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Stock assessment of the yelloweye rockfish (*Sebastes ruberrimus*) in state and Federal waters off California, Oregon and Washington

by

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Acronyms used in this document

ABC	Allowable Biological Catch
ACL	Annual Catch Limit
ADFG	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
A-SHOP	At-Sea Hake Observer Program
CalCOM	California Cooperative Groundfish Survey
CDFW	California Department of Fish and Wildlife
CPFV	Commercial Passenger Fishing Vessel
CRFS	California Recreational Fisheries Survey
DFO	Canada's Department of Fisheries and Oceans
IFQ	Individual Fishing Quota
IPHC	International Pacific Halibut Commission
MRFSS	Marine Recreational Fisheries Statistics Survey
NMFS	National Marine Fisheries Service
NORPAC	the North Pacific Database Program
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
OFL	Overfishing Limit
ORBS	Oregon Recreational Boat Survey
OY	Optimum Yield
PacFIN	Pacific Fisheries Information Network
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
RecFIN	Recreational Fisheries Information Network
SPR	Spawning Potential Ratio
SSC	Scientific and Statistical Committee
SWFSC	Southwest Fisheries Science Center
WCGOP	West Coast Groundfish Observer Program
WDFW	Washington Department of Fish and Wildlife

Executive Summary

Stock

This assessment reports the status of the yelloweye rockfish (*Sebastes ruberrimus*) resource off the coast of the United States from southern California to the U.S. - Canadian border using data through 2016. The species is modeled as a single stock, but with two explicit spatial areas: waters off California (area 1) and waters off Oregon and Washington (area 2). Each area has its own unique catch history and fishing fleets (commercial and recreational), but the areas are linked by a common stock-recruit relationship.

Catches

Yelloweye rockfish have historically been a prized catch in both commercial and recreational fisheries. Commercially, they have been caught by trawl and hook-and-line gear types (Figure ES-1). They have generally yielded a higher price than other rockfish and have largely been retained when encountered. Catches of yelloweye rockfish increased gradually throughout the first half of the 20th century, with a brief peak around World War II due to increased demand. The largest removals of the species occurred in the 1980s and 1990s and reached 552 mt in 1982.

After 2002 (when yelloweye were declared overfished), total catches have been maintained at much lower levels (Table ES-1). Currently, yelloweye are caught only incidentally in commercial and sport fisheries targeting other species that are found in association with yelloweye. The recent fishery encounters a very patchy yelloweye rockfish distribution, and extensive effort is made to avoid all but a small amount of bycatch.

Table ES-1: Recent yelloweye rockfish catches within each fleet used in the assessment (landings and discard combined).

Years	CA trawl (mt)	CA non-trawl (mt)	CA sport (mt)	OR-WA trawl (mt)	OR-WA non-trawl (mt)	OR sport (mt)	WA sport (mt)	WA sport (1000s fish)	Total Catch (mt)
2007	0	0.93	4	0.09	3.68	1.82	2.31	0.957	12.83
2008	0.02	0.64	1	0.16	3.43	2.1	1.95	0.807	9.29
2009	0.02	0.19	5	0.09	2.18	2.3	1.91	0.796	11.69
2010	0.06	0.04	1	0.08	0.86	2.41	2.27	0.952	6.72
2011	0	0.2	2	0.06	1.21	2.54	2.33	0.985	8.34
2012	0	0.88	2	0.06	1.91	3.05	3.26	1.383	11.16
2013	0.01	0.56	1	0.11	2.94	3.54	2.24	0.954	10.4
2014	0.06	0.02	1	0.03	2.16	2.64	2.91	1.241	8.81
2015	0	0.4	2	0.03	3.15	3.56	2.87	1.226	12.02
2016	0	0	1	0.07	2.59	2.68	3.24	1.382	9.59

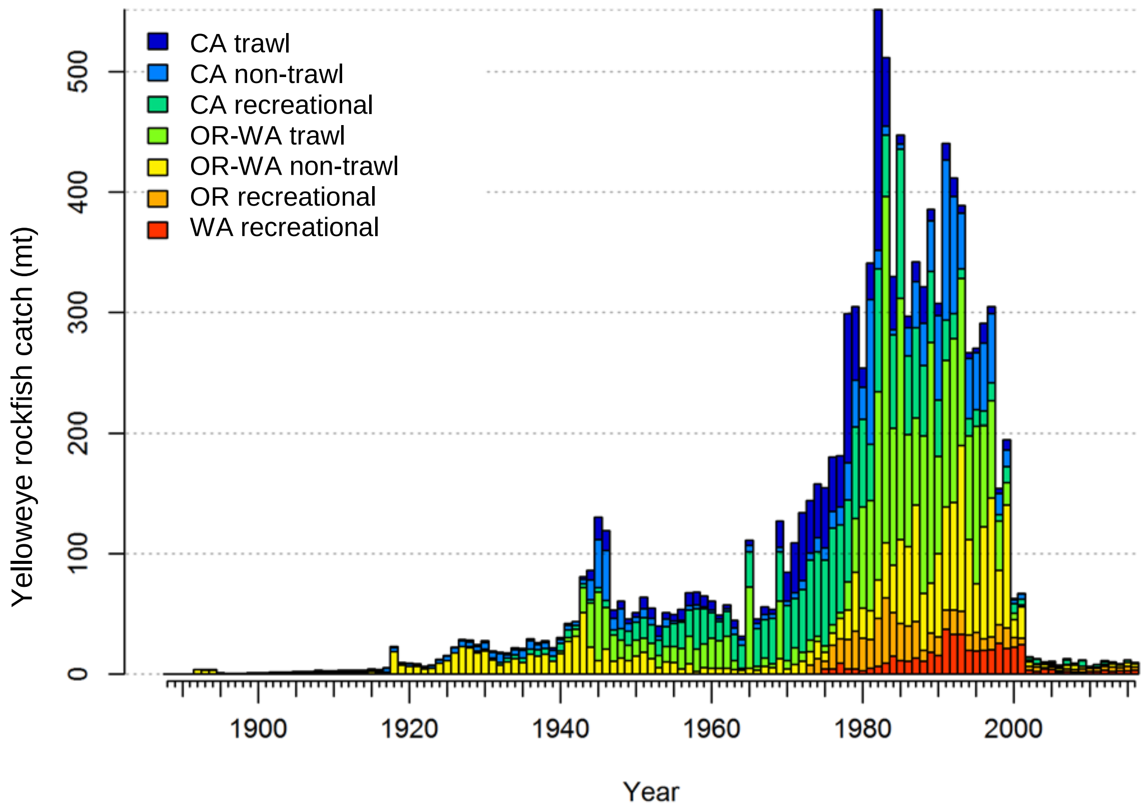

Figure ES-1: Yelloweye rockfish catch history between 1889 and 2016 by fleet.

Data and assessment

The last full stock assessment of yelloweye rockfish was conducted in 2009 and it was subsequently updated in 2011. This assessment uses the Stock Synthesis modeling framework (version 3.30.04.02, released June 2, 2017).

