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

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Executive Summary

Rockfish are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska (GOA) rockfish in alternate (even) years we present an executive summary to recommend harvest levels for the next two years. Please refer to the last full stock assessment report presented in 2015 for further information regarding the assessment calculations (Echave et al. 2015, http://www.afsc.noaa.gov/REFM/Docs/2015/GOAshortraker.pdf). A full stock assessment document with updated assessment results will be presented in next year's SAFE report.

We use a random effects model applied to the GOA trawl survey biomass estimates from 1984-2015 to estimate exploitable biomass and determine the recommended ABC for the shortraker rockfish stock. This stock is classified as a Tier 5 stock. For an off-cycle year, there is no new survey information for the shortraker rockfish stock; therefore, the 2015 estimates (Echave et al. 2015, http://www.afsc.noaa.gov/REFM/Docs/2015/GOAshortraker.pdf) are rolled over for the next year.

Summary of Changes in Assessment Inputs

Changes in the input data: There were no changes made to the assessment inputs since this was an off-cycle year.

Changes in assessment methodology: There were no changes in assessment methodology since this was an off-cycle year.

Summary of Results

For the 2017 fishery, we recommend the maximum allowable ABC of 1,286 t for shortraker rockfish. 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 last year.

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2016	2017	2017	2018
M (natural mortality rate)	0.03	0.03	0.03	0.03
Tier	5	5	5	5
Biomass (t)	57,175	57,175	57,175	57,175
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)	1,715	1,715	**1,715**	1,715
maxABC (t)	1,286	1,286	1,286	1,286
ABC (t)	1,286	1,286	**1,286**	1,286
Status	As determined *last* year for:		As determined *this* year for:	
	2014	2015	2015	2016
Overfishing	No	n/a	No	n/a

Updated catch data (t) for shortraker rockfish in the Gulf of Alaska as of October 9, 2016 (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	Gulfwide Total	Gulfwide ABC	Gulfwide TAC
2015	47	262	269	578	1,323	1,323
2016	47	365	292	704	1,286	1,286

Note that there are overages of allowable catch in both the Western (9 t) and Central (64 t) GOA. The 2016 apportioned ABC for the Western and Central GOA were 38 t and 301 t, respectively. An initial look at 2016 catch by region and fishery show that the pollock fishery in the Central GOA caught nearly 147 t of shortraker rockfish, whereas the average shortraker rockfish catch in the pollock fishery in this region during years 2009 – 2015 was under 2 t. Further discussion of the implications of these overages are addressed in the stock structure template (Appendix 11.A), and will be further investigated in next year's full SAFE report.

Area Apportionment

The following table shows the recommended apportionment for 2017. The apportionment percentages are the same as in the 2015 assessment (for the 2016 fishery). Please refer to the last full stock assessment report for information regarding the apportionment rationale for the shortraker rockfish stock.

	Western	Central	Eastern	Total
Area Apportionment	2.98%	23.4%	73.62%	100%
Area ABC (t)	**38**	**301**	**947**	**1,286**
OFL (t)				**1,715**

Summaries for Plan Team

Species	Year	Biomass[1]	OFL	ABC	TAC	Catch[2]
Shortraker Rockfish	2015	58,797	1,764	1,323	1,323	578
	2016	57,175	1,715	1,286	1,286	704
	2017	57,175	1,715	1,286	1,286	
	2018		*1,715*	*1,286*		

Stock/ Assemblage	Area	2016 OFL	2016 ABC	2016 TAC	2016 Catch[2]	2017 OFL	2017 ABC	2018 OFL	2018 ABC
Shortraker rockfish	W		38	38	47		38		38
	C		301	301	365		301		301
	E		947	947	292		947		947
	Total	1,715	1,286	1,286	704	1,715	1,286	1,715	1,286

[1]Total biomass from trawl survey estimates.

[2]Current as of October 9, 2016. Source: NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database (http://www.akfin.org).

SSC and Plan Team Comments on Assessments in General

Since this is an off-cycle year and only an executive summary is presented, we respond here to priority comments. For comments relevant to or that require a full assessment, we will present responses in next year's full assessment.

"Secondly, a few assessments incorporate multiple indices that could also be used for apportionment. The Team recommends an evaluation on how best to tailor the RE model to accommodate multiple indices." (Plan Team, November 2015)
This will be examined in the next full assessment.

"Finally, an area apportionment approach using the RE model which specifies a common "process error" has been developed and should be considered. This may help in some situations where observation errors are particularly high and/or vary between regions." (Plan Team, November 2015)
This will be examined in the next full assessment.

"The SSC requests that stock assessment authors bookmark their assessment documents and commends those that have already adopted this practice." (SSC, October 2016)
This will be examined in the next full assessment.

SSC and Plan Team Comments Specific to this Assessment

"The Team recommended looking at the sources of shortraker bycatch data. In particular, there appears to be an anomalously high value reported in 2010." (GOA Plan Team, November 2015)
This will be examined in the next full assessment.

"The PT expressed concern about a high bycatch of SR in 2010 and requested the authors examine the sources of bycatch data as well as present gear specific catches by region. The SSC supports these requests." (SSC, December 2015)
This will be examined in the next full assessment.

"The Plan Team recommended that authors present gear specific catch by region and explore incorporating the longline survey RPWs into area apportionment calculations." (GOA Plan Team, November 2015)
This will be examined in the next full assessment.

"The SSC supports the author's and PT's suggestion to explore incorporating the longline survey relative population weight as an additional index for future apportionment." (SSC, December 2015)
This will be examined in the next full assessment.

"The Plan Team recommends exploration of the geospatial estimator used in this year's dusky rockfish assessment as an alternative approach for estimating regional and overall biomass estimate." (GOA Plan Team, November 2015)
This will be examined in the next full assessment.

"The SSC also supports the PT recommendation for exploring the geostatistical GLMM estimator used in this year's dusky rockfish assessment as an alternative method for estimating regional and overall biomass." (SSC, December 2015)
This will be examined in the next full assessment.

*"The Team inventoried completed stock structure documents to date and recommended that the template be completed for shortraker rockfish for November 2016." (*GOA Plan Team, November 2016*)*
The shortraker rockfish stock structure template is included as an appendix in the 2016 shortraker rockfish executive summary.

Literature Cited

Echave, K. B., Hulson, P. J. F., S.K. Shotwell. 2015. Assessment of shortraker rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 975-1012. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501. Available online: http://www.afsc.noaa.gov/REFM/Docs/2015/GOAshortraker.pdf

Appendix 11.A Evaluation of stock structure for Gulf of Alaska Shortraker Rockfish

Executive Summary

We present various types of information on Gulf of Alaska (GOA) shortraker rockfish to evaluate potential stock structure for this species. We follow the stock structure template recommended by the Stock Structure Working Group (SSWG) and elaborate on each category within this framework. Available data are consistent with population structure by large management areas of Eastern, Central, and Western GOA defined by fishery and survey sampling. Harvest and trend data indicate population levels are stable and that fishing effort, is for the most part, consistent with abundance distribution. Shortraker rockfish are long-lived and have a long generation time. They are rather evenly distributed but there is little information regarding spawning, reproduction, larval dispersal, behavior, or movement. Length-weight relationships are similar among regions in the GOA. Little genetic information is available to infer any genetic stock structure components that might exist.

Currently, GOA shortraker rockfish is managed as a Tier 5 species with area-specific Acceptable Biological Catch (ABC) and gulf-wide Overfishing Level (OFL). Given that ABCs are set a 0.75 of a very low natural mortality rate, and shortraker rockfish catches are less than 42% of the gulf-wide OFL, the risk of overfishing is low. We continue to recommend the current management specifications for shortraker rockfish.

