Other Rockfish and Demersal Shelf Rockfish Stock Assessment Tasks in the Gulf of Alaska

Cindy A. Tribuzio and Katy B. Echave (AFSC)
Kristen Green and Ben Williams (ADF&G)
Pete Hulson (AFSC)
September 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 covers seven species of rockfish, in the East Yakutat/Southeast (EY/SEO) management area (i.e., GOA area east of the 140° W longitude, NMFS area 650). These seven species are included in the OR complex, along with 18 other species, in all areas west of EY/SEO (Figure 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 that determined that a GOA-wide model for Yelloweye Rockfish is not currently feasible given available data.

The requests made by the SSC and Plan Team 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. We are also including a discussion of using the random effects model for the Tier 5 species in these complexes as Task #4.

In summary, the stock structure template did not provide any information to suggest changes in management based on 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 overall, catches are generally low for all of these species (Task #2). The authors examined the random effects approach to survey averaging and determined that the best fit model was combining the OR species biomass estimates to create a single complex wide biomass, but run the model by region (Task #4). However, the authors do not recommend using the random effects approach for the assessment until the survey averaging working group finalizes the method development.

Investigating management alternative for DSR GOA – wide (Task #3) required consultations between assessment authors, Alaska Department of Fish and Game Southeast and Southcentral region staff and the Alaska Regional Office. Multiple management alternatives were discussed, and the authors recommend moving the seven DSR species which occur in the OR complex (i.e., those occurring to the west of EY/SEO) into the DSR assessment and expanding the DSR assessment to be GOA – wide. This option would not require regulatory or FMP level changes, but would enable managers to monitor the catch of these species more appropriately.

SSC and Plan Team Comments Specific to these assessments

Yelloweye 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

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

Catch and management alternatives for DSR gulfwide (Task #3)
"The SSC recommends that respective assessment authors work together with AKR 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

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 A of this document (Echave et al. 2015).

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 1). The RPNs are an area weighted Catch Per Unit Effort (CPUE), 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 all five of the species that regularly occur in the IPHC survey, the RPNs were greatest in the East Yakutat/Southeast Outside (EY/SEO) management area (Figure 2). The utility of the IPHC survey for each of the six 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 a variety of 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 for biomass estimation.

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 for biomass estimation.

Silvergray Rockfish:

- Caught at a variety of stations in EY/SEO, mostly at the southern stations, closer to Dixon Entrance.
- Extremely rare in W/CGOA. Caught in WY at least 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 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 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 1). In the EY/SEO areas, retention of all of the seven DSR species has been required since 2005, thus catch prior to then may not be representative of actual 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 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 1 and Table 2). It is unlikely that this increase in catch is solely due to improved catch accounting (i.e., the Rockfish Program, eLandings or observer restructuring) because most of the catch is retained and catch estimates are likely representative of total catch. 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, with the bulk of the biomass occurring 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 bulk of the catch composition of these species (Table 1, Figure 3) in all regions.

The bycatch only fishery for the DSR species in Prince William Sound and the 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 Prince William Sound, 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, NMFS annual longline and IPHC annual longline surveys. 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 information useful for these species. As described above, the IPHC 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, because this survey tends to fish deeper waters than the DSR species preferred habitat and catch of Yelloweye Rockfish is scattered, the abundance trends would be more uncertain than 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.

In the EY/SEO region, the Alaska Department of Fish and Game (ADFG) has operated index surveys in the form of manned submersibles (biennially 1988 – 2009) and remotely operated vehicles (ROV, annual 2012 – present) for Yelloweye Rockfish. These surveys are the primary index used in the DSR stock assessment. There are large mesh trawl surveys operating in the WGOA, Prince William Sound and Cook Inlet which provide CPUE and length data. However, these surveys are designed to target crab habitat and have a small number of samples, and the regularity of the surveys is 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 Prince William Sound which provides a presence index used for assessment of Yelloweye Rockfish in the state managed fishery in Prince William Sound, however that survey has also been subject to restrictions due to funding availability.

Alternative Management Options

We propose and discuss three potential management options: 1) status quo; 2) move all of the EY/SEO DSR species to the GOA - wide OR assessment; and 3) remove all seven of the DSR species from the OR assessment, place them in the DSR complex 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, thus these ABC/OFLs 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 complex structures, with the DSR complex assessment including the seven species ONLY in EY/SEO (NMFS area 650). The OR complex assessment includes the seven species in the WGOA, CGOA and WY portion of the Eastern GOA.

Alternative 2: Bring DSR into the OR complex

Alternative 2 would merge the EY/SEO DSR complex and the GOA OR complex assessment and would in essence dissolve the EY/SEO DSR complex. The biennial trawl survey does not provide a reliable biomass estimate for the DSR species in any area, thus if the DSR were included in the OR assessment, ABC/OFLs would have to be calculated for those species 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 complex ABC/OFL in Alternative 2. Alternative 2a would place all the DSR species in Tier 6, with ABC and OFL estimates based off of the historical time series of catch. The ABC/OFL would be calculated by species within a region and added to the apportioned ABC/total OFL from the OR complex Tier 4/5 species. Alternative 2b would have a separate ABC GOA - wide for the DSR species, based on Tier 6 calculations in each region, but still fall under the same OFL with the rest of the OR complex. Thus, there would be an ABC set for each management area based on the Tier 6 calculations of the seven DSR species, and they would fall under that same OFL cap as the full OR complex. Alternative 2c would classify all of the DSR species as Tier 6 and the ABC and OFL estimates would be incorporated into the

complex ABC for each region and GOA - wide OFL, with the exception of a separate ABC for DSR in EY/SEO (thus, the existing Tier 4 methods being employed in the DSR assessment would still be used).

The State of Alaska manages directed, subsistence and recreational fisheries in the EY/SEO region, which fall under the ABC in that region. The Alternative 2 scenarios need to account for that portion of State managed fishery catch in the complex ABC for that region. 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). 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 and that catch estimates by species are likely unbiased as far back as 1991 for the Other Rockfish. Thus catch estimates exist for the seven DSR species outside of the EY/SEO back to 1991. Landings data are available for the DSR by species in EY/SEO back to 1995, however, full retention wasn't required until 2005, thus the landings prior to then may be biased low relative to total catch. For the purposes of this document Tier 6 calculations are based on catch estimates from 2005 – 2014, to ensure consistency between regions and to use the most accurate catch estimates. Further, for the purposes of this document, maximum historical catch is the metric being used for Tier 6 OFL and ABC estimates (i.e., OFL = maximum historical catch, ABC = 0.75OFL) and the ABC is 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 includes estimated sport and subsistence catch because those sources of catch are incorporated into the assessment. Sport harvest estimates are available from 2006 when the current creel census program went into effect through 2013, as the 2014 estimates will not be available for the assessments until October 1. At the time of this document subsistence harvest estimates are not available prior to 2010. Further, sport harvest estimates from 2006 – 2008 extend to the 144 W longitude, encompassing more than EY/SEO. Thus, for the purposes of this document, the maximum non-Yelloweye Rockfish sport harvest from 2009 – 2013 and subsistence harvest from 2010 – 2013 were added to the maximum of the commercial catch described above to calculate the ABCs.

Alternative 3: Make a GOA - wide DSR assessment

Alternative 3 would make the DSR complex assessment GOA - wide, by moving the Canary, China, Copper, Quillback, Rosethorn, Tiger, and Yelloweye Rockfish occurring in the OR assessment (i.e., those to the west of the EY/SEO region) into the DSR assessment and expanding the assessment GOA - wide. The OR complex assessment would continue to use the same Tier 5 methods for those species as are currently in use. We describe two potential scenarios for this alternative with regards to the DSR complex. Alternative 3a would use Tier 6 methods for the six non-Yelloweye Rockfish species GOA - wide. In EY/SEO, the same approach would be used for Yelloweye Rockfish as is currently used, and Tier 6 methods used for Yelloweye Rockfish in all other regions. The complex ABC/OFLs would be the sum of the individual species estimates by region.

Alternative 3b would 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 Central GOA or Western GOA therefore available data are from incidental catch records. Further the surveys (e.g., trawl, IPHC, etc.) previously mentioned do not effectively capture DSR species (i.e., trawls), or may have poor estimates of CPUE (i.e., IPHC first 20 hook counts). Due to the lack of a targeted fishery or surveys for DSR in the Central GOA and Western GOA it is anticipated that model inputs will have high annual variability. In the EY/SEO, area(s) with the greatest DSR information, the IPHC longline survey data are highly variable and not terribly informative for the age-structured model. Further, aside from catch and survey data, there is limited biological data (e.g., maturity, size, age-structure) available for the CGOA and WGOA to inform a model and it is unclear how representative EY/SEO fish are or GOA - wide fish. For these reasons, Alternative 3b has not been pursued further at this time and results are not provided in the table below.

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

		Other Rockfish Sub Group ABC			Demersal Shelf Rockfish Sub Group ABC						
			Eastern GOA			Eastern GOA			GOA-wide		# ABCs
	Complex	W/ CGOA	WY	EY/ SEO	W/ CGOA	WY	EY/ SEO	ADFG	ABC	OFL	
Alt - 1	OR	1,031	580	2,468					4,079	5,347	3
	DSR						225		225	361	1
Alt - 2a	OR	1,116	614	2,550				60	4,440	5,829	3
Alt - 2b	OR	961	585	2,489	155	29	161	60	4,440	5,829	6
Alt - 2c	OR	1,116	614	2,489			161	73	4,453	5,917	4
Alt – 3a	OR	961	585	2,489					4,035	5,289	3
	DSR				155	29	234		418	629	3

[1]In these examples, the Alaska Department of Fish and Game (ADFG) ABC is not federally managed, but a calculated allocation delegated to State management for directed fisheries only. Nondirected (incidental catch from the IFQ halibut fishery) would be managed federally.
[2]161 t is the mean federal fishery total catch of DSR since observer restructuring took effect. 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 which would need to be allocated to the State of Alaska for the directed, subsistence and sport fisheries.
[3]This ABC only applies to Yelloweye Rockfish in EY/SEO, all of the other species ABCs are included with the full Other Rockfish complex.
[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. All 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 six species being considered here. There are a number of reason why having Yelloweye Rockfish combined into the OR complex, or not assessing it GOA -

wide is problematic: 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; and 3) this species is primarily caught by longline gear, thus it doesn't fit well in the OR complex where the catch is dominated by trawl fishery bycatch, and any trends in catch or survey indices are dampened by the large complex. The remaining six DSR species are believed to have life history more similar to the OR complex of species, even though they tend to prefer different habitats. While these six species are also predominantly caught by longline gear, they are not targeted and catch is small (~11 t, annually 2005 – 2014). As with Yelloweye Rockfish, the spatial composition of the catch of these six species has also shifted to the west (Figure 3).

Alternatives 2a – c (move all of the DSR into the OR assessment) are not recommended. Each of the scenarios in Alternative 2 are complex and in Alternative 2b, would result in six ABCs to manage in-season. ABCs under 50 t are potentially too small to effectively manage. It is possible to combine some ABCs, such as combine WY and EY/SEO, which would be similar to how many other species are managed in the GOA. However, 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." Thus, Alternative 2 would require an FMP amendment to dissolve the DSR complex as well as to potentially combine the WY and SE/EYO (if that were chosen), adding another level of challenge to this alternative.

Alternatives 2a & b would also effectively eliminate the long standing open access directed fisheries managed by ADFG because the apportioned ABCs would be prohibitively small to hold a fishery. The ADFG typically opens up 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 60 t would 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: ABC/OFLs and potential for overages; stock assessments, jurisdictions, regulatory implementation and in-season management.

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 proposed ABC for EY/SEO has not been exceeded, the WY ABC has been exceeded in three years and the combined proposed ABC for the W/CGOA has been exceeded four of the years. However, the GOA – wide proposed OFL has not been exceeded. We would recommend combining the ABCs from the WY with the WGOA and CGOA to reduce the likelihood of an overage. 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 only consistent survey which catches these species west of EY/SEO, the IPHC survey, suggests stable populations of the two most commonly caught DSR species: Quillback and Yelloweye Rockfish. Thus, data do not indicate a conservation concern at this time. The DSR species are not targeted, but have market value and are often retained. In the CGOA and WY regions the retention rates are > 95% and > 97% on average, respectively, both pre – (2003 – 2012) and post – observer restructuring (2013 – present). Retention in the WGOA was on average 64 % prior to observer restructuring and 38% since, however, catch in this region is low, ~ 30 t on average.

Alternative 3a would be an easy change to the existing stock assessments. The current DSR assessment is conducted by the ADFG, 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 those species to the existing assessment. The NMFS would participate in the

GOA – wide DSR assessment as well, in that NMFS will 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 jurisdictional structure currently in place. The State of Alaska would retain the management of the DSR fisheries in the EY/SEO and the NMFS would manage the federal fisheries catching DSR 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. This change would not need to be prior to the change in the assessment.

The primary challenge with Alternative 3a is the in-season management. From a management perspective, Alternative 3a is not favored. 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 the DSR species are rarely caught in the rockfish trawl, but instead by the Pacific halibut fishery. Thus, breaking the DSR species out from the OR complex in the WGOA and CGOA (and WY) would allow for better tracking of catch of the DSR species because they would not be overshadowed by the larger catch of the other OR species. However, the breakout would result is small 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, which NMFS does not have jurisdiction to manage. If a DSR OFL were approached, the NMFS may prohibit directed fishing for Federally managed groundfish fisheries (e.g., rockfish trawl), but not prohibit fishing 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 under discard status for the DSR species.

Therefore, the assessment authors of both the OR and DSR assessments recommend moving forward with Alternative 3a. While there are no obvious conservation concerns based on available data, the biology of the species in the DSR complex (in particular, Yelloweye Rockfish) is such that a higher degree of oversight is warranted. Implementing Alternative 3a has minimal regulatory changes and does not require an FMP amendment. While in-season management of small ABCs has challenges, this alternative may be necessary to adequately track individual species in complexes and to ensure the DSR species aren't overlooked in the larger OR complex.

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 for which we consider the trawl survey be provide reliable estimates of biomass (i.e., not the DSR species or 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 2013 to 2005.

Using the sum of squared first differences, model C3_P0 was selected as the preferred model for each model run (going back in time 5 surveys) (Table 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. Further, modeling by region accounts for the missing survey in the EGOA in 2001.