The assessed period begins in 1889, when the very first catch records are available for the stock, with the assumption that previously the stock was in an unfished equilibrium condition. Types of data that inform the model include catch, length and age frequency data from seven commercial and recreational fishing fleets. Fishery-dependent biological data used in the assessment originated from both port-based and on-board observer sampling programs. Recreational observer data from Oregon and California were used to construct indices of relative abundance. Yelloweye rockfish catch in the International Pacific Halibut Commission's (IPHC) long-line survey is also included via an index of relative abundance for Washington and Oregon; IPHC length and age frequency data are also used. Relative biomass indices and information from biological sampling from trawl surveys were included as well; these trawl surveys were conducted by the Northwest Fisheries Science Center (NWFSC) and the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS).

The previous assessment modeled three areas that corresponded to waters off California, Oregon and Washington. The choice to model the yelloweye rockfish stock with explicit areas is based on the fact that adult yelloweye have a sedentary life history; at the same time, exploitation rates among areas have been different over the years. In combination, these two factors could have contributed to different trends in abundance among areas and localized depletion. This assessment includes two areas (California and Oregon-Washington). Oregon vessels, particularly those from northern ports, frequently fish in waters off Washington but return to Oregon to land their catch. The same is true to some degree for Washington vessels as well. This issue has become more apparent in recent years, as larger, interagency catch reconstruction efforts have been made. It is infeasible at present to consistently assign removals and biological data landed in Oregon and Washington to area of catch (i.e. Oregon or Washington) with acceptable precision. Oregon and Washington were combined into one area because of this.

Growth is assumed to follow the von Bertalanffy growth model, and the assessment explicitly estimates all parameters describing somatic growth. Females and males in the model are combined, since estimates of growth parameters did not differ between sexes. Externally estimated life history parameters, including those defining the length-weight relationship, female fecundity and maturity schedule were revised for this assessment to incorporate new information. Recruitment dynamics are assumed to follow the Beverton-Holt stock-recruit function, and recruitment deviations are estimated. Natural mortality and stock-recruitment steepness are fixed at the values generated from meta-analytical studies.

Stock biomass

The yelloweye rockfish assessment uses estimates of the egg-to-length relationship from Dick et al. (2017), and spawning output is reported in millions of eggs. The unexploited level of spawning stock output is estimated to be 1,139 million eggs (95% confidence interval: 1,007-1,271 million eggs) (Figure ES-2). At the beginning of 2017, the spawning stock output is estimated to be 323 million eggs (95% confidence interval: 252–394 million eggs), which represents 28.4% of the unfished spawning output level. The biomass in Oregon and Washington is estimated to be larger than in California (Figure ES-3).

The spawning output of yelloweye rockfish started to decline in the 1940s. The species have been lightly exploited until the mid-1970s, when catches increased and a rapid decline in biomass and spawning output began. The relative spawning output reached a minimum of 14.2% of unexploited levels in 2000. Yelloweye rockfish spawning output has been gradually increasing since then in response to large reductions in harvest.

Table ES-2: Recent trends in estimated yelloweye rockfish spawning output, recruitment and relative spawning output.

Years	Spawning Output (million eggs)	~95% Asymptotic Interval	Recruitment	~95% Asymptotic Interval	Estimated Depletion (%)	~95% Asymptotic Interval
2007	210	160–260	200	98–407	18.4	14.9–21.9
2008	219	167–270	307	161–583	19.2	15.5–22.8
2009	228	174–281	226	111–460	20	16.2–23.7
2010	237	182–292	240	120–482	20.8	16.9–24.6
2011	247	190–304	227	111–468	21.7	17.7–25.7
2012	258	199–317	115	52–252	22.6	18.5–26.7
2013	269	208–331	117	52–264	23.6	19.4–27.9
2014	282	218–345	121	51–288	24.7	20.4–29.1
2015	295	229–361	141	57–347	25.9	21.4–30.4
2016	309	240–377	174	68–442	27.1	22.5–31.7
2017	323	252–394	176	69–448	28.4	23.6–33.1

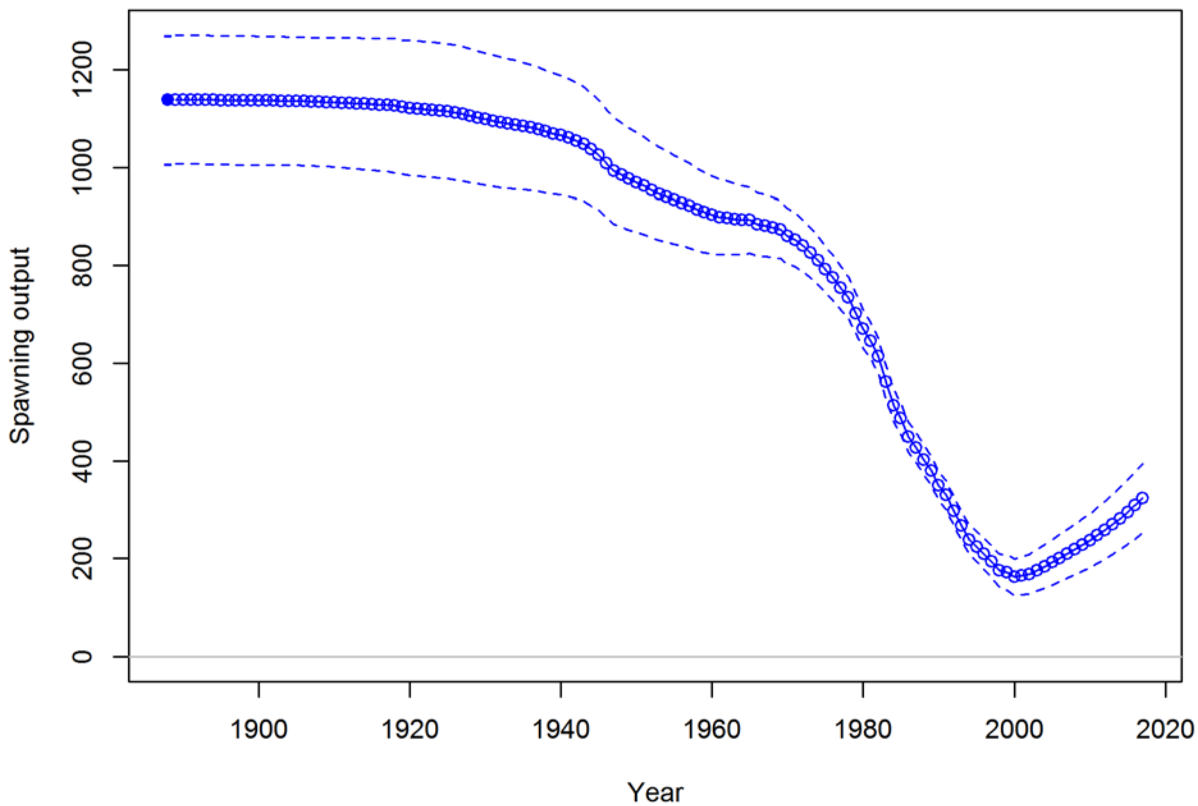

Figure ES-2: Time series of estimated spawning output (in million eggs) for the base model (circles) with ~ 95% interval (dashed lines). Spawning output is expressed in million eggs.

