacific ocean perch) or habitat preference. Despite its distribution in deep waters, the warming trend in bottom waters means shortraker is still potentially vulnerable. In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish such that, all else being equal, consumption must increase to maintain fish condition. Thus, the sustained higher temperatures may be considered a negative indicator for shortaker.

Prey: Increased bioenergetic demands may be mitigated by the shortraker's generalist diet. As a generalist, shortraker feeds on a variety of fish including myctophids and sculpins, squids, shrimp and benthic amphipods among others; no consistent prey item dominates their diet. Based on survey data, sculpins increased in biomass compared to 2018 (Ortiz, 2022), as did shrimp towards the east (Laman, 2022). There is no information on other prey.

Competitors and predators: As shortraker does not rely on copepods or euphausiids, it does not compete with POP for prey. It shares similar prey items and depth distribution with rougheye rockfish and shortspine thornyheads which also consume general fish, myctophids and shrimp (rougheye) as well as sculpins, squid and shrimps (shortspine thornyheads). Similar to shortraker, other fish feeding on fish and invertebrates (Pacific cod, arrowtooth flounder, skates) also decreased and have remained below the long term average biomass estimate. There are no recorded fish predators of shortraker in the Aleutian Islands and given its depth distribution it is unlikely that shortraker is included among the Sebastes species eaten by Stellar sea lions (Sinclair et al., 2002), harbor seals (London et al, 2022) and or tufted puffins (Rojek, et al 2022).

The indicator most relevant to reflecting habitat disturbance is the estimated area disturbed by trawls from the fishing effects model (Olson et al, 2021). Trends in potential habitat disturbance are relevant for adult shortraker, although their primary habitat is steep slopes which are generally not targeted by bottom trawlers. Some habitat forming species might be more impacted as the relative CPUE of sponges and hydrocorals from the bottom trawl survey show slight decreases (Laman, 2022b), coinciding with a decrease in bycatch of structural epifauna in the fishery (Whitehouse, 2022). Rooper et al (2019) concluded the removal of deep coral and sponges is likely to reduce the overall density of rockfishes. The fishing effects model has not indicated large changes in habitat disturbance trends, and has remained below 3% for the Aleutian Islands (EAI, CAI and WAI) since 2009, so we assume that the level of habitat disturbance for shortraker has been stable.

Taken together, these indicators suggest no clear concerns for the shortraker stock aside from the recent stretch of increased temperatures, so we scored a level 1, normal, for environmental/ecosystem considerations for this stock. However, both the lack of ecological data relevant to the stock as well as lack of data in 2020 limits our assessment of potential recent ecosystem impacts on this stock.

Fishery performance

There is no directed fishing of shortraker rockfish, and they can only be retained as "incidentally-caught." Catch of shortraker rockfish fluctuates moderately by gear type and year, but catch has always remained below the ABC. Due to their moderately high value, discard rates of shortraker rockfish have generally been low and stable since 2014. Since 2004, the catch trend is somewhat cyclic which, since 2010, could be related to the opening of the POP target fishery as shortraker are often caught as incidental catch in the POP fishery. There was an increase in catch in 2021 in the SBS and Bering Sea but did not exceed TAC or ABC. The catch has increased in 2021 similar to the catch in 2013, mostly due to increases in the flatfish and rockfish bottom trawl fisheries. The increase in 2021 may be due to shifts in the POP population or fishing practices to avoid large increases of small sablefish in the Bering Sea. Overall, we rated the fishery performance concern as Level 1, normal, since the catch is still below ABC and shifted to the rockfish and flatfish fisheries.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 1: Normal	**Level 1:** Normal	**Level 1:** Normal	**Level 1:** Normal

All scores were Level 1 suggesting no need to consider an ABC below the maximum permissible.

Ecosystem Considerations

In general, a determination of ecosystem considerations for shortraker rockfish is hampered by the lack of biological and habitat information.

Ecosystem Effects on the Stock

Prey availability/abundance trends:

Similar to other rockfish species, stock condition of shortraker rockfish is probably influenced by periodic abundant year classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval rockfish may be an important determining factor of year-class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year-class strength. Moreover, visual identification to the species level for field-collected larval or post-larval rockfish is generally not reliable, although genetic techniques allow identification for larvae/post-larvae of many rockfish, including shortraker (Gharrett *et. al* 2001; Kondzela *et al.* 2007). Very few juvenile shortraker rockfish have ever been caught in Alaska, and therefore there is no information on their food items. Adult shortraker rockfish are apparently opportunistic feeders that in Alaska prey on shrimp, deepwater fish such as myctophids, and squid (Yang and Nelson 2000; Yang 2003; Yang *et al.* 2006). Little if anything is known about abundance trends of these rockfish prey items.

Predator population trends:

Rockfish are preyed on by a variety of other fish at all life stages, and to some extent by marine mammals during late juvenile and adult stages. Whether the impact of any particular predator is significant or dominant is unknown. Predator effects would likely be more important on larval, post-larval, and small juvenile shortraker rockfish, but information on these life stages and their predators is unknown. Due to their large size, older shortraker rockfish likely have few potential predators other than very large animals such as sleeper sharks or sperm whales.

Changes in physical environment:

Strong year classes corresponding to the period around 1976-77 have been reported for many species of groundfish in the GOA, including Pacific ocean perch, northern rockfish, sablefish, and Pacific cod. Therefore, it appears that environmental conditions may have changed during this period in such a way that survival of young-of-the-year fish increased for many groundfish species, including slope rockfish. The environmental mechanism for this increased survival remains unknown. Changes in water temperature and currents could have an effect on prey item abundance and success of transition of rockfish from the pelagic to demersal stage. Rockfish in early juvenile stage have been found in floating kelp patches which would be subject to ocean currents.

Changes in bottom habitat due to natural or anthropogenic causes could affect survival rates by altering available shelter, prey, or other functions. Associations of juvenile rockfish with biotic and abiotic structure have been noted by Carlson and Straty (1981), Pearcy *et al.* (1989), Love *et al.* (1991), and Freese and Wing (2003). A study in the GOA based on observations from a manned submersible found that adult “large” rockfish had a strong association with *Primnoa* spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the “large” rockfish were next to boulders with coral (Krieger and Wing 2002). Although the "large" rockfish could not be positively identified, it is likely based on location and depth that many were shortraker rockfish. The Essential Fish Habitat Environmental Impact Statement (EFH EIS) for groundfish in Alaska (NMFS 2005) concluded that the effects of commercial fishing on the habitat of groundfish is minimal or temporary based largely on the criterion that stocks were above the Minimum Stock Size Threshold (MSST). However, a review of the EFH EIS suggested that this criterion was inadequate to make such a conclusion (Drinkwater 2004). The trend in shortraker abundance suggests that any adverse effect has not prevented the stock from increasing since 1990.

Fishery Effects on the Ecosystem

Most of the catch in the Aleutian Islands is taken incidentally in trawl and longline fisheries, specifically the rockfish trawl fishery for Pacific ocean perch and for Atka mackerel, and the longline fisheries for sablefish and flatfish. Thus, the reader is referred to the discussions on "Fishery Effects" in those assessment chapters in this SAFE report.

Bottom trawl fisheries for shortraker and rougheye rockfish accounted for very little bycatch of habitat areas of particular concern (HAPC) biota. This low bycatch is likely explained by the fact that little targeted fishing occurs for these fish. Fishery-specific concentration of target catch in space and time relative to predator needs in space and time relative to spawning components are unknown. Fishery-specific effects on amount of large size target fish are unknown. Annual fishery discard rates since 2004 have been 20-50% for shortraker rockfish. The discard amount of species other than shortraker rockfish in hauls targeting shortraker rockfish is unknown. Fishery-specific effects on age-at-maturity and fecundity of the target fishery are unknown. Fishery-specific effects on EFH non-living substrate are unknown, but the heavy-duty "rockhopper" trawl gear commonly used in the rockfish fishery can move around rocks and boulders on the bottom.

Data Gaps and Research Priorities

Validating aging techniques of shortraker rockfish, and obtaining ages from archived samples are the primary research priorities for this stock and are required for age-structured population modeling. More information on the genetic population structure within the BSAI area is needed. Also, much additional research is needed on other aspects of shortraker rockfish biology and assessment. There is little to no information on larval, post-larval, or early stage juveniles of shortraker rockfish. In particular, information is lacking on juvenile shortraker rockfish, which are very seldom caught in any sampling gear. Habitat requirements for larval, post-larval, and early stages are mostly unknown. Habitat requirements for later stage juvenile and adult fish are mostly anecdotal or conjectural. While recent work has improved our understanding greatly (Du Preez and Tunnicliffe 2011, Laman et al. 2015), further research needs to be done on the bottom habitat of the fishing grounds, on what HAPC biota are found on these grounds, and on what impact bottom trawling has on the grounds. Investigation is needed on the distribution and abundance of shortraker rockfish in areas of rough bottom that cannot be sampled by trawl surveys. Little is known regarding the reproductive biology and given the relatively unusual reproductive biology of rockfish and its importance in establishing management reference points, data on reproductive capacity should be collected on a periodic basis.

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Tables

Table 15.1a Total allowable catch (TAC), acceptable biological catch (ABC), and catch (t) of the species groups used to manage shortraker rockfish from 1988 to 2003. The "other red rockfish" group includes, shortraker rockfish, rougheye rockfish, northern rockfish, and sharpchin rockfish. The "POP complex" includes the other red rockfish species plus POP. Sources: North Pacific Groundfish Observer Program, NMFS Alaska Regional Office, AKFIN, and PACFIN. Data for the Bering Sea (BS) and Aleutian Islands (AI) management areas are shown separately.