For comparison, 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 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

At this time the assessment authors do not recommend switching to using the random effects modelling approach for survey averaging. The survey averaging working group is still developing methods and it is not finalized that this approach is to be used.

Literature Cited

Echave, K. B., C. A. Tribuzio, and K. M .Green. 2015. Evaluation of stock structure for the Other Rockfish and Demersal Shelf Rockfish complexes in the Gulf of Alaska. Prepared for the September Gulf of Alaska Plan Team meeting.

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 1. Catch of the seven Demersal Shelf Rockfish (DSR) species across the full Gulf of Alaska (GOA), broken out by Yelloweye Rockfish (YE) and all others combined. Data is 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. There are multiple caveats in this time series of data to make note of: 1) the restructured observer program went into effect for federal fisheries in 2013; 2) beginning in 2005, full retention of Demersal Shelf Rockfish species was required in EY/SEO; and 3) sport and subsistence catch is included in the EY/SEO total catch estimates beginning in 2006 and 2010, respecitively.

	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

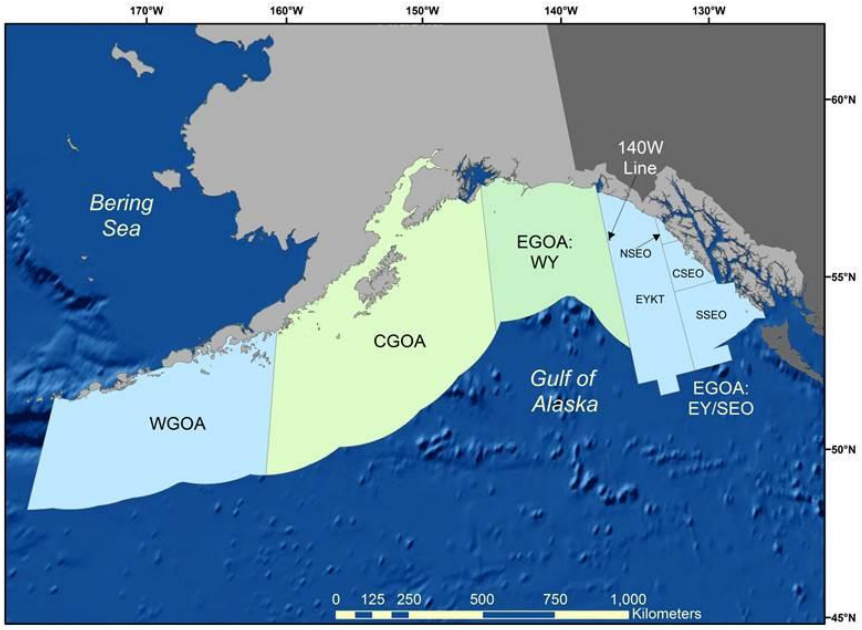
Table 2. Catch, acceptable biological catch (ABC) and total allowable catch (TAC) of the Other Rockfish (OR) and Demersal Shelf Rockfish (DSR) complexes. Data for the OR is from the Alaska Regional Office and for the DSR is from the most recent assessments (Green et al. 2014).

	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 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.

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 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.

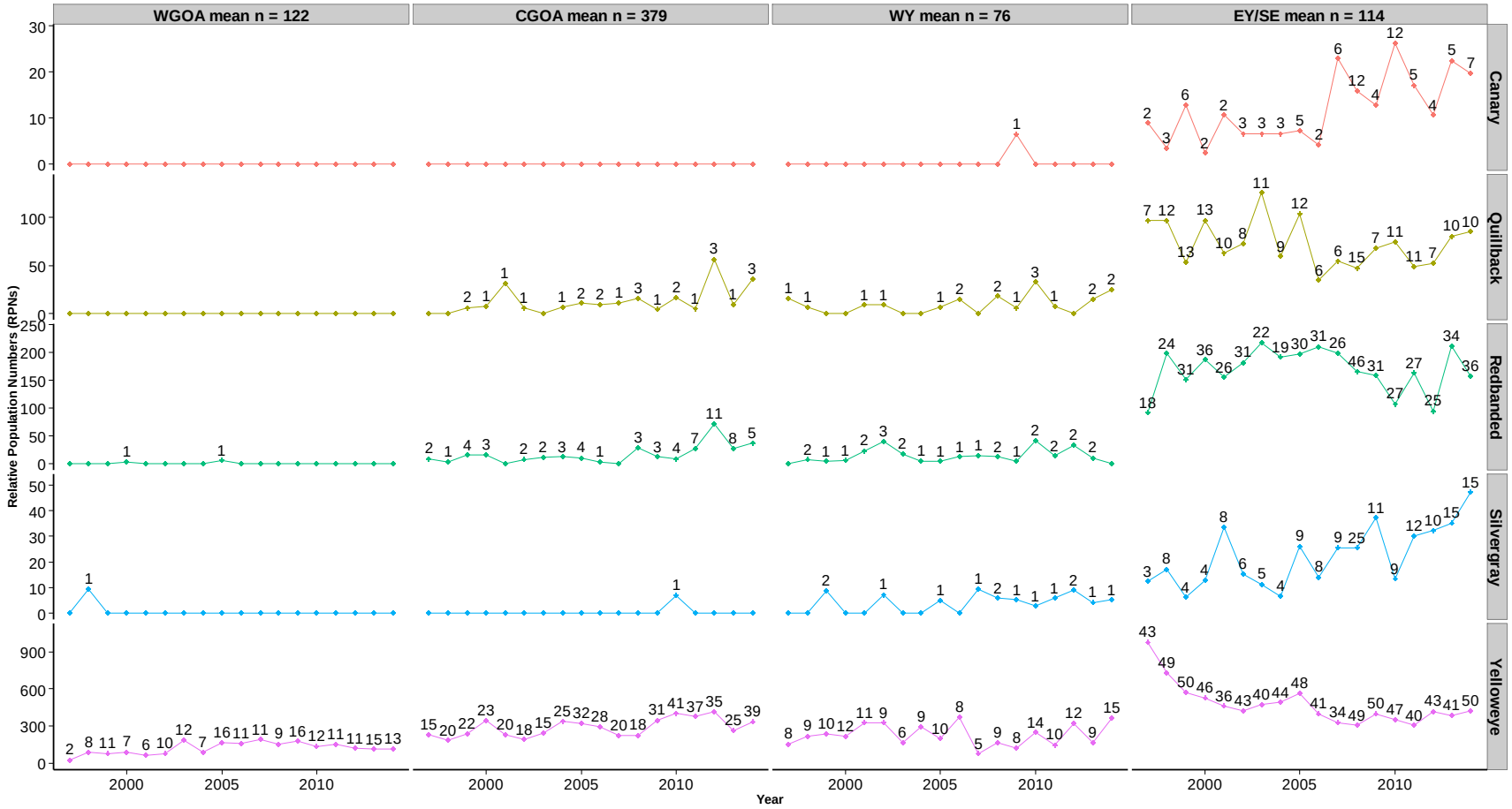


Figure 2. Relative Population Numbers (RPNs) from the International Pacific Halibut Commission (IPHC) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA),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

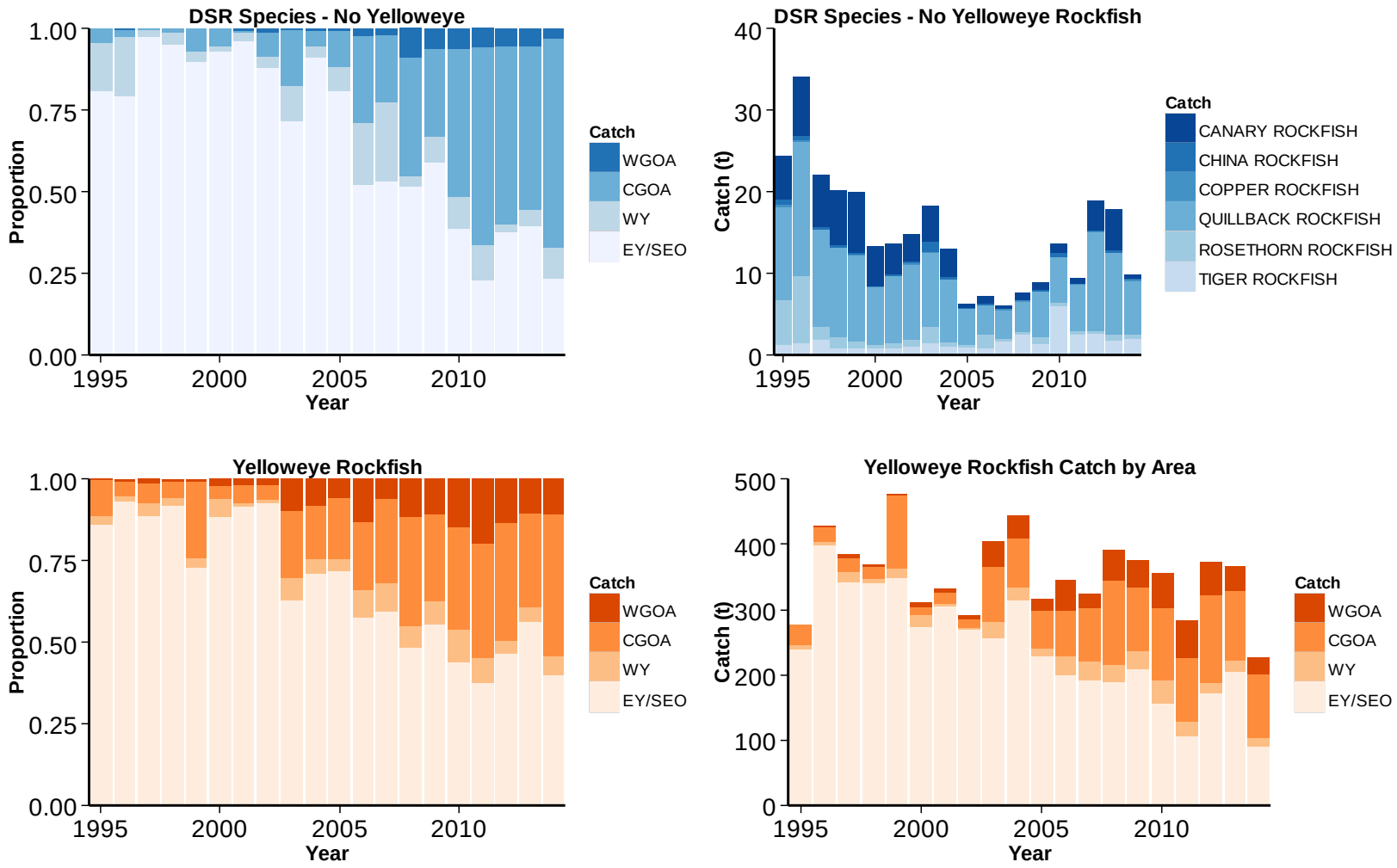


Figure 3. Catch distribution by management area for: A) all of the DSR species except Yelloweye Rockfish, and B) just Yelloweye Rockfish. C) Catch by species for all of the DSR species except Yelloweye Rockfish, and D) catch by area for just the Yelloweye Rockfish. Catch estimates in EY/SEO include estimated 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.

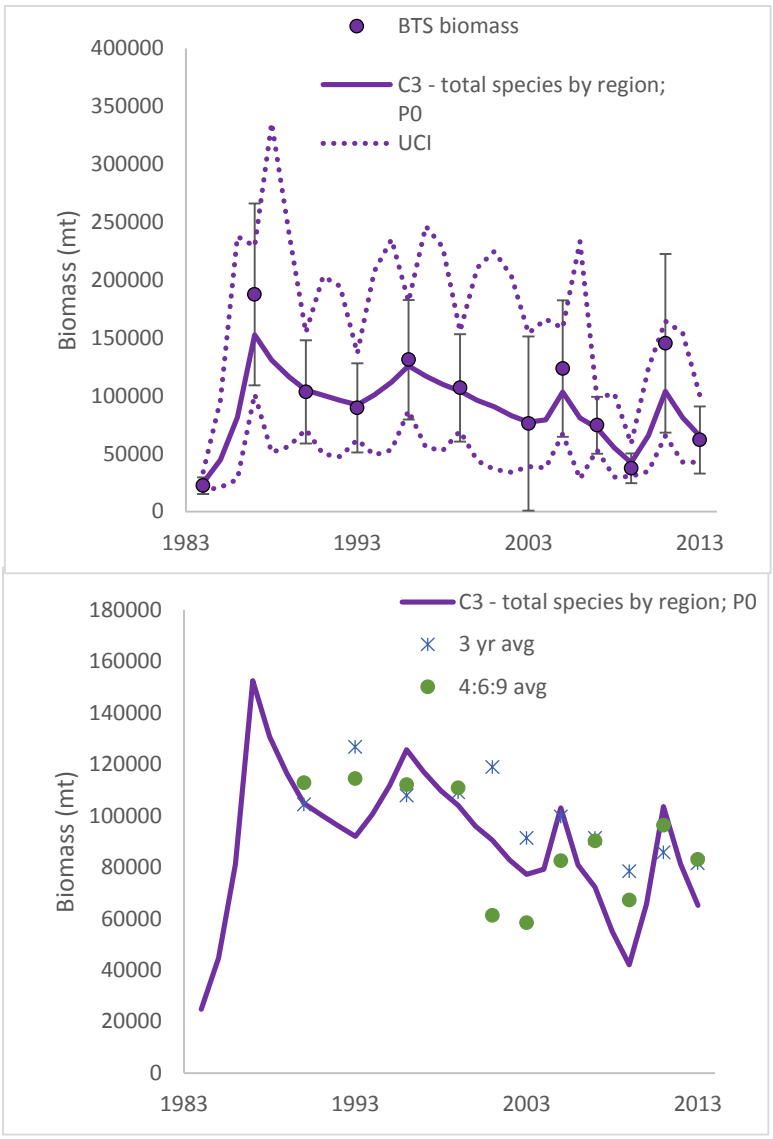


Figure 4. Top panel: Bottom trawl survey biomass estimates with 95% confidence intervals and the best fit random effects model estimates. Bottom panel: Random effects best fit model compared to the 3 survey average and the 4:6:9 weighted average. The 2001 survey did not sample the eastern Gulf of Alaska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

Appendix A. Evaluation of stock structure for the Other Rockfish and Demersal Shelf Rockfish complexes in the Gulf of Alaska

Katy B. Echave, Cindy A. Tribuzio and Kristen M. Green
September 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 Other Rockfish 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 Other Rockfish complex consists of 25 species (Table A.1). The DSR complex specific to the EGOA includes seven of the species in the Other Rockfish complex (Table A.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, Other Rockfish and DSR are most abundant in the EGOA with reduced abundance farther west. Other Rockfish 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 Other Rockfish, 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 Other Rockfish. However, there is a mismatch between the 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 composes > 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, what is available are insufficient for evaluating comparisons between species or across the GOA. Additionally, little genetic information is available to infer any genetic stock structure between or within areas.