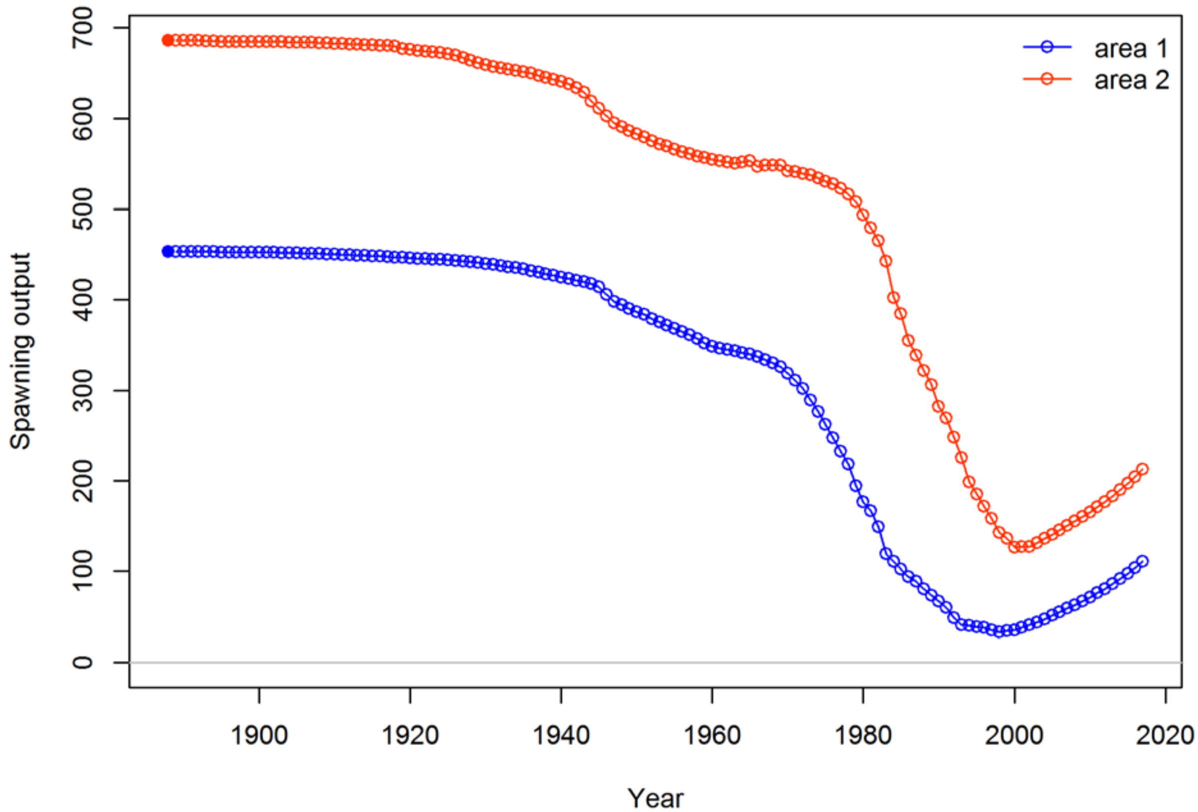

Figure ES-3. Time series of estimated spawning output (in million eggs) by area (Area 1 (lower line) = California; Area 2 (upper line) = Oregon and Washington).

Recruitment

Recruitment dynamics are assumed to follow Beverton-Holt stock-recruit function that includes an updated value of the steepness parameter (*h*). The steepness parameter was inestimable, and, therefore, it is fixed at the value of 0.718, which is the mean of steepness prior probability distribution, derived from this year's meta-analysis of Tier 1 rockfish assessments. The level of virgin recruitment (R_0) is estimated to inform the magnitude of the initial stock size. 'Main' recruitment deviations were estimated for modeled years that had information about recruitment, between 1980 and 2015. We additionally estimated 'early' deviations between 1889 and 1979. Peak recruitment events were estimated in years 1971, 1982, 2002, 2008 and 2009 (Figure ES-4). Both areas follow similar recruitment trends, as the overall recruitment pool is distributed between the two areas at an estimated constant fraction (60% to Oregon-Washington and 40% to California; Figure ES-5).

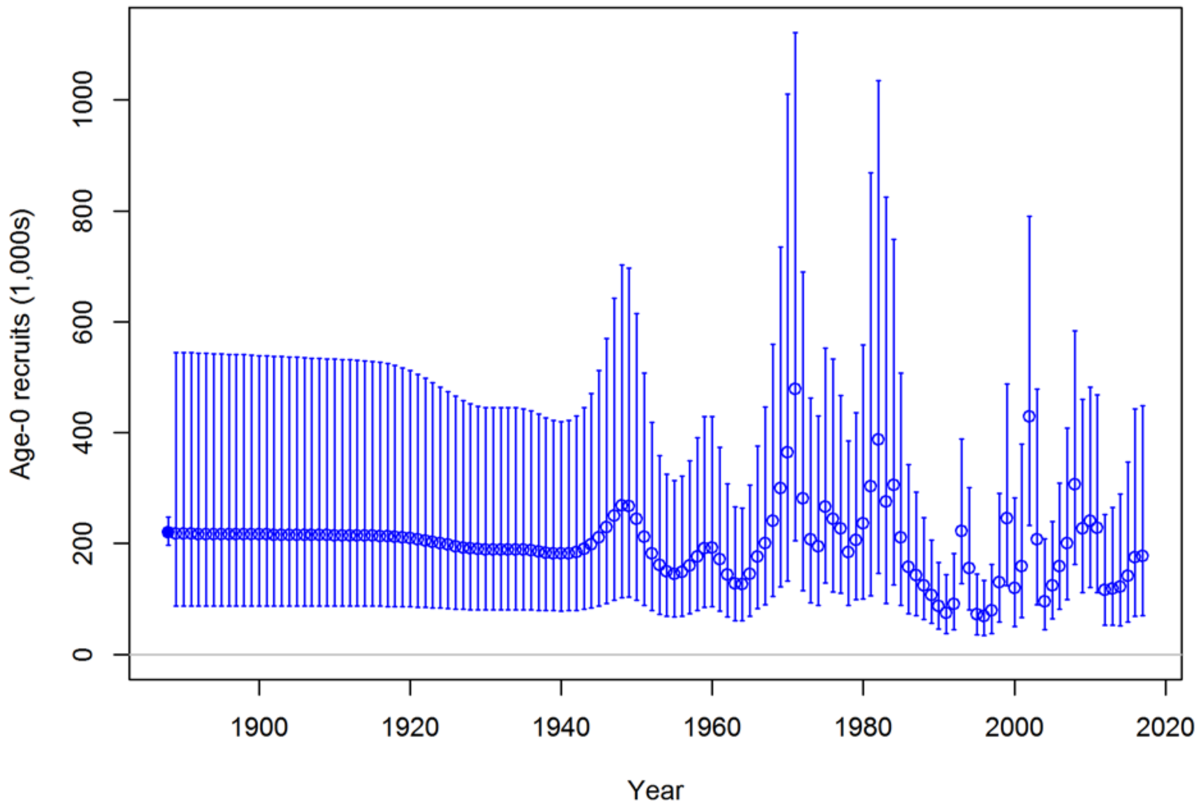

Figure ES-4: Time series of estimated yelloweye rockfish recruitments for the base model (circles) with approximate 95% intervals (vertical lines).