Year	Area	Management Group	ABC (t)	TAC (t)	Catch (t)
1988	BS	POP Complex	6,000		1,509
	AI	POP Complex	16,600		2,629
1989	BS	POP Complex	6,000		2,873
	AI	POP Complex	16,600		3,780
1990	BS	POP Complex	6,300		7,231
	AI	POP Complex	16,600		15,224
1991	BS	Other Red Rockfish	1,670	1,670	942
	AI	Shortraker/rougheye	1,245	1,245	388
1992	BS	Other Red Rockfish	1,400	1,400	467
	AI	Shortraker/rougheye	1,220	1,220	1,470
1993	BS	Other Red Rockfish	1,400	1,200	1,226
	AI	Shortraker/rougheye	1,220	1,100	1,139
1994	BS	Other Red Rockfish	1,400	1,400	129
	AI	Shortraker/rougheye	1,220	1,220	925
1995	BS	Other Red Rockfish	1,400	1,260	344
	AI	Shortraker/rougheye	1,220	1,098	559
1996	BS	Other Red Rockfish	1,400	1,260	207
	AI	Shortraker/rougheye	1,250	1,125	959
1997	BS	Other Red Rockfish	1,050	1,050	218
	AI	Shortraker/rougheye	938	938	1,043
1998	BS	Other Red Rockfish	267	267	112
	AI	Shortraker/rougheye	965	965	685
1999	BS	Other Red Rockfish	356	267	238
	AI	Shortraker/rougheye	1,290	965	514
2000	BS	Other Red Rockfish	259	194	253
	AI	Shortraker/rougheye	1,180	885	480
2001	BSAI	Shortraker/rougheye	1,028		
	BS	Shortraker/rougheye		116	72
	AI	Shortraker/rougheye		912	722
2002	BSAI	Shortraker/rougheye	1,028		
	BS	Shortraker/rougheye		116	105
	AI	Shortraker/rougheye		912	478
2003	BSAI	Shortraker/rougheye	967		
	BS	Shortraker/rougheye		137	124
	AI	Shortraker/rougheye		830	306

Table 15.1b Total allowable catch (TAC), acceptable biological catch (ABC), overfishing limit (OFL), and catch (t) of shortraker rockfish from 2004 to present in the Bering Sea and Aleutian Islands management area. Source: AKFIN NMFS AKRO BLEND/Catch Accounting System. *Estimated removals through October 15, 2022.

Year	OFL	ABC	TAC	Catch
2004	701	526	526	242
2005	794	596	596	169
2006	774	580	580	215
2007	564	424	424	324
2008	564	424	424	133
2009	516	387	387	184
2010	516	387	387	300
2011	524	393	393	346
2012	524	393	393	353
2013	493	370	370	429
2014	493	370	370	250
2015	690	518	250	211
2016	690	518	200	127
2017	666	499	125	188
2018	666	499	150	258
2019	722	541	358	399
2020	722	541	375	299
2021	722	541	500	496
2022*	722	541	541	257

Table 15.2 Catches of shortraker rockfish (t) in the Bering Sea and Aleutian Islands management area, obtained from the North Pacific Groundfish Observer Program, NMFS Alaska Regional Office, AKFIN, and PACFIN, 1977-2020 (*estimated removals through October 15, 2022).

	Eastern Bering Sea			Aleutian Islands			
Year	Foreign	Joint Venture	Domestic	Foreign	Joint Venture	Domestic	Total
1977	0	0		27	0		27
1978	1,069	0		874	0		1,943
1979	279	0		3,008	0		3,286
1980	649	0		185	0		833
1981	441	0		381	0		821
1982	242	0		379	0		621
1983	145	0		89	1		235
1984	54	0		28	0		83
1985	19	0		1	0		21
1986	2	2	14	0	0	12	30
1987	0	0	28	0	0	36	64
1988	0	0	31	0	0	37	69
1989	0	0	58	0	0	130	188
1990			116			546	662
1991			205			251	456
1992			79			289	368
1993			221			216	437
1994			46			176	223
1995			49			164	213
1996			87			143	230
1997			36			90	126
1998			52			159	211
1999			66			129	195
2000			130			200	330
2001			57			172	229
2002			93			206	299
2003			105			118	223
2004			118			123	242
2005			108			61	169
2006			47			168	215
2007			114			211	324
2008			41			91	133
2009			69			116	184
2010			160			140	300
2011			113			233	346
2012			123			230	353
2013			138			291	429
2014			132			118	250
2015			113			98	211
2016			60			67	127
2017			109			78	188
2018			172			87	258
2019			309			90	399
2020			188			111	299
2021			368			128	496
2022*			172			85	257

Table 15.3 Area-specific catches of shortraker rockfish (t) in the BSAI area from 1994-present (*October 15, 2022). Abbreviations are: Western Aleutian Islands (WAI), Central Aleutian Islands (CAI), Eastern Aleutian Islands (EAI), Southern Bering Sea (SBS), Eastern Bering Sea (EBS), and Bering Sea (BS). Since 2002, Bering Sea catch has been reported in the Southern Bering Sea and the remainder of the Bering Sea. The Bering Sea areas are all remaining NMFS areas not reported in the other categories. Source: AKFIN NMFS AKRO BLEND/Catch Accounting System.

Year	WAI (543)	CAI (542)	EAI (541)		BS	Total
1994	2	84	91		46	223
1995	7	44	113		49	213
1996	33	48	63		87	230
1997	47	14	29		36	126
1998	27	100	32		52	211
1999	23	63	43		66	195
2000	20	85	95		130	330
2001	58	87	27		57	229
2002	78	62	66		93	299
Year	WAI (543)	CAI (542)	EAI (541)	SBS (517+518)	BS	Total
2003	27	60	31	54	51	223
2004	32	76	15	50	69	242
2005	27	17	18	69	38	169
2006	39	106	23	21	26	215
2007	23	145	44	78	35	324
2008	40	35	17	15	26	133
2009	34	41	41	41	28	184
2010	48	39	53	48	112	300
2011	161	43	30	26	87	346
2012	168	33	28	46	77	353
2013	164	75	52	40	98	429
2014	25	37	56	20	113	250
2015	15	46	37	24	89	211
2016	15	28	24	20	40	127
2017	13	35	31	29	80	188
2018	27	32	28	79	93	258
2019	22	55	12	174	135	399
2020	52	28	30	78	110	299
2021	50	37	41	112	256	496
2022*	31	32	22	56	116	257

Table 15.4 Estimated catch retained (t), discarded (t), and percent discarded of other red rockfish (ORR) and shortraker/rougheye (SR/RE) from the eastern Bering Sea (EBS) and Aleutian Islands (AI) regions, 1993-present (through October 15, 2022*). Prior to 2001, ORR in the EBS was managed as a single complex. Between 2001-2003, it was managed as a SR/RE complex. Source: AKFIN NMFS AKRO BLEND/Catch Accounting System.

Area	Species Group	Year	Catch Retained	Discard	Total	Percentage
EBS	ORR	1993	916	308	1226	25.2%
		1994	29	100	129	77.6%
		1995	273	70	343	20.4%
		1996	58	149	207	71.9%
		1997	43	174	217	80.0%
		1998	42	70	112	62.4%
		1999	75	162	238	68.4%
		2000	111	141	252	55.9%
EBS.	SR/RE	2001	27	16	43	34.7%
		2002	50	54	104	51.9%
		2003	66	58	124	46.8%
AI	SR/RE	1993	737	403	1,139	35.3%
		1994	701	224	925	24.2%
		1995	456	103	559	18.4%
		1996	751	208	959	21.7%
		1997	733	310	1,043	29.7%
		1998	447	238	685	34.8%
		1999	319	195	514	38.0%
		2000	285	196	480	40.8%
		2001	476	246	722	34.1%
		2002	333	146	478	30.4%
		2003	214	92	306	29.9%
BSAI	Shortraker	2004	143	99	242	41.0%
		2005	129	40	169	23.9%
		2006	130	85	215	39.5%
		2007	163	162	324	49.9%
		2008	102	31	133	23.3%
		2009	136	48	184	26.2%
		2010	228	72	300	24.0%
		2011	303	43	346	12.4%
		2012	295	58	353	16.4%
		2013	267	162	429	37.8%
		2014	116	134	250	53.5%
		2015	117	94	211	44.6%
		2016	78	50	127	39.1%
		2017	103	85	188	45.3%
		2018	182	76	258	29.6%
		2019	289	110	399	27.6%
		2020	252	47	299	15.6%
		2021	342	154	496	31.1%
		2022*	211	46	257	17.8%

Table 15.5 Aleutian Islands sum of total catch (t) of shortraker rockfish by management area and target fishery from 2004-present. Source: AKFIN NMFS AKRO BLEND/Catch Accounting System.

		Management area				
Target Fishery	Gear	541	542	543	Total	% of Total
Pacific Cod	Longline	59.62	77.58	31.56	168.76	6.92
Halibut	Longline	100.84	54.69	13.46	168.99	6.93
Rockfish	Longline	0.02	8.44	1.02	9.49	0.39
Other species	Longline		6.18		6.18	0.25
Flatfish	Longline	2.85	179.05		181.90	7.45
Sablefish	Longline	87.07	92.60	20.09	199.75	8.19
Atka Mackerel	Bottom Trawl	61.52	131.87	79.03	272.42	11.16
Flatfish	Bottom Trawl	60.11			60.11	2.46
Kamchatka Flounder - BSAI	Bottom Trawl	64.78			64.78	2.65
Pacific Cod	Bottom Trawl	0.94	6.50	0.02	7.46	0.31
Pollock - bottom	Bottom Trawl	0.48	0.22		0.69	0.03
Rockfish	Bottom Trawl	133.06	347.68	808.21	1288.95	52.82
Pacific Cod	Pot	0.09	0.83		0.92	0.04
Rockfish	Pot	0.01			0.01	0.00
Sablefish	Pot	5.88	1.96		7.84	0.32
Rockfish	Pelagic Trawl	1.47			1.47	0.06
Pollock	Pelagic Trawl	0.49			0.49	0.02
Pacific Cod	Longline	59.62	77.58	31.56	168.76	6.92
Total		579.23	907.59	953.39	2440.21	100.00

Table 15.6 Eastern Bering Sea sum of total catch (t) of shortraker rockfish by management area and target fishery from 2004-2021. Source: AKFIN NMFS AKRO BLEND/Catch Accounting System. Bottom trawl is abbreviated "Bottom Trw.".