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 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) Groundfish Plan Team (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 FMP-wide specifications and because it is a complex of multiple species, as well as for the Demersal Shelf Rockfish complex (DSR).

Sebastes rockfish 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 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 Other Rockfish 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 A.1), are included in the OR complex. The OR complex consists of 25 species in total (Table A.1). The DSR complex is the seven above species, but only when occurring in the EY/SEO region (also called NMFS area 650, Figure A.1). In this document, any reference to the DSR complex only applies to these seven species when occurring in the EY/SEO, any reference to the Other Rockfish complex refers to the 18 species listed in Table A.1, as well as the seven DSR species only when occurring west of EY/SEO.

Included here is a summary of what is known 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 A.2A). One exception is Harlequin Rockfish, a predominantly Alaskan species widely distributed across the GOA (Figure A.2B). The center of abundance for Silvergray Rockfish, the most abundant of the Other Rockfish species based on recent trawl survey biomass estimates, appears to be southeast Alaska and British Columbia (Figure A.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/DSR complex species can be found in Table A.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 A.3.

Fishery

Other Rockfish

Fishery catch statistics for the Other Rockfish 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 Other Rockfish, 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 A.3A). 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 Other Rockfish 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 Other Rockfish species caught by commercial fisheries varies by area and gear. The primary species caught overall are: Harlequin (35%), Redbanded (17%), Sharpchin (13%), Yelloweye (12%), Redstripe (9%), and Silvergray (6%) (Figure A.4A). 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 importance in the more easterly areas. Redbanded Rockfish are the most common species caught in the Southeast area. 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 A.4B). 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 landings have often been constrained by other fishery management actions. In 1992, the directed DSR fishery was allotted a separate Pacific halibut prohibited species cap (PSC) and is therefore no longer affected when the PSC is met for other longline fisheries in the GOA. In 1993, the fall directed fishery was closed early due to an unanticipated increase in DSR incidental catch during the Pacific Halibut IFQ fishery. Directed fisheries are held if there is sufficient quota available after the DSR mortality in other commercial fisheries (primarily the Pacific Halibut IFQ fishery) is estimated. Estimated catch of Yelloweye Rockfish 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 A.3B)

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 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 A.4C). Geographically, most of the biomass for these species is found in the EGOA, especially the southeastern statistical area (Figure A.2 &Figure A.3B). 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 A.5). 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 gear 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 to 1,000 m. Five species of the Other Rockfish and DSR are caught somewhat regularly on the IPHC survey: Canary, Quillback, Redbanded, Silvergray and Yelloweye Rockfishes (Figure A.6). Two species are caught on the NMFS survey: Redbanded and Yelloweye Rockfish (Figure A.7). 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 A.3D & Figure A.4D). 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 and 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. Survey density estimates for Yelloweye Rockfish show declining trends in most areas (Figure A.8).

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 Overfishing Level (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 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 Other Rockfish 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 A.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 Other Rockfish 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 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 Other Rockfish complex in 1999 for this area only. Therefore, Northern Rockfish is listed as an OR species in Table A.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 (i.e., East Yakutat, EY, Northern Southeast Outside, NSEO, Central Southeast Outside, CSEO, and Southern Southeast Outside, SSEO, Figure A.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 ADFG 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 A.4). In the following sections, we elaborate on the available information used to respond to specific factors and criterion for defining Other Rockfish/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 half of OR catch is discarded (Clausen and Echave 2011), likely due to the undesirable small size of the predominant species. 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 (i.e. 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 $F_{40\%}=0.026$. 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 A.3). There are two potential reasons: 1) the trawl survey may not sample the rockfish species well; and 2) trawl fishing 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 Other Rockfish species (Figure A.9 – Figure A.14).

One example of the discontinuity between catch and abundance is Harlequin Rockfish (Figure A.9). 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, with its poor representation in the trawl survey the extent of the population abundance is poorly understood with relation to fishing harvest (Figure A.12). Note that the data provided in Figure A.14 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 A.6) 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 A.4 &Figure A.5). 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 A.8).

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 A.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 circulation patterns of the GOA are well documented. However, how these interact on small spatial scales in association with bathymetric features is largely unknown. In addition, larval and post-larval distribution of the OR/DSR complex species is poorly understood so interpreting physical limitations is difficult. With the exception of Harlequin Rockfish, abundance of the Other Rockfish/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 at least one species of OR (Table A.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 is some removal 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 A.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 A.15). 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 was sampled in 2005. 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 A.16. 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.

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 A.17). Age composition of Yelloweye Rockfish captured in the directed commercial fishery is shown in Figure A.18.

Spawning time differences

All species of *Sebastes* are ovoviviparous with fertilization, embryonic development, and larval hatching occurring inside the mother. After extrusion, larvae are pelagic, but larval studies are hindered because they can only be positively identified by genetic analysis. Therefore, recognizing differences in spawning times is not likely. 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 A.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 A.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 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 (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 A.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 A.1 & Figure A.9 – Figure A.14), however, this is likely due to the inability of the trawl survey to accurately sample many of these species. 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 Other Rockfish 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.

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 as well, 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 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. Lastly, available genetic and life history information does not suggest that changes to the management regime are necessary to protect the stock structure for either complex.

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.

References

Adams, P. B. 1980. Life history patterns in marine fishes and their consequences for fisheries management. Fish Bull. 78(1):1-12.

Allen, M. J. and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. NOAA Tech. Rep. NMFS 66, 151pp.

Archibald, C. P., W. Shaw, and B. M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-1979. Can. Tech. Rep. Fish. Aquat. Sci. 1048. 57 p.

Black, B.A.; I.D. Schroeder, W.J. Sydeman, S.J Bograd, B.K. Wells, F.B. Schwing. 2011. Winter and summer upwelling modes and their biological importance in the California Current Ecosystem.

Butler, J. L., L. D. Jacobson, and J. T. Barnes. 1998. Stock assessment for blackgill rockfish. Appendix to *Status of the Pacific Coast groundfish fishery through 1998 and recommended acceptable biological catches for 1999*. Portland, Ore.: Pacific Fishery Management Council.

Brylinksy, C., J. Stahl, D. Carlile, and M. Jaenicke. 2009. Assessment of the demersal shelf rockfish stock for 2010 in the southeast outside district of the Gulf of Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources for the Gulf of Alaska, North Pacific Fisheries Management Council, Anchorage, Alaska pp. 1067 – 1110.

Carlson, H.R and R. E. Haight. 1972. Evidence for a home site and homing of adult yellowtail rockfish, *Sebastes flavidus*. J. Fish. Res. Bd. Can. 29:1011-1014.

Carlson, H. R., R. E. Haight, and J. H. Helle. 1995. Initial behavior of displaced yellowtail rockfish *Sebastes flavidus* in Lynn Canal, southeast Alaska. Alaska Fish. Res. Bull. 2:76-80.

Chilton, D. E. and R. J. Beamish. 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Can. Spec. Pub. Fish. Aquat. Sci. 60.

Clausen, D. M. and K.B. Echave. 2011. Assessment of shortraker rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 971-1008. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501. Available online: http://www.afsc.noaa.gov/refm/docs/2011/GOAshortraker.pdf

Clausen, D., T. Pearson, and C. Lunsford. 2011. Management reorganization of species in the Gulf of Alaska pelagic shelf rockfish and "other slope rockfish" assemblages. Unpubl. discussion paper submitted to the NPFMC Gulf of Alaska Groundfish Plan Team, Sept. 2011. 12 p. Available from North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501.

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. Chapter 14 IN 2014 Stock Assessment and Fishery Evaluation Report for 2015. North Pacific Fishery Management Council, Anchorage, AK.

Gunderson, D. R. 1980. Using r-K selection theory to predict natural mortality. Can J. Fish. Aquat. Sci. 37:1522-1530.

Hannah, R. H., and P. S. Rankin. 2011. Site Fidelity and Movement of Eight Species of Pacific Rockfish at a High-Relief Rocky Reef on the Oregon Coast. N. Amer. J. of Fish. Mngt. 31:483-494.

Hartman, A. R. 1987. Movement of scorpionfishes (Scorpaenidae: *Sebastes* and *Scorpaena)* in the southern California Bight. Calif. Dep. Fish Game, Fish. Bull. 73(2):68-79.

Heifetz, J., J. N. Ianelli, and D. M. Clausen. 1998. Assessment of Slope rockfish. In Stock assessments and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 281-321. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501. Helser, T. E. 2005. Status of the blackgill rockfish resource in 2005. In Appendix to Status of the Pacific Coast groundfish fishery through 2005 and recommended acceptable biological catches for 2006 stock assessment and fishery evaluation. Portland, Ore.: Pacific Fishery Management Council.

Heyamoto, H., and C. R. Hitz. 1962. Northern Range Extensions of Three Species of Rockfish (*Sebastodes rubrivinctus, S. aurora*, and *S. helvomaculatus*). Copeia: 1962(4):847-848.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82: 898-903.

Jones, D.T., C.D. Wilson, A. De Roberts, C.N. Rooper, T.C. Weber and J.L. Butler. 2012. Evaluation of rockfish abundance in untrawlable habitat: combining acoustic and complimentary sampling tools. Fishery Bulletin. 110:332-343.

Kerr L.A., A.H. Andrews, K. Munk, G.M. Calliet, K.H. Coale, T.A. Brown, B.R. Frantz. 2003. Age validation of quillback rockfish (*Sebastes maliger*) using bomb radiocarbon. Fishery Bulletin. 103:97-107.

Leaman, B. M., and D. A. Nagtegaal. 1987. Age Validation and revised natural mortality rate for yellowtail rockfish. Trans. Amer. Fish. Soc. 116:171-175.

Love, M. S., P. Morris, M. McCrae, and R. Collins. 1990. Life history aspects of 19 rockfish species (*Scorpaenidae*: Sebastes) from the Southern California Bight. NOAA Tech Rep. NMFS 87. Seattle.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. Univ. Calif. Press, Berkeley. 405 p.

Malecha, P.W., D. H. Hanselman, and J. Heifetz. 2007. Growth and mortality of rockfish (Scorpaenidae) from Alaska waters. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/AFSC-172. 61 p.

Matthews, K. R. 1990a An experimental study of the habitat preferences and movement patterns of copper quillback and brown rockfishes *Sebastes* spp. Environ Biol Fishes. 29:161–178

Matthews, K. R. 1990b. A telemetric study of the home ranges and homing routes of copper and quillback rockfishes on shallow rocky reefs. Can J Zool. 68:2243–2250

McElderry, H. I. 1979. A comparative study of the movement habits and their relationships to buoyancy compensation in two species of shallow reef rockfish (Pisces: Scorpaenidae). M.Sc. thesis, Univ. Victoria, Victoria, B.C., 168 p.

Mecklenberg, C.W., T.A. Mecklenberg and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, MD. 1037pp.

Meyer, S.C. and B.J. Failor. In prep. Characteristics of the recreational rockfish (Sebastes) harvest in Southcentral Alaska, 1996 – 2013. Alaska Department of Fish and Game, Fishery Data Series No. YY – XX, Anchorage.

Moles. A., J. Heifetz, and D.C. Love. 1998. Metazoan parasites as potential markers for selected Gulf of Alaska rockfishes. Fish. Bull 96: 912-916.

Munk, K. M. 2001. Maximum ages of groundfishes in waters off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8:12-21.

Nichol, D. G. 1990. Life history examination of darkblotched rockfish (*Sebastes crameri*) off the Oregon coast. M.S. thesis, Oregon State Univ.

O'Connell, V. M. 1987. Reproductive seasons for some *Sebastes* species in southeastern Alaska. Alaska Dept. Fish Game, Informational Leaflet No. 263.

O'Connell, V. M., and F. C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrius*) landed in southeastern Alaska. In *Proceedings of the International Rockfish Symposium*, 171-185. Alaska Sea Grant Rep. 87-2. Fairbanks.

O'Connell, V. M. 1991. A preliminary examination of breakaway tagging for demersal rockfishes. Alaska Dep. Fish Game, Comm. Fish. Div., Fish. Res. Bull. 91-06, 8 p.

O'Connell, V.M. and D.W. Carlile. 1993. Habitat-specific density of adult yelloweye rockfish *Sebastes ruberrimus* in the eastern Gulf of Alaska. Fish Bull 91:304-309.

O'Connell, V. M., D. C. Carlisle, and C. Brylinksy. 1998. Summary of changes in the demersal shelf rockfish. In *Stock assessments and fishery evaluation report of the groundfish resources of the Gulf of Alaska*, 349-369. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501.

Pearcy, W. G. 1992. Movements of acoustically-tagged yellowtail rockfish *Sebastes flavidus* on Heceta Bank, Oregon. Fish. Bull. 90:726-735.

Ralston, S., D. E. Pearson, and J. A. Reynolds. 1998. Status of the chilipepper rockfish stock in 1998. Appendix to *Status of the Pacific Coast groundfish fishery through 1998 and recommended acceptable biological catches for 1999*. Portland, Ore.: Pacific Fishery Management Council.

Rogers, J. B., R. D. Method, T. L. Builder, K. Piner, and M. Wilkins. 2000. Status of the darkblotched rockfish (*Sebastes crameri*) resource in 2000. Appendix to *Status of the Pacific Coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001 stock assessment and fishery evaluation.* Portland, Ore.: Pacific Fishery Management Council.

Rocha-Olivares, A. and R. D. Vetter. 1999. Effects of oceanographic circulation on the gene flow, genetic structure, and phylogeography of the rosethorn rockfish (*Sebastes helvomaculatus*). Can. J. Fish. Aquat. Sci. 56: 803–813.

