Agenda Item H.3
Attachment 5
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Assessments of Black Rockfish (*Sebastes melanops*) Stocks in California, Oregon and Washington Coastal Waters

by

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Executive Summary

Stock

The assessments described in this document apply to the black rockfish (*Sebastes melanops*) stocks that reside in the waters from Point Conception (34°27' N latitude) in the south to the U.S.boundary with Canada (approximately 48°30' N latitude). Following the consensus recommendations from a preliminary stock assessment workshop in April 2015 (PFMC 2015), the stock assessment team (STAT) decided to prepare separate geographic stock assessments that are spatially stratified with boundaries at the CA/OR border (42°00' N latitude) and OR/WA border (46°16' N latitude).

Black rockfish are also caught from the waters off British Columbia and Alaska, but there have not been any formal assessments of stock status for those areas.

Catches

Black rockfish are caught by a wide variety of gear types and in recent decades have been a very important target species for recreational charter-boats and private sport anglers in Washington and Oregon, and to a lesser extent in California. In recent years the recreational fishery has accounted for most of the black rockfish catches (Figure ES-1 to Figure ES-3). Black rockfish can also be an important component of nearshore commercial fisheries, either as incidental catch by the troll fishery for salmon or as directed catch by jig fisheries for groundfish. Further, in California and Oregon there are nearshore fisheries that catch and sell fish live for the restaurant trade. Washington halted live-fish fishing in the mid-1990s, so commercial fishing there has essentially stopped. In all states there have been almost no trawl-caught landings of black rockfish in recent years (Table ES-1), but trawl landings in the past were substantial (Figure ES-1 to Figure ES-3).

Detailed reports of commercial landings of black rockfish are generally unavailable prior to 1981, when the Pacific Fishery Information Network (PacFIN) database began. The catch series prior to 1981 for these assessments were derived by applying available estimates or assumed values for the proportion of black rockfish landings in reported landings of rockfish. Observer data, which are available only for the past decade, indicate low levels of discarding of black rockfish, generally less than 2% of total catch.

Because of their nearshore distribution and low abundance compared to other rockfish species, black rockfish are unlikely to have ever comprised a large percentage of rockfish landings, but it seems quite certain that they have been more than a trivial component for many years. Black rockfish were one of only four rockfish species mentioned by scientific name in reports of rockfish landings in Oregon during the 1940s, and they were one of only six rockfish species mentioned by scientific name in reports of rockfish landings in California during the same period. Mentions of black rockfish extend back before the year 1900 in Washington.

Table ES-1: Recent black rockfish removals by state.

	Removals in mt				
Year	WA rec	OR comm	OR rec	CA comm	CA rec
2005	325	100	327	74	187

2006	312	95	281	63	199
2007	286	103	272	85	152
2008	222	100	253	85	168
2009	251	136	310	94	271
2010	219	102	318	52	217
2011	231	98	221	27	192
2012	281	98	233	22	221
2013	325	108	328	35	385
2014	355	124	362	41	361

