11. Assessment of the Shortraker Rockfish Stock in the Gulf of Alaska

Katy B. Echave, Kevin A. Siwicke, Peter-John F. Hulson, Ellen Yasumiishi, and Bridget Ferriss
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Executive Summary

Gulf of Alaska rockfish have historically been assessed on a biennial schedule to coincide with the availability of new trawl survey data (odd years). In 2017, the Alaska Fisheries Science Center (AFSC) participated in a stock assessment prioritization process. It was recommended that the Gulf of Alaska (GOA) shortraker rockfish remain on a biennial stock assessment schedule with a full stock assessment produced in odd years and no stock assessment produced in even years.

For this on-cycle year, we incorporate new Relative Population Weights (RPWs) from the 2020 and 2021 AFSC longline surveys, incorporate new survey biomass from the 2021 bottom trawl survey, and update auxiliary data sources.

This stock is classified as a Tier 5 stock. We continue to use a random effects (RE) model fit to the AFSC longline survey RPW index (1992-2021) and the AFSC bottom trawl survey biomass index (1984-2021) to estimate exploitable biomass and determine the recommended ABC. The RE model was fit to the time series of trawl survey biomass and longline survey RPW indices (with associated estimates of uncertainty) by region (western, central, and eastern GOA). These regional biomass estimates from the RE model were then summed to obtain total GOA biomass.

Summary of Changes in Assessment Inputs

Changes in the input data: Updated input data to the RE model included 2021 GOA bottom trawl survey biomass and 2020 and 2021 longline survey RPWs, with associated uncertainties. Data that were added and updated within this document were total catch through 2020 and partial catch for 2021 (through 3 October 2021), length compositions from the 2020 and 2021 longline and trawl fisheries, length composition from the 2021 GOA bottom trawl survey, length compositions from the 1992-2021 longline survey, and Relative Population Numbers (RPNs) from the 2020 and 2021 longline survey.

Changes in the assessment methodology:
There were no changes in the assessment methodology, the RE model used in this assessment is the same model that was accepted for the 2019 assessment.

Summary of Results

For the 2022 fishery, we recommend the maximum allowable ABC of 705 t for shortraker rockfish. This ABC is similar to the 2020 ABC of 708 t. The OFL is 940 t. Reference values for shortraker rockfish are summarized in the following table, with the recommended ABC and OFL values in bold. The stock was not being subjected to overfishing in 2020.

Quantity	As estimated or *specified last* year for: 2021	2022	As estimated or *recommended this* year for: 2022	2023
M (natural mortality rate)	0.03	0.03	0.03	0.03
Tier	5	5	5	5
Biomass (t)	31,465	31,465	31,331	31,331
F_{OFL}	F=M=0.03	F=M=0.03	F=M=0.03	F=M=0.03
$maxF_{ABC}$	0.75M=0.0225	0.75M=0.0225	0.75M=0.0225	0.75M=0.0225
F_{ABC}	0.0225	0.0225	0.0225	0.0225
OFL (t)	944	944	**940**	940
maxABC (t)	708	708	705	705
ABC (t)	708	708	**705**	705
Status	As determined *last* year for: 2019	2020	As determined *this* year for: 2020	2021
Overfishing	No	n/a	No	n/a

Updated catch data (t) for shortraker rockfish in the GOA as of October 3, 2021 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org) are summarized in the following table.

Year	Western	Central	Eastern	GOA Total	GOA ABC	GOA TAC
2020	6	186	299	492	708	708
2021	5	164	248	417	708	708

Area Apportionment

For apportionment of ABC/OFL, the random effects model was fit to area-specific biomass and subsequent proportions of biomass by area were calculated. The following table shows the recommended apportionment, estimated biomass, and ABC value by regulatory area for 2022.

	Regulatory area			
	Western	Central	Eastern	Total
Area Apportionment	7.3%	39.7%	53%	
Estimated Area Biomass (t)	2,287	12,438	16,606	31,331
Area ABC (t)	51	280	374	705
OFL (t)				940

Summaries for Plan Team

All values are in tons.

Species	Year	Biomass	OFL	ABC	TAC	Catch[1]
Shortraker rockfish	2020	31,465	944	708	708	492
	2021	31,465	944	708	708	417
	2022	31,331	940	705	705	
	2022	31,331	940	705	705	

Stock/		2021				2022		2023	
Assemblage	Area	OFL	ABC	TAC	Catch[1]	OFL	ABC	OFL	ABC
Shortraker rockfish	W		52	52	5		51		51
	C		284	284	164		280		280
	E		372	372	248		374		374
	Total	944	708	708	417	940	705	940	705

[1]Current as of October 3, 2021. Source: NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database (http://www.akfin.org).

Responses to SSC and Plan Team Comments on Assessments in General

The SSC agreed with the JGPT recommendation that Risk Tables should not be mandatory for Tiers 4-6; however, stock assessments must include compelling rationale for why a Risk Table would not be informative. (SSC, October 2021)
We continue to include the risk table in the current assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC requests the authors provide a time series of the longline survey length compositions for comparison with the trawl survey time series currently in the assessment. (SSC, December 2019)
We present a time series of both the longline survey and trawl survey length compositions for comparison.

In addition, the SSC requests the authors provide the regional catchability coefficients used in the assessment. (SSC, December 2019)
We provide a table of the regional catchability coefficients used in the random effects model (19.2a) to estimate exploitable biomass in the Parameter Estimates section. We will also note that to avoid confusion we will stop using the term 'catchability coefficient' but rather use the term 'scaling coefficient'. This is because the estimated coefficient simply scales biomass to RPW and isn't the same as what we normally refer to as 'catchability' in the survey sampling or Tier 3 assessment sense.

The SSC requests further clarification on the justification of the weightings used in the assessment. To the extent feasible, the authors should concisely describe differences in the type of information that each survey index provides about regional components of the shortraker population, and whether this is informative to the weighting of indices. (SSC, December 2019)
By region, the estimated uncertainty in the longline survey RPW index is consistently smaller than the uncertainty in the bottom trawl survey biomass. The ratio of coefficient of variation (CV) of the longline survey RPW compared to the bottom trawl survey biomass is 0.8 in the western and central GOA, and 0.5 in the eastern GOA, indicating that we estimate the RPW index to be more precise on average than the bottom trawl survey. However, as we note when describing these data

sources they both suffer from sampling error that makes it difficult to consider one source to be more accurate or reliable than the other when determining the population size of shortraker rockfish. By reducing the weight of the longline survey to 0.5 what the model is inherently doing is equalizing the relative contribution of these two indices to the model estimates. By means of comparison, the relative CVs between biomass and RPWs is much more similar for shortspine thornyheads, the other Tier 5 assessment that uses these two indices. Granted, we recognize that the choice of 0.5 is subjective, but with this relative weighting we noted in the 2019 assessment that the model is slightly more responsive to the bottom trawl survey biomass index, although, these differences in estimates between a weight of 1 or 0.5 for the longline survey was small. We will also note that in the October 2021 SSC minutes it was recommended that a working group be formed to develop standard practices for data weighting. We will closely monitor the progress of this working group and implement any pertinent recommendations into this assessment.

Additionally, the SSC looks forward to continued exploration of alternative apportionment methods and believes this should remain a high priority. (SSC, December 2019)
We agree with this comment and will continue exploration of alternative apportionment methods.

The SSC notes the large increase in the 2019 exploitation rate for the hook and line fleet in the Western GOA, which is over triple than what occurred in 2018. The SSC highlights that new regulations will require full retention of rockfish for hook and line fisheries in the GOA, and important impacts from this regulatory change should be considered in the next full assessment. (SSC, December 2019)
We continue to monitor exploitation and discard rates. While exploitation rates have decreased significantly in the western GOA, discard rates continue to remain high, particularly in the sablefish fleet. The reasons behind these increases, particularly following new regulations requiring full retention of rockfish by HAL catcher vessels, is unknown and will continue to be explored.

Introduction

General Distribution

Shortraker rockfish, *Sebastes borealis*, range from Hokkaido Island, Japan, north into the Sea of Okhotsk and the Bering Sea, and through the Aleutian Islands and Gulf of Alaska south to southern California. The center of abundance for this species appears to be in Alaskan waters. In the GOA, adults of this species inhabit a narrow band along the upper continental slope at depths of 300-500 m; outside of this depth interval, abundance decreases considerably (Ito 1999). Much of this habitat is steep and difficult to trawl in the GOA, and observations from a manned submersible also indicated that shortraker rockfish seemed to prefer steep slopes with frequent boulders (Krieger and Ito 1999). Adult shortraker rockfish may also be associated with *Primnoa* spp. corals that are used for shelter (Krieger and Wing 2002). Research focusing on non-trawlable habitats found rockfish species often associate with biogenic structure (Du Preez and Tunnicliffe 2011, Laman *et al*. 2015), and that shortraker rockfish are often found in both trawlable and untrawlable habitats (Rooper and Martin 2012, Rooper *et al*. 2012). Several of these studies are notable as results indicate adult shortraker biomass may be underestimated by traditional bottom trawl surveys because of issues with extrapolating survey catch estimates to untrawlable habitat (Jones *et al*. 2012, Rooper *et al*. 2012).

Life History Information

Life history information on shortraker rockfish is extremely sparse. The fish are presumed to be viviparous, as are other *Sebastes* spp. (Mecklenburg *et al.* 2002), with internal fertilization and development of embryos, and with the embryos receiving at least some maternal nourishment. There have been no fecundity studies on shortraker rockfish. One study on reproductive biology of the fish in the northeastern Pacific (most samples were from the GOA) indicated they had a protracted reproductive period, and that parturition (larval release) may take place from February through August (McDermott 1994). Another study indicated the peak month of parturition in Southeast Alaska was April (Westrheim 1975). Most recently, the reproductive development stage of shortraker rockfish was examined from samples collected opportunistically in the GOA throughout the year in 2008-2014 (Conrath 2017). Similar to McDermott's (1994) findings, shortraker rockfish were found to be seasonal synchronous spawners, with the onset of development occurring in the late summer months and parturition taking place from March through May. There is no information on when males inseminate females or if migrations occur for spawning/breeding. Genetic techniques have been used to identify a small number of post-larval shortraker rockfish from samples collected in epipelagic waters far offshore in the GOA, which is the only documentation of habitat for this life stage (Kondzela *et al*. 2007). No data exist on when juvenile fish become demersal in the GOA; in fact, few specimens of juvenile shortraker rockfish <35-cm fork length have ever been caught in this region, so information on this life stage is virtually absent. Off Kamchatka, juvenile shortraker are reported to become demersal starting at a length of about 10 cm (Orlov 2001). Orlov (2001) has also suggested that shortraker rockfish may undergo extensive migrations in the north Pacific. In his theory, which is mostly based on size compositions of shortraker rockfish in various regions, larvae/post-larvae of this species are transported by currents from the GOA to nursery areas in the Aleutian Islands, where they grow and subsequently migrate back to the GOA as young adults. More research is needed to substantiate this scenario. As mentioned previously, adults are particularly concentrated in a narrow band along the 300-500 m depth interval of the continental slope. Within the slope habitat, shortraker rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch (POP, *Sebastes alutus*; Clausen and Fujioka 2007). Shortraker rockfish attain the largest size of all *Sebastes* spp., with a maximum reported total length of 120 cm (Mecklenburg *et al*. 2002).

Evidence of Stock Structure

The stock structure of the GOA shortraker rockfish was examined and presented to the GOA Groundfish Plan Team in November 2016 (Echave *et al.* 2016). There are few data available to differentiate stocks across regions, and with such little information on growth and reproduction, what is available is insufficient for evaluating comparisons within the spatial extent of the species. The limited genetic information available have indicated evidence of stock structure in the GOA (Gharrett *et al.* 2003; Matala *et al*. 2004), but additional research is needed to better define this structure. Although not conclusive, the genetic studies do not support Orlov's theory of extensive migrations for shortraker rockfish. Please see Appendix 11.A of the 2016 GOA shortraker rockfish assessment for a more thorough evaluation of the potential stock structure for GOA shortraker rockfish (Echave *et al.* 2016).

Fishery

Fishery History

Throughout the 1991-2004 period during which shortraker/rougheye rockfish existed as a management category in the GOA, directed fishing was not allowed, and the fish could only be retained as an "incidentally-caught" species. This incidental catch status has continued for shortraker rockfish since it became a separate category in 2005. In the years since 2005, shortraker rockfish have been taken mostly in fisheries targeting rockfish, sablefish, *Anoplopoma fimbria,* and Pacific halibut, *Hippoglossus stenolepis,* with lesser amounts taken in the walleye Pollock, *Gadus chalcogrammus,* and other groundfish fisheries (Table 11-1). In 2021, the percentage of shortraker catch taken in rockfish directed fisheries reached a time-series high (58%, Table 11-1).

Shortraker rockfish can be caught with both trawls and longlines. The percent caught in each gear type is listed in the Table 11-1 for the years 2005-2021. Since 2005, shortraker catch has generally been caught in equal amounts on both trawl (pelagic and nonpelagic combined but the majority are caught by nonpelagic trawl) and longline gear, with the exception of 2010, 2011, 2016, and 2018. A higher percentage (62.3%) of total shortraker catch was taken in trawl gear in 2021 (Table 11-1).

Nearly all of the longline catch of shortraker rockfish appears to have come as "true" incidental catch in the sablefish or halibut longline fisheries. Historically, some of the shortraker catch in rockfish trawl fisheries was taken by actual targeting that some fishermen called "topping off" (Ackley and Heifetz 2001). "Topping off" worked in this way: fishery managers assign all vessels in a directed fishery a maximum retainable amount (MRA) for certain species that may be encountered as incidental catch. If a vessel manages to not catch its MRA during the course of a directed fishing trip, or the MRA is set overly high (as data presented in Ackley and Heifetz [2001] suggest), before returning to port the vessel may be able to make some target hauls on the incidental species and still not exceed its MRA. Such instances of "topping off" for shortraker rockfish appeared to have taken place in the POP, trawl fishery. Fisherman may have been motivated to "top off" because shortraker rockfish is the most valuable trawl-caught *Sebastes* spp. in terms of landed price. However, this practice is generally no longer thought to occur, and all shortraker catch is truly incidental.

In 2007, the Central GOA Rockfish Pilot Program was initiated to enhance resource conservation and improve economic efficiency for harvesters and processors who participate in the Central GOA rockfish fishery. In 2012 this pilot program was permanently put into place as the Central GOA Rockfish Program. This is a rationalization program that established cooperatives among trawl vessels that receive exclusive harvest privileges for rockfish management groups (for details, see North Pacific Fishery Management Council, 2008). The primary rockfish management groups for the program are POP, northern rockfish, *Sebastes polyspinis,* and pelagic shelf rockfish, but there is a small allocation for shortraker rockfish. Catches of shortraker rockfish taken by trawlers in the Central GOA decreased in 2007 (North Pacific

Fishery Management Council 2008), and the catches have remained relatively low in the Central GOA in subsequent years with the exception of 2016 and 2018. Other effects of the pilot program include: 1) mandatory at-sea and plant observer coverage for vessels participating in the program, which has greatly improved catch data for rockfish in the Central GOA; and 2) extending the fishery season when most trawl-caught shortraker rockfish are taken. Previously, most shortrakers were taken as incidental catch during the directed "derby-style" trawl fisheries for POP, northern rockfish, and pelagic shelf rockfish, which mostly occurred during July. In the Central GOA Rockfish Program, trawling can occur anytime between May 1 and November 15, and catches are now spread over this period.

Management Measures and History

The NPFMC established shortraker rockfish as a separate management category in the GOA in 2005. Previously, shortraker rockfish had been grouped from 1991 to 2004 with rougheye rockfish, *Sebastes aleutianus,* in the "shortraker/rougheye" management category because the two species are similar in appearance, share the same habitat on the upper continental slope, and often co-occur in hauls. Both species were assigned a single overall ABC (acceptable biological catch) and TAC (total allowable catch), and fishermen were free to harvest either species within this TAC. However, evidence from the NMFS Alaska Groundfish Observer Program indicated that shortraker rockfish were being harvested disproportionately within the shortraker/rougheye group, which raised the possibility that shortraker could become overexploited (Clausen 2004). Because of this concern, the NPFMC decided to establish separate management categories for shortraker and rougheye rockfish starting with the 2005 fishing season.

From 2005 to 2010, the assessment for shortraker rockfish was combined with that for another management group of rockfish in the GOA, "other slope rockfish." Although shortraker rockfish and "other slope rockfish" were distinct management entities, their assessments were presented in a single SAFE chapter because each group was assessed using a similar methodology based on the NPFMC's "tier 5" definition of overfishing. However, in 2010 both the GOA Groundfish Plan Team and the NPFMC SSC recommended that future assessments for shortraker rockfish and "other slope rockfish" be presented in separate SAFE chapters.

In practice, the NPFMC apportions the ABCs and TACs for shortraker rockfish in the GOA into three geographic management areas: the Western, Central, and Eastern GOA. This apportionment is to disperse the catch across the GOA and prevent possible depletion in one area.

A timeline of management measures that have affected shortraker rockfish, along with the corresponding GOA annual catch and ABC/TAC/OFL levels are listed Table 11-2.