Rosenthal, R. J., L. Haldorson, L. J. Field, V. Moran-O'Connell, M. G. LaRiviere, J. Underwood, and M. C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the southeastern Gulf of Alaska (1981-82). Anchorage: Alaska Dept. Fish Game.

Shaw, F. R. 1999. Life history traits of four species of rockfish (genus *Sebastes*). M.S. thesis, Univ. Wash.

Shotwell, S. K., D. H. Hanselman, and D. M. Clausen. 2014. Assessment of the rougheye and blackspotted rockfish stock complex in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 655-750. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501. Available online: http://www.afsc.noaa.gov/REFM/Docs/2014/GOArougheye.pdf

Snytko, V.A. 1986. New distribution records of rockfishes of the subfamily Sebastinae in the northern Pacific Ocean. J. Ichthyol. [English transl. Vopr. Ickhtiol.] 26(3):124-130.

Spencer, P., M. Canino, J. DiCosimo, M. Dorn, A. J. Gharrett, D. Hanselman, K. Palof, and M. Sigler. 2010. Guidelines for determination of spatial management units for exploited populations in Alaskan fishery groundfish management plans. Paper prepared for the September 2010 NPFMC Plan Team meeting.

Stanley, R. D., B. M. Leaman, L. Haldorson, and V. M. O'Connell. 1994. Movements of tagged adult yellowtail rockfish, *Sebastes flavidus*, off the west coast of North America. Fish. Bull. 92:655-663.

Stanley, R. D., and A. R. Kronlund. 2000. Silvergray rockfish (*Sebastes brevispinis*) assessment for 2000 and recommended yield options for 2001/2002. Can. Stock Assess. Secretariat Res. Doc. 2000/173, 116 p.

Stanley, R. D., and A. R. Kronlund. 2005. Life history characteristics for silvergray rockfish (*Sebastes brevispinis*) in British Columbia waters and the implications for stock assessment and management. Fish. Bull. 103: 670-684.

Starr, R. M., J. N. Heine, J. M. Felton, G. M. Cailliet. 2002. Movements of bocaccio (*Sebastes paucispinis*) and greenspotted (*S. chlorostictus*) rockfishes in a Monterey submarine canyon: implications for the design of marine reserves. Fish. Full. 100:324-337.

Tagart, J. V., F. R. Wallace, and J. N. Ianelli. 2000. Status of the yellowtail rockfish resource in 2000. In Appendix to Status of the Pacific Coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001 stock assessment and fishery evaluation. Portland, Ore.: Pacific Fishery Management Council.

Thorson J.T., I.J. Stewart, I.G. Taylor, A.E. Punt. 2013. Using a recruitment-linked multispecies stock assessment model to estimate common trends in recruitment for US West Coast groundfishes. Mar Ecol Prog Ser 483:245-256

Tolimieri, N., K. Andrews, G. Williams, S. Katz, and P. S. Levin. 2009. Home range size and patterns of space use by lingcod, copper rockfish and quillback rockfish in relation to diel and tidal cycles. Mar. Ecol. Prog. Ser. 380: 229-243.

Turner, C. H., E. E. Ebert, and R. R. Given. 1969. Man-made reef ecology. Calif. Dep. Fish Game, Fish Bull. 146, 221 p.

Wallace, J. and H.-L. Lai. 2005. Status of the yellowtail rockfish in 2005. National Marine Fisheries Service, Northwest Fishery Science Center, 2725 Montlake Blvd. E., Seattle WA 98028. 115 p

Wildermuth, D.A. 1983. Length-weight regression analysis for thirty-eight species of sport caught marine fishes. Wash. Dept. Fisheries Prog. Rep. No. 189, 7 p.

Wilkins, M. E., M. Zimmerman, and K. L. Weinberg. 1998. The 1995 Pacific west coast bottom trawl survey of groundfish resources: Estimates of distribution, abundance, and length and age composition. NOAA Tech. Mem. NMFS-AFSC-89.

Williams, E. H., A. D. MacCall, S. V. Ralston, and D. E. Pearson. 2000. Status of the widow rockfish resource in Y2K. In Appendix *to Status of the Pacific Coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001 stock assessment and fishery evaluation*. Portland, Ore.: Pacific Fishery Management Council.

Wilson, C. D., and G. W. Boehlert. 1990. The effects of different otolith ageing techniques on estimates of growth and mortality for the splitnose rockfish, *Sebastes diploproa*, and canary rockfish, *S. pinniger*. Calif. Fish Game 76:146-160.

Workman, G. D., N. Olsen, N., and A. R. Kronlund. 1998. Results from a bottom trawl survey of rockfish stocks off the west coast of the Queen Charlotte Islands, September 5 to 23, 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2457. Ottawa.

Tables

Table A.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. elongatus*	Other Slope Rockfish
Harlequin Rockfish	*S. variegatus*	Other Slope Rockfish
Northern Rockfish	*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 A.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 Other Rockfish 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 Prince William Sound 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 Other Rockfish 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 Other Rockfish 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 Other

Species	Distribution	Habitat
	has been well documented throughout this range, unlike many others within the Other Rockfish complex.	Rockfish 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 Other Rockfish complex.	In contrast to most of the Other Rockfish 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 A.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 Other Rockfish 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	2, 3, 10	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.

Species	Mortality Rate	Max Age	Age at Maturity	Size at Maturity	Area	References	Life History
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.
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.

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 A.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 A.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

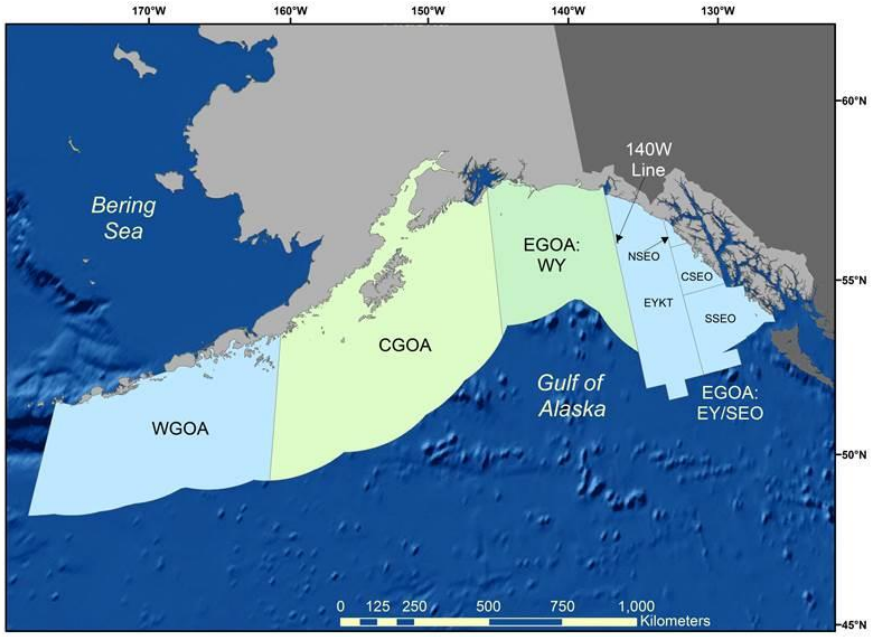
1) Love et al. 1990; 2) Butler et al. 1998; 3) Wilkins et al. 1998; 4) Ralston et al. 1998; 5) Wildermuth 1983; 6) James E. West (unpublished data via Love et al. 2002); 7) Nichol 1990; 8) Rogers et al. 2000; 9) Clausen and Echave 2011; 10) Love et al. 2002; 11) L. Yamanaka (unpublished data via Love 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 Other Rockfish species.

Table A.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})	NA, OR and DSR are Tier 4/5 species, catches for the GOA overall have been below ABC and OFL, regional ABCs have occasionally been exceeded.
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.
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 A.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.

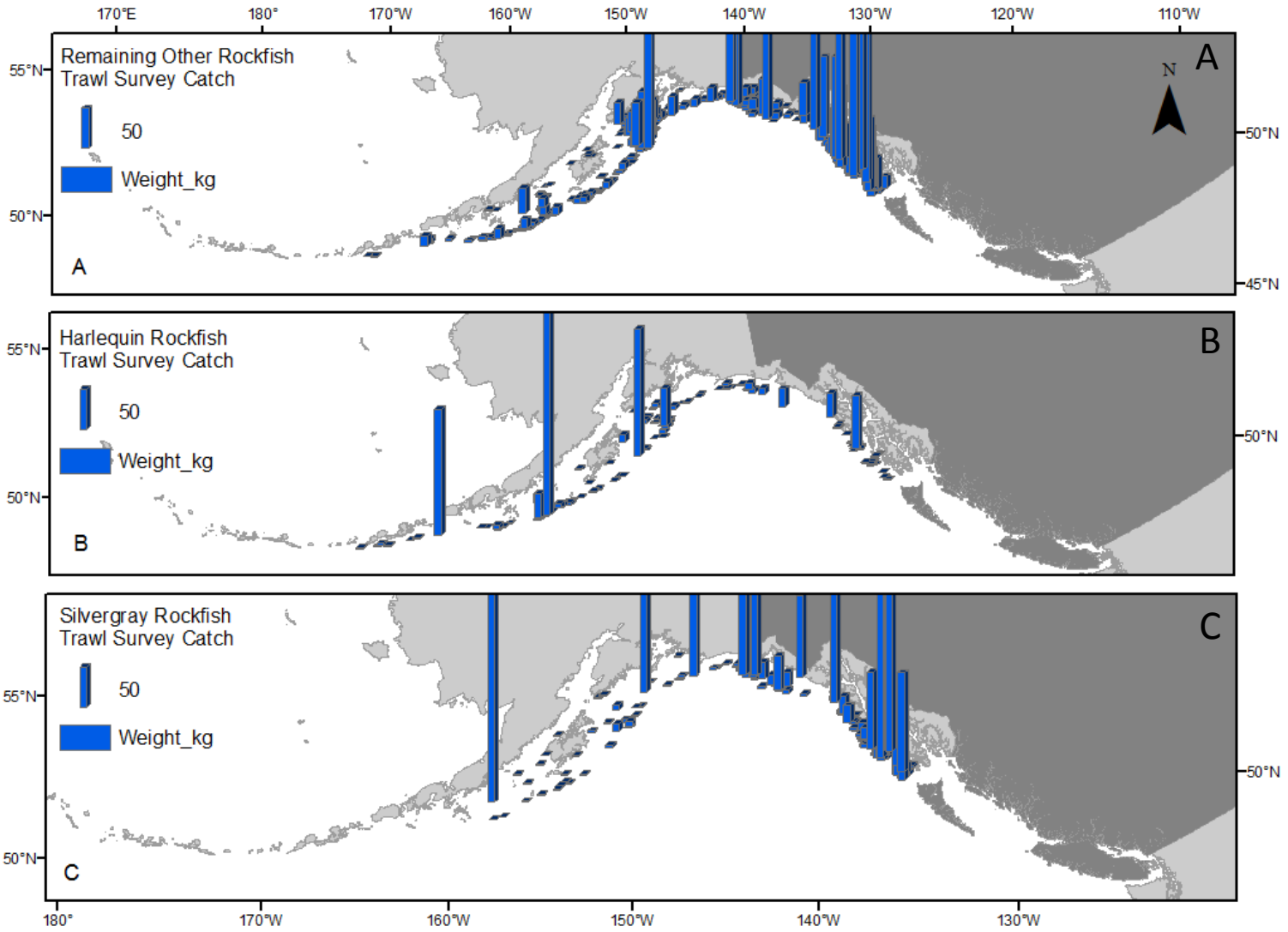


Figure A.2. Spatial distribution of survey catch in the Gulf of Alaska (GOA) from the three most recent National Marine Fisheries Service (NMFS) trawl surveys (2009, 2011, and 2013) for: (A) the Other Rockfish (OR) complex (with the exception of Harlequin and Silvergray Rockfish); (B) Harlequin Rockfish; and (C) Silvergray Rockfish.

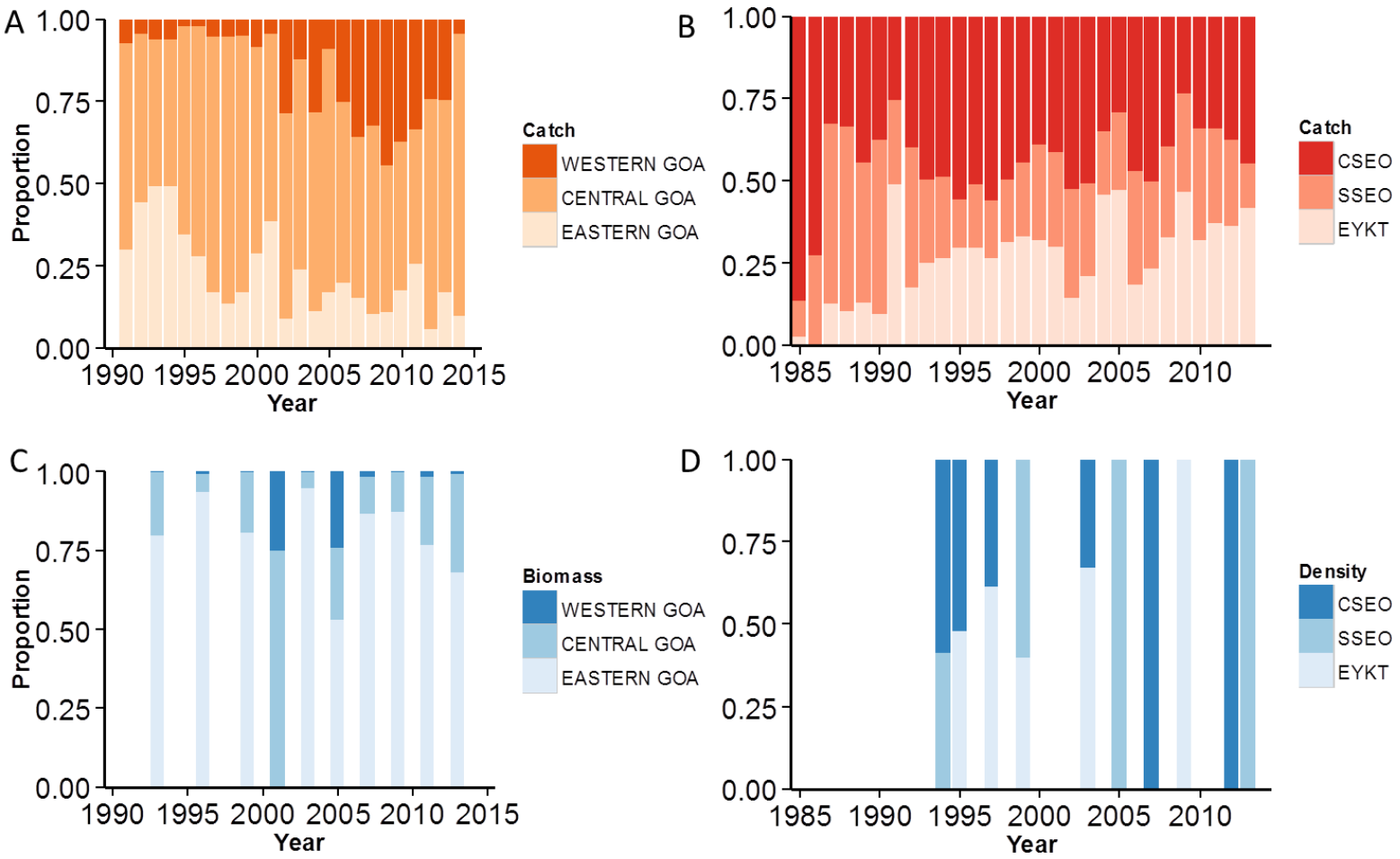


Figure A.3. Proportion of catch by region for (A) Other Rockfish (OR) by Western, Central and Eastern Gulf of Alaska (GOA) regions and (B) Yelloweye Rockfish catch by the Central Southeast Outside (CSEO), Southern Southeast Outdside (SSEO) and East Yakutat (EYKT) sub regions. (C) Proportion of biomass for the OR by Western, Central and Eastern GOA; and (D) proportion of Yelloweye Rockfish density by CSEO, SSEO and EYKT.