Introduction

The Stock Structure Working Group (SSWG) was formed in 2009 to develop a set of guidelines to assist stock assessment authors in providing recommendations on stock structure for Alaska stocks. The framework was presented at the September 2009 joint Groundfish Plan Team and a report was drafted shortly thereafter that included a template for presenting various scientific data for inferring stock structure. In November, 2010, the Gulf of Alaska Groundfish Plan Team (GOA GPT) discussed the advantages of having all stock assessment authors evaluate stock structure characteristics of specific stocks. Subsequently, the GOA GPT recommended that the shortraker rockfish template be completed for the November 2016 NPFMC Plan Team meeting.

Shortraker rockfish, *Sebastes borealis*, is managed as a Tier 5 species with area-specific ABC and gulf-wide OFL recommendations. Included here is a summary of what is known regarding the population of shortraker rockfish in the GOA relevant to stock structure concerns along with an evaluation of the stock structure template, author recommendations, and potential management implications to be considered. The majority of this information is excerpted from the most recent full stock assessment and can be found in more detail there (Echave *et al.* 2015).

Distribution

Shortraker rockfish ranges 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. Its center of abundance appears to be Alaska 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 *et al*. 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).

Life History

Life history information on shortraker rockfish is extremely sparse. The fish are presumed to be viviparous, as are other *Sebastes*, 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). There is no information on when males inseminate females or if migrations occur for spawning/breeding. Genetic techniques have been used recently 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 upper 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 (Clausen and Fujioka 2007). Shortraker rockfish attains the largest size of all *Sebastes*, with a maximum reported total length of 120 cm (Mecklenburg *et al*. 2002).

Fishery

Since the mid-1990s, directed fishing has not been allowed for shortraker rockfish in the GOA, and the fish can only be retained as “incidentally-caught” species. Therefore the description of the fishery is that of a bycatch only fishery and does not reflect targeted fishing behavior. Shortraker rockfish can be caught with both trawls and longlines: each gear type has comprised about half the annual catch since 2004. Shortraker rockfish have been taken mostly in fisheries targeting rockfish, sablefish, and Pacific halibut, with lesser amounts taken in the walleye pollock and other groundfish fisheries. Since 2004, 47% of shortraker rockfish catch has occurred during trips targeting rockfish, 41% during sablefish trips, and 6% each in flatfish and pollock directed trips.

Since becoming its own management category in 2005, Gulfwide catches of shortraker rockfish have averaged between ~450 – 750 t (Figure 1). The Central and Eastern GOA are the highest

reporting regions of shortraker rockfish catch. Gulfwide annual catch has always been much less than the gulf-wide ABC. However, catch in both the Central and Western GOA are currently over their allotted ABCs for 2016 (Figure 1). Historically, catch in the Central GOA has never shown any danger of exceeding the ABC. Catch and ABC in this region both increased from 2010 to 2013, and decreased from 2013 to 2015. In 2015, however, catch and ABC exhibited opposite trends: ABC decreased dramatically while catch increased. At this point, it is unclear if biomass is in fact decreasing in the Central GOA, or if the trawl survey isn't accurately surveying this species in this area. Additionally, the pollock fleet caught 147 t of shortraker rockfish in the Central GOA in 2016 (as of Oct. 9, 2016), while their average catch had been 2 t during years 2009 – 2015. While catch in both the Eastern and Central GOA regions have generally remained well below their harvest allocation (except for the previously mentioned 2016 catch in the Central GOA), catch in the Western GOA has historically tracked the region's ABC closely, or has slightly exceeded it (Figure 1). The recent overages (2015 and 2016) in the Western GOA are likely due to the decrease in ABC resulting from the trawl survey not accurately surveying this species in this area, and not because of any change in fishing behavior. Catch in this region follow the survey data. In 1998, Amendment 41 was passed which had important management implications for shortraker rockfish as it prohibited trawling in the Eastern GOA east of 140 degrees W. longitude. As a result, catch of shortraker rockfish has decreased in the East Yakutat/Southeast Outside area, an area where this species is abundant.

Survey

Standard bottom trawl and longline surveys conducted by the AFSC provide much of the information about shortraker rockfish. Each survey captures a different element of the population. The AFSC trawl survey (tri/biennial) stations cover the entire GOA from the nearshore to the shelf break (500-1000 m) and are distributed based on a stratified random sampling design but is designed as a multi-species survey. The standard bottom trawl surveys in the GOA provide estimates of absolute abundance (biomass) for setting harvest levels, population length and age compositions, and spatial distribution information. 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 they may not be showing a true picture of abundance or abundance trends. In addition, there have been fewer hauls allocated to these deep strata because of survey priorities and design. Comparative biomass estimates for the 14 bottom trawl surveys conducted have sometimes shown large fluctuations between surveys (Figure 2a). However, the biomass estimates for shortraker rockfish have historically shown relatively moderate confidence intervals (Figure 2a) that have usually overlapped, and low coefficient of variations (CVs) ranging between 16% and 34%. The low CVs are an indication of the generally even distribution of shortraker rockfish (Figure 3). On a geographical basis, the Eastern and Central Gulf regions have the highest biomass of shortraker biomass whereas the lowest estimates are in the Western Gulf region. Trawl survey data show that the Western GOA biomass estimates have been decreasing since 2009, while both the Central and Eastern GOA estimates increased significantly between 2007 and 2011, and then the Central GOA showed a sharp decline while the Eastern GOA continued to increase (Figure 4a).

Alternatively, the AFSC domestic longline survey (annual) in the GOA effectively samples stations that are systematically distributed along the upper continental slope and various gullies inhabited by shortraker rockfish, and provides supplementary information including estimates of relative abundance and spatial distribution. The longline survey is primarily directed at sablefish, but considerable numbers of shortraker rockfish are also caught. Results concerning rockfish on the longline survey, however, should be viewed with some caution, as the relative population weights (RPW) do not take into account possible effects of competition for hooks with other species caught on the longline, especially sablefish. However, the depth strata where sablefish are most abundant are deeper than the depth strata that shortraker are the most abundant. Definite trends in these data over the years are difficult to discern, and the Gulfwide values of relative abundance sometimes fluctuate considerably between adjacent years (Figure 2b). Unlike the trawl survey, the Western and Central GOA have historically displayed similar RPW values, while the Eastern GOA RPW estimates have always been significantly higher (Figure 4b). Western and Central GOA RPW estimates have generally remained steady, while the Eastern GOA estimates show large annual fluctuations, most recently with a large decrease.

We compare gulfwide trawl survey biomass estimates with longline survey RPW estimates in Figure 1. While these data aren't directly comparable due to the nature of the data collection and calculation of these values, it is possible to discern trends over time. It is thought that each survey captures a different element of the population, and by looking at data from both surveys, one may be able to track potential abundance trends throughout a larger span of the life history of shortraker rockfish, as well recognize potential concerns. In the future, the longline survey will be explored to be used with the trawl survey to account for the poor sampling and untrawlable or deeper water habitat (Shotwell *et al.* 2015).

Management

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 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 and TAC, 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. Beginning in 2015, methodology for determining current exploitable biomass that is used to calculate the ABC and OFL values changed from calculating the average of the last three trawl survey biomass estimates to the use of a random effects model, which utilizes trawl survey data from 1984-2015 to estimate the exploitable biomass.

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 Gulf of Alaska. This apportionment is to disperse the catch across the Gulf and prevent possible depletion in one area. The OFL (Overfishing Limit) is not apportioned to area but instead set at a gulf-wide level.

Application of Stock Structure Template

To address stock structure concerns, we utilize the existing framework for defining spatial management units introduced by Spencer et al. (2010) (Table 1). In the following sections, we elaborate on the available information used to respond to specific factors and criterion for defining shortraker rockfish stock structure.

