16. Assessment of the Other Rockfish stock complex in the Bering Sea/Aleutian Islands

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Executive Summary

The Bering Sea/Aleutian Islands (BSAI) Other Rockfish complex is currently managed in Tier 5 and is assessed on even years to coincide with the Aleutian Islands (AI) groundfish trawl survey. The Other Rockfish complex is assessed in two parts: (1) shortspine thornyhead (SST, *Sebastolobus alascanus*), which comprise approximately 95% of the estimated total Other Rockfish exploitable biomass; and (2) the remaining "non-SST" species, which are dominated by dusky rockfish (*Sebastes variabilis*) but include at least eleven other *Sebastes* and *Sebastolobus* species. The assumed natural mortality differs between SST (0.03) and the remaining non-SST species in the Other Rockfish complex (0.09). Therefore, they have different definitions of F_{OFL} and F_{ABC}.

Summary of Changes in Assessment Inputs

Changes in the input data

1) Catch and fishery lengths updated through October 13, 2020.
2) The only new survey biomass for this assessment is a zero biomass observation for non-SST species in the 2019 Eastern Bering Sea (EBS) shelf survey. The 2020 AI and EBS shelf surveys were canceled due to Covid-19, and there has been no EBS slope survey since 2016.
3) Following guidance from the Resource Assessment and Conservation Engineering Division (RACE) division, survey biomass inputs to the random effects (RE) model were limited to: AI (1991-present), EBS shelf (1982-present), and EBS slope (2002-present).

Changes in the assessment methodology

There were no changes in the assessment methodology.

Summary of Results

The recommended ABCs and OFLs (in bold) for 2021 and 2022 relative to last year for the Bering Sea/Aleutian Islands (BSAI) Other Rockfish complex is as follows:

Quantity	As estimated or *specified last* year for: 2020	2021	As estimated or *recommended this* year for: 2021	2022
M (natural mortality rate) for SST	0.03	0.03	0.03	0.03
M for non-SST	0.09	0.09	0.09	0.09
Tier	5	5	5	5
RE Model Combined Biomass (t)	53,290	53,290	53,248	53,248
F_{OFL} ($F=M$) for SST	0.03	0.03	0.03	0.03
F_{OFL} ($F=M$) for non-SST	0.09	0.09	0.09	0.09

$maxF_{ABC}$ for SST	0.0225	0.0225	0.0225	0.0225
$maxF_{ABC}$ for non-SST	0.0675	0.0675	0.0675	0.0675
F_{ABC} for SST	0.0225	0.0225	0.0225	0.0225
F_{ABC} for non-SST	0.0675	0.0675	0.0675	0.0675
OFL (t)	1,793	1,793	**1,751**	**1,751**
maxABC (t)	1,345	1,345	**1,313**	**1,313**
ABC (t)	1,345	1,345	**1,313**	**1,313**
	As determined *last* year for:		As determined *this* year for:	
Status	2018	2019	2019	2020
Overfishing	No	No	No	n/a

Area apportionment

The ABCs for the BSAI Other Rockfish complex are apportioned to the AI and EBS by summing the proportion of biomass in each region estimated by the random effects (RE) model for the SST and non-SST components of the complex. Separate ABCs and OFLs are presented below for each area and species/species group to illustrate how ABCs and OFLs are calculated for the complex. In recent years BSAI Other Rockfish have been managed with a BSAI-wide OFL and ABCs for the AI and EBS (in bold). The apportionment of ABCs and calculation of the OFL is as follows for 2021 and 2022:

		AI	**EBS**	**Total BSAI**
SST	RE model biomass (t)	14,609	36,085	50,694
	Proportion biomass by region	0.29	0.71	
	Area ABC (t)	329	812	1,141
	OFL (t)	438	1,083	1,521
non-SST	RE model biomass (t)	967	1,587	2,554
	Proportion biomass by region	0.38	0.62	
	Area ABC (t)	65	107	172
	OFL (t)	87	143	230
Total Other Rockfish	RE model biomass (t)	15,576	37,672	53,248
	ABC (t)	**394**	**919**	**1,313**
	OFL (t)			**1,751**

Summaries for Plan Team

The following table gives the projected biomass in the year harvest specifications were recommended, OFL, ABC, TAC and estimated catch to date for 2019-2022.

Species	Year	Biomass	OFL	ABC	TAC	Catch
Other rockfish	2019	55,312	1,793	1,345	663	1,266
	2020	53,290	1,793	1,345	1,088	916*
	2021	53,248	1,751	1,313		
	2022	53,248	1,751	1,313		

*Catch as of Oct 13, 2020

Responses to SSC and Plan Team Comments to Assessments in General

There were numerous SSC and Plan Team comments related to Ecosystem Socioeconomic Profiles (ESPs) and VAST modeling that were not relevant to the Other Rockfish stock and were therefore excluded from this section.

Risk Tables

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

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

"The Teams recommended that authors continue to fill out the risk tables for full assessments. The Teams recommended that adjustment of ABC in response to levels of concern should be left to the discretion of the author, the Team(s), and/or the SSC, but should not be mandated by the inclusion of a >1 level in any particular category. The Teams request clarification and guidance from the SSC regarding the previously noted issues associated with completing the risk table, along with any issues noted by the assessment authors. The Teams plan to discuss the risk table process at the September meeting." **(**Plan Team Nov 2019).

"*The SSC requests the the GPTs, as time allows, update the risk tables for the 2020 full assessments."* (Dec 2019)

"*The SSC provided direct responses to 10 specific requests raised by the Teams:*

1. *Whether an overall elevated risk level (>1) mandates a reduction in ABC, and, more generally, the relationship of the risk level to the amount of reduction (if any);*
   No. The intention was to organize, report and clarify risks that are not addressed in the assessment or the Tier system to promote transparency and consistency among assessments. The GPT minutes and the risk tables in this year's SAFE report suggest this is happening. As the SSC outlined in the December 2018 report, the risk tables are intended to be informative rather than prescriptive regarding potential reductions from maximum ABC.
2. *How to document changes that may not warrant higher levels of precaution, specifically when an overall elevated level of risk (>1) does not lead to a reduction in ABC (e.g., BSAI northern rockfish, GOA POP, GOA arrowtooth flounder);*
   Notation in the table along with associated explanation of the rationale in the SAFE reports is sufficient.
3. *The appropriateness of the overall level of risk being based on the maximum value across the categories, such that scores of 4, 4, 4, and 4 would be the same as a score of 1, 1, 1 and 4;*
   This approach is consistent with between-category variability in risk meaning and serves to elevate stocks with any risk concerns for further review (but see comments below regarding the overall rating).
4. *Whether to state a default level of no risk (=1) or an unknown level of risk when there is no information to evaluate the risk level for a given category (this was of particular concern for Tier 5 and 6 stocks);*
   "No risk" versus "no information" determinations are different and should be specified (GOA Atka mackerel and BSAI Alaska plaice provide good examples). Further, a rating of 1 does not necessarily mean no risk, but instead may reflect that the risks are dealt with in the assessment directly or via the Tier system and that no additional, unaccounted for risk was identified.
5. *How to determine the relative influence of stock-specific versus indirect ecosystem indicators for setting the risk level (e.g., EBS Pacific cod, BSAI northern rockfish);*
   This is at the discretion of the author/team. No between-category "influence" is likely to be consistent between assessments and attempts to establish category weights is likely to cause as many issues as it might address.
6. *How many direct or indirect ecosystem indicators would constitute an elevated concern;*

This is left to the judgement of the assessment author and the team on a case-by-case basis.

7. *How evaluations of fishery performance indicators determine risk to stock productivity;*
   As indicated in the SSC's December 2018 report, this additional column should include indications of fishery concern, such as inability to catch the TAC, large changes in CPUE (when not accounted for in the model), or dramatic changes in spatial or temporal distribution that could indicate anomalous biological conditions. If, and how, these indicators are developed is left up to the assessment author and GPT on a case-by-case basis.
8. *Delineating issues that fall under more than one category;*
   This is at the discretion of the author and GPT. Categories are not mutually exclusive, and risks can be attributed as deemed most appropriate by the author/GPT.
9. *Whether every item, positive or negative, listed in the context of the risk table necessarily constitutes a "concern" (e.g., for Alaska sablefish, is an unusually large year class necessarily a "concern" simply because it is unusual?);*
   No. The tables are intended to promote transparency and prompt further discussion as appropriate. Whether or not an unusual event (e.g. large year class) merits notation in the table is at the discretion of the assessment author and the GPT.
10. *The Teams noted that risk table discussions were time consuming and could be simplified if the process to determine levels of risk was decoupled from the decision to propose a reduction and the associated amount.*
    As stated in our December 2018 report, it is the intention of the SSC that these be decoupled but developed in concert: The SSC endorsed the Teams' request that the authors continue to fill out the risk tables for full assessments and affirmed the Teams' recommendation that adjustment from maxABC in response to levels of concern should be left to the discretion of the author, the Team(s), and/or the SSC, but should not be mandated by the inclusion of a >1 level in any particular category. The SSC encourages authors or Teams to provide recommendations on reductions and rationale for those reductions when appropriate. The SSC also requests authors to note changes in risk scoring from one assessment to the next, along with the rationale. The SSC reminds the authors that the tables are intended to capture risks and uncertainties that are NOT addressed in assessment and/or the application of the Tier system. In cases where these concerns are partially addressed, the SSC requests that the authors clearly articulate the extent to which the listed items are not already addressed by the assessment and/or the Tier system.

…..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)

We appreciate clarifications to the above questions, and the flexibility to fill in the risk table as most appropriate for each assessment. As a full assessment in 2020, we included a risk table for the first time for BSAI Other Rockfish. As requested, we did not include an overall risk score,

and the risk table explanation was copied into each chapter from the updated stock assessment guidelines. Filling in the risk table for this assessment was a time consuming but useful exercise.

Responses to SSC and Plan Team Comments Specific to this Assessment

There were no specific comments pertaining to this assessment.

Introduction

The Bering Sea/Aleutian Islands (BSAI) Other Rockfish complex is currently managed in Tier 5 and is assessed on a biennial basis to coincide with the Aleutian Islands groundfish trawl survey. The Other Rockfish complex includes all species of *Sebastes* and *Sebastolobus*, except Pacific ocean perch (POP, *Sebastes alutus*), northern rockfish (*Sebastes polyspinis)*, rougheye rockfish (*S. aleutianus*), and shortraker rockfish (*S. borealis*). The two most abundant species for Other Rockfish complex are SST and dusky rockfish. Other species include redstripe rockfish (*Sebastes proriger*), redbanded rockfish (*Sebastes babcocki*), yelloweye rockfish (*Sebastes ruberrimus*), harlequin rockfish (*Sebastes variegatus*), sharpchin rockfish (*Sebastes zacentrus*), longspine thornyhead (*Sebastolobus altivelis*), and broadbanded (also called broadfin) thornyhead (*Sebastolobus macrochir*). Current definitions of the complex do not specifically exclude blackspotted rockfish (S. *melanostictus)*, a recently recognized species (Orr and Hawkins 2008) that had historically been identified as rougheye rockfish in research surveys. However, blackspotted are currently not distinguished from rougheye rockfish in the fishery catches, and are therefore managed under the BSAI blackspotted/rougheye complex.