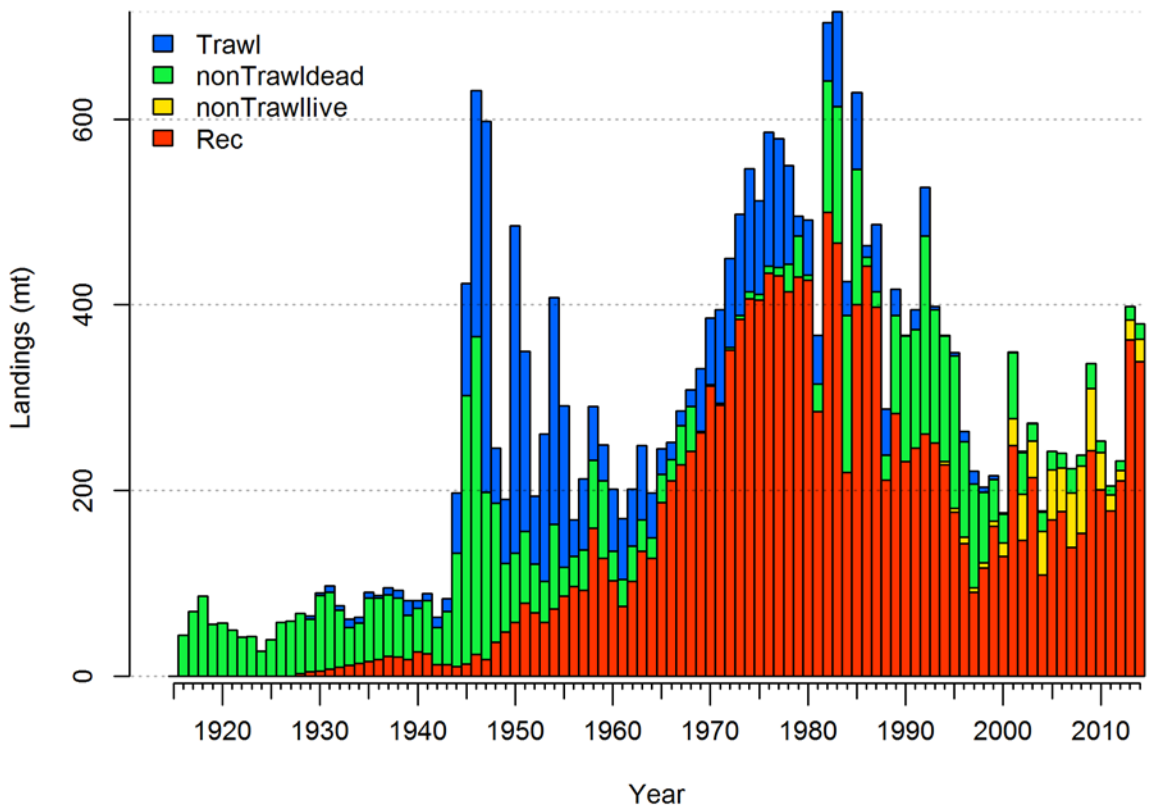

Figure ES-1. Landings history of black rockfish for California.

Figure ES-2. Landings history of black rockfish for Oregon.

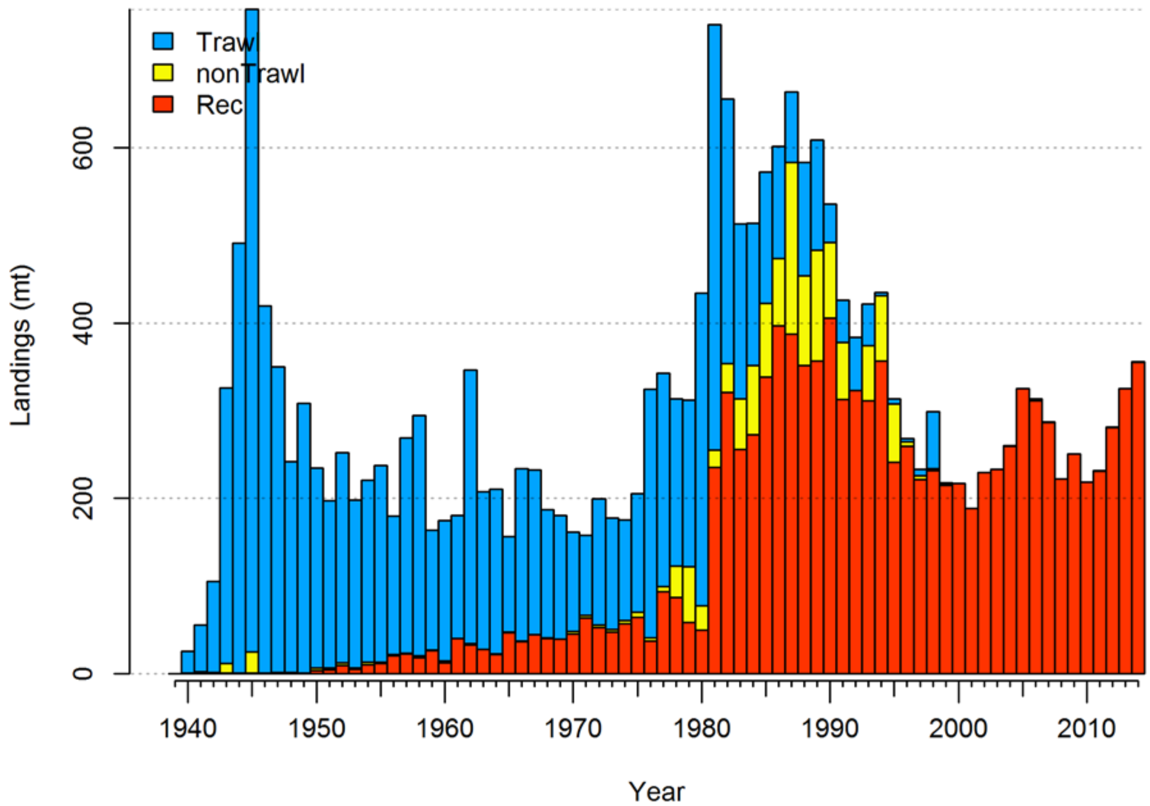

Figure ES-3. Landings history of black rockfish for Washington.