		Management Area									
Target	Gear	509	513	514	517	518	519	521	523	524	% of Total
Pacific Cod	Longline	0.0	0.1	0.0	22.4	4.0	19.2	207.5	54.3	0.1	12.1
Rockfish	Longline				1.0	0.0	1.6	5.7	2.1		0.4
Flatfish	Longline				2.1	0.6	0.2	83.9	35.3	1.6	4.9
Sablefish	Longline				8.8	3.7	1.4	1.3	0.5	0.0	0.6
Halibut	Longline		3.5	5.3	7.1	31.4	12.6	145.4	24.9	25.7	10.0
Other	Longline							0.5	4.3		0.2
Pollock	Longline							0.0			0.0
Atka Mackerel	Bottom Trw				7.5		7.8				0.6
Pacific Cod	Bottom Trw				0.2		5.0	1.4			0.3
Rockfish	Bottom Trw				278.1	6.5	60.3	199.1	97.5		25.2
Kamchatka FL	Bottom Trw				14.3	20.0	0.6	0.1	5.8	1.6	1.7
Flatfish	Bottom Trw	0.1	0.2	0.0	266.1	18.5	24.8	255.6	80.9	6.6	25.6
Sablefish	Bottom Trw				7.6		0.3				0.3
Other	Bottom Trw				1.3						0.1
Pollock	Bottom Trw				1.6	1.0	3.1	1.7		0.3	0.3
Pacific Cod	Pot	0.0			0.2		0.1				0.0
Flatfish	Pot					0.0					0.0
Sablefish	Pot				0.3	2.1	1.2	0.0			0.1
Rockfish	Pelagic Trw				0.0		0.0		0.2		0.0
Pollock	Pelagic Trw	0.3	2.4		296.7		5.8	121.7	19.2	4.1	17.7
Total		0.4	6.2	5.3	915	88	144	1024	325	40.1	100.00

Table 15.7 Estimated biomass (t) of shortraker rockfish from the NMFS bottom trawl surveys, with the coefficient of variation (CV) in parentheses. Regions presented are the western Aleutian Islands (WAI), central Aleutian Islands (CAI), eastern Aleutian Islands (EAI), the southern Bering Sea (SBS), and the eastern Bering Sea (EBS) slope. The SBS is surveyed as part of the Aleutian Islands survey.

Year	WAI	CAI	EAI	SBS	AI survey (total)	EBS Slope survey
1979						1,391
1980	0	2,665	4,165	45 (1.00)	6,829 (0.55)	
1981						3,571
1982						5,176
1983	7,249	7,239	11,787	9,477 (0.43)	26,276 (0.20)	
1985						4,010
1986	1,821	4,291	5,554	6,485 (0.64)	11,667 (0.25)	
1988						1,260 (0.43)
1991	17,558	3,225	1,053	1,925 (0.66)	21,835 (0.69)	2,758 (0.38)
1994	6,493	8,164	11,627	1,959 (0.78)	26,284 (0.22)	
1997	6,658	21,560	7,840	2,428 (0.97)	36,058 (0.27)	
2000	17,746	13,543	5,863	645 (0.73)	37,152 (0.45)	
2002	3,906	8,639	2,797	1,463 (0.65)	15,342 (0.20)	4,851 (0.44)
2004	16,333	8,779	7,499	630 (0.60)	32,612 (0.37)	2,570 (0.22)
2006	2,471	5,335	3,975	1,180 (0.52)	11,781 (0.25)	
2008						7,308 (0.31)
2010	6,729	7,424	4,071	15 (1.00)	18,224 (0.23)	4,365 (0.28)
2012	4,455	7,182	4,031	562 (0.71)	15,668 (0.26)	9,284 (0.57)
2014	1,579	12,678	2,144	28 (0.71)	16,401 (0.38)	
2016	5,846	3,150	6,030	74 (1.00)	15,025 (0.32)	6,258 (0.29)
2018	11,970	2,933	11,417	13 (1.00)	26,320 (0.56)	
2022	750	12,587	6,168	127 (0.60)	19,505 (0.36)	

Table 15.8 Shortraker rockfish relative population numbers (RPN) and relative population weight (RPW) estimated from the AFSC longline survey by region for 1997-2022.

	Aleutian Islands		Bering Sea	
	RPN	RPW	RPN	RPW
1997			6,278	12,478 (0.34)
1998	19,897	22,278		
1999			13,472	29,202 (0.41)
2000	28,842	24,993		
2001			9,913	21,571 (0.36)
2002	18,424	16,780		
2003			28,722	74,645 (0.47)
2004	24,385	21,142		
2005			9,108	14,453 (0.39)
2006	35,669	35,267		
2007			10,735	20,088 (0.40)
2008	18,474	16,247		
2009			4,129	7,513 (0.28)
2010	29,957	22,832		
2011			12,559	27,065 (0.58)
2012	24,073	21,779		
2013			7,747	12,588 (0.24)
2014	29,208	27,503		
2015			10,730	19,316 (0.19)
2016	17,732	14,629		
2017			13,502	23,006 (0.48)
2018	19,543	17,746		
2019			17,125	34,046 (0.47)
2020	19,380	17,905		
2021			10,728	18,660 (0.34)
2022	9,844	9,894		

Table 15.9 Shortraker rockfish relative population numbers (RPNs) and number of stations sampled from the IPHC longline survey by region for 1998-2019.

	Aleutian Islands		Bering Sea		BSAI	
	RPN	# of stations	RPN	# of stations	RPN	# of stations
1998	113.88	78	46.75	48	160.63	126
1999	190.38	91	56.43	8	246.80	99
2000	146.74	98	87.97	95	234.71	193
2001	88.95	96	30.30	100	119.25	196
2002	77.76	96	51.99	100	129.74	196
2003	84.22	92	144.42	103	228.64	195
2004	183.34	93	107.20	103	290.55	196
2005	284.26	98	82.23	100	366.49	198
2006	210.74	97	24.90	214	235.64	311
2007	190.47	92	47.80	133	238.28	225
2008	118.53	95	68.16	130	186.70	225
2009	128.78	95	234.74	129	363.51	224
2010	249.96	93	123.05	130	373.01	223
2011	292.36	93	76.47	129	368.82	222
2012	63.10	95	73.61	133	136.71	228
2013	138.33	95	150.31	127	288.64	222
2014	78.57	114	33.55	180	112.12	294
2015	116.66	96	158.13	215	274.79	311
2016	103.78	92	48.67	216	152.44	308
2017	93.70	207	28.69	133	122.39	340
2018	2.90	95	31.14	128	34.04	223
2019	79.03	94	141.48	127	220.51	221

Table 15.10 Parameter estimates with standard errors (SE) and lower/upper 95% confidence intervals (LCI/UCI) for the random effects (*re*) models fit for shortraker rockfish. Estimates are shown on the natural (i.e., arithmetic scale) for ease of interpretation but are estimated in log-space. Process error is pooled across all survey regions for both species groups. Results are shown for Model 18.9, the multivariate random effects (*rem*) model, and Model 22, which also fits to the EBS slope longline survey relative population weights for shortraker and thus has a scaling parameter (q). Model 22 is the author-preferred model.

Model	Parameter	Estimate	SE	LCI	UCI
Model 18.9	Aleutian Islands process error	0.09	0.06	0.03	0.32
Model 18.9	Bering Sea Slope process error	0.20	0.14	0.05	0.78
Model 18.9	Southern Bering Sea process error	0.73	0.31	0.32	1.67
Model 22	Aleutian Islands process error	0.09	0.06	0.03	0.32
Model 22	Bering Sea Slope process error	0.07	0.16	0.00	4.76
Model 22	Southern Bering Sea process error	0.73	0.31	0.32	1.67
Model 22	Scaling parameter q	3.79	0.70	2.64	5.44

Table 15.11 Estimated biomass for shortraker rockfish from the Model 18.9 and Model 22 (author recommended model).

Year	Model 18.9			Model 22		
	Biomass (t)	Lower CI	Upper CI	Biomass (t)	Lower CI	Upper CI
1991	30,937	20,733	46,162	31,783	22,067	45,776
1992	31,021	21,156	45,487	31,867	22,479	45,175
1993	31,106	21,736	44,515	31,952	23,062	44,268
1994	31,191	22,519	43,203	32,037	23,865	43,007
1995	31,122	22,121	43,785	31,968	23,376	43,719
1996	31,054	21,934	43,966	31,900	23,123	44,009
1997	30,987	21,931	43,781	31,832	23,070	43,923
1998	29,498	21,191	41,061	30,413	22,326	41,428
1999	28,142	20,681	38,296	29,128	21,770	38,973
2000	26,899	20,348	35,560	27,875	21,384	36,337
2001	25,567	19,933	32,793	26,533	20,895	33,692
2002	24,350	19,367	30,615	25,264	20,251	31,518
2003	23,606	18,592	29,972	24,681	19,648	31,003
2004	22,925	18,112	29,018	23,970	19,108	30,070
2005	22,465	17,414	28,980	23,112	18,095	29,521
2006	22,109	16,853	29,005	22,324	17,196	28,981
2007	22,265	16,946	29,252	21,986	16,903	28,596
2008	22,679	17,382	29,591	21,806	16,857	28,207
2009	22,532	17,506	29,000	21,599	16,745	27,860
2010	22,438	17,857	28,196	21,676	17,258	27,225
2011	22,734	17,807	29,025	21,714	17,210	27,398
2012	23,097	17,982	29,668	21,756	17,292	27,373
2013	23,086	17,712	30,091	21,710	17,046	27,650
2014	23,132	17,687	30,253	21,864	17,081	27,986
2015	23,275	17,731	30,553	22,120	16,991	28,798
2016	23,419	17,946	30,561	22,358	16,902	29,574
2017	23,709	17,602	31,934	22,727	16,769	30,802
2018	24,007	17,345	33,227	23,084	16,695	31,918
2019	24,107	16,932	34,323	23,243	16,430	32,882
2020	24,212	16,603	35,306	23,332	16,348	33,300
2021	24,323	16,344	36,196	23,427	16,307	33,657
2022	24,443	16,145	37,004	23,547	16,247	34,127

