16. Assessment of the Other Rockfish stock complex in the Gulf of Alaska

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November 2015

EXECUTIVE SUMMARY

The Other Rockfish (OR) complex (Table 16.1 and Figure 16.1) in the Gulf of Alaska (GOA) is assessed on a biennial stock assessment schedule to coincide with the availability of new trawl survey biomass estimates. The complex acceptable biological catch (ABC) and over fishing level (OFL) is the sum of the individual species recommendations. The appendices to this document, a discussion of ways to reorganize the Demersal Shelf Rockfish (DSR) and OR complexes (Appendix 16A) and a discussion of stock structure of DSR and OR species (Appendix 16B), were presented in September 2015 and have been updated for this document, based on comments from the Plan Team and Science and Statistical Committee (SSC).

Summary of Changes in Assessment Inputs

Changes to the input data

1. Total catch for GOA OR from 2003 – 2015 has been updated (as of October 15, 2015).
2. NMFS GOA bottom trawl survey data have been updated.
3. A new biomass time series is presented based on the random effects approach to survey averaging

Changes in assessment methodology

GOA OR ABC/OFL calculations have been based on Tier 4/5 methods, however, for this assessment we recommend that harvest ABC/OFL calculations be based on Tier 6 methods for species with no trawl survey biomass estimates but catch and those that are primarily caught in longline fisheries which are poorly sampled by the trawl survey. These Tier 6 species are the seven species that are managed as the DSR in the East Yakutat/Southeast region of the Eastern GOA (i.e., NMFS area 650).

Tier 6 OFL estimates were calculated individually by species for the Tier 6 species, since observer restructuring began (2013 – 2014). For this analysis we used OFL = maximum historical catch. This time frame is different from that specified in the Tier 6 definitions (1978 – 1995) because species specific catch data is not available prior to 1991. We recommend the time series since observer restructuring because those are the most unbiased catch estimates, however we do present the Tier 6 calculations using the 1997 – 2007 time series that is used by other non-target species without the long time series of catch.

The random effects approach to survey averaging was used to estimate the exploitable biomass of the 17 Tier 4/5 OR species (as presented at the September PT, and in Appendix 16A of this document). The OFL is the product of the random effects biomass and a species specific natural mortality of the Tier 5 species or the $F_{35\%}$ rate for the Tier 4 species sharpchin rockfish.

The allocation of the ABC for the Tier 4/5 species by NMFS regulatory area was estimated by the random effects model, and further subdivided in the Eastern GOA by applying the survey split fraction for West Yakutat and East Yakutat/Southeast. The Tier 6 ABCs were calculated by NMFS regulatory area and added to the Tier 4/5 ABCs.

Summary of Results

There is no evidence to suggest that over fishing is occurring for the OR complex in the GOA because the OFL has not been exceeded. Total OR catch in 2014 was 987 t and catch in 2015 was 1,077 t as of

October 15, 2015. We recommend that the OR complex be managed with 17 of the species as Tier 4/5 with biomass estimated by the random effects model, and seven of the species as Tier 6 using the maximum catch since observer restructuring. **The recommended ABC is 5,769 t and OFL is 7,424 t for the OR complex.** There are currently no directed commercial fisheries for OR species in federally managed fisheries; however, seven of the species (the same species which we recommend for Tier 6), are managed as DSR in the East Yakutat/Southeast region of the Eastern GOA (i.e., NMFS area 650). The recommended method results in and ABC and OFLs that are greater than other alternatives. The authors, Plan Team and SSC recommended that the ABCs for the Western GOA and Central GOA be combined for the 2014 – 2015 fisheries. We recommend continuing with this combination, as data do not suggest any developing conservation concerns that would be alleviated by splitting the ABCs.

ABC and OFL Calculations and Tier 4 recommendations for sharpchin rockfish for 2016 – 2017.

	As estimated or *specified last* year for*:		As estimated or *recommended this* year for:	
Quantity	2015	2016	2016	2017
M (natural mortality rate)			0.06	0.06
Tier			4	4
Biomass (t)			35,083	35,083
$F_{OFL} = F_{35\%}$			0.079	0.079
$maxF_{ABC} = F_{40\%}$			0.065	0.065
$F_{ABC} = F_{40\%}$			0.065	0.065
OFL (t)			2,772	2,772
maxABC (t)			2,280	2,280
ABC (t)			2,280	2,280
	As determined *last* year for:		As determined *this* year for:	
Status	2013	2014	2014	2015
Overfishing		n/a		n/a

*In the 2014 assessment the Tier 4 and Tier 5 recommendations were combined on one table, this year's assessment has them broken out to show the different methods.

ABC and OFL Calculations and Tier 5 recommendations for 17 OR species for 2016-2017.

	As estimated or *specified last* year for*:		As estimated or *recommended this* year for:	
Quantity	2015	2016	2016	2017
M (natural mortality rate)	0.02-0.10	0.02-0.10	0.02-0.10	0.02-0.10
Tier	5	5	5	5
Biomass (t)	83,383	83,383	69,743	69,743
F_{OFL}	0.02-0.10	0.02-0.10	0.02-0.10	0.02-0.10
$maxF_{ABC}$	0.0015-0.0750	0.0015-0.0750	0.0015-0.0750	0.0015-0.0750
F_{ABC}	0.0015-0.0750	0.0015-0.0750	0.0015-0.0750	0.0015-0.0750
OFL (t)	5,347	5,347	4,482	4,482
maxABC (t)	4,079	4,079	3,362	3,362
ABC (t)	4,079	4,079	3,362	3,362
	As determined *last* year for:		As determined *this* year for:	
Status	2013	2014	2014	2015
Overfishing		n/a		n/a

*In the 2014 assessment the Tier 4 and Tier 5 recommendations were combined on one table, the values *recommended this year* only include the Tier 5 species.

ABC and OFL Calculations and Tier 6 recommendations for seven OR species for 2016-2017. No estimates were available in the previous assessment thus the "*specified last year*" columns are blank.

Quantity	As estimated or *specified last* year for: 2015	2016	As estimated or *recommended this* year for: 2016	2017
Tier			6	6
OFL (t)			170	170
maxABC (t)			127	127
ABC (t)			127	127
Status	As determined *last* year for: 2013	2014	As determined *this* year for: 2014	2015
Overfishing		n/a		n/a

ABC and OFL recommendations for the full OR complex

All OR Combined	As estimated or *specified last* year for: 2015	2016	As estimated or *recommended this* year for: 2016	2017
Tier	4/5	4/5	4/5/6	6
OFL (t)	5,347	5,347	**7,424**	7,424
maxABC (t)	4,079	4,079	5,769	5,769
ABC (t)	4,079	4,079	**5,769**	5,769
Status	As determined *last* year for: 2013	2014	As determined *this* year for: 2014	2015
Overfishing		n/a		n/a

Updated catch data (t) for the OR stock complex in the GOA are summarized in the following table with ABCs and TACs. Source: NMFS Alaska Regional Office Catch Accounting System accessed through the Alaska Fisheries Information Network (AKFIN) database, http://www.akfin.org as of October 15, 2015.

Year	Western GOA	Central GOA	Eastern GOA		Gulfwide Total	Gulfwide ABC	Gulfwide TAC
			West Yakutat	E. Yak/ Southeast			
2014	171	717	61	38	987	4,079	1,811
2015	201	825	33	18	1,077	4,079	1,811

Area Apportionment

Area apportionment was estimated by the random effects model. Beginning in the 2014 fishery, the ABCs for the Western and Central GOA were combined, which is continued here for the 2016 fishery (1,534 t total ABC, if separated: WGOA = 55 t and CGOA = 1,479 t). The tables below show the apportionment for the Tier 4 (sharpchin rockfish), Tier 5 species and Tier 6 species separately.

Tier 4 - Sharpchin	Western/Central GOA	Eastern GOA (75.01%)		Total
		West Yakutat[1]	E Yakutat/ Southeast[1]	
Area Apportionment	12.49%	9.96%	65.05%	100%
Area ABC (t)	570	227	1,483	2,280
OFL (t)				2,772

[1]The West Yakutat and E Yakutat/Southeast values sum to the proportioned ABC of the Eastern GOA (75.01%).

Tier 5 – 16 species	Western/Central GOA	Eastern GOA (74.72%)		Total
		West Yakutat[1]	E Yakutat/ Southeast[1]	
Area Apportionment	25.28%	13.28%	86.72%	100%
Area ABC (t)	850	334	2,178	3,362
OFL (t)				4,482

[1]The West Yakutat and E Yakutat/Southeast values sum to the proportioned ABC of the Eastern GOA (74.72%).

Tier 6 – seven species	Western/Central GOA	Eastern GOA		Total
		West Yakutat	E Yakutat/ Southeast	
Area ABC (t)	114	13	0	127
OFL (t)				170

Total OR ABC apportioned by area

	Western/Central GOA	Eastern GOA		Total
		West Yakutat	E Yakutat/ Southeast	
Area ABC (t)	1,534	574	3,661	5,769
OFL (t)				7,424

Summaries for Plan Team

Species	Year	Biomass[1]	OFL	ABC	TAC	Catch[2]
Other Rockfish	2014	83,383	5,347	4,081[3]	1,811	987
	2015	83,383	5,347	4,081[3]	1,811	1,077
	2016	104,826	7,424	5,769		
	2017	104,826	7,424	5,769		

Stock/ Assemblage	Area	2015				2016		2017	
		OFL	ABC	TAC	Catch[2]	OFL	ABC	OFL	ABC
Other Rockfish	WGOA/CGOA		1,031	1,031	1,030		1,534		1,534
	EGOA								
	WY		580	580	33		574		574
	EY/SE		2,470[3]	200	18		3,661[3]		3,661
	Total	5,347	4,081	1,811	1,081	7,424	5,769	7,424	5,769

[1]Total biomass estimates from the random effects model for the Tier 4/5 species only.

[2]Current as of October 15, 2015. Source: NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database (http://www.akfin.org).

3These ABCs do include the 2 t that was transferred from the northern rockfish assessment to the OR assessment.

[4]The recommended ABC for EY/SE in 2016 does not include the ABC for northern rockfish, because the value has not been set for 2016. Historically, 2 t of northern rockfish ABC is taken from the northern rockfish assessment and added to the OR ABC in the EY/SE during Plan Team deliberations.

Responses to SSC and Plan Team Comments on Assessments in General

"The Teams recommended that SAFE chapter authors continue to include "other" removals as an appendix. Optionally, authors could also calculate the impact of these removals on reference points and specifications, but are not required to include such calculations in final recommendations for OFL and ABC." (Plan Team, September 2013)
We have included a table of non-commercial catches (Table 16.10).

"The SSC also requests that stock assessment authors utilize the random effects model for area apportionment of ABCs" (SSC, December 2014)

"*The Teams recommend that the random effects survey smoothing model be used as a default for determining current survey biomass and apportionment among areas.*" (Joint Plan Teams, September 2015)

"*The Teams recommend that stock assessment authors calculate biomass for Tier 5 stocks based on the random effects model and compare these values to status quo. In addition, the Teams recommend that the working group examine autocorrelation in subarea recruitment when conducting spatial simulations for evaluating apportionment."* (Plan Team, September 2014)

"*The Teams recommend that the random effects survey smoothing model be used as a default for determining current survey biomass and apportionment among areas.*"(Joint Plan Teams, September 2015)
In response to the above four comments: we have included the biomass estimates based on the random effects approach to survey averaging (Figure 16.9 and Table 16.14). This approach was investigated in detail and presented at the September Plan Team meeting. Details can be found in Appendix 16A. The model was used to apportion the ABC into NMFS regulatory areas (Western, Central and Eastern GOA), and the 4:6:9 weighted average of the survey split fraction was used to split the Eastern GOA ABC between the West Yakutat and East Yakutat/Southeast areas.

SSC and Plan Team Comments Specific to this Assessment

"The SSC supports the Plan Team request for a productivity-susceptibility analysis for the Other Rockfish complex. The SSC also encourages the authors to examine the relationship between environmental conditions and the distribution and abundance of silvergray rockfish and harlequin rockfish because the trawl survey data suggests that these stocks may move in and out of the GOA in response to changing conditions." (SSC, December 2011)
There is insufficient data to conduct the P-S analysis for many of the species in the OR complex. Ormseth and Spencer (2011) did calculate scores for 6 of the species, and these species are 6 of the 7 most vulnerable species (Pacific sleeper shark was the 7th) in that analysis. Potential distributional changes are discussed in general in the stock structure template (Appendix 16B) and the analysis presented in Appendix 16A. A more detailed discussion of the potential for distributional changes can be included in the next full assessment.

"In the interim period, the SSC requests that the authors carefully consider the recommendations of the rockfish CIE reviewers and that they work with NMFS Resource Assessment and Conservation

Engineering division to evaluate the evidence that harlequin rockfish biomass is underestimated by the NMFS trawl and if this hypothesis is confirmed whether it is possible to develop a correction factor to improve future estimates for this species." (SSC, December 2013)
This issue is common to many species of rockfish and is still under investigation.

"Because DSR species are currently included within the "other rockfish" assessment for NMFS areas north of area 650, there will have to be reconsideration of current species groupings in the GOA. The SSC recommends that respective assessment authors work together to provide detailed examination of fishery catch and survey data by subarea and season for DSR and "Other" rockfish species. Catch data from all sources (retained, discard, State waters) should be included and where data are lacking this should be noted and would feed into the revised assessments(s). Assessment authors should also attempt to derive a plausible range of historical catch trends where catch data may not be available. The goal of this work is to fully account for rockfish catches and align potential rockfish groupings to improve our ability to monitor and identify conservation issues. This may include species groupings that are biologically similar (i.e. with similar life history attributes) or potentially grouped as Tier 6 species where reliable estimates of biomass are unavailable" (SSC, October 2014)
The OR and Demersal Shelf Rockfish authors worked together to address this issue. The analysis was presented to the September Plan Teams and is included in Appendix 16A of this document. The appendix is updated from what was presented in September to include responses to comments made during discussions at the Plan Team meeting as well as SSC comments from the October 2015 meeting.

"The Plan Team recommended using the random effects model, rather than the weighted survey average approach, to the extent practicable, for POP and for rockfish in general. The SSC agrees with this advice." (SSC October 2014)

"The Team recommends that the authors follow the Plan Team guidance for applying the random effects smoother, which are located in the minutes of the September, 2015, meeting of the Joint Plan Team." (Plan Team September 2015)

"The analysts working on this project are still the developing methods and do not recommend switching to a random effects modelling approach for survey averaging at this time. The SSC looks forward to further progress on this research." (SSC October 2015)
With respect to the above three comments, the random effects model was applied to the trawl survey biomass of 17 of the OR species and presented at the September 2015 Plan Team meeting. In the September presentation, the authors recommended delaying implementation of the random effects model for this complex until further guidance was provided by the Plan Teams. The Plan Teams provided guidance on how to use random effects models to estimate biomass. Thus, the authors recommend using the random effects model for estimating exploitable biomass in this assessment.

"The SSC recommends that authors complete the stock structure template for yelloweye/DSR coastwide for the September 2015 Plan Team meeting." (SSC October 2014)

"The SSC supports the Plan Team's recommendation for authors to complete a stock structure template for other rockfish. The SSC also suppo1ts the Plan Team recommendation for authors to evaluate the IPHC survey data for the distribution of yelloweye/DSR in the Gulf of Alaska. In addition, the SSC recommends evaluation of the IPHC CPUE time series for DSR in the Gulf of Alaska." (SSC December 2014)

"The Team recommends comparison of exploitation rates (i.e., catch divided by survey biomass) over time for GOA subareas to the reference Tier 5 exploitation rates. (in reference to the stock structure template)" (Plan Team September 2015)

With respect to the above three comments, the stock structure template was completed and presented to the Plan Team at the September 2015 meeting. The template has been updated to address comments by the Plan Team and SSC and is included in Appendix 16B.

"The Team recommends further evaluation of the author preferred Alternative 3 in coordination with the Council's process for determining spatial management." (Plan Team September 2015)
The lead author of this assessment is now involved in the Council's spatial management working group.

"The SSC encourages the plan team to develop a prioritized list of species, based on their commercial importance." (SSC October 2015)
With the exception of yelloweye rockfish, most of these species have low commercial value. This document prioritizes the six species that comprise at least 95% of the catch and biomass of the complex.

"The SSC agrees with the Groundfish Plan Team that incorporating IPHC survey data from this area may be useful for these species, and encourages the assessment authors to investigate this possibility more fully." (SSC October 2015)
The utility of the IPHC survey for these species was investigated and presented at the September Plan Team meeting. The analysis is included in this document in Appendix 16A. The survey only provides useful information for five species, three of which are in the DSR complex. This survey may provide trend information, but at this time, how to incorporate that index into the assessment is unclear, the authors plan to investigate using this survey further.

"The SSC advises that additional consideration should be given to Alternative 2, as well. For example, if all these species are combined together, this may result in including species of divergent characteristics. For example, the composition of some non-DSR other rockfish is likely to change under climate change. Distributional shifts in silvergray rockfish are to be expected in Southeast Alaska." (SSC October 2015).
With respect, the authors do not support Alternative 2 (described in Appendix 16A). That alternative would effectively end the state managed directed fishery for Demersal Shelf Rockfish species, as well as create complex management issues. The authors do agree that combining all the species into one complex would group together species of divergent characteristics. We have included some discussion of the species differences in the stock structure life history section, as well as a figure showing the divergent life history (Figure 16B.2, where data is available). Silvergray rockfish are caught as bycatch in the DSR fishery, and were originally in the DSR complex, which is supported by life history as well. However, silvergray are primarily caught in trawl fishery, thus the species was moved to the Other Slope Rockfish (which became the OR) group. Redbanded rockfish are the other species that is difficult to definitively place in one group or the other. The species appears to have life history more similar to the DSR species, but it is caught ubiquitously in trawl and longline fisheries.

"The SSC suggests that this analysis should not be rushed. The prospects for developing a GOA-wide DSR assessment should consider that the survey information is best developed for Southeast Alaska, and that future funding for those surveys is uncertain. Also, for the various alternatives, assemblage membership should be carefully re-examined to make sure that species in the assemblage share some common characteristics. Alternative combinations of species should be considered. The SSC also encourages involvement of industry members in the process of alternative development so that alternatives are developed mindful of fishery and management complexity." (SSC October 2015)

The authors agree with the SSC comments. The authors continue to recommend Alternative 3; however, we agree that there are issues still needing to be addressed. We have added text to the Task #3 discussion in Appendix 16A to the effect that a longer time series of observer restructuring data is necessary and the authors need to work with the AKRO to clarify any differences/overlaps between the federal fisheries catch estimates and the State of Alaska fishery catch estimates of DSR in the Southeast region (NMFS area 650). Further, as mentioned above, we included a discussion of the biological differences of the groupings to the stock structure template and a figure showing life history characteristics (Figure 16B.2).

Introduction

The Other Rockfish stock complex (termed OR in this document) is a mixed group of up to 25 rockfish species depending on Gulf of Alaska (GOA) management area (Table 16.1, Figure 16.1). This assessment presents catch and survey information for these species and provides recommended management reference points. This complex is further complicated by eight species that occur in other assessments in certain regions.

The Demersal Shelf Rockfish (DSR) complex includes seven species (canary, China, copper, quillback, rosethorn, tiger and yelloweye rockfish) in the East Yakutat/Southeast Outside region (east of the 140° W longitude, NMFS Area 650). These seven species are managed as part of the OR complex west of the 140° W longitude (i.e., NMFS Areas 610 – 640, the Western and Central GOA and the West Yakutat portion of the Eastern GOA). While these species have not previously been included in the full OR assessments (Other Slope Rockfish in prior assessments), catch estimates have been included in the group total catch provided by the Alaska Region Office (AKRO). An analysis of the catch and biomass time series from these species in the OR complex was presented in the 2013 assessment (Tribuzio et. al, 2013), but due to the government shut down in 2013, a full assessment has not been conducted since 2011.

Northern rockfish are included in the OR complex only in the Eastern GOA and are a separate assessment in other management areas of the GOA. This is because of the extremely low abundance of northern rockfish in the Eastern GOA and the consequent difficulty of managing northern rockfish as a separate species in this area. In 1999 northern rockfish in the Eastern GOA was reassigned to the Other Slope Rockfish category for this area only. Therefore, northern rockfish is listed as an OR species in Table 16.1, but only for the Eastern GOA. Northern rockfish biomass is not included in the estimation of OFL/ABCs because it is already accounted for in the northern rockfish assessment. Instead, a portion of the ABC is taken from the northern rockfish assessment and added to the OR assessment during the Plan Team deliberations.

There are six species that generally comprise > 95 % of the OR catch and biomass: harlequin, redbanded redstripe, sharpchin, silvergray and yelloweye rockfish. This document focuses primarily on those species, with all other species being grouped into a category termed “minors”.

General Distribution of Other Rockfish

Nearly all of the OR species in the GOA are at the northern edge of their ranges; the center of abundance for most is farther south off British Columbia or the U.S. West Coast (Figure 16.2A). One exception is harlequin rockfish, a predominantly Alaskan species widely distributed across the GOA (Figure 16.2B). The center of abundance for silvergray rockfish, the most abundant of the OR species based on recent trawl survey biomass estimates, appears to be Southeast Alaska and British Columbia (Figure 16.2C). Much of the information describing the spatial distribution for the majority of the OR species comes from Mecklenberg et al. (2002) and Love et al. (2002), as reports of catch for many of these species are rare. Additionally, distribution information is often based on studies of fish in lower latitudes (British

Columbia and further south). Summarized information on the distribution of each of the OR complex species can be found in the stock structure document (Appendix Table 16B.2).

Evidence of Stock Structure

The stock structure of the GOA OR was examined in conjunction with the DSR complex and presented to the Plan Team in September 2015 (Appendix 16B). There are few data available to differentiate stocks across regions for any of the 25 species in the two complexes. Rockfish are generally considered long-lived and slow growing. Little information on growth and reproduction is available for either of the complexes' rockfishes, and what is available is insufficient for evaluating comparisons within the spatial extents of the complexes. Additionally, little genetic information is available to infer any genetic stock structure between or within areas. However, while data is limited, the life history characteristics suggest that the current complex groupings may not be biologically appropriate for these species. A potential alternative grouping would put the seven demersal species, (e.g., those species with longer life spans, slower growth rates and which are predominantly caught in longline fisheries) into one group and the remaining species, (e.g., those that grow faster, are more pelagic, and are primarily caught by trawl fisheries) into another group (Appendix 16B, Figure 16B.2).

Life History Information

Life history data are limited for most OR species, and are generally based on studies from waters in lower latitudes (British Columbia and further south). Life history data collected in Alaskan waters are available for harlequin, redstripe, sharpchin, silvergray, and yelloweye rockfish. All species of rockfish are ovoviviparous, with fertilization, embryonic development, and larval hatching occurring inside the female. Summarized information on the life history of the OR complex species can be found in Appendix 16B.

Of the primary species, sharpchin rockfish are the only species in the OR complex with sufficient maturity and growth data available for the GOA stock, and are considered a Tier 4 species. Maximum observed age in the GOA is 58 years, with age at 50% maturity at 10 years (Malecha et al. 2007). Maximum ages and ages at maturity data are available for silvergray (82 and 9 years, respectively, Malecha et al. 2007) and redbanded (106 and 19 years, Munk 2001) rockfish from outside of the GOA, but there is believed to be considerable geographic variation in age at maturity for redbanded rockfish (O'Connell 1987). Harlequin and redstripe rockfish have maximum observed ages of 47 and 55 years, respectively, (Malecha et al. 2007, Myer and Failor in prep), but no estimates of age at maturity. Yelloweye rockfish could be considered a Tier 4 species, with maximum observed age (118 years) and age at maturity data (22 years, O'Connell and Funk 1987); however, the survey biomass estimate is considered unreliable because this species tends to be closely associated with nearshore rocky habitats and is not commonly encountered by the trawl survey.

Beyond growth, life history information is limited to parturition timing. In Southeast Alaska and British Columbia, redbanded rockfish are thought to release larvae from March to September (O'Connell 1987), while female redstripe rockfish off Southeast Alaska appear to release larvae from April to July (Archibald et al. 1981, Chilton and Beamish 1982). In contrast, sharpchin rockfish in British Columbia primarily extrude larvae in July only (Archibald et al. 1981). Yelloweye rockfish in Southeast Alaska have been reported to extrude larvae from February through September, but peak between April and July (O'Connell and Funk 1987).

Fishery

Management History and Management Units

The history of management changes for the OR complex is presented in Table 16.2. The North Pacific Fishery Management Council (NPFMC) established a separate management category for Other Slope

Rockfish in the Gulf of Alaska (GOA) in 1991. The group initially included northern rockfish and 15 other diverse species, but northern rockfish was removed in 1993 to become its own separate management category. In 2010, the GOA Groundfish Plan Team and the NPFMC Scientific and Statistical Committee (SSC) both recommended that yellowtail rockfish and widow rockfish be moved from the Pelagic Shelf Rockfish complex to the Other Slope Rockfish complex (for the 2011 fishery). It was also recommended that the official name of Other Slope Rockfish be changed to Other Rockfish because yellowtail and widow rockfish mainly inhabit the continental shelf rather than the slope. Table 16.3 shows the catch estimates, the total allowable catch (TAC), acceptable biological catch (ABC) and overfishing level (OFL) for the various iterations of the Other Slope Rockfish and subsequent OR complexes.

From 2005 to 2010, the assessment for Other Slope Rockfish in the GOA was combined with that for shortraker rockfish. Although Other Slope Rockfish and shortraker rockfish were distinct management entities, their assessments were presented in a single SAFE chapter because each was assessed using a similar Tier 5 methodology. However, in 2010 the GOA Groundfish Plan Team and the SSC recommended that future assessments for shortraker rockfish and Other Slope Rockfish be presented in separate SAFE chapters.

Northern rockfish are managed as a separate species in the Central GOA and Western GOA; however, because of their extremely low abundance and the consequent difficulty of managing them as a separate species in the Eastern GOA they were reassigned to the OR complex in 1999 for this area only. The species is not included in the calculations of ABC and OFL conducted as part of this assessment because they are already accounted for in the northern rockfish assessment.

There are also species that have been accounted for in the AKRO Catch Accounting System (CAS) in the OR group, that were not previously included in the OR stock assessment. These are the seven species of DSR (canary, china, copper, quillback, rosethorn, tiger, and yelloweye rockfish) but only when occurring outside of the East Yakutat/Southeast management area (i.e. NMFS areas 610-640, the Western and Central GOA and the West Yakutat portion of the Eastern GOA).

The current OR complex comprises 25 species, depending on area (Table 16.1 and Figure 16.1). Beginning in the 2014 fishery, the ABC and TAC for the Western and Central GOA were combined. The ABC for the OR (formerly Other Slope Rockfish) has been exceeded in the Western GOA consistently since 2009. During this period harlequin rockfish was, on average, 77% of the OR catch in the Western GOA. In 2012 the ABC was similarly exceeded (although by a substantially smaller margin) in the Central GOA as well, and harlequin was 52% of the OR catch. Harlequin rockfish biomass is likely underestimated by the trawl survey, due to the species affinity for high relief rocky habitat not sampled by the survey. Therefore, the Plan Team and SSC agreed that the overages were likely not a conservation concern and that combining the Western and Central GOA ABC/TAC was an acceptable alternative.

Directed Fishery, Effort and CPUE

Since the mid-1990s, directed fishing has not been permitted for OR in the GOA, and the fish are only 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. There are, however, two exceptions: 1) in 1993, when directed fishing was permitted for OR, it appears some targeting by trawlers occurred in the eastern GOA for silvergray and yellowmouth rockfish, two larger sized species that can be caught in bottom trawls; and 2) in 2004 and 2005, a small experimental fishery was permitted in East Yakutat/Southeast Alaska that used modified trolling gear to catch the large amount of Pacific ocean perch quota unavailable to trawlers, but mainly was successful in catching silvergray rockfish (Clausen and Echave 2011). The CAS estimates of catch do not include catch from unobserved fisheries such as the Pacific halibut IFQ fleet prior to the 2013 observer restructuring, or state managed fisheries.

Discards

Gulfwide discard rates (% of the total catch discarded within management categories) are provided in two time series: 1) pre – 2003 where the catch and discards were estimated by species in Tribuzio and Echave 2013 by extrapolating observed species compositions to the total catch; and 2) 2003 – present from the CAS (Table 16.4). Discard rates have been on average 59 % over the entire time series. The high discard of OR is not surprising, as most of the abundant species in this category, such as harlequin and sharpchin rockfish, are small in size and of low economic value. There are some species with higher value, which are likely discarded at a lower rate.

Data

Time series of catch and biomass for the OR species were obtained from the following sources:

Source	Data	Years
AKRO Catch Accounting System	Catch estimates	1991 – 2015
NMFS Bottom Trawl Surveys –GOA (biennial)	Biomass Index, Age/length – compositions	1984 – 2015

Fishery

Fishery catch statistics for the OR complex are available from AKRO blend estimates and CAS beginning in 1991. Catch by species were estimated back to 1991 in Tribuzio and Echave 2013. Table 16.5 presents the time series of estimated catch of the current OR complex by species. Since the mid-1990s, directed fishing has not been allowed for OR (and previously when it was the Other Slope Rockfish) in the GOA, and the fish can only be retained as "incidentally-caught" species. With the exception of 1993, Gulfwide catches of OR have always been < 1,800 t. Annual catch since 1993 has always been much less than either the Gulfwide ABC or TAC. Catches of OR in the Eastern GOA (where these species are most abundant) have been especially small in the years since 1999, when trawling was prohibited east of 140° W. long. Estimated catch in the Western and Central GOA has not exceeded the ABC since it was combined in 2014.

Other Rockfish species are predominately caught in trawl fisheries (Table 16.6), with much of the bycatch occurring in the rockfish trawl fishery in the Central GOA (Figure 16.3). The predominance of trawl catches is not surprising, as many of the abundant species such as sharpchin and harlequin rockfish are thought to feed on plankton and thus are likely not attracted to longlines. Harlequin rockfish is generally the most common species caught, with the exception of East Yakutat/Southeast Alaska where redbanded rockfish is most common (Figure 16.4).

Catch distribution

The rockfish trawl fishery is the predominant source of OR catch and the overall distribution of the catch shows little change from year to year (Figure 16.3). However, there is some variability amongst the species of OR (Figure 16.4). Redbanded and silvergray are often caught in the Eastern GOA.

Catch at age and length

The numbers of lengths sampled by observers for Other Slope Rockfish in the GOA commercial fishery have been too small to yield meaningful data. Few age samples for any of these species have been collected from the fishery, and none have been aged.

Survey

NMFS AFSC bottom trawl survey biomass estimates are available for the OR species in the GOA (1984 – 2015, Table 16.8). Bottom trawl surveys were conducted on a triennial basis in the GOA from 1984 – 1996 and a biennial survey schedule has been used since 1999. The surveys covered all areas of the GOA out to a depth of 1,000 m, with the following exceptions: the 1990, 1993, 1996, and 2001surveys did not

sample deeper than 500 m and the 2003, 2011 and 2013 surveys did not sample deeper than 700 m. Species within the OR complex are found in depths < 500 m. Therefore, it is unlikely that this would impact the estimation of OR biomass. Other important caveats are that the 2001 survey did not sample the Eastern GOA, thus removing an entire area of the estimation of biomass and the 2013 survey had a reduced number of stations. It is unlikely that these survey caveats would impact the estimation of OR biomass, with the exception of the 2001 survey not sampling the Eastern GOA, however, it is important to note the potential for measurement error.

Geographically, most of the biomass for these species is found in the Eastern GOA (Table 16.9 and Figure 16.5). Harlequin rockfish is the one exception, as its highest biomass has often occurred in other areas west of the Eastern GOA (Table 16.9). Many of these species tend to inhabit areas that are considered untrawlable by the survey, and thus catches can be highly variable. The CVs for the estimates are generally higher than for many of the rockfish species in the GOA. For example, CVs for redstripe rockfish range from 36% to 87%, compared to a range of only 17% to 33% for shortraker rockfish and 11% to 23% for rougheye/blackspotted rockfish (see Shotwell et al. 2011 and Clausen and Echave 2011).

The total biomass from the 2015 trawl survey for all the OR species was 116,804 t. This is an 86% increase over the 2013 survey and 25% above the historical survey average. The survey biomass of redstripe (69%), sharpchin (202%), silvergray (130%) and yelloweye (17%) were increased over the 2013 survey. Harlequin and redbanded rockfish were both down from the previous survey, 69% and 7%, respectively. These dramatic changes in biomass estimates are likely due in a large part to the patchiness of the species, as suggested by the high CVs.

The biomass estimates for most species of OR have often been highly variable from survey to survey. One extreme example of this is silvergray rockfish, whose biomass estimate increased from 9,851 t in 2009 to 100,049 t in 2011, and then decreased to 19,239 t in 2013 (Table 16.8 and Figure 16.5). Such wide fluctuations in biomass do not seem reasonable given the slow growth and low natural mortality rates of all *Sebastes* species. Large catches of aggregating species, such as most OR appear to be, in just a few individual hauls can greatly influence biomass estimates and may be a source of much variability. For example, in the 2003 survey, an extremely large catch of 5 t of silvergray rockfish in one haul was mostly responsible for the very large biomass of that species in the East Yakutat/Southeast area, and it likely was a major cause for the high Gulfwide coefficient of variation that year of 73.4%. In contrast, the large biomass in 2011 does not appear to be caused by the chance encounter of one or two large aggregations, but several large as well as many moderate sized catches. This is reflected by the biomass' relatively low coefficient of variation of 34.5% (Table 16.9).

In past Other Slope Rockfish SAFE reports, the authors have also speculated that a change in availability of rockfish to the survey, caused by unknown behavioral or environmental factors, may explain some of the observed variation in biomass. It seems prudent to repeat this speculation in the present report, while acknowledging that until more is known about rockfish behavior, the actual cause of changes in biomass estimates will remain the subject of conjecture.

Also noteworthy is the small biomass of harlequin rockfish since 2007 (Table 16.8). In some of the previous trawl surveys, harlequin rockfish had been one of the most abundant of the OR species (e.g., 1987, 1996, and 2005), but since 2007 has had biomass below 5,000 t (much lower than the 2005 estimate of 33,124 t). The biomass of harlequin rockfish has shown unreasonably wide fluctuations between surveys, so it appears to be poorly sampled by the survey's gear and/or methodology. Hence, whether these recent low biomass estimates truly indicate a decline in abundance is uncertain.

In general, research catch is small relative to biomass (research catches are in Table 16.10 and biomass in Table 16.8). Sport catch of canary, China, copper, quillback, rosethorn, tiger and yelloweye rockfish was not included until 2013, and only includes catch of those species west of the 140º W Longitude (i.e., NMFS areas 610 – 640). Thus, the estimated catch from ADF&G sources increases dramatically in 2013.

Catch at age and length

What little is known of the size structure for OR comes from trawl survey data, and is limited to harlequin, redbanded, redstripe, sharpchin, silvergray and yelloweye rockfish. Age composition data is limited to harlequin, redstripe, sharpchin and silvergray rockfish. The ages are all based on the break-and-burn technique of ageing otoliths. No age validation has been done for any of these species, so the results should be considered preliminary.

Survey ages are available from between one and four survey years for each of the species aged (Figure 16.6). A large sampling effort was conducted during the 1996 survey, resulting in the greatest number of age samples. Other survey years generally had low sample sizes, with the exception of silvergray rockfish which had meaningful sample sizes from 1993 – 1999 and harlequin rockfish which was sampled in 2005. It is difficult to detect the presence of strong cohorts based on the age structure of available data. However, based on the 1996 survey samples, the 1981 – 1983 year classes appeared predominant in the age structures of redstripe, sharpchin and silvergray rockfish and the 1986 year class was predominant for harlequin rockfish.

Survey size compositions for the primary OR species are shown in Figure 16.7. It is not possible to determine significant recruitment events from the size composition data, nor if there are any shifts in mean length over time. Rockfish grow slowly and thus, the impact of a large recruitment event on the size composition could be dampened. The size composition data are limited in 2001, when the survey did not sample the Eastern GOA, as demonstrated by the small sample size for some of the species that are caught primarily in that area. Survey size composition data from the AFSC longline survey may also be useful for redbanded and yelloweye rockfish and will be investigated in the future.

Distribution of catch: fishery and survey

The vast majority of the survey biomass for OR occurs in the Eastern GOA, whereas much of the commercial catch occurs in the Western GOA and Central GOA. One example of the discontinuity between catch and abundance is harlequin rockfish (Figure 16.8). While the estimated biomass based on the trawl survey for harlequin rockfish is substantially lower than other species in the OR complex, it is the primary species caught by fisheries. Harlequin rockfish are caught in 7% of survey hauls, on average, in the Central GOA and 4% of hauls in the Western GOA. Catch per haul is generally low (average of 26 kg, st. dev. = 148 kg), with 91% of the hauls being below that average, indicating that there are few hauls with large catches. This is in stark comparison to the commercial catch, where harlequin rockfish catch is more broadly spread across the shelf and the shelf break with substantially larger mean catches. Similar maps are presented in Appendix 16B for several of the other species of OR.

Fishery data may provide a better picture of where certain species are distributed, but many of these species are primarily caught on trawl gear, and they are more abundant in the Eastern GOA where trawling is prohibited. The directed fishery for rockfish (e.g., Pacific ocean perch) in the Western GOA and Central GOA is responsible for the majority of the catch of OR. Thus the fishery data may provide some distribution information for the species farther west, in which untrawlable habitat may impact the survey catch. The survey is more restricted by untrawlable habitat than fishery gear.

Analytic Approach

Model Structure

The OR have historically been managed as a Tier 5 complex, with the exception of sharpchin rockfish, which are Tier 4, in which the over fishing limit (OFL) = biomass * F_{OFL}. Where F_{OFL} is either a proxy rate, assuming F_{OFL} = natural mortality (M) (Tier 5) or an estimated $F_{OFL} = F_{40\%}$ based on age of maturity information (Tier 4); and survey biomass is a 3-survey average. For this document we are presenting an alternative biomass time series using a random effects approach to survey averaging as well as

recommending that those species which are rarely caught in trawl surveys or commercial trawl gear be considered Tier 6.

The random effects model was put forth by the survey averaging working group. Recent assessments have used a biomass-based approach based on trawl survey data to calculate ABCs. We continue to use this approach in the present assessment; however, following the recommendations by the Survey Averaging working group, Plan Team and the SSC, methodology for calculating exploitable biomass has changed to the use of a random effects survey averaging approach. The process errors (step changes) from one year to the next are the random effects to be integrated over and the process error variance is the free parameter. The observations can be irregularly spaced; therefore this model can be applied to datasets with missing data. Large observation errors increase errors predicted by the model, which can provide a way to weight predicted estimates of biomass. Please see Survey Averaging Working Group document for more information on the random effects methodology and results across species (https://www.afsc.noaa.gov/REFM/stocks/Plan_Team/2012/Sept/survey_average_wg.pdf).