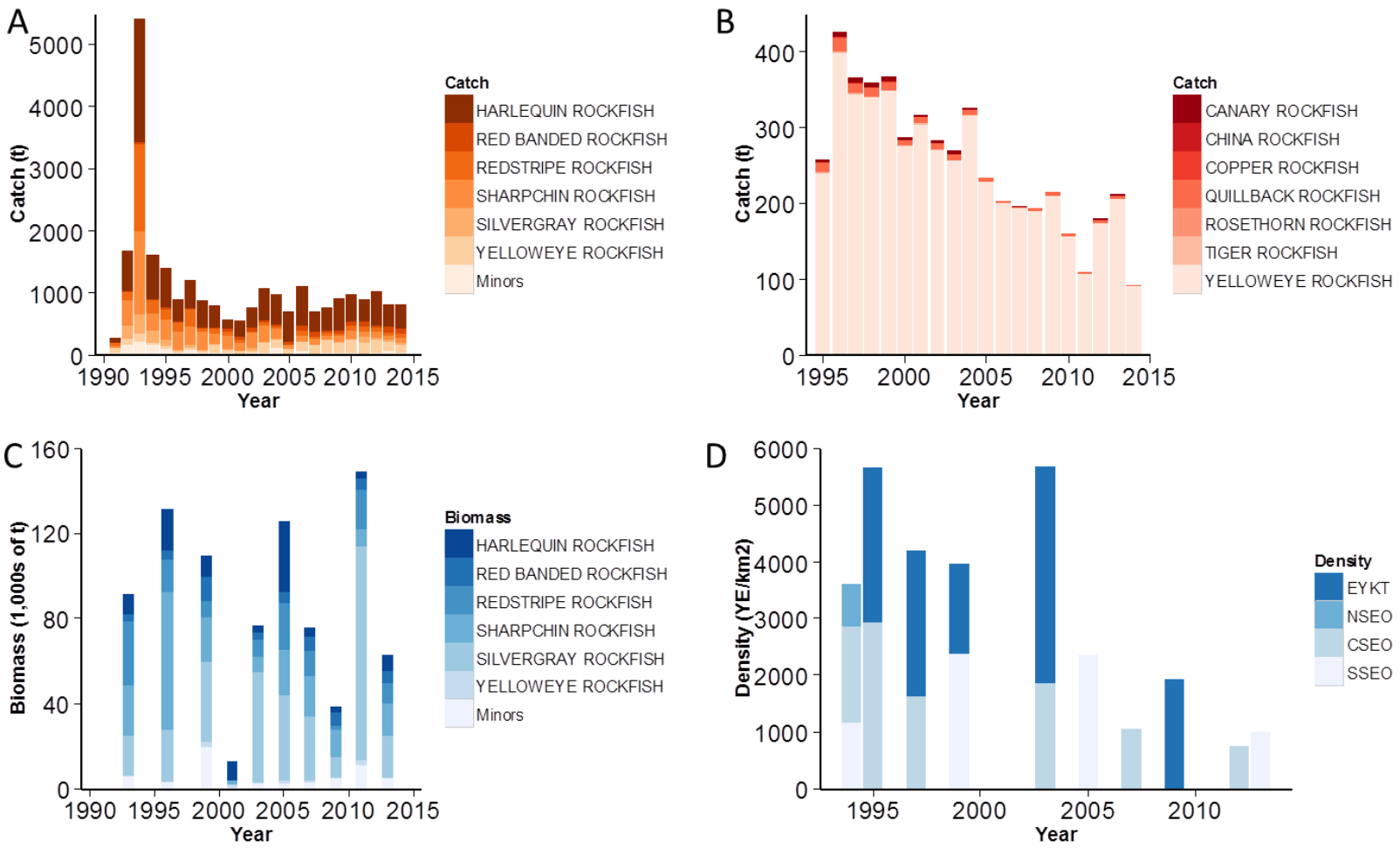


Figure A.4. Catch (t) of the (A) Other Rockfish (OR) complex, six primary species and all other species grouped as "minors"; and (B) Demersal Shelf Rockfish (DSR) complex. Data displayed are from the time series in which estimates of catch by species are available, and are not the same time frame for 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 (ADFG) submersible and ROV surveys.

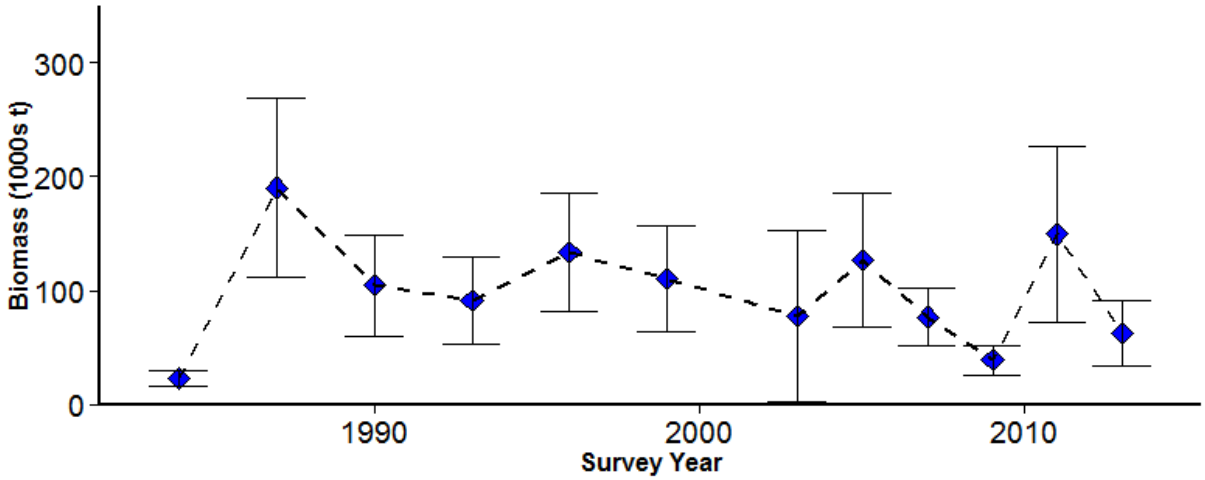


Figure A.5. Biomass (in 1,000s of tons, t) of the Other Rockfish (OR) complex with 95% confidence intervals. The survey biomass from the 2001 survey is not shown because that survey did not include the eastern Gulf of Alaska, the region with the greatest biomass of Other Rockfish.

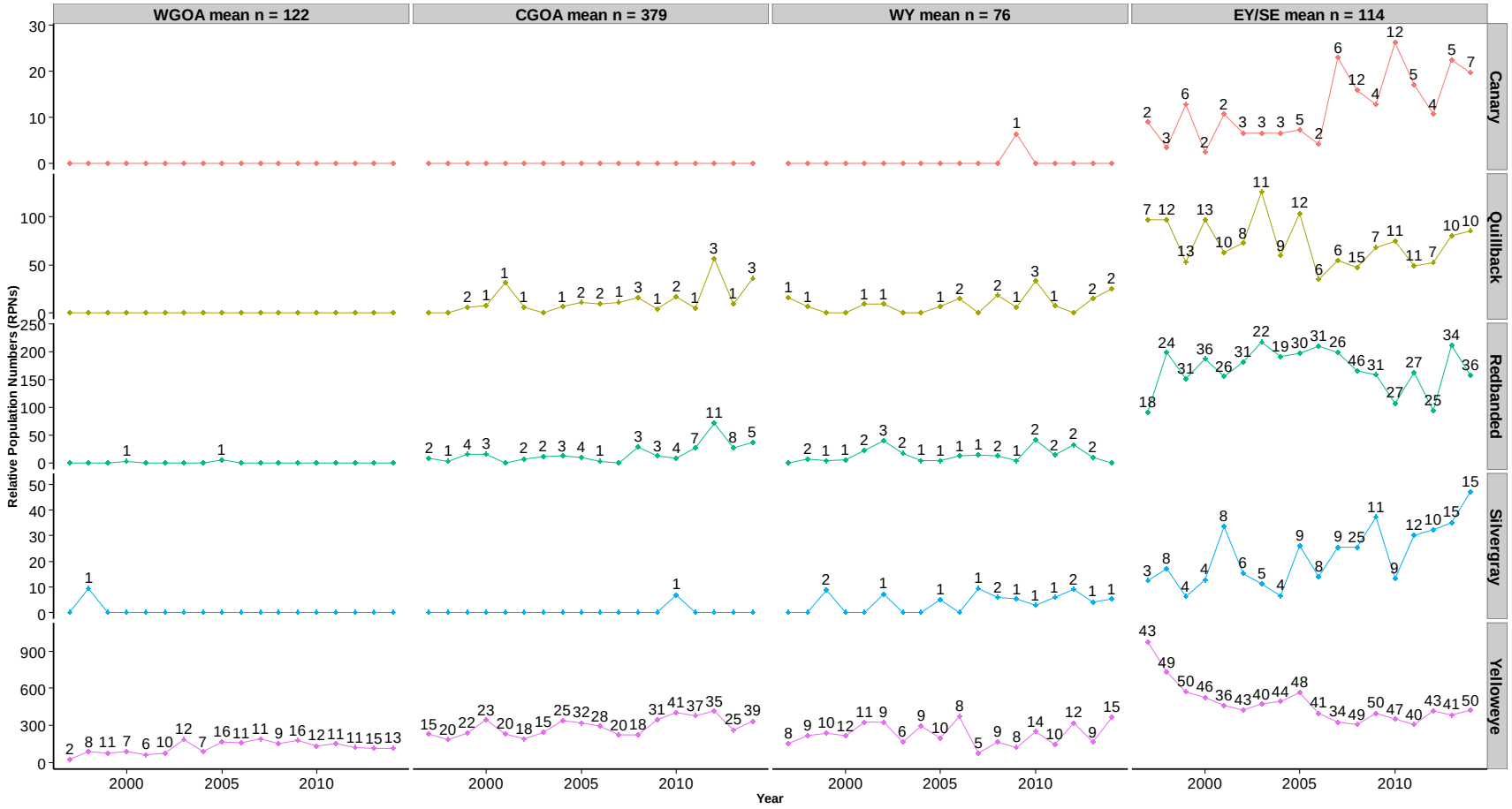


Figure A.6. Relative Population Numbers (RPNs) from the International Pacific Halibut Commission (IPHC) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA), West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO). The mean numbers of stations that occur in each area annually are provided. The numbers above the points represent the number of station in which that species was captured that year.

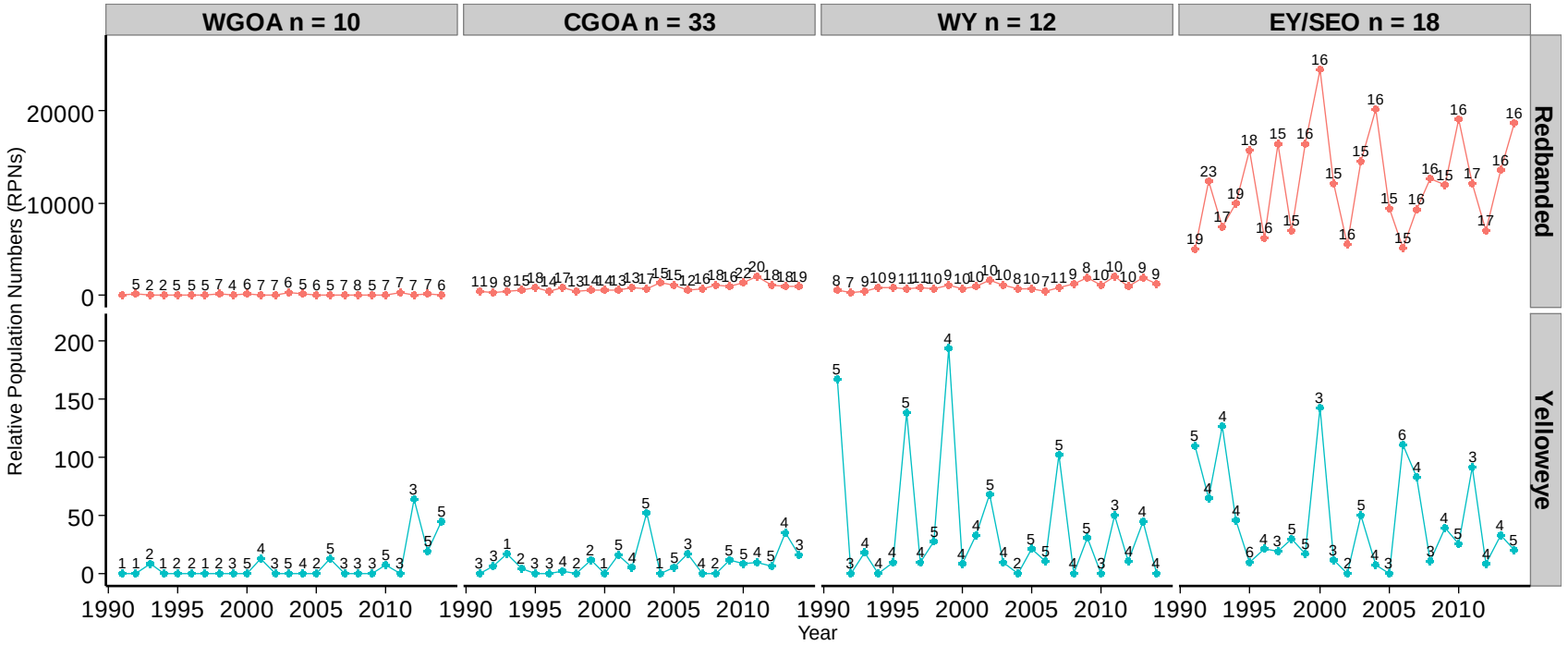


Figure A.7. Relative Population Numbers (RPNs) from the National Marine Fisheries Service (NMFS) annual longline survey for the most commonly caught species of Other Rockfish (OR) and Demersal Shelf Rockfish (DSR). The RPNs are calculated by region: Western Gulf of Alaska (WGOA), Central GOA (CGOA), West Yakutat (WY) and East Yakutat/Southeast Outside (EY/SEO). The numbers of stations that occur in each area annually are provided. The numbers above the points represent the number of station in which that species was captured that year.