Data and assessment

The last stock assessments for black rockfish were conducted in 2007 for areas north and south of Cape Falcon (45°46´ North latitude). The current assessments assumes three areas instead of two, delineated by the state lines as was agreed upon at a pre-assessment and data workshop in March 2015. The prior assessments used Stock Synthesis 2, while the current assessments use Stock Synthesis 3. The Washington base assessment includes a dockside and tag-based CPUE series, but does not include the abundance estimate time series from that same tagging study which was included in the last assessment due to too many violations in the assumptions of abundance estimation. The same two commercial and single recreational fleets are used as in the last assessment for Washington. The Oregon assessment has three commercial fleets and one recreational fleet, while using five surveys and two additional research studies for biological compositions. California also has three commercial fleets and 1 recreational fleet with three surveys of abundance, all based on recreational fisheries. All area models include age data as conditional age at lengths. Length compositions are also included in all models.

Spawning stock output

Spawning stock outputs are all above limit reference points in California and Washington (Table ES-2). Only California shows declines below this reference point at any point in the time series. California and Washington stocks show a declining population through most of the 20th Century, with stronger declines in the 1980s, and recoveries beginning in the mid-1990s. California (33%) is below the target biomass reference point with an increasing biomass trend (Figures ES-4 and ES-5). Washington (43%) dropped below the target biomass by in the early 1980s, then risen above since the late 1990s and has fluctuated above that point through 2014 (Figures ES-8 and ES-9).

Table ES-2: Recent trend in beginning of the year biomass and depletion for black rockfish by assessment area.

	California				Oregon				Washington			
Year	Spawning Output	~95% confidence interval	Estimated depletion	~95% confidence interval	Spawning Output	~95% confidence interval	Estimated depletion	~95% confidence interval	Spawning Output	~95% confidence interval	Estimated depletion	~95% confidence interval
2006	228	145-311	0.21	0.13-0.3					576	466-686	0.42	0.35-0.5
2007	231	145-317	0.22	0.13-0.31					564	455-672	0.42	0.35-0.49
2008	241	151-332	0.23	0.14-0.32					557	449-665	0.41	0.34-0.48
2009	257	159-354	0.24	0.14-0.34					558	450-665	0.41	0.34-0.48
2010	268	162-374	0.25	0.15-0.36					551	444-657	0.41	0.34-0.47
2011	285	170-401	0.27	0.15-0.38					550	444-656	0.41	0.34-0.47
2012	305	180-430	0.29	0.17-0.41					552	446-658	0.41	0.34-0.47
2013	322	189-454	0.30	0.17-0.43					557	449-664	0.41	0.34-0.48
2014	329	191-468	0.31	0.18-0.44					567	456-678	0.42	0.35-0.49
2015	353	204-503	0.33	0.19-0.48					582	467-698	0.43	0.36-0.5

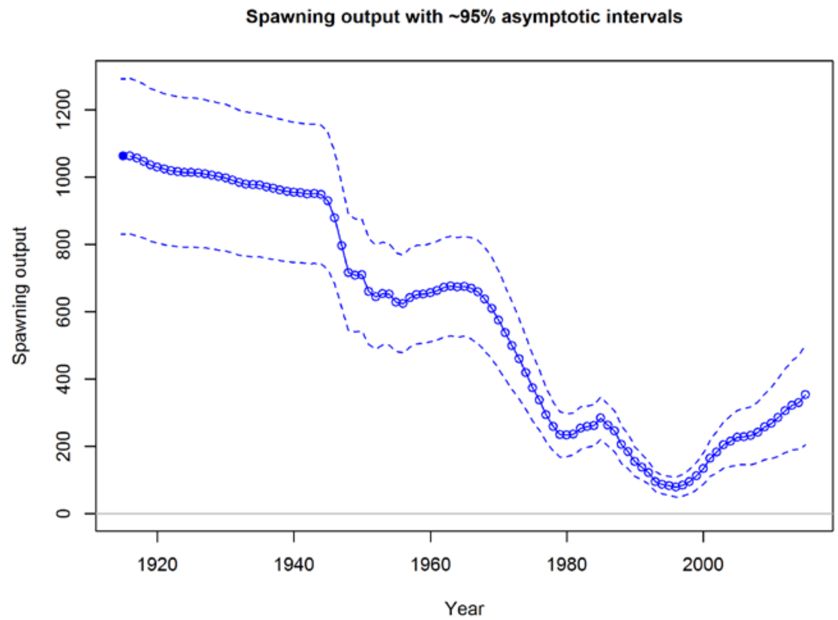

Figure ES-4. Time series of spawning out of black rockfish in California.