For OR, the model was run on the 17 species which have the most reliable biomass estimates, and are commonly caught in the trawl fisheries (the remaining seven species are generally poorly sampled by the trawl survey and almost exclusively caught by longline fisheries). The model estimates were made using the 1984 – 2015 time series of trawl survey biomass estimates and estimates uncertainty. We fit the random effects model to regional data (Western GOA, Central GOA and Eastern GOA) because the trawl survey did not sample the Eastern GOA in 2001, where a significant proportion of the OR population resides within the GOA.

Sharpchin rockfish is a Tier 4 species, so the random effects model was run on that species separately. The output of the random effects model provided a Gulfwide biomass estimate, as well as biomass by area and proportions for area allocation of the ABC. The OFL was calculated as the product of the Gulfwide biomass and F_{OFL}, which for this species is $F_{35\%} = 0.079$, and the Gulfwide ABC = Gulfwide biomass * $F_{40\%} = 0.065$.

For the remaining 16 species with reliable trawl survey biomass estimates, area-specific (Western, Central, and Eastern GOA) survey biomass estimates and variance were calculated for the 16 species combined and fit using the random effects model, providing estimates of the total biomass by area and Gulfwide. To estimate $F_{ABC/OFL}$ the model was fit to trawl survey biomass and variance estimates for sub-groups with the same natural mortality rates (resulting in 5 sub-groups for $M = 0.05$, 0.06, 0.07, 0.092, and 0.1). We were unable to run the model for each sub-group by area due to lack of data, and thus were forced to deviate from the Plan Team recommendations (2c in the September 2015 Plan Team minutes). Using the sub-group proportion of Gulfwide biomass, p_i (where the subscript i denotes the sub-group with a shared M), we then calculated $F_{OFL} = \Sigma p_i * F_i$, where F_i is the sub-group specific fishing mortality rate (using M as the proxy). The F_{ABC} is $0.75 * F_{OFL}$.

The seven species that primarily occur in longline fisheries, which are also generally not sampled or at best poorly sampled by the trawl survey are considered Tier 6 in the alternatives presented here. The time series of catch for Tier 6 calculations is defined as “reliable catch history from 1978-1995”. Species specific catch estimates are not available for these species prior to 1991. As an alternative time frame, other Tier 6 species us a 1997 – 2007 time series for Tier 6 calculations. In this assessment we also propose the time series of catch since observer restructuring began (i.e., 2013 – 2014) because those are the most unbiased catch estimates, and therefore “reliable”. Changes in the estimated discard rates of these species after 2013, suggest that a substantial portion of the discards may not have been captured in CAS with the earlier observer program, thus the most representative time series of catch is that beginning in 2013. Within the Tier 6 definition, there is flexibility to determine the most appropriate metric, thus we present a range of options that have been examined in other Tier 6 assessments, which include: average, median and maximum catch, and 95th and 99th percentile of catch.

Parameter Estimates

Estimates of mortality, maximum age, and female age- and size-at-50% maturity are shown in Table 16.11. The mortality rates are based on a variety of methods. Those that were calculated using the catch curve method are actually estimates of the total instantaneous mortality (Z) and should be considered as upper bounds for the natural mortality rate (*M*).

Results

Model Evaluation

The status quo calculations are presented in Table 16.12. The status quo approach treats all the species in the complex as Tier 5, and calculated the species specific OFL and ABC the product of the 3 – survey average biomass and natural mortality (or $F_{40\%}$ and $F_{35\%}$ for sharpchin rockfish)

The utility of using the random effect approach for survey averaging for the OR complex was investigated and presented at the September 2015 Plan Team meeting (Appendix 16A). Results suggest that either modeling the grouped OR species Gulfwide or the grouped species by region would be appropriate. However, the model with consistently the lowest variance estimator is the model by region. This model would also be simpler to use in the assessment due to the current apportionment strategy (i.e., by Western, Central and Eastern GOA). Further, modeling by region accounts for the missing survey in the Eastern GOA in 2001.

The random effect model was run for sharpchin separately from the other 16 OR species with reliable trawl survey biomass. Estimated biomass is presented in Table 16.13 and Figure 16.9, for sharpchin rockfish and Table 16.14 and Figure 16.9 for the 16 grouped species.

The ABC/OFLs were calculated for the Tier 6 species for two time series, 1997 – 2007, to be consistent with other Tier 6 species, and 2013 – 2014 to coincide with the availability of the most unbiased catch data. We include the average and maximum catches for both time series, and median catches, the 95th and 99th percentile of the data for the 1997 – 2007 time series (not included for the short time series because there are only two data points). Calculations are made for each species, then summed for the total Tier 6 options. It is important to note that these Tier 6 calculations are to be combined with that of the random effects ABC/OFLs and are not intended to be separately managed ABC/OFLs. The ABCs are calculated by species and area, thus the total Tier 6 ABC may not exactly equal 0.75*OFL.

Tier 6 options		Western GOA	Central GOA	West Yakutat	Total Tier 6 OFL	Total Tier 6 ABC
1997-2007	Avg	17	52	16	85	63
	Max	46	116	32	194	145
	Median	6	59	15	80	59
	95th Percentile	42	101	30	173	129
	99th Percentile	45	113	31	189	141
2013-2014	Avg	31	109	15	155	116
	Max	38	115	17	170	127

Harvest Recommendations

For the 2015 assessment cycle we are presenting the status quo method of ABC and OFL estimation, along with two alternatives.

1) Status quo: All species are Tier 4/5 (with the exception of sharpchin, which is Tier 4), and the complex OFL is the sum of the products of the species specific F_{OFL}s and the 3-survey biomass

averages, and the ABC is 75% of the OFL. Sharpchin rockfish use $F_{OFL} = F_{35\%}$ and $F_{ABC} = F_{40\%}$, while F_{OFL} for all other species is the mortality rate (M).

2) Tier 4/5/6 with 3-survey average biomass: Same as alternative 1, but with seven species calculated as Tier 6, using the maximum historical catch (2013 – 2014). Note that for the recommendations, the Tier 6 ABC and OFL results are rounded down to the nearest whole ton.
3) Tier 4/5/6 with random effects biomass estimates: Same as alternative 2, but with the random effects estimated biomass used as exploitable biomass.

		Exploitable Biomass	ABC	OFL
Alternative 1				
Tier 4/5 summed over each species	$F_{OFL} = M$, OFL = M*3 yr Avg Biomass, ABC = 0.75*OFL	83,325	4,012	5,350
	OR Complex Total		**4,012**	**5,350**
Alternative 2				
Tier 4/5 (17 species individually)	$F_{OFL} = M$, OFL = M*3 yr Avg Biomass, ABC = 0.75*OFL	81,522	3,972	5,295
Tier 6 (7 species individually)	OFL =max Catch 2013-2014, ABC = 0.75*OFL		129	172
	OR Complex Total		**4,101**	**5,467**
Alternative 3				
Tier 4	$F_{OFL} = F_{35\%}$, OFL = $F_{35\%}$*Rand Eff Biomass, FABC = $F_{40\%}$, ABC = $F_{40\%}$*Rand Eff Biomass,	35,083	2,280	2,772
Tier 5 (16 species grouped)	$F_{OFL} = M$, OFL = M*Rand Eff Biom, ABC = 0.75*OFL	69,743	3,362	4,482
Tier 6 (7 species individually)	OFL =max Catch 2013-2014, ABC = 0.75*OFL		127	170
	OR Complex Total		**5,796**	**7,424**

We recommend Alternative 3 because: 1) assessment authors have been instructed to use the random effects model for survey averaging by the Plan Team; 2) the random effects biomass was presented during the September Plan Team meeting and was approved; and 3) calculating the seven species as Tier 6 includes ABCs for species that either do not have a survey biomass but have commercial catch (e.g., quillback rockfish) or those species that are generally caught on longline gear (e.g., yelloweye rockfish). Further, we recommend using the 2013 – 2014 time series because it uses the improved catch data resulting from the restructured observer program and we recommend using the maximum catch because these species are patchily distributed and not targeted, thus large catches are likely anomalies and the maximum catch metric allows for these anomalies.

Area Allocation of Harvests

Based on the geographic distribution of the species' exploitable biomass in the trawl surveys, the NPFMC has apportioned the ABC and thus the TAC for OR in the GOA into three geographic management areas: the Western GOA, Central GOA, and Eastern GOA. Beginning in this year's assessment, the proportion of ABC in each area is estimated as part of the random effects model. Since 1999, trawling has been prohibited in the Eastern GOA east of 140° W. longitude. Because most species of the OR complex are caught exclusively with trawl gear, this closure could have concentrated the catch of these fish in the Eastern GOA in the relatively small area between 140° and 147° W longitude that remained open to trawling. To ensure that such a geographic over-concentration of harvest would not occur, beginning in 1999 the NPFMC divided the Eastern GOA into two smaller management areas: West Yakutat (area between 147° and 140° W long.) and East Yakutat/Southeast (area east of 140° W. long.) (Figure 16.1). Separate ABCs and TACs were assigned to each of these smaller areas for the OR complex. A

proportional fraction of the biomass in the West Yakutat vs. East Yakutat/Southeast areas is computed for each trawl survey (termed "split fraction"). The ABCs in West Yakutat and East Yakutat/Southeast are computed as a weighted average of the split fraction in the three most recent trawl surveys. In the computations, each successive survey is given a progressively heavier weighting using factors of 4, 6, and 9, respectively.

The random effect model estimates the apportionment proportions for each species group, therefore, the sharpchin estimated ABC is apportioned separately from all of the Tier 5 OR species. The Tier 6 ABCs were calculated by area for each species. The complex ABC by area is the sum of the Tier 4, Tier 5 and Tier 6 ABC by area. The split fractions for delineating the biomass between West Yakutat and the East Yakutat/Southeast portions of the Eastern GOA are calculated at the complex level, thus the same split fraction was used for sharpchin as for the Tier 5 OR species.

Tier 4	Western GOA	Central GOA	Eastern GOA (75.01%)		Total
			West Yakutat[1]	E Yakutat/ Southeast[1]	
Area Apportionment	0.20%	24.79%	9.96%	65.05%	100%
Area ABC (t)	5	565	227	1,483	2,280
OFL (t)					2,772

Tier 5	Western GOA	Central GOA	Eastern GOA (74.72%)		Total
			West Yakutat[1]	E Yakutat/ Southeast[1]	
Area Apportionment	0.65%	24.62%	13.28%	86.72%	100%
Area ABC (t)	22	828	334	2,178	3,362
OFL (t)					4,482

Tier	Western GOA	Central GOA	Eastern GOA		Gulfwide ABC	Gulfwide OFL
			West Yakutat	E. Yak/ Southeast		
4	5	565	227	1,483	2,280	
5	22	828	334	2,178	3,362	
6	28	86	13	0	127	
Total					5,769	7,424

Ecosystem Considerations

The ecosystem considerations for the GOA OR stock complex are summarized in Table 16.15.

Ecosystem Effects on Stock

Prey availability/abundance trends: similar to other rockfish species, stock condition of OR is probably influenced by periodic abundant year classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval rockfish may be an important determining factor of year-class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year-class strength; moreover, identification to the species level for field collected larval rockfish is difficult. Visual identification is generally not possible, although genetic techniques allow identification to species level for larvae of many OR species (Gharrett et. al 2001). Some juvenile rockfish found in inshore habitat feed on shrimp, amphipods, and other crustaceans, as well as some mollusks and fish (Byerly 2001). Food habits data on

OR species in Alaska is very sparse, but adult sharpchin rockfish in the GOA feed mostly on plankton such as calanoid copepods and euphausiids and also on pandalid shrimp (Yang et al. 2006). Redstripe rockfish in areas south of Alaska feed on euphausiids, shrimps, and small fish (Love et al. 2002). Little if anything is known about abundance trends of these rockfish prey items.

Predator population trends: Rockfish are preyed on by a variety of other fish at all life stages, and to some extent by marine mammals during late juvenile and adult stages. Whether the impact of any particular predator is significant or dominant is unknown. Predator effects would likely be more important on larval, post-larval, and small juvenile rockfish, but information on these life stages and their predators is nil.

Changes in physical environment: Strong year classes corresponding to the period around 1976 – 1977 have been reported for many species of groundfish in the GOA, including Pacific Ocean perch, northern rockfish, sablefish, and Pacific cod. Environmental conditions during this period were favorable for the survival of many young-of-the-year groundfish species and may have also been favorable for OR. The environmental mechanism for this increased survival remains unknown. Changes in water temperature and currents could have an effect on prey item abundance and success of transition of rockfish from the pelagic to demersal stage. Rockfish in early juvenile stage have been found in floating kelp patches which would be subject to ocean currents.

Changes in bottom habitat due to natural or anthropogenic causes could affect survival rates by altering available shelter, prey, or other functions. Associations of juvenile rockfish with biotic and abiotic structure have been noted by Carlson and Straty (1981), Pearcy et al. (1989), Love et al. (1991), and Freese and Wing (2003). 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).

Fishery Effects on Ecosystem

Because there is no targeted fishing on OR in the GOA, nearly all the catch of these species is taken incidentally in directed rockfish trawl fisheries for Pacific Ocean perch, northern rockfish, and dusky rockfish and in longline fisheries for sablefish and Pacific halibut. Thus, the reader is referred to the discussions on “Fishery Effects” in the chapters for these species in this SAFE report.

Data Gaps and Research Priorities

Data limitations are severe for OR in the GOA, and it is extremely difficult to determine whether current management is appropriate with the limited information available. Gaps include imprecise biomass estimates, limited and unvalidated ageing, and lack of life history information. Regardless of future management decisions regarding the OR complex management category, improving biological sampling of OR in fisheries and surveys is essential. A more detailed picture of age, growth and reproduction of OR would help determine if they are similar enough in life histories that they should be treated as one complex.

Acknowledgments

We gratefully acknowledge the following individuals for their timely and efficient work in providing survey and catch data for OR species: Wayne Paulson for the Gulf of Alaska trawl survey estimates (AFSC); the Alaska Regional Office (NMFS) provided estimates of commercial catch; and Bob Ryzner, and Rob Ames (Alaska Fisheries Information Network (AKFIN), Pacific States Marine Fisheries Commission) provided a user friendly portal to access Catch Accounting System data and multiple AFSC survey data sources.

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Table 16.1. Species comprising the Other Rockfish (OR) management category in the Gulf of Alaska.

Common name	Scientific name	Former (pre-2012) Management Category
blackgill rockfish	*Sebastes melanostomus*	Other Slope Rockfish
bocaccio	*S. paucispinis*	Other Slope Rockfish
canary rockfish [a]	*S. pinniger*	Other Rockfish
Chilipepper	*S. goodie*	Other Slope Rockfish
China rockfish [a]	*S. nebulosus*	Other Rockfish
copper rockfish [a]	*S. caurinus*	Other Rockfish
darkblotched rockfish	*S. crameri*	Other Slope Rockfish
greenstriped rockfish	*S. elongates*	Other Slope Rockfish
harlequin rockfish	*S. variegatus*	Other Slope Rockfish
northern rockfish[b]	*S. polyspinis*	Other Slope Rockfish
pygmy rockfish	*S. wilsoni*	Other Slope Rockfish
quillback rockfish[a]	*S. maliger*	Other Rockfish
redbanded rockfish	*S. babcocki*	Other Slope Rockfish
redstripe rockfish	*S. proriger*	Other Slope Rockfish
rosethorn rockfish [a]	*S. helvomaculatus*	Other Rockfish
sharpchin rockfish	*S. zacentrus*	Other Slope Rockfish
silvergray rockfish	*S. brevispinis*	Other Slope Rockfish
splitnose rockfish	*S. diploproa*	Other Slope Rockfish
stripetail rockfish	*S. saxicola*	Other Slope Rockfish
tiger rockfish[a]	*S. nigrocinctus*	Other Rockfish
vermilion rockfish	*S. miniatus*	Other Slope Rockfish
widow rockfish	*S. entomelas*	Other Slope Rockfish
yelloweye rockfish[a]	*S. ruberrimus*	Other Rockfish
yellowmouth rockfish	*S. reedi*	Other Slope Rockfish
yellowtail rockfish	*S. flavidus*	Other Slope Rockfish

[a]Only in the Western GOA, Central GOA and West Yakutat management areas, otherwise in the Demersal Shelf Rockfish assessment.
[b]Only in the West Yakutat and Southeast management areas (i.e. Eastern GOA), otherwise in the northern rockfish assessment.

Table 16.2. Management history for the Other Rockfish stock complex

Year	Management Measures
1988	The NPFMC implements the slope rockfish assemblage, which includes the species that will become "other slope rockfish", together with Pacific Ocean Perch, Northern Rockfish, Shortraker Rockfish and Rougheye Rockfish. Previously, *Sebastes* in Alaska were managed as the "Pacific Ocean Perch complex" or "Other Rockfish".
1988	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.
1991	Slope rockfish assemblage is split into three management subgroups with separate ABCs and TACs: Pacific Ocean Perch, Shortraker/Rougheye Rockfish, and "other slope rockfish".
1993	Northern Rockfish is split as a separate management entity from "other slope rockfish".
1997	Area apportionment procedure for "other slope rockfish" is changed. Apportionment is now based on 4:6:9 weighting of biomass in the most recent three NMFS trawl surveys.
1999	Trawling is prohibited in the Eastern Gulf east of 140° W long. Eastern Gulf trawl closure becomes permanent with the implementation of FMP Amendments 41 and 58 in 2000 and 2001, respectively.
1999	Northern Rockfish in the Eastern Gulf is reassigned to "other slope rockfish".
1999	Eastern Gulf is divided into West Yakutat and East Yakutat/Southeast Outside, and separate ABCs and TACs are assigned for "other slope rockfish" in these areas.
2007	Amendment 68 creates the Central Gulf Rockfish Pilot Program, which affects trawl catches of rockfish in this area.
2012	Yellowtail and Widow Rockfish are assigned to the "other slope rockfish" group, and group name is changed to "Other Rockfish".
2014	Merge Western and Central ABC and TAC

Table 16.3. Time series of catch estimates for the full Other Rockfish (OR) complex with total allowable catch (TAC), acceptable biological catch (ABC), over fishing level (OFL) and the management category. Catch values presented here show estimated catches for the complex at that time, meaning that in 1991 the catches in this table represent all of the species in the Other Slope Rockfish (OSR) group at that time, which includes northern rockfish GOA wide.

	Gulf of Alaska Region							
Year	Western	Central	Eastern	Total	TAC	ABC	OFL	Management Group
1991	20	175	83	4,806	10,100	10,100		OSR
1992	76	854	745	9,445	14,060	14,060	28,200	OSR
1993	342	2,423	2,577	5,342	5,383	8,300	9,850	OSR - northerns removed
1994	101	715	753	1,569	2,235	8,300	9,850	OSR
1995	31	883	431	1,345	2,235	7,110	8,395	OSR
1996	19	618	226	863	2,020	7,110	8,395	OSR
1997	68	941	186	1,195	2,170	5,260	7,560	OSR
1998	46	701	101	848	2,170	5,260	7,560	OSR
1999	39	614	135	788	5,270	5,270	7,560	OSR - EGOA northern included
2000	49	363	165	577	4,900	4,900	6,390	OSR
2001	25	318	216	559	1,010	4,900	6,390	OSR
2002	223	481	70	774	990	5,040	6,610	OSR
2003	133	677	249	1,059	990	5,050	6,610	OSR
2004	240	534	106	880	670	3,900	5,150	OSR
2005	64	516	118	698	670	3,900	5,150	OSR
2006	279	603	216	1,098	1,480	4,152	5,394	OSR
2007	249	339	106	695	1,482	4,154	5,394	OSR
2008	250	438	78	767	1,730	4,297	5,624	OSR
2009	403	399	96	899	1,730	4,297	5,624	OSR
2010	365	429	170	964	1,192	3,749	4,881	OSR
2011	301	359	228	888	1,192	3,749	4,881	OSR
2012	254	723	60	1,038	1,080	4,045	5,305	OR - includes widow and yellowtail
2013	202	474	140	817	1,080	4,045	5,305	OR
2014	171	718	99	987	1,811	4,081	5,374	OR
2015	201	825	51	1,077	1,811	4,081	5,374	OR

[a]The total OR catch includes Gulfwide catch of northern rockfish, catch by region are not currently available.

Table 16.4. Estimated discard rates for the Other Rockfish stock complex.

Year	Discards	Catch	Discard Rate
1991	255.2	364.4	70%
1992	1077.4	1733.4	62%
1993	2682.7	5462.5	49%
1994	1081.5	1638.6	66%
1995	1035.6	1421.0	73%
1996	678.0	893.5	76%
1997	634.2	1218.4	52%
1998	572.7	862.9	66%
1999	562.7	810.1	69%
2000	315.1	587.4	54%
2001	268.5	559.8	48%
2002	451.3	776.9	58%
2003	732.3	1069.4	68%
2004	577.1	967.3	60%
2005	301.1	699.7	43%
2006	797.3	1099.9	72%
2007	269.2	696.6	39%
2008	442.8	769.2	58%
2009	494.3	903.9	55%
2010	579.7	975.6	59%
2011	474.7	896.6	53%
2012	520.9	1037.9	50%
2013	558.3	816.6	68%
2014	404.4	987.4	41%
2015	571.1	1076.9	53%

Table 16.5. Time series of estimated catches of the species in the Other Rockfish complex. Catch by species from 1991 – 2002 from previous assessments, from 2003 – present from the Alaska Regional Office Catch Accounting System. Data queried through AKFIN on October 1, 2015.

Year	Harlequin	Redbanded	Redstripe	Sharpchin	Silvergray	Yelloweye	Minors	OR Total
1991	78.5	7.6	63.3	6.1	4.7	81.5	122.7	364.4
1992	653.9	15.3	131.5	393.3	216.7	106.1	216.7	1733.4
1993	1997.0	43.4	1393.6	1328.2	319.7	131.2	249.4	5462.5
1994	721.8	22.7	191.2	273.8	205.0	46.7	177.5	1638.6
1995	633.7	23.1	175.9	323.4	104.7	38.9	121.4	1421.0
1996	339.5	26.7	138.5	299.6	10.8	30.0	48.4	893.5
1997	460.6	15.6	279.1	307.8	34.3	43.1	77.9	1218.4
1998	418.4	23.3	52.8	295.2	7.5	29.2	36.5	862.9
1999	362.1	20.1	78.0	150.2	15.3	130.0	54.4	810.1
2000	157.8	40.9	59.7	221.7	24.9	35.4	47.0	587.4
2001	254.6	76.9	41.6	122.2	15.7	28.8	20.0	559.8
2002	346.4	59.8	15.3	242.6	57.0	20.7	35.0	776.9
2003	509.8	50.0	41.3	250.5	25.7	149.5	42.6	1069.4
2004	470.1	46.0	40.0	154.8	21.3	128.1	107.0	967.3
2005	475.2	62.7	9.9	51.4	4.3	88.9	7.3	699.7
2006	616.8	98.4	64.9	98.0	12.8	146.7	62.5	1099.9
2007	329.3	72.2	39.5	96.8	12.4	131.5	15.0	696.6
2008	366.1	52.4	31.0	78.3	9.6	200.4	31.3	769.2
2009	517.7	46.3	34.2	84.2	22.9	166.9	31.7	903.9
2010	446.1	65.4	77.3	122.2	35.6	200.0	28.9	975.6
2011	368.2	71.8	79.2	91.4	92.5	176.4	17.1	896.6
2012	566.6	38.2	60.7	98.9	40.5	200.3	32.7	1037.9
2013	368.4	89.4	43.5	75.8	24.6	160.2	54.8	816.6
2014	508.9	75.3	94.8	96.3	35.3	135.7	41.1	987.4
2015	592.4	56.6	31.4	86.4	52.5	206.8	50.6	1076.9

Table 16.6. Proportion of Other Rockfish (Other Slope Rockfish prior to 2011) catch by gear type. HAL = hook and line, which includes jig; TWL = trawl gear types, Other = primarily pot gear.

Year	HAL	TWL	Other
1991	8%	4%	0%
1992	4%	3%	0%
1993	3%	1%	0%
1994	9%	7%	0%
1995	14%	12%	0%
1996	16%	13%	0%
1997	2%	0%	0%
1998	3%	92%	0%
1999	1%	95%	0%
2000	1%	96%	0%
2001	2%	98%	0%
2002	3%	98%	0%
2003	7%	94%	0%
2004	6%	95%	1%
2005	6%	93%	0%
2006	12%	86%	1%
2007	6%	86%	0%
2008	4%	85%	0%
2009	4%	94%	0%
2010	8%	90%	0%
2011	7%	91%	0%
2012	12%	87%	0%
2013	36%	64%	0%
2014	19%	79%	0%
2015	17%	83%	0%

Table 16.7. Estimated catch of Other Rockfish (OR) by Gulf of Alaska (GOA) NMFS regulatory area. The acceptable biological catches (ABCs) are only presented for the years of the current OR complex. The ABCs for Western and Central GOA were combined starting in 2014.

	Gulf of Alaska Catch				Acceptable Biological Catch			
Year	Western GOA	Central GOA	West Yakutat	Southeast	Western GOA	Central GOA	West Yakutat	Southeast
1991	89.6	175.7	96.7	2.4				
1992	77.4	855.3	734.3	66.4				
1993	342.3	2462.1	735.4	1922.6				
1994	101.0	722.8	569.0	245.9				
1995	41.1	886.4	469.5	24.1				
1996	27.6	620.3	234.9	10.7				
1997	68.0	942.4	122.6	85.4				
1998	46.1	702.7	107.8	6.3				
1999	39.2	614.8	125.2	30.9				
2000	49.1	370.2	133.7	34.4				
2001	25.0	318.1	169.9	46.8				
2002	223.0	483.9	45.0	25.0				
2003	133.2	683.4	226.6	26.2				
2004	275.0	584.0	77.7	30.6				
2005	64.6	516.3	70.9	48.0				
2006	279.2	604.1	137.7	78.9				
2007	249.3	340.5	53.6	53.3				
2008	250.5	439.1	50.4	29.2				
2009	403.3	402.9	83.1	14.6				
2010	365.3	438.9	131.3	40.1				
2011	301.1	365.9	191.6	38.0				
2012	254.5	722.9	37.5	23.0	44	606	230	3,165
2013	201.9	474.4	77.3	63.0	44	606	230	3,165
2014	170.6	717.5	61.2	38.0	1,031		580	2,470
2015	200.7	825.2	33.0	17.9	1,031		580	2,470

Table 16.8. Comparison of Gulfwide biomass estimates (t) for species in the Other Rockfish (OR) management category in the Gulf of Alaska (GOA), based on bottom trawl surveys conducted between 1984 and 2015. The six primary species are shown with all other species being grouped as "minors." Note that biomass estimates for canary, china, copper, quillback, rosethorn and tiger rockfish (which are all in the minors group) and yelloweye rockfish do not include the Eastern GOA. These species are included in the OR complex in the West Yakutat portion of the Eastern GOA. Biomass estimates are calculated based on INPFC areas, which do not line up with NMFS Regulatory areas and split fractions commonly used to deal with this difference in strata have not been created for these seven species, thus the Eastern GOA biomass of canary, china, copper, quillback, rosethorn, tiger and yelloweye rockfish is not included in this table.

Survey Year	Harlequin	Redbanded	Redstripe	Sharpchin	Silvergray	Yelloweye	Minors	OR Total
1984	2,624.9	1,430.3	5,364.0	6,611.9	4,816.7	119.0	1,115.3	22,082.1
1987	72,405.1	1,822.2	26,518.6	80,438.5	5,425.9	422.6	1,078.4	188,111.3
1990	17,664.2	3,285.4	27,063.9	38,333.5	14,148.9	308.9	3,062.3	103,867.1
1993	9,280.6	3,675.1	29,619.3	23,675.9	18,978.9	593.3	5,284.7	91,107.8
1996	20,026.2	4,593.7	14,963.9	64,570.0	24,127.3	522.9	2,691.5	131,495.5
1999	9,876.5	10,941.1	8,225.9	20,840.6	37,641.1	2,280.8	19,399.4	109,205.4
2001[a]	8,364.9	414.6	126.7	1,797.2	63.0	1,549.8	278.3	12,594.5
2003	3,544.6	3,440.6	8,025.3	7,093.6	51,915.4	904.0	1,817.9	76,741.4
2005	33,123.8	5,610.3	21,702.5	21,135.2	41,080.7	1,891.4	2,069.2	126,613.1
2007	4,056.9	7,198.2	11,500.7	19,037.0	29,797.5	980.4	2,910.0	75,480.7
2009	2,686.2	6,442.3	1,591.5	12,492.7	9,851.4	777.0	4,487.5	38,328.6
2011	3,734.5	5,041.8	18,744.8	8,041.0	100,049.1	2,518.0	10,904.2	149,033.4
2013	7,485.3	5,867.9	9,871.1	14,919.7	19,238.5	747.1	4,483.2	62,612.8
2015	2,316.4	5,457.0	16,699.3	45,016.3	44,174.4	872.1	2,268.4	116,803.9

Table 16.9. Detailed biomass estimates (t) by NMFS regulatory area for the six primary species of Other Rockfish (OR) in the Gulf of Alaska (GOA), based on bottom trawl surveys conducted between 1984 and 2015. Note that biomass estimates for yelloweye rockfish do not include the Eastern GOA. This species is included in the OR complex in the West Yakutat portion of the Eastern GOA. Biomass estimates are calculated based on INPFC areas, which do not line up with NMFS Regulatory areas and split fractions commonly used to deal with this difference in strata have not been created for yelloweye rockfish, thus the Eastern GOA biomass for this species is not included in this table.

		Regulatory Area				
		Western GOA	Central GOA	Eastern GOA	Gulfwide Total	CV%
Harlequin	1984	65.1	1,313.6	1,246.2	2,624.9	31%
	1987	7,491.2	20,248.7	44,665.2	72,405.1	29%
	1990	124.6	13,584.0	3,955.6	17,664.2	51%
	1993	84.2	8,528.9	667.5	9,280.6	47%
	1996	772.7	2,882.5	16,371.0	20,026.2	64%
	1999	7.4	8,562.6	1,306.5	9,876.5	42%
	2001	2,987.2	5,377.7	0.0	8,364.9	50%
	2003	25.1	1,498.3	2,021.2	3,544.6	45%
	2005	26,667.6	1,930.3	4,525.9	33,123.8	64%
	2007	834.1	1,902.3	1,320.5	4,056.9	45%
	2009	44.2	839.8	1,802.2	2,686.2	43%
	2011	2,237.6	1,081.9	415.0	3,734.5	61%
	2013	122.8	6,720.4	642.1	7,485.3	71%
	2015	468.3	1,430.5	417.6	2,316.4	48%
Redbanded	1984	0.0	168.8	1,261.5	1,430.3	31%
	1987	21.1	604.0	1,197.1	1,822.2	33%
	1990	0.0	219.5	3,065.9	3,285.4	35%
	1993	10.5	434.2	3,230.4	3,675.1	29%
	1996	61.2	199.8	4,332.7	4,593.7	34%
	1999	118.4	402.7	10,420.0	10,941.1	41%
	2001	60.8	353.8	0.0	414.6	24%
	2003	18.9	889.3	2,532.4	3,440.6	22%
	2005	41.3	1,009.7	4,559.3	5,610.3	22%
	2007	51.8	1,164.2	5,982.2	7,198.2	25%
	2009	34.0	2,020.4	4,387.9	6,442.3	17%
	2011	12.2	1,304.0	3,725.6	5,041.8	23%
	2013	66.2	2,346.0	3,455.7	5,867.9	19%
	2015	52.1	1,901.0	3,503.9	5,457.0	18%
Redstripe	1984	0.0	138.8	5,225.2	5,364.0	41%
	1987	1,263.0	1,819.7	23,435.9	26,518.6	47%
	1990	0.0	14.7	27,049.2	27,063.9	52%
	1993	5.3	111.5	29,502.5	29,619.3	55%
	1996	152.1	90.8	14,721.0	14,963.9	54%
	1999	0.0	138.8	8,087.1	8,225.9	49%
	2001	2.5	124.2	0.0	126.7	60%
	2003	4.9	175.0	7,845.4	8,025.3	36%
	2005	2,796.2	12,826.8	6,079.5	21,702.5	58%
	2007	15.2	655.6	10,829.9	11,500.7	61%
	2009	1.2	48.3	1,542.0	1,591.5	46%
	2011	0.0	499.1	18,245.7	18,744.8	87%
	2013	17.8	8,721.5	1,131.8	9,871.1	87%
	2015	0.0	11,951.7	4,747.6	16,699.3	71%
Sharpchin	1984	0.0	1,945.4	4,666.5	6,611.9	36%
	1987	3,366.3	43.0	77,029.2	80,438.5	39%
	1990	1.6	3,363.3	34,968.6	38,333.5	37%
	1993	73.6	7,047.4	16,554.9	23,675.9	32%
	1996	72.2	1,921.4	62,576.4	64,570.0	32%
	1999	0.0	2,856.2	17,984.4	20,840.6	66%
	2001	23.2	1,774.0	0.0	1,797.2	69%
	2003	38.0	289.5	6,766.1	7,093.6	46%

		Regulatory Area				
		Western GOA	Central GOA	Eastern GOA	Gulfwide Total	CV%
Sharpchin	2005	194.7	10,757.3	10,183.2	21,135.2	32%
	2007	52.5	4,047.8	14,936.7	19,037.0	34%
	2009	14.7	654.6	11,823.4	12,492.7	35%
	2011	0.0	538.0	7,503.0	8,041.0	63%
	2013	160.1	810.6	13,949.0	14,919.7	50%
	2015	66.9	15,888.7	29,060.7	45,016.3	55%
Silvergray	1984	0.0	52.2	4,764.5	4,816.7	28%
	1987	37.4	149.1	5,239.4	5,425.9	40%
	1990	0.0	280.4	13,868.5	14,148.9	42%
	1993	0.0	543.8	18,435.1	18,978.9	31%
	1996	0.0	1,552.7	22,574.6	24,127.3	27%
	1999	0.0	6,745.1	30,896.0	37,641.1	33%
	2001	0.0	63.0	0.0	63.0	58%
	2003	0.0	64.8	51,850.6	51,915.4	73%
	2005	18.1	1,073.2	39,989.4	41,080.7	40%
	2007	0.0	358.9	29,438.6	29,797.5	26%
	2009	0.0	94.3	9,757.1	9,851.4	43%
	2011	0.0	24,109.7	75,939.4	100,049.1	35%
	2013	0.0	406.3	18,832.2	19,238.5	38%
	2015	0.0	1,497.6	42,676.8	44,174.4	35%
Yelloweye	1984	21.9	97.1		119.0	52%
	1987	73.2	349.4		422.6	35%
	1990	0.0	308.9		308.9	39%
	1993	13.7	579.6		593.3	33%
	1996	43.5	479.4		522.9	48%
	1999	0.0	2,280.8		2,280.8	46%
	2001	41.5	1,508.3		1,549.8	50%
	2003	45.9	858.1		904.0	49%
	2005	904.9	986.5		1,891.4	39%
	2007	325.9	654.5		980.4	33%
	2009	0.0	777.0		777.0	34%
	2011	173.5	2,344.5		2,518.0	44%
	2013	154.8	592.3		747.1	57%
	2015	49.0	823.1		872.1	36%

Table 16.10. Research survey catch of Other Rockfish 1977 - 2014 in the Gulf of Alaska (GOA). Beginning in 2010 all research and other non-commercial catch was provided by the Alaska Regional Office. These removals do not count against the total allowable catch.

Year	Source	AFSC Trawl Surveys (t)	AFSC LL Survey (#s)	AFSC LL Survey (t)	IPHC LL Survey (#s)	IPHC LL Survey (t)	ADF&G (t) (includes sport and research)
1977		0.8					
1978		9.5					
1979		0.4					
1980		0.4					
1981		16.3					
1982		2.9					
1983		0.1					
1984		3.4					
1985		1.7					
1986		0					
1987		19.8					
1988		0.7					
1989		0.1					
1990	Assessment of the Other Rockfish in the Gulf of Alaska (Clausen and Echave 2010)	11.8					
1991		tr					
1992		0					
1993		11.3					
1994		0					
1995		0					
1996		16.9					
1997		0					
1998		2.4					
1999		51.6					
2000		0					
2001		0.7					
2002		tr					
2003		8.7					
2004		tr					
2005		11					
2006		tr					
2007		8.1					
2008		tr					
2009		4.2					
2010	AKRO	tr	1,453.0	2.6	NA	7.3	4.7
2011		7.7	1,212.0	2.2	NA	4.8	3.9
2012			1,320.0	2.4	NA	5.1	4.9
2013		3.8	1,191.0	2.2	NA	4.7	50.8
2014			1,636.0	3.1	NA	6.9	55.7

Table 16.11. A description of the life history of each of the species within the Other Rockfish (OR) and complex along with mortality rates, maximum age, and female age and size at 50% maturity, where available. Size is fork length in cm. Area indicates location of study: California (CA), Oregon (O), British Columbia (BC), Gulf of Alaska (GOA), Eastern Gulf of Alaska (EGOA), and Washington (W). Mortality rates with no superscript have unknown methodology for their calculations.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References
blackgill rockfish		87			CA	1
bocaccio rockfish	0.06	> 40		54	O, CA	2, 3
canary rockfish	0.05	84		51	BC	2, 3
chilipepper rockfish		35			CA	2
China rockfish		79			GOA, EGOA	2, 4
copper rockfish		61				2, 15
darkblotched rockfish	0.07[a]	48, 105		39	BC	2, 5
greenstriped rockfish	0.07	54		22		2
harlequin rockfish	0.092[b]	47		23	EGOA	8
pygmy rockfish	0.06	26				2
quillback rockfish	0.06	95	11	29	BC	2, 3, 10
redbanded rockfish	0.06	106	19	42	BC	2, 3, 4
redstripe rockfish	0.1[a]	41			BC	2, 3, 5, 6, 7, 15
rosethorn rockfish	0.06	87		21.5		2, 3
sharpchin rockfish	0.056-0.059[a]	58	10	26.5	GOA	8
silvergray rockfish	0.05[b]	75	34-45		GOA	8
splitnose rockfish	0.06	86		27	BC	2
stripetail rockfish		38			CA	2
tiger rockfish		116			EGOA	2, 3, 5
vermilion rockfish		60			CA	2
widow rockfish	0.05[a]	59			BC	2, 7
yelloweye rockfish	0.02	118	22	45	EGOA	2, 13
yellowmouth rockfish	0.06[a]	71			BC	3, 5, 7
yellowtail rockfish	0.07	64			BC	2, 14

(1)Helser 2005; (2) Love et al. 2002; (3) Munk 2001; (4) O'Connell 1987; (5) Archibald et al. 1981; (6) Clausen and Echave 2011; (7) Chilton and Beamish 1982; (8) Malecha et al. 2007; (9) Heifetz et al. 1998; (10) Kerr et al. 2003; (11) Stanley and Kronlund 2005; (12) Stanley and Kronlund 2000; 13) O'Connell and Funk 1987; 14) Leaman and Nagtegaal 1987; 15) Meyer and Failor in prep.