The Other Rockfish complex was defined in the BSAI Fishery Management Plan since 1986 and is managed through annual catch limits (Table 16.1). Prior to 2005, separate OFLs were established for EBS and AI management areas for SST and non-SST Other Rockfish. In 2005, the overfishing level was set as a combined limit for the entire BSAI. In that year the BSAI Other Rockfish complex was moved to a biennial assessment schedule to coincide with the frequency of trawl surveys in the AI and the EBS slope surveys. For this assessment, ABCs and OFLs for SST are calculated separately from non-SST Other Rockfish because SST is the most abundant species in the BSAI Other Species complex, and because it is managed under a lower natural mortality estimate (M=0.03) than the non-SST Other Rockfish (M=0.09). However, the OFL and ABC reference points are for the entire Other Rockfish complex and are apportioned to the EBS and AI.

Distribution

SST and dusky rockfish are distributed in different depths and regions of the Bering Sea and Aleutian Islands. SST occur throughout the Aleutian Islands (AI) and eastern Bering Sea (EBS) slope but are most abundant in the western Aleutian Islands, where they are found between 200 m and 500 m depth (Reuter and Spencer 2001). In contrast, dusky rockfish are typically captured between 125-200 m in the Aleutian Islands, and are rarely encountered on the EBS slope in either survey or fishery catches. It is likely that numerous Other Rockfish species are found in high relief, untrawlable habitat, which may lead to the underestimation of total exploitable biomass (Darin et al. 2012).

Life History Information

Rockfish of the genus *Sebastes* are long-lived and do not attain reproductive maturity until 5-27 years of age (Conrath 2017). They are viviparious; they mate and fertilize the eggs internally. Embryos develop within the female, and thousands or millions of tiny larvae are released after

several months. Juveniles settle in kelp, eelgrass, or rocky habitat and move to deeper water as they mature. The maximum age of dusky rockfish (*Sebastes variabilis*) formerly known as light dusky (Orr and Blackburn 2004) in the Gulf of Alaska (GOA) is 59 years from the survey and 76 years from the fishery (Lundsford et al. 2009). The generation time for dusky rockfish has been estimated at 23 years following the methods described in Restrepo et al. 1998 and using the estimates available from the dusky age-structured model (Lunsford et al. 2009). Two studies described in GOA dusky rockfish assessment estimated the age at 50% maturity of dusky rockfish in the GOA and range from 9.2-11.3 years (Chilton 2010, Fenske et al. 2018). These values indicate dusky rockfish have a shorter generation time than other rockfish, likely due to the higher natural mortality and earlier maturity. Two specimens of harlequin rockfish collected in the Aleutian Islands reached over 70 years (maximum age of 76 years), easily eclipsing the previously known maximum age of 47 years (from a specimen collected in the GOA). Maturity estimates are not available for the Aleutian Islands; however, GOA harlequin rockfish mature at an early age (50% age and length = 4.7 years at 18.7 cm; personal communication Todd TenBrink, AFSC).

Species of the genus *Sebastolobus*, including SST, broadbanded thornyhead, and longspine thornyhead, spawn pelagic egg masses that are pelagic between April and July in Alaska (Pearson and Gunderson 2003). Longevity may be as long as 100 years in SST (Butler et al. 1995). Age determination for SST has been recently investigated, with the main focus on establishing some working age criteria. Precision between age readers showed promise for young to moderately old specimens, up to 25+ years. Older specimens resulted in generally poorer precision. Accuracy of SST ages, however, remain inconclusive from C_{14} bomb radiocarbon results (Kastelle et al. 2020). Maturity for SST in the Aleutian Islands showed a 50% length and age estimate at 23.1 cm and 12.6 years (personal communication Todd TenBrink, AFSC). Given that ageing SST are still a work in progress, the maturity-at-age estimate should be viewed as preliminary.

Prey and Predators

Juvenile rockfish are preyed upon by lingcod (Beaudreau and Essington 2007), salmon, and other fish speices (Palsson et al. 2009). Adults are consumed by harbor seals and other marine mammals (Lance and Jeffries 2007). SST are preyed upon by groundfish such as Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), arrowtooth (*Astheresthes stomias*) and Kamchatka flounder (*Astheresthes evermanni*), walleye pollock (*Gadus chalcogrammus*), and the longnose skate (*Raja rhina*). SST consume smaller fish and crustaceans, such as herring, capelin, and crab, as well as skates, eelpouts, krill, and shrimp.

Evidence of Stock Structure

There is no data on the genetic stock structure of dusky, harlequin, or redbanded rockfish. Isolation by distance population structure has been identified in rockfish species such as copper, brown, and grass rockfishes along the United States west coast (*Sebastes caurinus*, *S. rastrelliger*, and *S. auriculatus*; Buonaccorsi et al. 2002, 2004, 2005), Pacific ocean perch off Alaska (*Sebastes aleutus*; Palof et al. 2011), and northern rockfish in the Bering Sea and Aleutian Islands region of Alaska (*Sebastes polyspinis*; Gharrett et al. 2012). Given the similarity in life history among rockfish species, it may be hypothesized that such genetic population structure could exist in the species that comprise the Other Rockfish complex. Genetic data suggests that the genus *Sebastolobus*, which includes all thornyhead rockfish, are subject to genetic population structure (Stepien et al. 2000).

Fishery

Historically, foreign catch records did not identify the various Other Rockfish by species, but reported catches in categories such as "other species" (1977-1979), and "Other Rockfish" (1980-1990), with the definitions of these groups changing between years. In the domestic fishery, the NOAA Fisheries Alaska Regional Office “Blend” catch database often reported the catches of Other Rockfish species in a single “Other Rockfish” category, although species-specific catch records have been available with the Catch Accounting System (CAS) database beginning in 2003. From 1991-2002, species catches were 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. An identical procedure was used to reconstruct the estimates of catch by species 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 Other Rockfish since 1977 by area are shown in Table 16.2. Some relatively high catches occurred in the late 1970s – early 1980s; total catch has only exceeded 1,000 t in 1978, 1979, 1980, 1982, and 1990. Tables 16.2 and 16.3 report catches of the seven most common species identified above (dusky, yelloweye, sharpchin, redbanded, redstripe, and harlequin rockfish, and SST), less common species that are recorded to species (black, darkblotched, rosethorn, silvergray, and thornyhead rockfish), as well as a final category of rockfish not identified to species called “other rockfish.” Reported ABCs, TACs, and catches of Other Rockfish from 2004-2020 are shown in Table 16.1. The catch of other rockfish in the Bering Sea has remained stable, but catch in the AI increased substantially in 2011-2020 relative to the period from 1995-2010.

The catches of Other Rockfish are composed primarily of dusky rockfish and SST; from 2003-2020, these two species composed 83% of the catch in the AI and 90% in the EBS (Tables 16.3 and 16.4). Three species of *Sebastolobus* are routinely captured in BSAI trawl surveys; broadbanded thornyhead, longspine thornyhead, and SST. The SST is by far the most abundant, comprising more than 90% of the thornyheads identified in observer records since 2008 (Tables 16.3 and 16.4). Thornyheads are only identified to genus in the fishery; therefore annual observer records of the proportion of SST out of the total thornyhead catch was applied to fishery catch for an extrapolated estimate of the catch of SST. Fishery observers record SST, broadbanded, and longspine thornyhead, as well as thornyhead unid., which could include any of the thornyhead species. In the Bering Sea, SST are only encountered on the Bering Sea slope.

There is no directed fishing for any of the Other Rockfish species; however, incidental catch occurs in multiple fisheries and gear types (Figure 16.1). The highest proportion (36%) has been caught in the Atka mackerel fishery, followed by the rockfish fishery (18%), the flatfish fishery (13%), the sablefish fishery (10%), and Pacific cod fisheries (9%). Other less significant fisheries include Pacific halibut (4%) and walleye pollock (3%). Since 2003 Other Rockfish have been primarily caught by bottom trawl (71%) and hook and line (25%).

A summary of the Other Rockfish catch retained and discarded from 2003-2020 indicates that the percent of Other Rockfish discarded has ranged from 9% to over 47%, and has generally increased over time (Table 16.5). Discard rates are lower in fixed gear fisheries, which yield a higher quality product than trawl gear (Hiatt et al. 2002).

Data

Fishery

Fishery length samples have been collected by observers for both SST and dusky rockfish since 2002. Generally, between 500 and 1,500 length samples are taken each year. The fishery tends to encounter larger SSTs than the survey, although SST were smaller on average in the 2017-2019 fishery data (Figure 16.2). Similarly, the fishery tends to slightly larger dusky rockfish than the survey, and there has been little change in the fishery length compositions over time (Figure 16.3).

Catches of the Other Rockfish complex from non-commercial sources (i.e. those not included in the Alaska Regional Office's Catch Accounting System) are shown in Table A1.1. Non-commercial removals averaged from 6.1 t between 2004 and 2019.

Survey

Exploitable biomass of Other Rockfish is estimated using survey biomass from the AI, EBS shelf, and EBS slope bottom trawl surveys (Table 16.6). Standardized U.S. domestic trawl surveys were conducted in 1991, 1994, 1997, 2000, 2002, 2004, 2006, 2010, 2012, 2014, 2016, and 2018 in the AI; 2002, 2004, 2008, 2010, 2012, and 2016 on the EBS slope; and annually 1982-2019 on the EBS shelf. Planned 2020 AI and EBS shelf surveys were canceled due to Covid-19 restrictions. Historical survey data from cooperative U.S.-Japanese trawl surveys conducted in the AI, EBS shelf, and EBS slope exist; however, these surveys utilized different vessels, survey gear, and sampling designs and are therefore not comparable to contemporary survey estimates (Spies et al. 2018). The AI survey is a multi-species survey based on a stratified-random design of previously successful stations and is, therefore, an index survey. However, AFSC has estimated biomasses as though the survey was 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). Therefore, design-based biomass estimates may be more appropriately viewed as mean cpue's weighted and expanded by stratum areas over the survey area. The survey 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. The EBS slope survey samples depths from 200 to ~1200 m, whereas the AI survey samples depths to 500 m. Thus, survey biomass estimates of deep-water species such as SST are likely underestimated in the AI survey. Few rockfish are found on the EBS shelf, primarily dusky and harlequin rockfish.

The largest survey biomass for SST is found on the EBS slope, and there has been an increasing trend over the survey time period from 2002-2016 (Table 16.6, Figure 16.4). Similarly the biomass estimates for SST in the AI trawl survey gradually increased from 1980-2010 and have appeared to stabilize (Table 16.6, Figure 16.4). The Southern Bering Sea (SBS), an area defined by the International North Pacific Fisheries Commission (INPFC) northeast of Samalga Pass in the EBS, has the smallest survey biomass of any of the areas (Table 16.6, Figure 16.4). Like the other survey areas, the SBS has seen a modest increase in SST over the available time series. There are no SST on the EBS shelf.

Although modest in comparison to SST, the largest survey biomass for non-SST species occurs in the AI and SBS (Table 16.6, Figure 16.5). The non-SST component of the complex is dominated by dusky rockfish across all survey regions, though harlequin rockfish are sporadically sampled

in the AI and SBS (Figure 16.6). The EBS shelf survey frequently has zero biomass observations of non-SST, including in the 2019 survey (Figure 16.5). The treatment of these zeros in the estimation of exploitable biomass remains the subject of active discussion and analysis (Spies et al. 2018). The EBS slope hosts a very small biomass of non-SST, which includes several *Sebastes* and *Sebastolobus* species. The biomass estimates fluctuate in all areas, and the occasionally large biomass estimates are driven by a small number of large tows, leading to large coefficients of variation (CV) (Table 16.6, Figure 16.5). Such large fluctuations would not be expected in a long-lived species, and are attributed to high uncertainty in the biomass estimates or a mismatch between the areas surveyed and the untrawlable habitat preferred by many rockfish species.