Harvest and trends

Fishing mortality

Shortraker rockfish are Tier 5, thus a fishing mortality rate (*F*) is difficult to estimate. Directed fishing is not allowed for shortraker rockfish in the GOA, and the fish can only be retained as "incidentally-caught" species. Gulfwide discard rates (% of the total catch discarded within a management category) of shortraker rockfish have ranged between 16% and 44%. Discard mortality is assumed to be 100%, and thus all catch is considered mortality in the assessment. These catch estimates do not incorporate removals from sources other than federal groundfish fisheries, such as research catch, or unobserved fisheries (i.e. state-managed commercial and sport fisheries).

Population trends

Gulfwide biomass estimates for shortraker rockfish provided by the trawl surveys are highly variable, sometimes showing rather large fluctuations between surveys. For example, gulfwide biomass was 42,851 t in 1987 and then decreased to 12,681 t in 1990, and estimated biomass in the Yakutat Area increased from 22,561 t in 2011 to 49,374 t in 2013 (Echave *et al.* 2015). Shortraker rockfish are a long lived species, however, and an actual increase in abundance would not be seen in such a short time period. While the trawl survey may not sample this species well, trend information may still be inferred. While there has been a general upward trend in gulfwide biomass estimates since 1990, the estimated biomass in the Western Gulf and Central Gulf regions has been trending down since 2009 and 2011, respectively. The Central GOA did see a slight increase in 2015, however (Figure 4a).

Gulfwide relative abundance estimates (RPWs) for shortraker rockfish provided by the longline surveys are highly variable as well. Unlike the trawl survey, RPWs have remained rather steady in the Western and Central GOA on the longline survey since 2011, with a slight increases in 2016 (Figure 4b). RPW estimates for the Eastern GOA are highly variable from year to year, most recently showing a large decrease (Figure 4b).

Spatial overlap of fishery and survey data

We utilized the observed trawl fishery catch and trawl survey data to generate a series of spatial distribution maps of shortraker rockfish concentrations. We developed maps of mean conditions to identify long-term patterns in shortraker rockfish distribution (Figure 5). In order to compare the trawl survey and the trawl fishery data on the same map, we created an interpolated raster image of the trawl survey data from 1984-2015 (Figure 5a). The trawl survey provided the most complete spatial coverage and weight estimates were available by haul. We then calculated mean trawl fishery catches by aggregating the observed trawl fishery data in a raster image and converting the centroids of each raster cell to points. Observed fishery data was available from 1993-2015. Based on survey data, shortraker rockfish are rather evenly spread in a band along the continental slope, and not unexpectedly, display areas of high aggregations near gully entrances: the Shumagin Gully in the Western GOA, Amatuli and "Associated" Gullies in the Central GOA (shelf region southwest of Prince William Sound), the W-Grounds (shelf region south and east of

Prince William Sound) in the Eastern GOA, and Yakutat Valley in the Eastern GOA. In general, the mean catches for the observed trawl fishery are primarily distributed throughout a narrow band along the continental slope in the Central GOA. There is not as much effort in the EGOA, but high catch is evident around Yakutat Valley (Figure 5b). Similar to the trawl survey, there are higher concentrations of catch around Amatuli and "Associated" Gullies. Unlike the trawl survey, trawl fishery catch data show little catch in the W-Grounds.

Because shortraker rockfish can inhabit areas that are both trawlable and untrawlable by survey gear, and are evenly caught on both trawl and longline gear in the observed fisheries, we also considered the spatial distribution of shortraker rockfish caught on the longline survey. Following the same methodology described above, we first created an interpolated raster image of the average number of shortraker rockfish caught at each station from longline survey data during 1993-2016 (Figure 6a). We then overlaid the calculated mean longline fishery catches (1993 – 2015) over the longline survey data (Figure 6b). Similar to the trawl survey, the longline survey means show highest abundance in the Eastern GOA, particularly the West Yakutat area of the Eastern GOA. The longline survey also appears to better survey shortraker rockfish in the Western GOA. Longline fishery catch matches survey catch distribution. Trawl and longline survey abundance trends differ slightly in the Central GOA. While trawl survey data show high abundance around Amatuli and "Associated" Gullies, longline survey data show high abundance in the Albatross Bank area.

Finally, in order to provide a direct visual comparison of the spatial distribution of shortraker catch between the two surveys, we mapped catch in number from both the trawl and longline surveys in 2015, with 2015 observed fishery catch overlaid (Figure 7). Figure 7 shows that in general, both of the surveys display similar abundance and spatial trends: highest abundance in the Eastern GOA, particularly the West Yakutat area of the Eastern GOA, and lowest abundance in the Western GOA. The majority of observed fishery catch in 2015 was in the Central GOA, and it appears that neither survey showed the usual high abundance in the Amatuli Gully area, where the highest fishery catches of 2015 occurred. However, survey distribution and fishery effort are similar gulfwide.

Barriers and phenotypic characters

Generation time

Rockfish in the GOA are typically slow growing and long-lived. The two reported values for maximum age of shortaker rockfish in the GOA are 146 and 157, making this species one of the longest-lived of all fishes (Munk 2001, Echave *et al.* 2015). Estimates of natural mortality range from 0.027 to 0.042 (McDermott 1994).While we are unable to estimate generation time for shortraker rockfish, a similar species in maximum age and natural mortality is the rougheye rockfish, which has an estimated generation time of 52 years (Shotwell *et al.* 2015).

Physical limitations

General circulation patterns of the GOA are well documented. However, how these interact on small spatial scales in association with bathymetric features is largely unknown. In addition, larval and post-larval distribution of shortraker rockfish is poorly understood so interpreting physical limitations are difficult. Abundance of shortraker rockfish is lowest in the Western GOA, and highest in the Eastern GOA followed by the Central GOA, but what determines these abundances is unknown in regards to physical limitations.

Growth differences

Shortraker rockfish are generally larger in the Eastern GOA (Figure 8; e.g., Martin and Clausen 1995; Martin 1997; von Szalay *et al.* 2008 and 2010), however, length-weight relationships are

similar across regions. There is insufficient age data to evaluate growth at age differences in shortraker rockfish by management region. In addition, the limited age data available has only been partially validated.

Age/size structure

The best available knowledge on the age and size structure of shortraker rockfish in the GOA comes from bottom trawl survey data. Survey size and age compositions suggest that recruitment of shortraker rockfish is a relatively infrequent event and highly variable with magnitudes of difference large enough to drive the composition of the population. Mean population length over time has ranged from 53.9 cm to 62.5 cm (Echave *et al.* 2015).

Shortraker rockfish have long been considered among the most difficult rockfish species to age. An unvalidated aging methodology was used to determine the age compositions of shortraker rockfish from the 1996, 2003, and 2005 GOA trawl surveys. 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; Echave *et al.* 2015). At this time, production aging has been suspended for shortraker rockfish. Due to the high variability in recruitment events it is uncertain if there has been size or age truncation in this population or if there are significant differences among regions.

Spawning time differences

Life history information on shortraker rockfish is extremely sparse. The fish are presumed to be viviparous, as are other *Sebastes*, 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). There is no information on when males inseminate females or if migrations occur for spawning/breeding. Genetic techniques have been used recently 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).

Maturity-at age/length differences

McDermott (1994) determined that size-at-50% maturity for female shortraker rockfish was 44.9 cm based on samples collected in several regions of the northeast Pacific, including the Gulf of Alaska. 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 size-of-maturity to an age-at-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. Sufficient data for comparison of maturity at age or length among regions or through time is not available.

Morphometrics

Regional variation in morphometrics measurements have not been studied for this species.

Meristics

Regional variation in meristics have not been studied for this species.