Mortality rate methods

[a]: Total mortality (Z) as computed by catch curve analysis

[b]: Natural mortality (M) as computed by a combination of the Alverson and Carney (1975) and Hoenig (1983) methods

Table 16.12. Summary of computations of ABCs and overfishing levels for the Other Rockfish (OR) complex in the Gulf of Alaska, using the status quo approach. Since actual ABCs and overfishing levels for OR are based on the overall management category, individual species are shown only for illustrative purposes. For species with unknown natural mortality rates (M), a proxy value of 0.06 was used. (Because of rounding, numbers may not add exactly to totals.)

Species	Tier	Exploitable biomass	F_{OFL}	OFL (t)	F_{ABC}	ABC (t)
Canary	5	13.9	F = M = 0.05	0.7	F = 0.75FOFL	0.5
Darkblotched	5	417.7	F = M = 0.07	29.2	F = 0.75FOFL	21.9
Greenstripe	5	674.5	F = M = 0.06	47.2	F = 0.75FOFL	35.4
Harlequin	5	4,635.3	F = M = 0.09	426.5	F = 0.75FOFL	319.8
Pygmy	5	102.1	F = M = 0.06	6.1	F = 0.75FOFL	4.6
quillback	5	438.6	F = M = 0.06	26.3	F = 0.75FOFL	19.7
Redbanded	5	5,784.0	F = M = 0.06	347.0	F = 0.75FOFL	260.3
Redstripe	5	10,069.1	F = M = 0.1	1,006.9	F = 0.75FOFL	755.2
Rosethorn	5	1.2	F = M = 0.06	0.1	F = 0.75FOFL	0.1
Sharpchin	4	11,817.8	$F_{35\%}$ = 0.079	934.9	$F_{40\%}$ = 0.065	701.1
Silvergray	5	43,046.3	F = M = 0.05	2,152.3	F = 0.75FOFL	1,614.2
Splitnose	5	160.0	F = M = 0.06	9.6	F = 0.75FOFL	7.2
Tiger	5	1.4	F = M = 0.06	0.1	F = 0.75FOFL	0.1
Widow	5	65.9	F = M = 0.05	3.3	F = 0.75FOFL	2.5
Yelloweye	5	1,347.4	F = M = 0.02	26.9	F = 0.75FOFL	20.2
yellowmouth	5	14.4	F = M = 0.06	0.9	F = 0.75FOFL	0.6
Yellowtail	5	4,735.2	F = M = 0.07	331.5	F = 0.75FOFL	248.6
Total Other Rockfish		83,325		5,350		4,012

Table 16.13. Estimated random effects biomass for sharpchin rockfish by NMFS regulatory area and total Gulfwide biomass with 95% confidence intervals (CI) for the Gulfwide total.

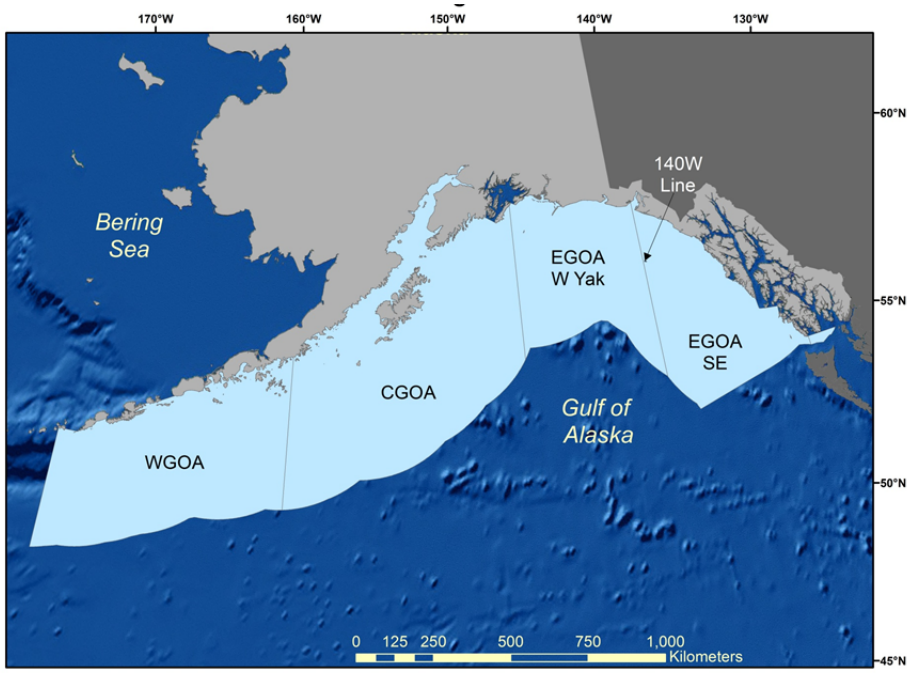
					95% Confidence Intervals	
	Western GOA	Central GOA	Eastern GOA	Gulfwide Total	Lower	Upper
1984	1,213.6	1,418.5	5,292.0	7,924.1	263.4	238,393.0
1985	1,213.6	522.2	12,331.6	14,067.4	2,056.5	96,230.0
1986	1,213.6	192.3	28,735.3	30,141.2	5,289.4	171,758.0
1987	1,213.6	70.8	66,959.7	68,244.1	33,013.1	141,073.0
1988	218.5	223.5	53,882.8	54,324.8	8,954.7	329,570.0
1989	39.3	705.9	43,359.8	44,105.0	7,372.0	263,869.0
1990	7.1	2,229.1	34,891.8	37,128.0	18,780.1	73,401.7
1991	14.3	2,973.3	27,592.4	30,580.0	5,716.2	163,593.0
1992	28.8	3,966.1	21,819.9	25,814.8	5,255.7	126,796.0
1993	58.0	5,290.4	17,255.1	22,603.5	13,146.5	38,863.5
1994	61.0	3,874.7	25,913.8	29,849.5	5,958.5	149,533.0
1995	64.2	2,837.8	38,917.4	41,819.5	7,673.0	227,925.0
1996	67.6	2,078.4	58,446.3	60,592.3	33,619.5	109,205.0
1997	57.0	2,245.8	40,159.1	42,461.9	7,344.6	245,490.0
1998	48.1	2,426.7	27,593.8	30,068.5	4,891.2	184,845.0
1999	40.5	2,622.1	18,960.0	21,622.6	7,352.3	63,591.0
2000	34.2	2,003.5	14,922.9	16,960.6	2,477.3	116,118.0
2001	28.8	1,530.9	11,745.4	13,305.1	1,555.3	113,820.0
2002	35.5	756.4	9,244.5	10,036.4	1,533.5	65,687.9
2003	43.7	373.7	7,276.1	7,693.5	3,451.0	17,151.8
2004	71.6	1,654.4	8,611.3	10,337.3	2,528.3	42,264.9
2005	117.2	7,323.9	10,191.5	17,632.6	10,088.2	30,819.1
2006	78.5	4,990.1	12,146.8	17,215.4	4,764.3	62,207.1
2007	52.5	3,400.0	14,477.3	17,929.8	9,876.3	32,550.3
2008	35.2	1,563.4	13,043.3	14,641.8	3,449.2	62,154.6
2009	23.6	718.9	11,751.3	12,493.7	6,607.5	23,623.7
2010	34.9	646.5	10,024.6	10,706.1	2,264.9	50,606.2
2011	51.7	581.5	8,551.6	9,184.8	3,421.5	24,656.3
2012	76.6	762.0	10,992.1	11,830.7	2,445.2	57,242.3
2013	113.5	998.5	14,129.2	15,241.1	6,582.3	35,290.6
2014	89.3	2,946.5	19,283.4	22,319.2	4,908.6	101,484.0
2015	70.2	8,695.5	26,317.7	35,083.5	13,764.1	89,424.7

Table 16.14. Estimated random effects biomass for 16 species of Other Rockfish with reliable trawl survey biomass estimates by NMFS regulatory area and total Gulfwide biomass with 95% confidence intervals (CI) for the Gulfwide total.

					95% Confidence Intervals	
	Western GOA	Central GOA	Eastern GOA	Gulfwide Total	Lower	Upper
1984	115.2	1,815.0	13,699.7	15,630.0	11,050.7	22,106.9
1985	412.0	4,075.6	23,851.3	28,338.8	5,042.7	159,258.0
1986	1,473.2	9,151.5	41,525.1	52,149.8	9,664.6	281,398.0
1987	5,267.2	20,549.3	72,295.4	98,112.0	62,837.7	153,188.0
1988	1,704.7	18,119.3	64,362.9	84,186.8	15,986.2	443,345.0
1989	551.7	15,976.6	57,300.8	73,829.1	13,756.4	396,233.0
1990	178.6	14,087.3	51,013.5	65,279.4	39,176.7	108,774.0
1991	153.6	12,368.2	52,606.4	65,128.2	11,718.9	361,952.0
1992	132.2	10,858.9	54,248.9	65,240.0	11,412.6	372,943.0
1993	113.7	9,533.8	55,942.8	65,590.3	39,078.4	110,088.0
1994	213.6	7,714.8	57,478.7	65,407.0	10,856.9	394,041.0
1995	401.1	6,242.8	59,056.8	65,700.7	10,725.3	402,466.0
1996	753.5	5,051.7	60,678.2	66,483.3	41,430.9	106,684.0
1997	491.1	7,116.2	63,577.4	71,184.7	11,749.6	431,272.0
1998	320.1	10,024.5	66,615.2	76,959.7	13,169.5	449,736.0
1999	208.6	14,121.3	69,798.1	84,128.0	54,983.0	128,722.0
2000	498.4	9,214.0	68,629.2	78,341.6	11,474.0	534,894.0
2001	1,190.5	6,012.0	67,479.9	74,682.4	7,353.4	758,487.0
2002	275.4	4,272.7	66,349.9	70,898.0	8,854.8	567,663.0
2003	63.7	3,036.6	65,238.8	68,339.1	26,500.3	176,233.0
2004	797.0	6,005.0	61,062.9	67,864.9	13,423.5	343,103.0
2005	9,968.9	11,875.3	57,154.3	78,998.6	49,020.1	127,311.0
2006	3,068.5	7,133.6	53,346.2	63,548.2	14,448.4	279,504.0
2007	944.5	4,285.2	49,791.7	55,021.4	38,014.4	79,637.2
2008	322.5	3,831.3	33,432.4	37,586.2	8,072.1	175,014.0
2009	110.1	3,425.5	22,448.0	25,983.6	17,957.1	37,597.7
2010	325.1	8,474.1	46,877.8	55,677.0	12,449.0	249,010.0
2011	959.7	20,963.7	97,894.0	119,817.0	71,249.3	201,493.0
2012	478.0	19,608.4	54,034.7	74,121.1	18,209.3	301,710.0
2013	238.1	18,340.6	29,825.6	48,404.4	29,414.3	79,654.4
2014	329.6	17,746.6	39,425.3	57,501.6	14,509.4	227,882.0
2015	456.3	17,171.9	52,114.8	69,743.0	41,169.5	118,148.0

Table 16.15. Analysis of ecosystem considerations for the Other Rockfish complex.

Ecosystem effects on *GOA Other Rockfish*			
Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Limited diet analyses	Stable, data limited	No concern
Non-pandalid shrimp and other benthic organism	Trends in indices are variable	Composes the main portion of many OR species diet	Unknown
Herring and other forage fish	Trends in indices are variable	Unknown	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	Reduced predation	No concern
Birds	Stable, some increasing some decreasing	Affects young-of-year mortality	No concern
Fish (walleye pollock, Pacific cod, halibut)	Stable to increasing	Possible increases to OR mortality	No concern
Sharks	Population indices show variable trends	Unknown	No concern
Changes in habitat quality			
Temperature regime	Warm and cold regimes	May shift distribution, and larval survival	Unknown
Prevailing currents	Larvae subject to currents	Potential to alter recruitment events	Unknown
***GOA Other Rockfish* effects on ecosystem**			
Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Not Targeted	None	No concern	No concern
Fishery concentration in space and time	None	No concern	No concern
Fishery effects on amount of large size target fish	If targeted, could reduce avg size of females, reduce recruitment, reduce fecundity, skewed sex ratio	No concern at this time	No concern at this time
Fishery contribution to discards and offal production	None	No concern	No concern
Fishery effects on age-at-maturity and fecundity	Age at maturity and fecundity decrease in areas that have targeted species	No concern at this time	No concern at this time



WGOA & CGOA	EGOA/W Yakutat	EGOA/Southeast
Blackgill Rockfish	Blackgill Rockfish	Blackgill Rockfish
Bocaccio	Bocaccio	Bocaccio
Canary Rockfish	Canary Rockfish	
Chilipepper Rockfish	Chilipepper Rockfish	Chilipepper Rockfish
China Rockfish	China Rockfish	
Copper Rockfish	Copper Rockfish	
Darkblotched Rockfish	Darkblotched Rockfish	Darkblotched Rockfish
Greenstriped Rockfish	Greenstriped Rockfish	Greenstriped Rockfish
Harlequin Rockfish	Harlequin Rockfish	Harlequin Rockfish
	Northern Rockfish	Northern Rockfish
Pygmy Rockfish	Pygmy Rockfish	Pygmy Rockfish
Quillback Rockfrish	Quillback Rockfrish	
Redbanded Rockfish	Redbanded Rockfish	Redbanded Rockfish
Redstripe Rockfish	Redstripe Rockfish	Redstripe Rockfish
Rosethorn Rockfish	Rosethorn Rockfish	
Sharpchin Rockfish	Sharpchin Rockfish	Sharpchin Rockfish
Silvergray Rockfish	Silvergray Rockfish	Silvergray Rockfish
Splitnose Rockfish	Splitnose Rockfish	Splitnose Rockfish
Stripetail Rockfish	Stripetail Rockfish	Stripetail Rockfish
Tiger Rockfish	Tiger Rockfish	
Vermilion Rockfish	Vermilion Rockfish	Vermilion Rockfish
Widow Rockfish	Widow Rockfish	Widow Rockfish
Yelloweye Rockfish	Yelloweye Rockfish	
Yellowmouth Rockfish	Yellowmouth Rockfish	Yellowmouth Rockfish
Yellowtail Rockfish	Yellowtail Rockfish	Yellowtail Rockfish

Figure 16.1. Map of the Gulf of Alaska (GOA) management areas: Western (WGOA), Central (CGOA) and Eastern (EGOA). The EGOA is subdivided into the West Yakutat (W Yak) and East Yakutat/Southeast (SE) areas. The table below the figure lists the species that are part of the Other Rockfish complex in each of the areas.

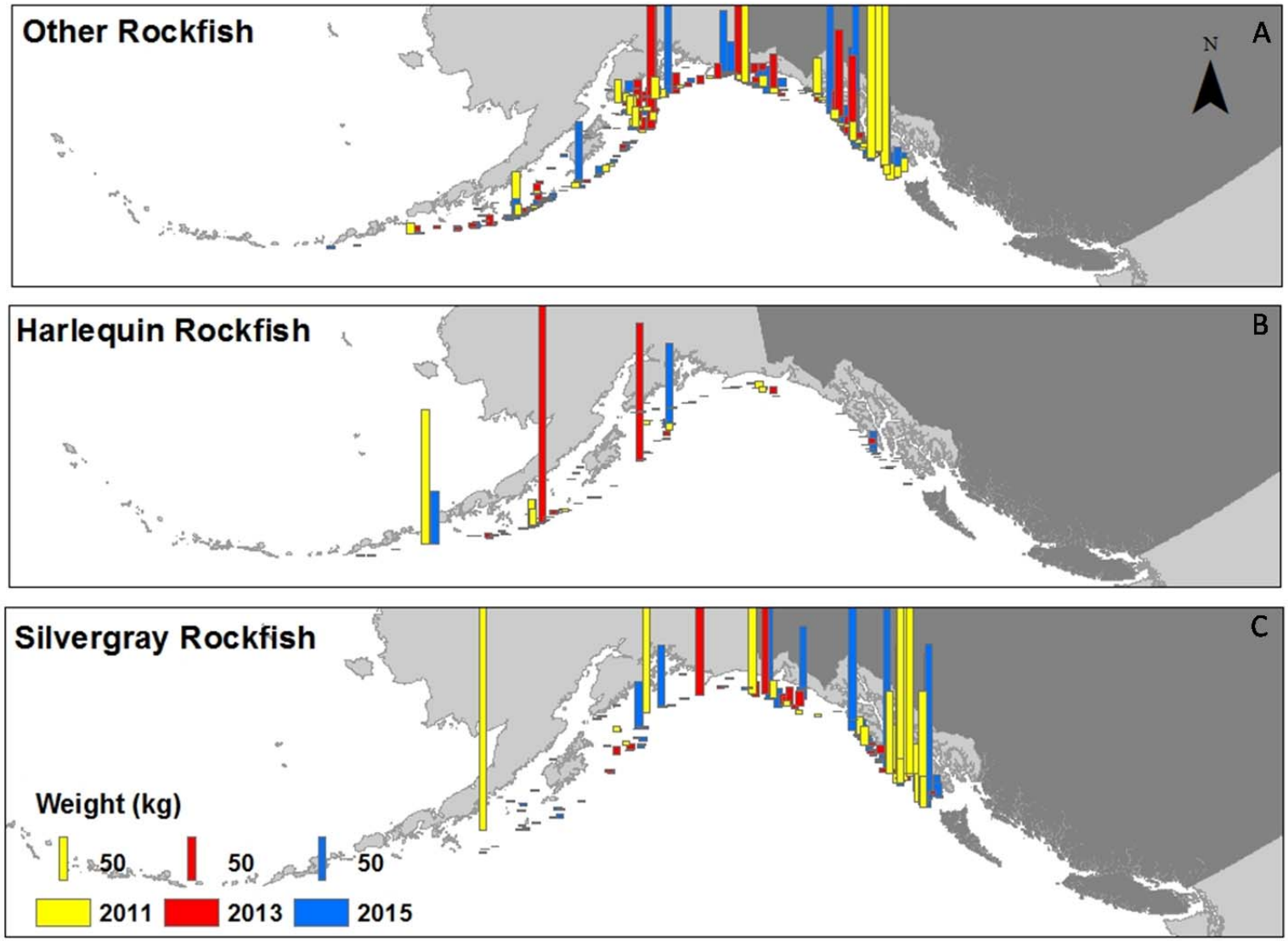


Figure 16.2. Spatial distribution of trawl survey catch in the Gulf of Alaska (GOA) from the three most recent National Marine Fisheries Service (NMFS) trawl surveys (2011, 2013, and 2015) for: (A) the Other Rockfish (OR) complex (with the exception of harlequin and silvergray rockfish); (B) harlequin rockfish; and (C) silvergray rockfish.

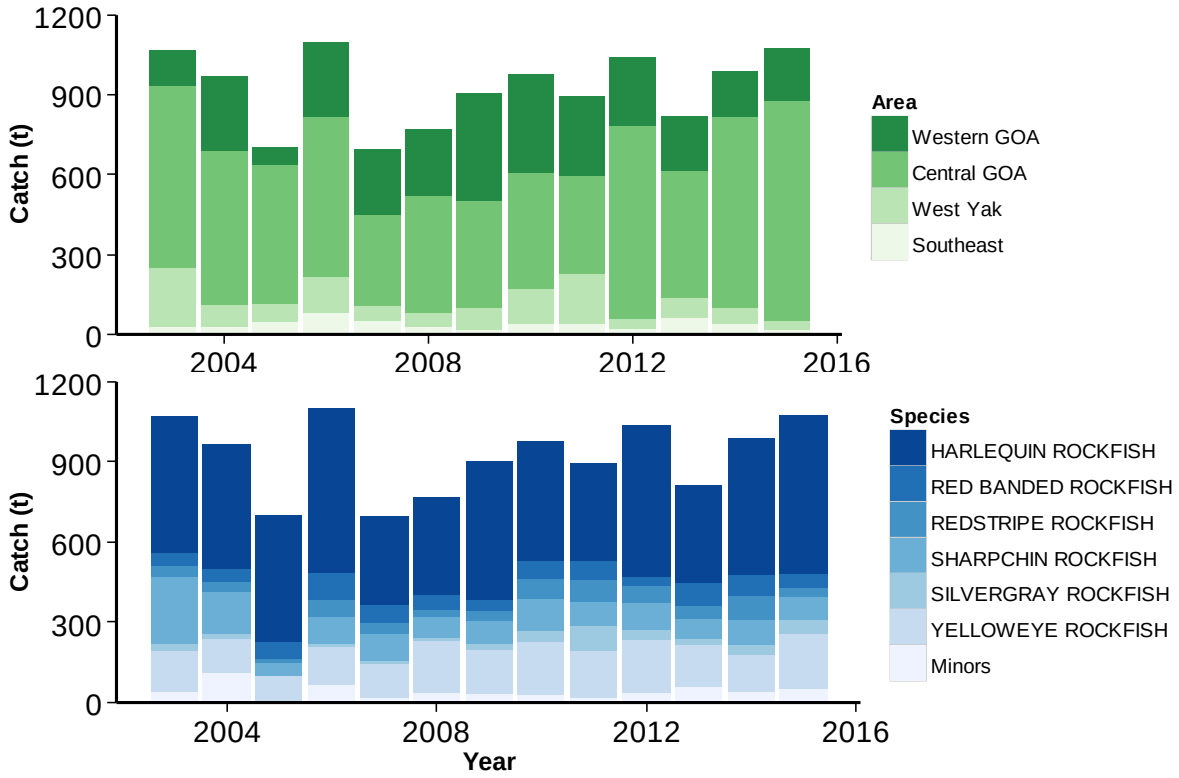


Figure 16.3. Estimated incidental catch (t) of Other Rockfish in Gulf of Alaska (GOA) by area (Western GOA, Central GOA, West Yakutat (West Yak), and East Yakutat/Southeast (Southeast)) and species. National Marine Fisheries Service Alaska Regional Office Catch Accounting System (queried through AKFIN on October 15, 2015).

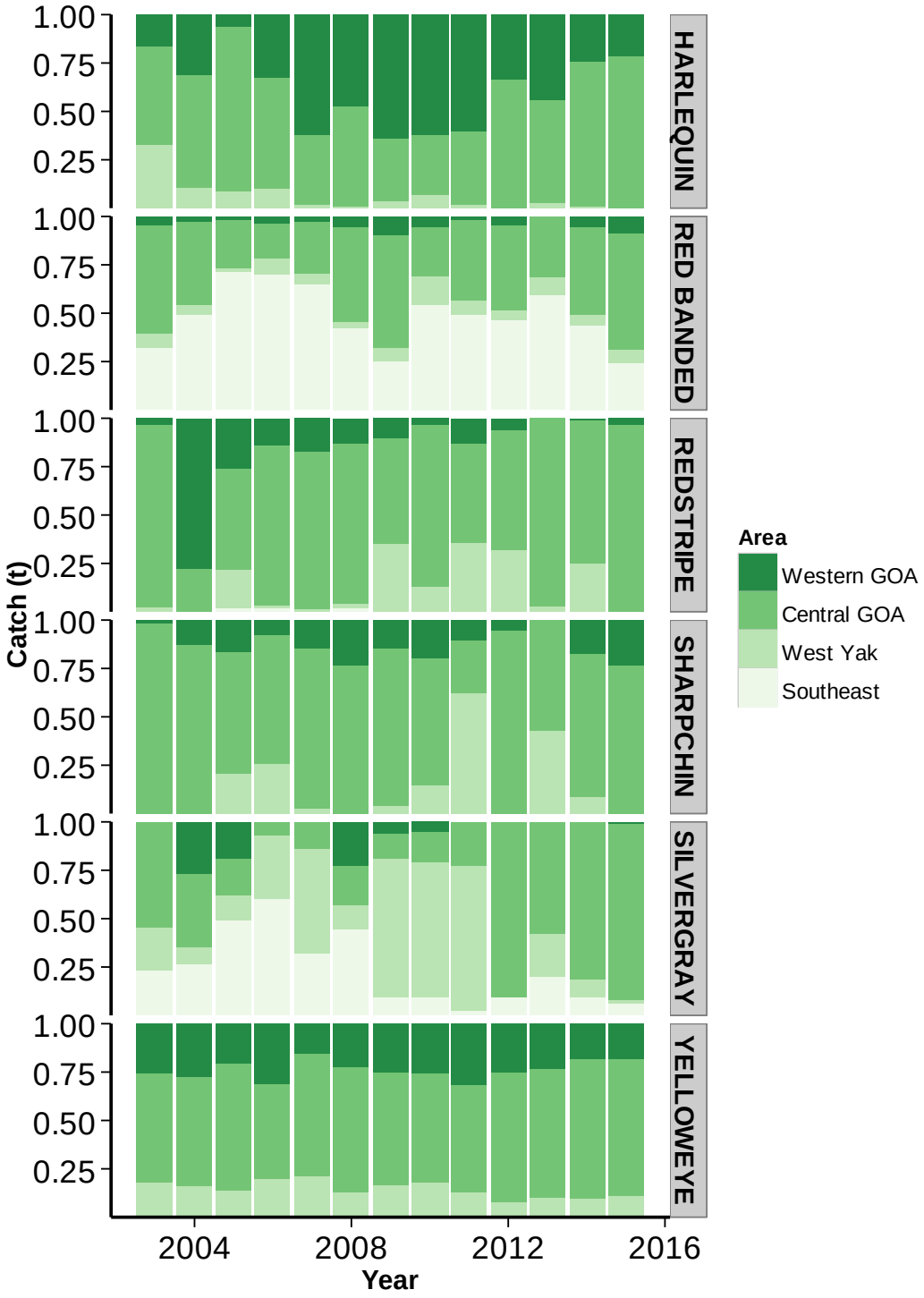


Figure 16.4. Proportion of catch by regulatory area (Western Gulf of Alaska (GOA), Central GOA, West Yakutat and East Yakutat/Southeast) for the six primary species of Other Rockfish. Note that the yelloweye rockfish panel does not include catch in the East Yakutat/Southeast regulatory area because that catch is included in the Demersal Shelf Rockfish complex. NMFS AKRO Catch Accounting System (queried through AKFIN on October 15, 2015).

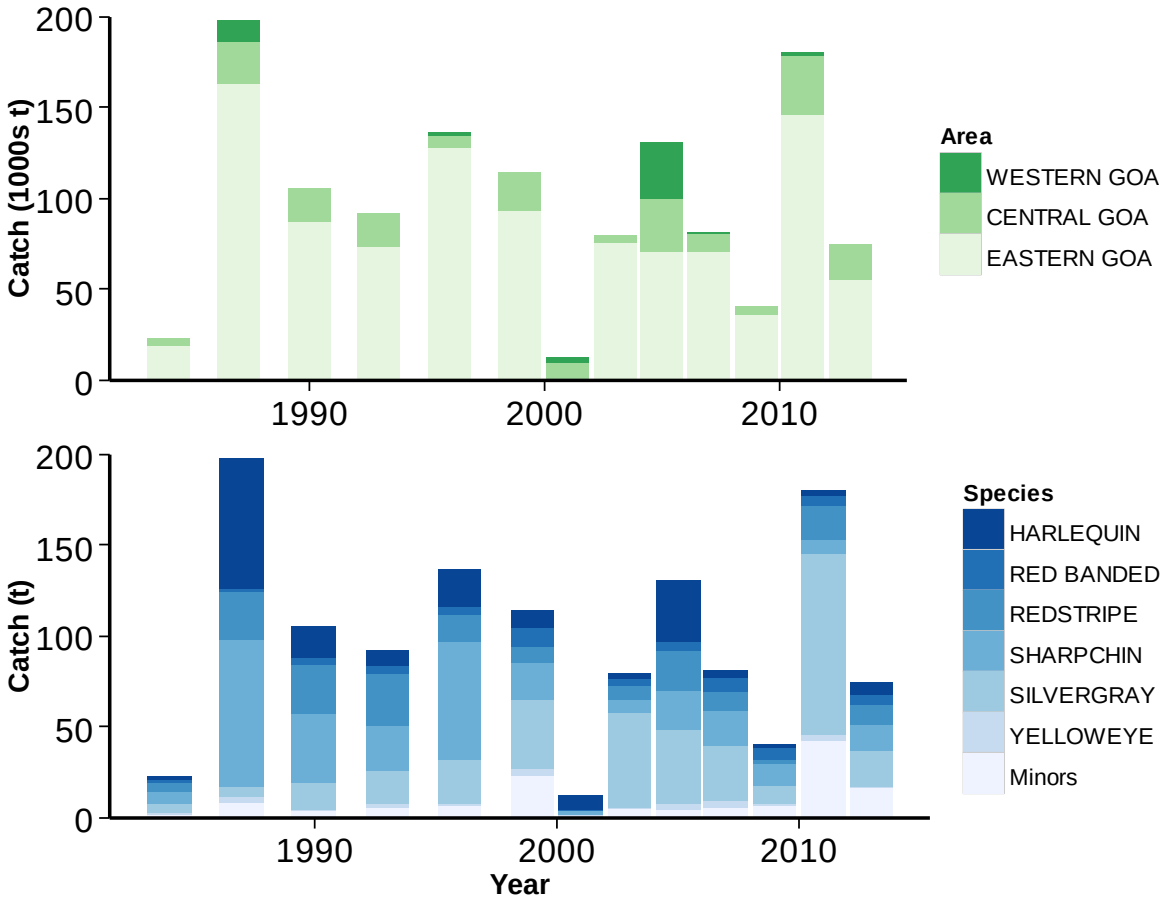


Figure 16.5. Trawl survey biomass estimates for the species in the Other Rockfish complex, by Gulf of Alaska (GOA) regulatory area (Western GOA, Central GOA, West Yakutat, and East Yakutat/Southeast) and by species (bottom).

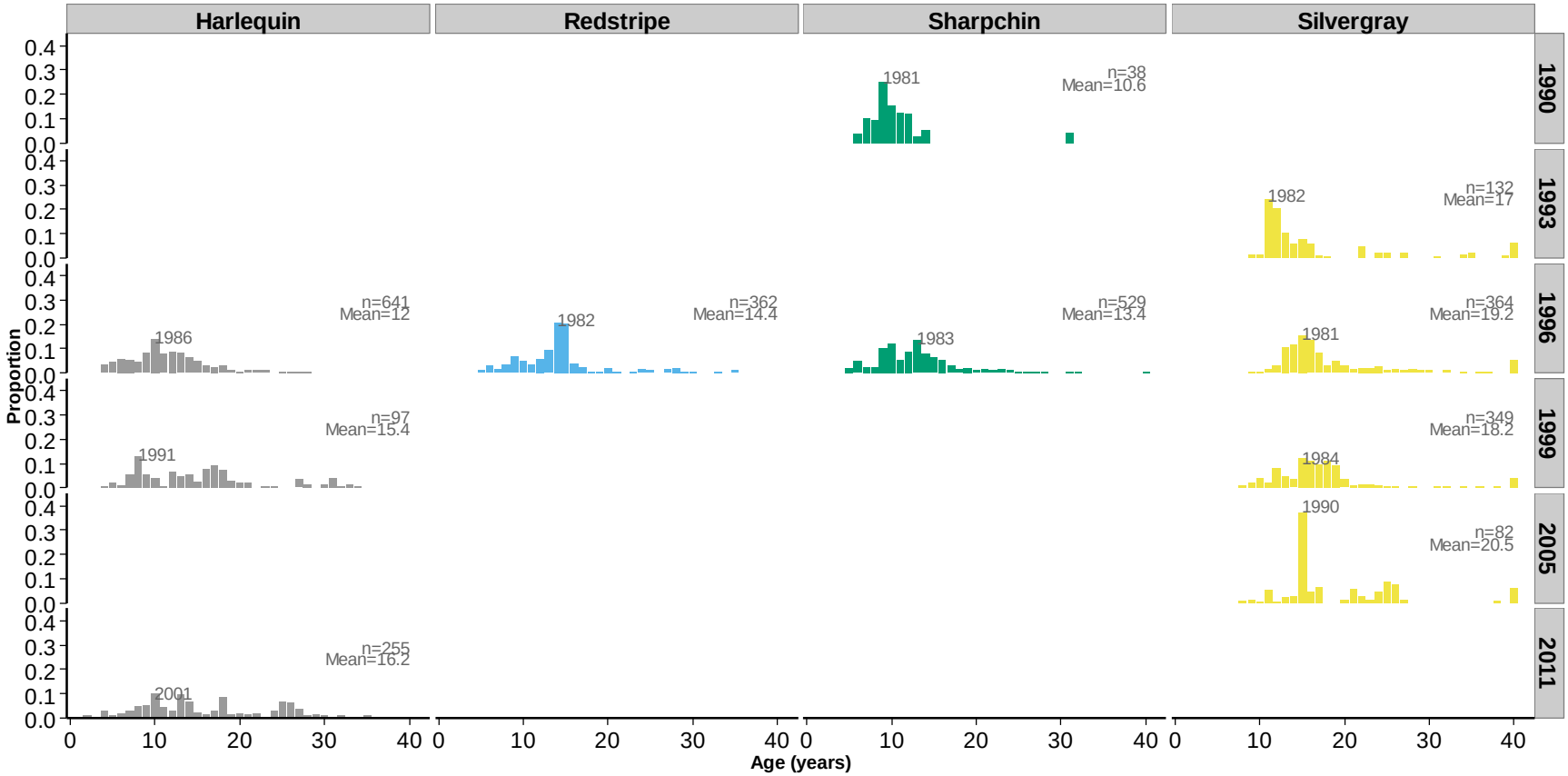


Figure 16.6. Age compositions of harlequin, redstripe, sharpchin and silvergray rockfish from the Gulf of Alaska (GOA) National Marine Fisheries (NMFS) bottom trawl survey. Sample size and mean age are presented for each species and survey year with age compositions available. The birth year of the largest cohort is labeled as well.

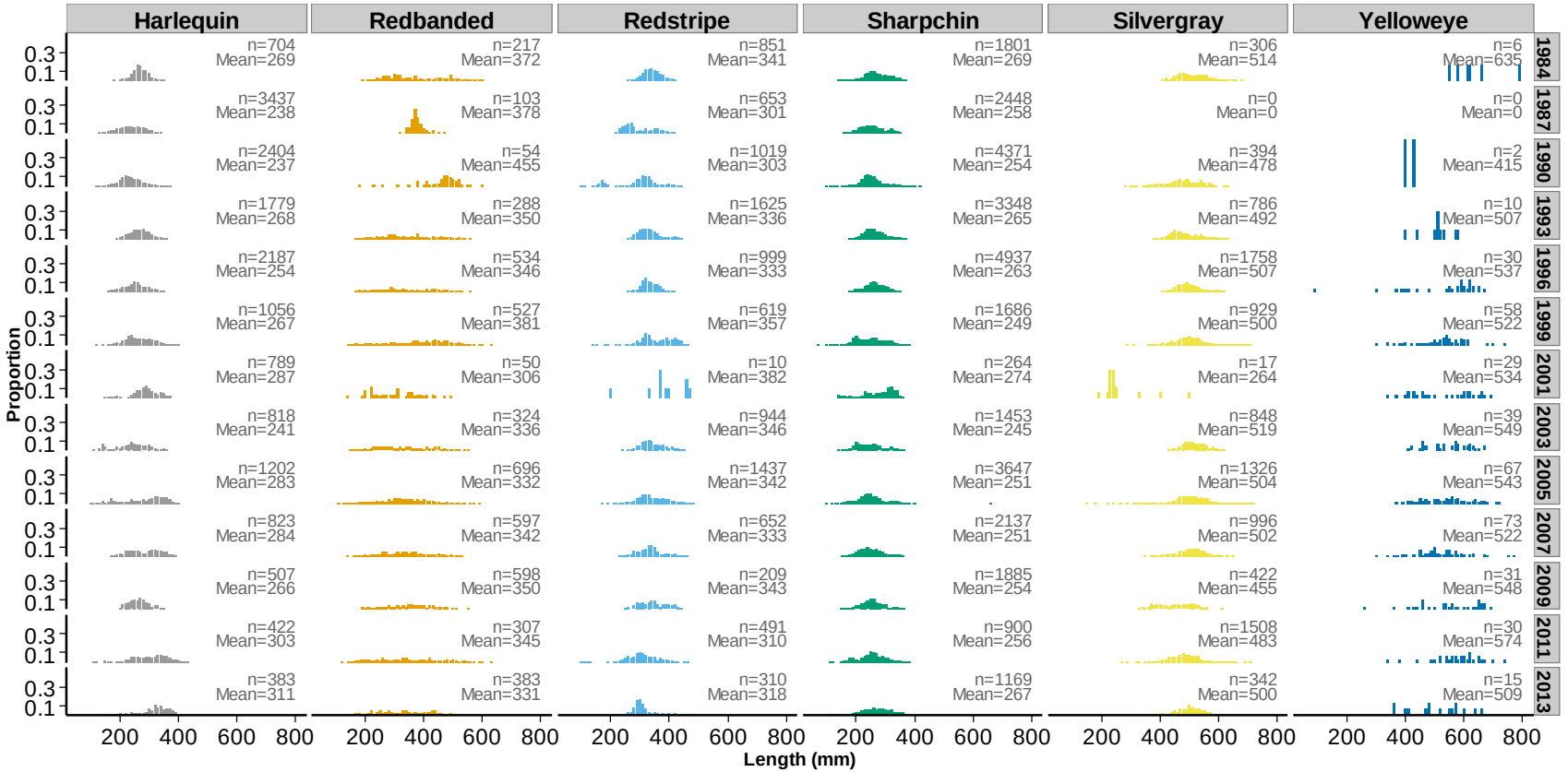


Figure 16.7. Size composition of the primary Other Rockfish (OR) species from the National Marine Fisheries Service (NMFS) bottom trawl survey. Sample size and mean length (mm) are presented for each of the primary species and survey year. Note that he survey did not sample the Eastern GOA in 2001, contributing to the low sample size.