SST lengths from the survey are smaller than those for the fishery, falling primarily between 20 and 44 cm (Figures 16.2). Assuming that larger SST in the AI inhabit deeper water, the larger length in the fishery difference is likely related to the 500 m depth limit of the AI survey. The lengths of dusky rockfish obtained in the 2000-2018 AI surveys were generally between 35 and 45 cm, corresponding closely to the length distribution in the AI fishery (Figures 16.3).

Analytic Approach

Model Structure

As a Tier 5 complex, no population modeling is conducted for BSAI Other Rockfish.

Modeling Approach

The Other Rockfish complex assessment uses a biomass-based approach based on trawl survey data. Following recommendations from the Survey Averaging working group and the SSC, methodology for calculating exploitable biomass was changed in 2014 from a survey averaging approach to the use of a random effects model (RE). The RE model smooths the time series of trawl survey data, and the most recent biomass predicted by the model is used as the best estimate of exploitable biomass. The RE model was fit separately to regional SST and non-SST estimates of survey biomass (Table 16.6, Figures 16.4 and 16.5). Following past assessments, survey observations of zero biomass were excluded from the model (Spies et al. 2018).

For Tier 5 stocks, F_{OFL} and F_{ABC} are defined as M and 0.75M, respectively. The acceptable biological catch (ABC) is obtained by multiplying F_{ABC} by the estimated biomass, and the overfishing level (OFL) is obtained by multiplying F_{OFL} by the estimated biomass. The estimated natural mortality differs between SST (0.03) and the remaining species in the Other Rockfish complex (0.09); therefore, ABC and OFL (and F_{OFL} and F_{ABC}) are calculated separately for SST and non-SST Other Rockfish. Apportionments between the AI and the EBS are based on survey estimates in those regions.

Parameter Estimates

We assumed a natural mortality (M) of 0.03 and 0.09 for the SST and non-SST components of the BSAI Other Rockfish complex. The SST M of 0.03 is borrowed from the current GOA thornyhead stock assessment and is the average M over a range of published values for SST (Echave and Hulson 2018). The non-SST M of 0.09 is the M previously used for dusky rockfish, the most abundant species in the non-SST component of the complex (Clausen and Heifetz 2001). The M for dusky rockfish in the GOA assessment changed to 0.07 in 2007, based on updated data and the Hoenig (1983) empirical estimator for natural mortality that uses maximum lifespan (Malecha et al. 2007).

Historically, the value of *M* of 0.07 was used to assess the Other Rockfish stock, which represents an approximation based on knowledge of rockfish life histories from other areas. This value is based on the estimate for SST from Ianelli and Ito (1994), as this species comprises well over 90% of the Other Rockfish biomass (as calculated by survey data). Estimates of natural mortality of SST have been variable due to the difficulty of ageing this species. In the GOA thornyhead assessment, Gaichas and Ianelli (2003) presented natural mortality estimates from several studies. Studies have calculated natural mortality differently due to the age of their oldest sample. Miller (1985) estimated natural mortality to be 0.07 from a sample of SST in Southeast Alaska whose oldest age was 62 years old. A study using west coast SST estimated a natural mortality between 0.05-0.07 with the oldest age in the sample being 80 (Kline 1996). Pearson and Gunderson (2003) suggest that SST from Alaska have an M = 0.013-0.017, based on a study using the gonadosomatic index to estimate natural mortality. A natural mortality rate that low suggests that these fish reach maximum ages from 250-350 years, which would be very old even among rockfish species. One source of variability in these estimates is the variation in otolith age reading techniques. Miller (1985) used surface ageing and the break and burn technique, and found that precision and comparability was low. Kline (1996) used a thin section technique that had better inter-reader ageing agreement, and radiometric verification supported this technique. Subsequent radiometric work by Kastelle et al. (2000) corroborated Kline's results. Thus, Kline's methodology and results are presumed to be the most accurate given the uncertainty of ageing SST. Work is currently being done at the Alaska Fisheries Science Center to determine the best ageing technique to use for SST (personal communication Todd TenBrink, AFSC).

Results

SST comprise approximately 95% of the total estimated exploitable biomass for BSAI Other Rockfish. RE model estimates outside the range of the data remain equal to the most recent model fit to data, while confidence intervals become increasingly large the further the model is pushed outside the range of observations. Because trawl surveys were canceled in 2020 due to Covid-19, no new survey data for SST were available since the last full assessment, resulting in wide uncertainty intervals for 2020 RE estimates of SST biomass (Figure 16.4). The RE-estimated 2020 SST biomass was greatest on the EBS slope (34,760 t) and in the AI (14,609 t). A smaller but consistently observed biomass exists in the Southern Bering Sea (1,324 t), and there are no SST on the EBS shelf. The RE model fit to SST survey biomass shows an increase on the EBS slope from 2002-2016, an increase in the AI from 1991-2005 followed by a slight decrease after 2010, as well as a slight increase in the Southern Bering Sea since 1980. The RE model performs well for SST in all survey regions. There is a clear, well-estimated trend in biomass in both the AI and EBS (Figure 16.7).

The remaining Other Rockfish species are classified as non-SST; however, dusky rockfish are the dominant species in this group in all survey areas (Figure 16.6). The only new survey data for the 2020 assessment was a zero biomass observation of non-SST on the EBS shelf (Table 16.6, Figure 16.5). This is a common occurrence in the EBS shelf survey; 13 of the 38 EBS shelf survey years between 1982 and 2019 were zero biomass observations for non-SST (Table 16.6, Figure 16.5). The RE-estimated 2020 non-SST biomass was greatest in the AI (967 t), Southern Bering Sea (927 t), and the EBS shelf (628 t). The EBS slope had the lowest estimated biomass by far (31 t). The RE model effectively dampens the spasmodic survey biomass estimates of non-SST, although estimates in most years are highly uncertain (Figure 16.7). The lack of a coherent trend in non-SST survey biomass in any region, coupled with the high frequency of zero biomass observations, warrants further examination.

Fishery exploitation rates are estimated as the observed catch divided by the RE model biomass (Figure 16.8). The exploitation rate for SST since 2003 has remained less than 2%. Currently, ABCs and OFLs are specified for all Other Rockfish (SST and non-SST combined); however, if they were specified at a finer resolution, SST catch in the AI and EBS would be well below area-specific ABCs and OFLs since 2003 (Figure 16.9). In contrast, the exploitation rate for non-SST has averaged 44% and 13% since 2003 in the AI and EBS, respectively (Figure 16.8). Notably, the estimate of catch/biomass exceeded 1.0 in 2011 and 2012 for non-SST in the AI, indicating catch was greater than the estimated biomass. Catches of dusky and harlequin rockfish in the AI have increased in recent years (Table 16.3), primarily due to bycatch in the Atka mackerel bottom trawl fishery in the eastern Aleutian Islands (NMFS reporting area 541; Figure 16.1). Catch has exceeded area-specific ABCs and OFLs for non-SST in the AI every year since 2003, and the 2020 catch to date is 5.5 times the AI non-SST OFL (Figure 16.9). Total Other Rockfish catches in the AI region exceeded ABC in all but three of the last ten years and BSAI catch exceeded TAC in 2014 and 2019 (Table 16.1). The overall BSAI OFL, however, remains well above the recent catch rates.

Harvest Recommendations

The 2020 biomass estimate of the BSAI Other Rockfish complex from random effect model results is 53,248 t, 50,694 t for the SST component and 2,554 t for the non-SST component.

In recent years, BSAI Other Rockfish have been managed with a BSAI-wide OFL level and separate acceptable biological catches (ABCs) for the AI and EBS. For the 2021 and 2022 fishery, we recommend the maximum allowable ABC of 919 t for the Other Rockfish complex in the EBS and 394 t in the AI. We recommend a BSAI-wide OFL of 1,751 t for the entire complex. Further breakdowns of reference values for SST and non-SST in the Other Rockfish complex are summarized in the following table.

2021	**SST**	**non-SST**	**Total Other Rockfish**
M	0.03	0.09	-
Biomass	50,694	2,554	53,248
F_{OFL}	0.03	0.09	-
$maxF_{ABC}$	0.0225	0.0675	-
F_{ABC}	0.0225	0.0675	-
OFL	1,521	230	1,751
maxABC	1,141	172	1,313
ABC	1,141	172	1,313
Aleutian Islands ABC	329	65	394
Eastern Bering Sea ABC	812	107	919

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 Other Rockfish complex is split into SST, which comprises ~95% of the total exploitable biomass for the complex, and the smaller non-SST component, which is dominated by dusky rockfish but includes at least eleven other *Sebastes* and *Sebastolobus* species. Both SST and non-SST components of the complex are assessed under Tier 5, and exploitable biomass is estimated by fitting the standard RE model to AI, EBS shelf, and EBS slope trawl survey biomass estimates (Table 16.6, Figures 16.4 and 16.5). The RE model performs reasonably well for the SST component of the stock; few survey data points fall outside the confidence interval, there are no concerning residual patterns, and the survey biomass trend is clear and consistent in all areas (Figures 16.4 and 16.7). However, the largest estimated biomass of SST is in on the EBS slope, which has not been surveyed since 2016 and may not be surveyed for the foreseeable future given planned survey reduction efforts (ICES 2020). This is concerning given the RE model is not well-suited to estimating biomass outside the range of available data. Instead of reverting to the mean or extrapolating an increasing or decreasing trend, the RE model estimates remain equal to the most recent model fit to data, while confidence intervals become increasingly large (Figure 16.4). There is no formal guidance to our knowledge about how many years the RE model can or should be used after the cessation of a survey.

The application of the RE model to the non-SST component of the complex is problematic for several reasons. The survey biomass estimates for non-SST are dominated by dusky rockfish, and therefore are not reliable indices for the numerous other species contained in the non-SST component of the complex (Figure 16.6). The trends in non-SST survey biomass are characterized by several years of zero or low biomass interspersed with high estimates of biomass with wide confidence intervals (Figures 16.5 and 16.7). The zero survey biomass observations are treated as N/As in the model, and despite analysis of this issue in past assessments, no suitable alternatives have been found (Spies et al. 2018). This method is consistent with other Tier 5 assessments, including GOA Other Rockfish and BSAI Other Flatfish (Tribuzio and Echave 2019, Monnahan 2020).

The exploitation rate (catch/biomass ratio) has been consistently high for the non-SST component of the Other Rockfish complex, averaging 0.44 and 0.13 since 2003 in the AI and EBS, respectively (Figure 16.8). Notably, the estimate of catch/biomass exceeded 1.0 in 2011 and 2012 for non-SST in the AI, indicating catch was greater than the estimated biomass. Catches of dusky and harlequin rockfish in the AI have increased in recent years (Table 16.3), primarily due to bycatch in the Atka mackerel bottom trawl fishery in the eastern Aleutian Islands (area 541; Figure 16.1). Catch has exceeded area-specific ABCs and OFLs for non-SST in the AI every year since 2003, and the 2020 catch to date is 5.5 times the AI non-SST OFL (Figure 16.9). These findings indicate biomass estimates of non-SST may not be reliable, making it difficult to evaluate current harvest rates of non-SST species.