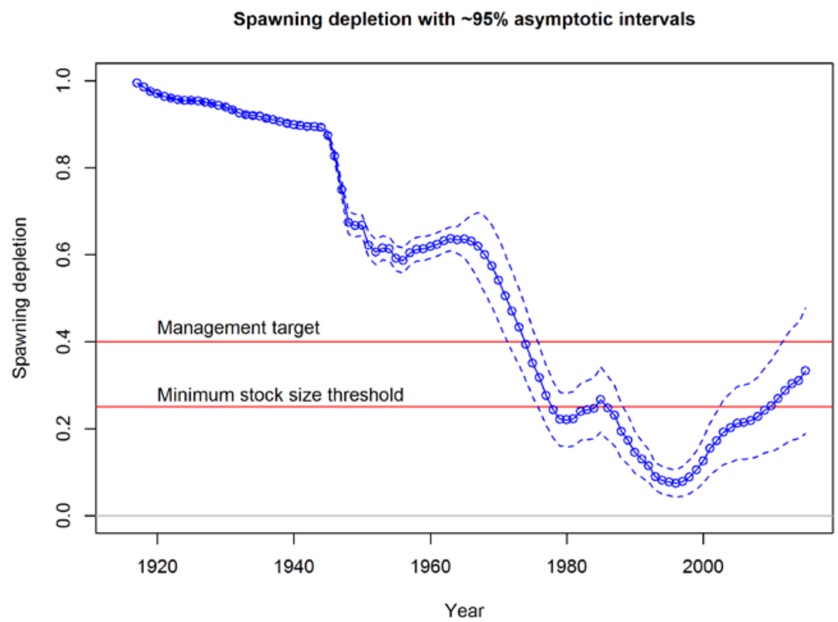

Figure ES-5. Time series of stock status (depletion) of black rockfish in California.

Figure ES-6. Time series of spawning output of black rockfish in Oregon.

Figure ES-7. Time series of stock status (depletion) of black rockfish in Oregon.

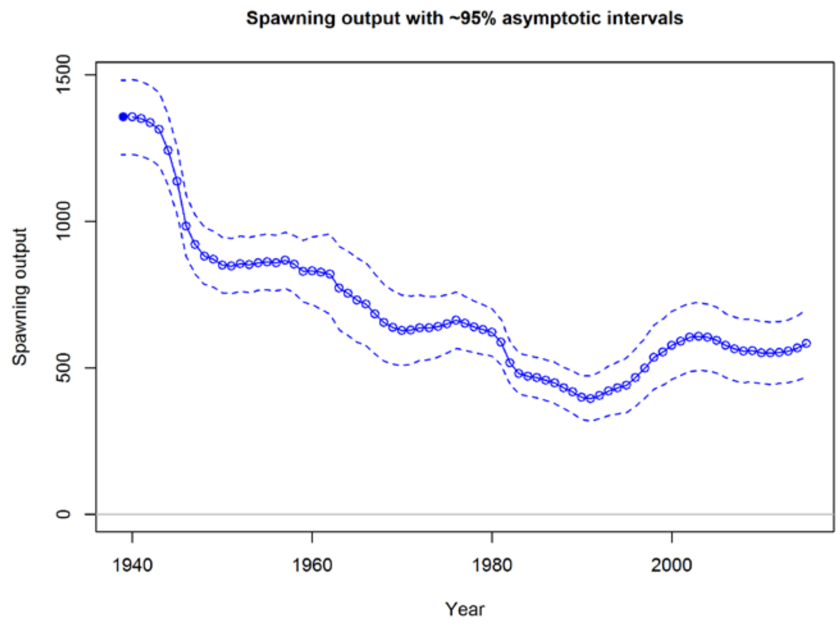

Figure ES-8. Time series of spawning output of black rockfish in Washington.

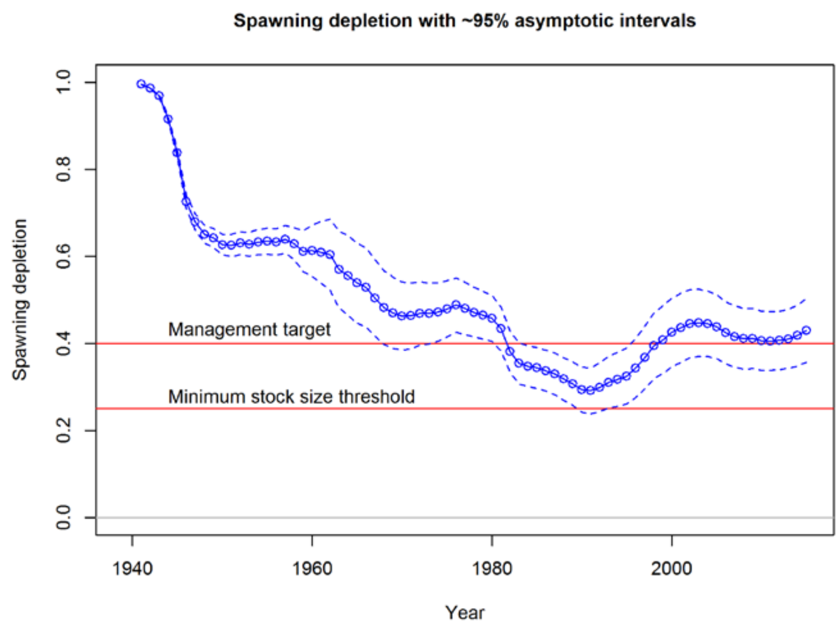

Figure ES-9. Time series of stock status (depletion) of black rockfish in Washington.