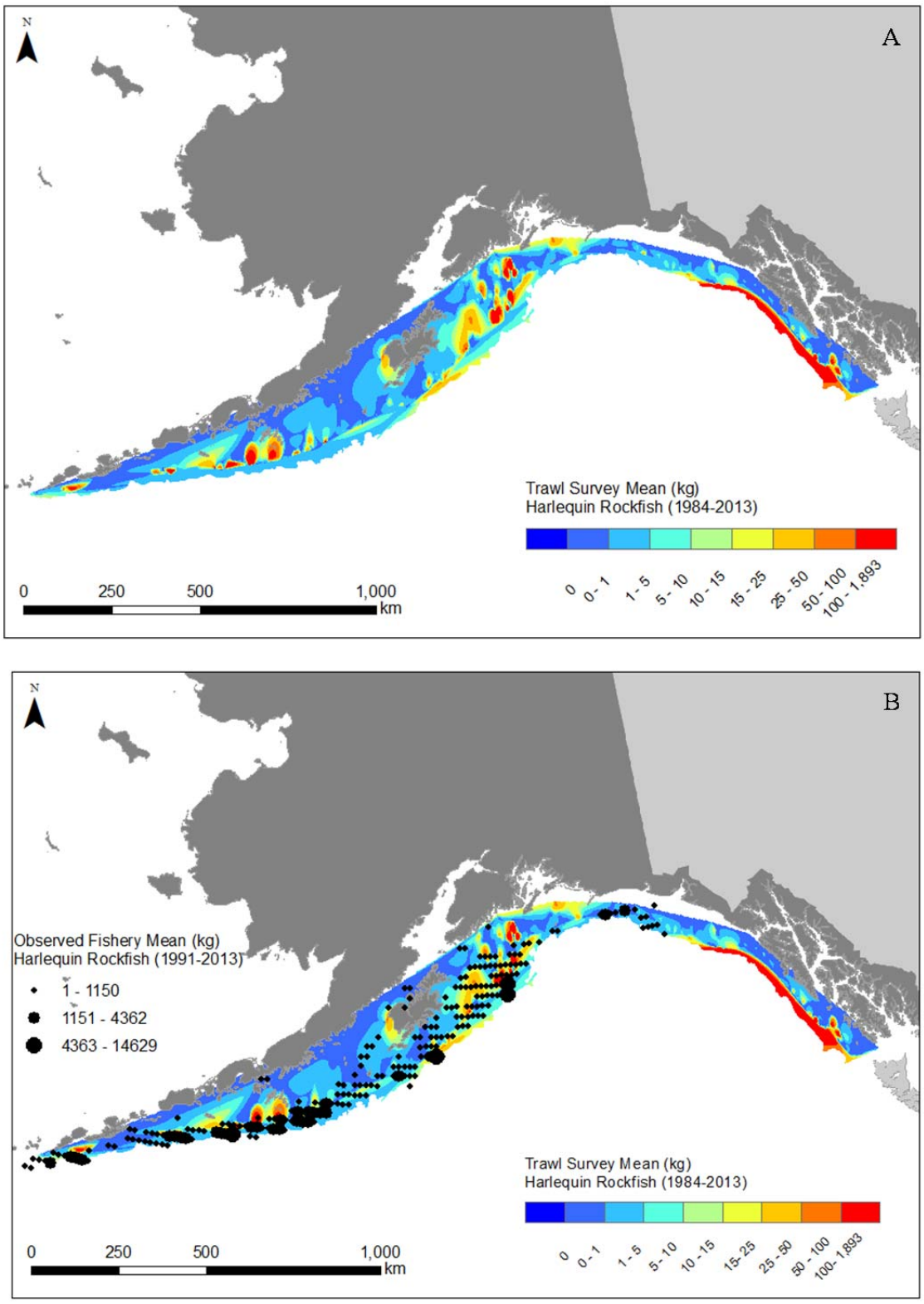


Figure 16.8. Distribution maps of harlequin rockfish (A) trawl survey mean kg per haul from 1984 – 2013 and (B) observed fishery catch mean kg per haul (1993 – 2013) overlaid with trawl survey mean conditions.

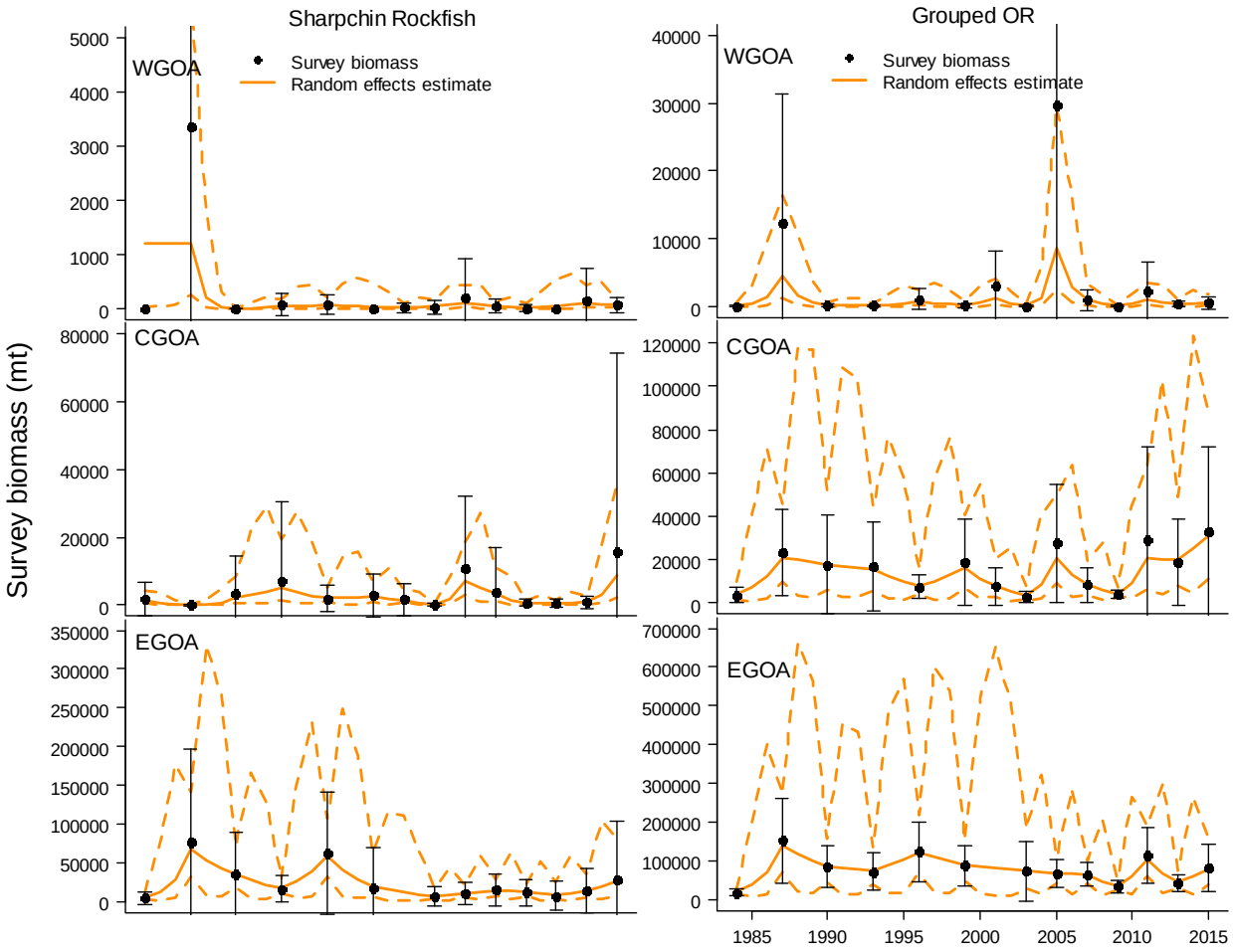


Figure 16.9. Estimated random effects biomass for sharpchin rockfish (left panel) and the 16 grouped Other Rockfish (OR) species (right panel) by NMFS regulatory areas: Western Gulf of Alaska (WGOA), Central GOA (CGOA) and Eastern GOA (EGOA). The regional model takes into account the missing survey in the EGOA in 2001.

Appendix 16A. Other Rockfish and Demersal Shelf Rockfish Stock Assessment Tasks in the Gulf of Alaska

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Kristen Green and Ben Williams (ADF&G)
Pete Hulson (AFSC)
November 2015

Executive Summary

The Gulf of Alaska (GOA) Plan Team and the Science and Statistical Committee (SSC) of the North Pacific Fishery Management Council made a number of requests for the 2015 assessments of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) stock complexes. The DSR complex exists only in the East Yakutat/Southeast (EY/SEO) management area (i.e., GOA area east of the 140° W longitude, NMFS area 650) covers seven species of rockfish in that management area (canary, China, copper, quillback, rosethorn, tiger and yelloweye rockfish). These seven species are managed in the OR complex in all other regions. The OR complex is GOA – wide, and includes the seven species covered in the DSR assessment to the west of EY/SEO (along with up to 18 other rockfish species), but in EY/SEO the OR complex does not have the seven DSR species (Figure 16A.1). Because of this overlap between the OR and DSR complexes, a number of the Plan Team and SSC comments are relevant to both complexes, thus, we have combined the responses to those comments into one document.

The SSC and Plan Team also requested that a working group be formed to develop a model for yelloweye rockfish in the EY/SEO, and to investigate data available and potential models for a GOA - wide yelloweye rockfish age-structured assessment model. A working group has been formed but have no results to present as yet.

The requests made by the SSC and Plan Team (see below under SSC and Plan Team comments) resulted in essentially three tasks: 1) complete the stock structure templates for both complexes; 2) evaluate the utility of using the International Pacific Halibut Commission (IPHC) annual survey data for OR or DSR species; and 3) investigate catch and management alternatives for the seven species of DSR GOA–wide; and 4) investigate using the random effects model to estimate biomass for the Tier 5 species in these complexes.

To summarize the results of these tasks, the stock structure template did not provide any information to suggest differences within the GOA in age, growth, or genetics (Task #1). The IPHC annual survey may be useful as an indicator of trends in in the EY/SEO area for canary, quillback, redbanded, and silvergray, and in all areas for yelloweye rockfish, but for all other species catches are generally low and so there is no utility as an abundance index (Task #2). The authors examined the random effects approach to survey averaging for estimating biomass from RACE trawl surveys and determined that the best fit model combines the OR species biomass estimates to create a single complex wide biomass. The model is evaluated by NMFS regulatory area (i.e., Western, Central and Eastern GOA, Task #4).

Investigating alternatives for the assessment and management of the DSR species GOA–wide (Task #3) required consultations between assessment authors, Alaska Department of Fish and Game (ADF&G) Southeast and Southcentral region staff, and the NMFS Alaska Regional Office. Multiple management alternatives were discussed, and the authors recommend expanding the DSR assessment to cover all regions of the GOA and include the seven species GOA – wide. This would remove those seven species from the OR assessment in the areas west of EY/SEO. This option would not require regulatory or FMP level changes, and would enable managers to monitor the catch of these species specifically GOA–wide. In contrast, the current complex groupings prevents monitoring of the catch of these species in the OR

complex because the catch in the complex is dominated by catch of trawl species and because managers have to track the catch from two separate complexes to monitor these species GOA – wide.

SSC and Plan Team Comments Specific to these assessments

Yelloweye rockfish model working group:
"The SSC recommends that a model development team be formed, following the November Plan Team review, with the goal to have the assessment complete enough for consideration for setting OFL and ABC at the September 2015 PT meeting." – SSC October 2014

"For the next iteration of the stock assessment in 2015, the SSC recommends that two yelloweye/DSR models be developed: (1) southeast Alaska yelloweye/DSR age structured model, and (2) GOA yelloweye/DSR age structured model that includes (at a minimum) southeast Alaska data sources, International Pacific Halibut Commission survey data, and coastwide catch. This second model would treat yelloweye/DSR as a single stock throughout the GOA including all sources of mortality." – SSC October 2014

"The Team recommends that an age error matrix for yelloweye rockfish be developed (perhaps using the software and methods provided by Punt et al. 2008)." – Plan Team November 2014

"The Team supports the SSC recommendation to form a small, informal model-development working group." – Plan Team November 2014

"The Team also recommends that the working group evaluate the feasibility of developing a southeast Alaska yelloweye/DSR age structured model and a GOA wide yelloweye/DSR age structured model." – Plan Team November 2014

Stock Structure templates (Task #1)
"The SSC recommends that authors complete the stock structure template for yelloweye/DSR coastwide for the September 2015 Plan Team meeting." – SSC October 2014

"In agreement with the SSC request, the Team recommends that a stock structure template be compiled for Other Rockfish." – Plan Team November 2014

"The SSC supports the Plan Team's recommendation for authors to complete a stock structure template for other rockfish." – SSC December 2014

"The SSC encourages the plan team to develop a prioritized list of species, based on their commercial importance" – SSC October 2015

Utility of IPHC survey data for OROX and DSR assessments (Task #2)
"The Team recommends that the assessment authors evaluate the IPHC survey data to look at the distribution of yelloweye/DSR in the Gulf of Alaska." - Plan Team November 2014

"The SSC also supports the Plan Team recommendation for authors to evaluate the IPHC survey data for the distribution of yelloweye/DSR in the Gulf of Alaska. In addition, the SSC recommends evaluation of the IPHC CPUE time series for DSR in the Gulf of Alaska." – SSC December 2014

"The SSC agrees with the Groundfish Plan Team that incorporating IPHC survey data from this area may be useful for these species, and encourages the assessment authors to investigate this possibility more fully." – SSC October 2015

Catch and management alternatives for DSR GOA – wide (Task #3)
"The SSC recommends that respective assessment authors work together with AKRO to provide detailed examination of fishery catch and survey data by subarea and season for DSR and "other" rockfish species. Catch data from all sources (retained, discarded, State waters) should be included and, where

data are lacking, this should be noted and included in the revised assessment(s). Assessment authors should also attempt to derive a plausible range of historical catch trends where catch data may not be available. The goal of this work is to fully account for rockfish catches and align potential rockfish groupings to improve our ability to monitor and identify conservation issues. This may include species groupings that are biologically similar (i.e., with similar life history attributes) or potentially grouped as Tier 6 species where reliable estimates of biomass are unavailable." – SSC October 2014

"The SSC suggests that this analysis should not be rushed. The prospects for developing a GOA–wide DSR assessment should consider that the survey information is best developed for Southeast Alaska, and that future funding for those surveys is uncertain. Also, for the various alternatives, assemblage membership should be carefully re-examined to make sure that species in the assemblage share some common characteristics. Alternative combinations of species should be considered. The SSC also encourages involvement of industry members in the process of alternative development so that alternatives are developed mindful of fishery and management complexity." – SSC October 2015

Random effects approach to survey averaging (Task #4)
"The analysts working on this project are still the developing methods and do not recommend switching to a random effects modelling approach for survey averaging at this time. The SSC looks forward to further progress on this research." – SSC October 2015

Task #1 – Stock Structure Template

The SSC and PT requested that the stock structure template be completed for both the Other Rockfish (OR) and the Demersal Shelf Rockfish (DSR) assessment for September of 2015. Due to the overlap in species between these assessments, the authors combined them into one document, Appendix 16B of this document.

Task #2 – Evaluate Utility of IPHC data for OR and DSR assessment

The International Pacific Halibut Commission (IPHC) annual longline survey will not be useful for most of the species of OR or DSR. Only canary, quillback, redbanded, silvergray, and yelloweye rockfish occur with any regularity in this survey; all other OR and DSR species either do not occur or occur rarely.

Relative population numbers (RPNs) are calculated for each Fishery Management Plan (FMP) sub area of the Gulf of Alaska (GOA), year, and species, based on the annual survey. The FMP sub areas are the western GOA (WGOA), central GOA (CGOA), and the eastern GOA (EGOA), which is further subdivided into west Yakutat (WY) and east Yakutat/Southeast outside (EY/SEO, Figure 16A.1). The RPNs are an area weighted catch per unit effort (CPUE, in numbers), a relative index of abundance. It is most meaningful for species commonly or at least consistently caught on the survey. One caveat of the IPHC survey data is that catch composition is based on the catch tallied from the first 20 hooks on each skate, not a complete census of all hooks fished, with the exception of EY/SEO where all yelloweye rockfish are counted. While this is sufficient for common species, it is possible that catch estimates may not be representative of true catch for rare species (Tribuzio et al. 2014).

For the five rockfish species that regularly occur in the IPHC survey, the RPNs were greatest in the East Yakutat/Southeast Outside (EY/SEO) management area (Figure 16A.2). The utility of the IPHC survey for each of the five species is described below.

Canary rockfish:

- Caught almost exclusively at a small number of stations in EY/SEO, primarily from Baranof Island south to Dixon Entrance.
- Catch is consistent in this area and the RPNs may be considered an indicator of abundance trends in this small area.

- Species is at the extreme northern end of its range and it is a very small component of the DSR and OR complexes.

Quillback rockfish:

- Caught regularly at many stations along the coast in EY/SEO area.
- Rarely caught in WY and CGOA, thus this survey is probably not good for the species in these areas.
- The IPHC survey may be useful for presence or trend information in EY/SEO but likely not informative enough to be used in assessment models.

Redbanded rockfish:

- Caught regularly at many stations along the coast in EY/SEO area.
- Rarely caught in WY and CGOA, thus this survey is probably not good for the species in these areas.
- The IPHC survey may be useful for presence or trend information in EY/SEO but likely not informative enough to be used in assessment models.

Silvergray rockfish:

- Caught at many stations in EY/SEO, mostly at the southern stations close to Dixon Entrance.
- Extremely rare in W/CGOA. Caught in WY at a minimum of one station per year, but generally rare.
- Survey may provide useful trend information in EY/SEO, and suggests an increasing trend in abundance, as well as an increasing number of stations catching silvergray each year.

Yelloweye rockfish:

- Caught at stations across the GOA, least common in WGOA, most common in EY/SEO.
- Survey index is used in the EY/SEO DSR assessment, and could be informative in other regions.
- Since 2007, IPHC samplers have surveyed 100% of the hook counts for yelloweye rockfish at stations that are east of 140° W. In all other areas, yelloweye rockfish are sub-sampled at the same rate as all other bycatch (first 20 hooks of each 100 hook skate).
- Other than a decline in the early years of the time series, trends suggest stability in the indices.

Task #3 – Examine fishery and survey data by sub area and management grouping alternatives for Other Rockfish and DSR

The SSC expressed concerns regarding the appropriateness of the current management grouping for the seven DSR species, in particular for yelloweye rockfish. These seven species (canary, China, copper, quillback, rosethorn, tiger and yelloweye rockfish) are managed in the DSR complex in the EY/SEO region (National Marine Fisheries Service, NMFS, area 650) and in the OR complex in all other regions. The primary question is if a GOA–wide assessment would be more appropriate for all of these species. To address these concerns the OR and DSR assessment authors have worked together to provide a discussion of catch, the available survey data from both state and federal surveys, and estimated ABC and OFLs for potential management alternatives.

Catch of the DSR species GOA–wide

Catch of the seven DSR species is provided by the NMFS Alaska Regional Office Catch Accounting System for catch in federally managed fisheries and the Pacific Halibut IFQ fishery. Other estimates of catch are provided by the State of Alaska for the directed, subsistence, and sport fisheries in EY/SEO, as well as estimated bycatch from the Pacific Halibut fishery, prior to the 2013 observer restructuring. Considering the seven DSR species in a GOA-wide context, total catches do not exceed 500 t and yelloweye rockfish is the predominant species (Table 16A.1). In the EY/SEO areas, retention of all seven

DSR species has been required since 2005, thus recorded catches prior to 2005 may not be representative of total catch.

While most of the catch has historically occurred in the EY/SEO area, the proportion of the total catch originating in the CGOA has been increasing (Figure 16A.3). The increase in the CGOA has not been previously investigated as the catch of DSR species within the larger OR complex is comparatively small (Table 16A.1 and Table 16A.2). Much of the catch occurs on hook and line vessels, primarily targeting Pacific cod and Pacific halibut. The increased catch is predominantly from quillback rockfish retention, suggesting a potential market demand. The GOA is believed to be at the edge of the ranges for the DSR species; therefore, the majority of the biomass is in the EY/SEO region. While the distribution of the catch appears to be expanding towards the west, the total catch of these seven DSR species is not increasing. Yelloweye rockfish comprises the majority of the catch composition of DSR species (Table 16A.1 and Figure 16A.3) in all regions.

The bycatch only fishery for the DSR species in Prince William Sound (PWS) and Cook Inlet is managed by the State of Alaska and is not subject to the GOA FMP. Both areas fall under a Guideline Harvest Limit which applies to all rockfish species, based on mean historical catch and is currently set at 68 t for each area. The mean catch from 2011 – 2014 in PWS, the primary area of catch, is 19 t, composed primarily of yelloweye rockfish with quillback rockfish being the second most common species caught. Catch in the Cook Inlet area is limited to sport fish and a small amount of bycatch in state managed fisheries.

Surveys available for the DSR species

There are three main surveys conducted regularly across the entire GOA: the NMFS biennial trawl survey, the NMFS annual longline survey, and the IPHC annual longline survey. The seven DSR species are not sampled well by trawl surveys due to their affinity for high relief rocky habitats; thus, the trawl survey provides limited useful information for these species. As described above, the IPHC survey data may be useful as an indicator of trends for three of the DSR species. The NMFS annual longline survey also provides RPNs for yelloweye rockfish, however this survey often samples deeper waters than preferred habitat for the DSR species and so catch of yelloweye rockfish is variable and abundance estimates are likely more uncertain that those from the IPHC survey. The RPNs provided by these two longline surveys may be useful as model inputs to estimate biomass used to calculate ABCs. However, in areas where the catch of the species of interest is irregular or rare, the RPN index may not be representative of the population and should be used with caution.

In the EY/SEO region, the ADFG has operated manned submersibles (biennially 1988 – 2009) and remotely operated vehicles (ROV, annual 2012 – present) surveys for yelloweye rockfish. Data collected during these surveys are used to calculate the primary abundance index used in the DSR stock assessment. There are large mesh trawl surveys operating in the WGOA, PWS, and Cook Inlet that provide CPUE and length data. However, these surveys are designed to target crab habitat and sample few DSR; furthermore, the surveys are subject to funding availability. Thus, these trawl surveys may not be useful for a GOA–wide assessment. The State of Alaska has also operated an ROV survey in PWS that provides a presence/absence index used for assessment of yelloweye rockfish in the state managed fishery in PWS. The future of the PWS survey is uncertain due to lack of funding.

Management Alternatives

We propose and discuss three potential management alternatives:

1) status quo;
2) move the EY/SEO DSR species to the GOA-wide OR assessment; and,
3) remove the seven DSR species from the OR assessment and make the DSR assessment GOA-wide rather than specific to EY/SEO.

The ABC/OFLs presented here were calculated for each scenario based on data provided in the 2014 assessments, and thus are examples of what would have been recommended in the 2014 assessment cycle with the proposed alternative management options (Green et al. 2014, Tribuzio and Echave 2014).

Alternative 1: Status Quo

Retain existing OR/DSR complex structures. The DSR complex assessment includes the seven DSR species in EY/SEO (NMFS area 650). The OR complex assessment consists of the DSR complex species and the OR complex species in the WGOA, CGOA and WY portion of the Eastern GOA and only the OR complex species in EY/SEO

Alternative 2: Bring DSR into the OR complex

Alternative 2 would merge the EY/SEO DSR complex and the GOA OR complex assessment and dissolve the EY/SEO DSR complex. The biennial NMFS trawl survey does not provide a reliable biomass estimate for the DSR species in any area, thus if DSR were included in the OR assessment, ABC/OFLs would be calculated using either Tier 6 or the existing Tier 4 methods for yelloweye rockfish in EY/SEO only. We present three potential scenarios for calculating the OR complex ABC/OFL in Alternative 2.

- Alternative 2, Scenario a) Place the DSR species in Tier 6 with ABC and OFL estimates based on the historical time series of catch calculated by species for each region and added to the apportioned ABC/total OFL for the OR complex.
- Alternative 2, Scenario b) Place the DSR species in Tier 6 with ABC and OFL estimates based on the historical time series of catch calculated by species for each region. ABCs would be maintained separately for each management region, the OFLs would be added to the apportioned total OFL for the OR complex.
- Alternative 2, Scenario c) Place the DSR species outside of the EY/SEO region in Tier 6 with ABC and OFL estimates based on the historical time series of catch calculated by species for each region. Maintain DSR in EY/SEO as Tier 4. ABCs would be added to the apportioned OR complex ABC with the exception of a separate ABC for EY/SEO. The OFLs would be added to the apportioned total OFL for the OR complex.

The State of Alaska manages directed, subsistence, and recreational fisheries that fall under the ABC in the EY/SEO region. The Alternative 2 scenarios need to account for this portion of the State managed fishery catch in the OR complex ABC. State managed fisheries do not fall under Federal in-season management, thus the ABC in the EY/SEO region would need to be partitioned between Federally managed fisheries and State managed fisheries. For the purposes of this document, we calculated the EY/SEO State fishery portion of the DSR ABC to be total ABC for the region less the mean catch in Federal fisheries (including the Pacific Halibut fishery) since observer restructuring went into effect (i.e., 2013 – 2014), thus, the State ABC = Total DSR species ABC – mean federal catch of DSR species. We used the author recommended DSR ABC from the 2014 SAFE (yelloweye rockfish = 218 t and all other DSR species = 7 t) as opposed to the maximum permissible as per historical precedence (Green et al. 2014).

Tier 6 methods are based on a fixed time frame of the historical catch data from which the ABC and OFL catch limits are derived. The commonly used time series for many of the GOA Tier 6 assessments is 1997 – 2007, based on when reliable species identification became available for those assessments. It is reasonable to assume that the species identification for the rockfish species listed here was accurate prior to 1997. It is possible that the time series of catch may be biased low due to unobserved discards prior to the observer restructuring, which occurred in 2013. Catch estimates exist for the seven DSR species outside of the EY/SEO beginning in 1991; however, the recent time series starting in 2013 may be the most reliable catch time series. The DSR species are not targeted, but have market value and are often retained. In the CGOA and WY regions the discard rates were 19% and 16% on average, respectively, prior to observer restructuring (2003 – 2012), and were 29% and 37% on average, respectively, post–

observer restructuring (2013 – present). Discard rates of the DSR species in the WGOA are generally higher, on average 48% prior to observer restructuring and 66% since. This change in discard rates suggests that time series of catch prior to observer restructuring may not have represented all discards. Discard rates are highly variable from year to year and the apparent increase in discard rates is not significantly different. However, there is a very short time series of data available post observer restructuring. Landings data are available for the DSR by species in EY/SEO beginning in 1995, but full retention was not enacted until 2005, thus the landings prior to 2005 may be biased low relative to total catch. All catch data for the DSR species in the EY/SEO are provided by ADF&G and it is currently unknown if there are any conflicts or overlaps between the ADF&G catch estimates and those generated by CAS. The CAS catch estimates are not included in the current DSR assessment (which is in EY/SEO only).

For the purposes of this document, Tier 6 calculations are based on catch estimates from 2013 – 2014, to ensure consistency in catch estimation and species identification between regions and data sources and to use the most representative catch estimate time series. These catches were used as maximum historical catch for Tier 6 calculations (OFL = maximum historical catch, ABC = 0.75*OFL) The ABC was calculated by area for each species and then added to the apportioned Tier 5 ABCs.

The Tier 6 estimates in the EY/SEO for the non-yelloweye rockfish species include estimated sport and subsistence catch to maintain consistency with the current assessment. Sport harvest estimates are available since 2006, when the current creel census program went into effect; however, sport harvest estimates from 2006 – 2008 extend to 144° W longitude, encompassing a greater area than EY/SEO (which extends to 140° latitude). Subsistence harvest estimates are available only from 2010 – 2014. Thus, for the purposes of this document, the maximum sport and subsistence harvest of the DSR species in the EY/SEO area from 2013 – 2014 were added to the maximum of the commercial catch described above to calculate ABCs.

Alternative 3: GOA-wide DSR assessment

Alternative 3 would create a GOA–wide DSR complex assessment by expanding the DSR assessment to be GOA – wide and moving the canary, China, copper, quillback, rosethorn, tiger, and yelloweye rockfish from the OR assessment (in all areas west of EY/SEO) to the expanded DSR. We describe two potential scenarios for this alternative with regards to the DSR complex.

- Alternative 3, Scenario a) Use Tier 6 methods for the six non-yelloweye rockfish DSR species GOA-wide. In EY/SEO, the Tier 4 approach currently used for yelloweye rockfish would be maintained, but Tier 6 methods would be used for yelloweye rockfish in all other regions. The complex ABC/OFLs would be the sum of the individual species estimates by region.
- Alternative 3, Scenario b) Create a GOA-wide age structured stock assessment for DSR, based on an expansion of the preliminary age-structured DSR assessment from the EY/SEO.

The working group established to examine the feasibility of a GOA-wide DSR age-structured assessment has concerns over limited data availability. Specifically, there is not a directed fishery for DSR in the CGOA or WGOA; therefore, existing data are from incidental catch records. The surveys (e.g., trawl, IPHC, etc.) previously mentioned do not effectively capture DSR species (i.e., trawls), or have poor estimates of CPUE (i.e., in the IPHC survey, DSR caught on the first 20 hook counts are recorded and extrapolated to the rest of the catch). Due to the lack of a targeted fishery or surveys for DSR in the CGOA and WGOA, it is anticipated that model inputs will have high annual variability. Even in the EY/SEO, area(s), which has the most abundant DSR data, the IPHC longline survey data are highly variable and not of great value in the age-structured model. Further, aside from catch and survey data, there are limited biological data (e.g., maturity, size – and age-structure) available for the CGOA and WGOA to inform a model and it is unclear how representative EY/SEO fish are for GOA-wide fish. For these reasons, Alternative 3b has not been pursued further and results are excluded from the table below.

Potential ABC estimates (t) for the alternatives described above where estimates were available. Estimates are separated by Other Rockfish (OR) or Demersal Shelf Rockfish (DSR) sub groups where applicable.

		Other Rockfish Sub Group ABC				Demersal Shelf Rockfish Sub Group ABC						
				Eastern GOA				Eastern GOA			GOA–wide	
Alt	Complex	W GOA	C GOA	WY	EY/ SEO	W GOA	C GOA	WY	EY/ SEO	ADFG[1]	ABC	OFL
1	OR	40	991	580	2,468						4,079	5,347
	DSR								225		225	361
2a	OR	69	1,068	587	2,597					44	4,321	5,730
2b	OR	40	982	574	2,444	29	87	13	153[2]	44	4,321	5,730
2c	OR	69	1,068	587	2,485				153[2,3]	83	4,362	5,851
3a	OR	40	982	574	2,444						4,039	5,295
	DSR					29	87	13	235[4]		364	556

[1]In these examples the ADF&G ABC is not federally managed, but a calculated allocation is delegated to State management for directed fisheries only. Non-directed (incidental catch from the IFQ halibut fishery) would be managed federally.

[2]153 t is the mean federal fishery total catch of DSR since observer restructuring took effect in 2013. This amount was subtracted from the yelloweye rockfish ABC (either by Tier 6 methods or the Tier 4 value from the most recent SAFE) to determine the amount of ABC needed for allocation to the State of Alaska for the directed, subsistence, and sport fisheries.

[3]This ABC only applies to yelloweye rockfish in EY/SEO.

[4]This is different from the status quo EY/SEO DSR ABC because ABCs were calculated for the non-yelloweye rockfish species using Tier 6 methods and added to the recommended yelloweye rockfish ABC/OFL. In the status quo approach, the yelloweye rockfish ABC is increased by 3% to account for the other six non-yelloweye rockfish species.

Discussion and Recommendations

We have presented a variety of alternative management scenarios to investigate if a different management scheme would be more appropriate for the DSR species GOA–wide. The three alternatives have pros and cons, but the authors feel that Alternative 3a is the most appropriate for this group of species.

Alternative 1 (status quo) is the simplest option. However, the management structure may not be appropriate for yelloweye rockfish and the other DSR species being considered here. Adding yelloweye rockfish to the OR complex or not assessing it GOA-wide is problematic based on the following:

1) This species has different life history from the other species in the OR complex;
2) There are directed State fisheries for the species, as well as substantial catch in federal fisheries;
3) This species is primarily caught by longline gear, but in the OR complex catch is dominated by trawl fishery bycatch, and any trends in catch or survey indices for yelloweye would be masked in this large complex.

The above comments also apply to the six non-yelloweye species, which are also predominantly caught by longline gear, poorly sampled by surveys, they are not targeted and catch is small (average ~11 t, annually 2005 – 2014). As with yelloweye rockfish, the spatial composition of the catch of these six species has shifted westward (Figure 16A.3).

Alternative 2, Scenarios a – c (moving DSR into the OR assessment) is not recommended. We do not recommend Alternative 2 for a number of reasons. First, any potential conservation issues that may arise within the DSR complex may be masked by the larger OR complex being dominated by trawl caught species such as harlequin and silvergray rockfish. Each of the scenarios in Alternative 2 is complex, e.g. Alternative 2b, would result in six ABCs to manage in-season. Additionally, ABCs under 50 t are potentially too small to effectively manage. It is possible to combine some ABCs, such as combining WY and EY/SEO, similar to how many species are managed in the GOA. The WY was split from EY/SEO to prevent disproportionate harvest relative to estimated biomass when GOA Groundfish FMP Amendment 11 was adopted by the Council in July 1982. The FMP states that: "This division is intended to protect localized sablefish stocks and demersal shelf rockfish stocks and is necessary to prevent overexploitation in the Eastern regulatory area. The Southeast Outside district delineates the primary rockfish fishing ground in this region." However, this amendment was put in place prior to the trawling restrictions in the EY/SEO area, and may not apply to this situation. Alternative 2 would require an FMP amendment to dissolve the DSR complex as well as to combine the WY and EY/SEO (if that were chosen), adding another level of challenge to this alternative.

Alternatives 2a & b would also eliminate the historical open access directed fisheries managed by ADF&G. The ADF&G typically opens up one to three of the four management areas with a combined annual directed quota of approximately 30 to 100 t. A directed quota on the order of 40 t may be insufficient to hold a directed fishery.

Our preferred option is Alternative 3a (GOA-wide DSR assessment). This alternative would afford the DSR species a higher level of management oversight in the WGOA and CGOA and would be relatively simple to implement from a stock assessment perspective. Relevant concerns and considerations for Alternative 3a are: potential ABC/OFL overages; stock assessments, jurisdictions, regulatory implementation, in-season management and potential for conservation concerns.

Exceeding the ABC or nearing the OFL could limit other fisheries as the Federally managed fisheries could be prohibited. When examining the most recent 10 years of catch, the estimated ABC for EY/SEO would not have been exceeded, the WY estimated ABC would have been exceeded in three years, the WGOA in five out of 10 years and the CGOA in four of the years. However, the GOA-wide proposed OFL would not have been exceeded. To reduce the potential of overages due to small ABCs and the non-target nature of the catch of these species, particularly outside of EY/SEO we recommend the following ABC groupings for a GOA-wide DSR complex:

	Western/Central GOA + West Yakutat	Eastern GOA – EY/SEO only	Total
Area ABC (t)	129	235	364
OFL (t)			556

We recommend combining the WY ABC with that of the WGOA and CGOA areas because the fishery characteristics differ between EY/SEO and the rest of the GOA. In EY/SEO there are state managed directed fisheries, and non-directed fisheries included in the assessment. The catch in the EY/SEO has been much less than the ABC for the last 5 years. In all other areas catch of the DSR species is incidental. With the above recommended ABCs, the WGOA/CGOA/WY ABC would have been exceeded in 3 of the last 10 years.

Alternative 3a would be easily implemented in the existing stock assessments. The current DSR assessment is conducted by the ADF&G, and includes state-managed fisheries. The proposed alternative would retain that assessment structure, and incorporate the DSR species to the west of EY/SEO. Being Tier 6, it would be relatively simple to add these species to the existing assessment. The NMFS would participate in the GOA-wide DSR assessment as well, in that NMFS would provide survey data and

estimates of catch from federal fisheries (and the Pacific Halibut IFQ fishery) and staff to participate in the assessment (i.e., co-authorship).

Alternative 3a would not change the current jurisdictional structure. The State of Alaska would maintain the management of the DSR fisheries in the EY/SEO and the NMFS would manage the DSR catch in the federal fisheries west of EY/SEO.

From a regulatory standpoint, implementing Alternative 3a would be relatively simple because it does not require changes to the FMP. Expanding the DSR assessment to be GOA-wide would only require a change to footnote 4 in Table 10 to Part 679 of the GOA FMP.

The primary challenge with Alternative 3a is in-season management. From a management perspective, Alternative 3a is challenging. The DSR species are currently part of the larger OR complex in all areas west of EY/SEO. The vast majority of the catch of the OR complex comes from the rockfish trawl fishery, while DSR species are rarely caught in the rockfish trawl fishery, but rather in the Pacific halibut fishery. Thus, breaking the DSR species out from the OR complex in the WGOA and CGOA (and WY) would improve tracking of DSR species because they would not be obfuscated by the more predominant OR species. However, the breakout would result in smaller and potentially difficult to manage ABCs, even if the WGOA, CGOA and WY were combined. Further, the Pacific halibut IFQ fishery is the primary source of catch for the DSR species, and NMFS does not have jurisdiction to manage this fishery. If a DSR OFL were approached, NMFS may prohibit directed fishing for federally managed groundfish fisheries (e.g., rockfish trawl), but not for Pacific halibut IFQ. On the other hand, under Alternative 3a, if the OR ABC is exceeded, the Pacific halibut fishery would not be put on discard status for the DSR fishery, as occurs with the existing management protocol.

Proposed Alternative 3a is the most appropriate alternative based on the biology of all 25 OR and DSR species. The stock structure analysis suggests that the biological characteristics of the DSR species are dissimilar from the other OR species; DSR species tend to be nearshore, slower growing with greater longevity, and thus likely have lower productivity. Whereas the 17 remaining OR species tend to be pelagic, offshore, faster growing, shorter-lived, and may have higher dispersal. The one exception is the redbanded rockfish, which is an intermediary to both groups. At this time, available data do not suggest a conservation concern in the DSR species to the west of the EY/SEO area. There is a paucity of data to inform managers on these species; however, it is reasonable to assume that the shift in catch from east to west could be indicative of a distributional shift. Further, the IPHC survey, the only consistent survey that catches these species west of EY/SEO exhibits stable catches of the two most commonly caught DSR species: quillback and yelloweye rockfish. In comparison, the EY/SEO ROV survey suggests declines in the density estimates of yelloweye rockfish.

In conclusion, the assessment authors of both the OR and DSR assessments recommend Alternative 3a as a more appropriate management grouping for these species. While there are no obvious conservation concerns based on available data, the biology of the species in the DSR complex (in particular, yelloweye rockfish) necessitates a higher degree of oversight. Implementing Alternative 3a has minimal regulatory changes and does not require an FMP amendment. In-season management of small ABCs has challenges, but this alternative ensures DSR catch won't be obscured in the larger OR complex, especially given the market value of the DSR species and the lower discard rate. This management change, if accepted, would likely not go into effect for a few years; thus the authors prefer to re-evaluate the catch time series for the 2017 assessment cycle to: 1) increase the time series of data available post observer restructuring for the Tier 6 species OFL/ABCs and to examine how likely catches are to exceed the potential ABCs; and 2) to clarify if there are any issues with overlap between catch estimates available in CAS and those estimated by the ADF&G for DSR species in EY/SEO.

Task #4 – Random Effects Model

The utility of using the random effect approach for survey averaging for the OR complex was investigated. The exercise was limited to the 17 species where the trawl survey biomass estimates are considered reliable (excluding all DSR species and Northern Rockfish). Due to the large number of species in this complex, multiple approaches were examined:

Case 1. Model species specific GOA biomass and sum to the complex
- C1_P0 – Estimated process error for each species
- C2_P1 – Estimated process error for all species combined

Case 2. Model total OR GOA biomass

Case 3. Model OR biomass by region (i.e., WGOA, CGOA, and EGOA) and sum to GOA–wide complex level
- C3_P0 – Estimated process error for each region
- C3_P1 – Estimated process error for all regions combined

Two statistics were used to compare the models: 1) sum of squared first differences in estimated standard deviation (SD) in biomass (i.e., determine the model with the most consistent SD across years); and 2) sum of the coefficient of variation (CV) ranks (i.e., determine the model with the lowest variance estimate in biomass). This analysis was conducted retrospectively to determine consistency across time, going back five surveys, from 2005, 2007, 2009, 2011, and 2013.