Given the combined concerns for the SST and non-SST components of the stock, we assigned the level of concern for assessment considerations at level 2. Discussion over these points may cogently lead to the consideration of moving non-SST to Tier 6. However, the dominance of SST biomass in the complex, coupled with the specification of a BSAI-wide OFL for combined Other Rockfish, means there is ample room for continued increase in harvest of non-SST species under any tier designation. An analysis of the spatial patterns of survey and fishery catch as they relate to trawlable and untrawlable habitat may be informative, although survey and catch data for non-SST species are very limited. Additionally, the utility of the AI survey as an abundance index for SST and non-SST species should be evaluated given the unique design of this survey compared to other bottom trawl surveys in Alaska (see the survey data section for more information). There is likely an underestimation of Other Rockfish biomass in the AI and SBS in both untrawlable habitats and deeper waters not sampled in the AI survey. It is possible alternative fishery-independent indices of abundance (e.g. the NMFS longline or IPHC setline surveys) may be useful in this context but have not been explored to date. Finally, further research into the connectivity or overlap of dusky rockfish in the eastern AI (area 541) and western GOA (area 610) would inform our understanding of stock structure and exploitation rates in this area.

Population dynamics considerations

Biomass trends for SST are stable or increasing for all areas (Figures 16.4 and 16.7) and the exploitation rate for this component of the complex has been less than 2% since 2003 (Figure 16.8). As described in the Assessment considerations, the index of non-SST biomass may not reliably reflect exploitable biomass, resulting in persistently high exploitation rates for this component of the stock. These biomass trends, although problematic for non-SST, are typical for the Other Rockfish stock. We therefore set the concern level to 1 for this consideration.

Environmental/Ecosystem considerations

Contributed by Ivonne Ortiz and Stephani Zador

For this risk table, ecosystem information is largely based on relevance to SST and dusky rockfish. Due to lack of 2020 surveys and fieldwork, many ecosystem indicators were not measured this year. Thus, much of the ecosystem information available for this year is derived from remote sensing. Duskies and SSTs are generally found between 3.5-5.7°C and 3.5-5°C, respectively. SST and dusky rockfish depth distributions have remained stable over time in the AI bottom trawl survey, unlike that of other *Sebastes* (Palsson and Rooper 2018, AI ESR). However, because the AI survey only samples depths up to 500 m, this finding is only relevant to the smaller, younger SST encountered in the AI survey (Figure 16.2). The National Centers for Environmental Prediction Global Ocean Data Assimilation System (GODAS) temperature anomalies for the 100–250m depth range show that significantly warmer temperatures have remained since 2016; the GODAS estimates are supported by the water column temperatures indicator for the AI (AI ESR Physical factors 2020). In general, higher ambient temperatures incur bioenergetic costs for ectothermic fish such that, all else being equal, consumption must increase to maintain fish condition. Thus, the persistent higher temperatures may be considered a negative indicator for rockfish occupying shallow depths like dusky rockfish. However, increased bioenergetic demands may be mitigated by their generalist diet.

Based on stomachs of dusky rockfish and SST sampled during the AI bottom trawl survey, the Other Rockfish can be split between planktivorous (duskies) and generalists (SSTs). Duskies feed largely on pelagic gelatinous filter feeders, jellyfish and shrimp in the western and central Aleutians (areas 543, 542), but feed more heavily on euphausiids, pelagic amphipods, copepods and other prey such as general crustaceans mysids in the eastern Aleutians (areas 541 and S. Bering Sea). In contrast, SSTs prey on shrimp, benthic amphipods and general fish when small (≤

20 cm) while larger fish (> 20 cm) feed primarily on sculpin, Atka mackerel, shrimp, cephalopods, snow and King crab, and occasionally on skates among other prey. Duskies may compete somewhat with Pacfic Ocean perch for prey, while SST share prey items with shortraker (sculpins, general fish and shrimp) and rougheye rockfish (Atka mackerel, shrimp and squid). There are no recorded fish predators of SST or dusky rockfish in the Aleutian Islands; however, thornyheads in the GOA are infrequently sampled in the diets of a variety of a piscivores, including arrowtooth flounder, sablefish, sharks, and sperm whales (Echave and Hulson 2018). Interestingly, there is also no documentation of predation on dusky rockfish in the GOA, although it is speculated that duskies may be occasional prey items for Pacific halibut and that predation effects for this species are most likely at early life history stages (Fenske et al. 2018).

In the absence of an available indicator for Other Rockfish habitat quality, the estimated area disturbed by trawls from the fishing effects model is used as the most relevant indicator reflecting impacts to habitat (Olson 2018, AI ESR). Trends in potential habitat disturbance are relevant for adult dusky and SST as they can be found on soft substrates, where shrimp are abundant, and in areas with frequent boulders and steep slopes, which are generally not targeted by bottom trawlers. 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 the Other Rockfish complex has been stable.

Taken together, these indicators suggest no clear concerns for the Other Rockfish stock complex, aside from the recent stretch of increased temperatures in depths 100-250 m which may be a relevant negative indicator for dusky rockfish. However, both the lack of ecological data relevant to the stock complex as well as lack of data in 2020 limit our assessment of potential recent ecosystem impacts on this stock complex. We therefore set the concern level to 1 for this consideration.

Fishery performance

There are no directed fisheries for Other Rockfish and the majority of catch is of non-SST dusky rockfish in the Atka mackerel bottom trawl fishery in the eastern AI (Tables 16.1 and 16.3, Figure 16.1). It seems plausible the dusky rockfish caught in this fishery, which is prosecuted close to the boundary line of areas 541 and 610, are a fringe component of the GOA dusky rockfish stock. There was an anomalously high catch of SST in flatfish bottom trawl fisheries in area 517 in 2019, which created an interesting contrast in the otherwise stable and low catch time series of SST (Figure 16.1). SST are caught as bycatch in the sablefish longline fishery in the AI; however, this catch has declined in recent years due to poor performance in that fishery (Figure 16.1; Hanselman et al. 2019). Exploitation rates are less than 2% for SST but are quite high for non-SST, averaging 44% and 13% since 2003 in the AI and EBS as described in the Assessment considerations (Figure 16.8). Any concerns related to the apparent high exploitation rate of non-SST are reflected in our Assessment concerns, and we set the concern level to 1 for this consideration.

Summary and ABC recommendation

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 2: Substantially increased assessment uncertainty/ unresolved issues.	Level 1: no increased concerns	Level 1: no increased concerns	Level 1: no increased concerns

Despite the elevated level of concern for the assessment, it does not warrant a reduction from the maximum permissible ABC under the relevant harvest control rule.

Status Determination

The stock/complex is not being subjected to overfishing as determined by comparing the catch from the most recent complete year to the specified OFL for that year.

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Tables

Table 16.1. Regulatory catch limits (OFL, ABC, and TAC) and total catch of Other Rockfish in the BSAI, 1995-2020. Data for 2003-2020 is from the NMFS AKRO Catch Accounting System, AKFIN database, accessed October 13, 2020. Catch data previous to 2003 was obtained using several different sources that are described in the text. Shading highlights years catch exceeded TAC or ABC.

	BSAI				AI				BS			
Year	OFL	ABC	TAC	Catch	OFL	ABC	TAC	Catch	OFL	ABC	TAC	Catch
1995		1135	1022	480	770	770	693	223	365	365	329	257
1996		1449	1354	436	952	952	857	272	497	497	447	164
1997		1087	1087	388	952	714	714	274	497	373	373	114
1998		1054	1054	482	913	685	685	327	492	369	369	155
1999		1054	1054	517	913	685	685	372	492	369	369	145
2000		1054	1054	797	916	685	685	558	492	369	369	239
2001		1037	1037	819	901	676	676	524	482	361	361	295
2002		1037	1037	872	901	676	676	502	482	361	361	370
2003		1594	1594	724	846	634	634	408	1280	960	960	316
2004		1594	1094	633	846	634	634	331	1280	960	460	302
2005	1,870	1,400	1,050	447		590	590	282		810	460	165
2006	1,870	1,400	1,050	570		590	590	421		810	460	149
2007	1,330	999	999	646		585	585	429		414	414	217
2008	1,330	999	999	596		585	585	382		414	414	214
2009	1,380	1,040	1,040	566		555	555	372		485	485	193
2010	1,380	1,040	1,040	766		555	555	498		485	485	269
2011	1,700	1,280	1,000	945		570	500	617		710	500	328
2012	1,700	1,280	1,070	921		570	570	712		710	500	209
2013	1,540	1,159	873	820		473	473	628		686	400	192
2014	1,550	1,163	773	953		473	473	629		690	300	324
2015	1,667	1,250	880	688		555	555	503		695	325	185
2016	1,667	1,250	875	789		555	550	507		695	325	282
2017	1,816	1,362	875	831		571	550	570		791	325	261
2018	1,816	1,362	845	828		571	570	663		791	275	164
2019	1,793	1,345	663	1,266		388	388	569		956	275	697
2020	1,793	1,345	1,088	916		388	388	640		956	700	276

Table 16.2. Historical catch (t) of Other Rockfish species from 1977 to 2003 in foreign, joint venture (JV), and domestic fisheries. Data were obtained using several different sources that are described in the text. Data prior to 1990 are on file at the Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Seattle, WA 98115.

	Eastern Bering Sea				Aleutian Islands				BSAI
Year	Foreign	JV	Domestic	Total	Foreign	JV	Domestic	Total	Total
1977	52	0		52	537	0		537	589
1978	304	0		304	795	0		795	1,099
1979	281	0		281	2,053	0		2,053	2,334
1980	566	1		567	484	0		484	1,051
1981	337	0		337	236	0		236	574
1982	365	0		365	2,057	0		2,057	2,422
1983	208	1		210	717	4		721	931
1984	112	7		119	57	25		81	200
1985	35	1		36	1	14		15	51
1986	4	14	81	99	0	10	147	157	256
1987	3	4	535	542	0	5	138	143	684
1988	0	3	252	254	0	68	168	237	491
1989	0	9	171	180	0	0	352	352	533
1990			395	395			822	822	1,217
1991			239	239			313	313	552
1992			201	201			470	470	671
1993			142	142			443	443	584
1994			123	123			272	272	395
1995			257	257			223	223	479
1996			164	164			272	272	437
1997			114	114			274	274	388
1998			155	155			327	327	482
1999			145	145			372	372	517
2000			239	239			558	558	797
2001			295	295			524	524	819
2002			370	370			502	502	872
2003			316	316			408	408	724

Table 16.3. Catch (t) of Other Rockfish species in the Aleutian Islands 2003-2020. Source: NMFS AKRO Catch Accounting System, AKFIN database, NMFS AFSC FMA Observer Debriefed Haul and Length tables, accessed Oct.13, 2020.