Catch History

Official fishery catch statistics for shortraker rockfish in the GOA are only available for 2005-2021, when the species catch was first reported separately for management purposes (Table 11-3). However, catch statistics are available for shortraker and rougheye rockfish combined for the years 1991-2004, when both species were classified together into one management group, and these are also listed in Table 11-3. Previous to 1991, shortraker rockfish was classified into larger management groups that included POP and other *Sebastes* spp., and it is generally not possible to separate out the shortraker catches.

Although official catch statistics for shortraker rockfish started in 2005, unofficial estimates of the GOA catch of shortraker rockfish were computed in Clausen (2004) for the years 1993-2003 (Table 11- 4). The estimates are based on a combination of data from the observer program and the NMFS Alaska regional office, and they take into account differences in catch by area and gear type. The estimates indicate that annual shortraker catch was generally around 1,000-1,500 t during these years. Annual TACs for the shortraker/rougheye group were the major determining factor of these catch amounts. The total GOA catch of shortraker/rougheye for a given year was generally very similar to the corresponding TAC (Table

11-3). The 2005-2021 shortraker rockfish official catches have been consistently lower than any of the unofficial estimates in previous years. These low catches in the last sixteen years correspond to the years when shortraker rockfish has been in its own management category separate from rougheye rockfish.

Catch of shortraker rockfish varies greatly by area, gear type, and year, but has trended downward in the last two years (Figure 11-1). Before the prohibition of trawling east of 140°W longitude in the eastern GOA in 1999, shortraker rockfish were predominately caught in trawl gear (average 67% of catch). Note that for 1993-2004, information on catch by gear is only available for the shortraker/rougheye category and not for shortraker alone. Since 1999, trawl and longline gear have generally each comprised about half the annual catch in the GOA; however, the dominant gear type for shortraker catch varies significantly by region. Since 2010, the majority of shortraker catch in the central GOA has been in nonpelagic trawl gear (Figure 11-2), while the amount of shortraker catch with longline gear has decreased significantly since 2018. This can likely be attributed to the increased use of traditional pots and collapsible slinky pots by the sablefish fleet in this area. While shortraker rockfish are generally caught in trawl gear in the rockfish fishery, the recent spike in the central GOA in 2016 was the result of the anomalously large amount of shortraker catch in the pollock fishery (Table 11-5). Historically, shortraker rockfish have predominantly been caught in longline gear in both the western and eastern GOA, but in recent years, shortraker catch in longline gear has decreased and catch has been similar in both gear types (Figure 11-2). Again, this trend can likely be attributed to increased use of pot and slinky pot gear. In the western GOA, shortrakers have been caught in equal amount in both gear types since 2020 (Figure 11-2).

Exploitation rates of shortraker rockfish also vary annually by area and gear type, but in recent years have generally been low and relatively stable within the trawl fisheries, and trending downward in the hook and line fleet (Figure 11-3). Exploitation rates in 2021 decreased or remained stable in all areas and for all gear types (Figure 11-3).

Survey research catches of shortraker rockfish are a very small component of overall removals and recreational and other catches are assumed negligible. Non-commercial (research and sport) catches of shortraker rockfish are reported and discussed in Appendix 11A.

Bycatch

The only analysis of bycatch in shortraker/rougheye rockfish fisheries of the GOA is that of Ackley and Heifetz (2001), in which they examined data for 1994-1996. In the hauls identified as targeting shortraker/rougheye (most of which were presumably “topping off” hauls as described previously), the major bycatch was arrowtooth flounder, sablefish, and shortspine thornyhead, in descending order by weight (Ackley and Heifetz 2001).

Discards

Discard rates of shortraker rockfish are higher than those for the three species of *Sebastes* in the GOA that have directed fisheries, (POP, northern rockfish, and dusky rockfish, *Sebastes ciliates)*, but are less than the "Other rockfish" management category in this region (see chapters in this SAFE report for POP, northern rockfish, dusky rockfish, and other rockfish). The GOA total discard rate for shortraker rockfish increased for the first time in 2021 (rate of 32.9%) since reaching a historical high of 53.8% in 2018 (Table 11-5). The 2021 discard rate is similar to the time series mean (33%). In addition, discard rates continue to be disproportionate between gear types. For example, the 2021 GOA discard rate is, on average, ~17% in the trawl rockfish fisheries and ~63% in the hook and line sablefish fishery (Table 11-5). The increased discard rate in 2021, as well as the continued disproportionate discard rate in the sablefish fleet is unexpected, as full retention of rockfish by catcher vessels using pot, hook-and-line, and jig gear while fishing for groundfish or halibut is now required as of March 23, 2020 per Amendment 107 to the Fishery Management Plan for Groundfish of the Gulf of Alaska (https://www.fisheries.noaa.gov/action/amendment-119-fmp-groundfish-bering-sea-and-aleutian-islands-and-amendment-107-fmp).

Discard rates for fixed gear under full retention mandates are higher than expected, and an overall review has not yet been conducted on how well this new regulation was implemented. Alaska Regional Office staff comment that changes such as these take time and outreach to educate the fleet, so discarding remains common. Additionally, the estimate of the amount of catch that is discarded at sea for each species encountered in the haul is based on the observer's best professional judgment, and is challenging because it can occur at many places in a fishing and processing operation (Cahalan et al. 2010). These estimates are then applied to the unobserved fleet, and if data is limited or based on a small number of hauls with large catch, these numbers have the potential of being extrapolated to inaccurate values (M. Furuness, pers. comm.). These methods and extrapolations apply to observed data collected via electronic monitoring (EM) as well. As of 13 October 2021, 31 mt of discards were from GOA hook-and-line catcher vessels (CVs) and 64 mt were from hook-and-line catcher processors (CPs; M. Furuness, pers. comm. AKRO CAS). The CPs aren't in the full retention regulations like the CVs, and may be discarding to not exceed the maximum retainable amounts.

Data

Fishery Data

Catch

Detailed catch information for shortraker/rougheye and shortraker rockfish is listed in Table 11-3.

Size and Age Composition

While the number of lengths sampled by observers for shortraker rockfish in the GOA commercial fishery are few, we are able to use available data to compare length frequencies by gear type (Figure 11- 4). Unimodal length frequency distributions and average length caught are similar between both gear types in the commercial fishery: the average length of shortraker caught in the longline fishery is 57.6 cm, and 59.3 cm in the nonpelagic trawl fishery. Few age samples for this species have been collected from the fishery, and none have been aged.

Survey Data

Longline Surveys in the Gulf of Alaska

Two longline surveys of the continental slope of the GOA have provided data on the relative abundance of shortraker rockfish: the Japan-U.S. cooperative longline survey (1979-1994) and the Alaska Fisheries

Science Center (AFSC) longline survey (1988-present). Data from these surveys are used to compute relative population numbers (RPNs) and relative population weights (RPWs) for use as indices of stock abundance. The surveys were primarily designed to sample sablefish but also catch considerable numbers of shortraker rockfish. Rockfish catch rates should be viewed with some caution, however, as the RPNs and RPWs do not take into account possible effects of competition for hooks with other species, especially sablefish. An analysis of survey data indicated there was a negative correlation between catch rates of sablefish and shortraker rockfish in the GOA, and there was likely competition for hooks between species (Rodgveller *et al*. 2008). The study concluded that further research was needed to better quantify the effects of hook competition and to compute adjustment factors for the surveys' catch rates. Another study compared longline survey catch rates of shortraker and rougheye rockfish with observed densities of fish around the longline from a manned submersible (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 was needed to better determine the suitability of using longline survey results for assessment of this species.

The Japan-US cooperative longline survey was conducted annually during 1979-94, but RPNs for rockfish are only available for the years 1979-87 (Sasaki and Teshima 1988). These data are highly variable and difficult to interpret, but suggest that abundance of shortraker rockfish remained stable in the GOA (Clausen and Heifetz 1989). The data also indicate that shortraker rockfish are most abundant in the eastern GOA.

The AFSC longline survey has been conducted annually since 1988, and RPNs and RPWs have been computed each year (Table 11-6). For shortraker rockfish, GOA RPNs have ranged from a low of ~10,133 in 1992 to a high of ~27,319 in 2000 (Table 11-6). Meaningful trends in these data over the years are difficult to discern, and GOA RPNs and RPWs can fluctuate considerably between adjacent years. For example, the RPW in 2009 was 35,621 t, dropped to 22,861 t in 2010, and increased to 32,256 t in 2011. Some of the fluctuations may be related to hook competition among species, but it may also indicate substantial sampling error, similar to what occurs in the bottom trawl survey. The 2021 longline survey RPW for shortraker rockfish is up 29% from 2020 (Figure 11-5), which is slightly above the historical average.

Similar to the Japan-US cooperative longline survey, the AFSC longline survey results show that abundance of shortraker rockfish is highest in the eastern GOA; the Yakutat area consistently has the greatest RPN and RPW values for shortraker rockfish (Figure 11-6).

Longline Survey Size Compositions

Size compositions for shortraker rockfish from the 1992-2021 AFSC longline surveys were all unimodal with a relatively constant mean length (Figure 11-7). The AFSC longline survey has a long term average fork length of 60.8 cm (Figure 11-8). The 2021 longline survey mean fork length (63.4 cm) has increased slightly from 2020 (62.0 cm) and is larger than the average length caught in the 2021 observed hook and line fishery (55.2 cm).

AFSC Trawl Survey Biomass Estimates

Bottom trawl surveys were conducted on a triennial basis in the GOA in 1984 through 1999, and these surveys became biennial starting in 2001 (Table 11-7). The surveys provide much information on shortraker rockfish, including estimates of absolute abundance (biomass) and population length compositions. The trawl surveys have covered all areas of the GOA out to a depth of 500 m (in some surveys to 1,000 m), but the 2001 survey did not sample the eastern GOA. The random effects model is fit by region, which is able to compensate for the missing eastern GOA survey in 2001. This model is also able to compensate for depth strata that were not sampled by the bottom trawl survey (e.g., Hulson et al.

2021), however, the majority of biomass for shortraker occurs at depths less than 500 m, so we do not account for the missing depth strata in this assessment. Also, the 1984 and 1987 survey results should be treated with some caution. A different, non-standard survey design was used in the eastern GOA in 1984; furthermore, much of the survey effort in the western and central GOA in 1984 and 1987 was by Japanese vessels that used a very different net design than what has been the standard used by U.S. vessels throughout the surveys. To deal with this latter problem, fishing power comparisons of rockfish catches have been done for the various vessels used in the surveys (for a discussion see Heifetz et al. 1994). Results of these comparisons have been incorporated into the biomass estimates discussed here, and the estimates are believed to be the best available. Even so, the reader should be aware that an element of uncertainty exists as to the standardization of the 1984 and 1987 surveys.

Total GOA biomass estimates for shortraker rockfish have sometimes shown rather large fluctuations between surveys; for example, biomass was 62,317 t in 2015, decreased by 49% to 31,534 t in 2017, increased 42% to 44,773 t in 2019, and decreased again by 39% to 27,182 t in 2021 (Table 11-7). However, the confidence intervals have usually overlapped (Table 11-7 and Figure 11-9). In 2021, all GOA areas show a decrease in biomass with the exception of an increase in the Shumagin area (WGOA) (Table 11-7). This is the opposite of what was seen in 2019, in which all GOA areas increased in biomass with the exception of Shumagin and a small decrease in Kodiak (Table 11-7).

Spatial distribution of catches of shortraker rockfish in the last three GOA trawl surveys indicate the fish are rather evenly spread in a band along the continental slope (Figure 11-6). The 2021 survey continues the trend seen in 2019 and 2017 with fewer large catches but an increase in near shore catch of shortraker rockfish (Figure 11-6). In the Yakutat area in 2013, there was a very large catch of over 1,900 kg in a single haul, and again in 2015 there was a single haul of over 1,200 kg in the Yakutat area and over 1,110 kg in the Southeast area. In contrast, the largest haul in 2021 was 430 kg in the Yakutat Area, and the second highest was 177 kg in the Kodiak Area. This absence of large catches in 2021 are responsible at least in part for the narrow confidence bounds of the 2021 biomass estimate and the lowered coefficient of variation (CV) of 21.5%. Compared with many other *Sebastes* spp., the biomass estimates for shortraker rockfish have historically shown relatively moderate confidence intervals and low CVs (compare CVs for shortraker in Table 11-7 vs. those for sharpchin, *S. zacentrus*, redstripe, *S. proriger*, harlequin, *S. variegatus*, and silvergray, *S. brevispinis***,** rockfish in the “Other Rockfish” chapter of this SAFE report). The low CVs are an indication of the generally even distribution of shortraker rockfish that was noted in the introduction of this chapter.

Despite the relative precision of the biomass estimates historically, assessment authors have been uncertain whether the trawl surveys are accurately assessing abundance of shortraker rockfish. Nearly all the catch of these fish is found on the upper continental slope at depths of 300-500 m. Much of this area in the GOA is not trawlable by the survey’s gear because of the area’s steep and rocky bottom, except for gully entrances where the bottom is more gradual. Consequently, biomass estimates for shortraker rockfish are mostly based on the relatively few hauls in gully entrances, and are variable when estimating abundance or abundance trends. One possible problem in the trawl survey results can be seen when longline survey RPWs for shortraker rockfish are compared with corresponding statistical area biomass estimates from trawl surveys. Historically, the longline survey has consistently indicated that shortraker rockfish are most abundant in the Yakutat area, and catches in this area often comprise >50% of the GOA RPW for this species. In contrast, the trawl survey results by area have been much more variable, and the Yakutat area, with few exceptions, has never stood out as a particular area of high abundance. This example highlights the differences between the ability of the trawl survey and longline survey to sample and assess abundance of shortraker rockfish. Although, as we note above, the longline survey also can have a large amount of sampling error for shortraker rockfish.

Trawl Survey Size Compositions

Size compositions for shortraker rockfish from the 1990-2007 and 2011-2021 trawl surveys were all unimodal, with almost no fish < 35 cm in length (Figure 11-7). However, results from the 2009 trawl survey were different because there was a modest catch of small fish that ranged in size between 10 and 35 cm long. The reason these small fish occurred in 2009, and not in the other surveys, is unknown. The 2001 results may be biased by the fact that they do not include fish from the eastern GOA because this area was not sampled that year. Shortraker rockfish are generally larger in the eastern GOA (e.g., Martin and Clausen 1995; Martin 1997; von Szalay et al. 2008 and 2010) and the 2001 survey seems to be missing many fish >70 cm in length compared to the other surveys. Based on trawl survey samples the mean length of the shortraker rockfish population in the GOA progressively declined from 61.2 cm in 1990 to 53.9 cm in 2003, followed by increases in 2005, 2007, 2011, 2013, 2015, and 2017 with a mean for the latter year of 62.8 cm. Both the 2019 and 2021 trawl surveys have shown slight decreases in mean length, 61.6 cm and 59 cm respectively. The relatively low mean length in 2009 of 54.7 cm is largely attributable to the fish < 35 cm that were caught that year. Mean length of shortraker rockfish caught on the trawl survey (all years combined; 59.1 cm, Figure 11-8) is similar to the mean length observed in the trawl fishery (nonpelagic trawl all years combined; 59.3 cm, Figure 11-4).

Trawl Survey Age Compositions

Shortraker rockfish have long been considered among the most difficult rockfish species to age. The usual method for determining rockfish ages, i.e., counting annular growth zones on otoliths, did not appear to work because the growth pattern of shortraker otoliths is so unclear. However, Hutchinson (2004) developed a new aging method for this species based on using thin sections of otoliths and on applying an innovative set of aging criteria to determine which growth bands correspond to annuli. A comparison between his results and those of a previous radiometric study of shortraker rockfish age (Kastelle *et al.* 2000) indicated general agreement and provided a limited degree of validation. This new aging methodology was used to determine the age compositions of shortraker rockfish in the 1996, 2003, and 2005 GOA trawl surveys (Figure 11-10). Ages ranged from 5 to 146 years, and the results indicate the shortraker rockfish population in the GOA is quite old (mean age varied between 32 and 44 years, depending on the survey). To provide direct validation of the new aging method, in 2008 a validation study was conducted based on carbon 14 levels in shortraker rockfish otoliths from nuclear bomb testing in the 1960s. Results were unsuccessful, however, because carbon 14 could not be found in sufficient quantities in the otoliths[1]. Thus, alternative validation techniques will be necessary to verify the aging methodology. One possibility is to conduct an updated and more detailed radiometric study than the previously mentioned Kastelle *et al.* (2000) study, which was done before Hutchison (2004) and was somewhat problematic because it was based on using length of the fish as a proxy for age.

Because of the lack of direct validation for the aging method, and the consequent uncertainty about the ages, production aging for shortraker rockfish has now been put on hold. Due to this uncertainty, use of an age-structured model to assess GOA shortraker rockfish is not recommended at present. Although we hope to move to an age-structured assessment at some time in the future, better validation of the shortraker rockfish aging methodology is needed before we do so.