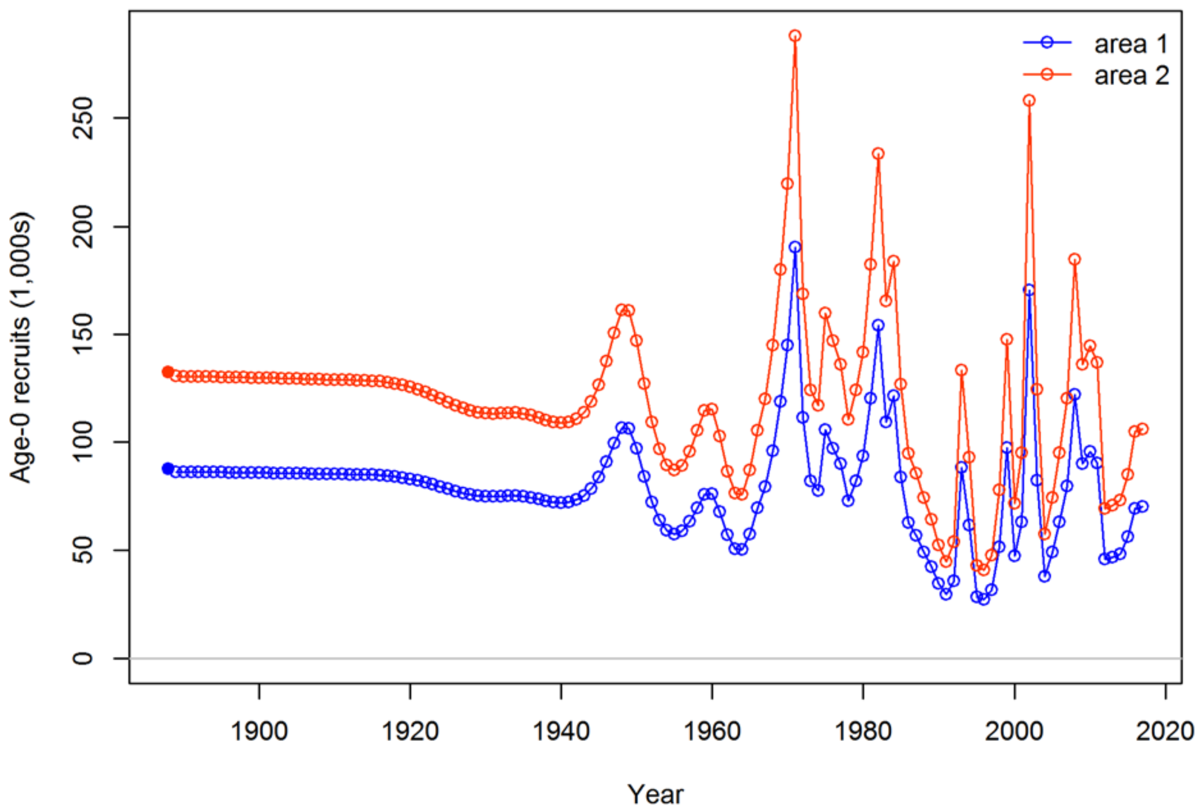

Figure ES-5 Time series of estimated yelloweye rockfish recruitments for each area of the base model. Area 1 (lower line) = California; Area 2 (upper line) = Oregon and Washington.

Exploitation status

This assessment estimates that the stock of yelloweye rockfish off the continental U.S. Pacific Coast is currently at 28.4% of its unexploited level (Figure ES-6). This is above the overfished threshold of $SB_{25\%}$, but below the management target of $SB_{40\%}$ of unfished spawning output. Both areas are above the overfished level of 25% (Figure ES-7). This is 7.4 percent higher than the estimated relative spawning output of 21.0% from the previous assessment, conducted in 2011.

This assessment estimates that historically, the coastwide spawning output of yelloweye rockfish dropped below the $SB_{40\%}$ target for the first time in 1986, and below the $SB_{25\%}$ overfished threshold in 1993 as a result of intense fishing by commercial and recreational fleets. It continued to decline, and dipped to 14.2% of its unfished output in 2000. In 2002, the stock was declared overfished. Since then, the spawning output is slowly increasing due to management regulations implemented for this and other overfished rockfish species.

This assessment estimates that the Spawning Potential Ratio (SPR) for 2016 was 91%. The SPR used for setting the OFL is 50%, while the SPR-based management fishing mortality target specified in the current yelloweye rockfish rebuilding plan and used to determine the Annual Catch Limit (ACL) is 76%. Relative exploitation rates (calculated as catch/biomass of age-8 and older fish) are estimated to have been below 1% during the last decade (Figure ES-8). As estimated for the historical period, the yelloweye rockfish was fished at a rate above the relative SPR ratio target (calculated as 1-SPR/1-$SPR_{Target=0.5}$) between 1977 and 2000 (Figure ES-9).

Table ES-3. Recent trend in relative spawning potential ratio and summary exploitation rate (catch divided by biomass of age-8 and older fish).

Years	Estimated (1-SPR)/(1-SPR_50%) (%)	~95% Asymptotic Interval	Harvest Rate (proportion)	~95% Asymptotic Interval
2007	38.11	30.66–45.55	0.006	0.005–0.007
2008	25.49	20.43–30.54	0.004	0.003–0.005
2009	32.96	26.47–39.45	0.005	0.004–0.006
2010	17.46	13.94–20.99	0.003	0.002–0.003
2011	21.26	17.01–25.51	0.003	0.002–0.004
2012	26.51	21.38–31.64	0.004	0.003–0.005
2013	23.00	18.61–27.39	0.004	0.003–0.004
2014	18.84	15.23–22.45	0.003	0.002–0.004
2015	24.74	20.12–29.36	0.004	0.003–0.005
2016	18.79	15.29–22.29	0.003	0.002–0.004