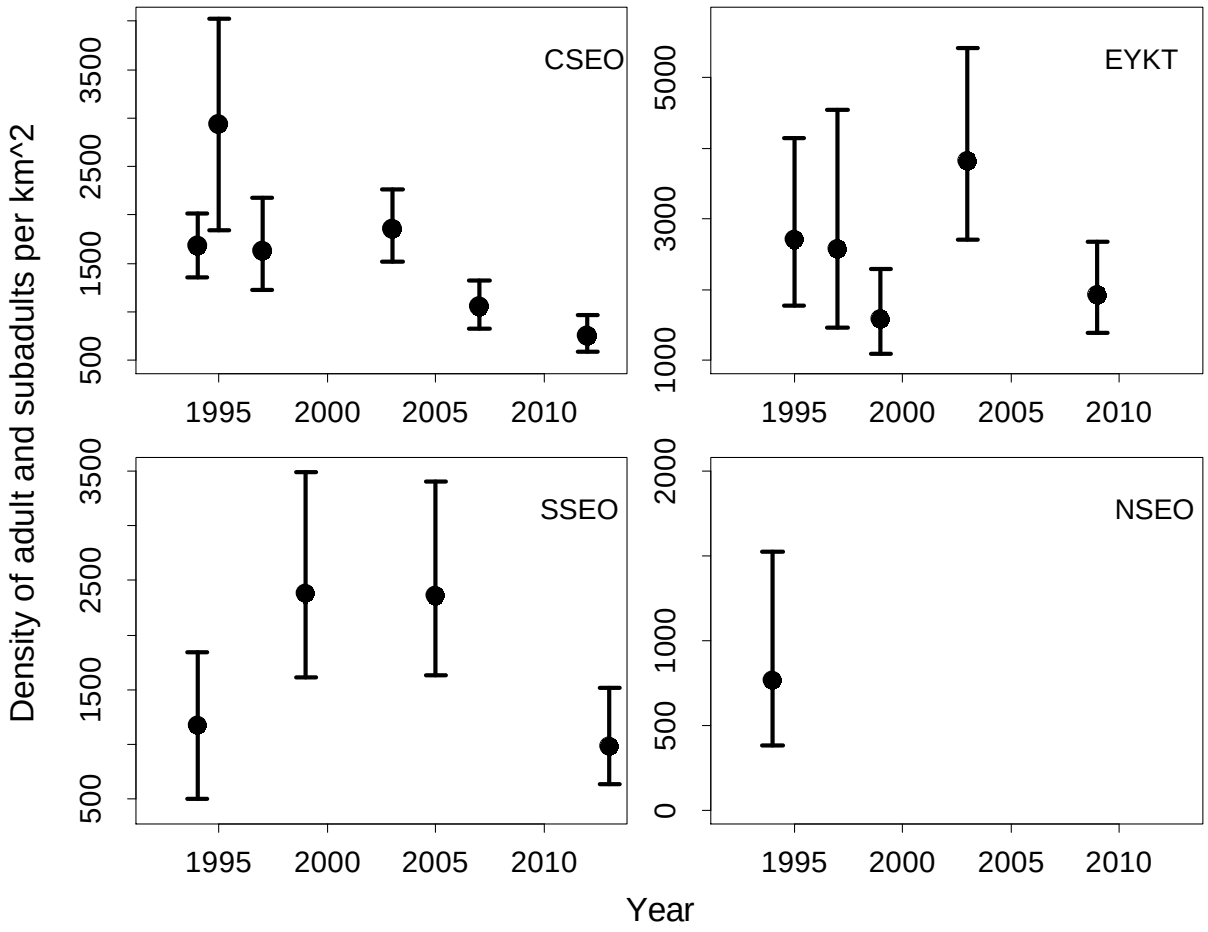


Figure A.8. Density (adults and sub-adults per square kilometer) of Yelloweye Rockfish predicted by DISTANCE (squares) +/- two standard deviations in each management area (East Yakutat (EYKT), Central Southeast Outside (CSEO), Northern Southeast Outside (NSEO), and Southern Southeast Outside (SSEO)).

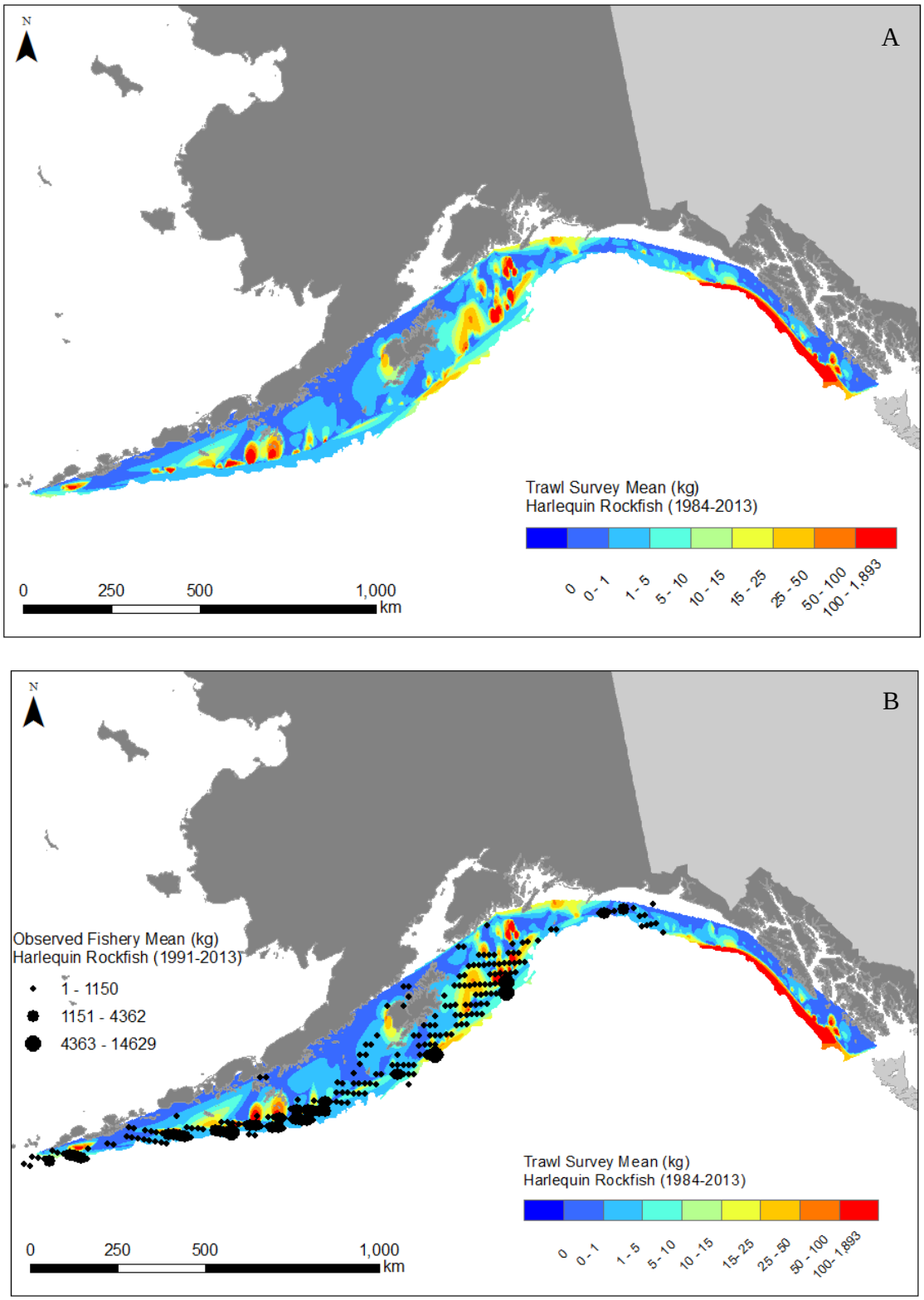


Figure A.9. Distribution maps of Harlequin Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

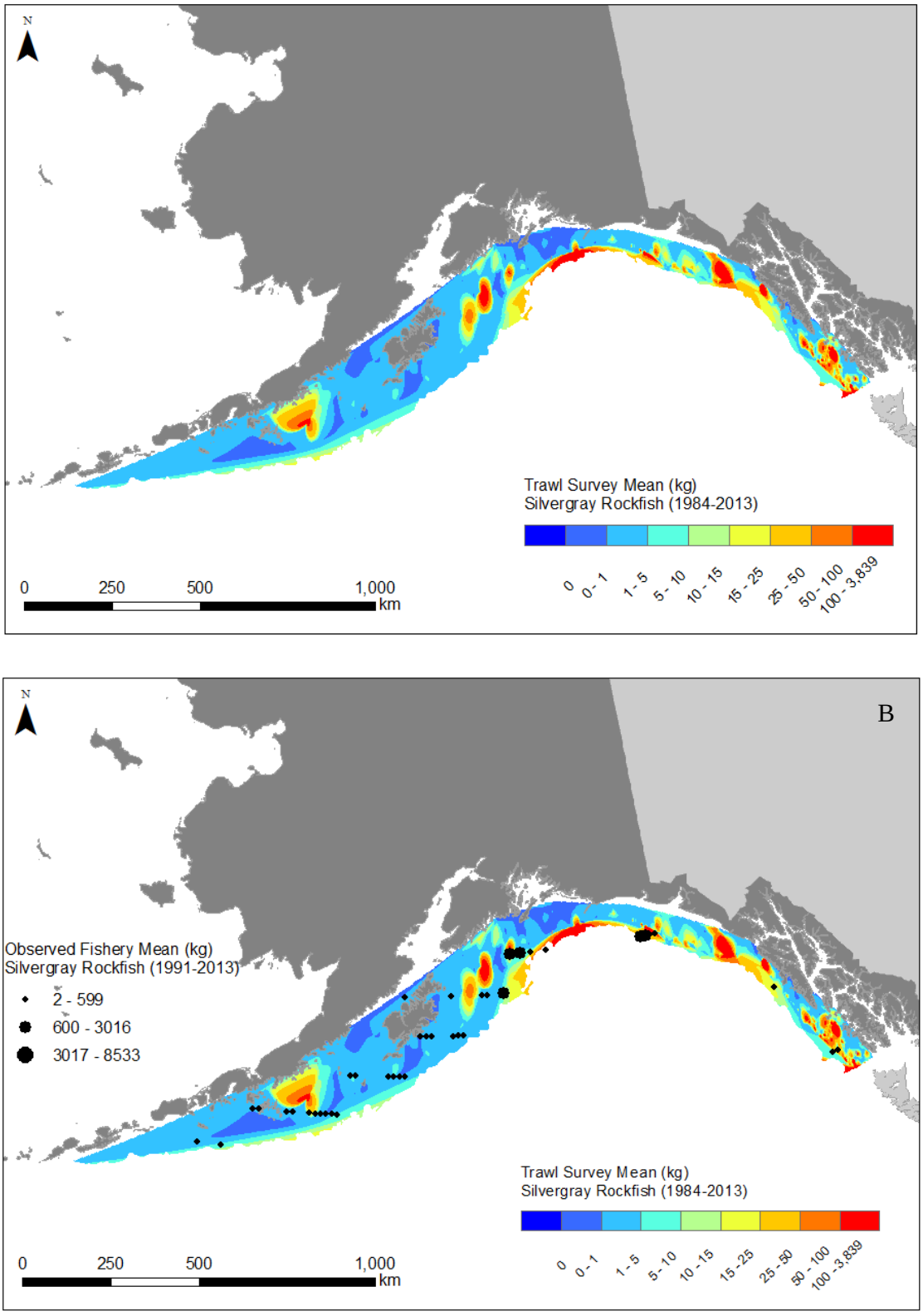


Figure A.10. Distribution maps of Silvergray Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