Figures

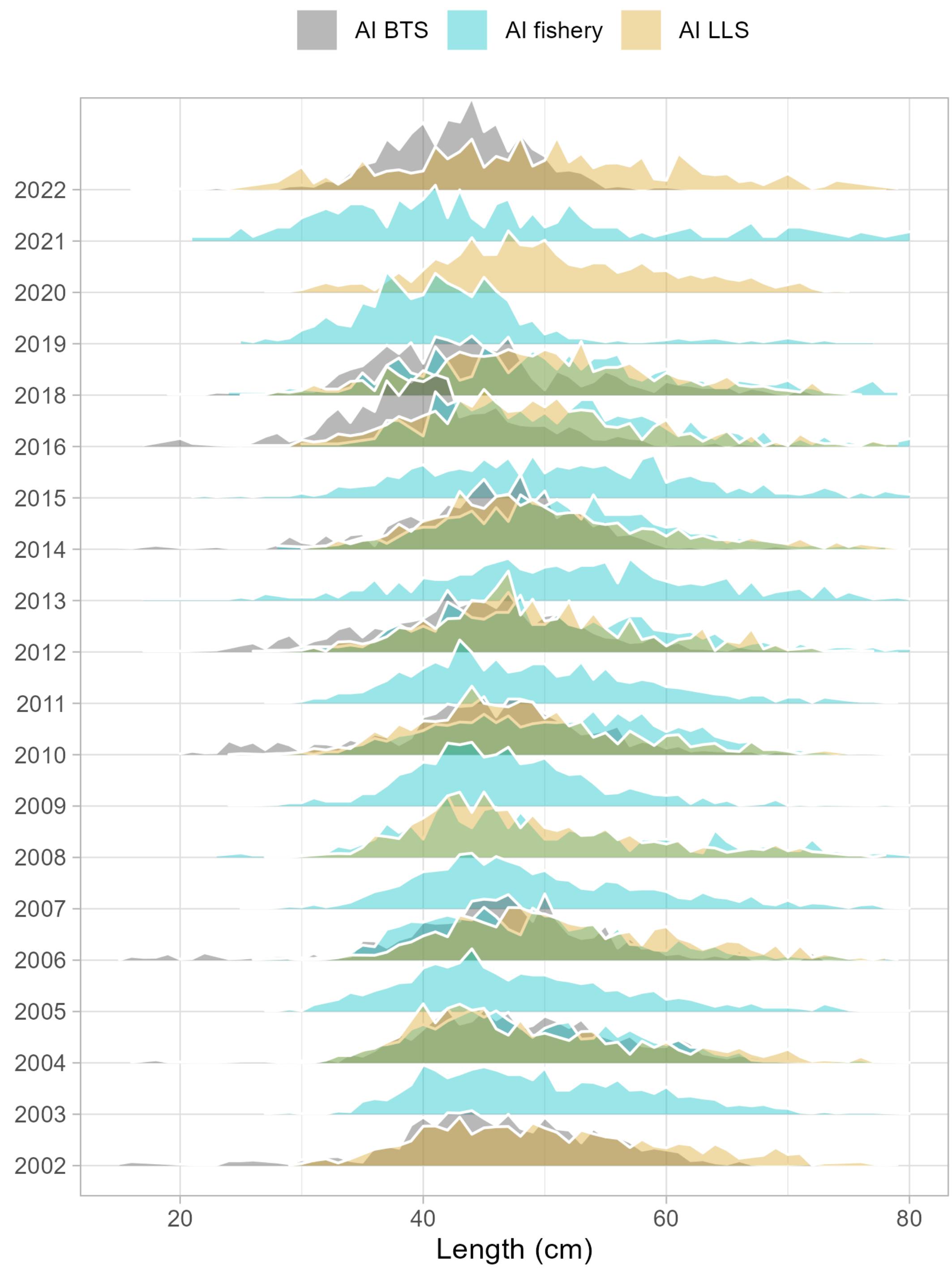

Figure 15.1a Length frequency data from the Aleutian Islands (AI) bottom trawl survey (BTS; grey), fishery (teal), and the Aleutian Islands longline survey (AI LLS; goldenrod) from 2002-2021. Fishery data source: NMFS AFSC FMA Observer Debriefed Haul and Length tables. BTS data source: NMFS AFSC RACE AI Biomass and Length tables. LLS data source: NMFS AFSC ABL AI Area RPN tables.

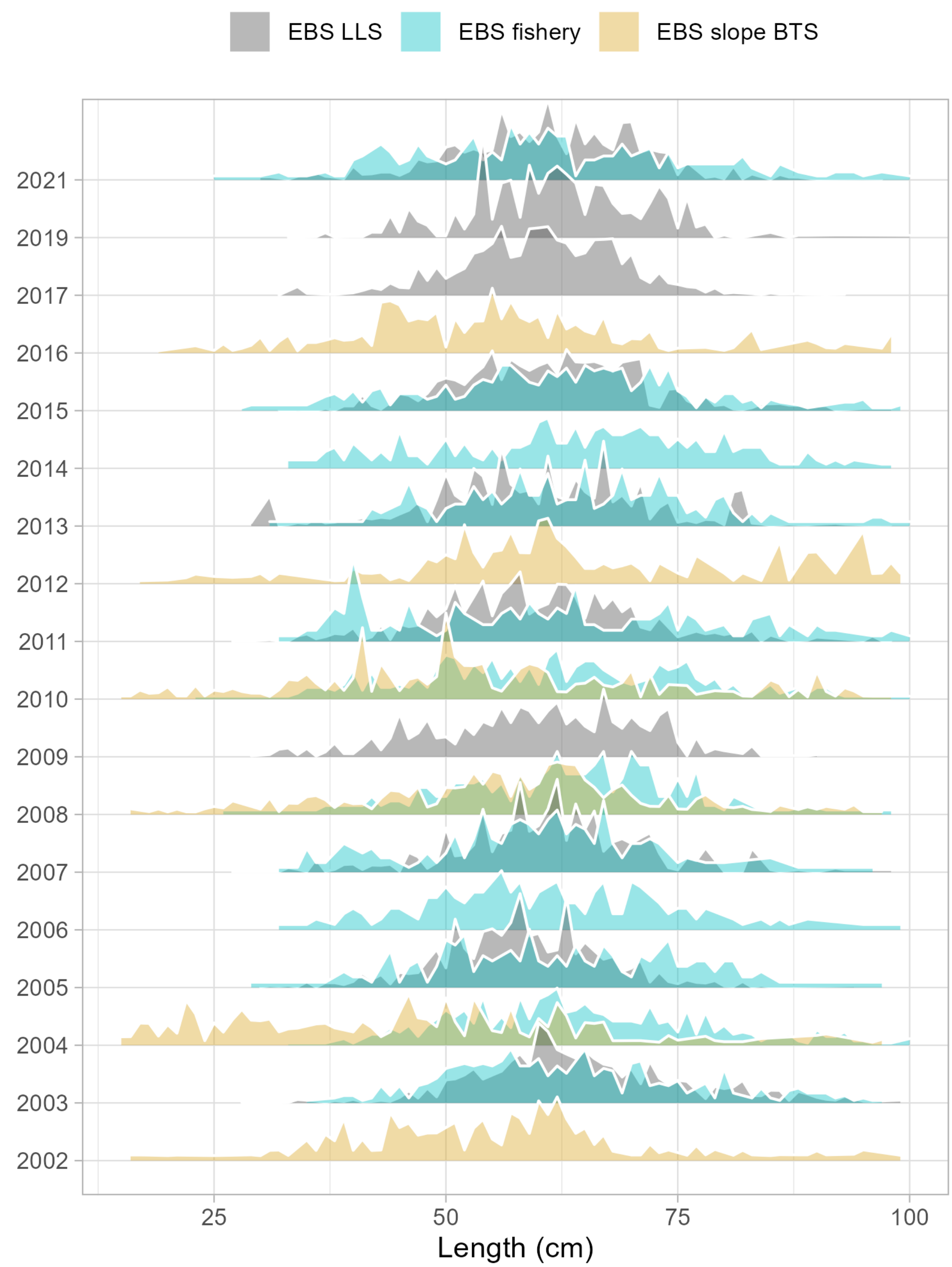

Figure 15.1b Length frequency data from the eastern Bering Sea longline survey (EBS LLS; grey), fishery (teal), and eastern Bering Sea slope bottom trawl survey (EBS slope BTS; goldenrod) from 2002-2021. Fishery data source: NMFS AFSC FMA Observer Debriefed Haul and Length tables. BTS data source: NMFS AFSC RACE EBS slope Biomass and Length tables. LLS data source: NMFS AFSC ABL EBS slope Area RPN tables.