Analytic Approach

General Model Structure

Due to the lack of biological information for shortraker rockfish (especially an absence of validated age data), recent assessments used a biomass-based approach to estimate ABCs. Both trawl and longline

[1] C. Hutchinson, National Marine Fisheries Service, Alaska Fisheries Science Center, REFM Division, 7600 Sand Point Way NE, Seattle WA 98115. Pers. commun. Jan. 2009.

survey data are used to model shortraker biomass. The application of the random effects model (RE) smooths trends in survey estimates. The process errors (step changes) from one year to the next are the random effects that are integrated over, and the process error variance terms are freely estimated. The observations can be irregularly spaced so for years where data are missing estimates can be made, such as the missing 2001 eastern GOA biomass estimate from the bottom trawl survey. Specified survey observation error terms (provided each year) effectively weights the survey estimates and can affect the predictions. We applied Model 19.2a (Echave and Hulson 2019) which incorporates the 1984-2021 GOA trawl survey time series for estimates of biomass and uncertainty, and the 1992–2021 AFSC longline survey RPW index and associated uncertainty. The RE model was fit separately by region to account for missing survey data, and then summed to obtain total GOA biomass. Please see the 2019 Assessment of Shortraker rockfish in the Gulf of Alaska (Echave and Hulson 2019) for further explanation of the model and selection process.

In Model 19.2a, the AFSC longline survey RPW index is added to the random effects model by estimating a scaling coefficient parameter that scales the random effects biomass estimates to the longline survey RPWs. The longline survey RPW index is available with associated uncertainty at the regional scale. The estimate of the longline survey RPW index by region is then given by:

$$\widehat{RPW}_{r,y} = \hat{\alpha}_r e^{\hat{\varepsilon}_{r,y}}$$

where $\widehat{RPW}_{r,y}$ is the estimated regional RPW in year y, $\hat{\alpha}$ is the estimated regional scaling coefficient by region r, and $\hat{\varepsilon}_{r,y}$ are the random effects parameter estimates for region r in year y.

An additional observation error component is then added to the objective function, which is the negative log-likelihood of the model fit to the longline survey RPWs, given by:

$$-lnL_O^L = \lambda_L \sum_Y \frac{1}{2}\left[ln\left(2\pi\sigma^2_{RPW,r,y}\right) + \frac{1}{\sigma^2_{RPW,r,y}}\left(ln\left(\widehat{RPW}_{r,y}\right) - ln\left(RPW_{r,y}\right)\right)^2\right]$$

where $\sigma^2_{RPW,r,y}$ is the regional variance of the longline survey RPW index in year y, $RPW_{r,y}$ is the observed longline survey RPW index by region and year, and λ_L is the weighting coefficient for the longline survey RPW index. We applied a weight of 0.5 to the longline survey RPW index in order to balance the relative contribution of the bottom trawl and longline survey indices.

Thus, the model has three likelihood components: 1) the process error component (which represents the amount of variation across time of the random effects parameters), 2) the bottom trawl survey biomass observation error component, and 3) the longline survey RPW index observation error component. It is through the addition of the observation error component of the longline survey index to the total likelihood that the biomass estimates from the random effects model are sensitive to both the bottom trawl biomass and longline RPW indices.

When adding the longline survey RPW index to the random effects model, the fit to the bottom trawl survey biomass is not as precise. Additionally, the bottom trawl survey has larger uncertainty for shortraker rockfish, so the estimated biomass is less sensitive to the bottom trawl survey biomass index and more influenced by the longline survey RPW. By reducing the relative weight of the longline survey to 0.5, the bottom trawl survey biomass is more responsive while the influence from the longline survey RPW index is maintained (Echave and Hulson 2019). This also has the effect of balancing the relative contributions for both surveys, as the longline survey is more precise than the bottom trawl survey on average and it is unclear which survey provides a more accurate estimate of population abundance, as both surveys suffer from potentially large sampling error. Additionally, the inclusion of regional specific scaling coefficients in the shortraker random effects model improved the model fit to the longline survey regional RPW indices, possibly highlighting the differences between availability of shortraker rockfish to the bottom trawl survey and the longline survey across regions. By including both of these surveys, different habitats and presumably different life history stages of shortraker rockfish are captured. The primary result of including two population indices in the random effects model are that biomass estimates across time are more stable (and subsequent apportionment across regions) and there has been a reduction of over fitting of bottom trawl survey biomass values.

Shortraker rockfish in the GOA are managed under Tier 5, where OFL = M * exploitable 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. M is assumed equal to 0.03 and is discussed further in the following section.

Parameter Estimates

Mortality, Maximum Age, Female Age- and Length-at-50% Maturity:

Estimates of mortality, maximum age, and female age- and size-at-50% maturity for shortraker rockfish are listed as follows:

Mortality rate	Mortality rate method	Maximum age	Age at Maturity	Length at Maturity	Area	References
-	-	120	-	-	BC	1
0.027-0.042	GSI	-	21.4	44.9	WC,GOA,AI,EBS	2,3
-	-	157	-	-	GOA	4
-	-	146	-	-	GOA	5
-	-	-	-	49.9	GOA	6

Area indicates location of study: British Columbia (BC), West Coast of U.S. (WC), Gulf of Alaska (GOA), Aleutians (AI), and eastern Bering Sea (EBS).
GSI: gonad somatic index (Gunderson and Dygert (1988).
References: 1) Chilton and Beamish 1982; 2) McDermott 1994: 3) Hutchinson 2004; 4) Munk 2001; 5) this report; 6) Conrath 2017.

The two values for maximum age of shortraker rockfish in the GOA (146 and 157), if true, would make this species one of the longest-lived fishes. McDermott (1994) determined that length-at-50% maturity for female shortraker rockfish was 44.9 cm based on samples collected in several regions of the northeast Pacific, including the GOA, while Conrath's (2017) more recent study based on specimens collected solely from the GOA was slightly larger, at 49.9 cm. Hutchinson's (2004) experimental aging study of shortraker rockfish computed von Bertalanffy growth parameters for females, and he used these parameters to convert McDermott's length-of-maturity to an age-of-50% maturity of 21.4 years. Because it was based on experimental aging, however, and was also determined indirectly, the estimate needs to be confirmed by additional study.

When the shortraker/rougheye category was created in 1991, there was no estimate at that time of M or Z for shortraker rockfish. Therefore, the SSC suggested the following computation for a proxy estimate of M: use the ratio of maximum age of rougheye to shortraker (140/120) from British Columbia and then multiply this value by the mid-point of the range of Z for rougheye rockfish in British Columbia (mid-point = 0.025) to yield an M of 0.03 for shortraker rockfish. In a later study, M for shortraker rockfish was estimated to range between 0.027 and 0.042 (McDermott 1994), so the original estimate of 0.03 for M seems reasonable.

Length- and Weight-at-Age:

Length-weight coefficients and von Bertalanffy parameters for shortraker rockfish are listed below. Length-weight coefficients are from the formula $W = aL^b$ where W = weight in kg and L = length in cm (based on data from the 1996 GOA trawl survey in Martin 1997):

Sex	a	b	# sampled
combined	9.85×10^{-6}	3.13	620
males	1.26×10^{-5}	3.07	302
females	1.02×10^{-5}	3.12	318

Von Bertalanffy parameters for shortraker rockfish (GOA = Gulf of Alaska; AI = Aleutian Islands: EBS = Eastern Bering Sea):

Area	Sex	t_0	K	L_{inf} (cm)
GOA/AI/EBS	female	-3.62	0.030	84.60

The von Bertalanffy parameters are based on the previously discussed Hutchinson (2004) study which has been only partially validated, so they should be used with caution. Although the analysis combined samples from the GOA, Aleutian Islands, and eastern Bering Sea, most were from the GOA.

Regional Biomass to RPW scaling Coefficients used in the Random Effects Model:

The following are the regional biomass to RPW scaling coefficients as estimated from model 19.2a for the longline survey in the GOA:

	Western GOA	Central GOA	Eastern GOA
$\hat{\alpha}_r$	2.02	0.43	1.34

Results

Harvest Recommendations

Amendment 56 Reference Points

In previous assessments, shortraker rockfish were always classified as “tier 5” in the NPFMC definitions for ABC and Overfishing Level (OFL) based on Amendment 56 to the Gulf of Alaska FMP. The population dynamics information available for Tier 5 species consists of reliable estimates of biomass and natural mortality M, and the definitions state that for these species, the fishing rate that determines ABC (i.e., F_{ABC}) is $\leq 0.75M$. Because age and maturity data are available for shortraker rockfish (Hutchinson 2004), theoretically this species could be moved into tier 4, where $F_{ABC} \leq F_{40\%}$. However, because of the uncertainty of the present aging method and the lack of age validation, we recommend keeping shortraker rockfish in tier 5 for the present. Thus, the recommended F_{ABC} for shortraker rockfish is 0.0225 (i.e., 0.75 * M, where M = 0.03). The overfishing limit for Tier 5 species is defined to occur at a harvest rate of $F=M$.

As described in the previous section, the recommended RE model was fit to the 1984–2021 GOA trawl survey time-series of biomass values and estimates of uncertainty by region to account for missing survey data and regional RPW indices from the 1992–2021 AFSC longline survey (with associated estimates of uncertainty). These regional biomass estimates from the RE model were then summed to obtain total

GOA biomass of 31,331 t (+/- CI of 26,742 and 36,707; Table 11-8) for shortraker rockfish (Figure 11-11).

The random effects methodology has been recommended for all tier 5 stocks managed by the NPFMC.

Specification of OFL and Maximum Permissible ABC

Applying the F_{ABC} to the estimate of current exploitable biomass (using the random effects methodology) of 31,331 t (+/- CI of 26,742 and 36,707; Table 11-8) for shortraker rockfish results in a total GOA ABC of 705 t and OFL of 940 t for the 2022 fishery. This ABC is slightly lower than the 2020 ABC of 708 t.

Risk Table and ABC Recommendation

The following table is to be 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 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: 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—
   a. Data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data
   b. Model fits: poor fits to fishery or survey data, inability to simultaneously fit multiple data inputs
   c. Model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds
   d. Estimation uncertainty: poorly-estimated but influential year classes
   e. 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.

<u>Assessment considerations</u>*:*

The GOA shortraker stock is a Tier 5 species, meaning only biomass estimates are available to calculate ABCs. The GOA shortraker assessment is one of a few Tier 5 assessments in Alaska that is fit to multiple abundance indices (trawl survey biomass estimates and longline survey RPWs) using the RE model. While these two surveys have often shown opposing trends (trawl survey biomass decreased in 2021 while longline survey RPWs increased), which is not unexpected due to the differing habitats sampled, the inclusion of these two data sources in the RE model has allowed for increased stability of biomass estimates (Table 11-8) and more consistent regional apportionments across time. Historically, the biomass estimates for shortraker rockfish have shown relatively moderate confidence intervals and low CVs. We rated the assessment-related concern as level 1, normal. While survey biomass estimates have historically shown large changes from year to year (typical of several rockfish assessments), the CVs have generally remained low.

<u>Population dynamics considerations:</u>

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 GOA. Any data collected during larval cruises lump all rockfish species together. Even with large annual survey variability, recent biomass estimates have generally been stable. 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 and survey biomass estimates have shown normal variability for this species.

<u>Environmental/Ecosystem considerations:</u>

Shortraker rockfish are benthic continental slope (300-500m) dwellers as adults (Krieger and Ito 1999), with post-larval rockfish documented in epipelagic waters in offshore waters of the GOA (Kondzela et al. 2007). While optimal spawning and larval survival temperature ranges are not known for shortraker rockfish, it is reasonable to expect that the 2021 and predicted 2022 average deeper ocean temperatures will provide good spawning habitat, and average to cooler surface temperatures contribute to good pelagic conditions for age-0 rockfish during a time when they are growing to a size that promotes over winter survival. Sea temperatures at the surface and at depth on the shelf were around the long-term average in 2021 (not a marine heatwave year, Watson and Callahan 2021; AFSC Bottom Trawl Survey, Laman 2021; AFSC EcoFOCI survey, Rogers *et al*. 2021; Seward Line Survey, Danielson and Hopcroft 2021), although the western GOA started the year with warmer surface waters (satellite data; Watson 2021) and there was above average warmth (5.2°C) at 200m depth along the outer edge of the shelf during the summer (AFSC Longline Survey; Siwicke 2021). Numerous temperature time series showed signs of cooling from previous surveys (returning to average from recent marine heatwave years 2014-2016, 2019) at the surface and at depth, and 2022 surface temperatures are predicted to continue cooling, in alignment with La Niña conditions and a negative Pacific Decadal Oscillation. Additional epifauna habitat and rockfish distribution data show a continued decline in sponges since 2015, particularly in the Shumagin and Kodiak areas (AFSC Bottom Trawl Survey; Palsson 2021$_b$) and no change in relative abundance of soft corals (AFSC Bottom Trawl Survey; Palsson 2021$_b$). In general, no changes have been observed over the AFSC Bottom Trawl catch time series (1989-2021) in the distribution of shortraker rockfish catch relative to depth, temperature, or east/west position in the GOA (AFSC Bottom Trawl Survey; Palsson 2021$_a$).

Larval rockfish are planktivorous and the primary prey items of adult shortraker rockfish are shrimp, squid, and deepwater fish in the GOA (Yang 2000). For larval rockfish, zooplankton productivity was moderate and regionally variable across the GOA in 2021. The western GOA had lower spring biomass of large copepods and approximately average biomass of smaller copepods was around Kodiak, characteristics of previous warm, less productive years (e.g., 2019). Planktivorous seabird reproductive success, an indicator of zooplankton availability and nutritional quality, was below average just north of Kodiak (E. Amatuli Island; Drummond 2021). Around the eastern edge of the central GOA (Seward Line, Middleton Island) the biomass of large copepods was average to above-average (Seward Line Survey, Hopcroft and Coyle 2021) and planktivorous seabirds had better reproductive success (Middleton Island, Hatch 2021), indicating improved forage conditions. The eastern GOA inside waters of Icy Strait, northern southeast Alaska, had higher than average large copepods and euphausiids (AFSC SECM Survey, Icy Strait, Fergusson 2021), however planktivorous seabirds had mixed reproductive success. Little is known about the adult prey base (shrimp, squid, deepwater fish).The body condition of other adult rockfish species (northern and southern rockfish) was below average (lower weight for a given length) continuing a seven year trend, but increased closer to the long-term average from the low in 2019 (AFSC Bottom Trawl Survey, O'Leary *et al*. 2021). Shrimp have been increasing around Chirikof, Yakutat, and southeastern GOA regions, but declining around Kodiak over the past 5 years (AFSC Bottom Trawl Survey, Palsson 2021$_c$). While we have no data on squid abundance, 2021 is having large adult returns of pink salmon, which predate heavily on squid and some research points to competitive effects in the marine environment (Shaul *et al*. 2021, Aydin 2000). The large 2016 year class of sablefish is shifting to the edge of the GOA shelf as they mature, potentially increasing the overlap in distribution and potential for competition with slope rockfish.

Little is known about the impacts of predators, such as fish and marine mammals, on adult shortraker rockfish. Juvenile rockfish could be preyed upon by cod, arrowtooth flounder, halibut, sablefish, and seabirds. In general, apex fish predators in the GOA are at relatively low abundances (including cod and arrowtooth flounder, although sablefish are abundant) (Whitehouse and Aydin 2021) and we do not have seabird population abundance data. There is no cause to suspect increased predation pressure on larval or adult shortraker rockfish.

We scored this category as level 1, normal concern for adult shortraker rockfish, given approximately average physical environmental conditions, mixed trends/unknown foraging conditions (mixed trends in shrimp abundance, negative body condition of other rockfish), potential for competition with pink salmon and sablefish but the actual effect is unknown, and unknown predation pressure.

Fishery performance:

There is no directed fishing of shortraker rockfish, and they can only be retained as "incidentally-caught." Catch of shortraker rockfish varies greatly by area, gear type, and year, but catch has always remained below the TAC. Shortraker catch has generally been stable, but has decreased in recent years. This decrease is likely due in part to the increased use of traditional pot gear and slinky pots in the sablefish fishery. Due to their high value, discard rates of shortrakers have generally been low, however, discard rates in the longline fisheries have been increasing in recent years for unknown reasons, even after regulations requiring mandatory retention by fixed gear CVs were passed. Overall, we rated the fishery performance concern as level 1, normal, due to the low stable catch of this non-directed fishery species that historically has always remained below the TAC.

Area Allocation of Harvests

Since 1991, the GOA ABC for shortraker/rougheye rockfish or shortraker rockfish alone has been allocated amongst the western, central, and eastern GOA regulatory areas based on the geographic distribution of the species' exploitable biomass in the trawl surveys. We used area-specific survey biomass estimates and a random-walk smoother (the 'random effects' model) to apportion ABCs among regions. The fit of this model is shown in Figure 11-12 (for bottom trawl survey biomass) and Figure 11-13 (for longline survey RPWs). The result is responsive to both the bottom trawl and longline survey indices which may reflect different components of the population. For 2022, the estimated distribution of biomass is shown as:

GOA Area	2022 Biomass (t)	Percent of Total Biomass	Area ABC Apportionment (t)
Western	2,287	7.3%	51
Central	12,438	39.7%	280
Eastern	16,606	53%	374
GOA Total	31,331	100%	705

The 2022 recommended apportionment values are similar to 2020: WGOA (52 t), CGOA (284 t), and EGOA (372 t).

Status determination

Based on Amendment 56 in the Gulf of Alaska FMP, overfishing for a Tier 5 species such as shortraker rockfish is defined to occur at a harvest rate of $F=M$. Therefore, applying the estimate of M for shortraker rockfish (0.03) to the estimate of current exploitable biomass (31,331 t) yields an overfishing catch limit of 940 t for 2022. This stock is not being subjected to overfishing.