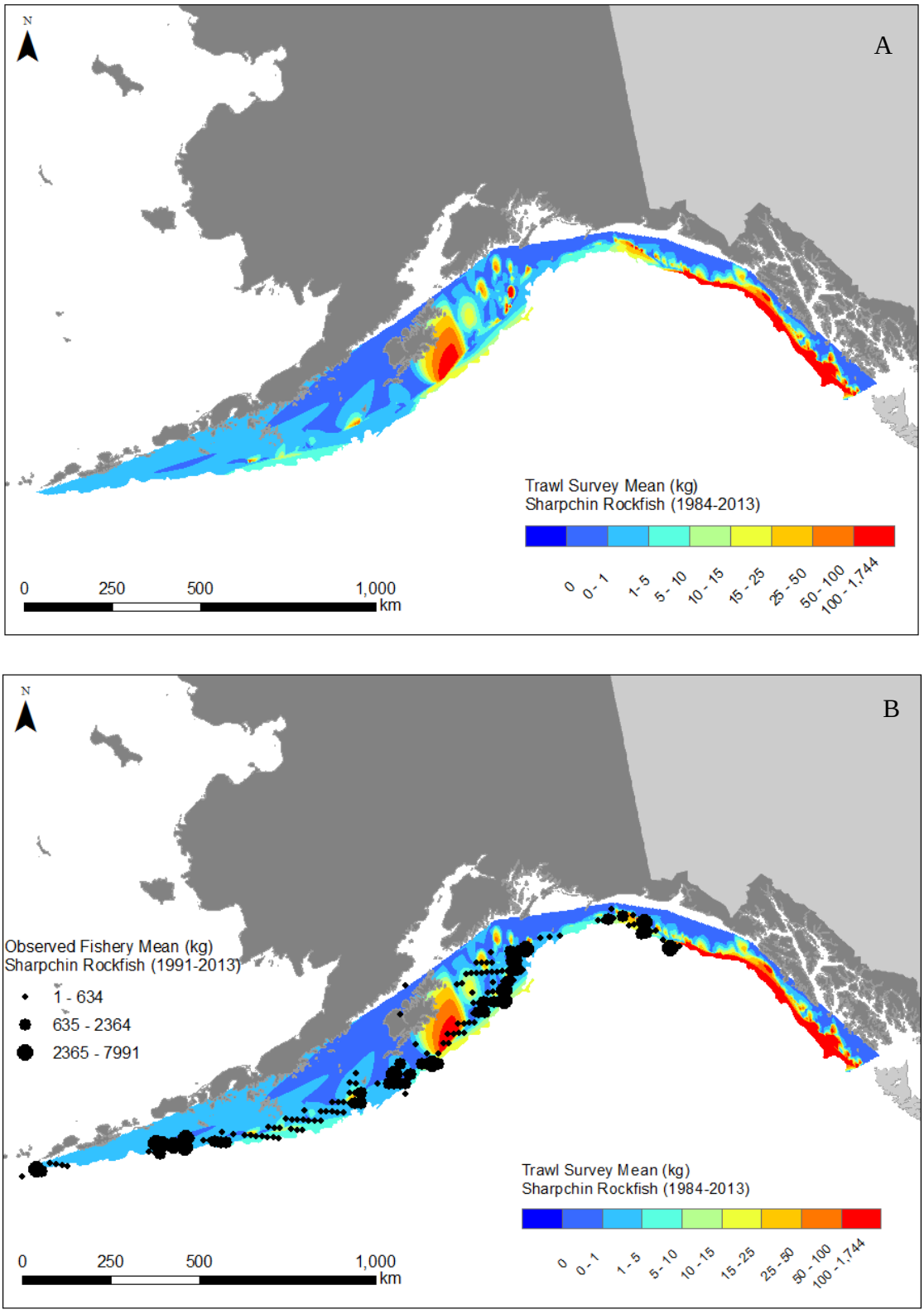


Figure A.11. Distribution maps of Sharpchin Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

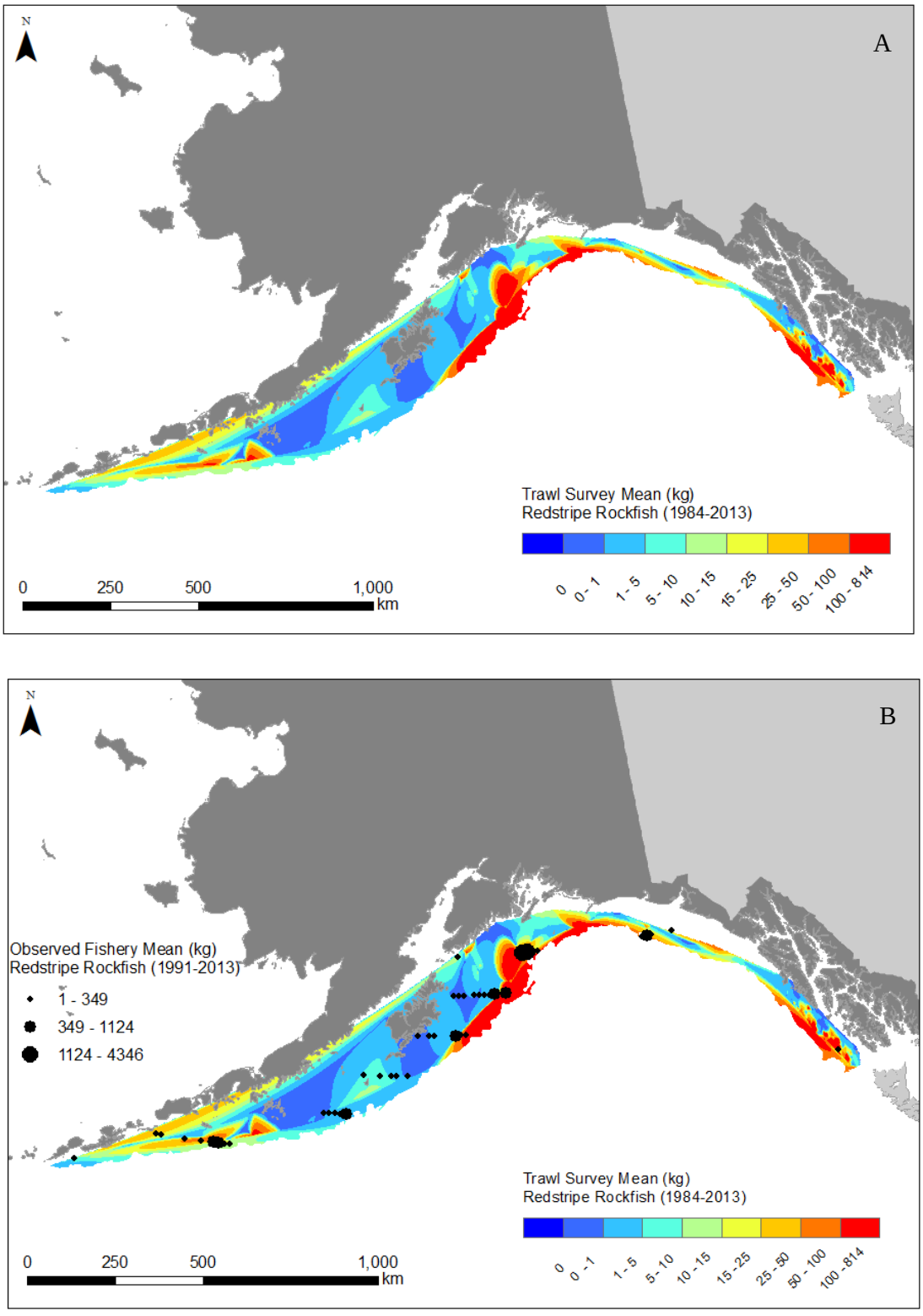


Figure A.12. Distribution maps of Redstripe Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

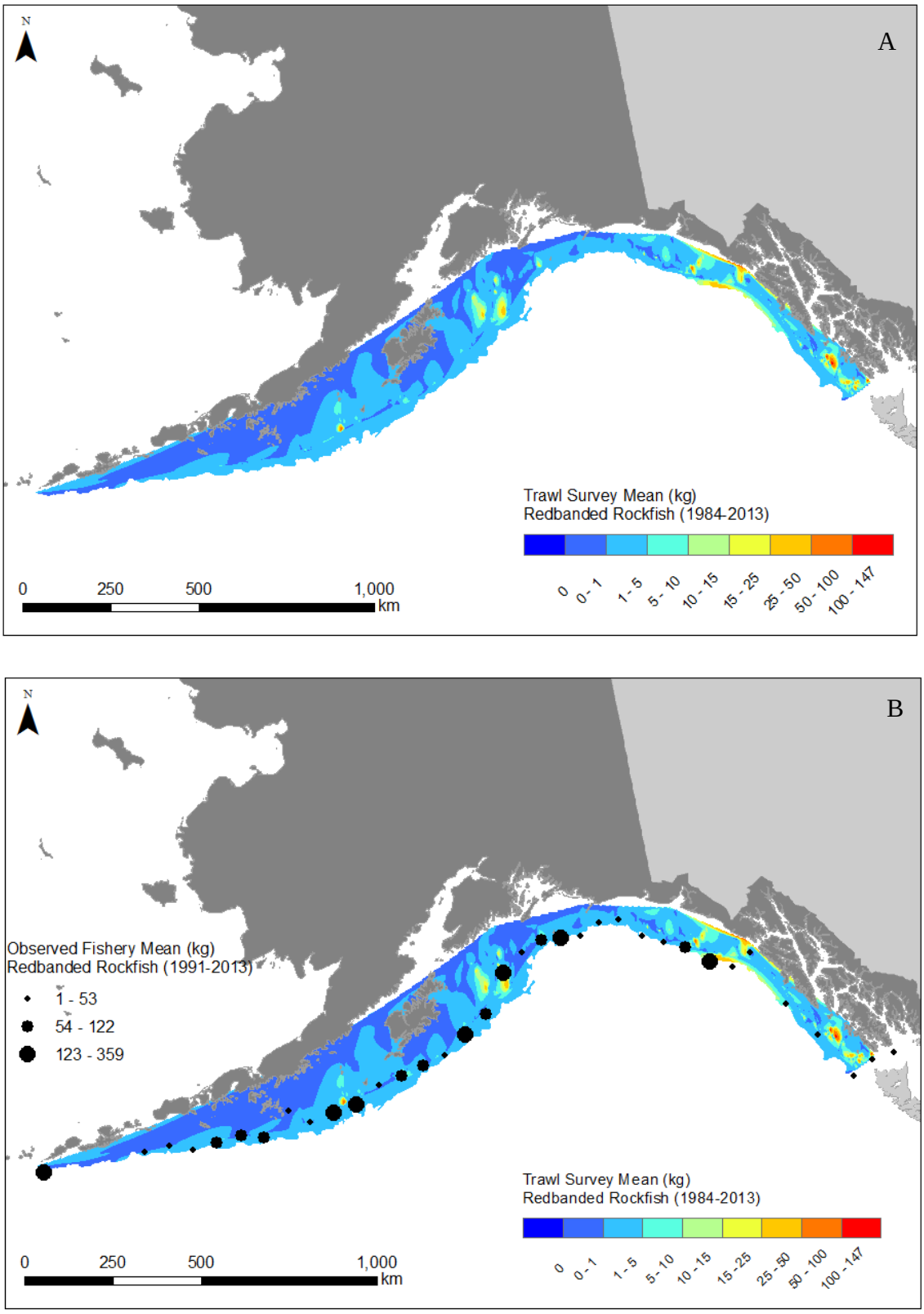


Figure A.13. Distribution maps of Redbanded Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions.

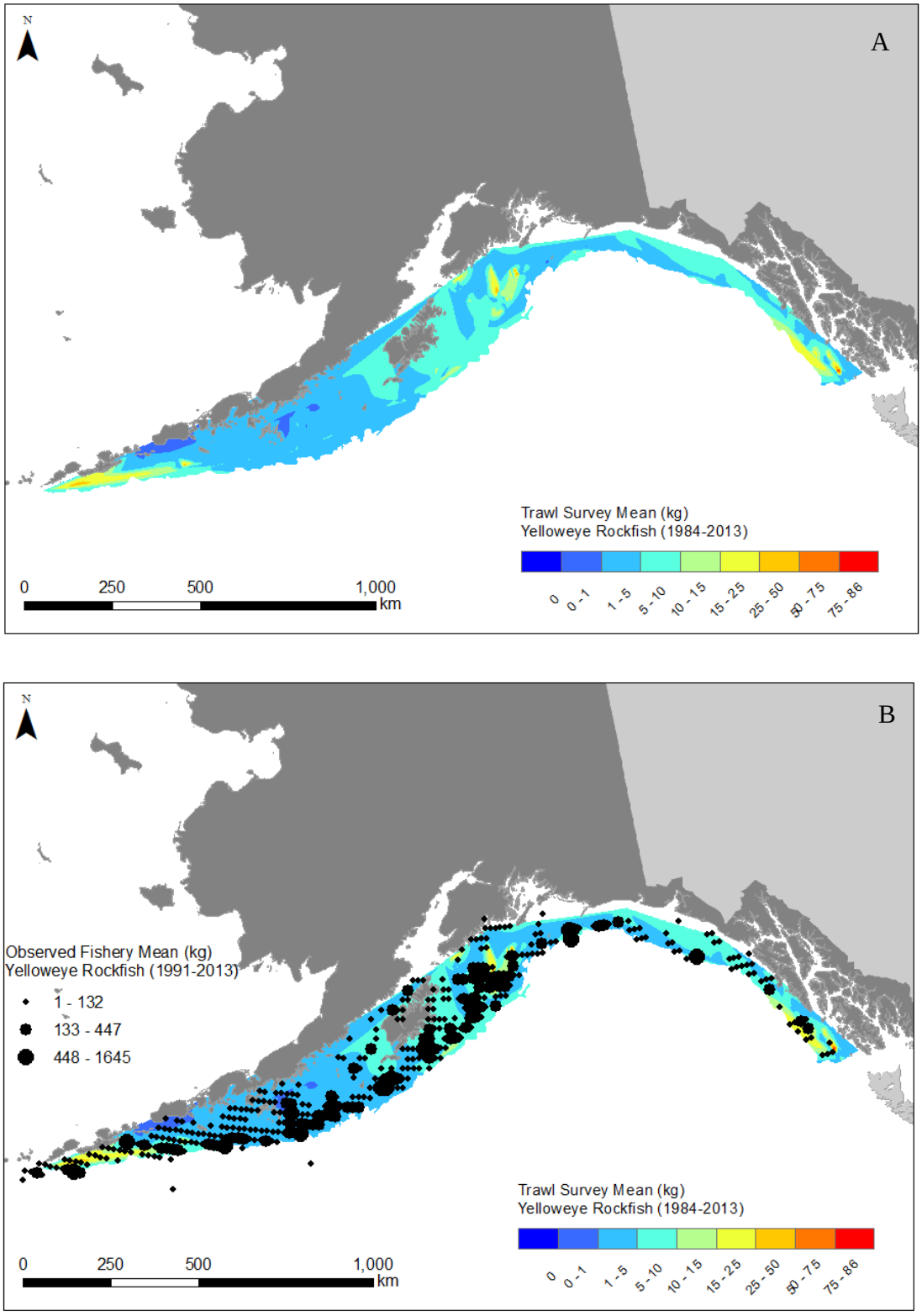


Figure A.14. Distribution maps of Yelloweye Rockfish (A) trawl survey mean conditions from 1984 – 2013 and (B) observed fishery catch mean (1993 – 2013) with trawl survey mean conditions. Catch in the East Yakutat/Southeast Outside (EY/SEO) only represents catch estimates available through the Alaska Regional Office and does not include the state managed fisheries.