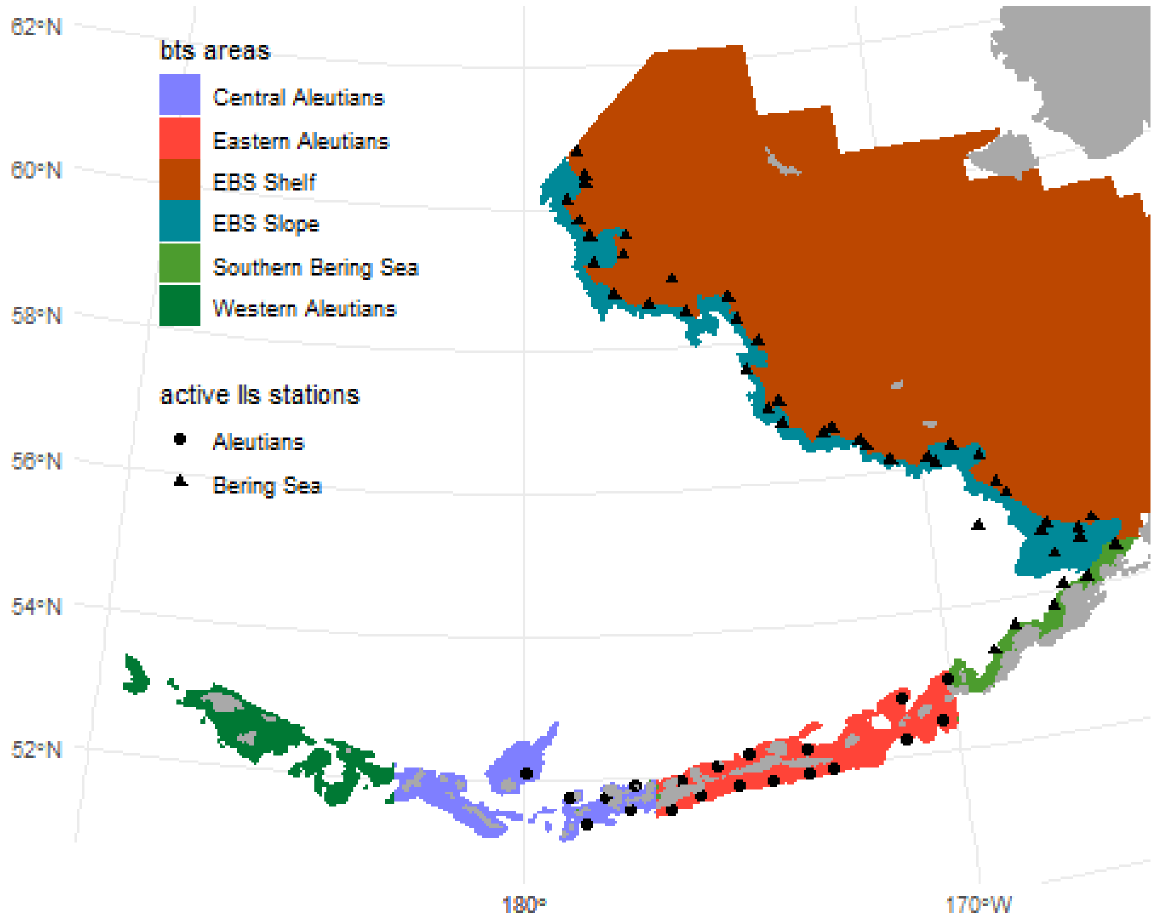

Figure 15.2 Bottom trawl surveys (BTS) strata and active longline survey (LLS) stations in the Aleutian Islands and eastern Bering Sea.

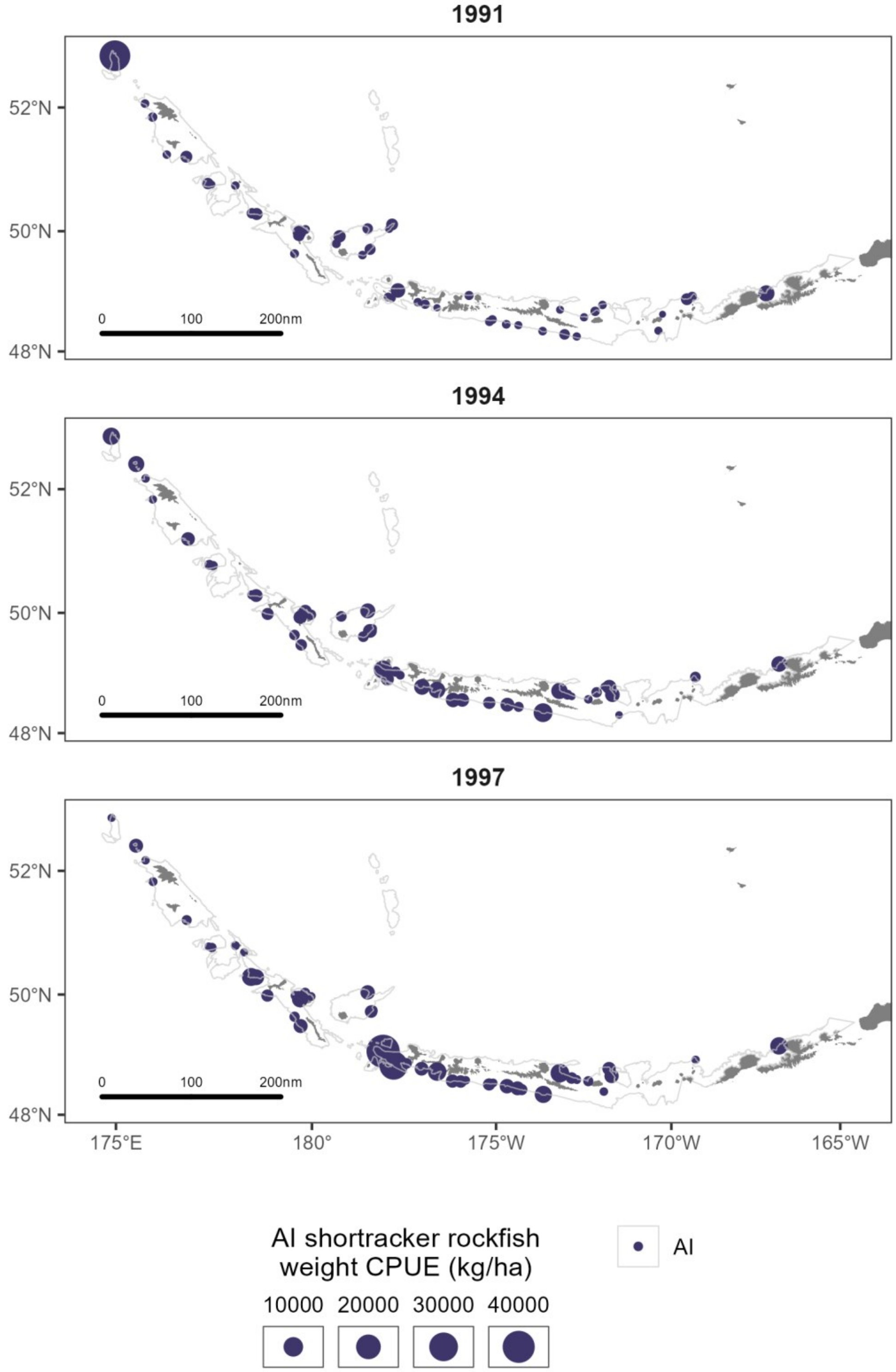

Figure 15.3 Spatial distribution map of catch-per-unit-effort (CPUE) in kg/ha of shortraker rockfish on the Aleutian Islands bottom trawl survey from 1991 to present.

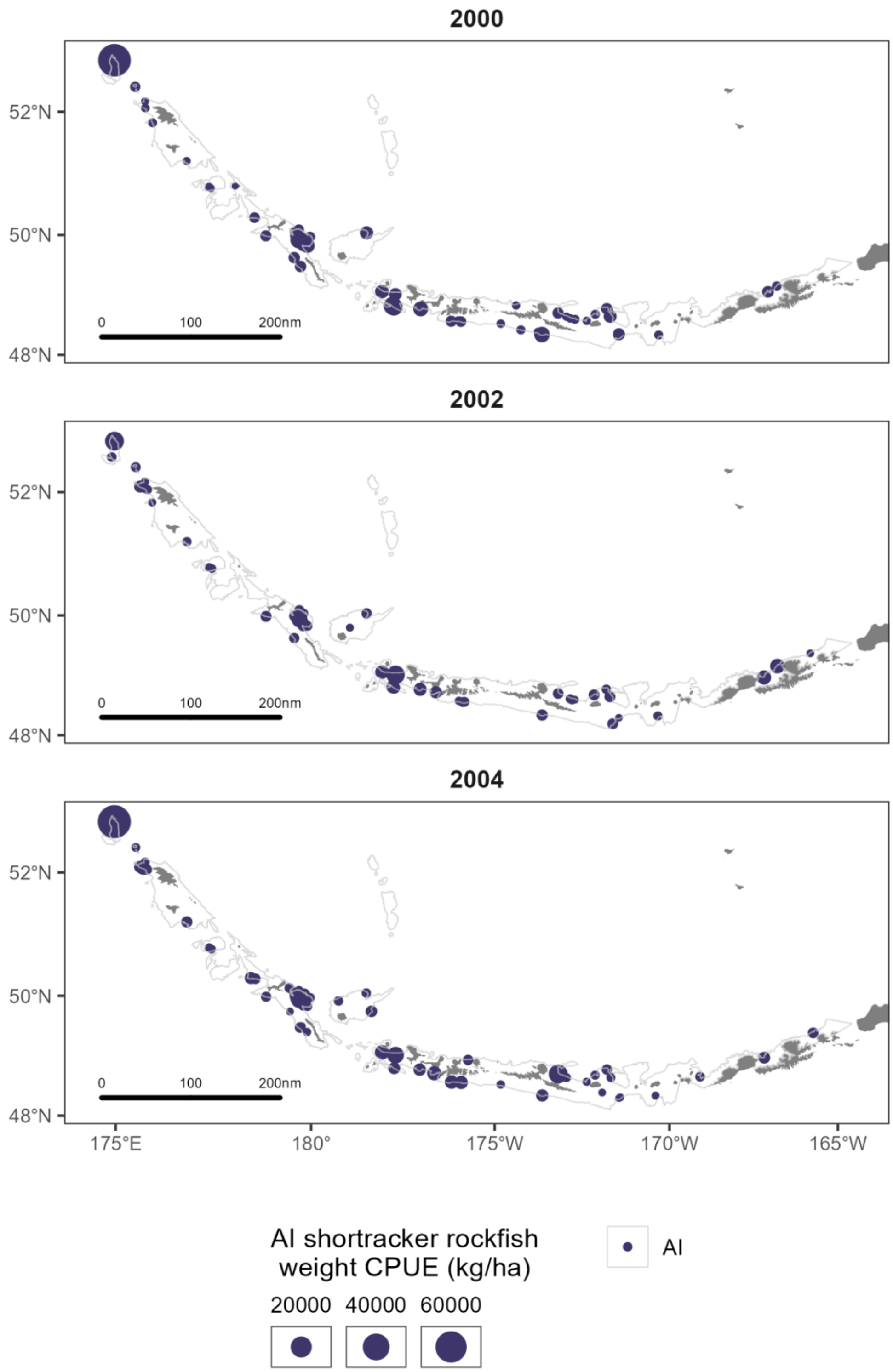

Figure 15.3 (cont.) Spatial distribution map of catch-per-unit-effort (CPUE) in kg/ha of shortraker rockfish on the Aleutian Islands bottom trawl survey from 1991 to present.