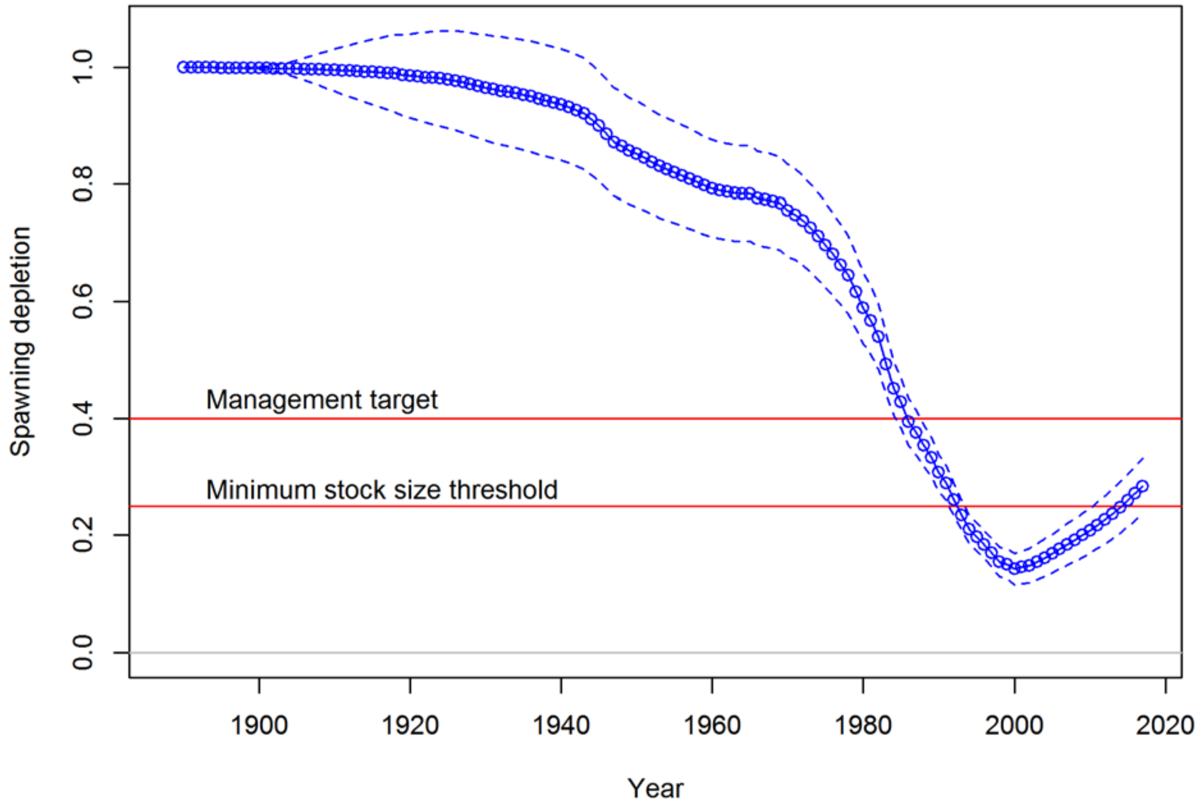

Figure ES-6. Estimated relative spawning output with approximate 95% asymptotic confidence intervals (dashed lines) for the base model.

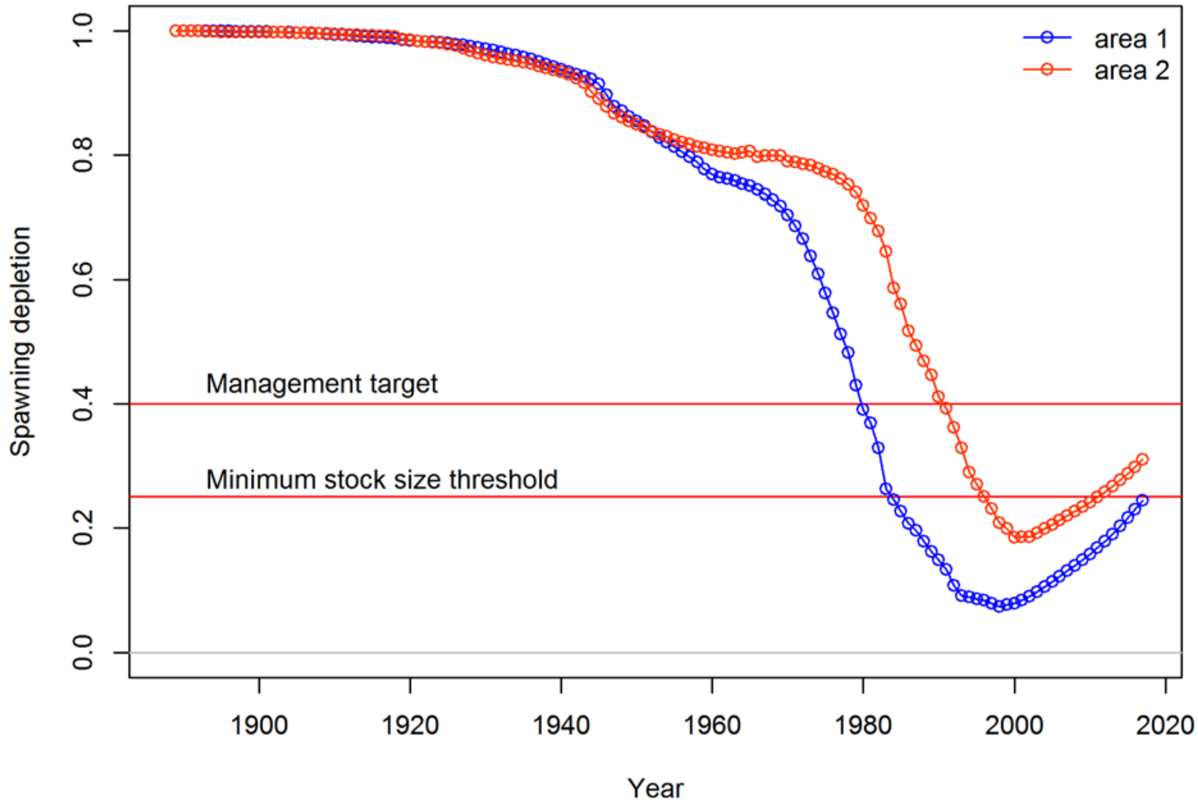

Figure ES-7. Estimated relative spawning output for the each area of the base model. Area 1 (lower line) = California; Area 2 (upper line) = Oregon and Washington.