Ecosystem Considerations

In general, a determination of ecosystem considerations for shortraker rockfish is hampered by the lack of biological and habitat information. A summary of the ecosystem considerations presented in this section is listed in Table 11-9.

Ecosystem Effects on the Stock

Prey availability/abundance trends:

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. Although few juvenile shortraker rockfish have ever been caught in Alaska, precluding species-specific information on their food items, generally zooplankton productivity was moderate and regionally variable across the GOA. In the western GOA there was lower spring biomass of large copepods and approximately average biomass of smaller copepods around Kodiak, characteristics of previous warm, less productive years (e.g., 2019). Planktivorous seabird reproductive success, an indicator of zooplankton availability and nutritional quality, was below average just north of Kodiak (E. Amatuli Island). Around the eastern edge of the central GOA (Seward Line, Middleton Island), the biomass of large copepods was average to above-average (Danielsen and Hopcroft 2021), and planktivorous seabirds had better reproductive success indicating improved forage conditions (Middleton Island, Hatch 2021). The eastern GOA inside waters of Icy Strait, northern southeast Alaska, had higher than average large copepods and euphausiids (Fergusson 2012), however planktivorous seabirds had mixed reproductive success.

Adult shortraker rockfish in Alaska are opportunistic feeders that prey on shrimp, deepwater fish (e.g., myctophids), and squid (Yang and Nelson 2000; Yang 2003; Yang *et al.* 2006). Shrimp have been increasing around Chirikof, Yakutat, and southeastern GOA regions, but declining around Kodiak over the past 5 years (AFSC Bottom Trawl Survey). While we have no data on squid abundance, adult returns of pink salmon, which prey heavily on squid, were high in 2021. The large 2016 year class of sablefish is shifting to the edge of the GOA shelf as they mature, potentially increasing the overlap in distribution and potential for competition with slope rockfish.

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 sparse. 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 POP, 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.

While optimal spawning and larval survival temperature ranges are not known for shortraker rockfish, it is reasonable to expect that the 2021 and predicted 2022 average deeper ocean temperatures will provide good spawning habitat and average to cooler surface temperatures contribute to favorable pelagic conditions for age-0 rockfish during a time when they are growing to a size that promotes overwinter survival. Sea temperatures at the surface and at depth on the shelf were around the long-term average in 2021 (not a marine heatwave year; AFSC Bottom Trawl Survey, AFSC EcoFOCI survey, Seward Line Survey). Numerous temperature time series showed signs of cooling from previous surveys (returning to average from recent marine heatwave years 2014-2016, 2019) at the surface and at depth, and 2022 surface temperatures are predicted to continue cooling, in alignment with La Niña conditions and a negative Pacific Decadal Oscillation.

Epifauna habitat and rockfish distribution data show a continued decline in sponges since 2015, particularly the Shumagin and Kodiak areas (AFSC Bottom Trawl Survey; Palsson 2021), and no change in relative abundance of soft corals (AFSC Bottom Trawl Survey; Palsson 2021). 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. 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 GOA is taken incidentally in longline fisheries for sablefish and Pacific halibut or in the rockfish trawl fishery for POP. Thus, the reader is referred to the discussions on “Fishery Effects” in the sablefish and POP chapters in this SAFE report.

Fishery-specific contribution to bycatch of HAPC biota:

In the GOA, bottom trawl fisheries for shortraker and rougheye rockfish accounted for very little bycatch of HAPC biota (Table 11-10). 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 (if known) and relative to spawning components:

Unknown.

Fishery-specific effects on amount of large size target fish:

Unknown.

Fishery contribution to discards and offal production:

Annual fishery discard rates since 2011 have been 22-54% 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:

Unknown.

Fishery-specific effects on EFH non-living substrate:

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

Currently, validation of aging methods for shortraker rockfish is the most important research priority so that an age-structured model can be used for assessment. Additional research is needed on other aspects of shortraker rockfish biology and assessment. There is little information on larval, post-larval, or early stage juveniles of shortraker rockfish. In particular, juvenile shortraker rockfish are very seldom caught in any sampling gear. 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 on the fishing grounds needs to be done on the bottom habitat, HAPC biota , and impacts from bottom trawling. Investigation is needed on the distribution and abundance of shortraker rockfish in untrawlable habitat.

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Tables

Table 11-1.--Estimated catch (%) of shortraker rockfish in the Gulf of Alaska by target fishery and gear type, 2005-2021.

	Target Fishery						Gear Type		
Year	Rockfish	Sablefish	Halibut	Pollock	Pacific Cod	Total*	Trawl	Longline	Total*
2005	51	39	6	3	<1	100	54.8	45.2	100
2006	38	28	22	10	1	100	49.2	50.8	100
2007	44	35	13	8	<1	100	54.0	46	100
2008	39	35	15	11	1	100	53.2	46.8	100
2009	47	29	19	4	1	100	56	44	100
2010	27	56	14	2	1	100	39.4	60.6	100
2011	52	28	13	5	1	100	65.1	34.9	100
2012	45	45	7	3	1	100	49	51	100
2013	43	39	16	2	1	100	48.7	51.3	100
2014	42	40	17	<1	1	100	50.6	49.4	100
2015	43	45	10	1	<1	100	49.2	50.8	100
2016	38	29	8	24	<1	100	64	36	100
2017	50	36	13	<1	2	100	53	47	100
2018	37	51	12	<1	1	100	42.7	57.3	100
2019	40	50	9	1	<1	100	43.5	56.5	100
2020	47	42	6	5	<1	100	54.6	45.4	100
2021	58	31	10	<1	<1	100	62.3	37.7	100

Source: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 3, 2021. * Numbers may not sum to 100 due to rounding.

Table 11-2.--A summary of key management measures and the time series of catch (t), ABC, TAC, and OFL for shortraker rockfish in the Gulf of Alaska (GOA). Source: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 2, 2021.

Year	GOA Total	GOA ABC	GOA TAC	GOA OFL	Management Measures
1988					The NPFMC implements the slope rockfish assemblage, which includes shortraker rockfish and the species that will become “other slope rockfish”, together with Pacific ocean perch, northern rockfish, and rougheye rockfish. Previously, *Sebastes* in Alaska were managed as the “Pacific ocean perch complex” or “other rockfish”. Apportionment of ABC among management areas in the Gulf (Western, Central, and Eastern) for slope rockfish assemblage is determined based on average percent biomass in previous NMFS trawl surveys.
1989		2,092	2,092		
1990					
1991	702	2,000	2,000		Slope rockfish assemblage is split into three management subgroups with separate ABCs and TACs: Pacific ocean perch, shortraker/rougheye rockfish, and “other slope rockfish”.
1992	2,165	1,960	1,960		
1993	1,932	1,960	1,764		
1994	1,832	1,960	1,960		
1995	2,250	1,910	1,910		
1996	1,661	1,910	1,910		
1997	1,609	1,590	1,590		Area apportionment procedure for shortraker/rougheye is changed. Apportionment is now based on 4:6:9 weighting of biomass in the most recent three NMFS trawl surveys.
1998	1,734	1,590	1,590		
1999	1,311	1,590	1,590		Trawling is prohibited in the Eastern Gulf east of 140 degrees W longitude. Eastern Gulf trawl closure becomes permanent with the implementation of FMP Amendments 41 and 58 in 2000 and 2001, respectively.
2000	1,745	1,730	1,730	2,513	
2001	1,976	1,730	1,730	2,513	
2002	1,323	1,620	1,620	2,343	
2003	1,402	1,620	1,620	2,343	
2004	997	1,318	1,318	2,512	

Table 11-2.(continued)

Year	GOA Total	GOA ABC	GOA TAC	GOA OFL	Management Measures
2005	501	753	753	982	Shortraker rockfish is split as a separate management entity from rougheye rockfish and now has its own ABC and TAC.
2006	747	843	843	1,124	
2007	680	843	843	1,124	Amendment 68 creates the Central Gulf Rockfish Pilot Program, which affects trawl catches of rockfish in this area.
2008	607	898	898	1,197	
2009	562	898	898	1,197	
2010	498	914	914	1,219	
2011	546	914	914	1,219	
2012	687	1,081	1,081	1,441	The Central Gulf Rockfish Program is permanently put into place.
2013	697	1,081	1,081	1,441	
2014	664	1,323	1,323	1,764	
2015	571	1,323	1,323	1,764	
2016	782	1,286	1,286	1,715	
2017	537	1,286	1,286	1,715	
2018	747	863	863	1,151	Estimation of exploitable biomass and area apportionment procedures for shortraker is changed. Apportionment is now based on applying the time series of trawl survey data to a random effects model.
2019	697	863	863	1,151	Longline survey RPWs are added to the random effects model used to estimate exploitable biomass and apply apportionment.
2020	492	708	708	944	Amendment 107 requires GOA wide full retention of rockfish by catcher vessels using pot, hook-and-line, and jig gear while fishing for groundfish or halibut.
2021	417	705	705	940	

Table 11-3.--Commercial catch (t) of fish in the shortraker/rougheye rockfish and shortraker rockfish management categories in the Gulf of Alaska, with total GOA values of acceptable biological catch (ABC) and total allowable catch (TAC), 1991-2021. Updated through October 3, 2021.

	Area of Gulf			GOA	GOA	GOA
Year	Western	Central	Eastern	Total	ABC	TAC
			Shortraker/Rougheye Rockfish			
1991	123	408	171	702	2,000	2,000
1992	115	1,367	683	2,165	1,960	1,960
1993	85	1,197	650	1,932	1,960	1,764
1994	114	996	722	1,832	1,960	1,960
1995	216	1,222	812	2,250	1,910	1,910
1996	127	941	593	1,661	1,910	1,910
1997	137	931	541	1,609	1,590	1,590
1998	129	870	735	1,734	1,590	1,590
1999	194	580	537	1,311	1,590	1,590
2000	137	887	721	1,745	1,730	1,730
2001	126	998	852	1,976	1,730	1,730
2002	263	631	429	1,323	1,620	1,620
2003	225	856	321	1,402	1,620	1,620
2004	277	337	383	997	1,318	1,318
			Shortraker Rockfish			
2005	71	224	205	501	753	753
2006	91	336	320	747	843	843
2007	194	214	272	680	843	843
2008	134	238	235	607	898	898
2009	152	189	221	562	898	898
2010	72	131	295	498	914	914
2011	81	237	228	546	914	914
2012	90	304	293	687	1,081	1,081
2013	37	423	237	697	1,081	1,081
2014	76	325	263	664	1,323	1,323
2015	46	259	266	571	1,323	1,323
2016	52	433	298	782	1,286	1,286
2017	43	219	275	537	1,286	1,286
2018	30	310	407	747	863	863
2019	57	231	410	697	863	863
2020	6	186	299	492	708	708
2021	5	164	248	417	708	708

Sources: Catch: 1991-2021: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 3, 2021. ABC and TAC: 1991-2007, Clausen (2007); 2008 - 2021, North Pacific Fishery Management Council website (http://www.fakr.noaa.gov/npfmc/Council0910specs.pdf).

Table 11-4.--Estimated commercial catch (t) of shortraker rockfish in the Gulf of Alaska, 1993-2003, based on data from the NMFS Alaska Observer Program database and from the NMFS Alaska Regional Office. See Clausen (2004) for an explanation of how these numbers were estimated.

Year	Catch (t)
1993	1,348
1994	1,254
1995	1,545
1996	1,102
1997	1,065
1998	1,069
1999	992
2000	1,214
2001	1,385
2002	1,051
2003	1,010

Table 11-5.-- Gulf of Alaska (GOA) shortraker rockfish retained (t) and discarded (t) by target fishery, and total GOA discard rate, 2005–2021; approximate percentage of total discards in parentheses. 2005-2021: National Marine Fisheries Service, Alaska Region, Catch Accounting System, accessed via the Alaska Fishery Information Network (AKFIN). Updated through October 3, 2021.

	Halibut		Pollock-nonpelagic		Rockfish		Sablefish		Total GOA
Year	Retained	Discarded	Retained	Discarded	Retained	Discarded	Retained	Discarded	Discard Rate
2005	30	1 (4%)	1	0 (0%)	239	10 (4%)	126	64 (34%)	15.9%
2006	52	109 (68%)	6	0 (0%)	266	8 (3%)	112	91 (45%)	32.3%
2007	61	26 (30%)	1	0 (0%)	283	8 (3%)	98	130 (57%)	27%
2008	77	9 (10%)	17	0 (0%)	219	13(6%)	120	83 (41%)	19.4%
2009	73	29 (29%)	14	0 (0%)	207	41(16%)	83	72 (46%)	27.3%
2010	69	2 (2%)	1	0 (0%)	121	10 (8%)	119	154 (56%)	34.9%
2011	45	15 (25%)	15	0 (0%)	213	28 (12%)	77	54 (41%)	21.8%
2012	38	9 (20%)	3	0 (0%)	276	25 (8%)	129	175 (58%)	32%
2013	40	70 (63%)	2	0 (0%)	247	42 (15%)	93	169 (65%)	42.3%
2014	32	66 (67%)	1	0 (0%)	238	5 (2%)	92	136 (60%)	36.2%
2015	34	19 (37%)	2	0 (0%)	235	3 (1%)	95	154 (62%)	32.6%
2016	30	32 (52%)	2	154 (99%)	276	18 (6%)	63	161 (72%)	49.6%
2017	25	40 (61%)	<1	0	227	29 (11%)	62	125 (67%)	38.2%
2018	27	59 (69%)	<1	0	244	25 (9%)	64	307 (83%)	53.8%
2019	27	32 (54%)	<1	0	248	21 (8%)	91	247 (73%)	45.1%
2020	24	5 (16%)	6	<1 (2%)	221	4 (2%)	100	102 (50%)	23.8%
2021	26	12 (32%)	1	<1 (7%)	194	41 (17%)	47	78 (63%)	32.9%

Table 11-6.--Relative population number (RPN) and relative population weight (RPW) with the associated coefficient of variation (CV) for Gulf of Alaska shortraker rockfish in the Alaska Fishery Science Center longline survey, 1992-2021. Data are for the upper continental slope only, 201-1,000 m depth (gullies are not included): western Gulf of Alaska (WG), central Gulf of Alaska (CG), eastern Gulf of Alaska (EG). RPN and RPW values are calculated using the most recent calculated geographic area sizes for the AFSC longline survey (Echave *et al.* 2013).

Year	RPN			GOA	RPW			GOA	
	WG	CG	EG	Total	WG	CG	EG	Total	CV
1992	1,291	1,653	7,188	10,133	1,735	3,212	14,855	19,802	18%
1993	3,266	3,781	6,471	13,518	2,103	5,297	13,297	20,696	23%
1994	4,129	2,976	10,184	17,290	3,718	3,346	11,349	18,413	14%
1995	5,272	1,591	7,480	14,343	7,288	2,924	14,691	24,902	13%
1996	3,745	2,577	8,600	14,923	5,428	5,036	18,316	28,780	13%
1997	2,675	2,680	12,515	17,870	4,143	4,933	26,966	36,042	16%
1998	4,325	3,020	13,415	20,761	6,268	5,814	26,184	38,265	12%
1999	4,616	3,385	11,674	19,674	6,380	5,883	22,062	34,324	11%
2000	8,775	3,634	14,911	27,319	13,795	6,218	30,901	50,914	13%
2001	4,732	4,217	13,321	22,270	6,699	8,263	27,740	42,701	19%
2002	3,159	2,687	9,800	15,646	4,693	4,460	19,286	28,439	15%
2003	3,344	2,098	8,754	14,196	5,525	4,167	18,450	28,142	14%
2004	6,079	1,636	8,948	16,663	9,282	2,716	17,069	29,068	21%
2005	1,852	1,899	7,524	11,276	3,126	3,214	14,804	21,144	15%
2006	3,749	3,496	7,700	14,945	5,650	6,233	13,825	25,707	14%
2007	3,344	4,428	12,486	20,258	4,629	8,224	23,271	36,124	12%
2008	3,598	4,076	11,921	19,594	5,684	6,590	21,270	33,545	12%
2009	3,980	6,491	10,148	20,620	5,608	12,407	17,607	35,621	18%
2010	4,309	2,858	6,732	13,899	6,328	4,664	11,869	22,861	15%
2011	7,512	4,671	7,544	19,727	10,808	8,135	13,312	32,256	17%
2012	3,471	3,684	8,739	15,894	5,212	6,024	17,173	28,409	13%
2013	3,661	3,023	5,689	12,373	5,136	4,726	10,380	20,243	14%
2014	2,718	4,515	10,947	18,181	3,955	7,698	21,997	33,650	13%
2015	3,057	3,601	10,614	17,272	4,456	5,497	21,746	31,699	13%
2016	3,196	4,073	5,607	12,875	5,505	6,456	12,053	24,015	15%
2017	5,269	4,715	6,462	16,446	7,426	7,676	11,479	26,581	13%
2018	3,431	3,821	6,496	13,748	4,432	6,042	12,148	22,622	17%
2019	4,325	3,640	6,974	14,939	6,848	5,696	13,905	26,449	21%
2020	1,746	2,749	9,703	14,198	2,557	4,174	20,015	26,746	23%
2021	3,208	3,324	11,041	17,573	4,894	5,967	23,635	34,496	14%

Table 11-7.--Biomass estimates (t) for shortraker rockfish in the Gulf of Alaska (GOA), by statistical area, based on bottom trawl surveys conducted between 1984 and 2021. Total GOA 95% confidence bounds, variance, and coefficient of variation (CV) are also shown for each year.