Using the sum of squared first differences, model C3_P0 was selected as the preferred model (i.e., lowest values) for all 5 model runs, one for each survey (Table 16A.3). Model C1_P1 and C2 had similar results with slightly poorer fits than the preferred model. Model C1_P0 did not converge in many of the runs. Results were similar when using the sum of the CV ranks.

Results suggest that either modeling the full OR complex GOA–wide or the full complex but by region would be appropriate. However, the model with consistently the lowest variance estimator is the model by region (C3_P0). This model would also be simpler to use in the assessment due to the current apportionment strategy, which apportions ABCs by region. Further, modeling by region accounts for the missing survey in the EGOA in 2001.

For comparison to the status quo, the 2014 exploitable biomass based on model C3_P0 is 65,172 t and the exploitable biomass from the most recent assessment (excluding the DSR species) was 83,056 t (Figure 16A.4). The recommended ABCs and OFL would then be (using a mean natural mortality value for the full complex):

	Western/Central GOA	Eastern GOA (74.7%)		Total
		West Yakutat	E Yakutat/ Southeast	
Area Apportionment	25.3%	14.2%	60.5%	100%
RE Area ABC (t)	804	451	1,922	3,177
2014/2015 ABC (t)	961	585	2,489	4,035
RE OFL (t)				4,236
2014/2015 OFL (t)				5,289

The Plan Team provided guidance after the September 2015 meeting, which explained how to incorporate the random effects model into assessments. Thus, this model is recommended for OR.

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Green, K., K. Van Kirk, J. Stahl, M. Jaenicke, and S. Meyer. 2014. Assessment of the demersal shelf rockfish stock for 2014 in the southeast outside district of the Gulf of Alaska. *In* 2014 Stock Assessment and Fishery Evaluation Report for 2015. North Pacific Fishery Management Council, Anchorage, AK. Pgs. 751 – 838.

Tribuzio, C. A. and K. B. Echave. 2014. Assessment of the other rockfish stock complex in the Gulf of Alaska. *In* 2014 Stock Assessment and Fishery Evaluation Report for 2015. North Pacific Fishery Management Council, Anchorage, AK. Pgs. 843 – 848.

Tribuzio, C.A., J.R. Gasper and S.K. Gachais. 2014. Estimation of bycatch in the unobserved Pacific halibut fishery off Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-265, 506 p.

Tables

Table 16A.1. Catch of the seven Demersal Shelf Rockfish (DSR) species across the Gulf of Alaska (GOA), separated by Yelloweye Rockfish (YE) and all other rockfish (Others) combined. Data are provided by the Alaska Regional Office for the Western Gulf of Alaska (WGOA), Central GOA (CGOA) and West Yakutat (WY) regions. Data for the East Yakutat/Southeast Outside (EY/SEO) Region is provided by the Alaska Department of Fish and Game. The following should be noted regarding these data: 1) the restructured observer program went into effect for federal fisheries in 2013; 2) full retention of Demersal Shelf Rockfish species was required in EY/SEO in 2005; and 3) sport and subsistence data are included in the EY/SEO total catch estimates beginning in 2006 and 2010, respectively.

	WGOA		CGOA		WY		EY/SEO		Totals		
Year	YE	Others	YE	Others	YE	Others	YE	Others	YE	Others	Total
1995	0	0	30	1	8	4	238	20	276	25	301
1996	2	0	21	1	7	6	398	27	428	34	462
1997	6	0	22	0	15	0	343	22	386	22	408
1998	2	0	18	0	9	1	340	19	369	20	389
1999	3	0	112	1	15	1	348	18	478	20	498
2000	7	0	13	1	16	0	275	12	311	13	324
2001	6	0	18	0	5	0	304	13	333	13	346
2002	6	0	12	1	3	1	270	13	291	15	306
2003	39	0	84	3	26	2	256	13	149	5	155
2004	35	0	73	1	20	0	315	12	128	1	129
2005	18	0	59	1	12	0	228	5	89	1	90
2006	46	0	71	2	29	1	199	4	146	3	150
2007	21	0	83	1	28	1	192	3	132	2	134
2008	46	1	129	3	25	0	190	4	390	8	398
2009	41	1	99	2	27	1	209	5	376	9	385
2010	52	1	112	6	36	1	156	5	356	13	370
2011	56	1	98	6	22	1	106	2	282	10	292
2012	51	1	133	10	15	0	173	7	372	18	392
2013	38	1	106	9	17	1	205	7	366	18	384
2014	25	0	98	6	13	1	90	2	226	9	248

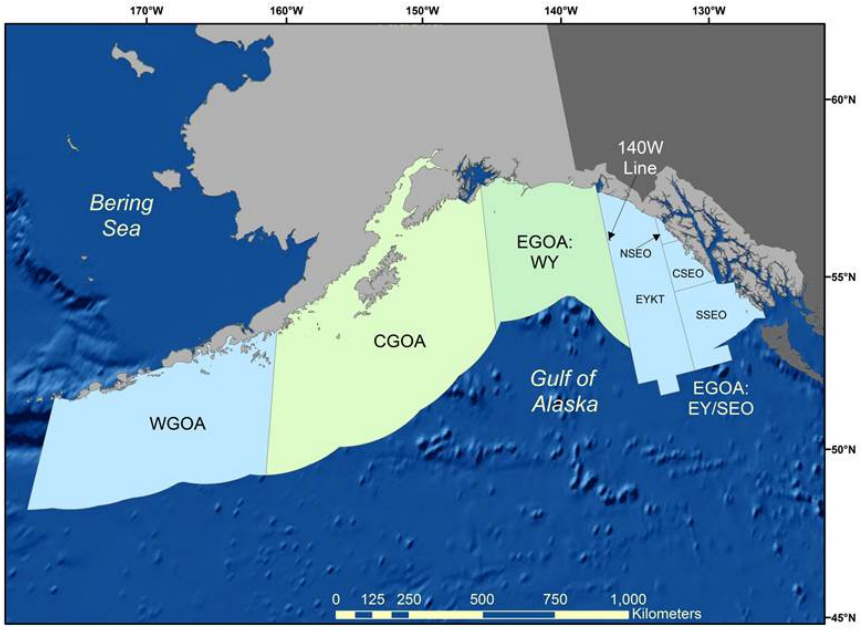
Table 16A.2. Historical catch (by region and Total Gulfiwide), acceptable biological catch (ABC) and total allowable catch (TAC) of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) complexes. Data for the OR is from the Alaska Regional Office and for the DSR are from the most recent assessments (Green et al. 2014).

	Other Rockfish							Demersal Shelf Rockfish		
Year	WGOA	CGOA	WY	EY/SE	Total	ABC	TAC	EY/SE	ABC	TAC
1991	20	175	81	2	278	10,100	10,100			
1992	76	854	731	14	1675	14,060	14,060	478	550	550
1993	342	2423	735	1,923	5,423	8,300	5,383	535	800	800
1994	101	715	564	233	1,613	8,300	2,235	604	960	960
1995	31	883	460	23	1,397	7,110	2,235	271	580	580
1996	19	618	233	11	881	7,110	2,020	436	945	945
1997	68	941	123	85	1,217	5,260	2,170	380	945	945
1998	46	701	108	6	861	5,260	2,170	361	560	560
1999	39	614	125	10	788	5,270	5,270	368	560	560
2000	49	363	132	33	577	4,900	4,900	295	340	340
2001	25	318	169	47	559	4,900	1,010	324	330	330
2002	223	481	45	25	774	5,040	990	285	350	350
2003	133	683	227	26	1,069	5,050	990	275	390	390
2004	275	584	78	3	967	3,900	670	329	450	450
2005	65	516	71	48	700	3,900	670	237	410	410
2006	279	604	138	79	1,100	4,152	1,480	269	410	410
2007	249	340	54	53	697	4,154	1,482	273	410	410
2008	251	439	50	29	769	4,297	1,730	246	382	382
2009	403	403	83	15	904	4,297	1,730	250	362	362
2010	366	439	131	40	976	3,749	1,192	217	295	287
2011	301	366	192	38	897	3,749	1,192	144	300	294
2012	254	723	37	23	1,038	4,045	1,080	223	293	286
2013	202	474	77	68	816	4,045	1,080	247	303	296
2014	171	717	61	38	987	4,080	1,811	100	274	267

Table 16A.3.Model comparison statistics for the random effects approach to survey averaging for the Other Rockfish complex. DNC = Did not converge. Bold text shows preferred model (those with the lowest values).

Sum of squared 1st differences in Standard Deviation					
Model end year	C1_P0	C1_P1	C2	C3_P0	C3_P1
2013	DNC	2.340	2.619	**0.922**	8.242
2011	10.732	2.547	2.707	**1.204**	9.080
2009	DNC	2.564	2.256	**1.140**	8.089
2007	10.723	2.922	2.260	**1.355**	7.501
2005	10.682	4.269	2.456	**1.027**	7.892
Sum of Coefficient of Variation Ranks					
Model end year	C1_P0	C1_P1	C2	C3_P0	C3_P1
2013	DNC	81	76	**41**	102
2011	89	90	81	**47**	113
2009	DNC	66	65	**38**	91
2007	90	72	65	**40**	93
2005	86	72	56	**35**	81

Figures



Other Rockfish			Demersal Shelf Rockfish
WGOA & CGOA	EGOA:WY	EGOA:EY/SEO	EGOA:EY/SEO
Blackgill Rockfish	Blackgill Rockfish	Blackgill Rockfish	
Bocaccio	Bocaccio	Bocaccio	
Canary Rockfish	Canary Rockfish		Canary Rockfish
Chilipepper Rockfish	Chilipepper Rockfish	Chilipepper Rockfish	
China Rockfish	China Rockfish		China Rockfish
Copper Rockfish	Copper Rockfish		Copper Rockfish
Darkblotched Rockfish	Darkblotched Rockfish	Darkblotched Rockfish	
Greenstriped Rockfish	Greenstriped Rockfish	Greenstriped Rockfish	
Harlequin Rockfish	Harlequin Rockfish	Harlequin Rockfish	
	Northern Rockfish	Northern Rockfish	
Pygmy Rockfish	Pygmy Rockfish	Pygmy Rockfish	
Quillback Rockfish	Quillback Rockfish		Quillback Rockfish
Redbanded Rockfish	Redbanded Rockfish	Redbanded Rockfish	
Redstripe Rockfish	Redstripe Rockfish	Redstripe Rockfish	
Rosethorn Rockfish	Rosethorn Rockfish		Rosethorn Rockfish
Sharpchin Rockfish	Sharpchin Rockfish	Sharpchin Rockfish	
Silvergray Rockfish	Silvergray Rockfish	Silvergray Rockfish	
Splitnose Rockfish	Splitnose Rockfish	Splitnose Rockfish	
Stripetail Rockfish	Stripetail Rockfish	Stripetail Rockfish	
Tiger Rockfish	Tiger Rockfish		Tiger Rockfish
Vermilion Rockfish	Vermilion Rockfish	Vermilion Rockfish	
Widow Rockfish	Widow Rockfish	Widow Rockfish	
Yelloweye Rockfish	Yelloweye Rockfish		Yelloweye Rockfish
Yellowmouth Rockfish	Yellowmouth Rockfish	Yellowmouth Rockfish	
Yellowtail Rockfish	Yellowtail Rockfish	Yellowtail Rockfish	

Figure 16A.1. Map of the Gulf of Alaska (GOA) management areas: Western (WGOA), Central (CGOA) and Eastern (EGOA) with the species of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) included for each area. The EGOA is subdivided into the West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO) areas. The EY/SEO is subdivided for the DSR complex into East Yakutat (EYKT), Northern, Central, and Southern Southeast Outside (NSEO, CSEO, and SSEO, respectively). The table below the figure lists the species that are part of the each complex in each of the areas.

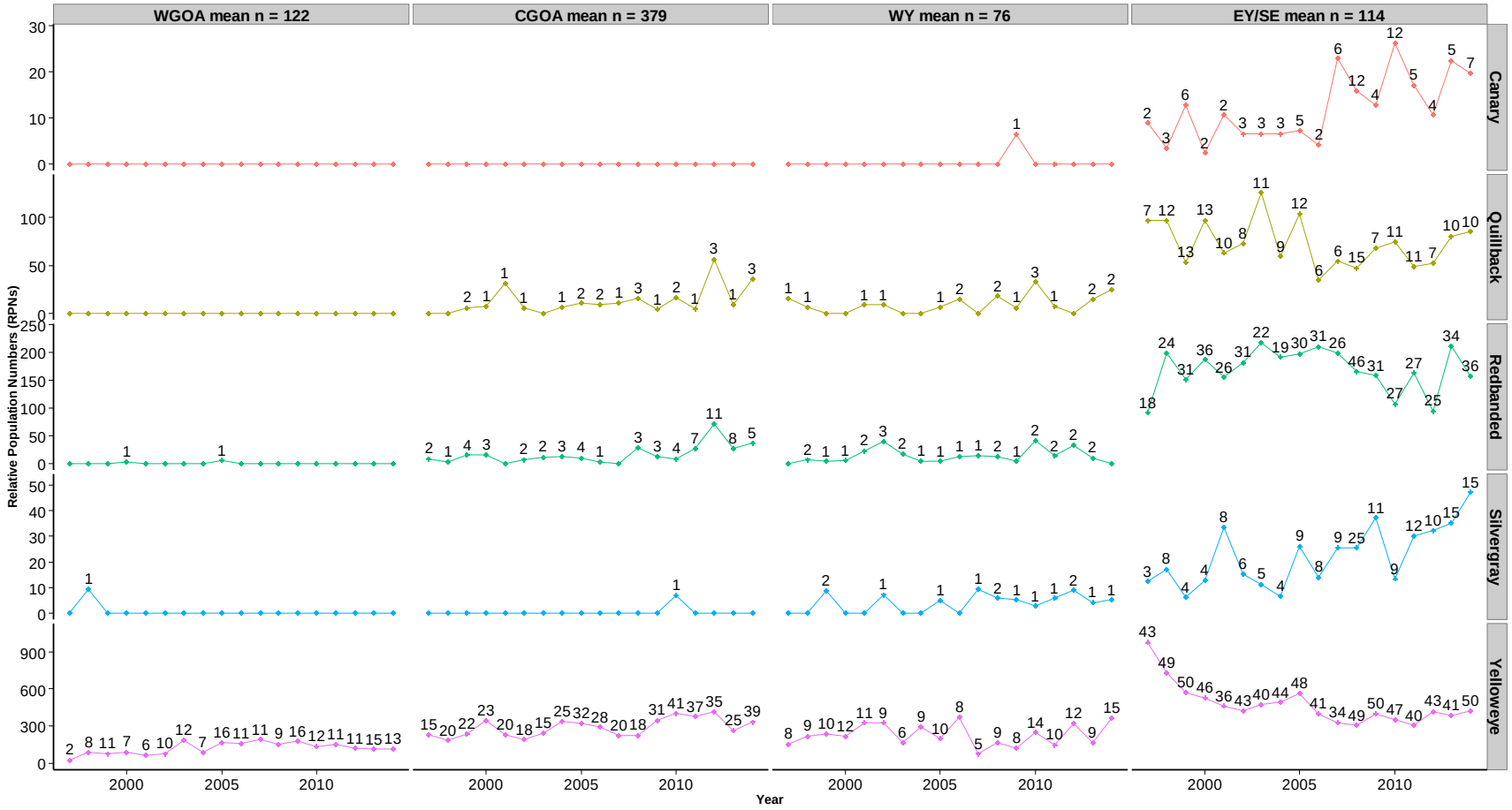


Figure 16A.2. Relative Population Numbers (RPNs) from the International Pacific Halibut Commission (IPHC) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA), West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO). The mean numbers of stations that occur in each area annually are provided along the top of the figure. The numbers above the points are the number of stations in which that species was captured.

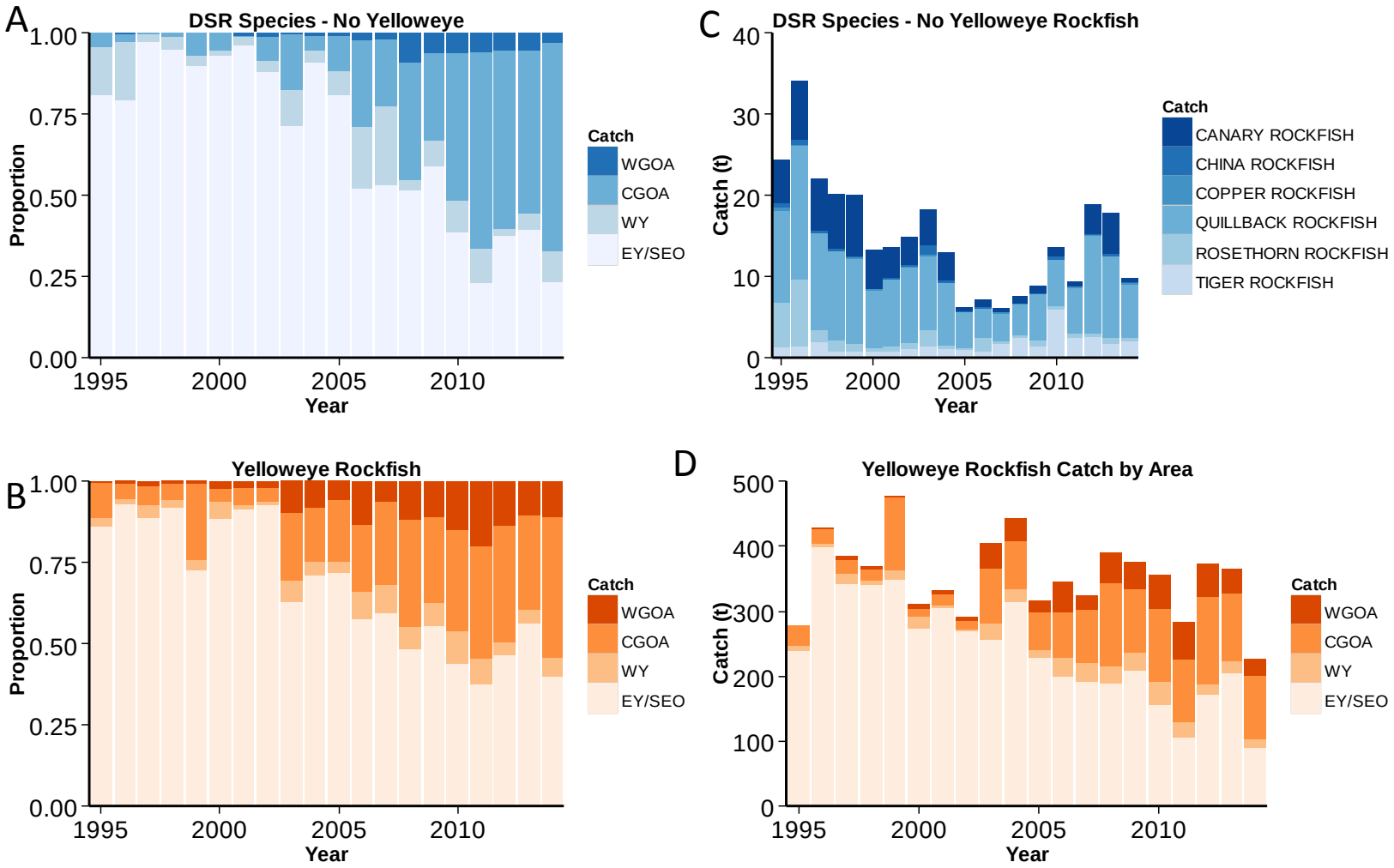


Figure 16A.3. Catch distribution by management area for: A) all of the DSR species except yelloweye rockfish B) just yelloweye rockfish, C) catch by species for all of the DSR species except yelloweye rockfish and D) catch by area for just the yelloweye rockfish Catch estimates in EY/SEO include estimated catch from State managed directed fisheries, subsistence and sport fisheries. The time series of catch in EY/SEO has the following caveats: retention was not required until 2005, sport fishery estimates are not available prior to 2006 and subsistence prior to 2010. Further, the restructured observer program went into effect in 2013.

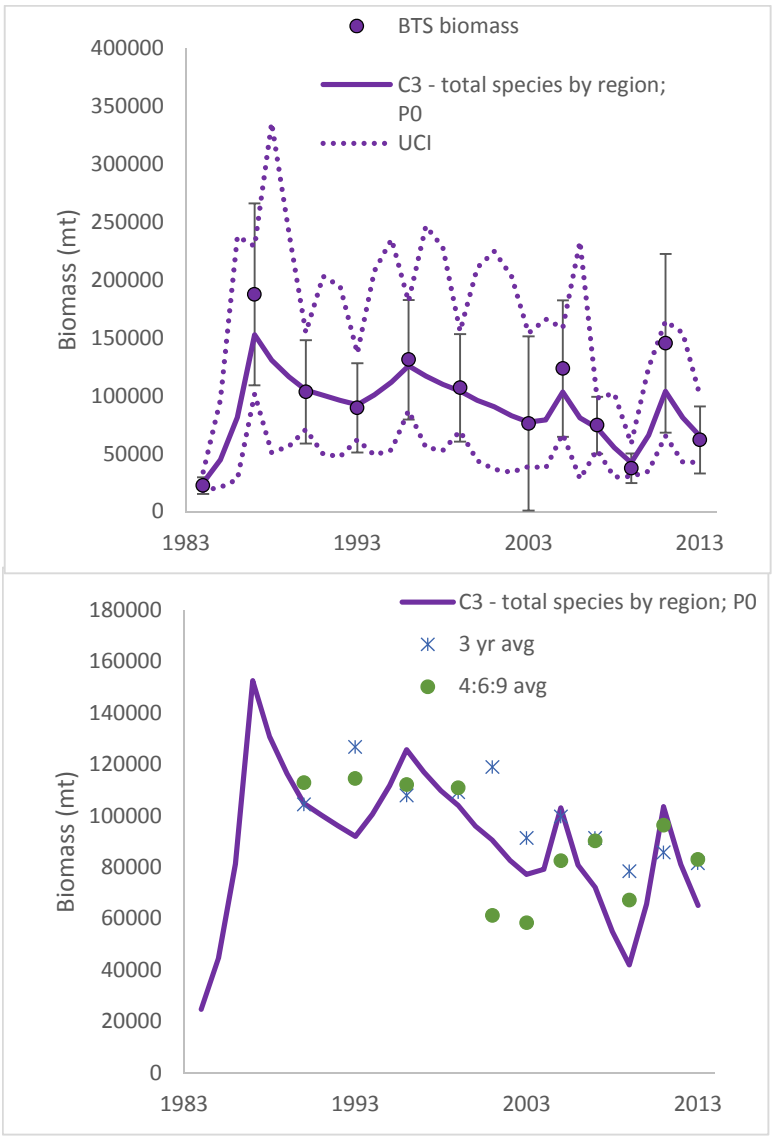


Figure 16A.4. Top panel: Bottom trawl survey biomass estimates with 95% confidence intervals and the best fit random effects model estimates. Bottom panel: Random effects best fit model compared to the 3 survey average and the 4:6:9 weighted average. The 2001 survey did not sample the eastern Gulf of Alaska (EGOA) and was accounted for by the random effects model, but the other averages still include that survey.

Appendix 16B: Evaluation of stock structure for the Other Rockfish and Demersal Shelf Rockfish complexes in the Gulf of Alaska

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November 2015

Executive Summary

We present information available on the Other Rockfish (OR) complex in the Gulf of Alaska (GOA) and the Demersal Shelf Rockfish (DSR) complex in the East Yakutat/Southeast Outside (EY/SEO) portion of the Eastern Gulf of Alaska (EGOA) Fishery Management Plan area to evaluate potential stock structure for these species. Due to the overlap of species between the OR and DSR complexes, we have combined the two documents. The complexes are described separately where appropriate given differences in management, fisheries, and survey techniques.

The GOA OR complex consists of 25 species (Table 16B.1). The DSR complex specific to the EGOA includes seven of the species in the OR complex (Table 16B.1). The GOA is the northern edge of most of these species ranges; abundances center off British Columbia or the U.S. West Coast. Within the GOA, OR and DSR are most abundant in the EGOA with reduced abundance farther west. OR are currently managed as non-target species in groundfish fisheries. The DSR complex is harvested in directed and incidental commercial, subsistence and recreational fisheries.

There are no directed fisheries for any of the species of OR, thus all catch is incidental in other groundfish fisheries. Available catch data indicate no evidence of localized depletion. Annual catch since 1993 has been below the Gulfwide complex acceptable biological catch (ABC), with the exception of overages of the apportioned ABC in the western GOA (WGOA) and central GOA (CGOA) in recent years. It is unlikely that these overages represent a biological over harvest as the ABCs may not accurately represent the true abundance due to the NMFS biennial bottom trawl survey not completely sampling these species in rocky habitat. Data do not suggest trends in either biomass or catch for OR. However, there is a mismatch between the geographical distributions of fishing effort and survey abundance, likely due to the aforementioned trawl survey's difficulty in sampling rocky habitat.

The ABC and over fishing limit (OFL) for the DSR complex are calculated for yelloweye rockfish, which comprises > 96% of the complex, and adjusted for the complex as a whole. Survey data suggest declines in the complex biomass overall and in sub regions of the EY/SEO for yelloweye rockfish. However, catches have been constrained by the reduction of the total allowable catch (TAC) and overfishing is not occurring.

There are few data available to differentiate stocks among regions within the GOA for any of the 25 species in the two complexes. Rockfish are generally long-lived and slow growing. Little information on growth and reproduction is available for any of the complexes' rockfishes, and available data are insufficient for evaluating comparisons within the spatial extents of the complexes. Additionally, little genetic information exists to infer any genetic stock structure between or within areas. However, while data are limited, the life history characteristics suggest that the current complex groupings are not appropriate for these species.

Introduction

The Stock Structure Working Group was formed in 2009 to develop a set of guidelines to assist stock assessment authors in providing recommendations on stock structure for Alaska groundfish stocks. The framework was presented at the September 2009 joint Groundfish Plan Team (GPT) 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 (GOA) GPT discussed the advantages of having all stock assessment authors evaluate stock structure characteristics of specific stocks. This analysis was deemed necessary for the Other Rockfish (OR) complex because it has GOA-wide overfish limit specifications and because it is a complex of multiple species, as well as for the Demersal Shelf Rockfish complex (DSR).

Sebastes species in the GOA Fishery Management Plan (FMP) area were first split into three broad management assemblages by the North Pacific Fishery Management Council (NPFMC) in 1988: Slope Rockfish, Pelagic Shelf Rockfish (PSR), and DSR. Since 1988, major modifications have occurred to break out these broad groupings into finer scale assemblages. The NPFMC established a separate management category for Other Slope Rockfish in the GOA in 1991. This group initially included northern rockfish and 15 other diverse species; northern rockfish was removed (with the exception of northern rockfish occurring in the eastern GOA, EGOA) in 1993 to become its own separate management category. In 2010, the GOA GPT and the NPFMC Scientific and Statistical Committee (SSC) both recommended that yellowtail and widow rockfish be added to GOA Other Slope Rockfish (Clausen et al. 2011). Previously, the two species were part of the GOA PSR management group. It was also recommended that the official name of Other Slope Rockfish be changed to OR because yellowtail and widow rockfish primarily inhabit the continental shelf rather than the slope. In the 2012 fishery season, the OR complex was first managed in its current configuration, (Other Slope Rockfish with the addition of widow and yellowtail rockfish from the former PSR category). There are seven species that occur in both the OR and DSR complexes, depending on location: canary, *S. pinniger;* China, *S. nebulosus;* copper, *S. caurinus;* quillback, *S. maliger*; rosethorn, *S. helvomaculatus*; tiger, *S. nigrocinctus*; and yelloweye, *S. ruberrimus*. These seven species, when occurring outside of the East Yakutat/Southeast Outside (EY/SEO) management area (i.e., NMFS areas 610 – 640, or the western and central GOA, WGOA and CGOA respectively, and the West Yakutat, WY, portion of the EGOA, Figure 16B.1), are included in the OR complex. The OR complex consists of 25 species in total (Table 16A.1). The DSR complex is the seven above species, but only when occurring in the EY/SEO region (also called NMFS area 650, Figure 16B.1). In this appendix, any reference to the DSR complex only applies to these seven species when occurring in the EY/SEO, any reference to the OR complex refers to the 18 species listed in Table 16B.1, as well as the seven DSR species only when occurring west of EY/SEO.

This appendix is a summary of information regarding the populations of the 25 rockfish species of the OR and DSR complexes in the GOA FMP 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 assessments and can be found in more detail there (Clausen and Echave 2011, Green et al. 2014).

Distribution

Nearly all of the OR/DSR species in the GOA are at the northern edge of their ranges; the center of abundance for most is farther south off British Columbia or the U.S. West Coast (Figure 16B.3A). One exception is harlequin rockfish, a predominantly Alaskan species widely distributed across the GOA (Figure 16B.3B). The center of abundance for silvergray rockfish, the most abundant of the OR species based on recent trawl survey biomass estimates, appears to be southeast Alaska and British Columbia (Figure 16B.3C). Much of the information describing the spatial distribution for the majority of the OR species comes from Mecklenberg et al. (2002) and Love et al. (2002), as reports of catch for many of these species are rare. Additionally, distribution information is often based on studies of fish in lower latitudes (British Columbia and further south). Summarized information on the distribution of each of the OR/DSR complex species can be found in Table 16B.2.

Life History

Life history data are limited for most OR/DSR species, and generally based on studies in waters in lower latitudes (British Columbia and further south). Life history data collected in Alaska waters are available for sharpchin, harlequin, redstripe, yelloweye, and silvergray rockfish. All species of rockfish are ovoviviparous, with fertilization, embryonic development, and larval hatching occurring inside the female. Summarized information on the life history of the OR/DSR complex species can be found in Table 16B.3.

The species in these two complexes span a wide range of life history characteristics (Figure.16B.2). The current complex definitions are based the fisheries in which the species are primarily caught in. The DSR species tend to be longer lived and grow more slowly than the OR species, with the exception of canary, copper, silvergray, rosethorn and redbanded rockfish. As part of this stock structure analysis, we examined the species groupings to determine if a more biologically meaningful grouping exists.

Copper and splitnose rockfish are rare, with < 2 t caught total since 2003. Copper rockfish is a species closely associated with high relief rocky habitat, found in shallow nearshore waters and a benthic feeder only caught on hook and line gear. Thus, even though it's growth characteristics place it with the OR species, it is appropriate to group it with the DSR species. Splitnose rockfish are more pelagic and are primarily caught by the rockfish trawl fishery, and are appropriately grouped with the other OR species.

Rosethorn and canary rockfish are both in the DSR complex in EY/SEO. Both species feed on benthic foods (canary also feeds on pelagic), observer data suggests both are primarily caught on the slope in trawl gear, but on hook and line gear in EY/SEO (trawling is not allowed in EY/SEO). GOA–wide, catches average < 2 t and < 1 t annually since 2003 (rosethorn and canary, respectively). Canary are primarily caught in the EY/SEO region, while rosethorn are primarily caught in the WY region. While these two species span characteristics of both complexes, the life history suggests they should be grouped with the other DSR species.

Silvergray rockfish were initially targeted as part of the DSR complex, and landings of silvergray rockfish still occur in the DSR fishery. When Amendment 21 of the GOA FMP went into effect, silvergray rockfish were moved out of DSR and into the then Other Slope Rockfish complex. The age and growth characteristics of silvergray rockfish would group them with DSR species; however, the species tends to school off bottom and while it is caught in hook and line fisheries, it is primarily caught in trawl fisheries, similar to the OR species.

Redbanded rockfish are the species which is most difficult to associate with either complex. Prior to the formation of the DSR complex, the redbanded rockfish were part of the "Slope Rockfish" group. When the DSR complex was formed, Amendment 21 moved the species into DSR, but the species was moved back to the then Other Slope Rockfish group in 1997. The species appears to be long lived and presumably slow growing (only maximum age is available, Table 16B.3), it is a benthic feeder and does not tend to form schools. It tends to be found inhabiting hard bottom habitats, which are subject to both trawl and hook and line gear and is caught in inshore and offshore waters. Redbanded rockfish is one of the more common species of OR or DSR both in catch and trawl survey biomass, thus its assignment to a complex has a large impact on that complex estimated ABC/OFL.

While data is limited, the life history characteristics suggest that the current complex groupings are not appropriate for these species. The life history and ecology is divergent enough to suggest that the seven DSR species should be grouped together GOA – wide. The current grouping puts these species in with the OR species in all areas west of EY/SEO.

Fishery

Other Rockfish

Fishery catch statistics for the OR complex are available from Alaska Regional Office blend estimates and catch accounting system beginning in 1991. Since the mid-1990s, directed fishing has not been permitted for OR in the GOA, and the fish are only 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. There are, however, two exceptions: 1) in 1993, when directed fishing was permitted for OR, it appears some targeting by trawlers occurred in the eastern GOA for silvergray and yellowmouth rockfish, two larger sized species that can be caught in bottom trawls; and 2) in 2004 and 2005, a small experimental fishery was permitted in Southeast Alaska that used modified trolling gear to catch the large amount of Pacific Ocean Perch quota unavailable to trawlers, but mainly was successful in catching Silvergray Rockfish (Clausen and Echave 2011). The catch accounting system estimates of catch do not include catch from unobserved fisheries such as the Pacific halibut IFQ fleet prior to the 2013 observer restructuring or state managed fisheries.

With the exception of 1993, GOA - wide catches of OR have always been < 1,700 t and since 1998 have usually been ~600 – 900 t. Most catch of OR occurs in the CGOA (Figure 16B.4A). Annual catch since 1993 has always been below the ABC and TAC. Amendment 41 was implemented in 1998 prohibiting trawling in the GOA east of 140° W. longitude resulting in decreased catches of OR species in the EGOA where these species are most abundant.

Most years, trawling has accounted for a substantial majority of the OR catch (Clausen and Echave 2011). Since 1993, ~86% of the OR catch has occurred in trawl fisheries (55 – 96% range). The predominance of trawl catches is not surprising, as many of the abundant OR species such as Sharpchin and Harlequin Rockfish are primarily planktivorous and thus not likely attracted to longlines.

The composition of the OR species caught by commercial fisheries varies by area and gear. The primary species caught overall are: harlequin (35%), redbanded (17%), sharpchin (13%), yelloweye (12%, west of EY/SEO only), redstripe (9%), and silvergray (6%) (Figure 16B.5A). During 1991 - 2012, these species comprised 94% (SD = 10.87%) of the catch of OR (Tribuzio and Echave 2013). Harlequin rockfish are the dominant species caught in the WGOA, CGOA, and WY areas, with decreasing relative catch in the EGOA. Redbanded rockfish are the most common species caught in the EGOA. Yelloweye rockfish are the dominant species caught on fixed gear and harlequin rockfish are the dominant species caught in trawl gear.

DSR

In the DSR complex, yelloweye rockfish is the primary species caught (> 96%, Green et al. 2014, Figure 16B.5B). Although the fishery for the DSR complex has been active since the late 1970s, catch reconstruction for DSR prior to 1992 is problematic due to changes in the species assemblage as well as the lack of a directed fishery harvest reporting prior to 1990 or 1992 depending on the sub region. The directed DSR catch in EY/SEO was above 350 t in the mid-1990s. Since 1998, landings have been below 250 t, and since 2005, directed landings have typically been less than 100 t. During the reported years (1992 - 2014), total catches peaked at 502 t in 1996. Since 2000, most of the DSR total reported catch is from incidental catch of DSR in the Pacific halibut IFQ fishery. It should be emphasized that full retention of DSR was not required in state and federal waters until 2000 and 2005, respectively, prior to then incidental catch is likely underestimated. Directed commercial fishery DSR landings have often been constrained by fishery management actions. In 1992, the directed DSR fishery was allotted a Pacific halibut prohibited species cap (PSC) specifically for this fishery and is, therefore, no longer affected when the PSC is met for other longline fisheries in the GOA. In 1993, the fall directed DSR fishery was closed early due to an unanticipated increase in DSR incidental catch during the Pacific Halibut IFQ fishery.

Directed DSR fisheries are held if there is sufficient quota available after the DSR mortality in other commercial fisheries is estimated (primarily the Pacific halibut IFQ fishery). Estimated catch of yelloweye rockfish, the most commonly caught DSR species, is available by sub region from 1985 through 2013 from the most recent full assessment (Green et al. 2014). Most of the catch of yelloweye rockfish occurs in the nearshore districts of the Central and Southern Southeast Outside sub regions (CSEO and SSEO, respectively, Figure 16B.4B).

Survey

Standard bottom trawl surveys (tri/biennial) in the GOA provide the most comprehensive data on OR. The trawl survey is based on a stratified random sampling design designed as a multi-species survey. There is high variability in survey biomass estimates of the OR complex because it is difficult to sample the high relief rocky habitat inhabited by many of these rockfish species and many of these species are thought to be patchily distributed and highly aggregated.

The trawl survey biomass estimates indicate that six species have comprised most of the biomass: sharpchin, redstripe, harlequin, silvergray, redbanded, and yellowtail rockfish (Figure 16B.5C). Geographically, most of the biomass for these species is found in the EGOA, especially the southeastern statistical area (Figure 16B.3 & Figure 16B.4B). Harlequin rockfish is the one exception, as its highest biomass has often occurred in the WGOA. Biomass estimates from trawl surveys show wide fluctuations with large confidence intervals (Figure 16B.6). The coefficients of variation (CVs) for the estimates are generally higher than for many of the other species of rockfish in the GOA. For example, CVs for redstripe rockfish range from 36% to 87%, compared to a range of only 17% to 33% for shortraker rockfish (Clausen and Echave 2011) and 11% to 23% for rougheye/blackspotted rockfish (Shotwell et al. 2014). Many of the less common species of OR often have CVs near 100%.

Other available surveys, such as longline surveys, do not effectively sample many of the OR species due to habitat or diet preferences. However, these surveys may be informative for a few of the OR and DSR species. Longline surveys do not provide a biomass estimate, but do provide a relative index of abundance (termed relative population numbers, RPN), which can be used to infer population trends. The International Pacific Halibut Commission (IPHC) annual longline survey samples a large number of station on the continental shelf, to 500 m depth, while the NMFS annual longline survey fishes fewer stations and samples the continental slope from 150 m to 1,000 m. Five species of the OR and DSR are caught somewhat regularly on the IPHC survey: canary, quillback, redbanded, silvergray and yelloweye rockfishes (Figure 16B.7). Two species are caught on the NMFS survey: redbanded and yelloweye rockfish (Figure 16B.8). Both surveys primarily catch these species in the EY/SEO region.

The DSR species occur in rocky habitats, not conducive to trawling, and are assessed using visual survey techniques. Between 1988 and 2010, density estimates derived from yelloweye rockfish counts from submersible video observations were extrapolated over the total yelloweye rockfish habitat (Figure 16B.4D & Figure 16B.5D). In 2012, ADF&G transitioned to using a remote operated vehicle (ROV) for visual surveys given the unavailability of a cost-effective and appropriate submersible. Although the survey vehicle has changed, the basic methodology to perform the stock assessment for the DSR complex remains unchanged.