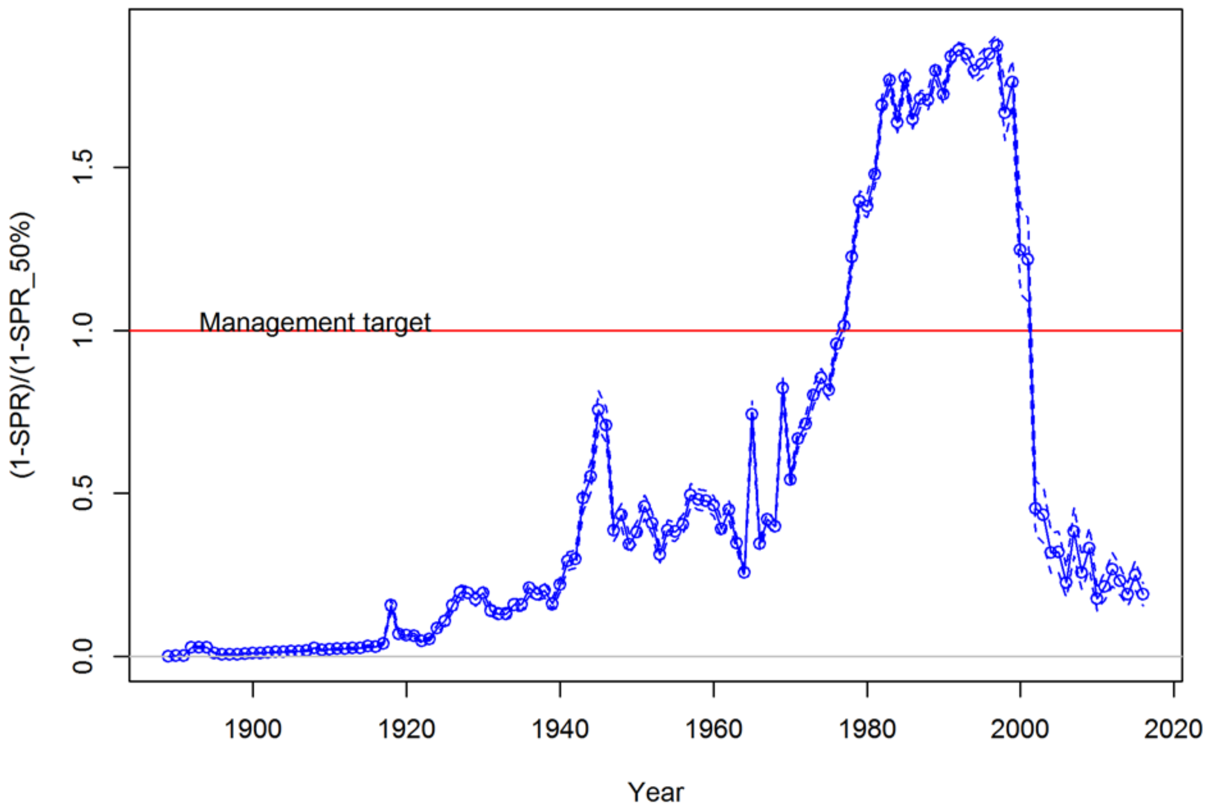

Figure ES-8. Estimated spawning potential ratio (SPR) for the base model with approximate 95% asymptotic confidence intervals. One minus SPR standardized to the target is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$.

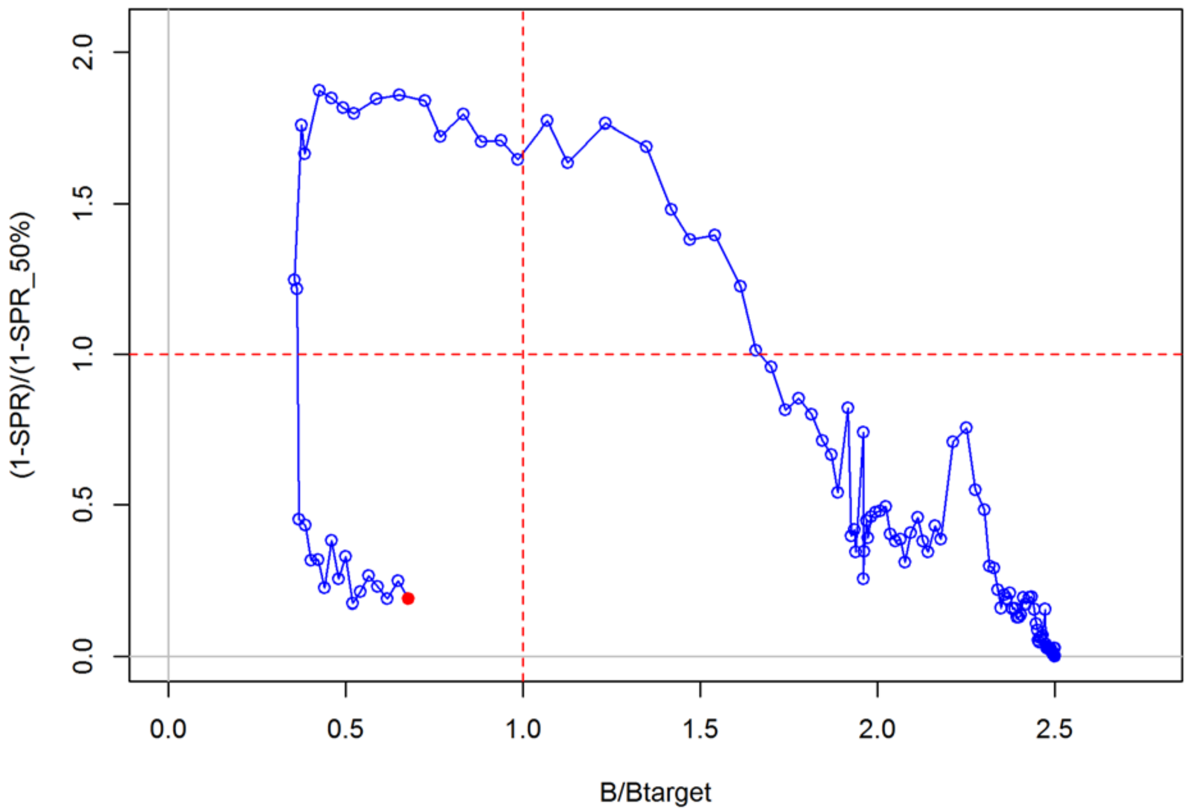

Figure ES-9. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base model. The relative (1-SPR) is (1-SPR) divided by 0.5 (the SPR target). Relative spawning output is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2016.

Ecosystem considerations

In this assessment, ecosystem considerations were not explicitly included in the analysis. This is primarily due to a lack of relevant data and results of analyses (conducted elsewhere) that could contribute ecosystem-related quantitative information for the assessment.

Reference points

Unfished spawning stock output for yelloweye rockfish was estimated to be 1,139 million eggs (95% confidence interval: 1,007-1,271 million eggs). The management target for yelloweye rockfish is defined as 40% of the unfished spawning output ($SB_{40\%}$), which is estimated by the model to be 456 million eggs (95% confidence interval: 403-509), which corresponds to an exploitation rate of 0.025. This harvest rate provides an equilibrium yield of 109 mt at $SB_{40\%}$ (95% confidence interval: 99-122 mt). The model estimate of maximum sustainable yield (MSY) is 114 mt (95% confidence interval: 101-127 mt). The estimated spawning stock output at MSY is 335 million eggs (95% confidence interval: 296-374 million eggs). The exploitation rate corresponding to the estimated SPR_{MSY} of $F_{36\%}$ is 0.034. The equilibrium estimates of yield relative to biomass is provided in Figure ES-10.

Table ES-4. Summary of reference points for the base model.