Recruitment

The California model shows a few extraordinarily high recruitment events that are supported by the length composition data, index data and on-the-water reports (Table ES-3; Figure ES-10). Washington recruitment is dynamic, but also shows the most informed recruitment time series, which is consistent with the extent of length and age compositions available to that assessment (Table ES-3; Figure ES12). Both California and Washington support elevated recruitment in the late 2000s.

Table ES-3. Recent trend in recruitment for black rockfish by assessment area.

	California		Oregon		Washington	
Year	Estimated recruitment (1,000's)	~95% confidence interval	Estimated recruitment (1,000's)	~95% confidence interval	Estimated recruitment (1,000's)	~95% confidence interval
2005	1371	714-2029			1773	1257-2288
2006	984	465-1504			3518	2543-4493
2007	1327	565-2088			1739	1181-2297
2008	4509	2176-6842			3346	2312-4379
2009	4323	1560-7086			518	184-852
2010	2997	841-5153			2670	1178-4161
2011	1765	306-3223			1157	161-2153
2012	1701	1206-2195			1899	1396-2402
2013	1719	1226-2213			1901	1398-2404
2014	1728	1233-2223			1907	1403-2411

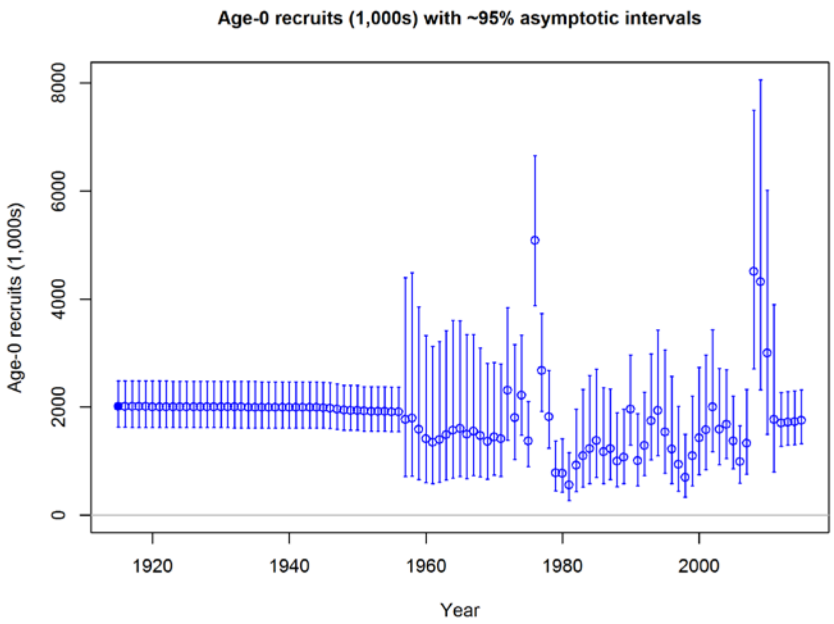

Figure ES-10. Time series of black rockfish recruitment in California.

Figure ES-11. Time series of black rockfish recruitment in Oregon.

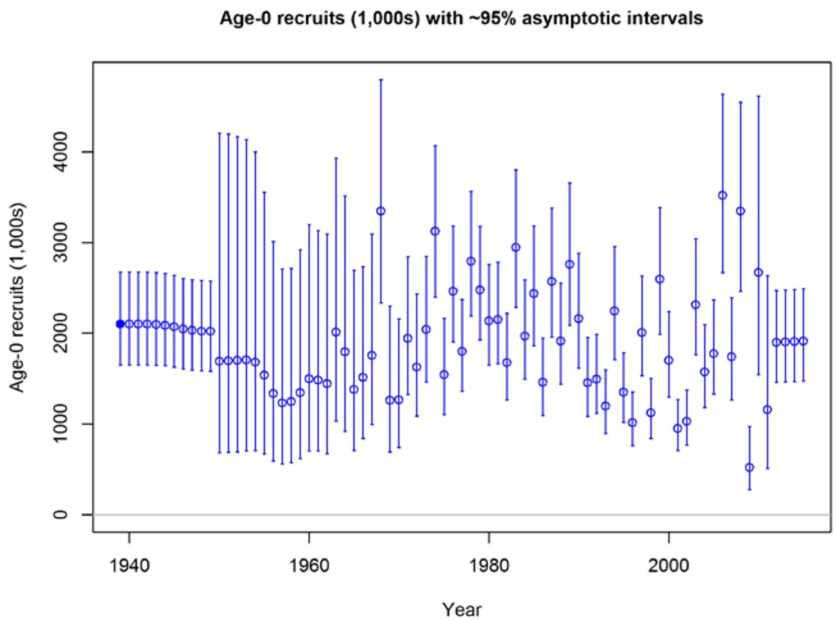

Figure ES-12. Time series of black rockfish recruitment in Washington.