The product of average yelloweye rockfish weight landed as bycatch in directed commercial fisheries and the density estimate are extrapolated over total rockfish habitat to obtain a biomass estimate for the EY/SEO in the EGOA (O'Connell and Carlile 1993, Brylinsky et al. 2009). This biomass estimate is used to set the ABC for the DSR complex (EY/SEO only). Survey density estimates for yelloweye rockfish suggest declining trends in most areas (Figure 16B.9).

Management

All species within the OR complex have been classified as Tier 5, with the exception of sharpchin rockfish, which is Tier 4. Tier 5 is a classification from the NPFMC definitions for ABC and OFL based on Amendment 56 to the GOA 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 $\leq 0.75M$. Exploitable biomass for each of the OR Tier 5 species is calculated based on the average GOA–wide biomass estimates for the three most recent trawl surveys. The estimated biomasses are multiplied by 75% of *M* to calculate the ABCs. One ABC is set for the entire OR complex by summing the individual species recommended ABCs.

Based on the geographic distribution of the species' exploitable biomass in the trawl surveys, the NPFMC has apportioned the ABC and thus the total allowable catch (TAC) for OR in the GOA into three geographic management areas: the WGOA, CGOA, and EGOA (Figure 16B.1). Beginning in the 1997 fishery, this distribution has been computed as a weighted average of the percent survey biomass distribution for each area in the three most recent trawl surveys. In the computations, each successive survey is given a progressively heavier weighting using factors of 4, 6, and 9, respectively. Since 1999, trawling has been prohibited in the Eastern GOA east of 140° W. longitude. Because most species of the OR complex are caught exclusively with trawl gear, this closure could have concentrated the catch of these fish in the Eastern GOA in the relatively small area between 140° and 147° W. longitude that remained open to trawling. To ensure that such a geographic over-concentration of harvest would not occur, beginning in 1999 the NPFMC divided the EGOA into two smaller management areas: WY (area between 147° and 140° W. long.) and EY/SEO (area east of 140° W. long.) (Figure 16B.1). Separate ABCs and TACs were assigned to each of these smaller areas for the OR complex.

Northern rockfish are managed as a separate species in the CGOA and WGOA; however, because of their extremely low abundance and the consequent difficulty of managing them as a separate species in the EGOA they were reassigned to the OR complex in 1999 for this area only. Therefore, Northern Rockfish is listed as an OR species in Table 16B.1 but only for the Eastern GOA.

DSR are managed under Tier 4 harvest rules, where maximum allowable $F_{ABC} \leq F_{40\%}$ and $F_{OFL} = F_{35\%}$, with complex catch limits based on the estimated yelloweye rockfish biomass. The biomass estimates are derived from the most recent ROV and submersible density estimates in each sub management area (East Yakutat, EY, Northern Southeast Outside, NSEO, Central Southeast Outside, CSEO, and Southern Southeast Outside, SSEO, Figure 16B.1). Per the 2009 Board of Fisheries (BOF) decision, subsistence DSR removals are deducted from the ABC prior to the allocation of the TAC to the commercial and sport fisheries. Since 2006, the BOF has allocated 84% of the EY/SEO DSR TAC to the commercial fishery and 16% to the sport fishery.

A timeline of management measures that have affected OR and DSR in the GOA are listed in the following table.

Year	Management Measures
1988	The NPFMC implements the slope rockfish assemblage, which includes the species that will become "other slope rockfish", together with Pacific ocean perch, northern rockfish, shortraker rockfish and rougheye rockfish. Previously, *Sebastes* in Alaska were managed as the "Pacific ocean perch complex" or "Other Rockfish".
1988	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.
1990/1992	Directed DSR fishery harvest card implemented for DSR fisheries in the EGOA; improves catch accounting.
1991	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	DSR complex fishery in EGOA allotted a separate halibut prohibited species catch (PSC)
1993	Northern rockfish is split as a separate management entity from "other slope rockfish".
1997	Area apportionment procedure for "other slope rockfish" is changed. Apportionment is now based on 4:6:9 weighting of biomass in the most recent three NMFS trawl surveys.
1998	NPFMC passed an amendment to require full retention of DSR in EGOA in federal waters.
1999	Trawling is prohibited in the Eastern Gulf east of 140° W. long. Eastern Gulf trawl closure becomes permanent with the implementation of FMP Amendments 41 and 58 in 2000 and 2001, respectively.
1999	Northern rockfish in the Eastern Gulf is reassigned to "other slope rockfish".
1999	Eastern Gulf is divided into West Yakutat and East Yakutat/Southeast Outside, and separate ABCs and TACs are assigned for "other slope rockfish" in these areas.
2005	Final rule for full retention of DSR in federal waters published for EGOA.
2006	Board of Fisheries allocated ABC for the EGOA 84% to the commercial fisheries, 16% to the recreational fisheries.
2007	Amendment 68 creates the Central Gulf Rockfish Pilot Program, which affects trawl catches of rockfish in this area.
2009	DSR Subsistence removals are deducted from the TAC prior to allocation of the ABC per the ADF&G Board of Fisheries
2012	Yellowtail and widow rockfish are assigned to the "other slope rockfish" group, and group name is changed to "Other Rockfish".

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 16B.4). In the following sections, we elaborate on the available information used to respond to specific factors and criterion for defining OR/DSR stock structure.

Harvest and trends

Fishing mortality

The OR and DSR complexes are Tier 4/5, thus a fishing mortality rate (F) is difficult to estimate. Directed fishing is not permitted for OR in the GOA, and the fish can only be retained as "incidentally-caught" species. It is estimated that most of OR catch is discarded, likely due to the undesirable small size of the predominant species (Clausen and Echave 2011). Discard mortality is assumed to be 100%, 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 (state-managed commercial and sport fisheries).

DSR are managed under Tier 4, however because DSR are particularly vulnerable to overfishing given their longevity, late maturation, and habitat-specific residency the assessment authors recommend a more conservative *F* value: $F=M=0.02$ (where *M* is natural mortality) as opposed to the traditional Tier 4 rate that would be estimated at $F_{40\%}=0.026$ (Green et al. 2014). Full retention regulations for the commercial fleet have been in place since 2005, and discards are estimated to be small, however discard mortality is likely 100%. Beginning in 2013, full retention of DSR had been required for the recreational fleet until the daily bag limit is reached. Since 2013, all charter operators in Southeast Alaska are required to possess and utilize deep-water release devices for releasing non-pelagic (i.e., DSR) rockfish once the daily bag limit is met. However, research into the survival of deep-water released rockfish is ongoing and it is not yet known what the survival rate is for the DSR species when released at depth.

Spatial concentration of fishery relative to abundance

The vast majority of the survey biomass for OR occurs in the EGOA, whereas much of the commercial catch occurs in the WGOA and CGOA (Figure 16B.4). There are two potential reasons: 1) the trawl survey may not sample the rockfish species well; and 2) trawl fishing is prohibited in the EGOA, thus effort is primarily in the WGOA and CGOA. To examine these differences, a series of maps were produced to compare survey abundance to fishery harvest for the primary OR species. The trawl survey provides the most complete spatial coverage compared to other surveys and weight estimates were available by haul, allowing for interpolated raster images of the trawl survey data from 1984 – 2013. The mean fishery catch (1991 – 2013) was overlaid on this raster image to compare the different patterns for the primary OR species (Figure 16B.10. – Figure 16B.15).

One example of the discontinuity between catch and abundance is harlequin rockfish (Figure 16B.10). While the estimated biomass based on the trawl survey for harlequin rockfish is substantially lower than other species in the OR complex, it is the primary species caught by fisheries. Harlequin rockfish are caught in 7% of survey hauls, on average, in the CGOA and 4% of hauls in the WGOA. Catch per haul is generally low (average of 26 kg, st. dev. = 148 kg), with 91% of the hauls being below that average. This is in stark comparison to the commercial catch, where harlequin rockfish catch is more broadly spread across the shelf and the shelf break with substantially larger mean catches. This pattern holds consistently for many OR species. One exception is yelloweye rockfish, a species typically associated with untrawlable habitat and primarily caught by hook and line gear, with its poor representation in the trawl survey the extent of the population abundance is poorly understood with relation to fishing harvest (Figure 16B.13.). Note that the data provided in Figure 16B.15. represents data available through the Alaska Regional Office and does not include the state managed fisheries which occur in the EY/SEO.

Fishery data may provide a better picture of where certain species are distributed, but many of these species are primarily caught on trawl gear, and they are more abundant in the EGOA where trawling is prohibited. The directed fishery for rockfish (e.g., Pacific ocean perch) in the WGOA and CGOA is responsible for the majority of the catch of OR. Thus the fishery data may provide some distribution information for the species farther west, in which untrawlable habitat may impact the survey catch.

The directed DSR commercial fishery in the EGOA is divided into four management areas. Survey densities are highest in EYKT (Figure 16B.4 and Figure 16B.9) probably due to habitat quality. The directed fishery quotas are established after the incidental bycatch of DSR from the Pacific halibut IFQ fishery is deducted from the TAC, by management area. However, the recreational and subsistence fishery is allocated for the EY/SEO as whole.

Population trends

The NMFS bottom trawl surveys have been conducted in the GOA since 1984 providing the longest time series of data. These surveys may not sample the OR species well and biomass estimates are imprecise. However, trend information may be inferred (Figure 16B.5 & Figure 16B.6). The abundance estimates are variable, but data do not suggest trends in population abundances. In the EY/SEO region

submersible/ROV survey density estimates for yelloweye rockfish show declining trends in most areas (Figure 16B.9).

Barriers and phenotypic characters

Generation time

Rockfish in the GOA are typically slow growing and long-lived. Estimates of mortality, age and size at maturity, and maximum age, for some of the OR and DSR species, are provided in Table 16B.3. The mortality rates are based on a variety of methods. Those that were calculated using the catch curve method are actually estimates of the total instantaneous mortality (Z) and should be considered as upper bounds for *M*. Mortality rate estimates range from as low as 0.01 for silvergray rockfish to a high of 0.157 for harlequin rockfish. We are able to use existing estimates of maturity and weight at age to estimate generation time for sharpchin rockfish (11.5 years) and yelloweye rockfish (71.7 years).

Physical limitations

General oceanic current patterns in 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 the OR/DSR complex species is poorly understood so interpreting physical limitations is difficult. With the exception of harlequin rockfish, abundance of the OR/DSR complex species is highest in the EGOA, decreasing drastically moving westward. What determines these abundances is unknown in regards to physical limitations. The waters off of Southeast Alaska are the northernmost range for many of these species, while their center of abundance is generally found off British Columbia and further south. Therefore, water temperature, among other oceanographic features, may be a major limiting factor as to why many of these species are only found in Southeast Alaska, and in only sparse numbers. It is believed that the Alaska Gyre significantly retains larvae in the GOA for of OR (Table 16B.3, Rocha-Olivares and Vetter 1999).

Strong year classes for many species of fish correlate with environmental conditions. Black et al. (2011) documented seasonal (winter and summer modes) upwelling as an index for predicting rockfish productivity. Increased yelloweye rockfish growth was associated with the winter upwelling mode but not summer upwelling in the California Current Ecosystem.

Availability of physical bottom habitat would impact yelloweye rockfish at many different stages of life. Both juveniles and adults are associated with high relief rock habitat, as well as corals and sponges (O'Connell and Carlile 1993). Bottom trawling is not a legal gear type in the EGOA so the effects of commercial fishing on the bottom habitat are minimal; although, there are some removals of coral and sponges from non-trawl gear that comes in contact with the bottom (e.g., hook and line, dingle bar gear.)

Growth differences

Evaluating growth differences by management area within the GOA for each of the species within the OR/DSR complexes is not possible due to the lack of data. Available growth parameters for several of these species come from more southern latitudes. The few species with growth data throughout their entire spatial range often present a latitudinal gradient. Length-weight coefficients and von Bertalanffy parameters for several species of the OR/DSR complexes are listed in Table 16B.5. All DSR are considered highly K-selective, exhibiting slow growth and extreme longevity (Adams 1980, Gunderson 1980, Archibald et al. 1981).

Age/size structure

The numbers of lengths sampled for OR in the GOA commercial fishery have been too small to yield meaningful data for the age/size structure. Few age samples for any of these species have been collected from the fishery, and none have been aged. What little is known of the age and size structure for OR comes from trawl survey data, and only for sharpchin, redstripe, harlequin, and silvergray rockfish. The

ages are all based on the break-and-burn technique of ageing otoliths. No age validation has been done for any of these species, so the results should be considered preliminary. There is not enough data to determine if differences in size or age compositions exist among the different regions in the GOA or in time apart from recruitment events, which are highly variable for rockfish species.

Survey ages are available from between one and four survey years for each of the species aged (Figure 16B.16). A large sampling effort was conducted in the 1996 survey, resulting in the greatest number of age samples. Other survey years generally had low sample sizes, with the exception of silvergray rockfish, which had meaningful sample sizes from 1993 – 1999 and harlequin rockfish, which were sampled in 2011. It is difficult to determine if strong cohorts progressed through the age structure based on available data. However, based on the 1996 survey ages, the 1981 – 1983 year classes appeared predominant in the age structures of redstripe, sharpchin, and silvergray rockfish and the 1986 year class was predominant for harlequin rockfish.

Population size compositions for the primary OR species are shown in Figure 16B.17. It is not possible to determine significant recruitment events from the size composition data, nor if there are any shifts in mean length over time. Rockfish grow slowly and thus the impact of a large recruitment event on the size composition could be dampened. The size composition data are limited in 2001, when the survey did not sample the EGOA, as demonstrated by the small sample size for some of the species that are caught primarily in that area.

Estimates of yelloweye rockfish size and age composition are derived from data collected through port sampling from the directed fishery and from incidental catch in the commercial Pacific halibut fisheries. These are sampled individually from each of the four management areas in EY/SEO. Species other than yelloweye rockfish in the DSR complex are not sampled. The commercial directed fisheries landing data show that most fish are captured between 450 and 650 mm (Figure 16B.18). Age composition of yelloweye rockfish captured in the directed commercial fishery is shown in Figure 16B.19.

Spawning time differences

All species of *Sebastes* are ovoviviparous, with internal fertilization, embryonic development, and hatching. After extrusion, larvae are pelagic, but larval studies are hindered because they can only be identified to species by genetic analysis. Therefore, recognizing differences in spawning times is not possible. Information regarding spawning timing is very limited for several of the species within the OR and DSR complexes, especially for fish in Alaska waters. Most of what is known comes from studies in more southern latitudes, and is summarized in Table 16B.3. Within the DSR complex, parturition occurs from February through September with the majority of species extruding larvae in spring. Yelloweye rockfish extrude larvae over an extended time period, with the peak period of parturition occurring in April and May in Southeast Alaska (O'Connell 1987). It is unknown if this spawning timing for yelloweye rockfish is consistent across the GOA.

Maturity-at age/length differences

Sufficient data for comparison of maturity at age or length among regions of the GOA or through time is not available. In addition, data from Alaska waters for several of the OR species are not available. Limited data is available for some of the species of DSR. Most of what is known comes from studies in more southern latitudes, and is summarized in Table 16B.3.

Morphometrics

Regional variation in morphometric measurements have not been studied for any of the species.

Meristics

Regional variation in meristics has not been studied for any of the species.

Behavior and movement

Spawning site fidelity

Whether the behavior displayed is for spawning purposes or not is unknown, but telemetric studies on quillback, vermilion, tiger, china, canary, copper, and yelloweye rockfish show high site fidelity (Matthews 1990a, 1990b; Tolimieri, et al. 2009; Hannah and Rankin 2011). Several observations suggest that many yellowtail rockfish inhabit the same general area for extensive periods and exhibit strong homing behavior (Carlson and Haight 1972). Off Southeast Alaska, one adult yellowtail returned to the site of capture from as far away as 22.5 km after being transported away from their home rock outcrop (Carlson et al. 1995).

Mark-recapture data

Very few tagging studies have been conducted on *Sebastes* species, mostly because of the difficulty in achieving high survival rates for fish tagged at depths greater than 100 m. Of the tagging studies conducted on shallow demersal (< 100 m) rockfish, little to no movement has been observed. Mark-recapture studies conducted on China (McElderry 1979), copper (Hartmann 1987), and yelloweye rockfish (O'Connell 1991) showed very little movement, all less than three km. More movement has been seen in bocaccio (Hartmann 1987, Starr et al. 2002), vermilion (Turner et al. 1969), and yellowtail rockfish (Carlson and Haight 1972, Pearcy 1992, and Stanley et al. 1994), with maximum recovery distances of 148, 10, and 1,400 km, respectively. However, several observations also suggest that many of these tagged fish inhabit the same general area for extensive periods and exhibit strong homing behavior (e.g., yellowtail rockfish, Carlson and Haight 1972).

Natural tags

No studies have addressed otolith microchemistry of any OR/DSR complex species 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 these species.

Genetics

No specific studies have been done to determine if any of the OR/DSR populations are one stock within the GOA, or if subpopulations occur. Because of the lack of genetic data analyses, evidence of genetic population structure or genetic variation within the GOA is unknown. Siegle et al. (2013) detected subtle population genetic structure in yelloweye rockfish from the outer British Columbia coast and inner waters, but a lack of genetic structure on the outer coast (between the Bowie Seamount and other coastal locations in British Columbia). These data suggest that due to the long pelagic larval duration for *Sebastes* spp. (several months to one year) there is not significant genetic stock structure for the DSR complex in the EY/SEO management area. However, additional life history data analyses at finer spatial scales are needed to evaluate DSR stock structure in the EY/SEO. Genetic studies on some of the more commercially caught species have shown genetic structure at relatively small scales, but without genetic studies there is little evidence for OR and DSR.

Isolation by distance

Not Available

Dispersal distance

Not Available

Pairwise genetic differences

Not Available

Summary, Implications, and Recommendations

We summarize the available information on stock structure for the OR/DSR complexes in the GOA in (Table 16B.6). Even with recent ABC overages in the WGOA and CGOA, harvest and trend data, where available, indicate OR population levels are stable and that fishing mortality in recent years is below maximum permissible *F*. For some of the OR species, fishery catch is distributed differently from the survey catch (Figure 16B.1 & Figure 16B.10 – Figure 16B.15), however, this is likely due to the inability of the trawl survey to accurately sample many of these species (e.g., preference for untrawlable habitat). Fishery and survey catch appear to be focused in smaller spatial areas, which have likely contributed to the phenomena of one or two hauls of large catch describing the overall abundance and distribution.

The ABC and OFLs for the DSR complex have not been exceeded since full retention went into effect, prior to that the discard mortality was unknown. Further, the authors' recommended harvest rate is lower than the maximum allowable under Tier 4. The submersible/ROV surveys likely sample the DSR species well, and survey abundances and distribution of yelloweye rockfish appear to be similar to fishery catch.

Typical of *Sebastes* species, species within the OR/DSR complexes are long-lived and have a long generation time. Little information is available regarding reproduction and mechanisms responsible for larval dispersion. Data do not exist to examine growth differences among regions in the GOA. The majority of the OR species tend to inhabit the EGOA. Only harlequin rockfish have greater abundance levels in the CGOA and WGOA. Behavior and movement information for most *Sebastes* species is lacking in the GOA, however, yellowtail rockfish appear to display some large-scale movement. No information is available regarding spawning movements or inter-annual movement. No genetic information is available to infer any genetic stock structure components that might exist. Site fidelity of species in the DSR complex in EGOA is assumed to be high, but not necessarily indicative of home range size.

The current management regime for the OR complex apportions the stock and catch into three large geographical regions. The DSR complex in EY/SEO is apportioned into four small geographical regions. Survey and fishery information indicates that abundance levels differ among the regions for both complexes. With the lack of available data on fine scale genetic population structure, it is difficult to determine if current management practices effectively protect these populations from disproportionate harvest in certain areas. Current management practices apportion ABC by management area but use a GOA–wide OFL for OR and the EY/SEO for DSR.

The ABC for the OR has been exceeded in the WGOA consistently since 2009. During this period harlequin rockfish was, on average, 77% of the OR catch in the WGOA. In 2012 the ABC was similarly exceeded (although by a substantially smaller margin) in the CGOA, and harlequin rockfish was 52% of the OR catch. Beginning in 2014, the ABCs for the WGOA and CGOA were combined, to reduce the likelihood of an overage. Because of the apparent habitat preferences for untrawlable areas, it is likely that the biomass used for computing the ABC is underestimated for harlequin rockfish and the catch of harlequin rockfish may not be a conservation concern (Jones et al. 2012). Due to the relatively small ABC and low market value, vessels targeting rockfish actively try to avoid catching OR and have voluntarily taken measures to attempt to reduce catch of all non-target rockfish species. Based on available data, it is unclear if the initiation of area-specific OFL's is recommended.

For both complexes, there are multiple levels of precaution built into the current management recommendations and overharvest is unlikely. There are few data available to differentiate stocks across regions for any of the 25 species in the two complexes. Rockfish are generally considered long-lived and slow growing. Little information on growth and reproduction is available for any of the complexes' rockfishes. What is available are insufficient for evaluating comparisons within the spatial extents of the complexes. Additionally, little genetic information is available to infer any genetic stock structure between or within areas. However, while data is limited, the life history characteristics suggest that the

current complex groupings are not appropriate for these species. A more appropriate grouping would put the seven demersal species, those species with longer life spans, the slowest growth rates, and which tend to be caught in longline fisheries, in one group and the remaining species, those with which grow faster, are more pelagic, and are primarily caught by trawl fisheries, into another group.

Research Priorities

Data limitations are severe for OR in the GOA, and it is extremely difficult to determine whether current management is appropriate with the limited information available. Gaps include imprecise biomass estimates, limited and unvalidated ageing, and lack of life history information. Regardless of future management decisions regarding the OR complex management category, improving biological sampling of OR in fisheries and surveys is essential. A more detailed picture of age, growth, and reproduction of OR would help determine if they are similar enough in life histories that they should be treated as one complex.

For DSR, there is a need for better estimation of rockfish habitat through more complete geophysical surveys and validation of the technique of using commercial fishery logbook data as a proxy for rock habitat in areas without geophysical surveys.

There is limited information on yelloweye rockfish fecundity, and it would be useful to conduct a fecundity study specific to Southeast Alaska. Little is known about the timing of yelloweye rockfish recruitment or post larval survival. A recruitment index for yelloweye rockfish would improve modeling estimates for total yelloweye rockfish biomass. Ageing methods for yelloweye rockfish need to be examined to allow for the construction of an improved age-error matrix.

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Tables

Table 16B.1. Species comprising the Other Rockfish (OR) management category in the Gulf of Alaska.

Common name	Scientific name	Former (pre-2012) Management Category
blackgill rockfish	*Sebastes melanostomus*	Other Slope Rockfish
bocaccio	*S. paucispinis*	Other Slope Rockfish
canary rockfish [a]	*S. pinniger*	Other Rockfish
Chilipepper	*S. goodei*	Other Slope Rockfish
China rockfish [a]	*S. nebulosus*	Other Rockfish
copper rockfish [a]	*S. caurinus*	Other Rockfish
darkblotched rockfish	*S. crameri*	Other Slope Rockfish
greenstriped rockfish	*S. elongates*	Other Slope Rockfish
harlequin rockfish	*S. variegatus*	Other Slope Rockfish
northern rockfish[b]	*S. polyspinis*	Other Slope Rockfish
pygmy rockfish	*S. wilsoni*	Other Slope Rockfish
quillback rockfish[a]	*S. maliger*	Other Rockfish
redbanded rockfish	*S. babcocki*	Other Slope Rockfish
redstripe rockfish	*S. proriger*	Other Slope Rockfish
rosethorn rockfish [a]	*S. helvomaculatus*	Other Rockfish
sharpchin rockfish	*S. zacentrus*	Other Slope Rockfish
silvergray rockfish	*S. brevispinis*	Other Slope Rockfish
splitnose rockfish	*S. diploproa*	Other Slope Rockfish
stripetail rockfish	*S. saxicola*	Other Slope Rockfish
tiger rockfish[a]	*S. nigrocinctus*	Other Rockfish
vermilion rockfish	*S. miniatus*	Other Slope Rockfish
widow rockfish	*S. entomelas*	Other Slope Rockfish
yelloweye rockfish[a]	*S. ruberrimus*	Other Rockfish
yellowmouth rockfish	*S. reedi*	Other Slope Rockfish
yellowtail rockfish	*S. flavidus*	Other Slope Rockfish

[a]Only in the WGOA, CGOA and W. Yakutat management areas, otherwise in the Demersal Shelf Rockfish assessment.

[b]Only in the W. Yakutat and Southeast management areas (i.e. EGOA), otherwise in the northern rockfish assessment.

Table 16B.2. A description of the distribution and habitat of each of the species within the Other Rockfish (OR) and the Demersal Shelf Rockfish (DSR) complexes.

Species	Distribution	Habitat
blackgill rockfish[1,2,3]	Distributed from Washington to central Baja California but are extremely rare off Washington and Oregon. Reports of Blackgill Rockfish in the GOA have not been verified but have been taken close to Alaska off northern British Columbia.	Found in deep water over soft bottom, rocky outcrops, and on seamounts at depths of 250 – 600 m.
bocaccio rockfish [2,4]	Found throughout the GOA, as far west as the Shumagin Islands, down the Pacific Coast to central Baja California.	Often found around reefs and seamounts and over soft bottoms, at depths of 20 – 475 m.
canary rockfish [2,4]	Distributed as far west as Shelikof Strait on the western side of Kodiak Island in the CGOA to northern Baja California. Very few documented specimens have been caught in the GOA, however, they inhabit untrawlable habitat and therefore may be more common in Alaska than currently thought.	Found in schools around reefs and over hard bottoms, at depths of 50 – 250 m.
chilipepper rockfish[4,5]	Range from Queen Charlotte Sound, British Columbia to Baja California. Only two specimens have been captured in the GOA: one on Pratt Seamount and one on Durgin Seamount.	Generally found around reefs and seamounts and over soft bottoms near surface to depths of 425 m.
China rockfish [2,4]	Found in the CGOA near the Kenai Peninsula through the EGOA and down the Pacific Coast to southern California. The westernmost occurrence of china rockfish was off Kodiak Island.	Found over reefs and in crevices, more often on open coasts than in inside waters, generally in waters less than 91 m.
copper rockfish [2,4]	Distributed from Kodiak Island in the CGOA throughout the EGOA and down the Pacific coast to central Baja California.	Known as one of the shallower rockfish, generally in less than 120 m of water close to the bottom in rocky areas.
darkblotched rockfish[2,4]	Range from the eastern Bering Sea and Aleutian Islands to southern California.	Found over soft bottom at depths of 100-400 m.
greenstriped rockfish[2,4]	Documented catch of greenstriped rockfish in the GOA has been rare, but their distribution is reported as far west as Kodiak Island and throughout the CGOA and EGOA, down the Pacific Coast to central Baja California.	Generally found over sandy bottoms inshore and offshore between depths of 100 to 250 m.
harlequin rockfish[4,6]	Distributed throughout the Aleutian Islands, GOA, south to the coast of Oregon. Harlequin rockfish is the one exception within the OR complex that is predominantly an Alaskan species widely distributed across the GOA.	Found over high relief substrata usually either on the bottom or within a few meters of the rocks. Anecdotal observations of fishermen and research scientists in Alaska suggest that they also are frequently found on relatively hard bottom. Most commonly found between depths of 100– 300 m.
northern rockfish [2,4]	Found throughout the Bering Sea, Aleutian Islands, and GOA to Graham Island, British Columbia. Most common west of PWS in the CGOA.	Found offshore over rocky bottom at depths of 100 – 300 m.
pygmy rockfish [2,4]	Range from the Kenai Peninsula in the CGOA down to southern California. Very few documented specimens in the GOA.	Usually found offshore, and over boulders and other high relief at depths of 30 – 275 m.

Species	Distribution	Habitat
quillback rockfish [2,4]	Generally distributed throughout the CGOA from the Kenai Peninsula throughout the EGOA. The westernmost occurrence of Quillback Rockfish was off Kodiak Island.	Found close to or on rocky bottom and reefs inshore in waters less than 145 m.
redbanded rockfish [2,4]	Distributed in the Bering Sea, Aleutian Islands, and the GOA, continuing down the Pacific Coast to southern California.	Found in offshore reefs, seamounts and smoother bottoms at depths of 150 – 400 m.
redstripe rockfish [2,4,6]	Found in the southeastern Bering Sea and Aleutian Islands throughout the GOA and down the Pacific Coast to southern California. Most abundant in southeast Alaska to central Oregon.	Found in schools over high relief, rocky bottoms at depths of 100 – 300 m. Anecdotal observations of fishermen and research scientists in Alaska suggest they are found on relatively hard bottom as well.
rosethorn rockfish [1,2,4,7]	Distributed from the WGOA east of Sitkinak Island through the GOA and down the Pacific Coast to Baja California. Are relatively rare west of Yakutat in the EGOA.	Found offshore around rocky reefs and seamounts at depths of 125 – 350 m. Rosethorn are strictly benthic fish, rarely seen over a meter off the bottom.
sharpchin rockfish [2,4,6]	Distributed throughout the Aleutian Islands and GOA to southern California. One of the most abundant OR species in Alaska waters. Recent surveys suggest they are extremely abundant from the GOA to central Oregon.	Anecdotal observations of fishermen and research scientists in Alaska suggest that they also are frequently found on relatively hard bottom. Are generally at depths of 100 – 350 m. This species is often associated with sponge and crinoids.
silvergray rockfish [8]	Distributed throughout the entire GOA down to central Baja California. As opposed to the majority of species within the OR complex, the center of abundance for silvergray rockfish based on recent trawl surveys now appears to be southeast Alaska and British Columbia.	The fish are almost never caught in mid-water and anecdotal reports suggest they are found on relatively hard bottom. During the summer, silvergray rockfish are most abundant on the outer continental shelf at depths 100 – 200 m, whereas in late winter they were concentrated deeper at depths 180 – 280 m.
splitnose rockfish [2,4]	Range from the WGOA off Sanak Islands to central Baja California. Very few verified specimens have been taken from Alaska waters, and those were off Sanak Island and Kachemak Bay. Most common off southern California.	Found in deep water offshore over soft, level bottoms, usually in waters less than 450 m.
stripetail rockfish [2,4]	Found from Yakutat Bay in the EGOA to central Baja. Very few specimens have been verified in Alaska waters, and those were off the outer coast of southeast Alaska and Yakutat Bay.	Found offshore on soft bottoms and around reefs, in depths of 100 – 350 m.
tiger rockfish [2,4]	Distributed from the CGOA near the Kenai Peninsula through the EGOA and down the Pacific Coast to southern California. The westernmost occurrence of the tiger rockfish was in Eider Point on Unalaska Island. They are most common from southeast Alaska to northern California.	Found around reefs and boulder fields, at depths of 55 – 274 m.
vermilion rockfish [2]	Found from Montague Island in the CGOA down to central Baja California. Very few specimens have been verified in Alaska waters. They are most abundant in northern California waters.	Found on rocky reefs and seamounts in waters less than 180 m.
widow rockfish [4]	Distributed from Kodiak Island in the CGOA down to central Baja California. This species	Generally found schooling on offshore reefs and seamounts. In contrast to most of the OR

Species	Distribution	Habitat
	has been well documented throughout this range, unlike many others within the OR complex.	species, widow rockfish are often distributed considerably off-bottom from the near surface to depths upwards of 800 m.
yelloweye rockfish[2]	Found throughout the Aleutian Islands and GOA down the Pacific coast to northern Baja California.	Found around rocky reefs and boulder fields at depths of 50 – 400 m.
yellowmouth rockfish [2]	Found in the EGOA down to northern California. There have been unconfirmed reports from the WGOA.	Found offshore over very rough bottoms, at depths of 140-365 m.
yellowtail rockfish [4,8,9,10]	Distributed from the Aleutian Islands throughout the GOA and down the Pacific Coast to southern California. This species has been well documented throughout the GOA, unlike many others within the OR complex.	In contrast to most of the OR species, yellowtail rockfish are often distributed considerably off-bottom; most abundant in depths 90 – 180 m over the continental shelf.

(1) Allen and Smith 1988; (2) Mecklenberg et al. 2002; (3) Workman et al. 1998; (4) Love et al. 2002; (5) Snytko 1986; (6) Clausen and Echave 2011; (7) Heyamoto and Hitz 1962; (8) Stanley and Kronlund 2005; (9) Wallace and Lai 2005; (10) Williams et al. 2000

Table 16B.3. A description of the life history of each of the species within the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) complexes along with mortality rates, maximum age, and female age and size at 50% maturity, where available. Size is fork length in cm. Area indicates location of study: California (CA), Oregon (O), British Columbia (BC), Gulf of Alaska (GOA), Eastern Gulf of Alaska (EGOA), and Washington (W). Mortality rates with no superscript have unknown methodology for their calculations.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References	Life History
blackgill rockfish		87			CA	1	Larvae are extruded in winter. Most juveniles settle to the bottom by summer (after 3 – 4 months) at depths greater than 185 m, but sometimes after 7 months.
bocaccio rockfish	0.06	> 40		54	O, CA	2, 3	Larvae are extruded in winter. Late larval and pelagic juvenile bocaccio are found close to the surface and may be distributed over a wide area extending several hundred miles offshore, but generally settle to the bottom after 3.5 months.
canary rockfish	0.05	84		51	BC	2, 3	Fertilization primarily occurs in December, and larvae are released from February to March in Alaska. Larvae and pelagic juvenile Canaries occur in the upper 100 m of the water column for up to 3-4 months before descending to the benthic habitat. Juveniles move from shallow habitat to deeper adult habitat toward the end of summer.
chilipepper rockfish		35			CA	2	Chilipeppers mate in September and release larvae from November to June, peaking in January-February. Juveniles remain pelagic for 3.5 – 5.5 months. Adults tend to be midwater.
China rockfish		79			GOA, EGOA	2, 4	Larvae are released from April to August in Alaska, peaking in May. Juveniles in Southeast Alaska live in shallow subtidal water during the summer and early fall.
copper rockfish		61				2, 15	Larval release occurs in March-May in Alaska waters. Coppers lack an extensive pelagic juvenile stage. Young fish first settle around large algae and eelgrass, moving out of the mid-surface waters to the bottom within a few months.
darkblotched rockfish	0.07[a]	48 105		39	BC	2, 5	Off of British Columbia, darkblotched rockfish mate from August to December; fertilization of eggs occurs from October through March, and larvae are released from November to June. After settling to the bottom at a length of 3 cm, darkblotched rockfish move to deeper water as they mature.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References	Life History
greenstriped rockfish	0.07	54		22		2	Larvae are released after June in British Columbia. After settling to the bottom at a length of 3 cm, greenstripes move to deeper water as they mature.
harlequin rockfish	0.127-0.157[b]	43			BC	2, 6, 7, 8	No other knowledge of life history.
		34			GOA		
	0.092[b]	47		23	EGOA		
northern rockfish	0.08	57	13	36	GOA	2, 9	Females likely release larvae in the spring when they are in relatively deep water. Juveniles tend to live more inshore than adults.
pygmy rockfish	0.06	26				2	Females likely release larvae form July to October. Older larvae and pelagic juveniles are found deeper than many OR species. In California waters, young of the year are observed on rocks in 44 – 200 m of water.
quillback rockfish	0.06	95	11	29	BC, GOA	2, 3, 10, 16	Parturition in Southeast Alaska occurs in the spring. Young of the year quillback are found from July to November on shallow rocks. Juveniles inhabit nearshore benthic habitats.
redbanded rockfish	0.06	106	19	42	BC	2, 3, 4	Larval release occurs from March to September in Southeast Alaska. Reports have found there to be considerable geographic variation in the estimates of size at first maturity.
redstripe rockfish	0.1[a]	41		29	BC	2, 3, 5, 6, 7, 15	Off southeast Alaska, female redstripes release larvae from April to July.
		55			BC		
		55			GOA		
rosethorn rockfish	0.06	87		21.5		2, 3	Larvae are extruded in February to September, with an April-June peak.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References	Life History
sharpchin rockfish	0.05[a]	46			BC	2, 5, 8, 9	Larval release off British Columbia occurs primarily in July. Smaller fish are generally found in shallower water than larger individuals.
	0.056-0.059[b]	58	10	26.5	GOA		
silvergray rockfish	0.01-0.07[a]	80			BC	2, 4, 5, 7, 8, 11, 12	Larvae extrusion has been reported based on a small number of samples in southeast Alaska.
	0.041-0.057[b]	75		34-45	GOA		
		82	9	34-45	BC		
	0.06[c]				BC		
splitnose rockfish	0.06	86		27	BC	2	Larval release off British Columbia could occur during two time periods: July and October-December. Young juveniles live at the surface for several months, followed by a transitory midwater residence before settling to benthic habitats near the end of their first year of life.
stripetail rockfish		38			CA	2	Ripe females have been observed off Oregon in February. Off Central California, juveniles settle to nearshore benthic habitats from April to October. Stripetails gradually move to deeper water as they mature.
tiger rockfish		116			EGOA	2, 3, 5	They are generally a solitary species, coming out during twilight hours and during the darkest of winter days. Larval release occurs from February to June in southeast Alaska, peaking in April to May. Aggregations of tiger rockfish have been observed off southeast Alaska, and strong winter storms will drive tiger rockfish from shallow to deeper depths in this region.
vermilion rockfish		60			CA	2	Larval release occurs in September, December, and April-June off northern California. In nearshore water, young of the year settle out of the plankton in two recruitment pulses, one from February to April and another from August to October. Juveniles gradually move into slightly deeper water after about two months.
widow rockfish	0.05[a]	59			BC	2, 7	Larval release occurs from January to April off British Columbia. Pelagic juveniles may remain in the plankton for as long as 5 months, recruiting to nearshore areas with kelp and other algae.
yelloweye rockfish	0.02	118	22	45	EGOA	2, 13	In southeast Alaska, larval release occurs primarily between February and September, with a peak between April and July.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References	Life History
yellowmouth rockfish	0.06[a]	71 99		38	BC	3, 5, 7	No other knowledge of life history.
yellowtail rockfish	0.07	64			BC	2, 14	Larval release occurs in January-April in British Columbia waters. Juveniles remain pelagic for approximately 3.5 months. As they grow, juveniles ascend in the water column. Yellowtail migrate to deeper waters as they mature, however, adults have occasionally been found in kelp beds.

(1)Helser 2005; (2) Love et al. 2002; (3) Munk 2001; (4) O'Connell 1987; (5) Archibald et al. 1981; (6) Clausen and Echave 2011; (7) Chilton and Beamish 1982; (8) Malecha et al. 2007; (9) Heifetz et al. 1998; (10) Kerr et al. 2003; (11) Stanley and Kronlund 2005; (12) Stanley and Kronlund 2000; 13) O'Connell and Funk 1987; 14) Leaman and Nagtegaal 1987; 15) Meyer and Failor in prep.; 16) Rodgveller et al. 2011

Mortality rate methods
[a]: Total mortality (Z) as computed by catch curve analysis
[b]: Natural mortality (M) as computed by a combination of the Alverson and Carney (1975) and Hoenig (1983) methods
[c]: Natural mortality (M) as computed by the Hoenig (1983) method

Table 16B.4. 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 16B.5. Von Bertalanffy parameters and length-weight coefficients for the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) species, where available, by area and sex. GOA = Gulf of Alaska; OUT = Pacific waters other than Alaska. Length-weight coefficients are from the formula $W = aL^b$ where W = weight in kg and L = length in cm.