Quantity	Estimate	~95% Asymptotic Interval
Unfished Spawning Output (million eggs)	1,139	1,007-1,271
Unfished Age 8+ Biomass (mt)	9,796	8,664–10,928
Unfished Recruitment (R_0)	220	194–245
Depletion (2017)	28.37	23.60–33.13
Reference Points Based $SB_{40\%}$		
Proxy Spawning Output ($SB_{40\%}$)	456	403–509
SPR resulting in $SB_{40\%}$	0.459	0.459–0.459
Exploitation Rate Resulting in $SB_{40\%}$	0.025	0.025–0.025
Yield with SPR Based On $SB_{40\%}$ (mt)	109	96–122
Reference Points based on SPR proxy for MSY		
Proxy Spawning Output ($SPR_{50\%}$)	508	449–567
SPR_{50}	0.5	NA
Exploitation rate corresponding to $SPR_{50\%}$	0.022	0.021–0.022
Yield with $SPR_{50\%}$ at SB_{SPR} (mt)	105	93–117
Reference points based on estimated MSY values		
Spawning Output at MSY (SB_{MSY})	335	296–374
SPR_{MSY}	0.363	0.361–0.365
Exploitation rate corresponding to SPR_{MSY}	0.034	0.033–0.035
MSY (mt)	114	101–127

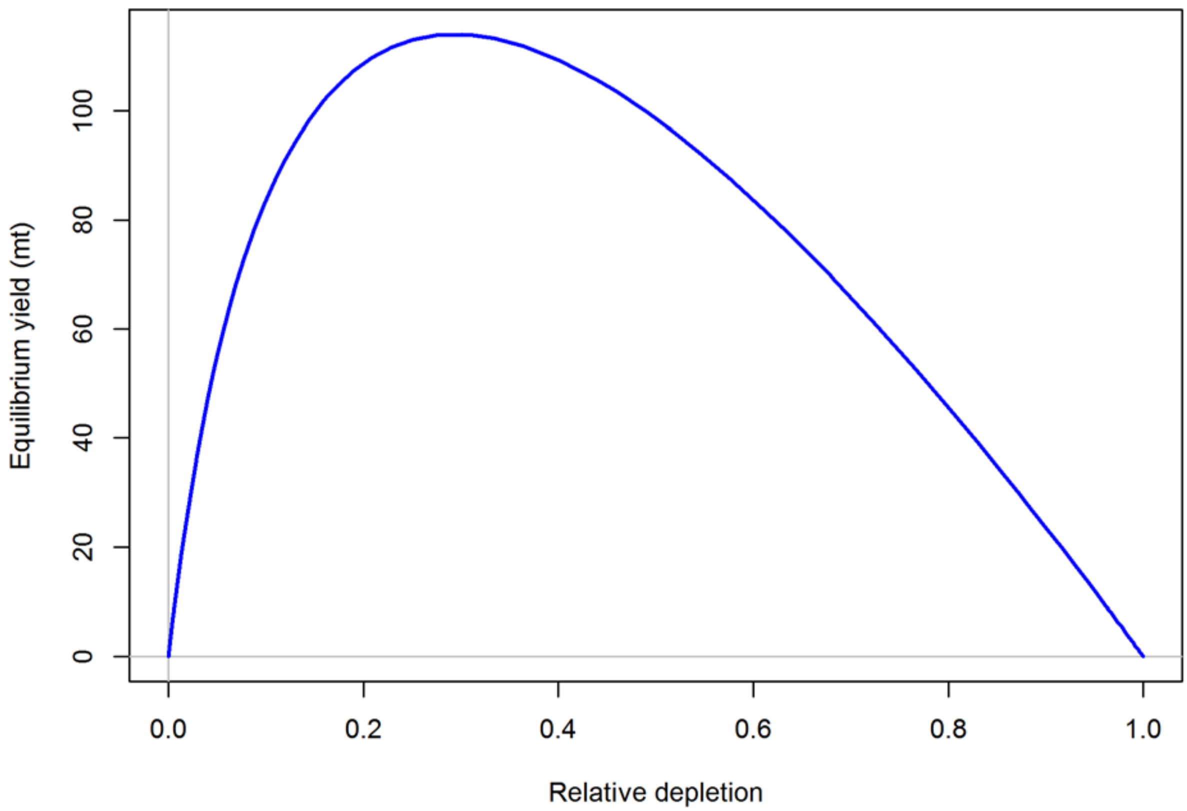

Figure ES-10. Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the base model. Values are based on 2016 fishery selectivity and distribution with steepness fixed at 0.718. The depletion is relative to unfished spawning output.

Management performance

Before 2000, yelloweye rockfish were managed as part of the *Sebastes* Complex, which included all rockfish species without individual assessments, Overfishing Limits (OFLs) and Allowable Biological Catches (ABCs). In 2000, the *Sebastes* Complex was divided into three depth-based group (nearshore, shelf and slope), and yelloweye rockfish were managed as part of the "minor shelf rockfish" group until 2002. Since then, there has been species specific management of yelloweye rockfish, and total catch of this species has been below both the OFL and ABC for yelloweye rockfish each year (Table ES-5).

Management measures implemented for yelloweye rockfish included constraining catches by eliminating all retention of yelloweye rockfish in both commercial and recreational fisheries, instituting broad spatial closures (some specifically for moving fixed-gear fleets away from known areas of yelloweye abundance), and creating new gear restrictions intended to reduce trawling in rocky shelf habitats and bycatching rockfish in shelf flatfish trawls.

Table ES-5. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus the model estimated discarded biomass*.

Years	OFL	ABC	ACL	Landings	Total Catch
2007	47	NA	23	12.83	12.83
2008	47	NA	20	9.29	9.29
2009	31	NA	17	11.69	11.69
2010	32	NA	17	6.72	6.72
2011	48	46	17	8.34	8.34
2012	48	46	17	11.16	11.16
2013	51	43	18	10.4	10.4
2014	51	43	18	8.81	8.81
2015	52	43	18	12.02	12.02
2016	52	43	19	9.59	9.59
2017	57	47	20	NA	NA

* The current OFL was called the ABC prior to 2011. The ABCs provided in this table for 2011-2018 refer to the new definition of ABC implemented with FMP Amendment 23. The current ACL was called the OY prior to 2011.

Unresolved problems and major uncertainties

Approximate asymptotic confidence intervals were estimated within the model for key parameters and management quantities and reported throughout the assessment. To explore uncertainty associated with alternative model configurations and evaluate the responsiveness of model outputs to changes in key model assumptions, a variety of sensitivity runs were performed, including runs with different assumptions fishery removals, life-history parameters, shape of selectivity curves, stock-recruitment parameters, and many others. The uncertainty in natural mortality, stock-recruit steepness and the unfished recruitment level was also explored through likelihood profile analysis. Additionally, a retrospective analysis was conducted where the model was run after successively removing data from recent years, one year at a time.

Main life history parameters, such as natural mortality and stock-recruit curve steepness, generally contribute significant uncertainty to stock assessments, and they continue to be a major source of uncertainty in this assessment. The model was unable to reliably estimate these quantities, due to the short time-series of data, which are primarily available after the period of largest removals from the stock. These quantities are essential for understanding the dynamics of the stock and determining projected rebuilding. Alternative values of these parameters were explored through both sensitivity and likelihood profile analyses.

Although significant progress has been made in reconstructing historical landings on the U.S. West Coast, early catches of yelloweye rockfish continue to be uncertain. This species comprised a small percentage of overall rockfish removals and actual species-composition samples are infrequently available for historical analyses. For instance, the lack of early species composition data does not allow the reconstruction to account for a gradual shift of fishing effort towards deeper areas, which can cause the potential to underestimate the historical contribution of shelf species (including yelloweye rockfish) to overall landings of the mixed-species market category (i.e., "unspecified rockfish").

Decision table

The base model estimate for 2017 spawning depletion is 28%. The primary axis of uncertainty about this estimate used in the decision table was based on natural mortality. Natural mortality in the assessment model is fixed at the median of the Hamel prior (0.044 y^{-1}), estimated using the maximum age of 123 years. Natural mortality value for high state of nature was calculated to correspond to 97 years of age, which is the 99th percentile of the age data available for the assessment; this value was 0.056 y^{-1}. The natural mortality value for low state of nature was calculated to correspond to 147 years of age, which is the maximum age reported for the yelloweye rockfish; this value was 0.037 y^{-1}.