	Statistical areas						GOA Total			
							95% Conf. bounds			
Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	GOA Total	Lower	Upper	Biomass variance	Biomass CV (%)
					Shortraker Rockfish					
1984	4,874	659	4,685	6,288	2,051	18,557	4,600	32,515	34,829,252	31.8
1987	3,232	13,182	18,950	4,408	3,079	42,851	13,392	72,311	196,602,336	32.7
1990	284	1,729	3,027	6,037	1,604	12,681	6,412	18,951	9,085,499	23.8
1993	2,775	2,320	4,735	7,740	1,903	19,472	11,290	27,654	15,474,771	20.2
1996	1,905	2,406	7,726	4,523	3,699	20,258	10,652	29,865	20,532,868	22.4
1999	2,208	3,931	8,459	9,831	3,845	28,275	16,841	39,709	30,393,883	19.5
2001*	4,313	1,589	11,513	7,350	3,149	27,914	18,819	37,008	21,530,717	16.6
2003	11,166	2,996	14,292	11,936	1,633	42,023	23,572	60,474	81,168,454	21.4
2005	5,946	6,342	10,741	16,866	2,673	42,575	25,611	59,540	69,018,739	19.5
2007	2,492	1,911	8,275	8,197	14,250	35,125	17,296	52,954	66,950,870	23.3
2009	8,810	3,209	13,541	12,518	6,109	44,185	25,332	63,039	79,840,212	20.2
2011	2,464	23,784	9,113	22,561	7,316	65,237	17,752	112,722	474,895,139	33.4
2013	2,248	2,410	6,318	49,374	7,021	67,370	13,999	120,740	535,643,928	34.4
2015	1,064	4,881	9,191	32,662	14,520	62,317	19,200	105,433	404,045,782	32.3
2017	2,542	1,595	12,197	13,228	1,973	31,534	13,684	49,383	75,372,223	27.5
2019	431	5,700	11,967	20,473	6,203	44,773	18,103	71,444	158,269,748	28.1
2021	2,270	852	9,379	13,381	1,301	27,182	15,004	39,360	34,279,280	21.5

*The 2001 survey did not sample the eastern Gulf of Alaska (Yakutat and Southeastern areas). Substitute estimates of biomass for these areas in 2001 were obtained by averaging the Yakutat and Southeastern biomass in the 1993, 1996, and 1999 surveys. These eastern Gulf of Alaska estimates have been included in the 2001 biomass estimates, confidence bounds, biomass variances, and biomass CVs listed in this table.

Table 11-8.--Time series of estimated exploitable biomass using the random effects model (19.2a) for the western Gulf of Alaska (WGOA), central Gulf of Alaska (CGOA), eastern Gulf of Alaska (EGOA), and the total Gulf of Alaska (GOA Total), with 95 % lower (LCI) and upper confidence intervals (UCI).

Year	WGOA	CGOA	EGOA	GOA Total	LCI	UCI
1984	2,570	10,919	11,772	25,261	21,599	29,544
1985	2,566	10,982	11,779	25,327	21,722	29,531
1986	2,562	11,046	11,785	25,393	21,846	29,517
1987	2,558	11,110	11,792	25,460	21,972	29,502
1988	2,550	11,137	11,868	25,555	22,122	29,521
1989	2,543	11,164	11,945	25,651	22,276	29,538
1990	2,535	11,191	12,022	25,748	22,432	29,553
1991	2,537	11,243	12,147	25,927	22,675	29,644
1992	2,540	11,295	12,273	26,107	22,922	29,735
1993	2,542	11,347	12,401	26,289	23,173	29,825
1994	2,543	11,422	12,563	26,528	23,472	29,982
1995	2,545	11,496	12,728	26,769	23,774	30,141
1996	2,547	11,572	12,894	27,013	24,079	30,305
1997	2,552	11,654	13,109	27,314	24,432	30,537
1998	2,557	11,736	13,327	27,620	24,784	30,781
1999	2,561	11,819	13,549	27,930	25,132	31,038
2000	2,568	11,901	13,771	28,240	25,433	31,356
2001	2,574	11,983	13,997	28,554	25,728	31,691
2002	2,573	12,054	14,226	28,854	25,985	32,039
2003	2,573	12,125	14,459	29,158	26,235	32,406
2004	2,560	12,174	14,700	29,435	26,438	32,771
2005	2,548	12,224	14,945	29,716	26,635	33,155
2006	2,529	12,252	15,164	29,945	26,767	33,501
2007	2,510	12,281	15,386	30,177	26,895	33,860
2008	2,492	12,333	15,584	30,409	27,006	34,240
2009	2,473	12,386	15,783	30,643	27,116	34,629
2010	2,452	12,407	15,954	30,813	27,151	34,969
2011	2,430	12,429	16,127	30,985	27,186	35,315
2012	2,408	12,424	16,269	31,101	27,182	35,585
2013	2,387	12,419	16,413	31,219	27,180	35,857
2014	2,366	12,434	16,486	31,286	27,166	36,032
2015	2,346	12,450	16,559	31,354	27,155	36,204
2016	2,331	12,454	16,574	31,359	27,112	36,271
2017	2,316	12,459	16,589	31,363	27,072	36,335
2018	2,301	12,460	16,610	31,371	27,017	36,427
2019	2,286	12,461	16,632	31,379	26,964	36,518
2020	2,286	12,450	16,619	31,355	26,892	36,559
2021	2,286	12,438	16,607	31,331	26,822	36,598
2022	2,286	12,438	16,607	31,331	26,742	36,707

Table 11-9.--Analysis of ecosystem considerations for shortraker rockfish.

Indicator	***Observation***	***Interpretation***	***Evaluation***
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends	important for larval and post-larval survival, but no information known	may help to determine year class strength	possible concern
Predator population trends	Unknown		little concern for adults
Changes in habitat quality	Variable	variable recruitment	possible concern
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	Unknown		
Forage (including herring, Atka mackerel, cod, and pollock)	Unknown		
HAPC biota (sea pens/whips, corals, sponges, anemones)	fishery disturbing hard-bottom biota, i.e., corals, sponges	could harm the ecosys-tem by reducing shelter for some species	concern
Marine mammals and birds	probably few taken		little concern
Sensitive non-target species	Unknown		
Fishery concentration in space and time	little overlap between fishery and reproductive activities	fishery does not hinder reproduction	little concern
Fishery effects on amount of large size target fish	Unknown		
Fishery contribution to discards and offal production	discard rates moderate	some unnatural input of food into the ecosystem	some concern
Fishery effects on age-at-maturity and fecundity	Unknown		

Table 11-10.--Average bycatch (kg) and bycatch rates during 1997 - 99 of living substrates in the Gulf of Alaska; POT - pot gear; BTR - bottom trawl; HAL - Hook and line (source - Draft Programmatic SEIS).

		Bycatch (kg)				Target	Bycatch rate (kg/t target)			
Target fishery	Gear	Coral	Anemone	Sea whips	Sponge	catch (t)	Coral	Anemone	Sea whips	Sponge
Arrowtooth flounder	POT	0	0	0	0	4	0.0000	0.0000	0.0000	0.0000
Arrowtooth flounder	BTR	58	99	13	24	2,097	0.0276	0.0474	0.0060	0.0112
Deep water flatfish	BTR	1,626	481	5	733	2,001	0.8124	0.2404	0.0024	0.3663
Rex sole	BTR	321	306	11	317	2,157	0.1488	0.1417	0.0053	0.1468
Shallow water flatfish	POT	0	0	0	0	5	0.0000	0.0000	0.0000	0.0000
Shallow water flatfish	BTR	53	4,741	115	403	2,024	0.0261	2.3420	0.0567	0.1993
Flathead sole	BTR	3	267	1	136	484	0.0071	0.5522	0.0019	0.2806
Pacific cod	HAL	28	4,419	961	33	10,765	0.0026	0.4105	0.0893	0.0030
Pacific cod	POT	0	14	0	1,724	12,863	0.0000	0.0011	0.0000	0.1340
Pacific cod	BTR	34	5,767	895	788	37,926	0.0009	0.1521	0.0236	0.0208
Pollock	BTR	1,153	55	0	23	2,465	0.4676	0.0222	0.0000	0.0092
Pollock	PTR	41	110	0	0	97,171	0.0004	0.0011	0.0000	0.0000
Demersal shelf rockfish	HAL	0	0	0	141	226	0.0000	0.0000	0.0000	0.6241
Northern rockfish	BTR	25	90	0	103	1,938	0.0127	0.0464	0.0000	0.0532
Other slope rockfish	HAL	0	0	0	0	14	0.0000	0.0000	0.0000	0.0000
Other slope rockfish	BTR	0	0	0	0	193	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	HAL	0	0	0	0	203	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	BTR	324	176	3	245	1,812	0.1788	0.0969	0.0017	0.1353
Pacific ocean perch	BTR	549	90	5	1,968	6,564	0.0837	0.0136	0.0007	0.2999
Pacific ocean perch	PTR	7	0	0	55	1,320	0.0052	0.0000	0.0000	0.0416
Shortraker/rougheye	HAL	6	0	0	0	19	0.3055	0.0000	0.0000	0.0000
Shortraker/rougheye	BTR	0	18	0	0	21	0.0000	0.8642	0.0000	0.0000
Sablefish	HAL	156	154	68	27	11,143	0.0140	0.0138	0.0061	0.0025
Sablefish	BTR	0	0	0	0	27	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	HAL	0	0	0	0	2	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	BTR	0	9	0	1	2	0.0000	4.8175	0.0000	0.4069

Figures

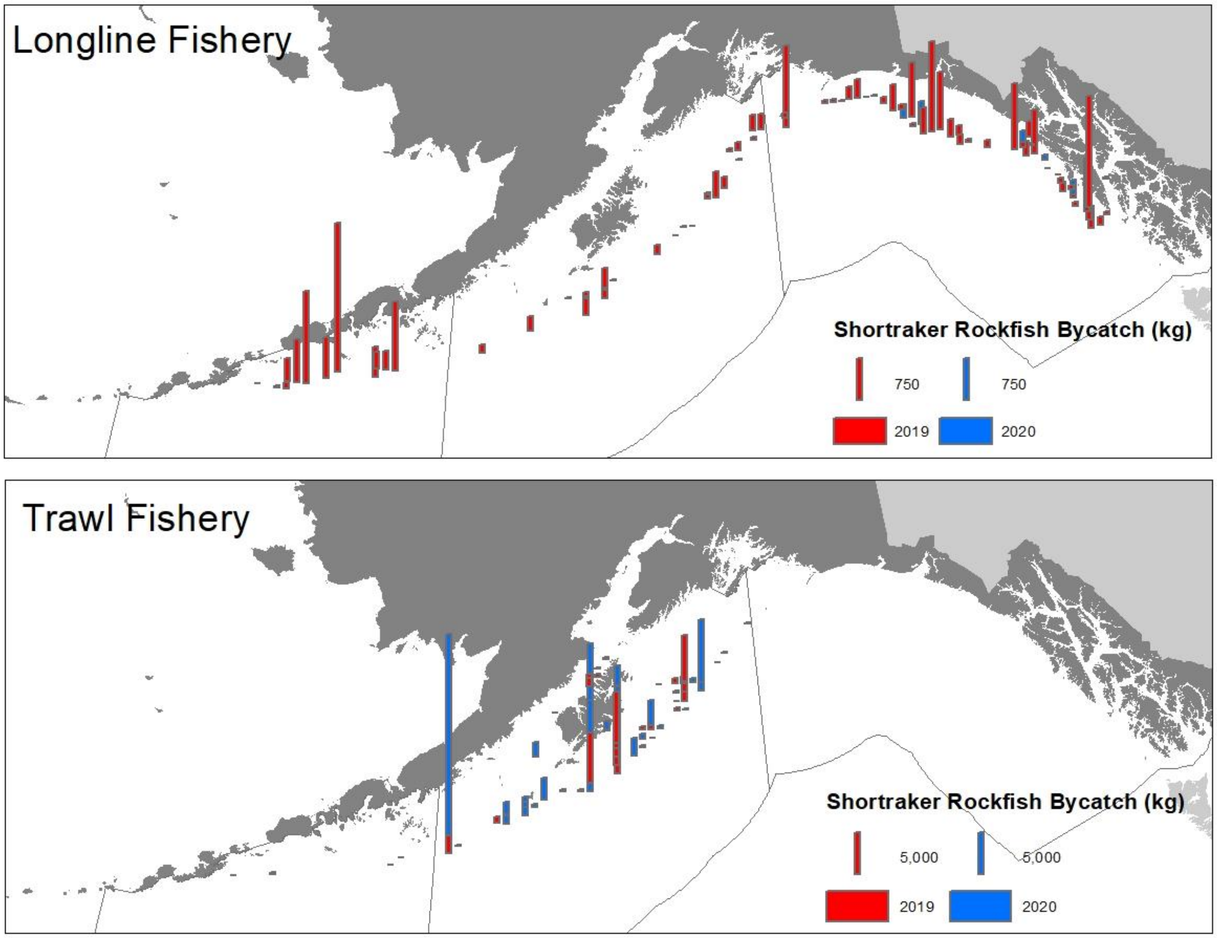


Figure 11-1.--Spatial distribution of observed shortraker rockfish catch in the Gulf of Alaska from 2019 (red bars) and 2020 (blue bars) in the longline fishery (top panel) and trawl fishery (bottom panel). Height of the bar represents the catch in kilograms. Each bar represents non-confidential catch data summarized into 400 km^2 grids. Grid blocks with zero catch were not included for clarity. Data provided by the Fisheries Monitoring and Analysis division website, queried October 15, 2021 (https://www.fisheries.noaa.gov/resource/map/spatial-data-collected-groundfish-observers-alaska).

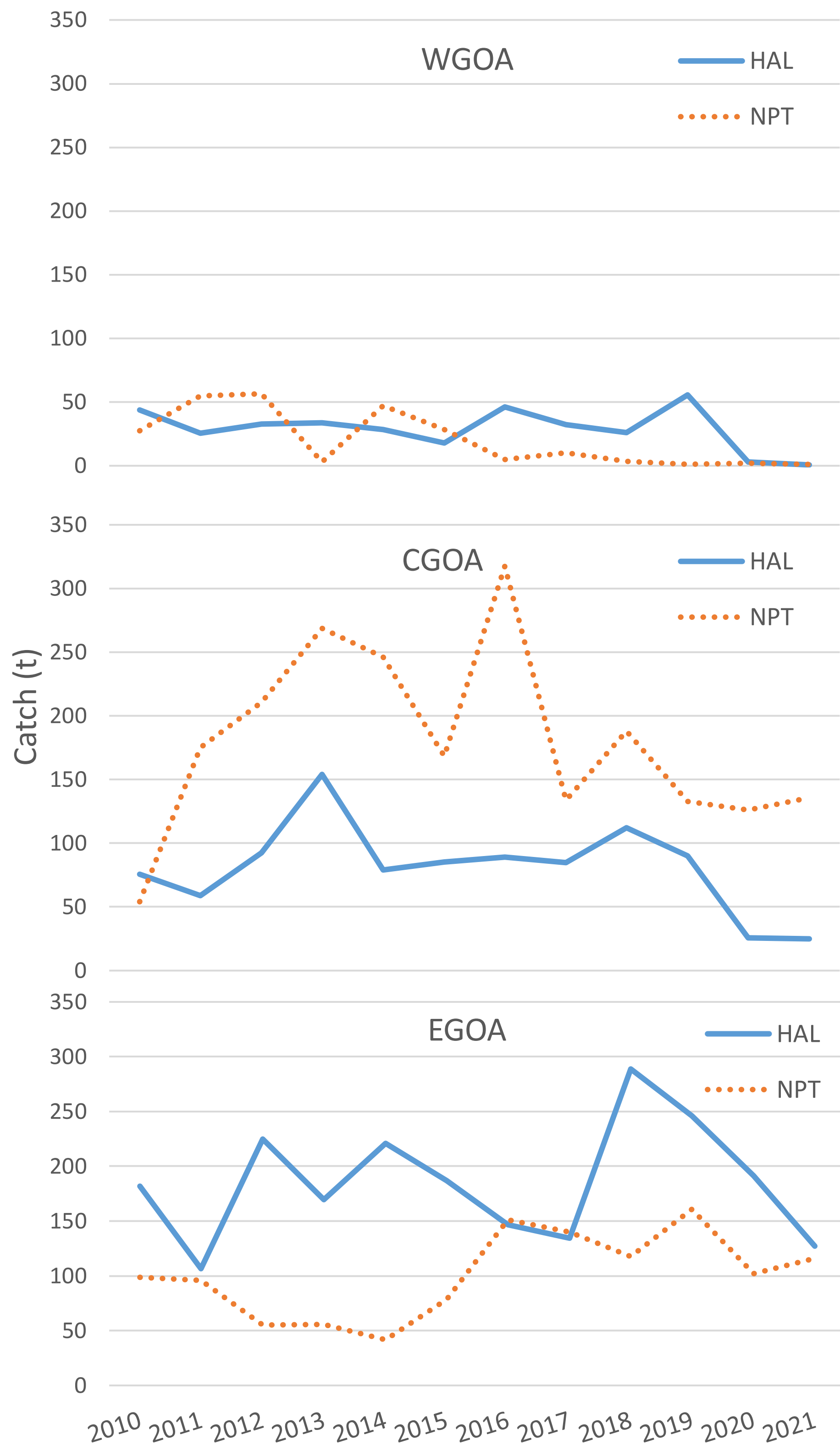


Figure 11-2--Catch (t) of shortraker rockfish by gear type, area and year. Gear type: hook and line (HAL) and nonpelagic trawl (NPT). Area: western Gulf of Alaska (WGOA), central Gulf of Alaska (CGOA), and eastern Gulf of Alaska (EGOA).