Exploitation status

California and Washington models indicate that current fishing practices are near or above the SPR rate fishing intensity target (table ES-4, compare to SPR=0.5; Figure ES-13 to Figure ES-18), though the steepness value (0.773) indicates a much lower value of SPR for sustainable removals. Fishing rates have been above the target in California in nearly all years since the 1980s, but have dropped considerably in recent years. Washington show a dramatic decline in fishing intensity since the late 1990s and has fluctuated mostly below the target since.

Table ES-4. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate (catch divided by biomass of age-3 and older fish)

	Washington				Oregon				California			
Year	Estimated 1-SPR	~95% confidence interval	Harvest rate (ratio)	~95% confidence interval	Estimated 1-SPR	~95% confidence interval	Harvest rate (ratio)	~95% confidence interval	Estimated 1-SPR	~95% confidence interval	Harvest rate (ratio)	~95% confidence interval
2005	0.60	0.48-0.72	0.09	0.06-0.12					0.54	0.47-0.61	0.08	0.07-0.1
2006	0.58	0.45-0.7	0.08	0.06-0.11					0.54	0.47-0.61	0.08	0.07-0.1
2007	0.53	0.41-0.65	0.08	0.05-0.1					0.52	0.45-0.59	0.08	0.06-0.09
2008	0.53	0.41-0.66	0.08	0.05-0.1					0.45	0.38-0.51	0.06	0.05-0.07
2009	0.65	0.52-0.78	0.10	0.07-0.14					0.48	0.41-0.55	0.07	0.06-0.08
2010	0.56	0.42-0.69	0.08	0.05-0.11					0.44	0.37-0.51	0.06	0.05-0.07
2011	0.46	0.33-0.59	0.06	0.04-0.08					0.45	0.38-0.51	0.06	0.05-0.07
2012	0.45	0.32-0.57	0.05	0.03-0.07					0.49	0.42-0.56	0.07	0.06-0.08
2013	0.57	0.44-0.7	0.08	0.05-0.11					0.52	0.45-0.59	0.08	0.06-0.09
2014	0.53	0.4-0.67	0.07	0.05-0.1					0.54	0.47-0.61	0.08	0.07-0.1

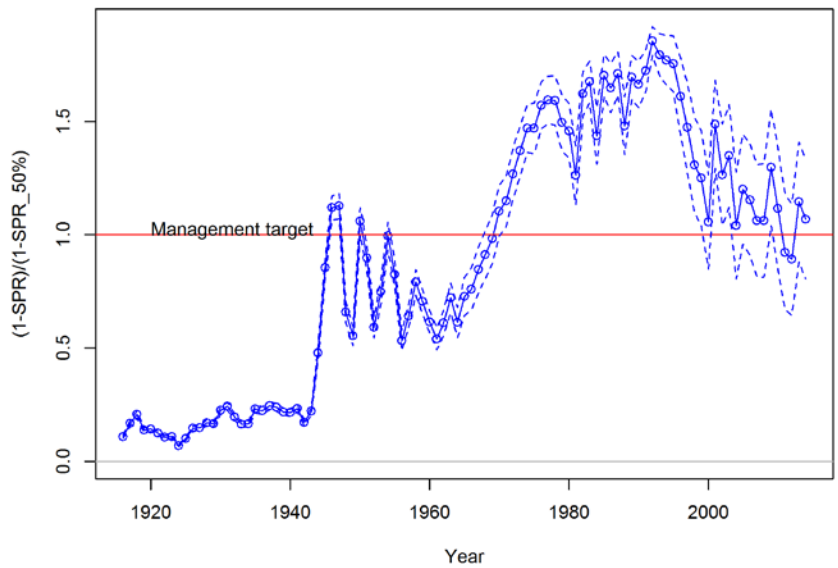

Figure ES-13. Estimated spawning potential ratio (SPR) for the California assessment. Relative SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2014.

Figure ES-14. Estimated spawning potential ratio (SPR) for the Oregon assessment. Relative SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2014.