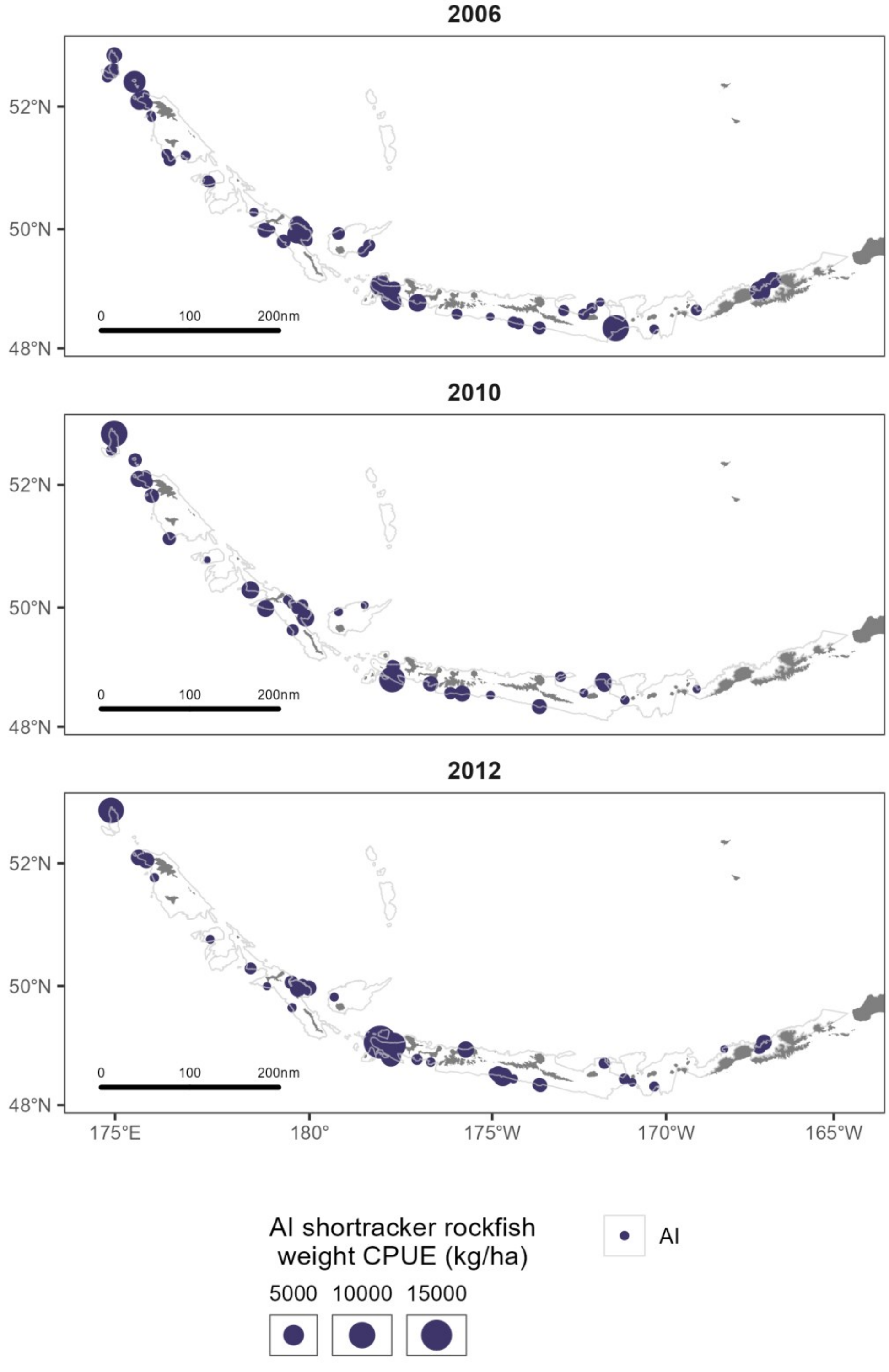

Figure 15.3 (cont.) Spatial distribution map of catch-per-unit-effort (CPUE) in kg/ha of shortraker rockfish on the Aleutian Islands bottom trawl survey from 1991 to present.

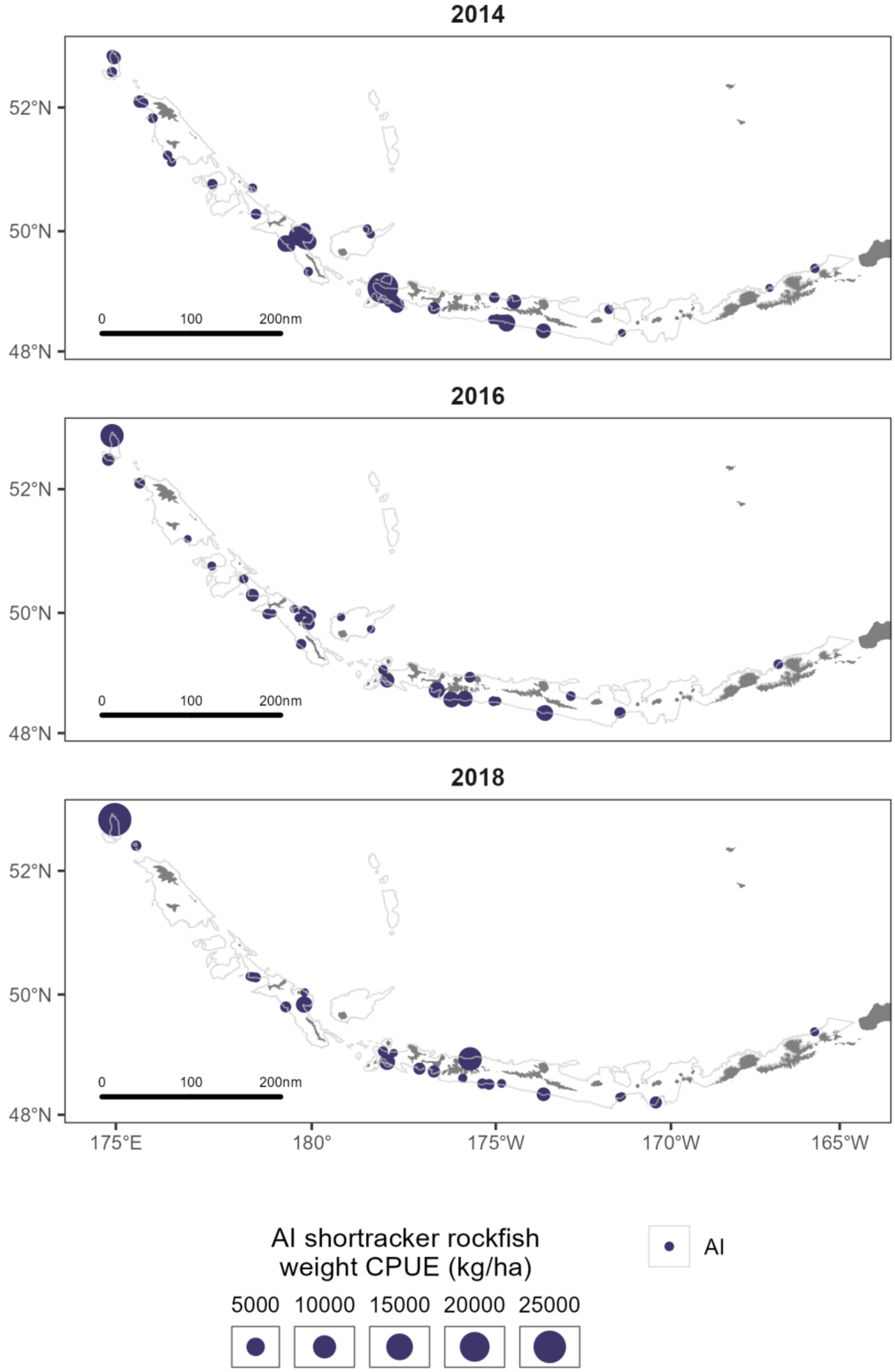

Figure 15.3 (cont.) Spatial distribution map of catch-per-unit-effort (CPUE) in kg/ha of shortraker rockfish on the Aleutian Islands bottom trawl survey from 1991 to present.