Species	Area	Sex	t_0	K	L_{inf} (cm)	a	b	Reference
blackgill	OUT	combined				0.0122	3.04	1
	OUT	male	-2.98	0.06	46.71			2
	OUT	female	-4.66	0.04	55.39			2
bocaccio	OUT	male				0.0081	3.06	1
	OUT	female				0.0162	2.88	1
canary	OUT	combined				0.0504	2.66	3
chilipepper	OUT	combined				0.0076	3.12	1
	OUT	male	-1.28	0.28	39			4
	OUT	female	-1.04	0.2	52			4
China	OUT	combined				0.0548	2.72	5
copper	OUT	combined	-3.7	0.1	45.6	0.0334	2.82	6
darkblotched	OUT	combined				0.0147	3.04	7
	OUT	male	-0.59	0.21	37.36			8
	OUT	female	-1	0.16	41.78			8
greenblotched	OUT	male	-2.1	0.06	56.11			1
	OUT	female	-2.47	0.05	57.99			1
greenstriped	OUT	combined				0.0079	3.13	1
	OUT	male	-2.73	0.12	29.65			1
	OUT	female	-2.36	0.1	37.26			1
harlequin	GOA	combined	-1.7	0.141	30.66	6.11×10^{-6}	3.24	9
	GOA	male	-1.27	0.164	29.02	8.96×10^{-6}	3.13	9
	GOA	female	-1.58	0.137	31.53	5.96×10^{-6}	3.24	9
quillback	OUT	combined				0.0255	2.93	10
	OUT	male	-5.5	0.09	39.5			11
	OUT	female	-6.8	0.07	41.8			11
redbanded	OUT	combined				0.0206	2.94	10
redstripe	GOA	combined				1.00×10^{-5}	3.07	9
	GOA	males				1.07×10^{-5}	3.07	9
	GOA	females				9.97×10^{-6}	3.07	9
rosethorn	OUT	male	-2.07	0.11	27.93	0.0045	3.3	12
	OUT	female	-2.77	0.1	28.66	0.0066	3.22	12
sharpchin	GOA	combined	-0.81	0.131	32.64	1.13×10^{-5}	3.07	9, 13
	GOA	male	-0.48	0.167	28.44	8.89×10^{-6}	3.15	9, 13
	GOA	female	-0.75	0.122	35.02	1.19×10^{-5}	3.06	9, 13
silvergray	GOA	combined	-1.68[a]	0.1	59.8	7.26×10^{-6}	3.15	9, 13
	GOA	male	-1.68[a]	0.11	57.14	7.34×10^{-6}	3.14	9, 13

Species	Area	Sex	t_0	K	L_{inf} (cm)	a	b	Reference
	GOA	female	-1.68[a]	0.093	62.25	9.97×10^{-6}	3.07	9, 13
splitnose	OUT	combined				0.0195	2.93	3
	OUT	male	-2.01	0.16	29.9			14
	OUT	female	-4.45	0.1	34.1			14
tiger	OUT	combined				0.009	3.21	10
vermillion	OUT	combined				0.0216	2.92	1
widow	OUT	combined				0.0164	2.94	1
	North of 43° Lat	male	-2.81	0.18	44			15
	North of 43° Lat	female	-2.68	0.14	50.54			15
yelloweye	GOA	combined				0.0074	3.22	16
	GOA	male	-5.44	0.05	64.4			17
	GOA	female	-11.65	0.04	65.93			17
yellowmouth	OUT	combined				0.0187	2.97	18
	OUT	male	-1.09	0.22	45.18			18
	OUT	female	-2.14	0.25	46.36			18
yellowtail	OUT	male	-1.69	0.19	47.57	0.0287	2.82	1, 19
	OUT	female	-0.75	0.17	52.21	0.0359	2.75	1, 19

1) Love et al. 1990; 2) Butler et al. 1998; 3) Wilkins et al. 1998; 4) Ralston et al. 1998; 5) Wildermuth 1983; 6) James E. West (unpublished data via Love et al. 2002); 7) Nichol 1990; 8) Rogers et al. 2000; 9) Clausen and Echave 2011; 10) Love et al. 2002; 11) L. Yamanaka (unpublished data via Love et al. 2002); 12) Shaw 1999; 13) Malecha et al. 2007; 14) Wilson and Boehlert 1990; 15) Williams et al. 2000; 16) Rosenthal et al. 1982; 17) O'Connell et al. 1998; 18) Workman et al. 1998; 19) Tagart et al. 2000

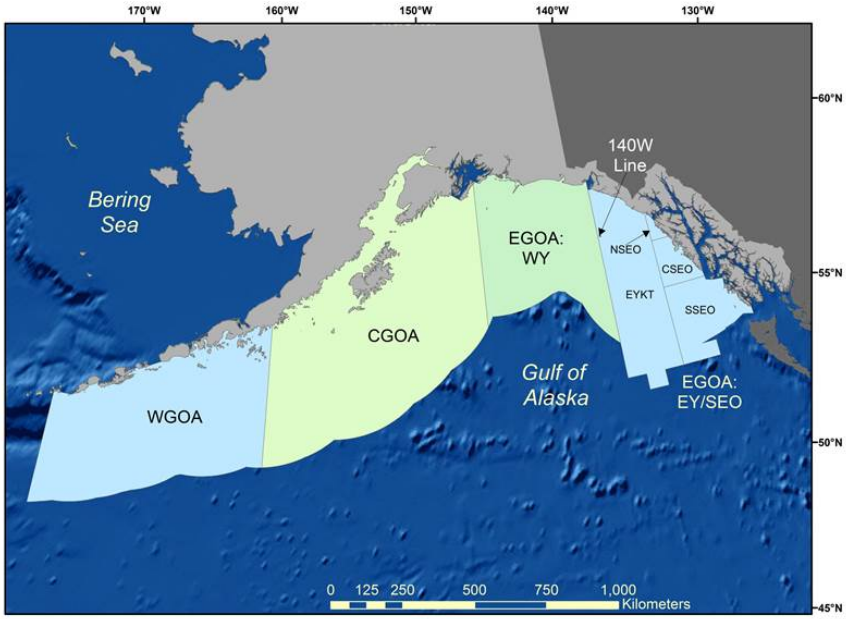
[a]t_0 for Silvergray Rockfish could not be accurately estimated from the data; therefore t_0 was constrained at the average value for all OR species.

Table 16B.6. Summary of available data on stock structure evaluation of GOA Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) complexes. 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})	Based on the ABCs estimated from the three most recent trawl surveys for the OR species with reliable trawl survey biomass: Full complex = 24%, harlequin = 195%, widow = 142%, darkblotched = 45%, redbanded = 30% and all the rest are <20%. yelloweye rockfish in EY/SEO (DSR only) = 50%
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	Fishing appears to be distributed differently than survey abundance and distribution for many of the OR and DSR species. Overall, biomass is greatest in the Eastern GOA, but the fishery catch is concentrated in the Western GOA. In the Western GOA the catch has been on average 19% of exploitable biomass since 2011, 3% in the Central GOA and < 1% in the Eastern GOA.
Population trends (Different areas show different trend directions)	Overall population trend is relatively stable or increasing. No major differences within regions. Changes in biomass by region due to high variability of survey. Yelloweye sub/ROV surveys suggest a possible decline, but data is sporadic.
Barriers and phenotypic characters	
Generation time (e.g., >10 years)	sharpchin = 11.5 yrs, yelloweye = 71.7 yrs, all other likely long (> 10 yrs)
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)	Unknown if major differences exist among regions in the GOA.
Age/size-structure (Significantly different size/age compositions)	Age and size structures driven by major recruitment events. Unknown if major differences exist among regions in the GOA.
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 if related to spawning, but limited tagging (both via telemetry and conventional tags) suggest high site fidelity (quillback, vermillion, tiger, China, canary, copper, yelloweye and yellowtail),
Mark-recapture data (Tagging data may show limited movement)	Limited mark-recapture data shows minimal movement, with some large distances upwards of 1,400 km in yellowtail. However, that species has also been shown to have a fairly strong homing behavior with extended use of specific areas.
Natural tags (Acquired tags may show movement smaller than management areas)	Unknown
Genetics	
Isolation by distance (Significant regression)	Unknown
Dispersal distance (<<Management areas)	Unknown

Pairwise genetic differences (Significant differences between geographically distinct collections)	Unknown

Figures



Other Rockfish			Demersal Shelf Rockfish
WGOA & CGOA	EGOA:WY	EGOA:EY/SEO	EGOA:EY/SEO
Blackgill Rockfish	Blackgill Rockfish	Blackgill Rockfish	
Bocaccio	Bocaccio	Bocaccio	
Canary Rockfish	Canary Rockfish		Canary Rockfish
Chilipepper Rockfish	Chilipepper Rockfish	Chilipepper Rockfish	
China Rockfish	China Rockfish		China Rockfish
Copper Rockfish	Copper Rockfish		Copper Rockfish
Darkblotched Rockfish	Darkblotched Rockfish	Darkblotched Rockfish	
Greenstriped Rockfish	Greenstriped Rockfish	Greenstriped Rockfish	
Harlequin Rockfish	Harlequin Rockfish	Harlequin Rockfish	
	Northern Rockfish	Northern Rockfish	
Pygmy Rockfish	Pygmy Rockfish	Pygmy Rockfish	
Quillback Rockfish	Quillback Rockfish		Quillback Rockfish
Redbanded Rockfish	Redbanded Rockfish	Redbanded Rockfish	
Redstripe Rockfish	Redstripe Rockfish	Redstripe Rockfish	
Rosethorn Rockfish	Rosethorn Rockfish		Rosethorn Rockfish
Sharpchin Rockfish	Sharpchin Rockfish	Sharpchin Rockfish	
Silvergray Rockfish	Silvergray Rockfish	Silvergray Rockfish	
Splitnose Rockfish	Splitnose Rockfish	Splitnose Rockfish	
Stripetail Rockfish	Stripetail Rockfish	Stripetail Rockfish	
Tiger Rockfish	Tiger Rockfish		Tiger Rockfish
Vermilion Rockfish	Vermilion Rockfish	Vermilion Rockfish	
Widow Rockfish	Widow Rockfish	Widow Rockfish	
Yelloweye Rockfish	Yelloweye Rockfish		Yelloweye Rockfish
Yellowmouth Rockfish	Yellowmouth Rockfish	Yellowmouth Rockfish	
Yellowtail Rockfish	Yellowtail Rockfish	Yellowtail Rockfish	

Figure 16B.1. Map of the Gulf of Alaska (GOA) management areas: Western (WGOA), Central (CGOA) and Eastern (EGOA) with the species of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) included for each area. The EGOA is subdivided into the West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO) areas. The EY/SEO is subdivided for the DSR complex into East Yakutat (EYKT), Northern, Central and Southern Southeast Outside (NSEO, CSEO, and SSEO, respectively). The table below the figure lists the species that are part of the each complex in each of the areas.

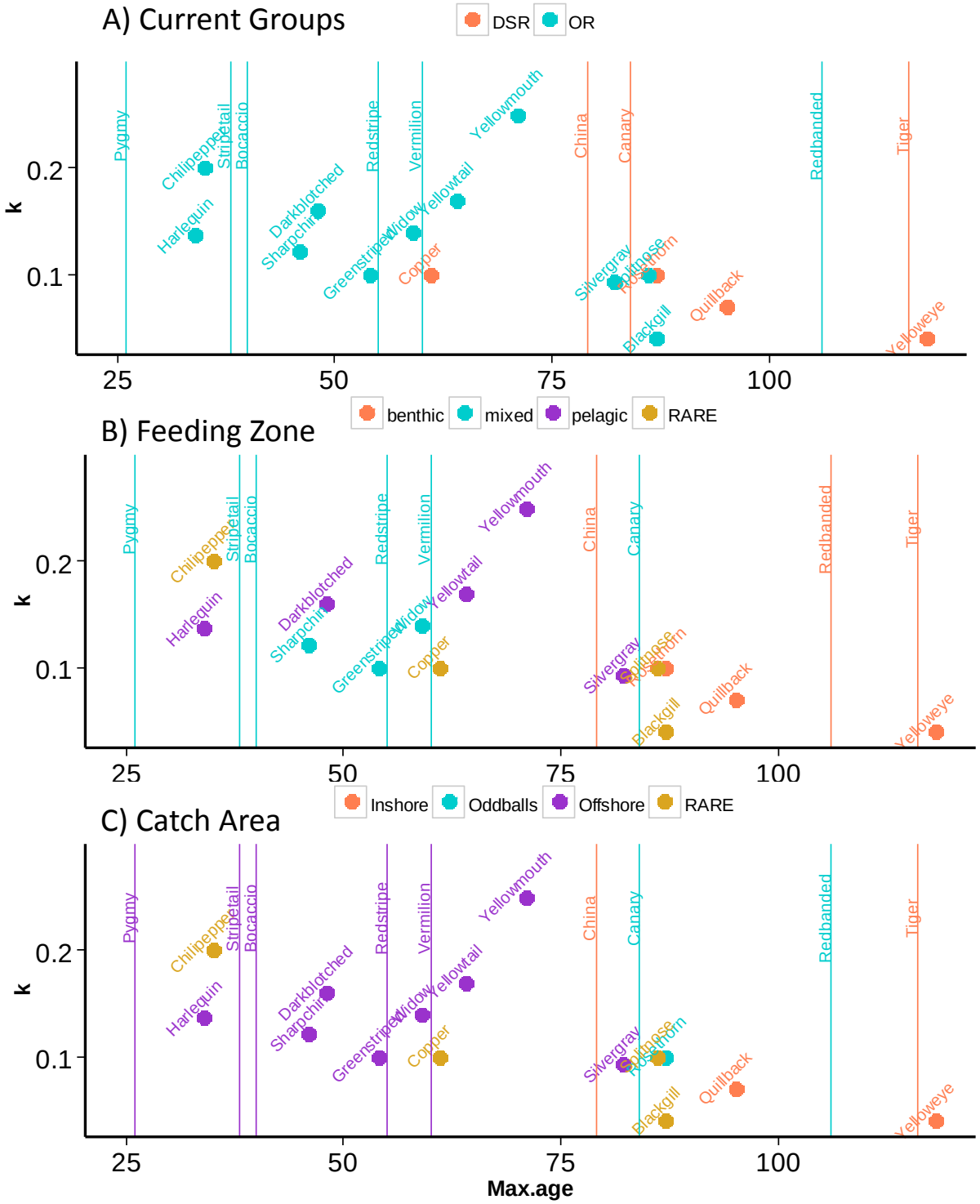


Figure.16B.2. Life history comparison of the species of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) complexes, categorized by: A) current complex groupings; B) primary feeding zone; and C) area of primary catch.

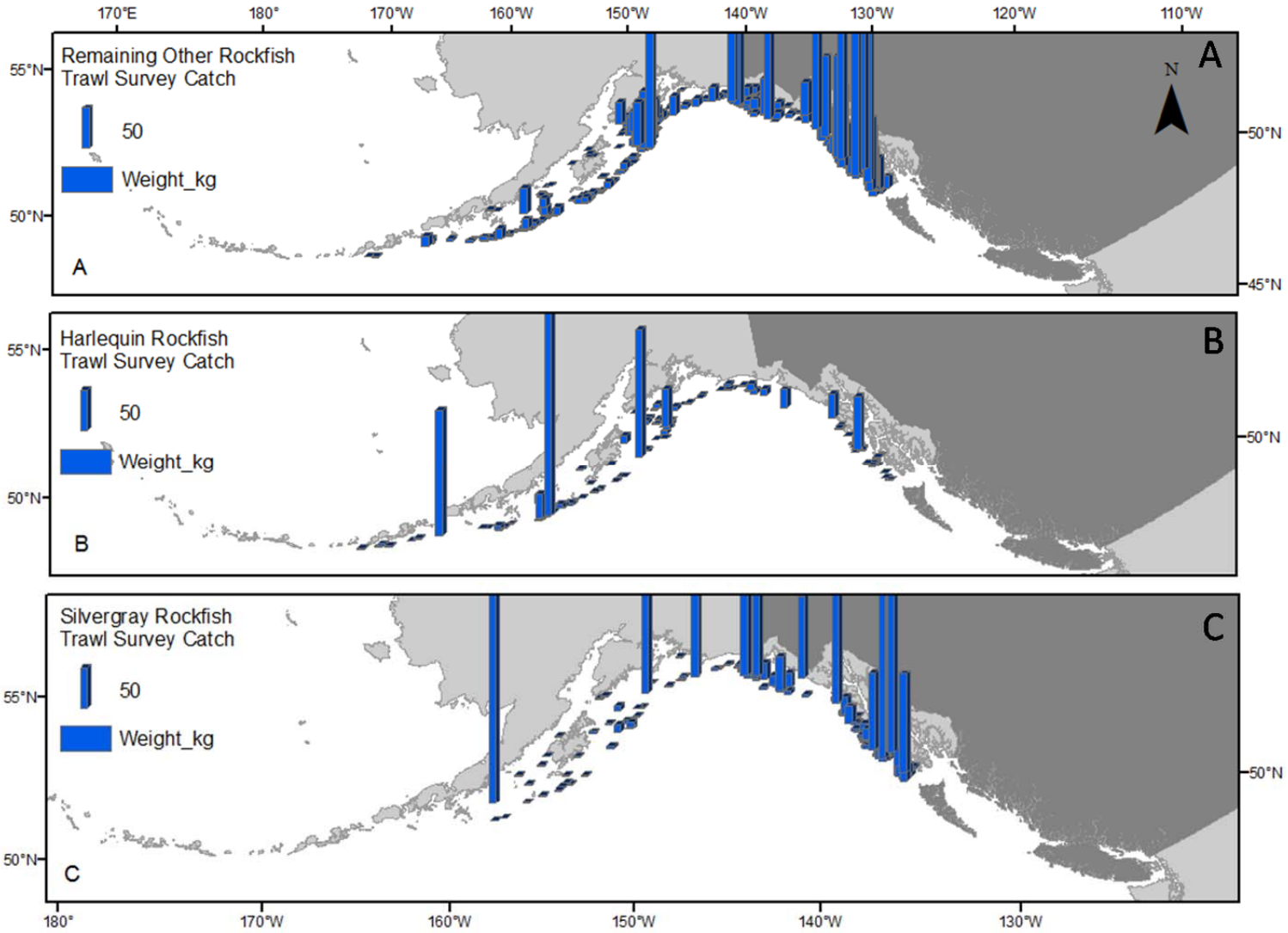


Figure 16B.3. Spatial distribution of survey catch in the Gulf of Alaska (GOA) from the three most recent National Marine Fisheries Service (NMFS) trawl surveys (2009, 2011, and 2013) for: (A) the Other Rockfish (OR) complex (with the exception of Harlequin and Silvergray Rockfish); (B) Harlequin Rockfish; and (C) Silvergray Rockfish.

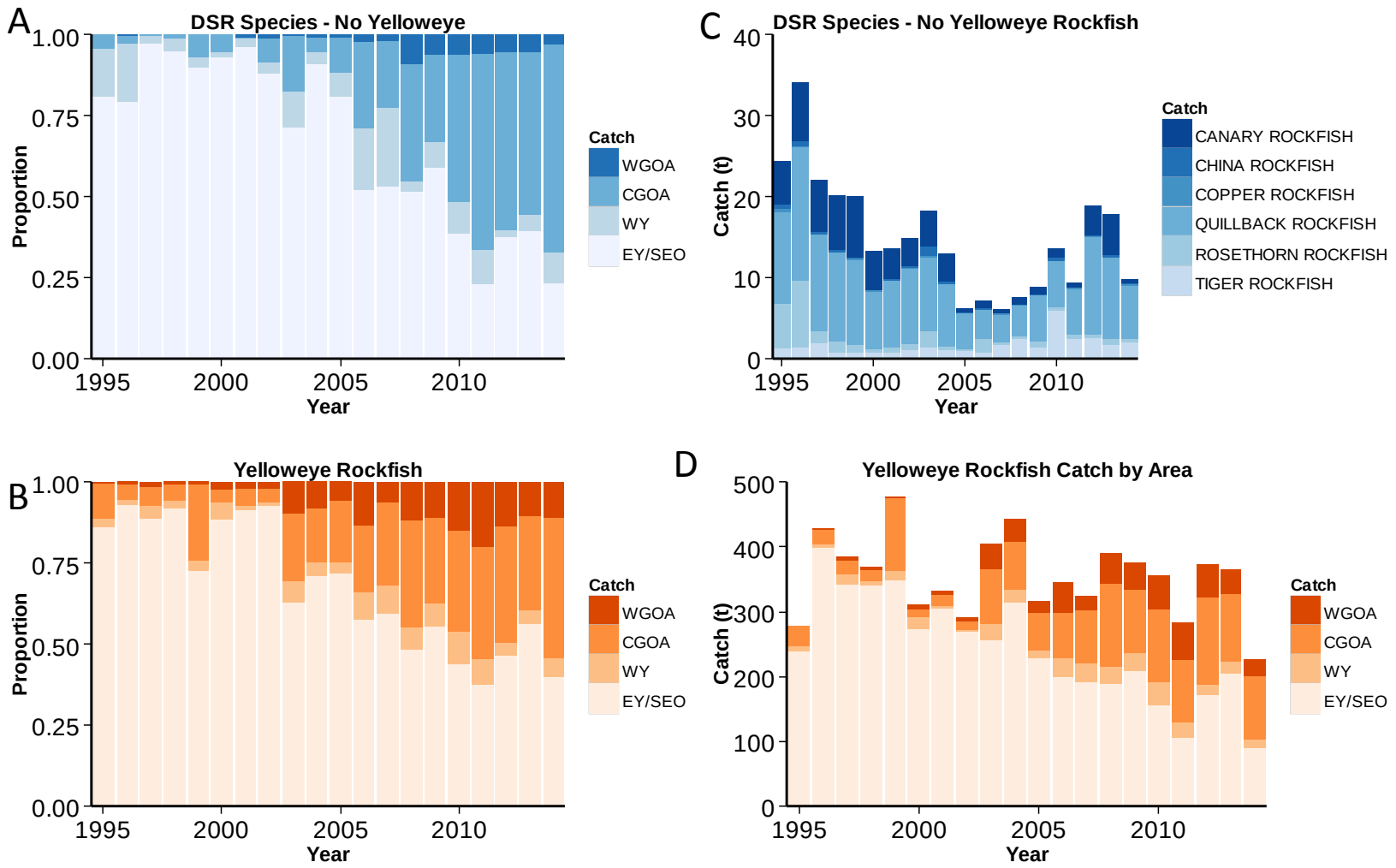


Figure 16B.4. Proportion of catch by region for (A) Other Rockfish (OR) by Western, Central and Eastern Gulf of Alaska (GOA) regions and (B) Yelloweye Rockfish catch by the Central Southeast Outside (CSEO), Southern Southeast Outside (SSEO) and East Yakutat (EYKT) sub regions (C) Proportion of biomass for the OR by Western, Central and Eastern GOA and (D) proportion of Yelloweye Rockfish density by CSEO, SSEO and EYKT.

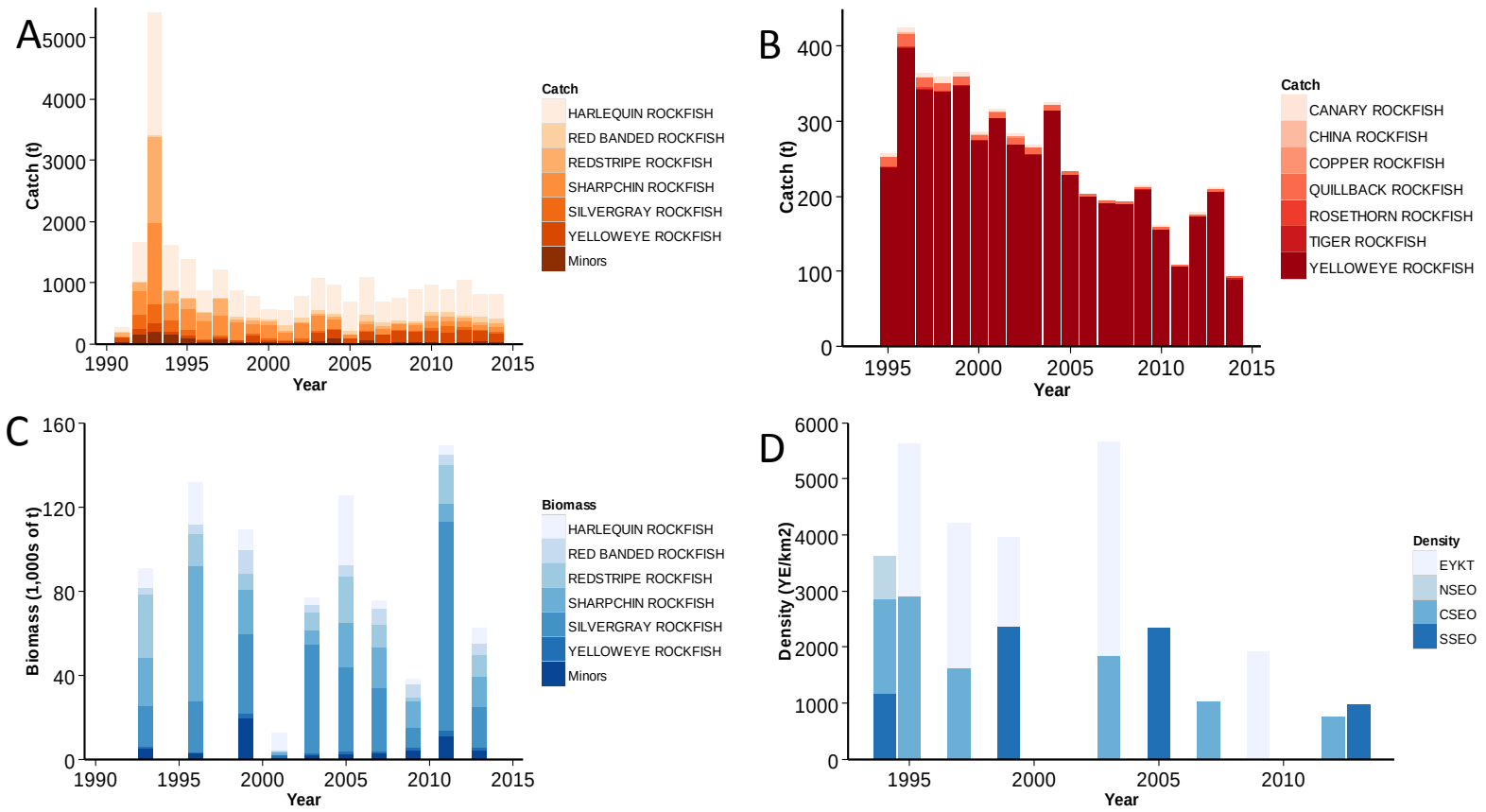


Figure 16B.5. Catch (t) of the (A) Other Rockfish (OR) complex, six primary species and all other species grouped as "minors"; and (B) Demersal Shelf Rockfish (DSR) complex. Data displayed are from the time series in which estimates of catch by species are available, and are not the same time frame for both complexes. Note that catch estimates of OR may be impacted by the observer restructuring which occurred in 2013 and the catch estimate of DSR are impacted by the 2005 regulation requiring retention. (C) The estimated biomass (1,000s of tons, t) of OR from the National Marine Fisheries Service (NMFS) biennial trawl survey; and (D) density estimates for Yelloweye Rockfish based on the Alaska Department of Fish and Game (ADF&G) submersible and ROV surveys.

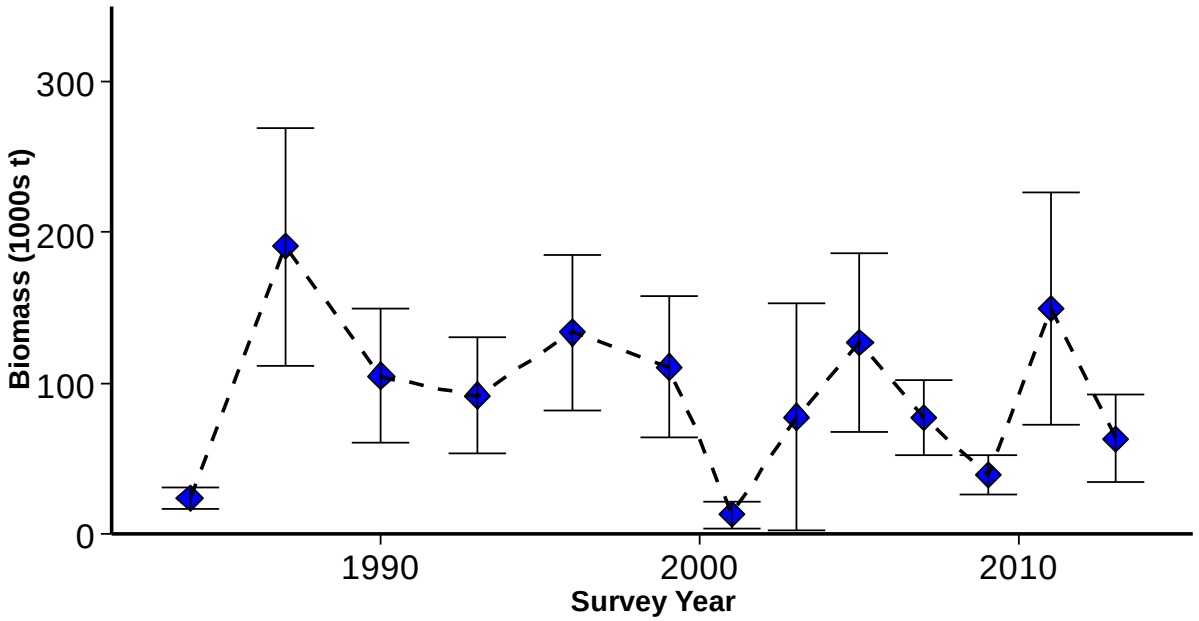


Figure 16B.6. Biomass (in 1,000s of tons, t) of the Other Rockfish (OR) complex with 95% confidence intervals. The survey biomass from the 2001 survey is not shown because that survey did not include the eastern Gulf of Alaska, the region with the greatest biomass of OR.

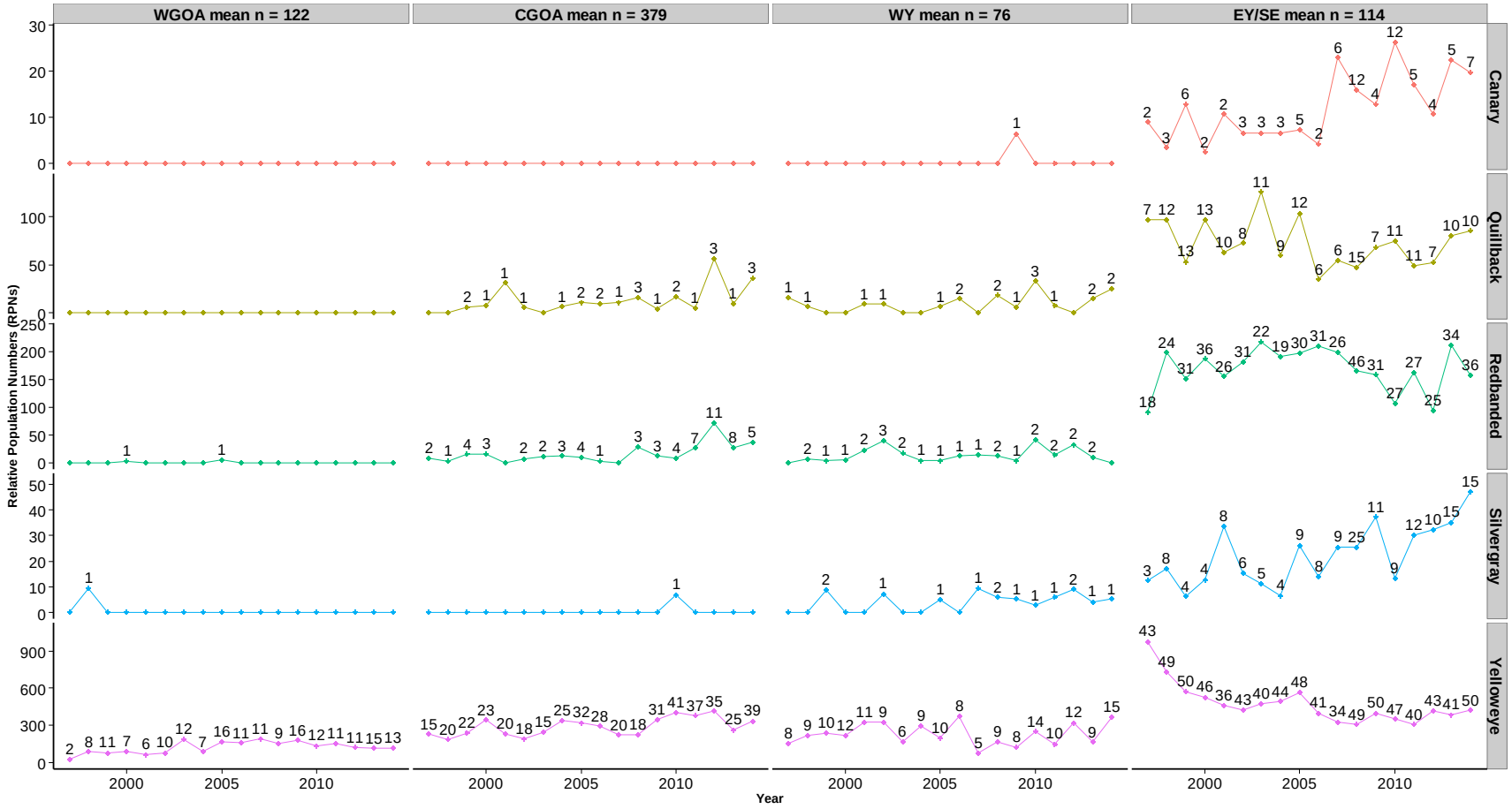


Figure 16B.7. Relative Population Numbers (RPNs) from the International Pacific Halibut Commission (IPHC) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA), West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO). The mean numbers of stations in each area are along the top of the figure. The numbers above the points are the number of stations that species was captured that year.

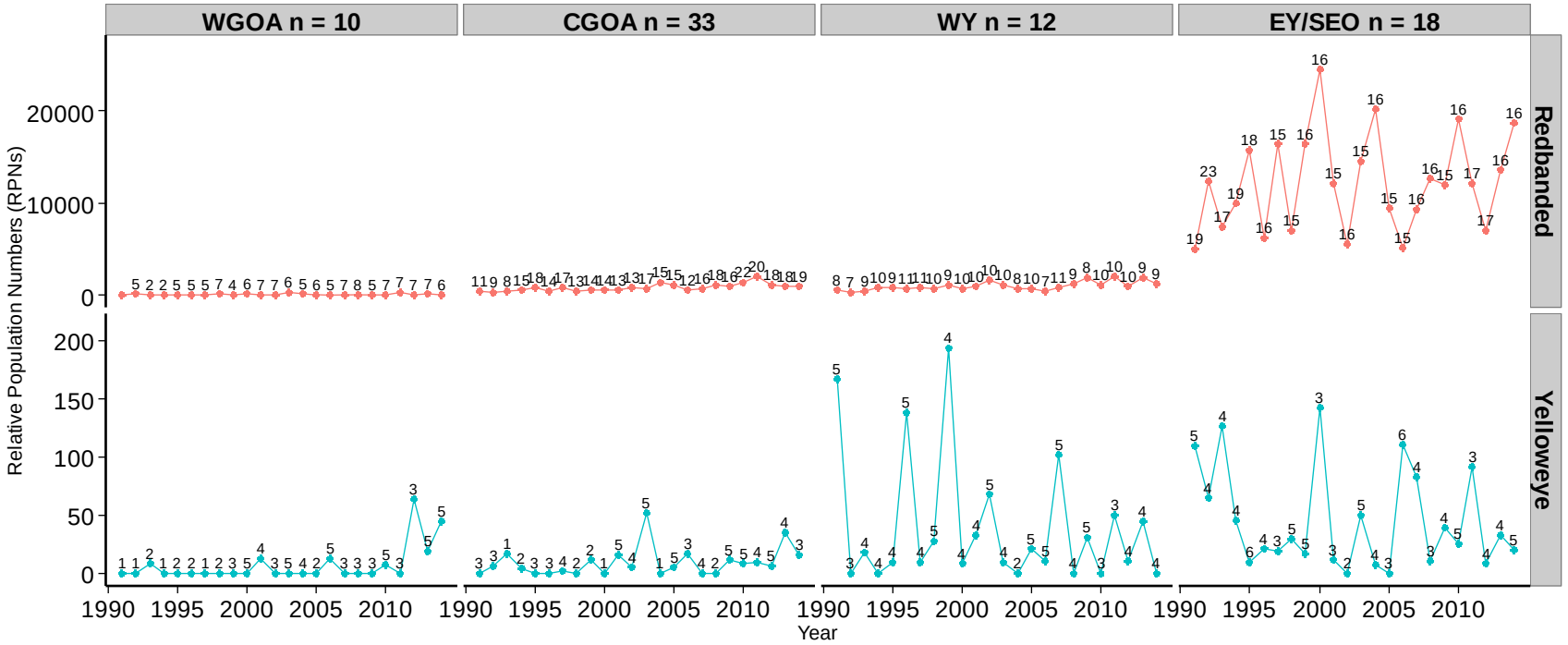


Figure 16B.8. Relative Population Numbers (RPNs) from the National Marine Fisheries Service (NMFS) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA), West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO). The numbers of stations that occur in each area annually are along the top of the figure. The numbers above the points are the numbers of stations that species was captured that year.