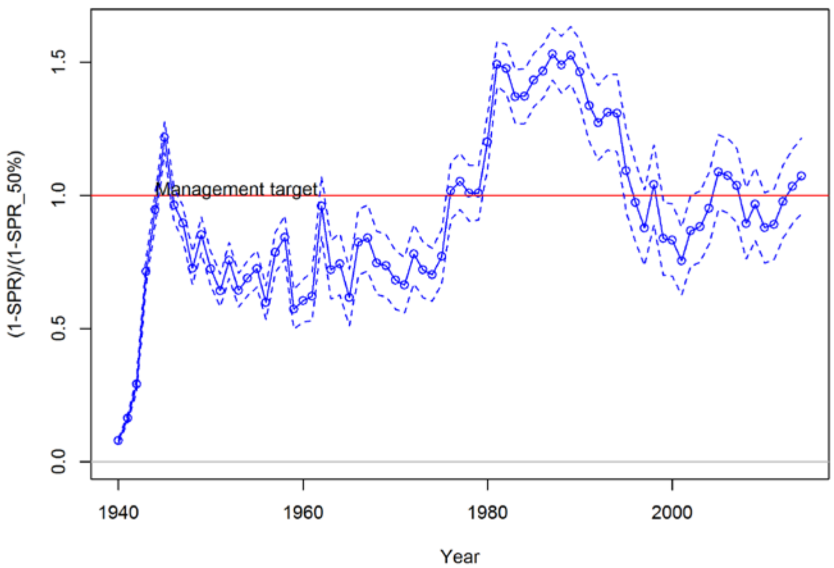

Figure ES-15. Estimated spawning potential ratio (SPR) for the Washington assessment. Relative SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing proxy based on the $SPR_{50\%}$ harvest rate. The last year in the time series is 2014.

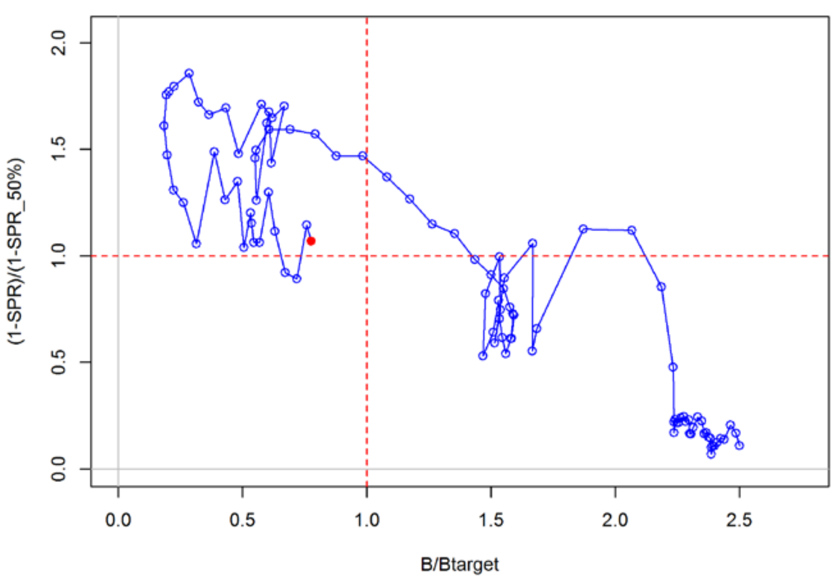

Figure ES-16. Phase plot of relative spawning biomass vs fishing intensity for the California model. The relative fishing intensity is (1-SPR) divided by 1-the SPR target. The vertical red line is the relative spawning biomass target defined as the annual spawning output divided by the spawning biomass corresponding to 40% of the unfished spawning biomass.

Figure ES-17. Phase plot of relative spawning biomass vs fishing intensity for the Oregon model. The relative fishing intensity is (1-SPR) divided by 1-the SPR target. The vertical red line is the relative spawning biomass target defined as the annual spawning biomass divided by the spawning output corresponding to 40% of the unfished spawning biomass.