Year	dusky rockfish	SST	other thornyheads	% SST in thornyhead catch	harlequin rockfish	yelloweye rockfish	redbanded rockfish	redstripe rockfish	black rockfish	other rockfish	Total (t)
2003	151.5	129.3	47.8	73.00%	34.5	2.4	0.2	0.9	0.2	3.2	389.6
2004	129.5	60.3	37	62.00%	36.9	0.9	0.2	3.1	1.4	47.9	331.2
2005	134.2	78.1	35.1	69.00%	14.3	5.6	0.2	0	0	14.1	281.6
2006	161.4	118.7	39.7	74.90%	25.2	0.4	0.1	1.7	0.1	72.2	421.6
2007	231.7	115.9	15.4	88.30%	39.9	0.6	1.4	0.5	0.1	23.9	429.4
2008	179.8	107.4	7.8	93.20%	34.3	4.5	1	0.6	3.2	43.3	382
2009	142	131.8	10.8	92.40%	22.8	0.2	0.4	0	1.2	63	372.3
2010	226.2	154.8	14.9	91.20%	42.6	0.5	3.6	0.9	0.4	53.5	497.6
2011	380.5	152.8	10.7	93.40%	59.3	0.3	0.7	0	0.1	12.4	616.8
2012	435.2	171.4	2.7	98.40%	51.9	0.1	3.7	0	0.3	46.3	711.7
2013	334.4	255.5	5.1	98.10%	25.9	0.7	1	0	0.5	6.2	629.2
2014	349.3	241.7	9.1	96.40%	20	0.1	1.5	0.3	0.4	6.2	628.5
2015	294.4	150.3	2.9	98.10%	32.7	0.1	4.3	0	0.1	17.8	502.5
2016	337.6	130.2	0	100.00%	36.1	1.3	0.5	0.1	0.3	0.7	506.8
2017	403.6	100.7	0.8	99.20%	47.9	0.2	1.7	4.5	0.6	10.1	569.9
2018	570.6	90.2	1.3	98.60%	95.4	0.8	0.9	0	0.3	15.3	774.8
2019	331.6	135	0	100.00%	92.2	0.3	2	0	0.8	7.2	569.2
2020	352.6	171.1	0.3	99.80%	92.9	1	2.2	0.3	2	17.5	639.9
Average	285.9	138.6	13.4	90.30%	44.7	1.1	1.4	0.7	0.7	25.6	514.1

Table 16.4. Catch (t) of Other Rockfish species in the Bering Sea 2003-2020. Source: NMFS AKRO Catch Accounting System, AKFIN database, NMFS AFSC FMA Observer Debriefed Haul and Length tables, accessed Oct.13, 2020.

Year	dusky rockfish	SST	other thornyheads	% SST in thornyhead catch	harlequin rockfish	yelloweye rockfish	redbanded rockfish	redstripe rockfish	black rockfish	other rockfish	Total (t)
2003	22.2	218.9	20.8	91.30%	0	1.1	17	1	0.3	13.6	295
2004	31.9	224.3	17.7	92.70%	0.4	1.4	10.4	0	0.9	15	301.9
2005	36.2	103	15.9	86.60%	0.2	0.7	0.3	0	7.2	1.6	165.2
2006	46.6	89	4.3	95.40%	0	1.4	0.4	0.1	0.2	6.9	148.8
2007	44.9	163.1	5.1	97.00%	0	1.7	0	0	0.3	1.8	217.1
2008	15.4	179.1	7.3	96.10%	0	1	0	0.1	2.2	9.2	214.3
2009	10.2	177.6	1	99.40%	0.1	1.1	0.2	0	0.2	2.8	193.3
2010	33.3	199.5	7.8	96.20%	0.3	1.4	0.5	0	1.5	23.8	268.3
2011	45.8	257.8	1.2	99.50%	4.6	1.4	0.5	0	3.5	13.8	328.6
2012	36.1	136.1	9.2	93.70%	0.1	0.5	2.6	0.1	7.2	18.5	210.4
2013	33.3	142.3	3.3	97.70%	0.6	0.7	0.2	0	4.6	6.6	191.7
2014	42.2	246.3	3.3	98.70%	1.5	1.5	0.1	4.6	1.8	22.8	324.3
2015	47.7	100.4	2.4	97.70%	2.3	1.4	0.2	0	1.7	28.5	184.6
2016	36.4	210.5	9.9	95.50%	3.1	2.5	0.1	0	6.2	10.3	279.1
2017	30.2	211.4	1.1	99.50%	1.7	1.3	1.6	0.3	0.8	11.6	260
2018	38.4	148.6	0.7	99.60%	0.5	1	0.2	0.1	5.2	16.7	211.4
2019	87.5	594.4	1.9	99.70%	3.4	1.3	0.6	0.1	0.7	7.3	697.2
2020	58.2	171.7	0	100.00%	0.2	0.8	0	0	11.4	33.6	275.9
Average	38.7	198.6	6.3	96.50%	1.1	1.2	2	0.4	3.1	13.6	264.8

Table 16.5. Retained and discarded catch of Other Rockfish species from 2003-2020 in the Aleutian Islands and Bering Sea. Accessed October 13, 2020 from the NMFS AKRO Catch Accounting System, AKFIN database.

Area	Year	Discard	Retained	Total catch	% Discarded
AI	2003	187	202	390	48%
	2004	166	165	331	50%
	2005	95	186	282	34%
	2006	177	245	422	42%
	2007	218	212	429	51%
	2008	114	268	382	30%
	2009	116	256	372	31%
	2010	124	373	498	25%
	2011	143	474	617	23%
	2012	99	613	712	14%
	2013	164	465	629	26%
	2014	162	466	629	26%
	2015	84	418	503	17%
	2016	43	464	507	9%
	2017	104	466	570	18%
	2018	197	578	775	25%
	2019	255	315	569	45%
	2020	297	342	640	47%
EBS	2003	44	251	295	15%
	2004	73	229	302	24%
	2005	21	144	165	13%
	2006	26	123	149	18%
	2007	73	144	217	34%
	2008	70	144	214	33%
	2009	23	170	193	12%
	2010	66	203	268	24%
	2011	50	278	329	15%
	2012	46	165	210	22%
	2013	45	146	192	24%
	2014	68	257	324	21%
	2015	68	117	185	37%
	2016	85	194	279	31%
	2017	57	203	260	22%
	2018	60	151	211	29%
	2019	160	537	697	23%
	2020	101	175	276	37%

Table 16.6. Biomass estimates (t) and CVs (in parentheses) from the standardized time series of Aleutian Islands (AI), Eastern Bering Sea (EBS) shelf, and EBS slope bottom trawl surveys that were used as inputs to the random effects model for the shortspine thornyhead (SST) and non-SST components of the Other Rockfish complex, 1982-2020. The Southern Bering Sea is defined by the International North Pacific Fisheries Commission (INPFC) and is sampled during the AI trawl survey. SST do not occur on the EBS shelf. No surveys occurred in 2020.

	SST			non-SST			
Year	AI	S. Bering Sea (AI survey)	EBS Slope survey	AI	S. Bering Sea (AI survey)	EBS Shelf survey	EBS Slope survey
1982						0	
1983						0	
1984						18 (1.00)	
1985						36 (1.00)	
1986						0	
1987						50 (1.00)	
1988						0	
1989						0	
1990						0	
1991	6,153 (0.24)	187 (0.58)		494 (0.38)	61 (0.83)	857 (0.94)	
1992						14 (1.00)	
1993						86 (1.00)	
1994	6,244 (0.16)	1,071 (0.52)		213 (0.61)	101 (0.49)	47 (1.00)	
1995						76 (0.70)	
1996						36 (1.00)	
1997	8,894 (0.18)	1,545 (0.69)		643 (0.68)	138 (0.46)	126 (1.00)	
1998						538 (0.68)	
1999						398 (0.75)	
2000	10,648 (0.19)	1,051 (0.48)		1,276 (0.33)	55 (0.36)	0	
2001						0	
2002	14,244 (0.20)	1,012 (0.41)	16,940 (0.12)	554 (0.31)	99 (0.36)	0	38 (0.42)
2003						55 (0.70)	

	SST			non-SST			
Year	AI	S. Bering Sea (AI survey)	EBS Slope survey	AI	S. Bering Sea (AI survey)	EBS Shelf survey	EBS Slope survey
2004	17,335 (0.19)	945 (0.56)	18,793 (0.09)	1,231 (0.41)	5,528 (0.78)	0	31 (0.35)
2005						36 (1.00)	
2006	17,878 (0.12)	968 (0.55)		6,003 (0.88)	738 (0.95)	357 (0.85)	
2007						0	
2008			26,055 (0.12)			0	27 (0.45)
2009						122 (0.58)	
2010	18,075 (0.16)	1,052 (0.73)	29,334 (0.12)	588 (0.32)	120 (0.44)	57 (0.92)	147 (0.70)
2011						56 (1.00)	
2012	14,443 (0.15)	452 (0.77)	29,565 (0.11)	250 (0.30)	135 (0.57)	37 (1.00)	52 (0.49)
2013						40 (1.00)	
2014	17,611 (0.24)	2,567 (0.67)		5,643 (0.81)	232 (0.50)	28 (1.00)	
2015						143 (1.00)	
2016	16,541 (0.16)	1,607 (0.53)	35,948 (0.11)	1,765 (0.33)	218 (0.54)	20 (1.00)	30 (0.33)
2017						169 (0.73)	
2018	13,216 (0.20)	1,605 (0.68)		914 (0.32)	1,638 (0.77)	1,593 (0.70)	
2019						0	
2020							