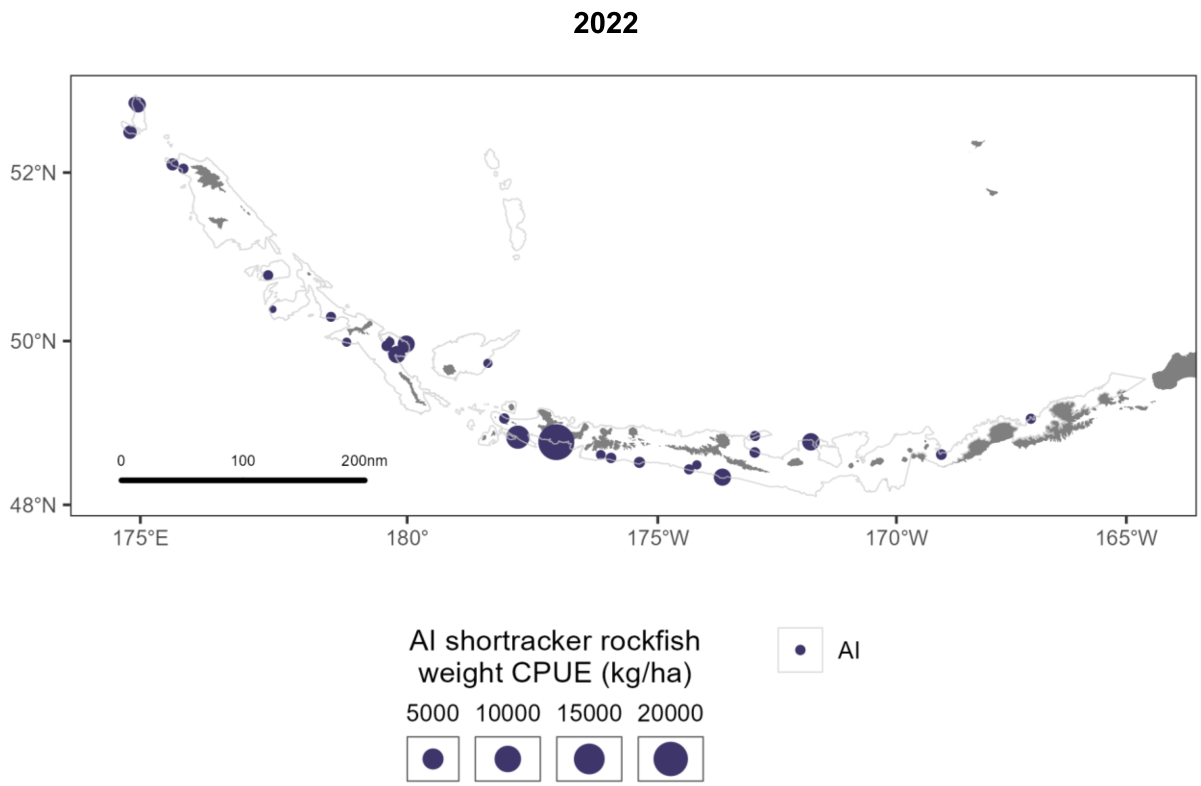

Figure 15.3 (cont.) Spatial distribution map of catch-per-unit-effort (CPUE) in kg/ha of shortraker rockfish on the Aleutian Islands bottom trawl survey from 1991 to present.

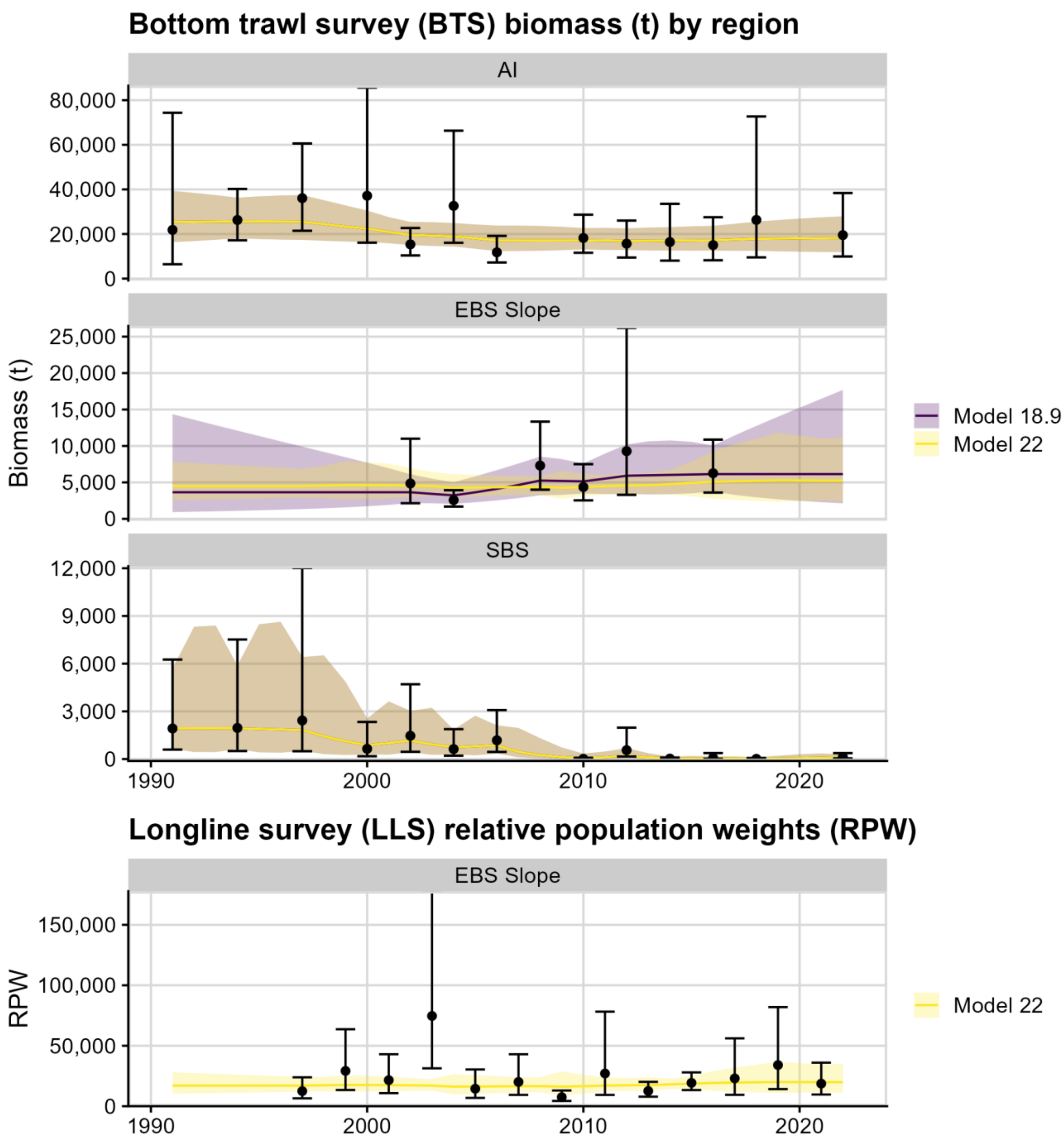

Figure 15.4 Observed biomass estimates and model fits to the Aleutian Islands (AI), eastern Bering Sea (EBS) slope, southeastern Bering Sea (SBS) bottom trawl surveys (BTS) by region (top), fits to the EBS slope longline survey relative population weights (RPWs; bottom) for shortraker rockfish. Results are shown for Model 18.9 (purple), the multivariate random effects (*rem*) model, and the Model 22 (yellow), which also fits to the EBS slope RPWs. Model 22 is the author-recommended model.

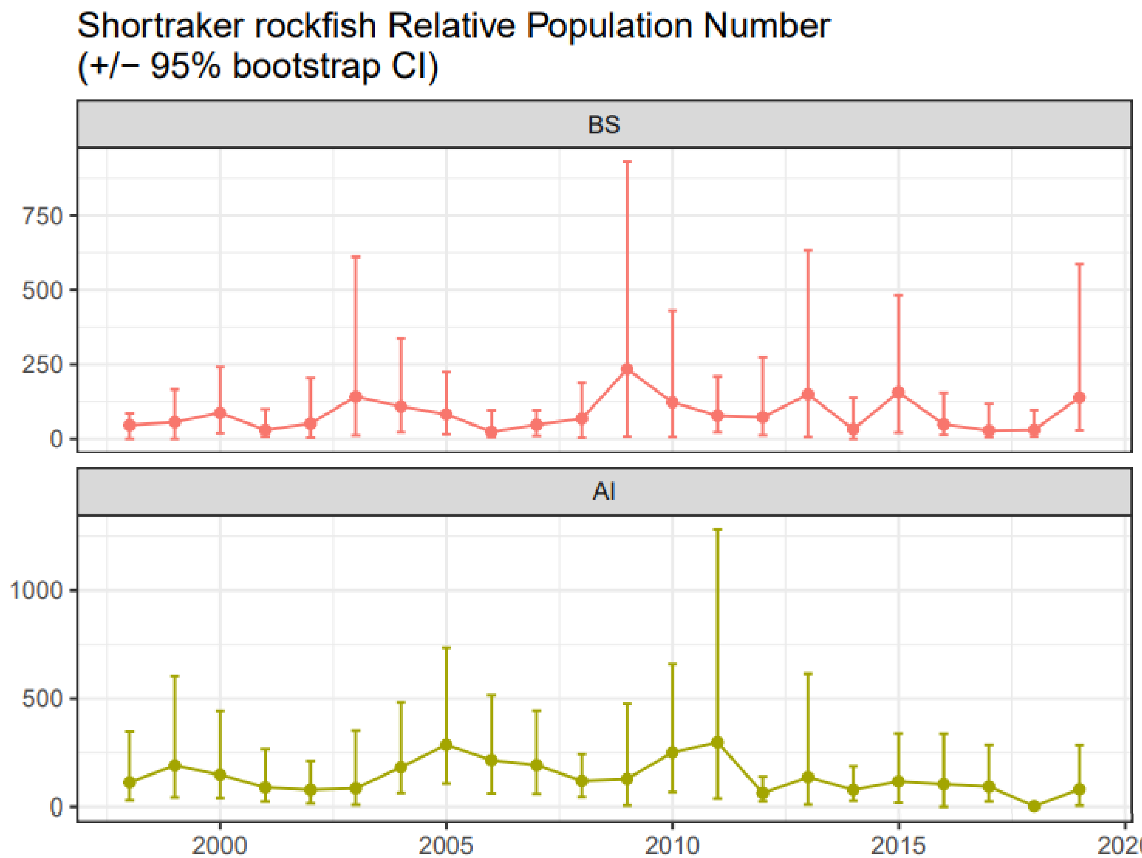

Figure 15.5 International Pacific Halibut Commission survey index for shortraker rockfish in all Alaska regions, 1998-2019.