Behavior and movement

Spawning site fidelity

Little is known regarding the spawning habits of shortraker rockfish in the GOA. There is no information on when males inseminate females or if migrations occur for spawning/breeding. Harvest or catch data from this time period (fall/winter) is sparse from fisheries or surveys so annual distribution changes are difficult to detect.

Mark-recapture data

Because rockfish are physoclistic and subject to barotrauma there is little information regarding movement studies of deep-water rockfish. Promising results for tagging rougheye rockfish indicates that tagging of shortraker rockfish may be possible in the future (Rodgveller *et al.* in press).

Natural tags

No studies have addressed otolith microchemistry of shortraker rockfish in the GOA. Parasite infestation has been used as a natural occurring tag in some rockfish species in the GOA (Moles *et al.* 1998). However, no studies have addressed parasite tags in shortraker rockfish.

Genetics

Genetic studies of shortraker rockfish have indicated evidence of fine scale population structure in the GOA under different scenarios of groupings of samples. The most efficient partitioning scheme of the samples formed three groups (Southeast Alaska, Northern Southeast and CGOA, and Kodiak to Western AI, [Gharrett *et al.* 2003; Matala *et al.* 2004]). Although not conclusive, the genetic studies do not support Orlov's theory of extensive migrations for shortraker rockfish, but initially show less genetic structure than POP, rougheye or blackspotted rockfish. Additional research is needed to better define this structure.

Factors and criterion specific to genetics of shortraker rockfish are:

Isolation by distance

No significant isolation by distance (Matala *et al.* 2004)

Dispersal distance

Not Available

Pairwise genetic differences

Not significant (Cockerham's theta, Matala *et al.* 2004)

Summary, Implications, and Recommendations

We summarized the available information on stock structure for shortraker rockfish in the GOA in Table 2. Even with recent ABC overages in the Western and Central GOA, harvest and trend data indicate population levels are stable and that gulfwide fishing mortality in recent years is below maximum permissible *F*. Since ABCs are set at 0.75 of a very low natural mortality rate, a small overage in a given year is still a very small fraction of the population, so it is probably useful to examine a longer time horizon than one or two years. Fishery effort matches survey catch distribution when looking at both trawl and longline survey data combined (Figures 5 and 6). While the trawl survey may likely be unable to accurately sample the entire habitat of this species, including longline survey data provides a more complete spatial distribution of this species. Trawl survey catch appears to be focused in smaller spatial areas (gully entrances), and longline survey catch captures more of the slope inhabited fish. Fishing is broadly spread throughout a narrow band along the continental slope, with a few smaller spatial areas displaying higher catch (Amatuli Gully). Distribution of effort appears to be consistent with abundance.

Typical of *Sebastes* species, shortraker rockfish are long-lived and have a long generation time. Little information is available regarding reproduction and mechanisms responsible for larval dispersion but shortraker rockfish are found throughout the GOA in varying levels of abundance. Growth differences (length-weight) among regions in the GOA are insignificant, but there has been evidence of regional differences in size compositions (Figure 8). Behavior and movement information for most *Sebastes* species is lacking in the GOA. No information is available regarding spawning movements or inter-annual movement. Genetic studies of shortraker rockfish 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.

The current management regime apportions the stock and catch into three large geographical regions. Survey and fishery information indicates that abundance levels differ among the regions. Mixing and dispersal of fish among areas is unknown; therefore the capacity of the population for repopulating small spatial areas is unknown. The most efficient partitioning of population structure from the available genetic samples corresponded roughly to the current spatial structure of area-specific ABCs. Shortraker rockfish are of concern due to their apparent concentration in narrow depth band along the continental slope, but they have a relatively even distribution, and no available data indicates that stock structure is at risk under the current management regime.

Current management practices apportion ABC by management area but use a gulf-wide OFL. Shortraker rockfish catches in the GOA are near 56% of maximum permissible and risk of overfishing is low, however, the ABC has been exceeded in the Western GOA since 2015 and in the Central GOA in 2016. The estimated amount of shortraker rockfish biomass from the trawl survey in the Western GOA decreased by 59%, and by 24% in the Central GOA, from 2013 to 2015. Reasons for this decrease are unknown, but due to the previously stated concerns over the accuracy of the trawl survey to sample this species, these overages may not be a conservation concern. Shortraker rockfish are more abundant on the longline survey in the Western GOA than the trawl survey, and the spatial distribution of survey abundance matches fishery effort. Based on available data, initiating area-specific OFL's is not recommended as there are multiple levels of precaution built into the current management recommendations and overharvest is unlikely. Given the available evidence on GOA shortraker rockfish stock structure, the current resolution of spatial management is likely adequate and consistent with management goals.

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Tables

Table 1. Framework of types of information to consider when defining spatial management units (from Spencer *et al.* 2010).

Factor and criterion	Justification
Harvest and trends	
Fishing mortality (5-year average percent of F_{abc} or F_{ofl})	If this value is low, then conservation concern is low
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	If fishing is focused on very small areas due to patchiness or convenience, localized depletion could be a problem.
Population trends (Different areas show different trend directions)	Differing population trends reflect demographic independence that could be caused by different productivities, adaptive selection, differing fishing pressure, or better recruitment conditions
Barriers and phenotypic characters	
Generation time (e.g., >10 years)	If generation time is long, the population recovery from overharvest will be increased.
Physical limitations (Clear physical inhibitors to movement)	Sessile organism; physical barriers to dispersal such as strong oceanographic currents or fjord stocks
Growth differences (Significantly different LAA, WAA, or LW parameters)	Temporally stable differences in growth could be a result of either short term genetic selection from fishing, local environmental influences, or longer-term adaptive genetic change.
Age/size-structure (Significantly different size/age compositions)	Differing recruitment by area could manifest in different age/size compositions. This could be caused by different spawning times, local conditions, or a phenotypic response to genetic adaptation.
Spawning time differences (Significantly different mean time of spawning)	Differences in spawning time could be a result of local environmental conditions, but indicate isolated spawning stocks.
Maturity-at-age/length differences (Significantly different mean maturity-at-age/ length)	Temporally stable differences in maturity-at-age could be a result of fishing mortality, environmental conditions, or adaptive genetic change.
Morphometrics (Field identifiable characters)	Identifiable physical attributes may indicate underlying genotypic variation or adaptive selection. Mixed stocks w/ different reproductive timing would need to be field identified to quantify abundance and catch
Meristics (Minimally overlapping differences in counts)	Differences in counts such as gillrakers suggest different environments during early life stages.
Behavior & movement	
Spawning site fidelity (Spawning individuals occur in same location consistently)	Primary indicator of limited dispersal or homing
Mark-recapture data (Tagging data may show limited movement)	If tag returns indicate large movements and spawning of fish among spawning grounds, this would suggest panmixia
Natural tags (Acquired tags may show movement smaller than management areas)	Otolith microchemistry and parasites can indicate natal origins, showing amount of dispersal
Genetics	
Isolation by distance (Significant regression)	Indicator of limited dispersal within a continuous population
Dispersal distance (<<Management areas)	Genetic data can be used to corroborate or refute movement from tagging data. If conflicting, resolution between sources is needed.
Pairwise genetic differences (Significant differences between geographically distinct collections)	Indicates reproductive isolation.

Table 2. Summary of available data on stock structure evaluation of GOA shortraker rockfish. Template from Spencer *et al.* 2010.