Figures

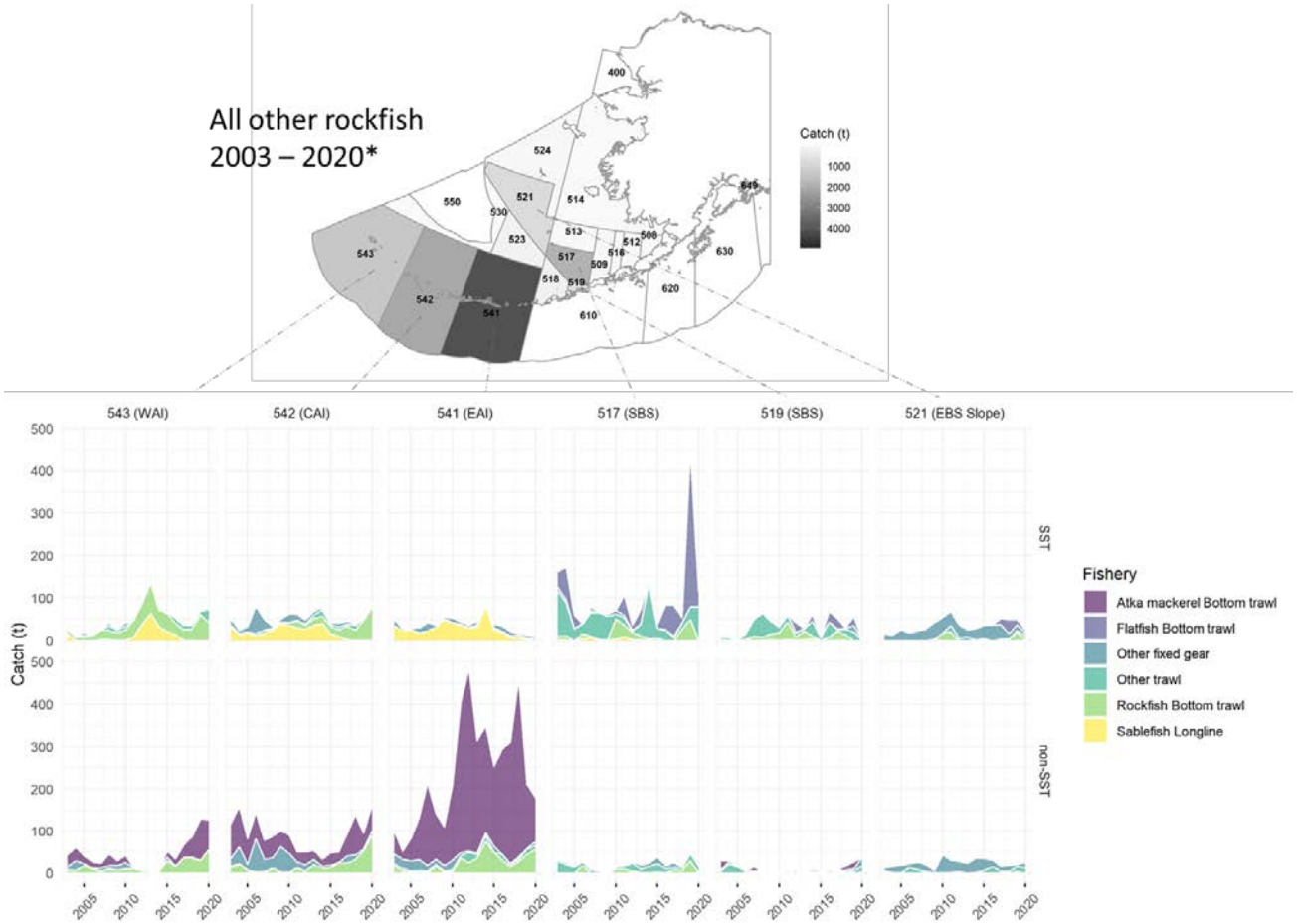

Figure 16.1. Upper panel: Map of aggregated catch of all Other Rockfish in the Bering Sea and Aleutian Islands (BSAI) by NMFS reporting area, 2003-2020. Lower panel: Annual catches of shortspine thornyhead (SST) and non-SST rockfish by dominant fishery and gear type for the NMFS reporting areas with the greatest catch. Source: NMFS AKRO Catch Accounting System, AKFIN database, as of October 13, 2020*.

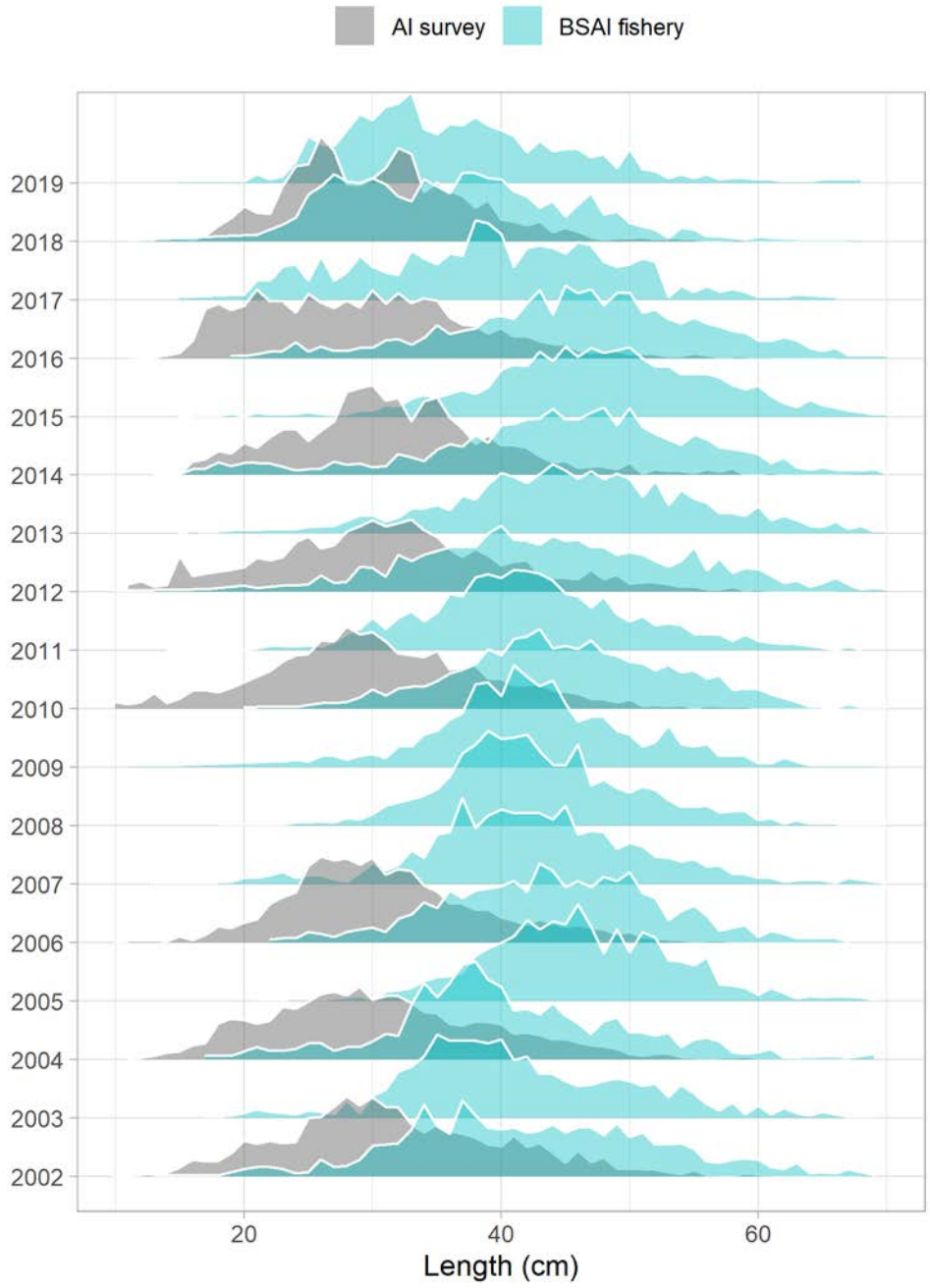

Figure 16.2. Shortspine thornyhead length frequency data from the AI trawl survey (grey) and BSAI fishery (teal), 2002-2019. Fishery data source: NMFS AFSC FMA Observer Debriefed Haul and Length tables.

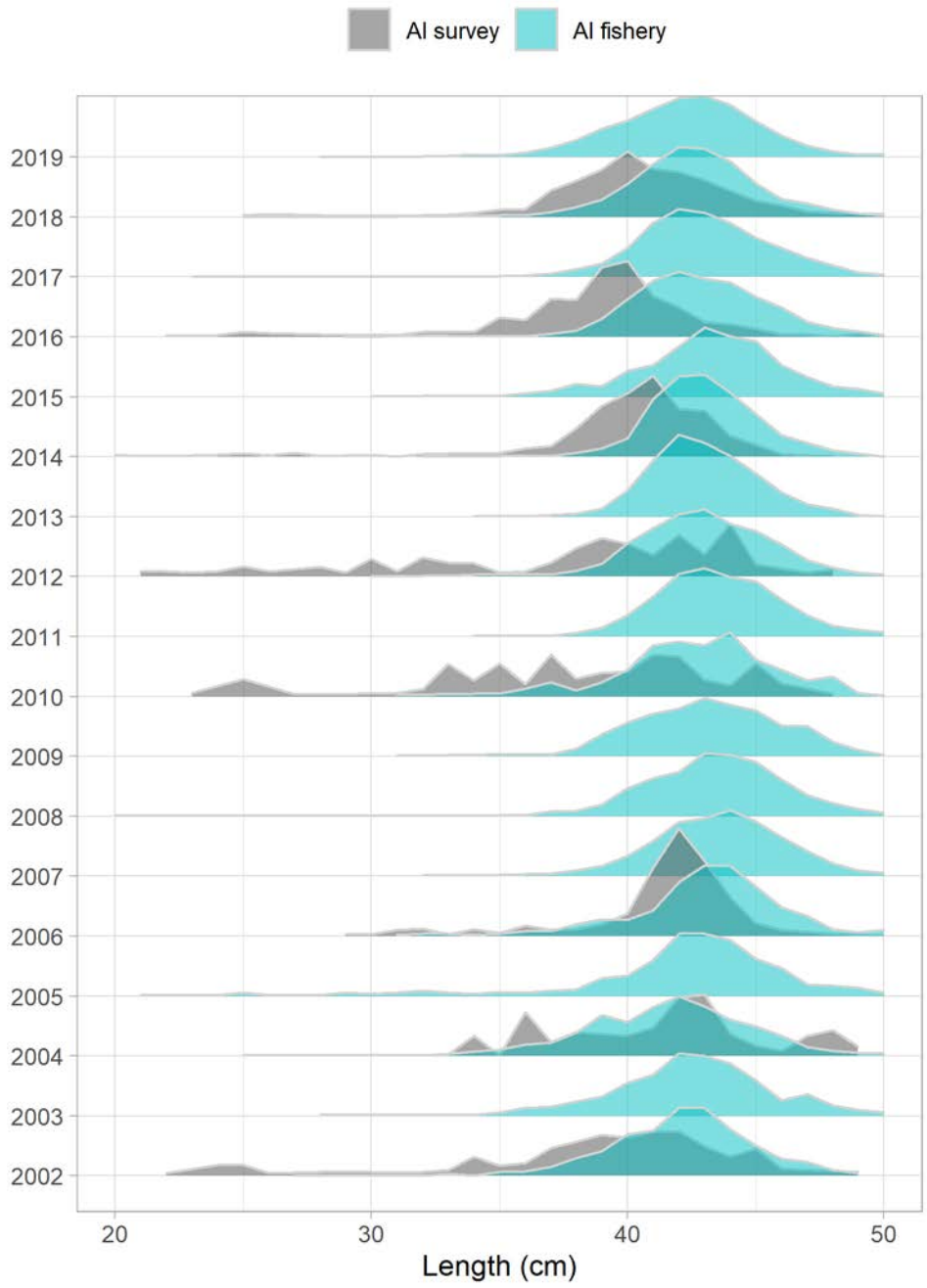

Figure 16.3. Dusky rockfish length frequency data from the AI trawl survey (grey) and fishery (teal), 2002-2019. Fishery data source: NMFS AFSC FMA Observer Debriefed Haul and Length tables.