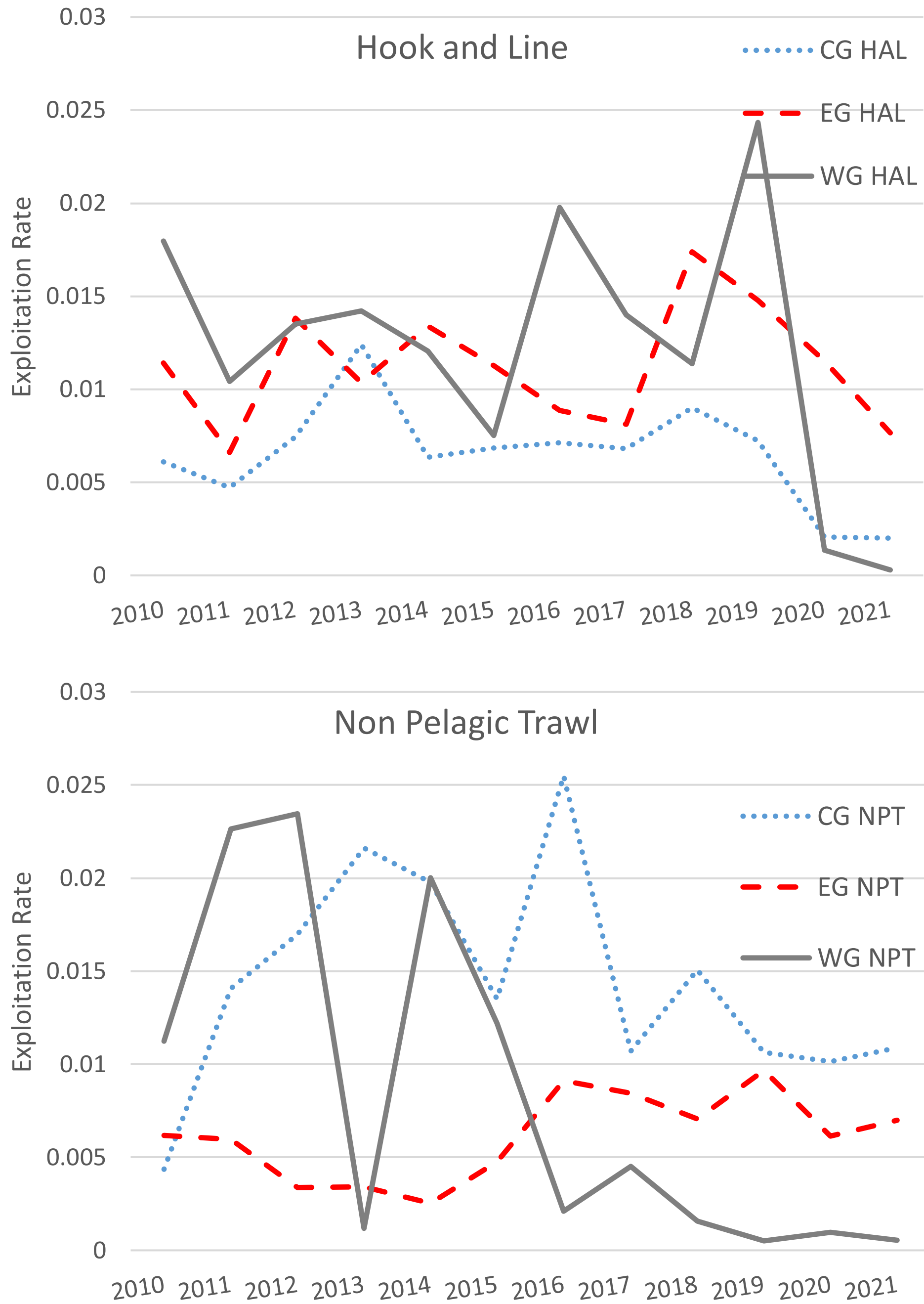


Figure 11-3.--Time series of the exploitation rates of shortraker rockfish in the observed hook and line (HAL) fishery (top panel) and the nonpelagic trawl (NPT) fishery (bottom panel), by area [central Gulf of Alaska (CG), eastern Gulf of Alaska (EG), and western Gulf of Alaska (WG)].

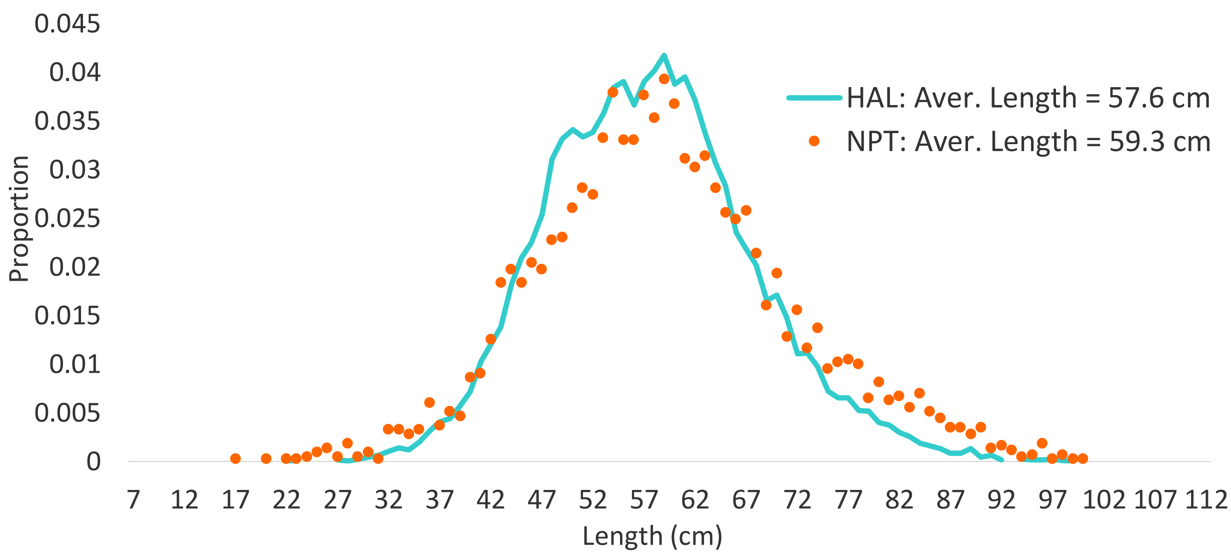


Figure 11-4.--Length frequencies as observed in the hook and line (HAL; solid blue line) and the nonpelagic trawl (NPT; orange dots) fisheries, 2005–2021 years combined.

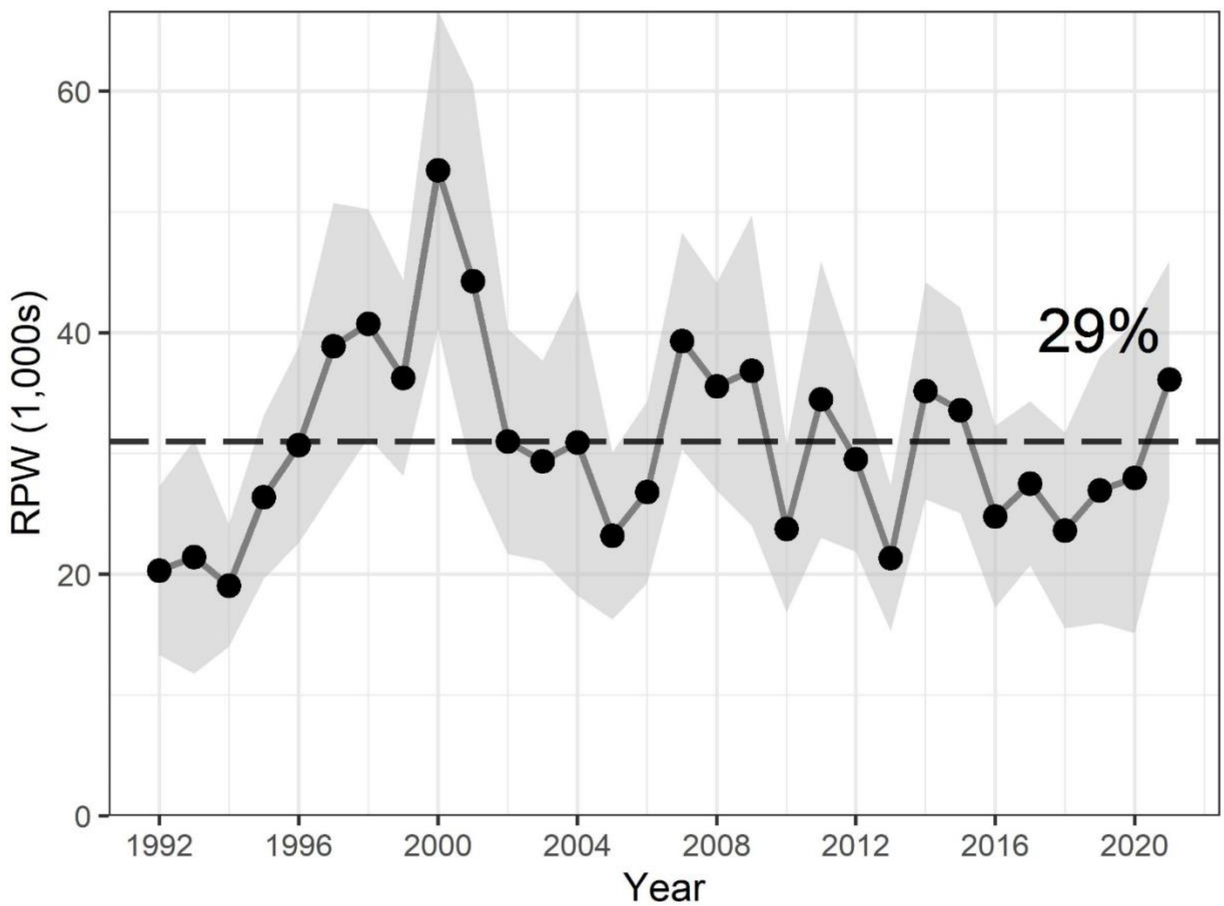


Figure 11-5.--Time series of the relative population weights (RPW, 1,000s) of Gulf of Alaska (GOA) shortraker rockfish caught on the longline survey with 95% confidence intervals. Dashed line depicts the histrorical average. The 2021 RPW value is up 29% from 2020.

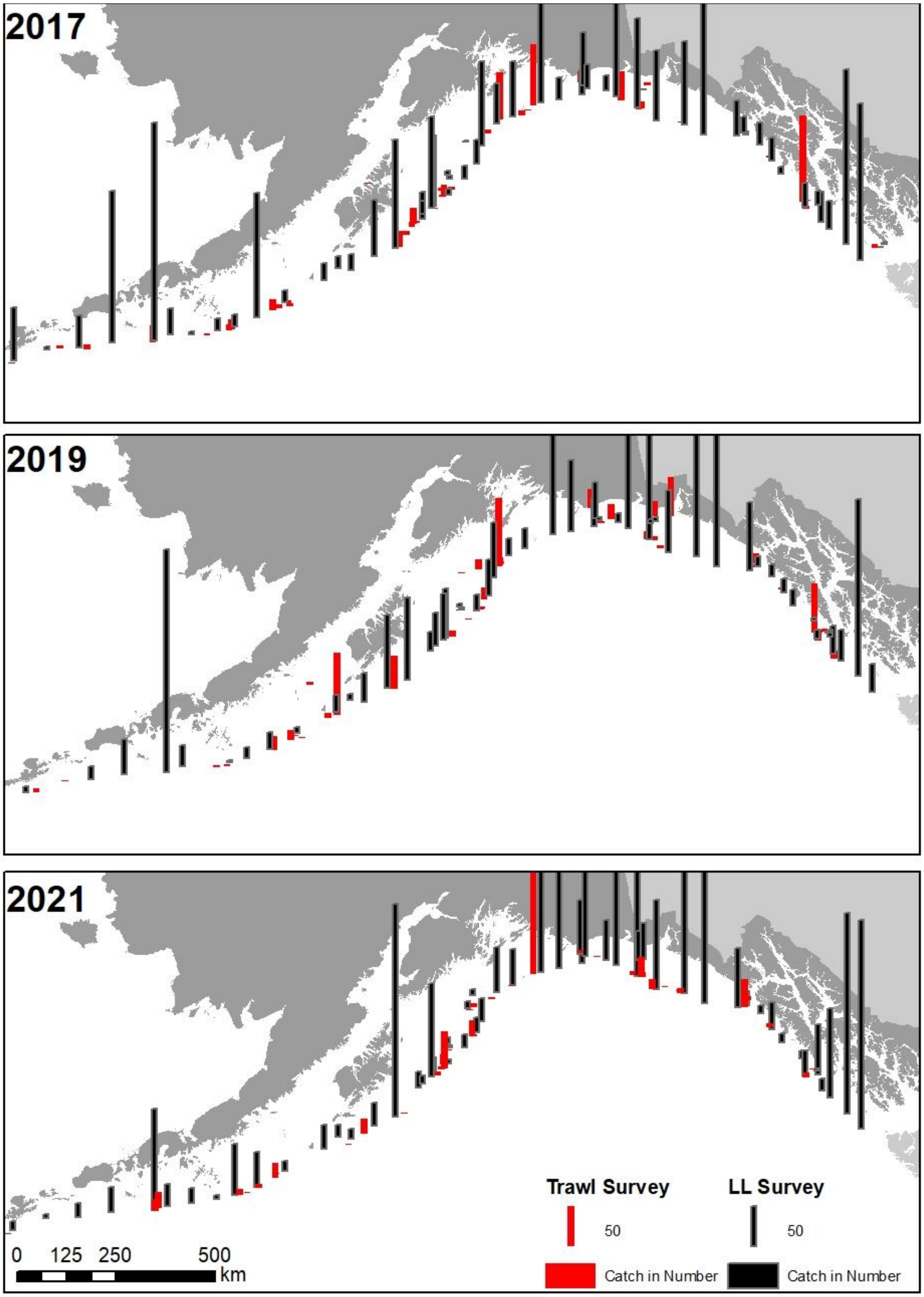
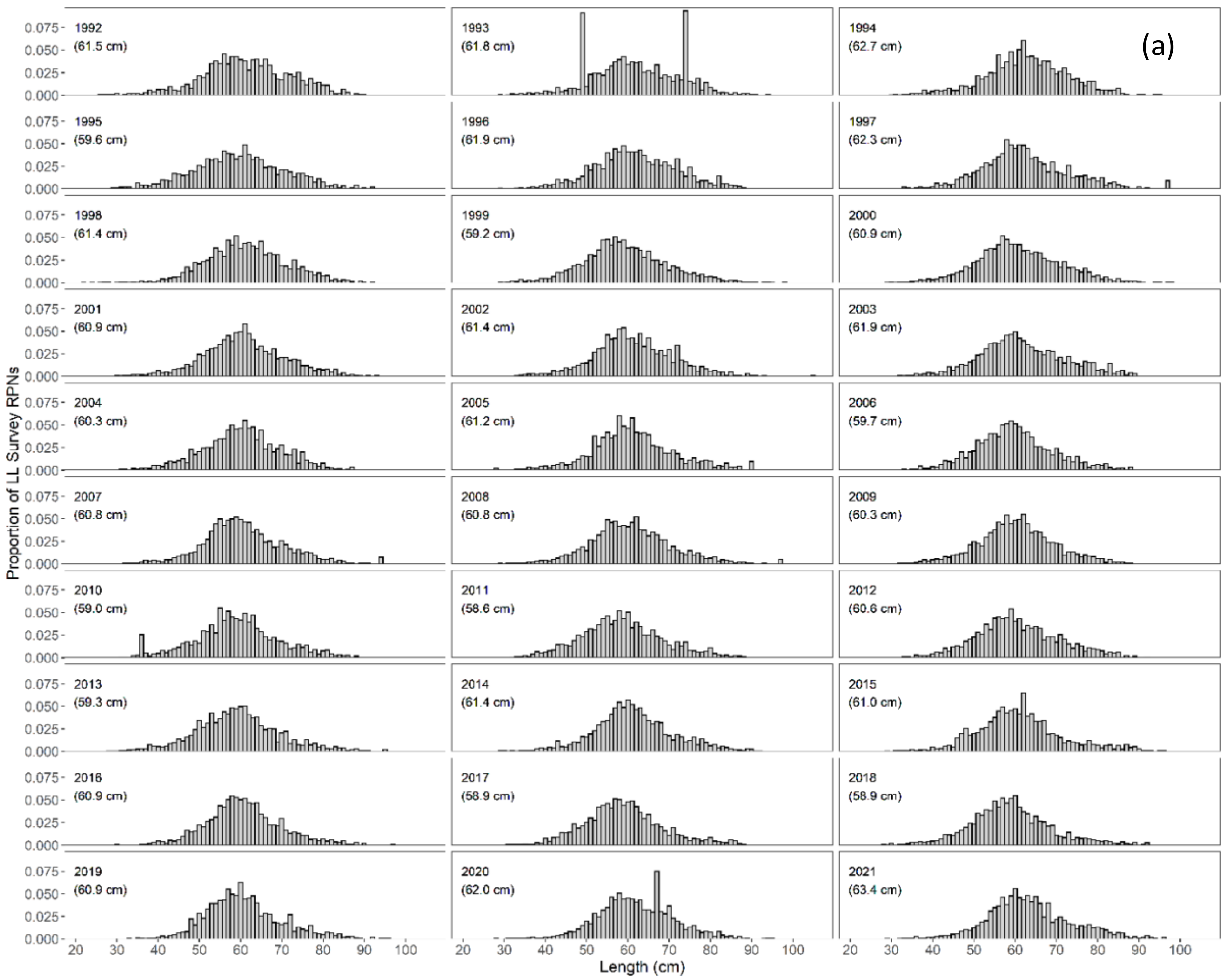


Figure 11-6.--Spatial distribution of shortraker rockfish catches (in number caught) in the Gulf of Alaska during the 2017, 2019, and 2021 NMFS bottom trawl surveys (red bars) and longline surveys (black bars).