Factor and criterion	Justification
Harvest and trends	
Fishing mortality (5-year average percent of F_{abc} or F_{ofl})	Recent years have low fishing mortality rates and catches are below gulfwide ABC.
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	Fishing effort is distributed gulfwide around the continental slope with areas of high catch near Amatuli Gully and in the Yakutat Area, and trawl survey abundance is aggregated near most gully entrances.
Population trends (Different areas show different trend directions)	Overall population trend is relatively stable or increasing. Biomass estimates for the Western and Central GOA have been trending downward. Changes in biomass by region may be due to high variability of survey.
Barriers and phenotypic characters	
Generation time (e.g., >10 years)	Generation time is long.
Physical limitations (Clear physical inhibitors to movement)	No physical limitations known, but larval dispersal poorly understood.
Growth differences (Significantly different LAA, WAA, or LW parameters)	No major differences in growth (LW) among the Eastern GOA, Central GOA, and Western GOA.
Age/size-structure (Significantly different size/age compositions)	Age and size structures driven by major recruitment events. There is evidence of larger sized fish in the Eastern GOA based on trawl survey data.
Spawning time differences (Significantly different mean time of spawning)	Unknown
Maturity-at-age/length differences (Significantly different mean maturity-at-age/ length)	Unknown
Morphometrics (Field identifiable characters)	Unknown
Meristics (Minimally overlapping differences in counts)	Unknown
Behavior & movement	
Spawning site fidelity (Spawning individuals occur in same location consistently)	Unknown
Mark-recapture data (Tagging data may show limited movement)	Mark-recapture data unavailable.
Natural tags (Acquired tags may show movement smaller than management areas)	Unknown
Genetics	
Isolation by distance (Significant regression)	No significant isolation by distance (Matala *et al.* 2004)
Dispersal distance (<<Management areas)	Not available
Pairwise genetic differences (Significant differences between geographically distinct collections)	Not significant (Cockerham's theta, Matala *et al.* 2004)

Figures

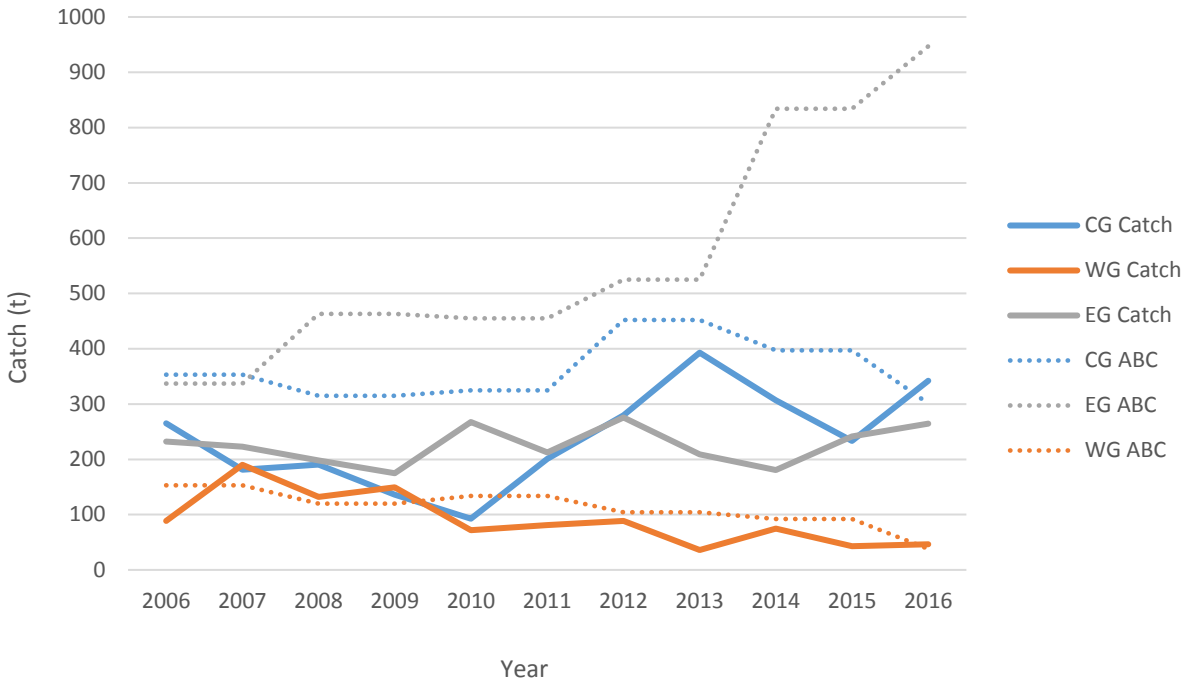

Figure 1.--Time series of catch (t) by management area: Central Gulf of Alaska (CG), Western Gulf of Alaska (WG), and Eastern Gulf of Alaska (EG), with each region's respective ABC (dashed lines).