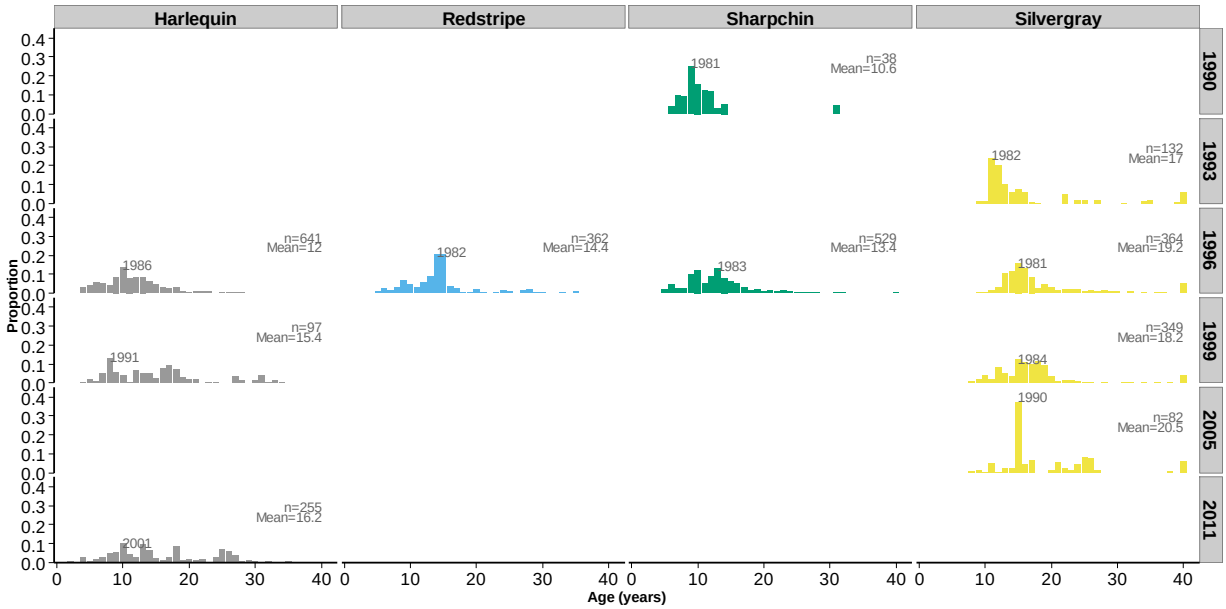


Figure A.15. Age compositions of Harlequin, Redstripe, Sharpchin and Silvergray Rockfish from the Gulf of Alaska (GOA) National Marine Fisheries (NMFS) bottom trawl survey. Sample size and mean age are presented for each species and survey year with age compositions available. The birth year of the largest cohort is labeled as well.

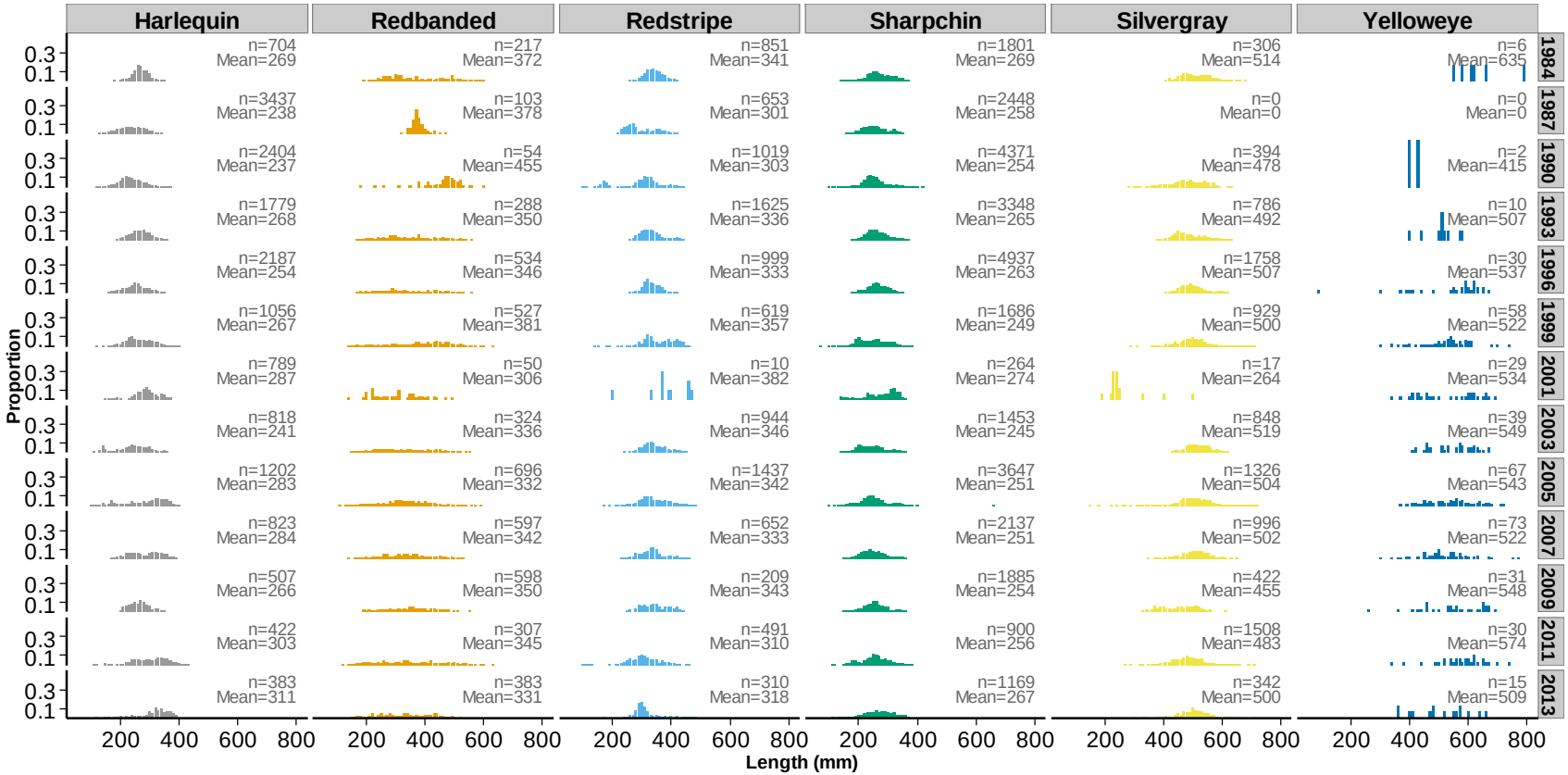


Figure A.16. Size composition of the primary Other Rockfish (OR) species from the National Marine Fisheries Service (NMFS) bottom trawl survey. Sample size and mean length (mm) are presented for each of the primary species and survey year.

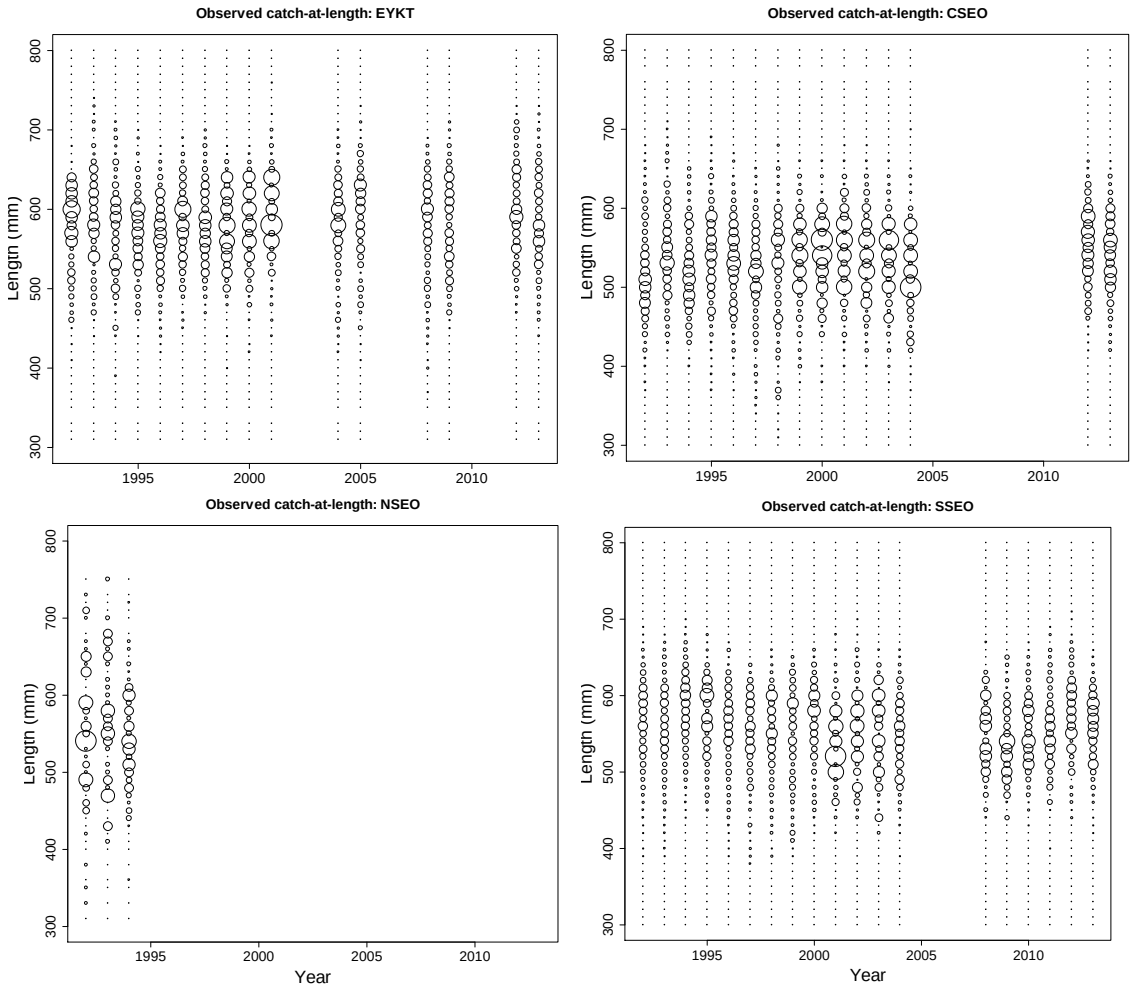


Figure A.17. Length compositions of Yelloweye Rockfish captured in the directed fishery in East Yakutat (EYKT), Central Southeast Outside (CSEO), Norther Southeast Outside (NSEO), and Southern Southeast Outside (SSEO).

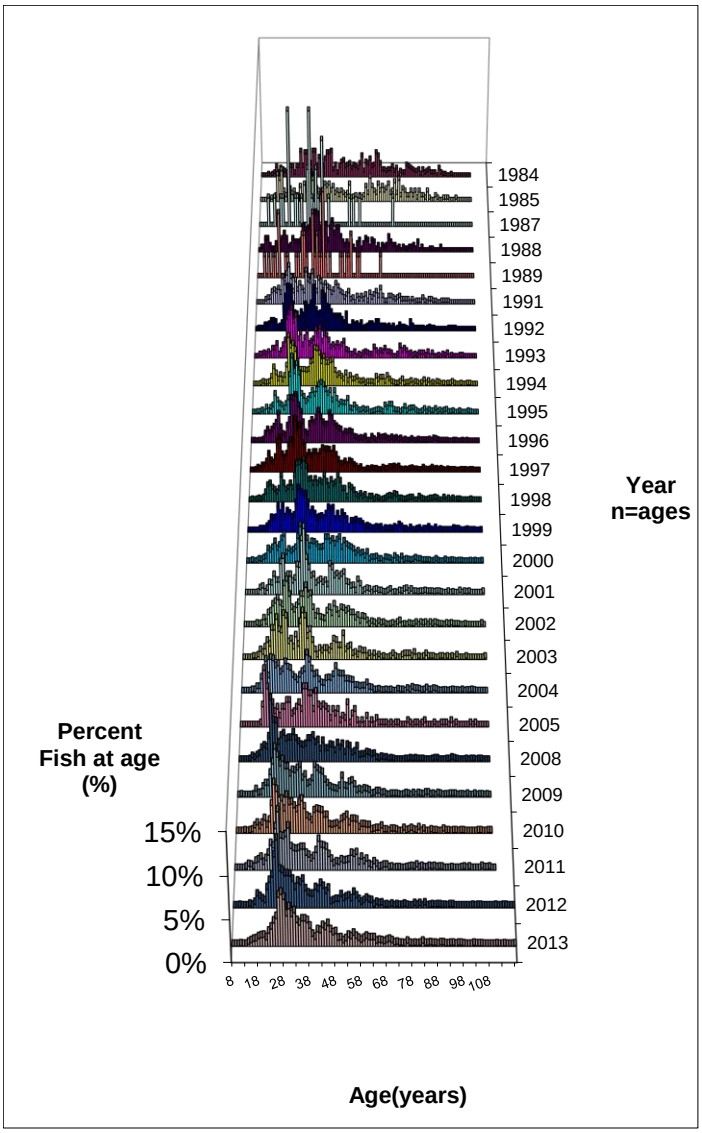


Figure A.18. Age (years) frequency histogram from Yelloweye Rockfish in the East Yakutat/Southeast Outside (EY/SEO) landed in both the commercial directed fishery and as incidental catch in the Pacific Halibut IFQ fishery from 1984 through 2013.