We explored different approaches to identify alternative natural mortality values, including using the 12.5 and 87.5 percentiles of the Hamel prior distribution. However, this approach yielded values that were considered to be not realistic. For instance, the 12.5 percentile value of 0.031y^{-1} corresponded to an age of 175 years, which substantially exceeds the oldest yelloweye rockfish individual ever reported.

Twelve-year forecasts for each state of nature were calculated for two catch scenarios (Table ES-6). One scenario assumes 2017-2018 catches to be 60% of year-specific ACL values, and 2019-2028 catches to be 60% of removals calculated using current rebuilding SPR of 76% applied to the base model. The second catch scenario assumes 2017-2018 removals to be equal to year-specific ACLs, and 2019-2028 catches calculated using current rebuilding SPR of 76% applied to the base model.

Research and data needs

The following research could improve the ability of future stock assessments to determine the status and productivity of the yelloweye rockfish population:

A. The available data for yelloweye rockfish remains relatively sparse given the limited sampling effort available under the rebuilding plan. It is essential to continue yelloweye data collection, especially in this recent period, when commercial and recreational catches are considerably lower than the historical period, to provide a fuller picture of age structure and population dynamics. Further length and age collections will also refine estimate of year class strength in the late 2000s, which will improve estimates of stock status and productivity.

B. Poorly informed parameters, such as natural mortality and stock-recruit steepness will continue to benefit from meta-analytical approaches until there is enough data to estimate them internal to the model. A more thorough examination of yelloweye longevity off the West Coast of the United States is needed to get a better understanding of natural mortality.

C. The age data used in this assessment were generated by two ageing laboratories, the WFDW ageing lab and the NWFSC ageing lab. Even though growth estimates from these two labs are similar, there are still questions regarding the level of bias and precision in the ages coming from each lab. A larger, systematic comparison of age estimates between labs as well as with outside agencies could help resolve the issue of between-lab agreement. To this end, WDFW and NWFSC labs have been in correspondence and are currently seeking resolution to this issue.

D. Continue to refine historical catch estimates. Disentangling catch and biological records between Oregon and Washington would allow further spatial exploration. A better quantification of uncertainty among different periods of the catch history among all states would also be beneficial. These issues are relevant for all West Coast stock assessments.

E. Continue to evaluate the spatial structure of the assessment, including the number and placement of boundaries between areas. While this assessment took a step back from a more refined spatial resolution given data limitations, further detailed examination of yelloweye rockfish stock structure would be useful. This includes the exploration of area-specific life history characteristics and recruitment.

F. Develop and implement a comprehensive visual survey, as currently available bottom trawl surveys do not encounter yelloweye rockfish often and the hook-and-line IPHC survey targets halibut and incidentally encounters rockfish.

G. Yelloweye rockfish is a transboundary stock with Canada. However, a legal mandate and management framework for using the advice of a transboundary stock assessment does not exist. Data sharing is currently happening at a scientific level with Canadian scientists. A transboundary (including Mexico) stock assessment and the management framework to support such assessments would be beneficial. This is relevant to many stocks off the West Coast of the United States.

Most of the research needs listed above entail investigations that need to take place outside of the routine assessment cycle and require additional resources to be completed.

Rebuilding projections

The rebuilding projections will be presented in a separate document and will reflect the results of the rebuilding analysis.

Table ES-6. 12-year projections for alternate states of nature defined based on natural mortality. Columns range over low, mid, and high state of nature, and rows range over different assumptions of catch levels.

			States of nature					
			Low: *M* =0.037		Base model: *M* =0.044		High: *M* =0.056	
Management decision	Year	Catch (mt)	Spawning output	Depletion	Spawning output	Depletion	Spawning output	Depletion
2017-2018 catches are 60% of ACLs. 2019-2028 are 60% of catches calculated using current rebuilding SPR of 76% applied to the base model.	2017	12	227	20%	323	28%	535	43%
	2018	12	238	21%	338	30%	556	44%
	2019	17	249	22%	353	31%	578	46%
	2020	18	260	23%	368	32%	599	48%
	2021	19	271	24%	384	34%	621	50%
	2022	20	282	25%	399	35%	643	51%
	2023	21	294	26%	415	36%	665	53%
	2024	22	304	27%	430	38%	687	55%
	2025	22	315	28%	444	39%	707	57%
	2026	23	325	29%	458	40%	726	58%
	2027	23	334	30%	471	41%	744	59%
	2028	24	343	31%	483	42%	760	61%
2017-2018 catches are full ACLs. 2019-2028 catches are calculated using current rebuilding SPR of 76% applied to the base model.	2017	20	227	20%	323	28%	535	43%
	2018	20	237	21%	337	30%	555	44%
	2019	29	247	22%	351	31%	576	46%
	2020	30	257	23%	365	32%	596	48%
	2021	31	267	24%	379	33%	617	49%
	2022	33	277	25%	394	35%	638	51%
	2023	34	286	26%	408	36%	659	53%
	2024	35	296	27%	421	37%	679	54%
	2025	36	304	27%	434	38%	698	56%
	2026	37	313	28%	446	39%	715	57%
	2027	38	320	29%	457	40%	731	58%
	2028	38	328	30%	468	41%	746	60%

Table ES-7. Summary table of the results.

Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Landings (mt)	12.83	9.29	11.69	6.72	8.34	11.16	10.4	8.81	12.02	9.59	NA
Estimated Total catch (mt)	12.83	9.29	11.69	6.72	8.34	11.16	10.4	8.81	12.02	9.59	NA
OFL (mt)	47	47	31	32	48	48	51	51	52	52	57
ACL (mt)	23	20	17	17	17	17	18	18	18	19	20
1-SPR	0.35	0.23	0.3	0.16	0.2	0.25	0.21	0.17	0.23	0.17	NA
Exploitation_Rate	0.005	0.004	0.004	0.002	0.003	0.004	0.003	0.003	0.004	0.003	NA
Age 8+ Biomass (mt)	2,433	2,521	2,623	2,818	2,937	3,041	3,143	3,257	3,384	3,545	3,711
Spawning Output (million eggs)	210	219	228	237	247	258	269	282	295	309	323
~95% Confidence Interval	160–260	167–270	174–281	182–292	190–304	199–317	208–331	218–345	229–361	240–377	252–394
Recruitment	200	307	226	240	227	115	117	121	141	174	176
~95% Confidence Interval	98–407	161–583	111–460	120–482	111–468	52–252	52–264	51–288	57–347	68–442	69–448
Depletion (%)	18.4	19.2	20	20.8	21.7	22.6	23.6	24.7	25.9	27.1	28.4
~95% Confidence Interval	14.9–21.9	15.5–22.8	16.2–23.7	16.9–24.6	17.7–25.7	18.5–26.7	19.4–27.9	20.4–29.1	21.4–30.4	22.5–31.7	23.6–33.1