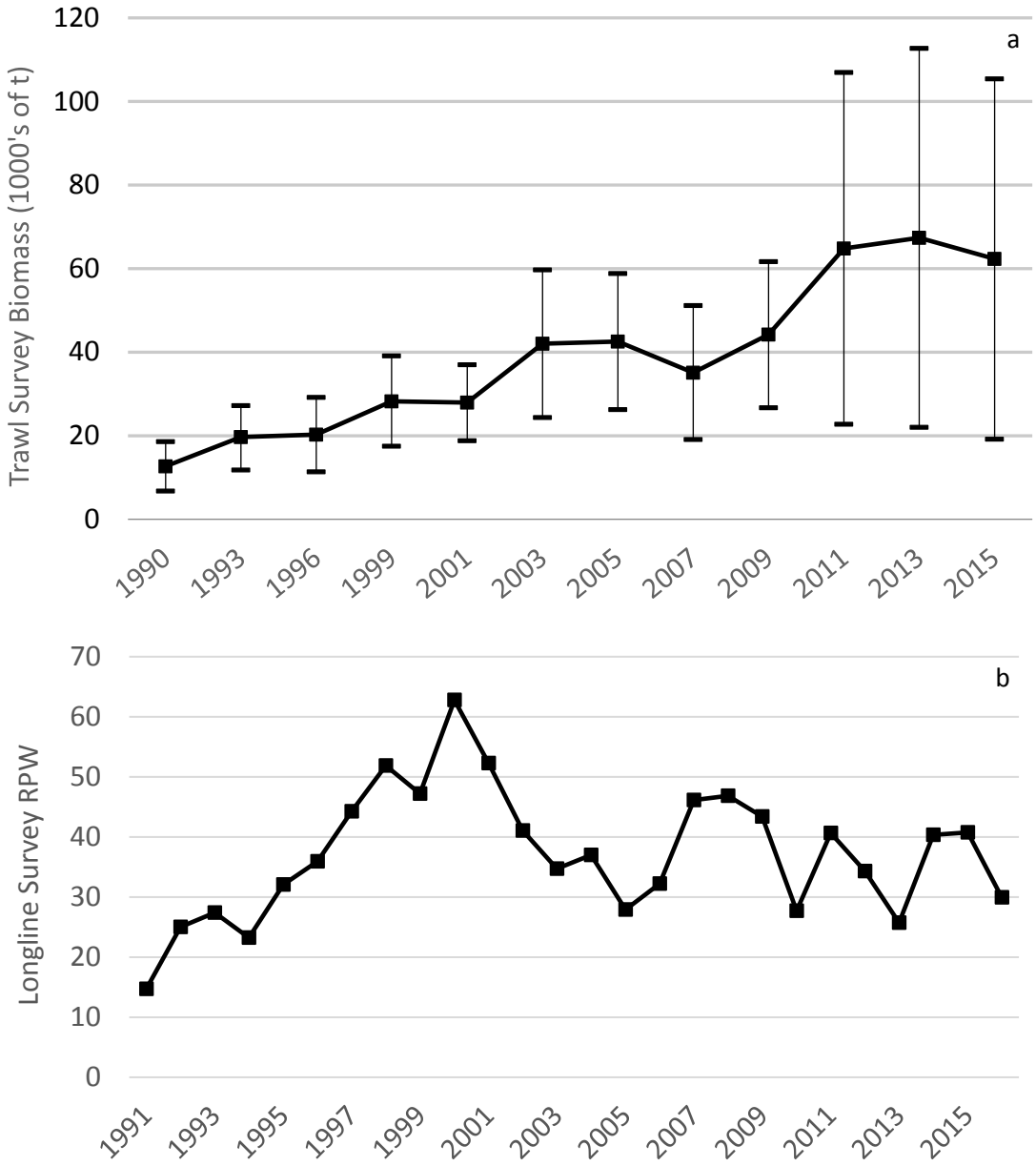

Figure 2.--(a) Estimated biomass (1,000s of t) of shortraker rockfish in the Gulf of Alaska based on results of bottom trawl surveys from 1990 through 2015. The vertical bars show the 95% confidence limits associated with each estimate. This survey is tri/biennial. (b) Estimated Relative Population Weight of shortraker rockfish in the Gulf of Alaska based on results of longline surveys from 1991 through 2016. This survey is annual. Please note the different scales between the top and bottom figures. Values between the two figures can not be compared directly, but are shown together for a visual comparison of trends.

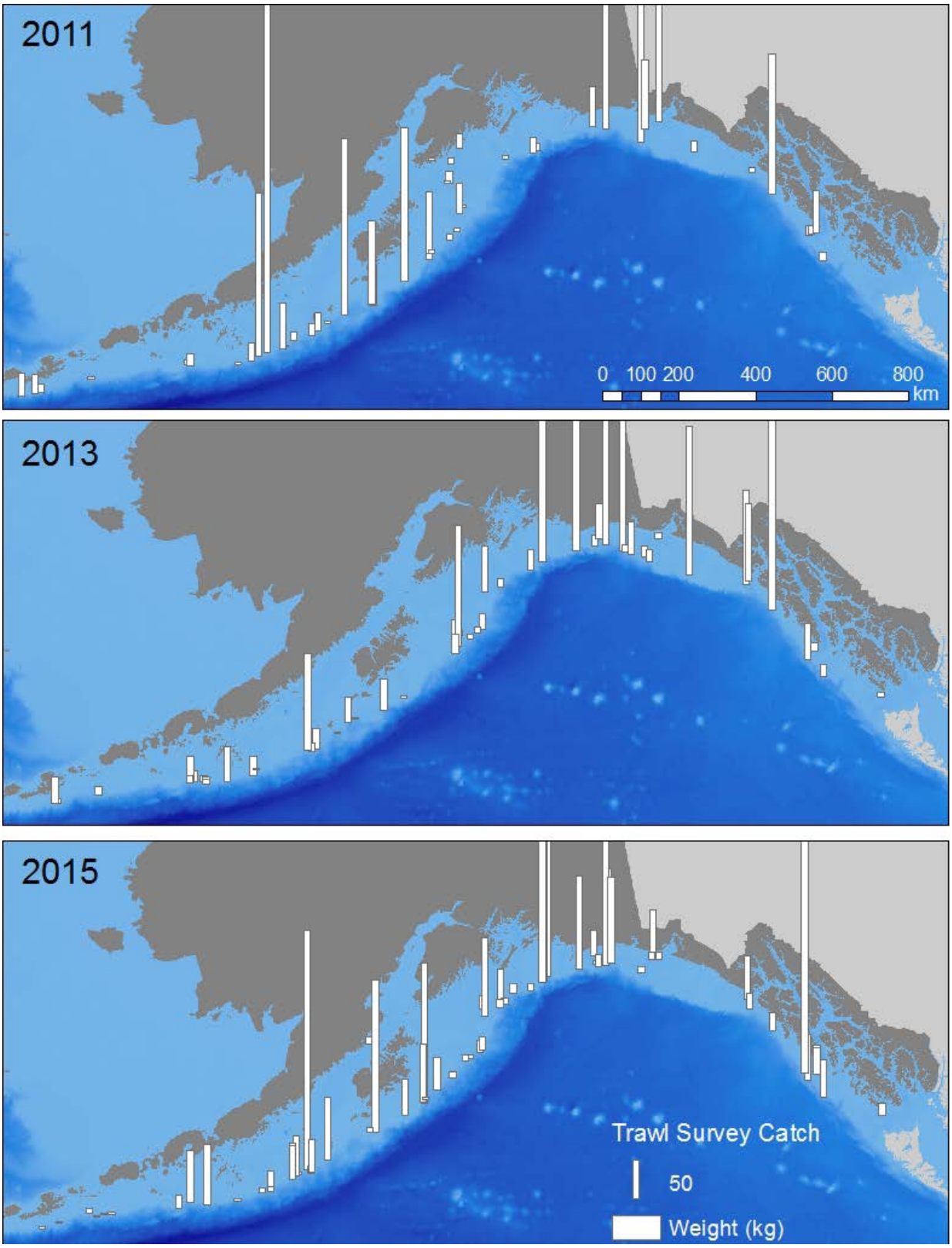

Figure 3.--Spatial distribution of shortraker rockfish catches in the Gulf of Alaska during the 2011, 2013, and 2015 NMFS bottom trawl surveys.