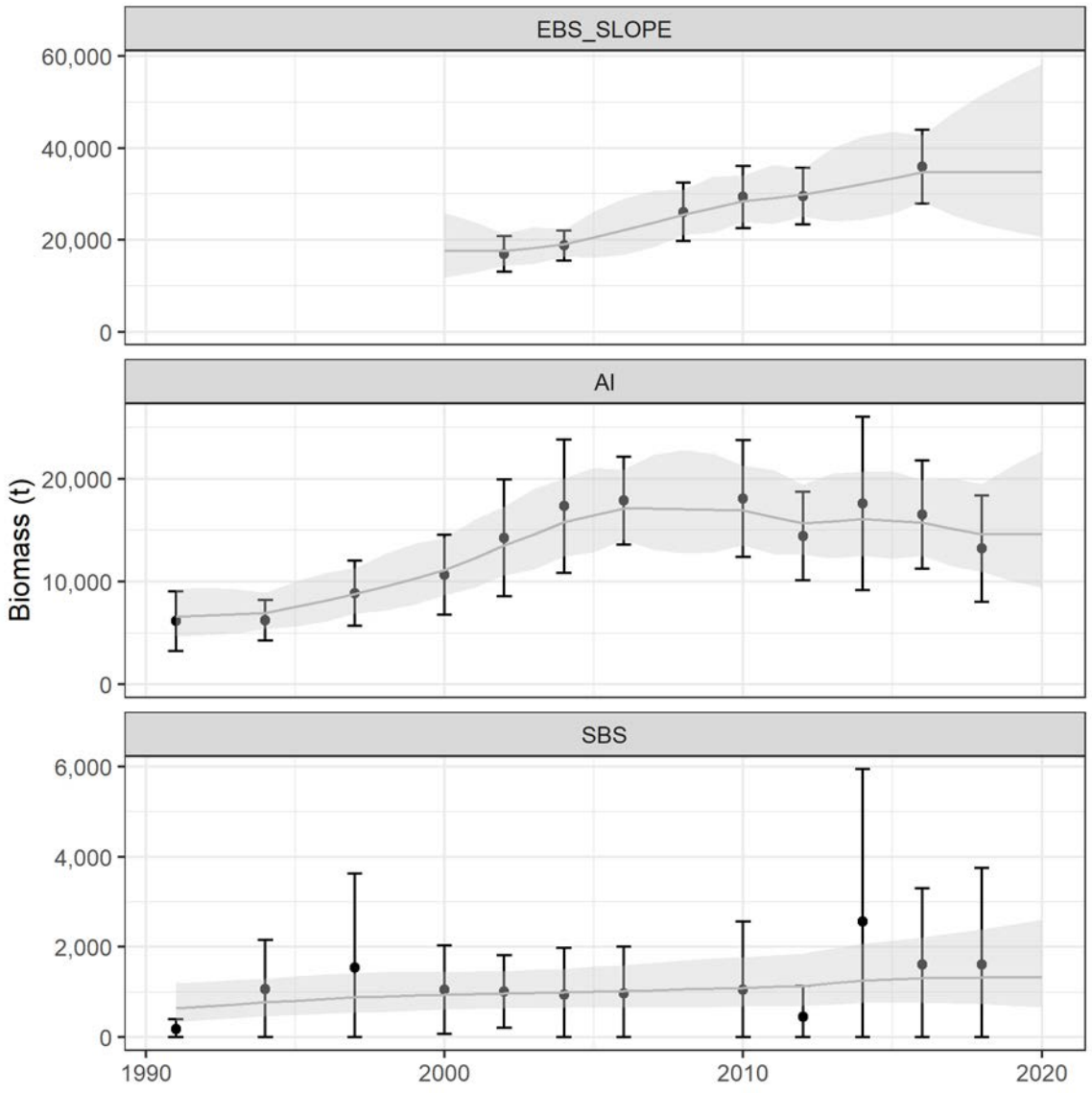

Figure 16.4. Random effects model fits (grey lines) to survey biomass (black points) for the shortspine thornyhead (SST) component of the Other Rockfish complex in the Eastern Bering Sea (EBS) slope, Aleutian Islands (AI), and Southern Bering Sea (SBS) regions. Shaded regions and error bars show 95% confidence intervals for the model fits and survey biomass data, respectively. There are no SST in the EBS shelf. The SBS is defined by the International North Pacific Fisheries Commission (INPFC) and is sampled during the Aleutian Islands (AI) survey. Note the difference in *y*-axis scales.

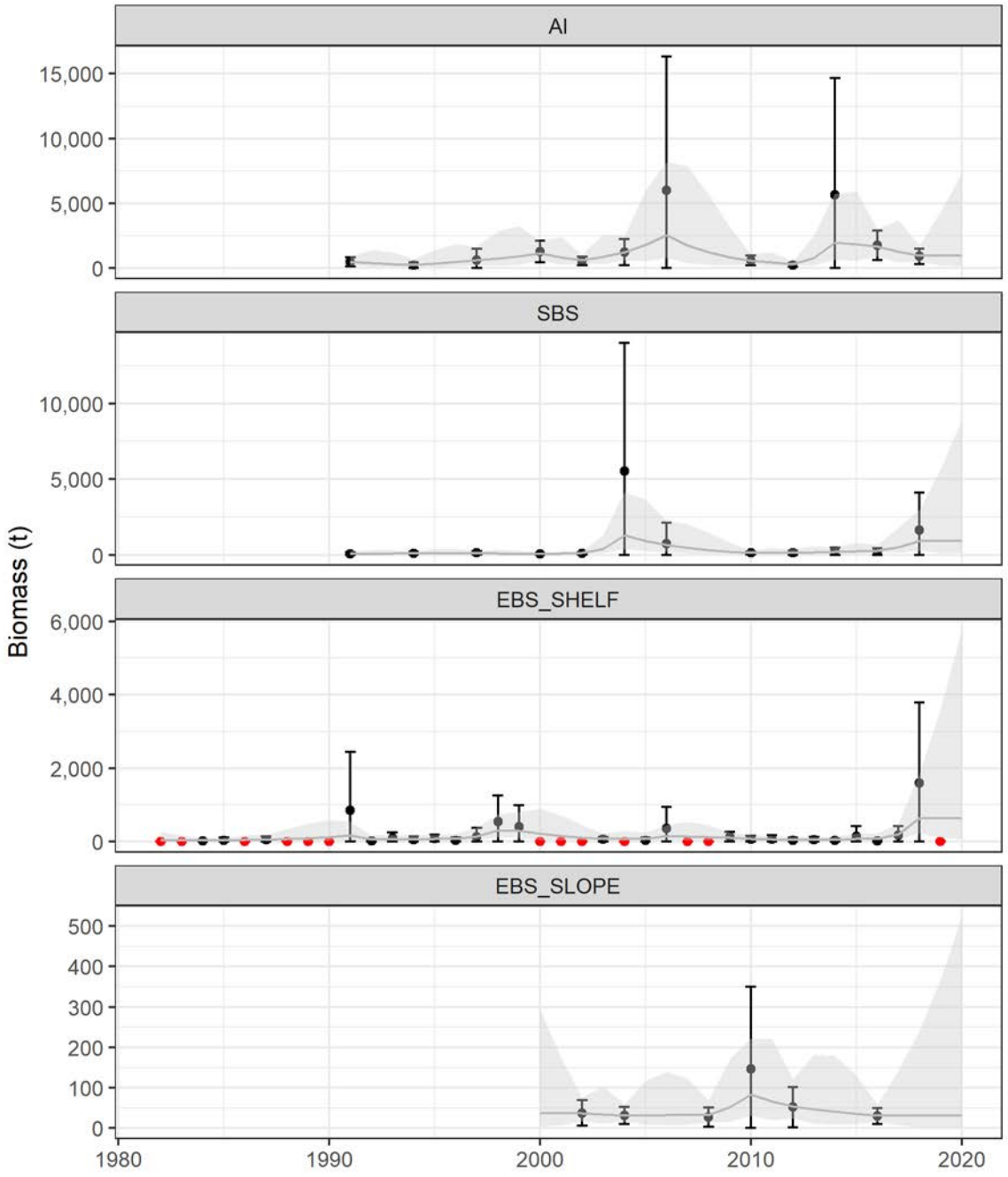

Figure 16.5. Random effects model fits (grey lines) to survey biomass (black and red points) for the non-shortspine thornyhead (non-SST) component of the Other Rockfish complex in the Aleutian Islands (AI), Southern Bering Sea (SBS), Eastern Bering Sea (EBS) shelf, and EBS slope regions. Shaded regions and error bars show 95% confidence intervals for the model fits and survey biomass data, respectively. Red points highlight years with zero observations. The SBS is defined by the International North Pacific Fisheries Commission (INPFC) and is sampled during the Aleutian Islands (AI) survey. Note the difference in *y*-axis scales.

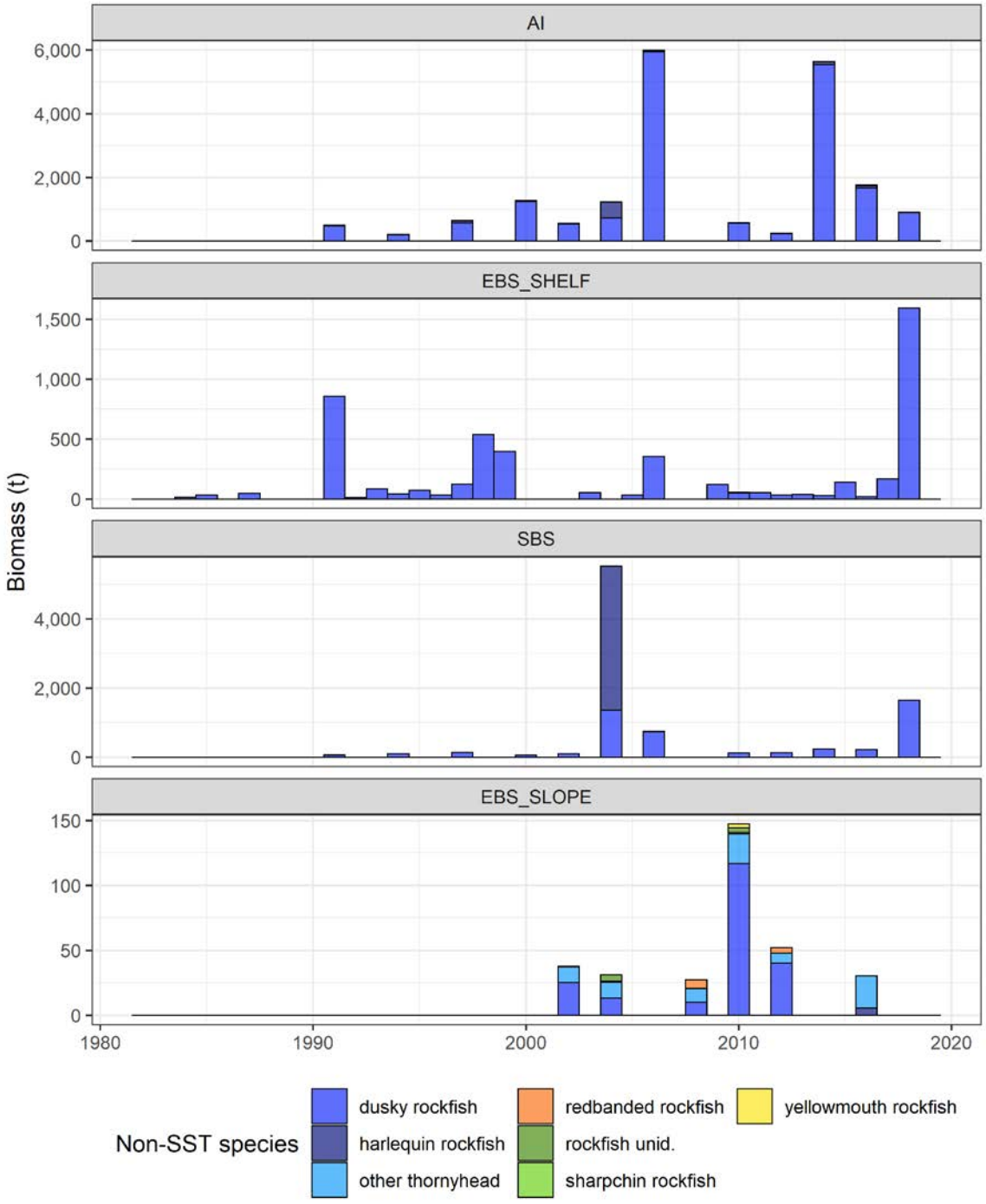

Figure 16.6. Survey biomass of non-SST (all Other Rockfish except shortspine thornyhead, SST) in the Aleutian Islands (AI), Southern Bering Sea (SBS), Eastern Bering Sea (EBS) shelf, and EBS slope regions. The SBS is defined by the International North Pacific Fisheries Commission (INPFC) and is sampled during the Aleutian Islands (AI) survey. Note the difference in *y*-axis scales.