(a)
Proportion of LL Survey RPNs
Length (cm)
1992 (61.5 cm)
1993 (61.8 cm)
1994 (62.7 cm)
1995 (59.6 cm)
1996 (61.9 cm)
1997 (62.3 cm)
1998 (61.4 cm)
1999 (59.2 cm)
2000 (60.9 cm)
2001 (60.9 cm)
2002 (61.4 cm)
2003 (61.9 cm)
2004 (60.3 cm)
2005 (61.2 cm)
2006 (59.7 cm)
2007 (60.8 cm)
2008 (60.8 cm)
2009 (60.3 cm)
2010 (59.0 cm)
2011 (58.6 cm)
2012 (60.6 cm)
2013 (59.3 cm)
2014 (61.4 cm)
2015 (61.0 cm)
2016 (60.9 cm)
2017 (58.9 cm)
2018 (58.9 cm)
2019 (60.9 cm)
2020 (62.0 cm)
2021 (63.4 cm)

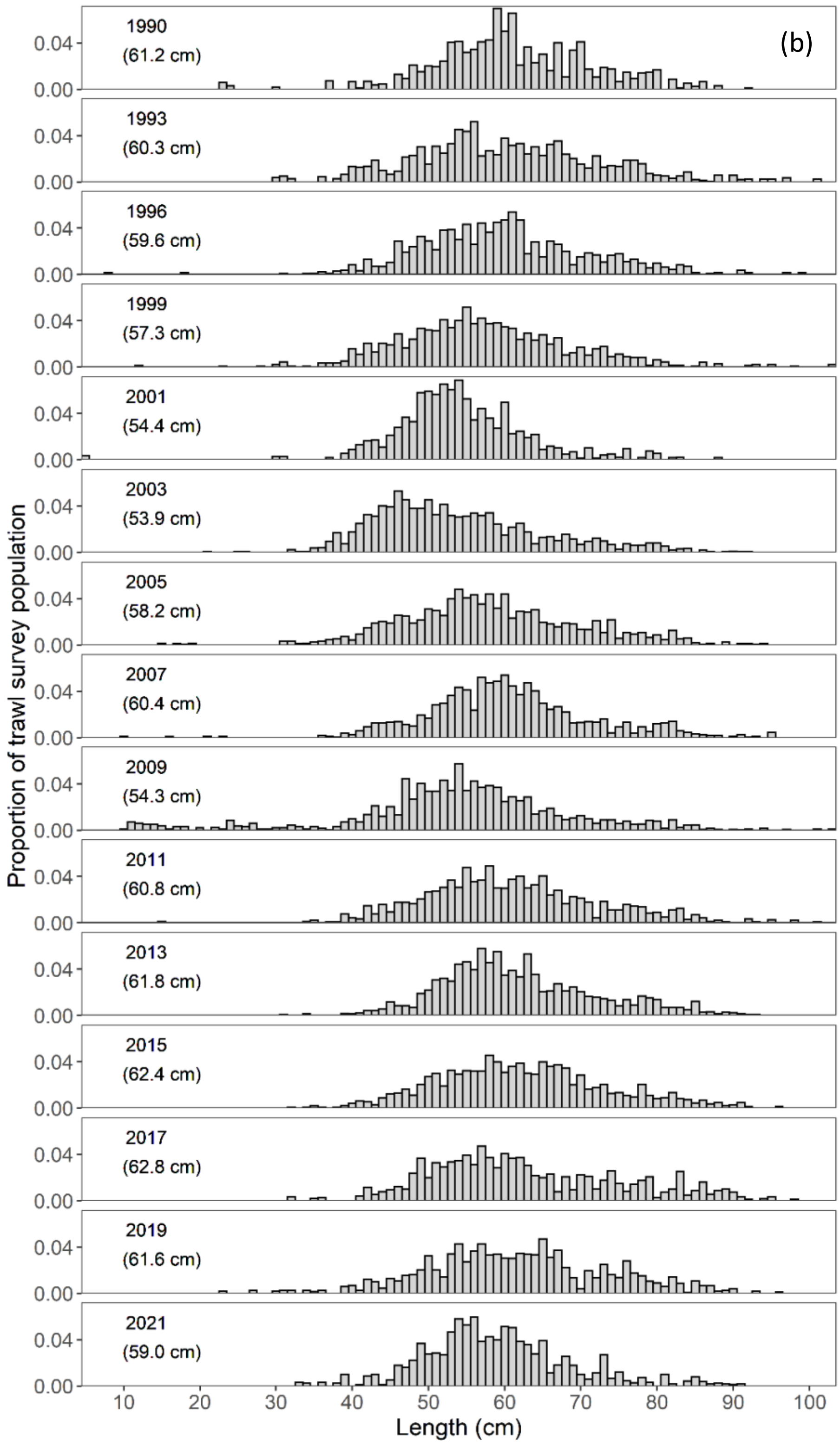


Figure 11-7.--Size composition of the estimated population of shortraker rockfish in the Gulf of Alaska based on lonline surveys (upper panel a) and trawl surveys (lower panel b) conducted between 1990 and 2021.

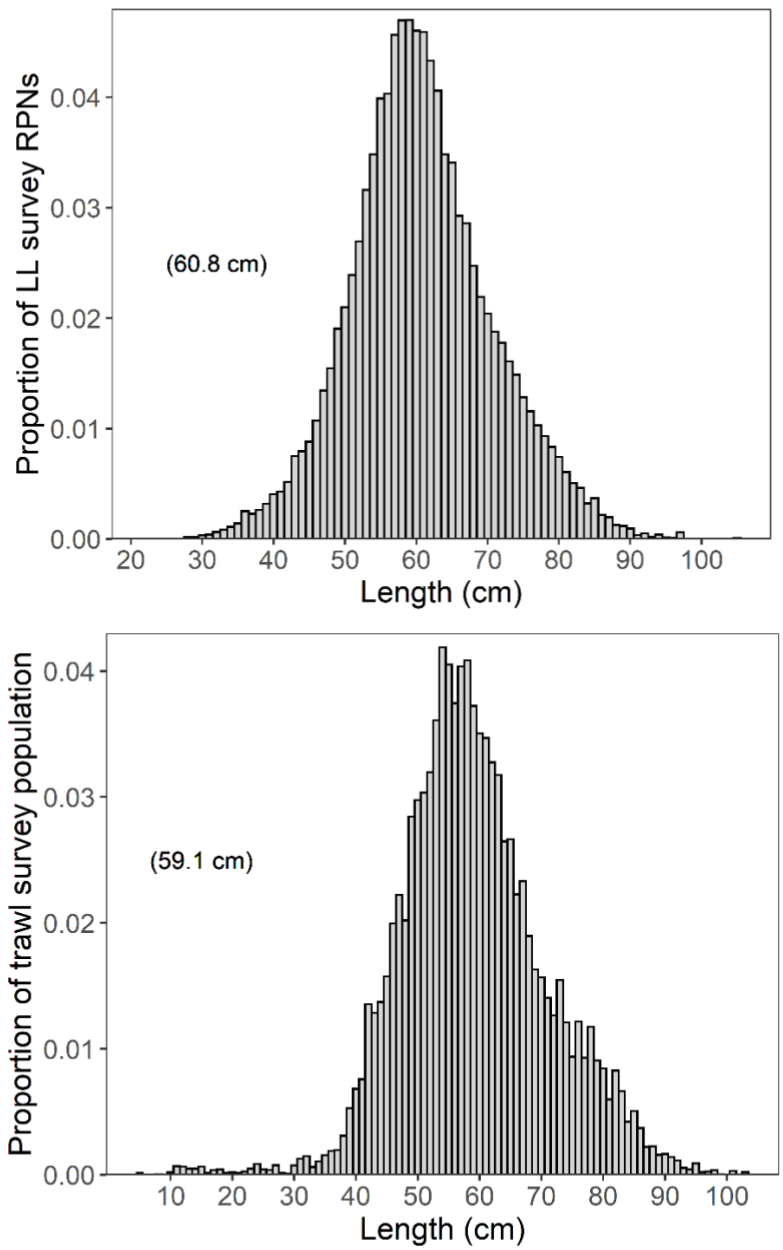


Figure 11-8.--Average length frequency distribution across years of shortraker rockfish caught on the domestic longline survey (top panel) and bottom trawl survey (bottom panel). Note the different axis scales.

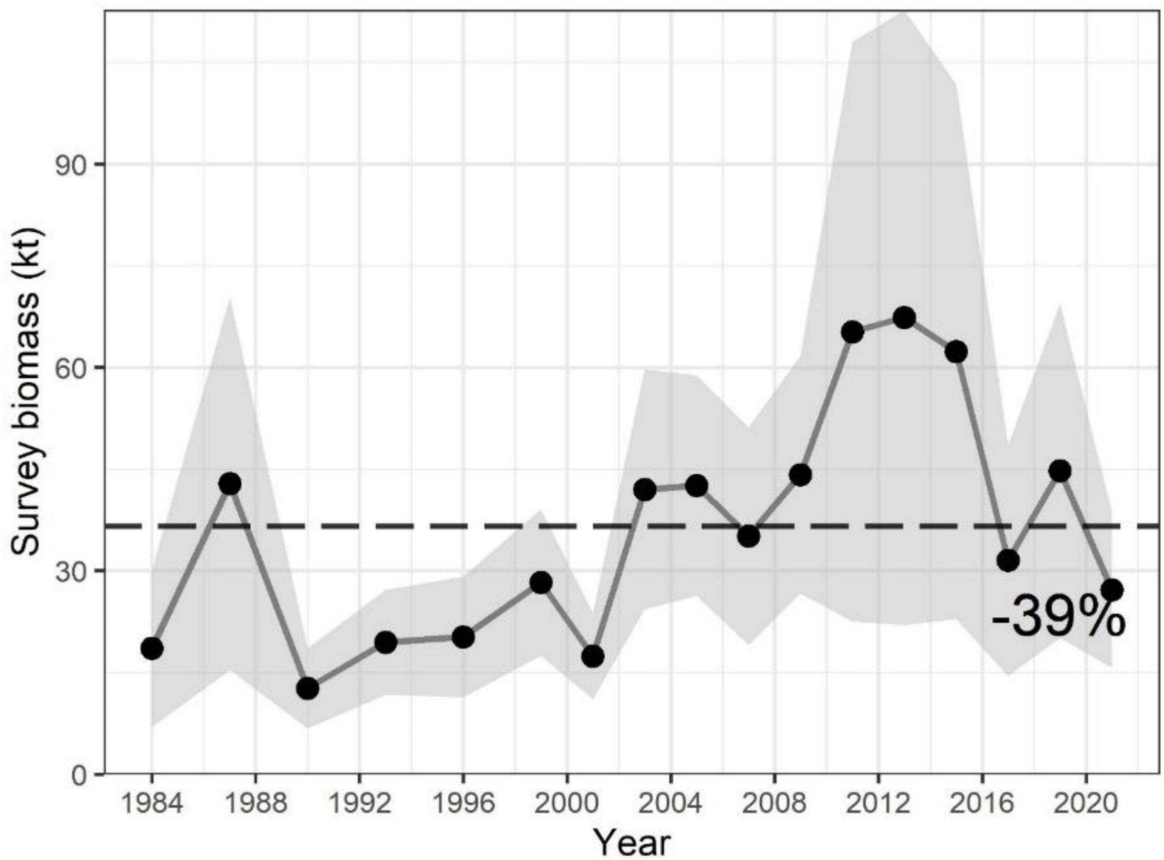


Figure 11-9.-- Estimated biomass (t) of shortraker rockfish in the Gulf of Alaska based on results of bottom trawl surveys from 1984 through 2021 with 95% confidence intervals. Note that the eastern Gulf of Alaska was not sampled in the 2001 survey. Dashed line depicts the histrorical average. The 2021 estimated biomass value is down 39% from 2019.

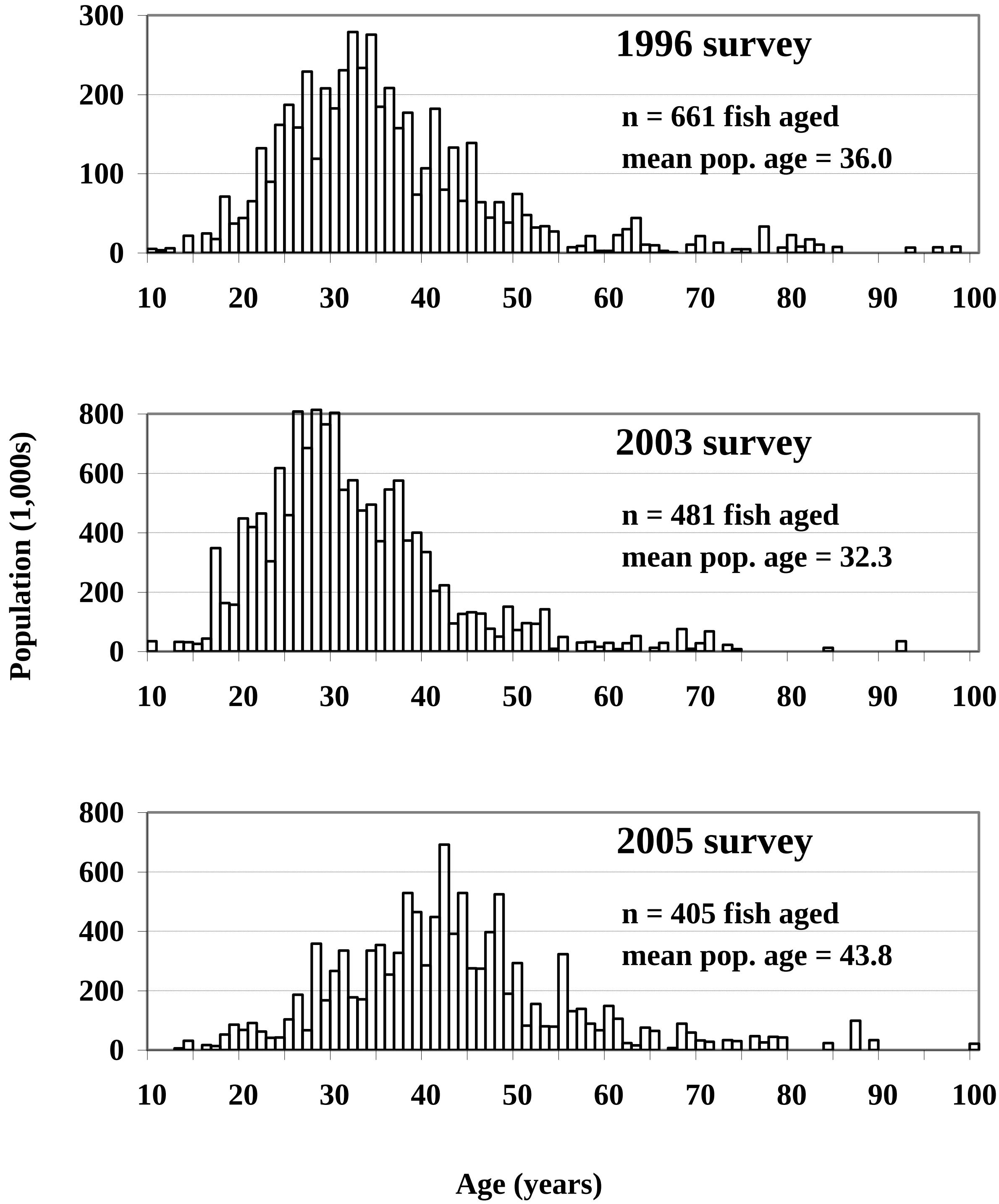


Figure 11-10.--Age composition of the estimated population of shortraker rockfish in the 1996, 2003, and 2005 Gulf of Alaska bottom trawl surveys.