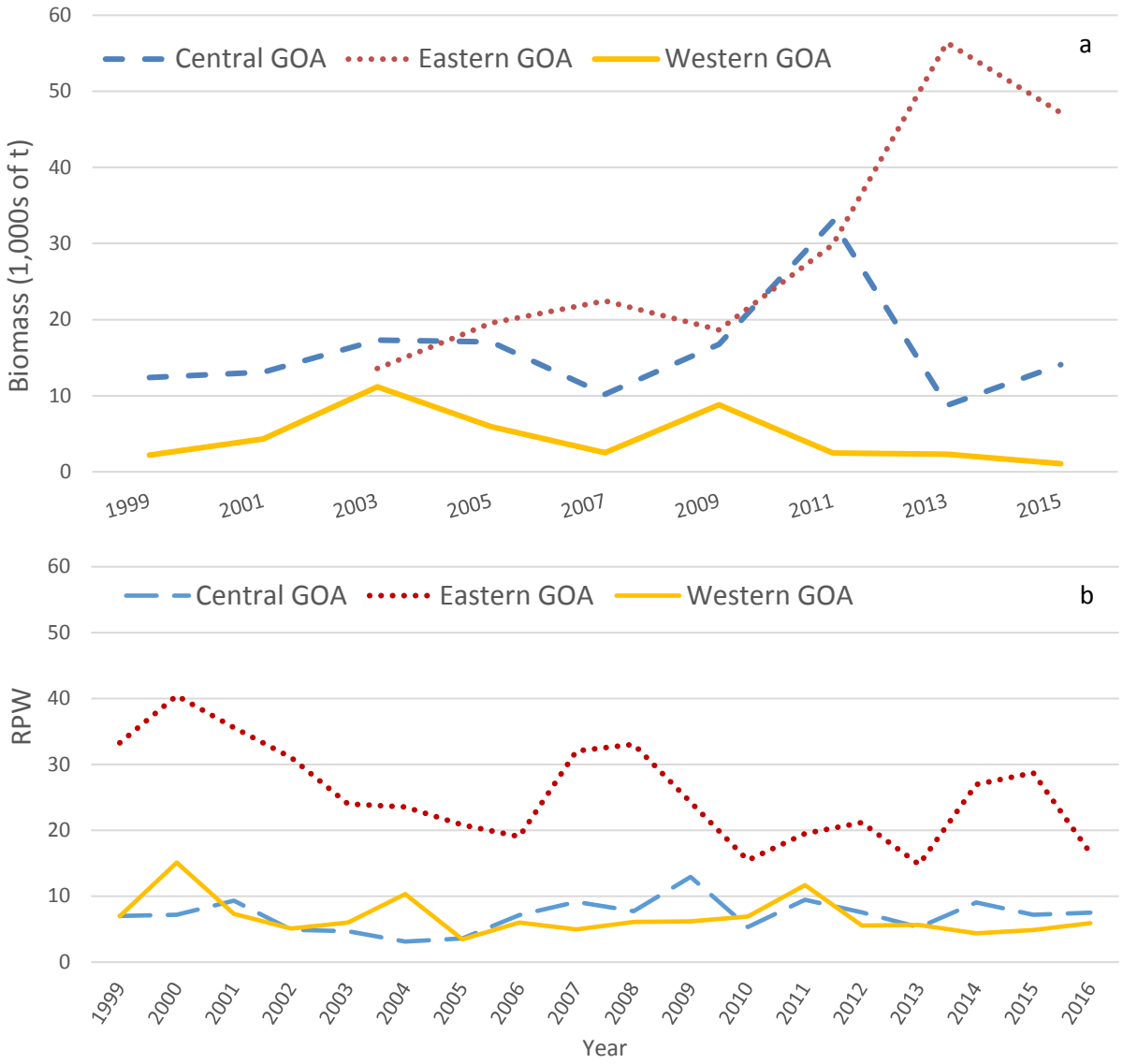

Figure 4.--(a) Estimated biomass (t) of shortraker rockfish by management area in the Gulf of Alaska (GOA) based on results of bottom trawl surveys from 1999 through 2015. This survey is tri/biennial. (b) Estimated Relative Population Weight (RPS) of shortraker rockfish by management area in the GOA based on results of longline surveys from 1999 through 2016. This survey is annual. Values between the two figures can not be compared directly, but are shown together for a visual comparison of regional trends.

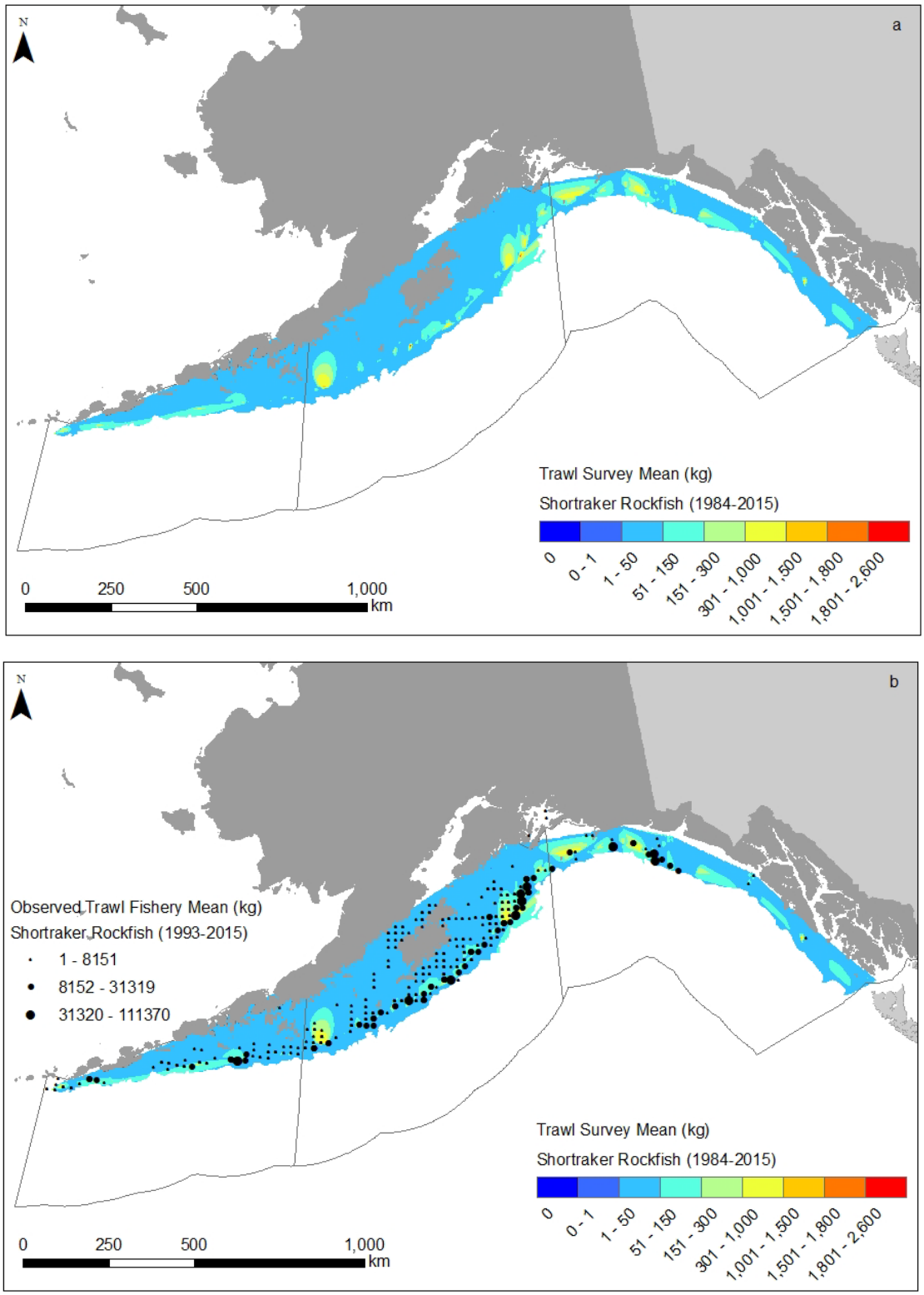

Figure 5.--Distribution maps of shortraker rockfish (a) trawl survey mean conditions from 1984 – 2015 and (b) observed trawl fishery catch mean (1993 - 2015) with trawl survey mean conditions.