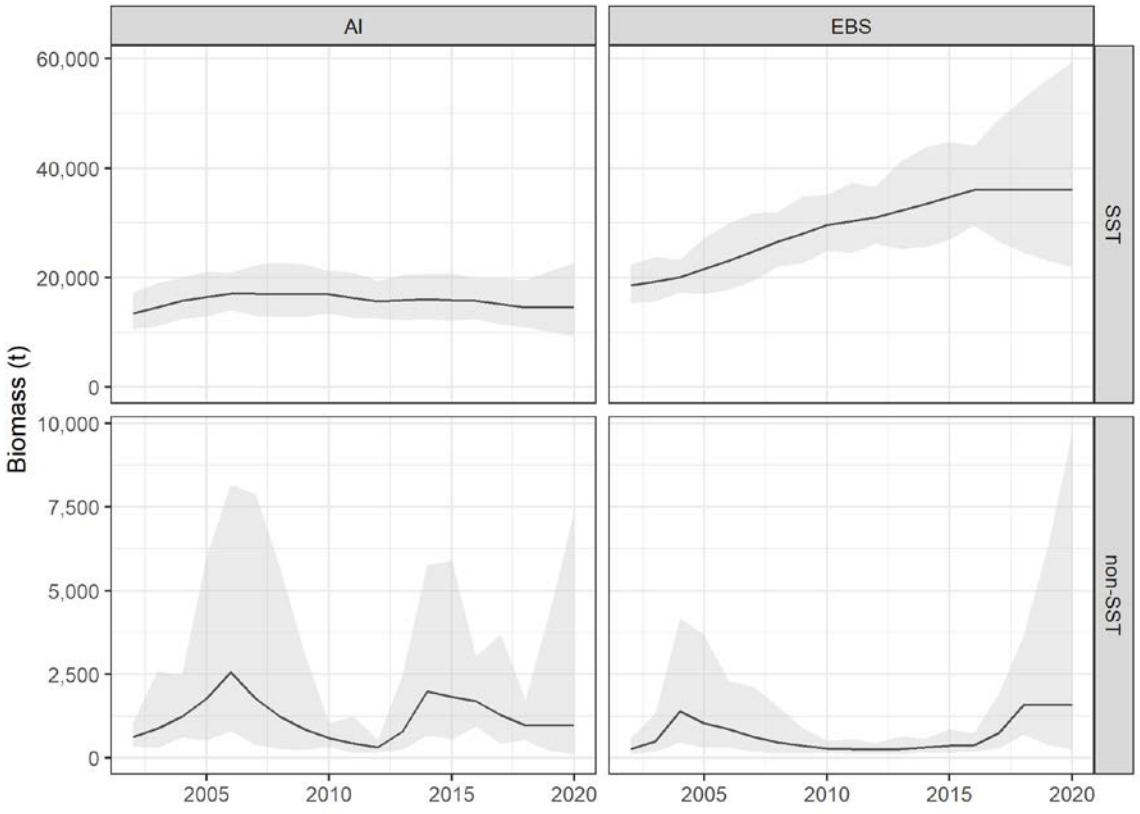

Figure 16.7. Combined biomass estimates (solid black line) with 95% confidence intervals (shaded region) from the random effects models by Aleutian Islands (AI), Eastern Bering Sea (EBS), shortspine thornyhead (SST), and non-SST. Note the difference in *y*-axis scales.

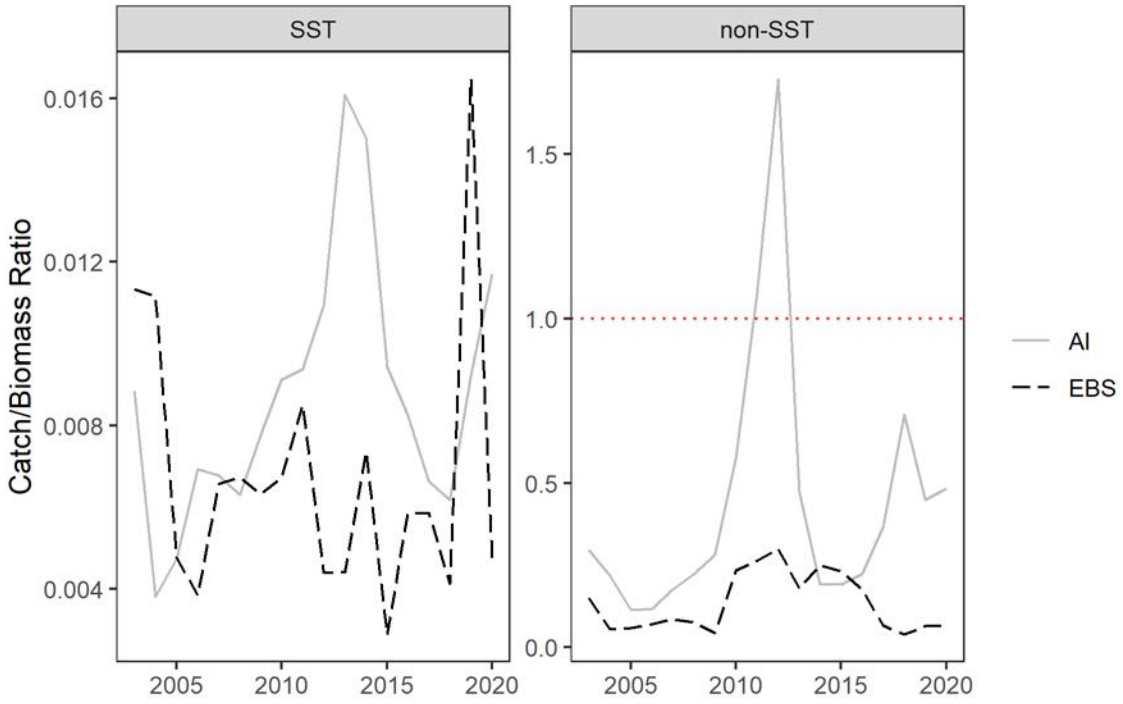

Figure 16.8. Exploitation rates (catch/biomass ratio) for the shortspine thornyhead (SST) and non-SST components of the Other Rockfish complex in the Aleutian Islands (AI) and the Eastern Bering Sea (EBS). The red dotted line highlights the point beyond which catch exceeds estimated biomass. Catch data for 2003-2020 is from the NMFS AKRO Catch Accounting System, AKFIN database, accessed October 13, 2020. Note the difference in *y*-axis scales.

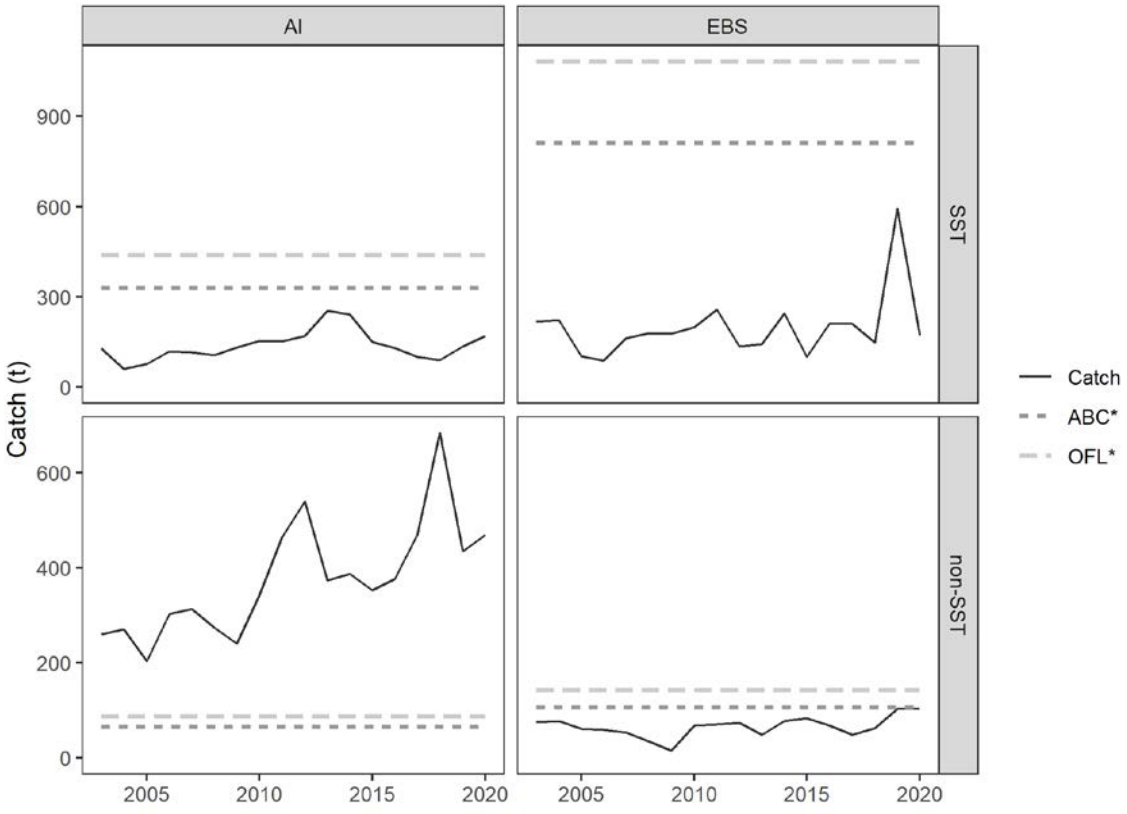

Figure 16.9. A comparison of observed catch relative to OFLs and ABCs if they were specified by species/species group and area for shortspine thornyhead (SST) and non-SST components of the Other Rockfish complex in the Aleutian Islands (AI) and the Eastern Bering Sea (EBS). Currently, a single OFL is specified for all Other Rockfish (SST and non-SST combined). The Other Rockfish ABC is apportioned to the AI and EBS.

Table A1.1. Removals from sources other than those included in the Alaska Region's official estimate of catch (e.g., removals due to scientific surveys, subsistence fishing, recreational fishing, fisheries managed under other FMPs) from the Alaska Department of Fish and Game (ADFG), International Pacific Halibut Commission (IPHC), and National Marine Fisheries Service (NMFS). Source: NMFS AKRO Catch Accounting System, AKFIN database, accessed October 19, 2020. Data for the current year are not yet available.

	Agency			
Year	ADFG	IPHC	NMFS	Total (t)
2004			1.5	1.5
2005			1.4	1.4
2006			1.7	1.7
2007			1.8	1.8
2008			1.5	1.5
2009			2	2.0
2010	0	0.7	12.8	13.5
2011	0	0.3	23.1	23.4
2012	0	0.3	9.9	10.2
2013	0.1	0.8	3	3.9
2014	0	0.8	4.8	5.6
2015	0.2	0.9	2.9	4.0
2016	0.1	0.3	12	12.4
2017	0.1	2.5	3	5.6
2018	0.4	0.4	4.4	5.0
2019	0.6	1.2	2.2	4.0
Average	0.2	0.8	5.5	6.1