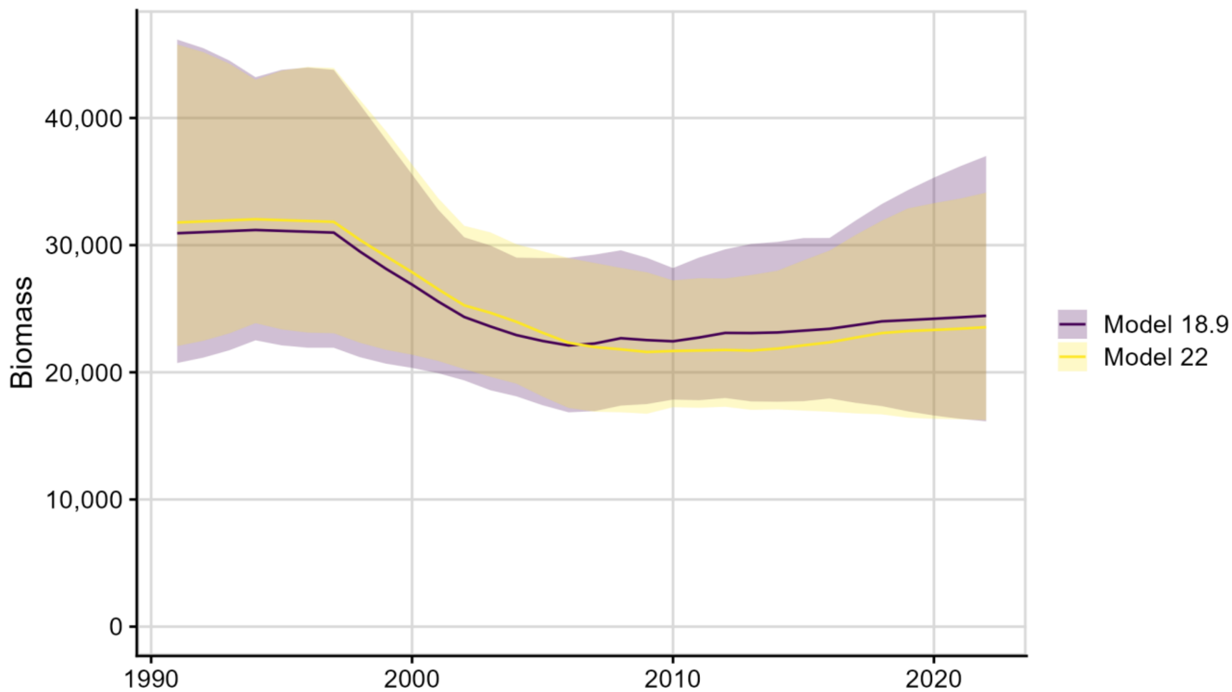

Figure 15.6 Total predicted biomass estimates for shortraker rockfish. Results are shown for Model 18.9 (purple), the multivariate random effects (*rem*) model, and the Model 22 (yellow), which also fits to the EBS slope RPWs. Model 22 is the author-recommended model.

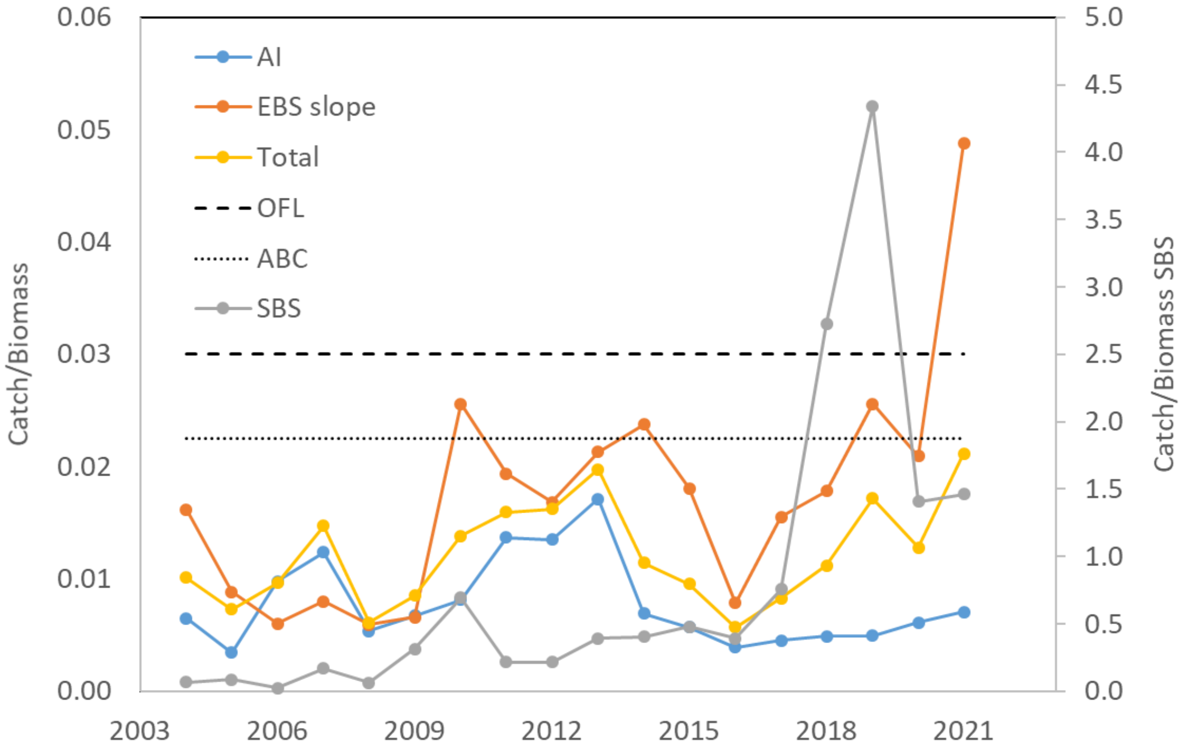

Figure 15.7 Area-specific exploitation rates for BSAI shortraker rockfish from 2004-2021, and for the entire BSAI (yellow line). Abbreviations are: Aleutian Islands (AI, blue line), eastern Bering Sea (EBS) slope (orange line), overfishing limit (OFL, M=0.03, black dashed line), acceptable biological catch (ABC, 0.75*M, black dotted line), southern Bering Sea (SBS, gray line, note on secondary axis).

Appendix 1. Supplemental Catch Data

Here we present non-commercial removals, estimates of total removals that do not occur during directed groundfish fishing activities, in order to comply with the Annual Catch Limit (ACL) requirements (Tables A1.1 and A1.2). Data is not available for 2020; therefore data is presented through 2019. This includes removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but does not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. For Bering Sea/Aleutian Islands (BSAI) shortraker rockfish, these estimates can be compared to the trawl research removals reported in previous assessments. Shortraker rockfish research removals are small relative to the fishery catch. The majority of removals are taken by the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey which is the primary research survey used for assessing the population status of BSAI shortraker rockfish. Other research activities that harvest shortraker rockfish include other trawl research activities and minor catches occur in longline surveys conducted by the International Pacific Halibut Commission and the AFSC. Some catches in the AFSC longline survey are reported as shortraker/rougheye. Total removals of shortraker and "shortraker/rougheye" rockfish were less than 3 t and 2 t in 2018 and 2019, respectively, which represent less than 1% of the ABC in these years. Research harvests in even years beginning in 2000 (excluding 2008, when the Aleutian Islands (AI) trawl survey was canceled) are higher due to the biennial cycle of the AFSC bottom trawl survey in the AI. These catches have varied between 1 and 15 t (in 1983). Additionally in 2020, several research surveys were cancelled due to the COVID-19 pandemic. Total removals for 2020 were approximately 1 t, which is about half of the 2019.

Table 15.A.1 Removals (t) of BSAI shortraker rockfish from activities other than groundfish fishing, 1977-2004. Trawl and longline include research survey and occasional short-term projects. “Other” is recreational, personal use, and subsistence harvest.

		Shortraker			Shortraker/Rougheye	
Year	Source	Trawl	Longline	Other	Trawl	Longline
1977						
1978						
1979		0.933				
1980		5.707				
1981		4.972				
1982		7.646				
1983		15.496				
1984						
1985		9.246				
1986		9.151				
1987						
1988		0.336				
1989						
1990	NMFS-AFSC survey databases					
1991		3.437				
1992						
1993		0.008				
1994		4.604				
1995						
1996						
1997		5.824				
1998			0.830			2.174
1999		0.017	1.198			0.494
2000		6.348	0.973			2.066
2001		0.010	1.258			0.422
2002		3.875	0.785			1.649
2003			2.138			0.376
2004		5.367	0.691			1.680

Table 15.A.2 Removals (kg) of BSAI shortraker rockfish from activities other than groundfish fishing, 2005-2020. Data from 2021 is not yet available for shortraker rockfish.

Year	Aleutian Islands Survey	AFSC Longline Survey	Bering Sea slope survey	IPHC Longline survey	Total
2005	0	1,300	0	0	1,300
2006	0	1,154	0	0	1,154
2007	0	1,323	0	0	1,323
2008	0	647	0	0	647
2009	0	1,708	0	0	1,708
2010	1,397	974	1,367	1,595	5,333
2011	0	1,424	0	1,120	2,544
2012	2,009	690	1,176	561	4,436
2013	0	1,239	0	509	1,748
2014	1,571	904	0	851	3,326
2015	0	1,496	0	1,062	2,558
2016	1,564	700	967	541	3,772
2017	0	2,260	0	972	3,232
2018	1,318	709	0	303	2,331
2019	0	1,000	0	1,007	2,007
2020	0	880	0	197	1,077