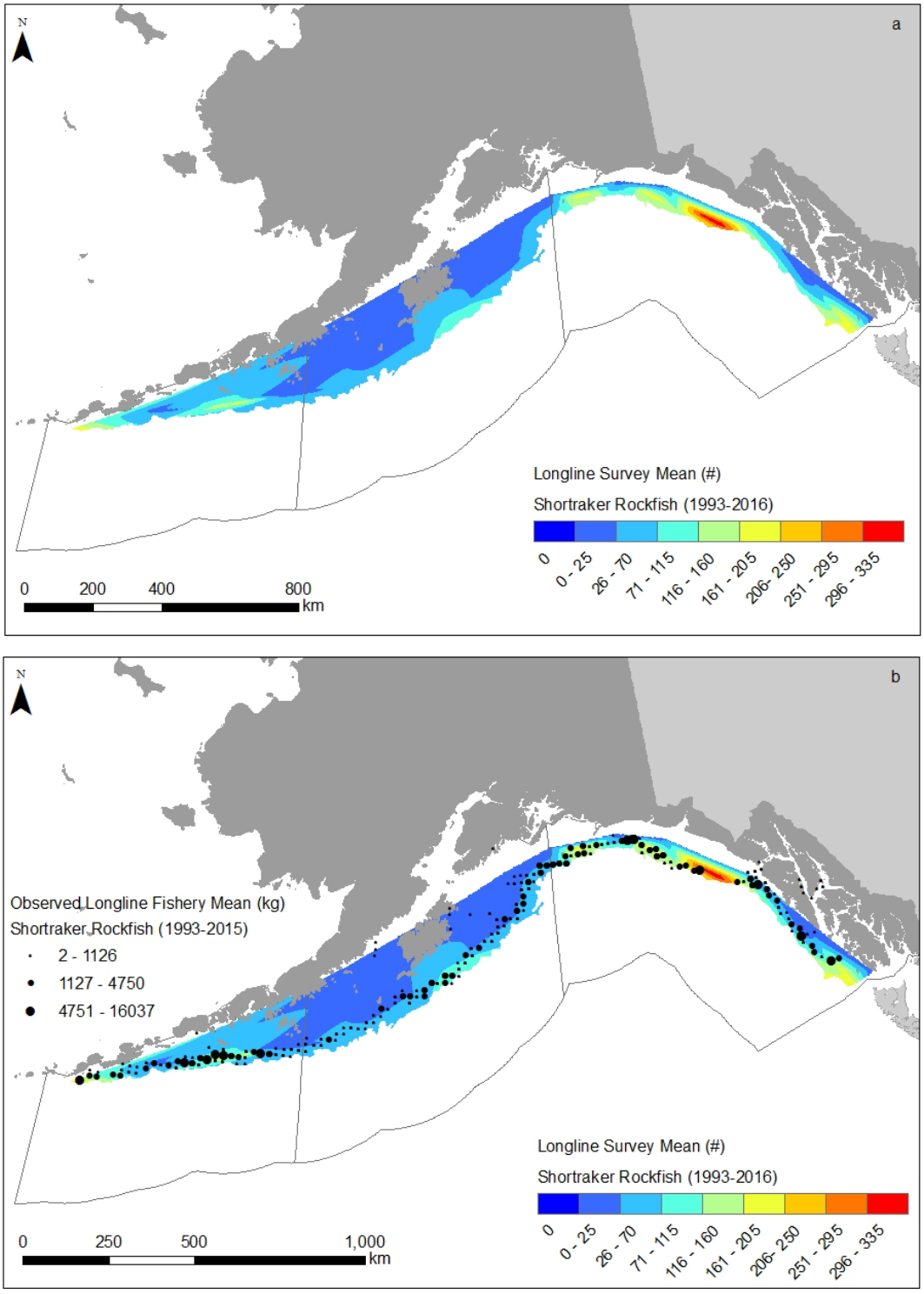

Figure 6.--Distribution maps of shortraker rockfish (a) longline survey mean conditions from 1993 – 2016 and (b) observed longline fishery catch mean (1993 - 2015) with longline survey mean conditions.

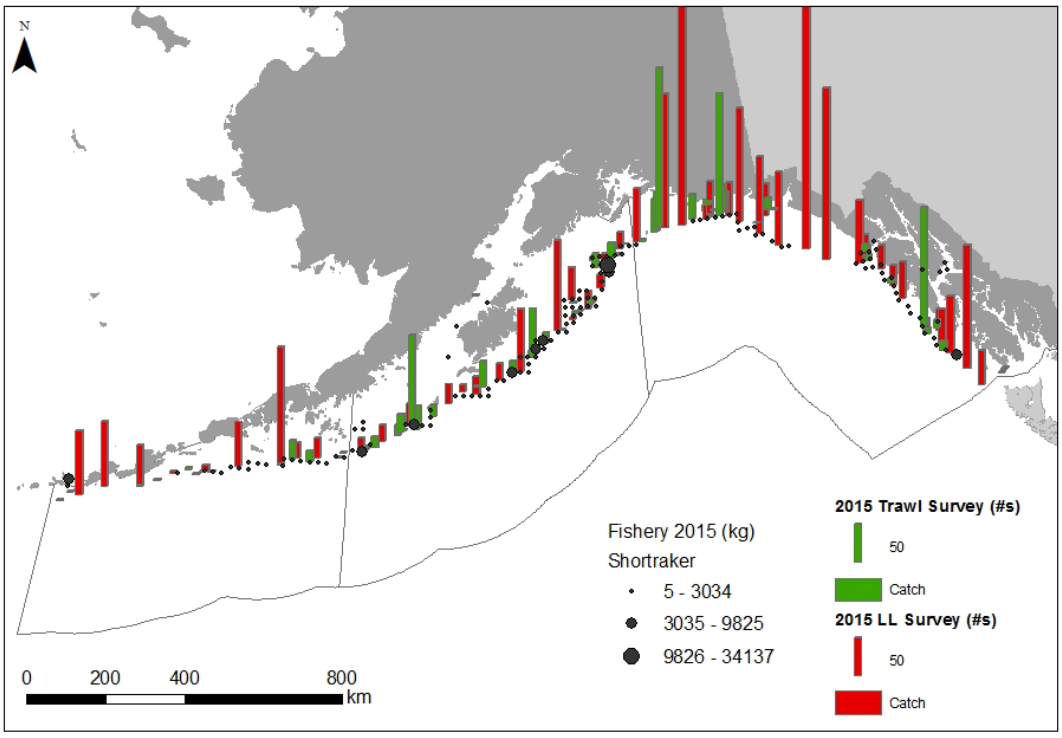

Figure 7.--Distribution map of shortraker rockfish catch on the trawl (green bars) and longline (red bars) surveys in 2015, and the observed fishery catch (filled black circles, kg).

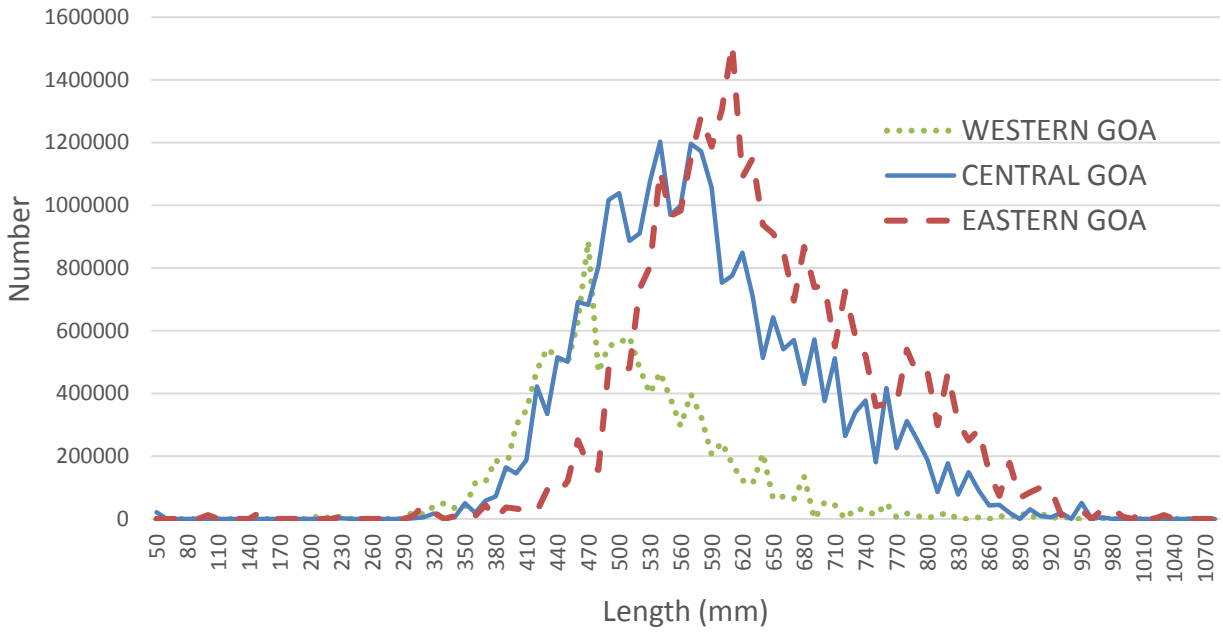

Figure 8.--Length frequency by management area of female shortraker rockfish from all Gulf of Alaska trawl surveys combined: Western Gulf of Alaska (GOA), Central GOA, and Eastern GOA.

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