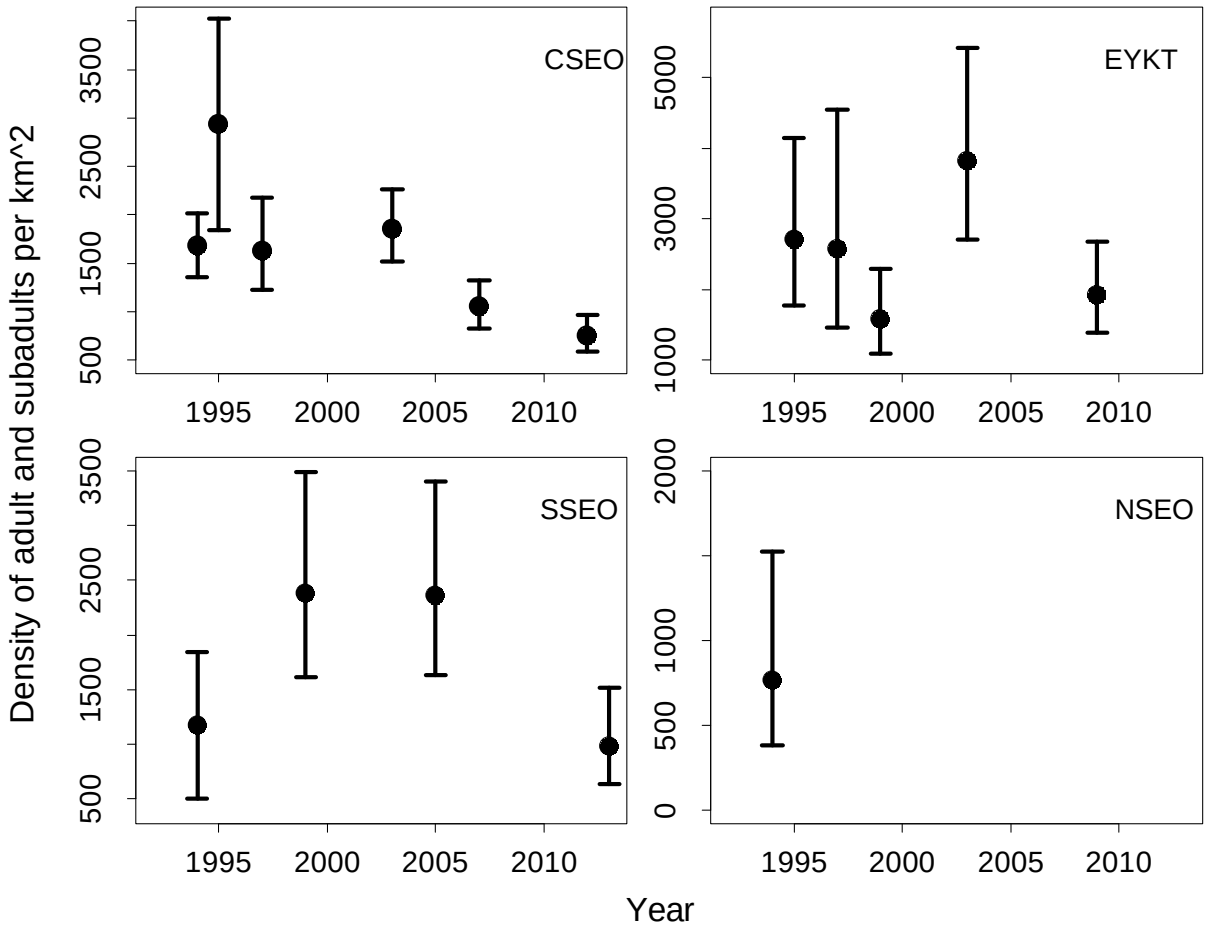


Figure 16B.9. Density (adults and sub-adults per square kilometer) and confidence interval (+/- two standard deviations) of yelloweye rockfish predicted using underwater observations and DISTANCE statistical software in each management area (East Yakutat (EYKT), Central Southeast Outside (CSEO), Northern Southeast Outside (NSEO), and Southern Southeast Outside (SSEO)).

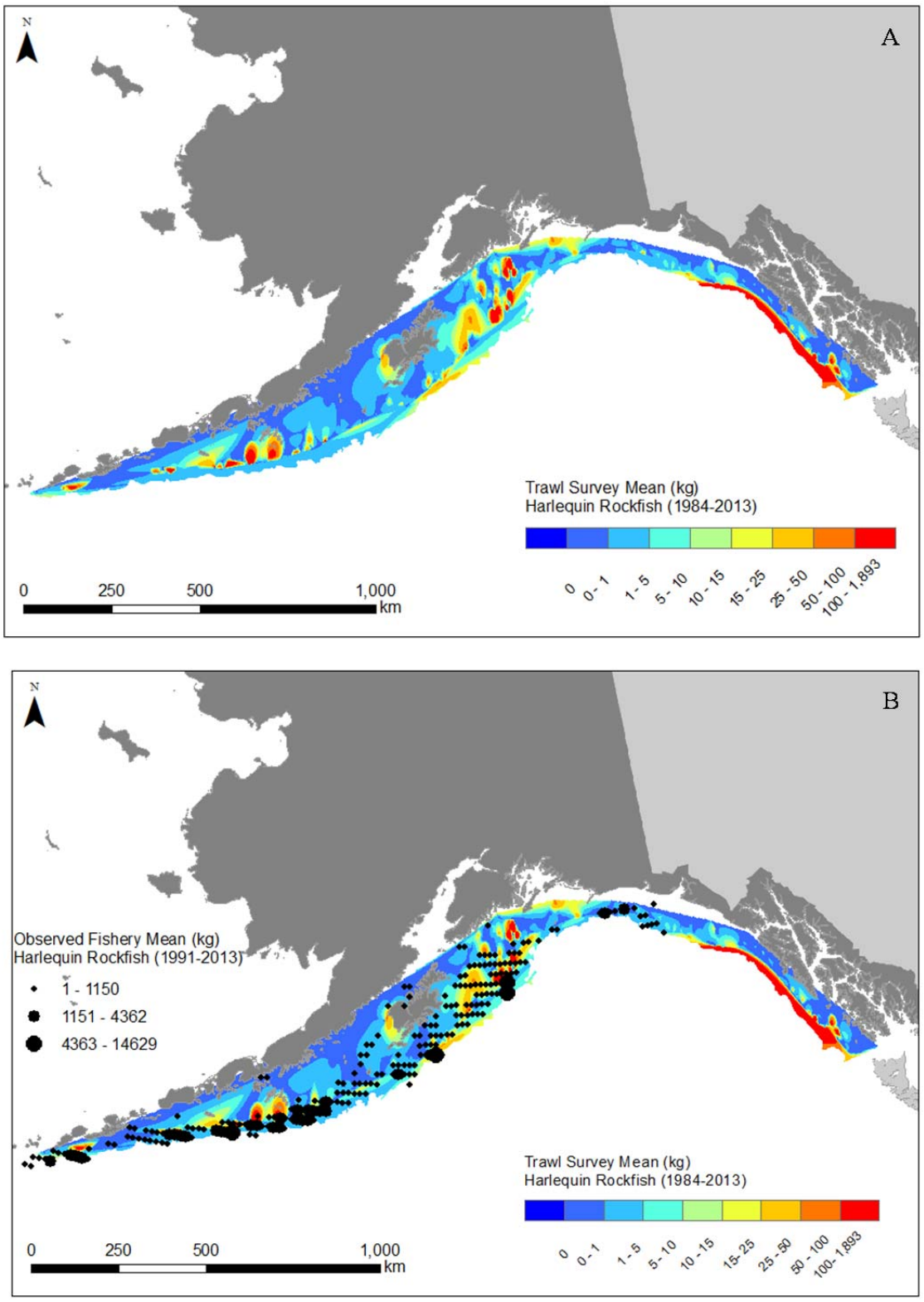


Figure 16B.10. Distribution maps of harlequin rockfish. (A) trawl survey mean kilogram per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

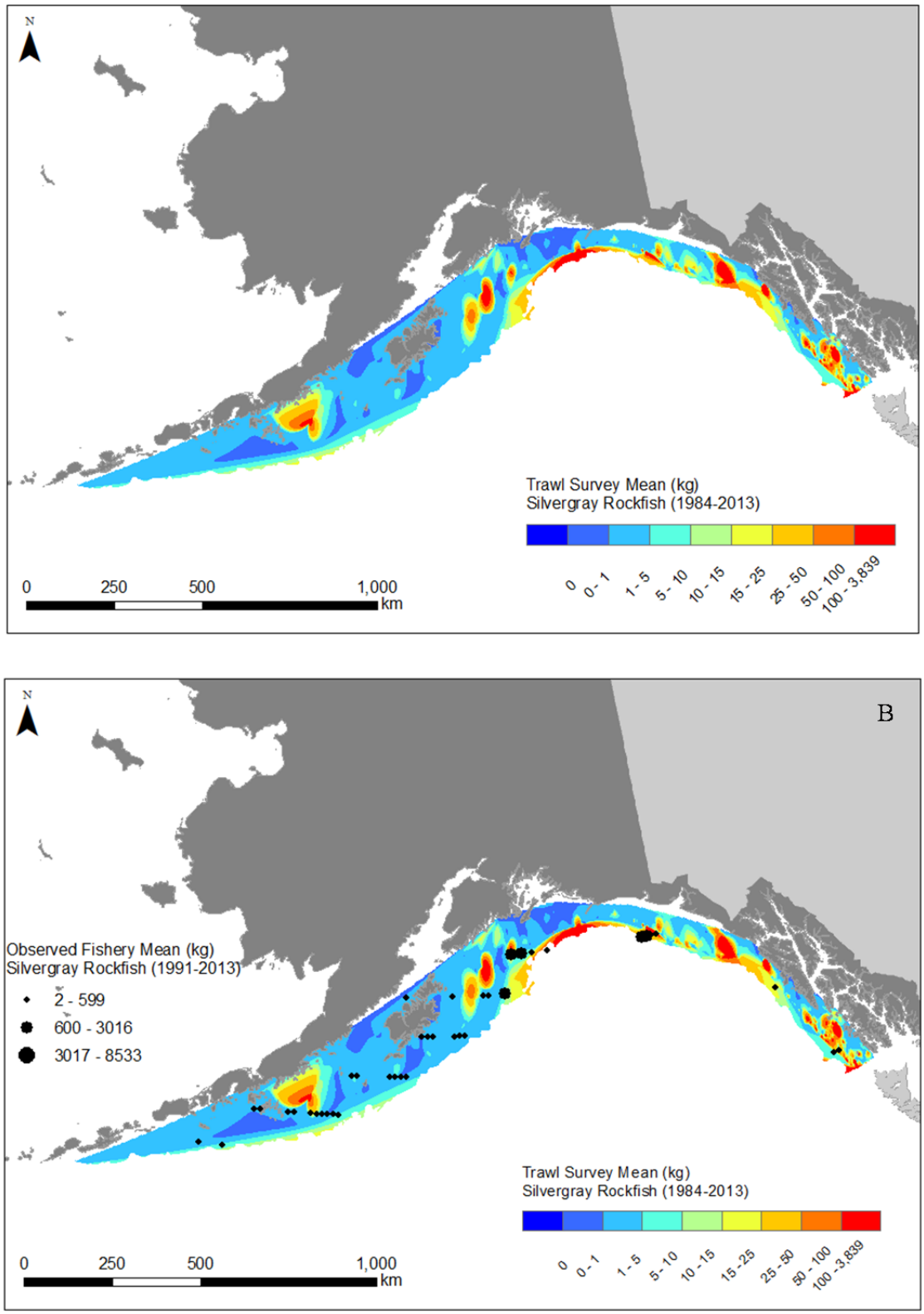


Figure 16B.11.Distribution maps of silvergray rockfish (A) trawl survey mean kilogram per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

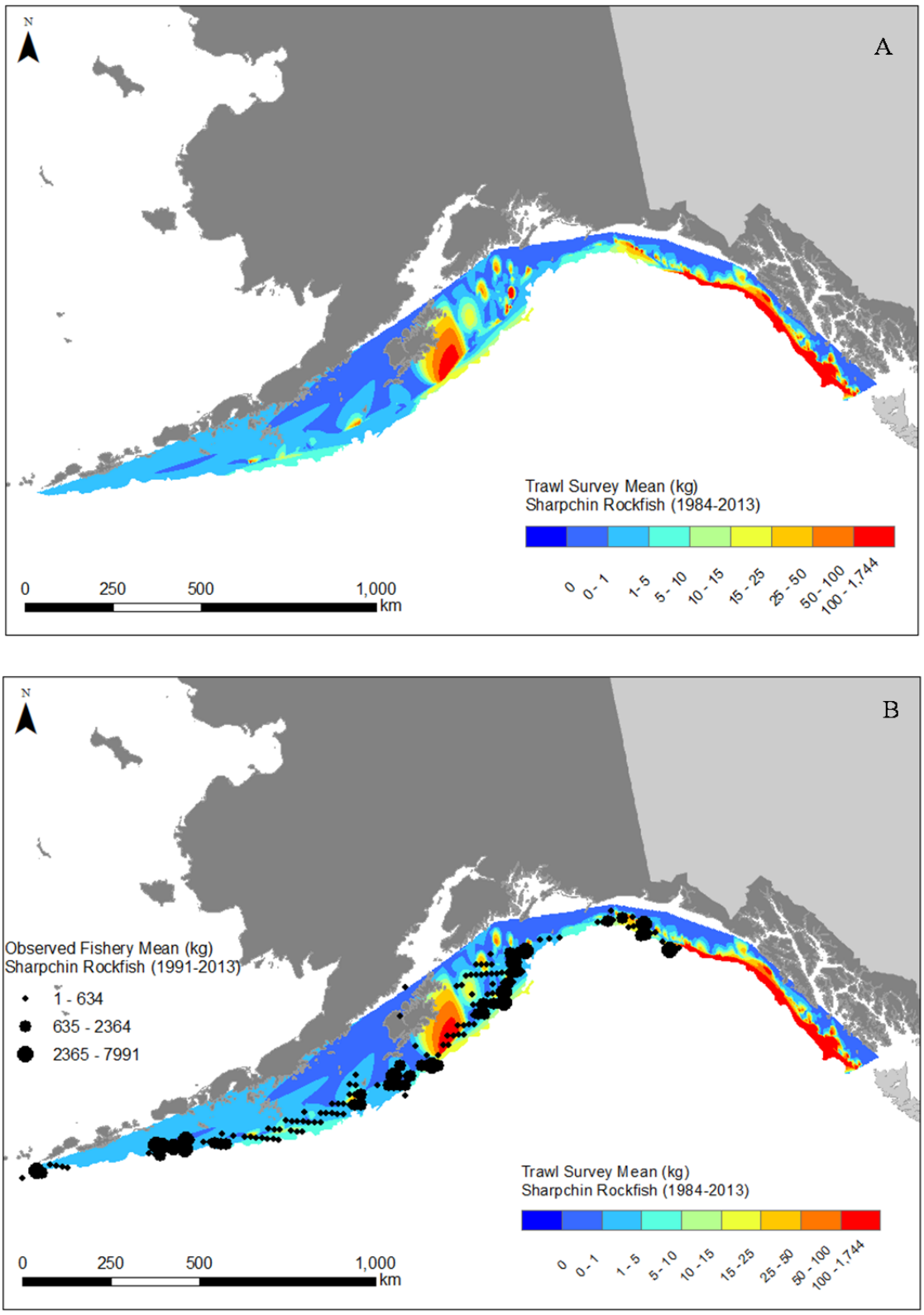


Figure 16B.12.Distribution maps of sharpchin rockfish (A) trawl survey mean kilogram per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

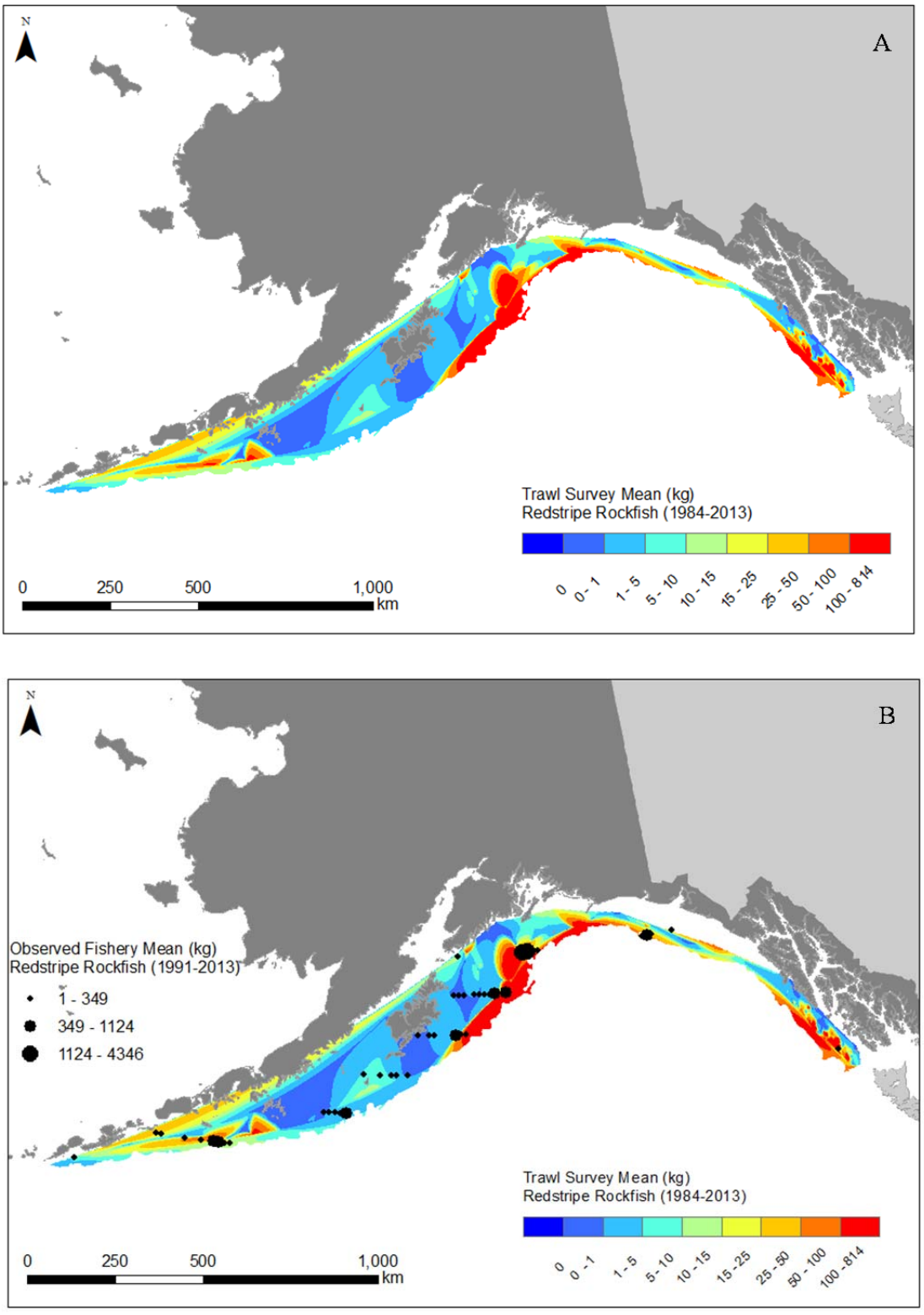


Figure 16B.13.Distribution maps of redstripe rockfish (A) trawl survey mean kilograms per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

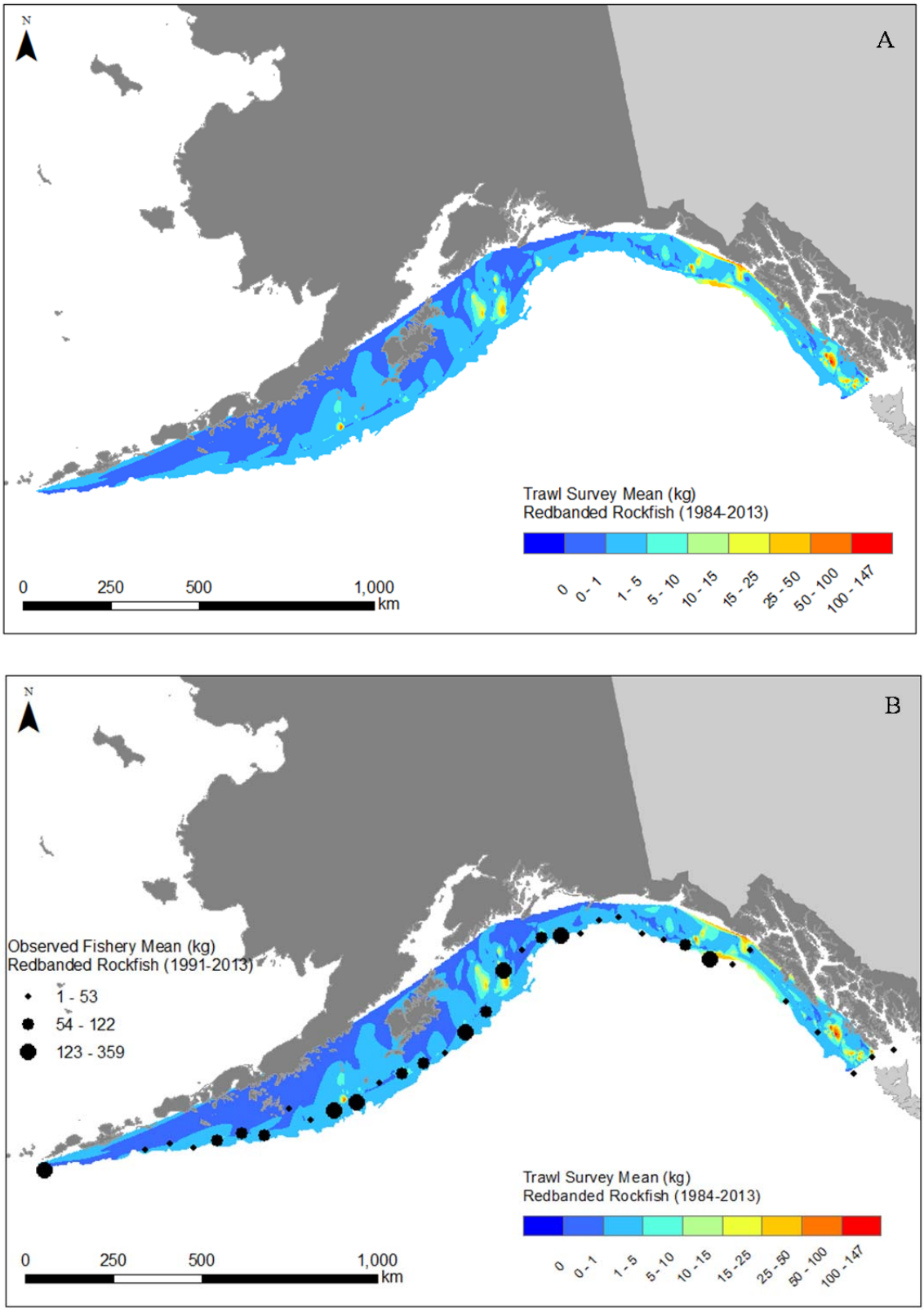


Figure 16B.14.Distribution maps of red banded rockfish (A) trawl survey mean kilograms per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

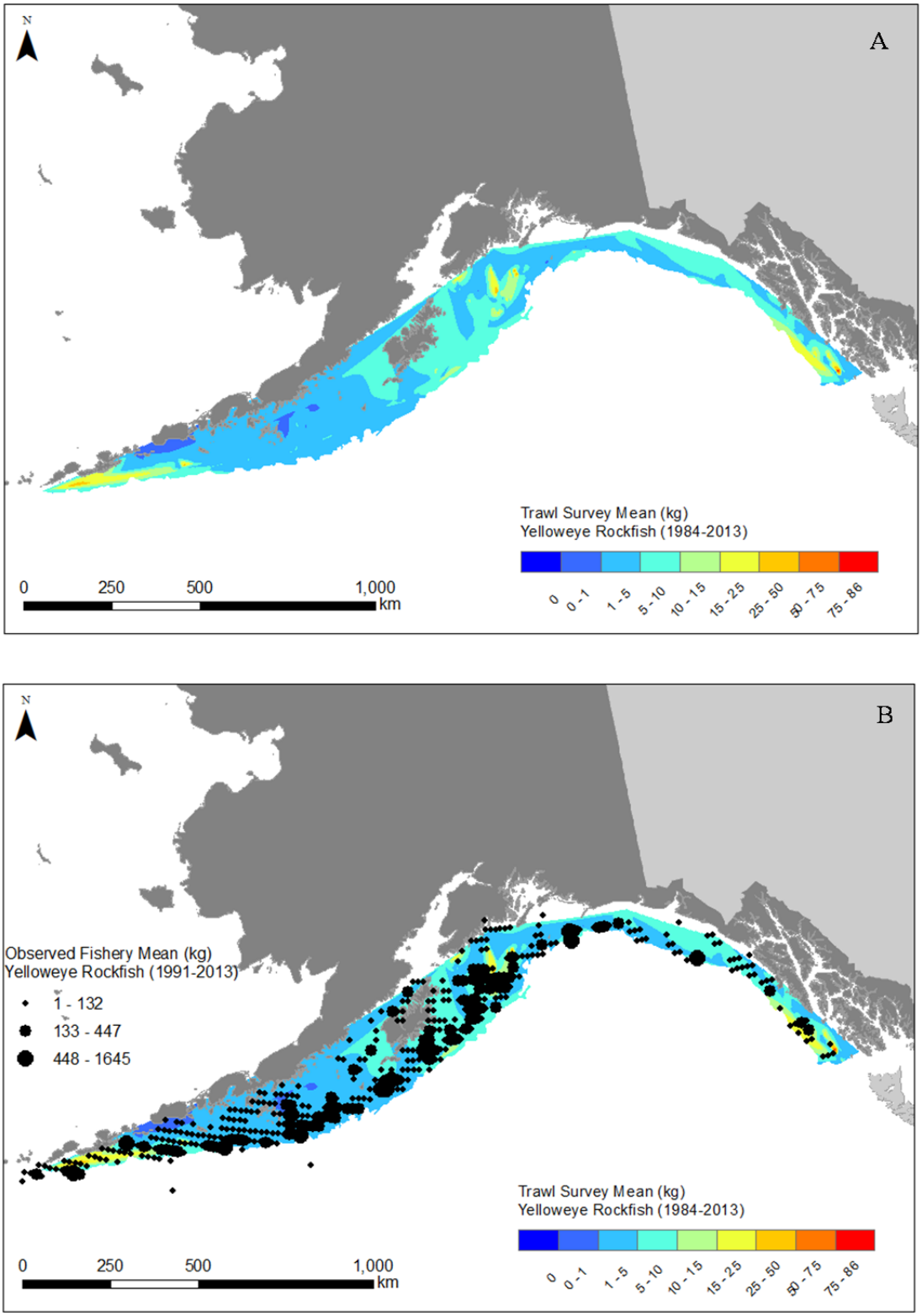


Figure 16B.15.Distribution maps of yelloweye rockfish (A) trawl survey mean kilogram per haul from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions. Catch in the East Yakutat/Southeast Outside (EY/SEO) only represents catch estimates available through the Alaska Regional Office and does not include the state managed fisheries.

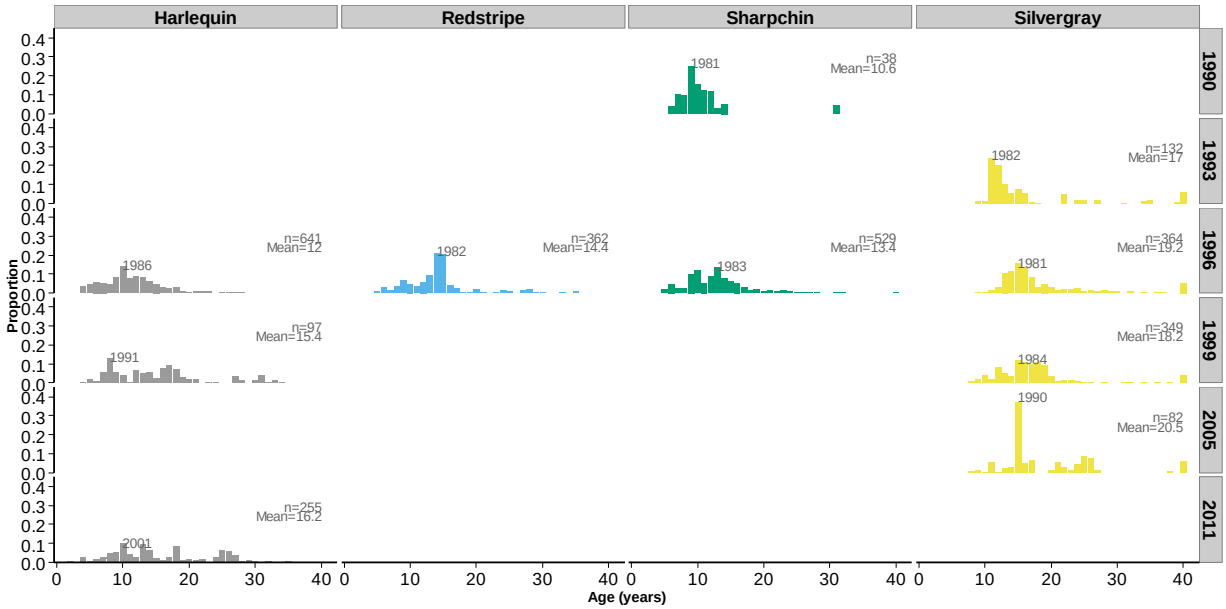


Figure 16B.16. Age compositions of harlequin, redstripe, sharpchin, and silvergray rockfish from the Gulf of Alaska (GOA) National Marine Fisheries (NMFS) bottom trawl survey. Sample size and mean age are presented for each species and survey year with age compositions available. The birth year of the largest cohort is labeled as well.

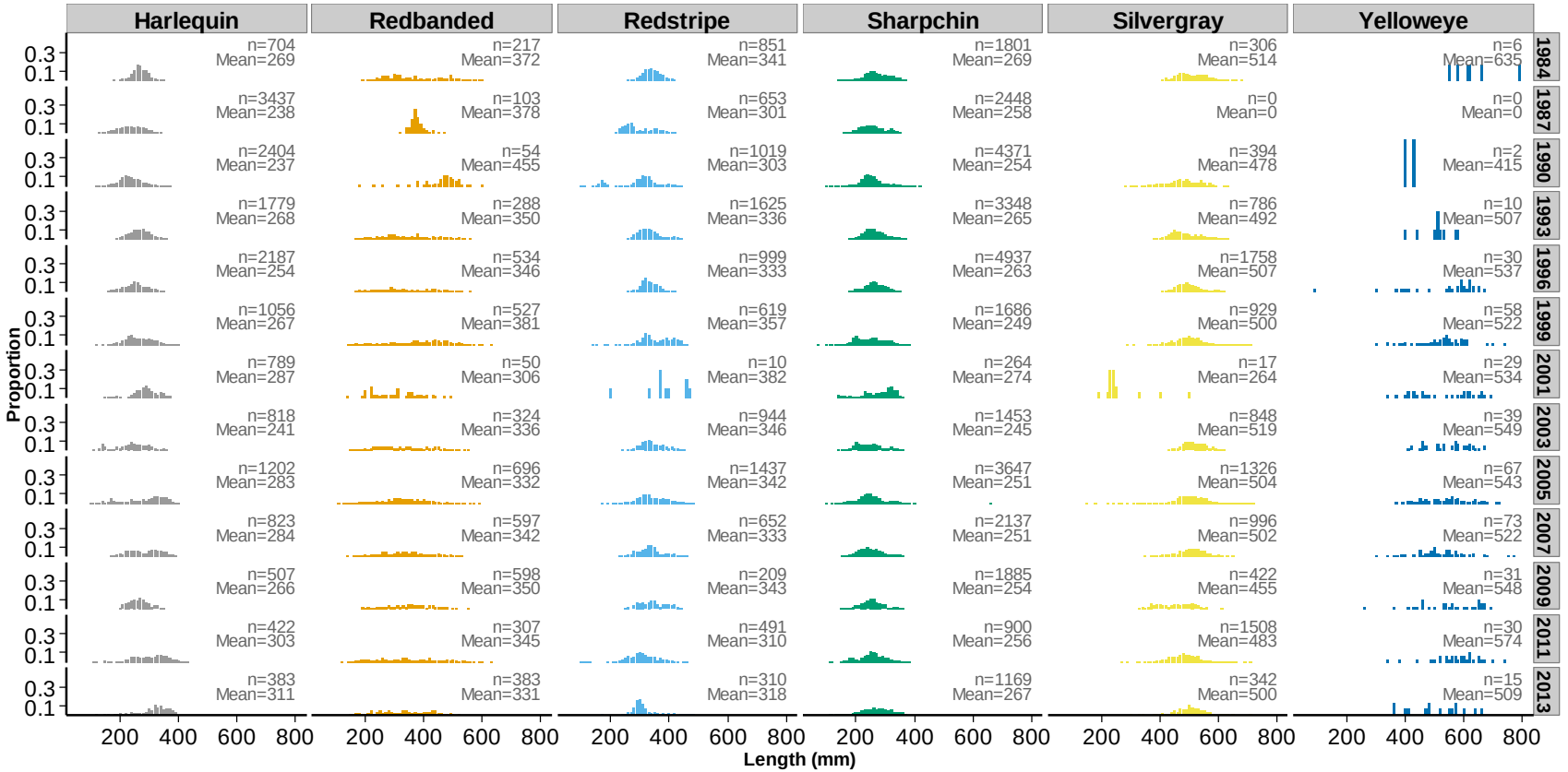


Figure 16B.17. Size composition of the primary Other Rockfish (OR) species from the National Marine Fisheries Service (NMFS) bottom trawl surveys. Sample size and mean length (mm) are presented for each of the primary species.

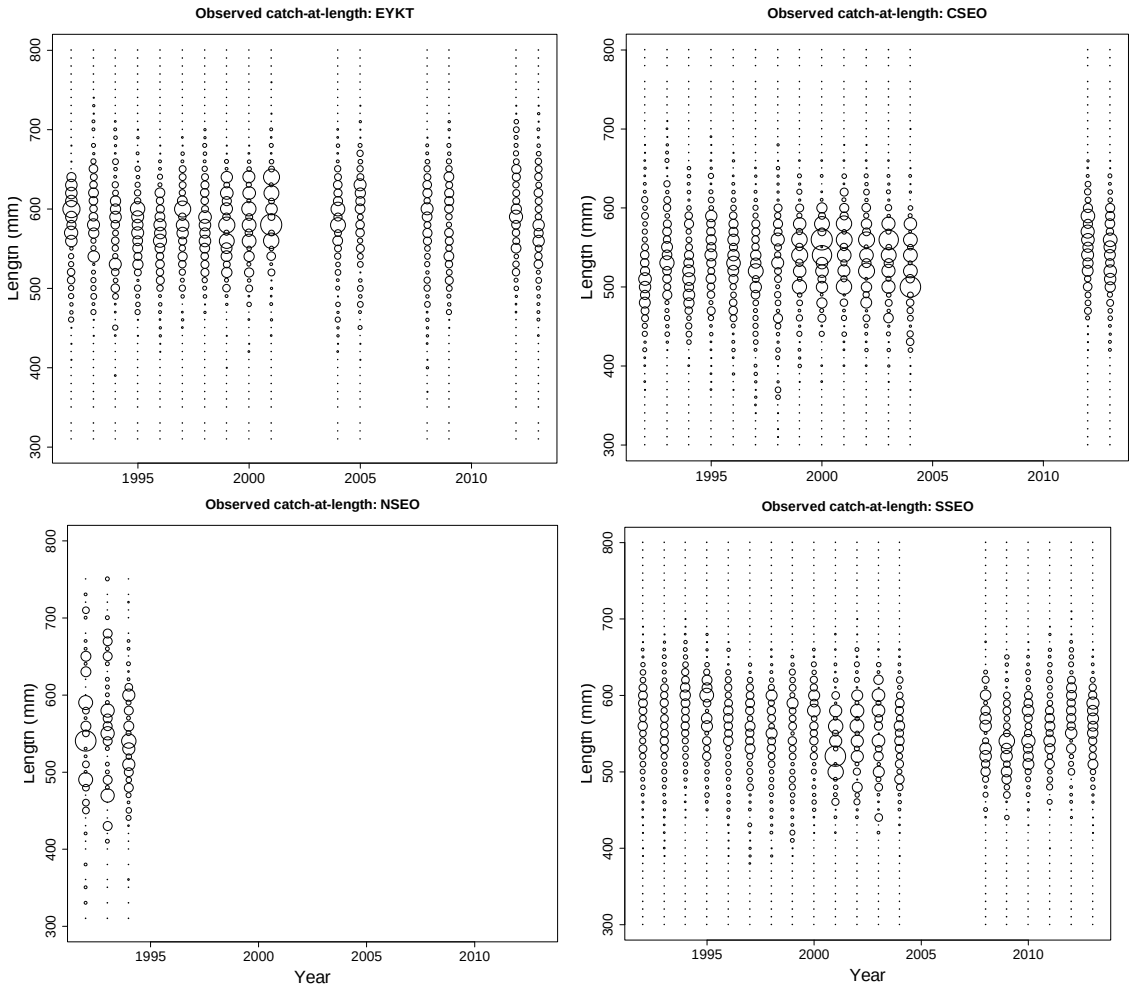


Figure 16B.18.Length compositions of yelloweye rockfish captured in the directed fishery in East Yakutat (EYKT), Central Southeast Outside (CSEO), Northern Southeast Outside (NSEO), and Southern Southeast Outside (SSEO).

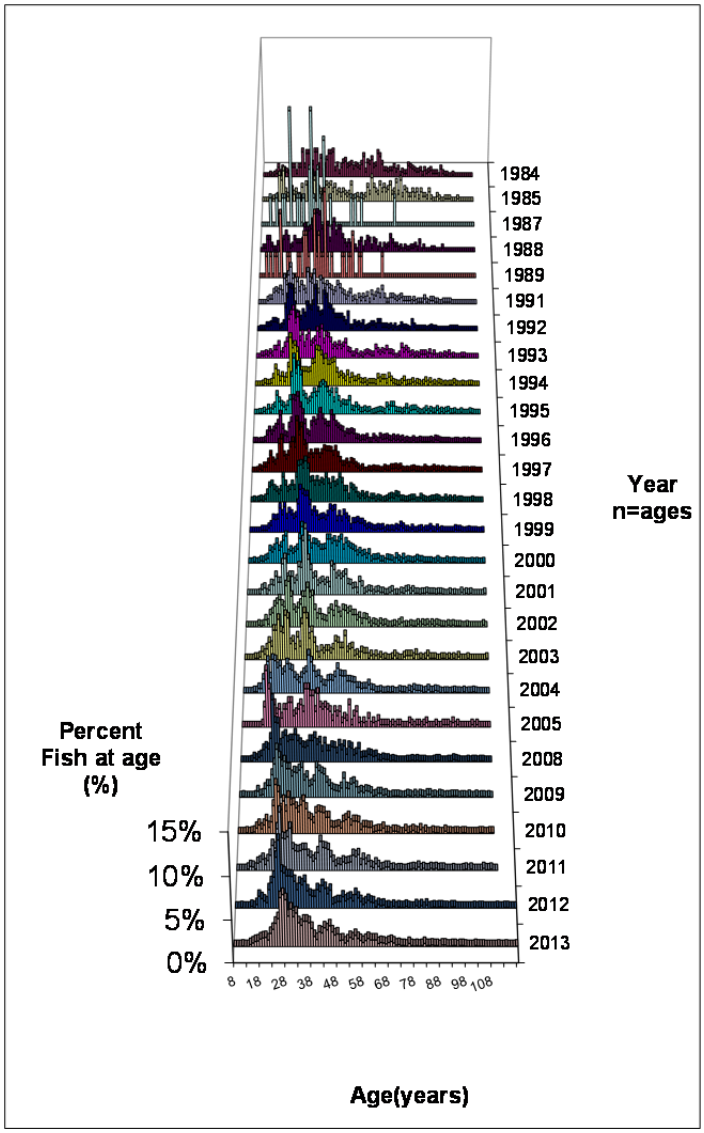


Figure 16B.19.Age (years) frequency histogram from yelloweye rockfish in the East Yakutat/Southeast Outside (EY/SEO) landed in both the commercial directed fishery and as incidental catch in the Pacific halibut IFQ fishery from 1984 through 2013.