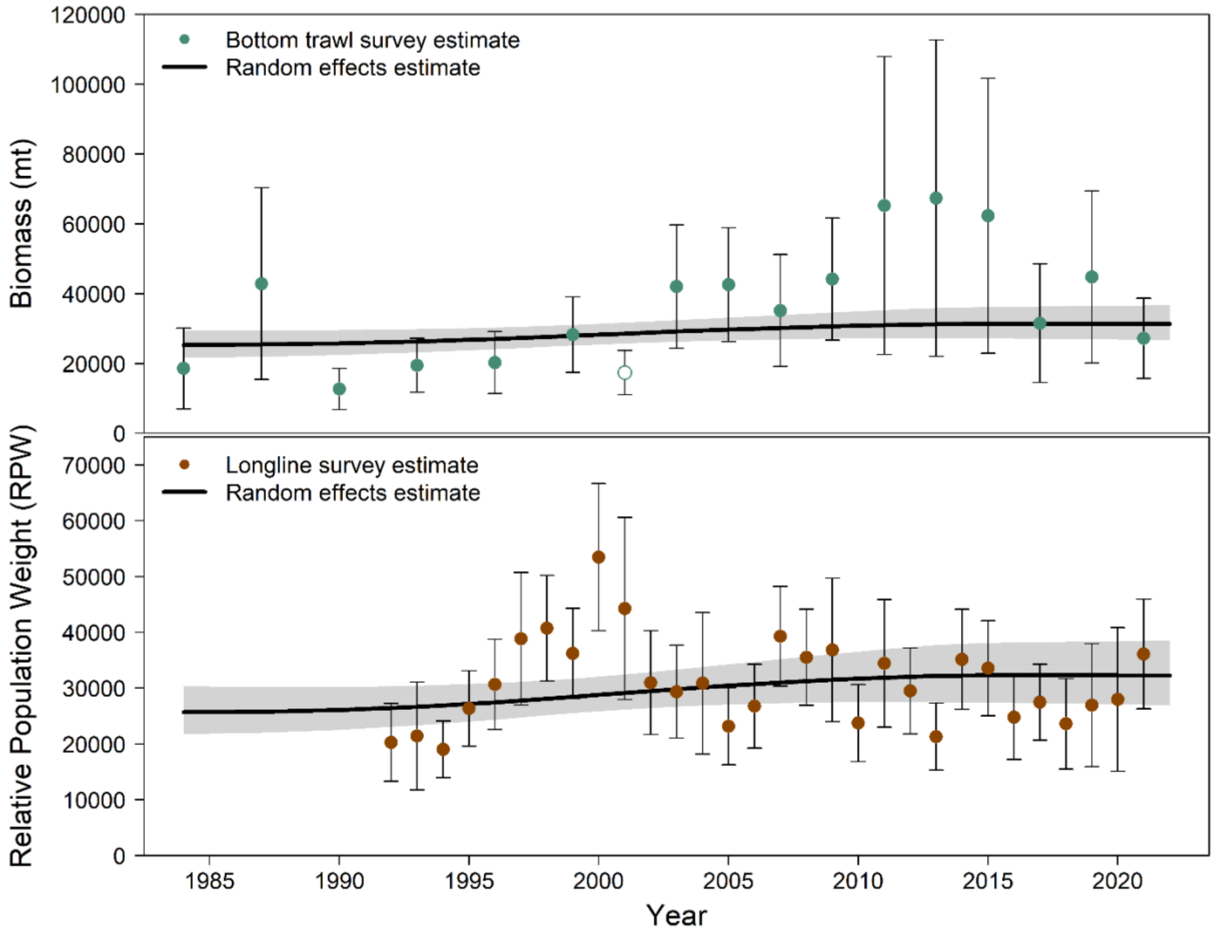


Figure 11-11.--Biomass estimates (t, top panel) of shortraker rockfish from the random effects model (solid black line with 95% confidence interval in grey shaded region) for the AFSC bottom trawl survey (1984-2021, filled circle with error bars for 95% confidence intervals, open circles denotes years with missing regional data), and Relative Population Weight estimates (RPW, lower panel) from the random effects model (solid black line with 95% confidence interval in grey shaded region) for the AFSC longline survey (filled circle with error bars for 95% confidence intervals).

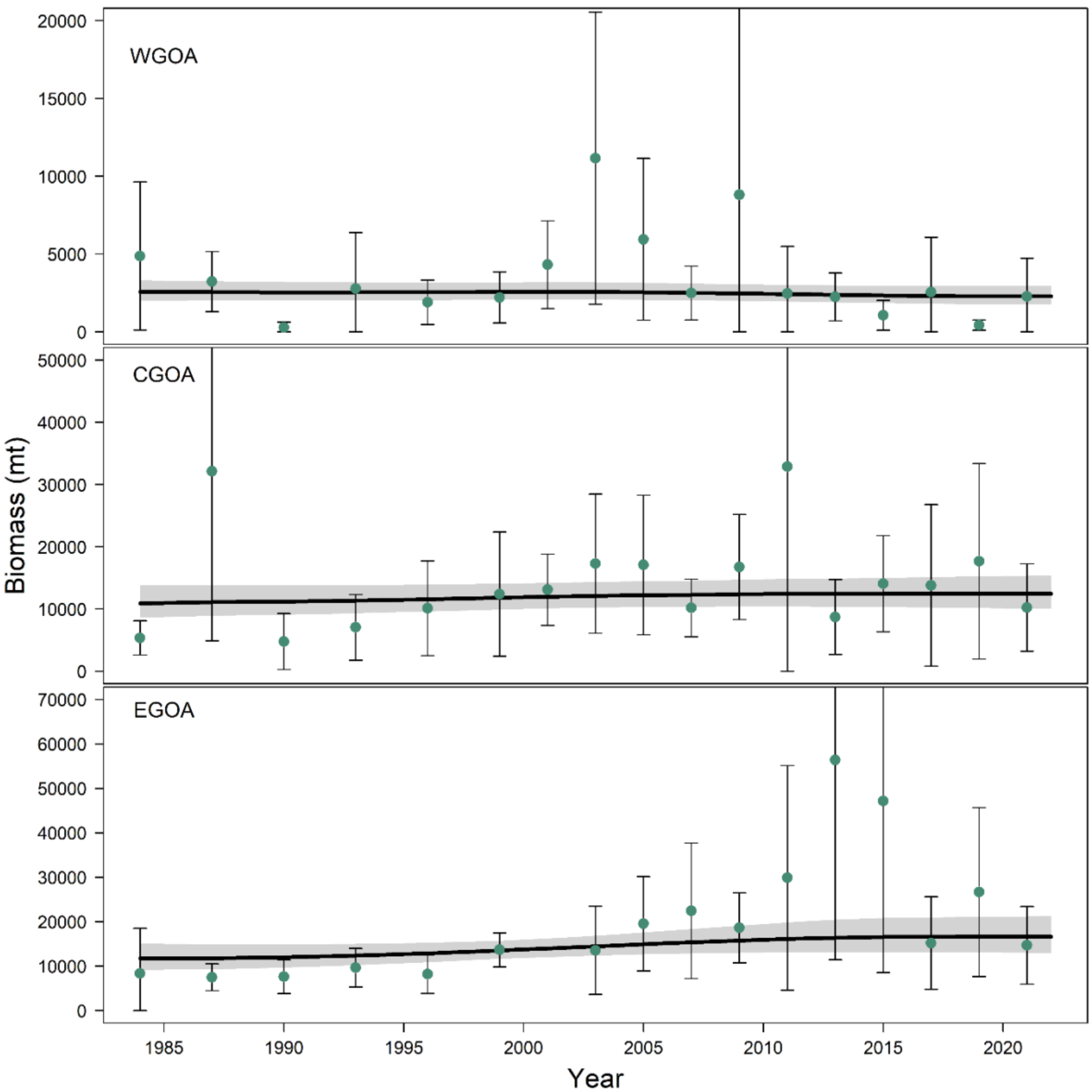


Figure 11-12.--Biomass estimates (t) of shortraker rockfish by area from NMFS bottom trawl surveys (filled circle) and from a random effects model (solid black line with grey region denoting 95% confidence interval) that utilizes trawl survey biomass estimates from all years (1984 – 2021, with 95% sampling error confidence intervals shown with error bars). Top panel is the western Gulf of Alaska (WGOA) Area, middle panel is the central Gulf of Alaska (CGOA) Area, and bottom panel is the eastern Gulf of Alaska (EGOA) Area. Note the different scales between panels on the y-axis.

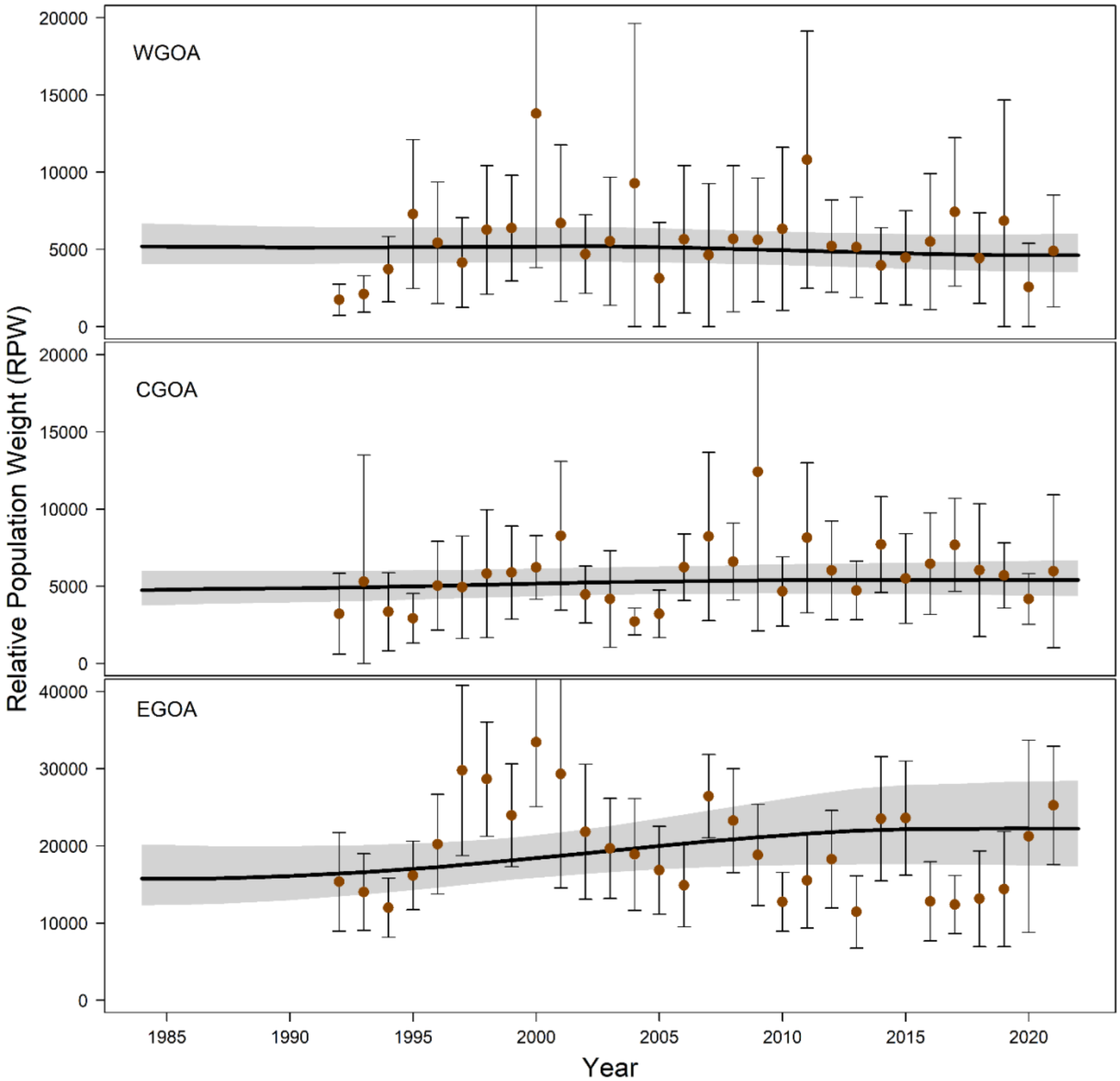


Figure 11-13.--Relative Population Weight (RPW) of shortraker rockfish by area from AFSC longline surveys (1992-2021, filled circle with error bars for the 95% confidence intervals) fit to the recommended random effects model (solid black line with 95% confidence intervals shown in grey shaded region). Top panel is the western Gulf of Alaska (WGOA) Area, middle panel is the central Gulf of Alaska (CGOA) Area, and bottom panel is the eastern Gulf of Alaska (EGOA) Area. Note the different scales between panels on the y-axis.

Appendix 11A – Supplemental Catch Data

In order to comply with the Annual Catch Limit (ACL) requirements, non-commercial removals in the Gulf of Alaska (GOA) are presented. Non-commercial removals are estimated total removals that do not occur during directed groundfish fishing activities (Table 11A-1). 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.

Research catches of shortraker rockfish for the years 1977-2020 are listed in Table 11A-2. Although data are not available for a complete accounting of all research catches, the values in the table indicate that generally these catches have been modest. The one exception is 1999, when a total of almost 110 t was taken, mostly by research trawling. The majority of research removals of shortraker rockfish are taken by the Alaska Fisheries Science Center's (AFSC) annual longline survey and the biennial bottom trawl survey, which are the primary research surveys used for assessing the population status of GOA shortraker rockfish. Other research activities that harvest minor amounts of shortraker rockfish include other trawl research activities conducted by the Alaska Department of Fish and Game (ADFG) and the International Pacific Halibut Commission's (IPHC) longline survey. Recorded recreational harvest or harvest that was non-research related in 2011-2020 have varied between 1 and 6.5 t , surpassing AFSC longline survey research catch for the first time in 2018, and then decreasing again in both 2019 and 2020 to values below 1.5 t. The non-commercial removals show that a little over 14.9 t of shortraker rockfish was taken in 2020 during research cruises and in sport fisheries (Table 11A-1). Nearly equal amounts (between 5 – 6 t) have been taken in longline surveys by either the International Pacific Halibut Commission or the NMFS Alaska Fishery Science Center, and the NMFS trawl survey since 2011. This total was ~3% of the reported commercial catch of 492 t for shortraker rockfish in 2020 (see Table 11-2 in the main document). Therefore, this presents no risk to the stock especially because commercial catches in recent years have been much less than ABCs.

Table 11A-1.--Estimated research and sport catches (t) of shortraker rockfish in the Gulf of Alaska in 2020, based on data provided by the NMFS Alaska Regional Office (AK R.O.). AFSC trawl = NMFS Alaska Fishery Science Center bottom trawl survey; IPHC longline = International Pacific Halibut Commission longline survey; AFSC longline = NMFS Alaska Fishery Science Center longline survey; ADFG PWS = Alaska Department of Fish and Game Prince William Sound sablefish tagging survey.

Source	AFSC trawl	IPHC longline	AFSC longline	ADFG PWS	Sport	Total
AK R.O.	-	7.62	5.95	-	1.36	14.94

Table 11A-2.--Catch (t) of shortraker rockfish taken during NMFS research cruises in the Gulf of Alaska, 1977-2020. Longline data refers only to catches in the AFSC longline survey and does not include the International Pacific Halibut Commission longline survey. (n.a.=not available; tr=trace).

	Gear		
Year	Trawl	Longline	Total
1977	0.1	0.0	0.1
1978	0.6	n.a.	0.6
1979	0.5	n.a.	0.5
1980	1.0	n.a.	1.0
1981	6.2	n.a.	6.2
1982	2.4	n.a.	2.4
1983	0.2	n.a.	0.2
1984	6.8	n.a.	6.8
1985	3.5	n.a.	3.5
1986	0.9	n.a.	0.9
1987	15.5	n.a.	15.5
1988	0.0	n.a.	0.0
1989	0.1	n.a.	0.1
1990	2.4	n.a.	2.4
1991	tr	n.a.	tr
1992	0.1	n.a.	0.1
1993	3.0	n.a.	3.0
1994	0.1	n.a.	0.1
1995	tr	n.a.	tr
1996	4.3	5.9	10.2
1997	0.0	11.1	11.1
1998	20.7	9.7	30.4
1999	101.5	8.1	109.6
2000	0.0	10.0	10.0
2001	1.0	7.1	8.1
2002	0.5	6.1	6.6
2003	4.3	5.5	9.8
2004	0.0	4.7	4.7
2005	4.1	4.5	8.6
2006	0.0	6.0	6.0
2007	4.7	7.9	12.6
2008	0.0	8.4	8.4
2009	8.3	6.7	15.0
2010	0.0	4.2	4.2
2011	4.6	6.7	11.3
2012	0.0	5.3	5.3
2013	5	4.1	9.1
2014	0.0	6.8	6.83
2015	6.1	5.9	12
2016	0.0	5.0	5.0
2017	2.9	5.8	8.7
2018	0.0	5.1	5.1

2019	2.8	5.5	8.3
2020	0.0	5.9	5.9