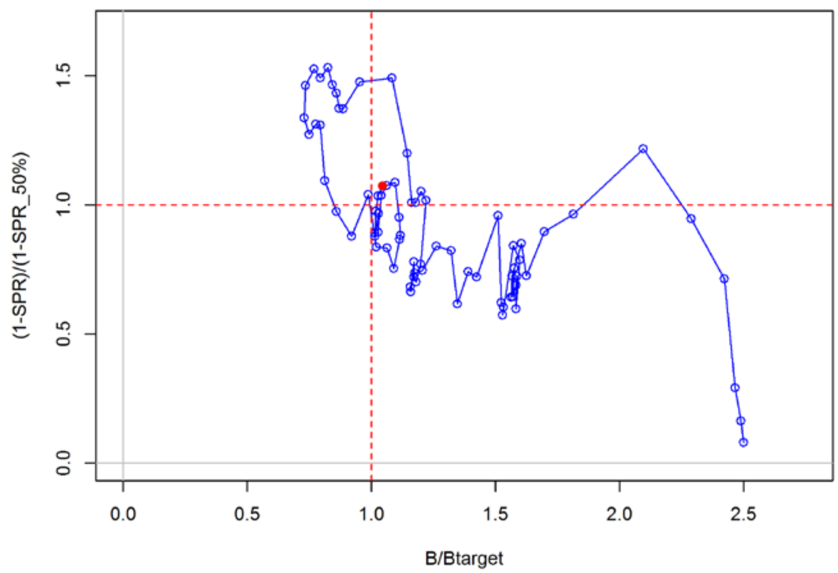

Figure ES-18. Phase plot of relative spawning biomass vs fishing intensity for the Washington model. The relative fishing intensity is (1-SPR) divided by 1-the SPR target. The vertical red line is the relative spawning biomass target defined as the annual spawning output divided by the spawning biomass corresponding to 40% of the unfished spawning biomass.

Ecosystem considerations

Ecosystem considerations were not explicitly included in these models, though growth deviations were considered in the Washington model. While no mechanisms have been put forth for these time-varying changes in growth, an environmental component is possible. Limited data in Oregon and California also suggest the possibility that growth has changed over time.

Reference points

Reference points were based on the rockfish F_{MSY} proxy ($SPR_{50\%}$), target relative biomass (40%) and model-estimated selectivity for each fleet. California is below the target biomass reference point, but above the limit reference biomass (25%). Washington relative biomass is above the target biomass. California and Washington yield values are lower than the previous assessment for similar reference points due to lower overall natural mortality values (Table ES-5). The proxy MSY values of management quantities are the most conservative compared to the estimated MSY and MSY relative to 40% biomass for both California and Washington (Table ES-5). The equilibrium estimates of yield relative to biomass are provided in Figure ES-19 to Figure ES-21.

Table ES-5. Summary of reference points for each black rockfish base case model.

California

Quantity	**Estimate**	**~95% Confidence Interval**
Unfished Spawning output (mt)	1062	830-1293
Unfished age 3+ biomass (mt)	9540	8862-10219
Unfished recruitment (R0)	2010	1580-2440
Depletion (2015)	0.33	0.19-0.48
Reference points based on $SB_{40\%}$		
Proxy spawning output ($B_{40\%}$)	425	332-517
SPR resulting in $B_{40\%}$ ($SPR_{50\%}$)	0.444	0.44-0.44
Exploitation rate resulting in $B_{40\%}$	0.075	0-0.0811
Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt)	343	316-369
Reference points based on SPR proxy for MSY		
Spawning output	489	382-595
SPR_{proxy}	0.5	
Exploitation rate corresponding to SPR_{proxy}	0.064	0.06-0.07
Yield with SPR_{proxy} at SB_{SPR} (mt)	319	295-344
Reference points based on estimated MSY values		
Spawning output at *MSY* (SB_{MSY})	254	199-309
SPR_{MSY}	0.295	0.29-0.3
Exploitation rate corresponding to SPR_{MSY}	0.117	0.11-0.13
MSY (mt)	376	345-408

Oregon

Quantity	**Estimate**	**~95% Confidence Interval**
Unfished Spawning biomass (mt)		
Unfished age 3+ biomass (mt)		
Unfished recruitment (R0)		
Depletion (2015)		
Reference points based on $SB_{40\%}$		
Proxy spawning biomass ($B_{40\%}$)		
SPR resulting in $B40_{\%}$ ($SPR_{50\%}$)		
Exploitation rate resulting in $B_{40\%}$		
Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt)		

Reference points based on SPR proxy for MSY		
Spawning biomass		
SPR_{proxy}		
Exploitation rate corresponding to SPR_{proxy}		
Yield with SPR_{proxy} at SB_{SPR} (mt)		
Reference points based on estimated MSY values		
Spawning biomass at *MSY* (SB_{MSY})		
SPR_{MSY}		
Exploitation rate corresponding to SPR_{MSY}		
MSY (mt)		

Washington

Quantity	**Estimate**	**~95% Confidence Interval**
Unfished Spawning output (mt)	1356	1228-1483
Unfished age 3+ biomass (mt)	9119	8467-9772
Unfished recruitment (R0)	2102	1593-2610
Depletion (2015)	0.43	0.36-0.5
Reference points based on $SB_{40\%}$		
Proxy spawning output ($B_{40\%}$)	542	491-593
SPR resulting in $B_{40\%}$ ($SPR_{50\%}$)	0.444	0.44-0.44
Exploitation rate resulting in $B_{40\%}$	0.086	0.08-0.09
Yield with $SPR_{50\%}$ at $B_{40\%}$ (mt)	337	298-376
Reference points based on SPR proxy for MSY		
Spawning output	624	565-683
SPR_{proxy}		
Exploitation rate corresponding to SPR_{proxy}	0.072	0.07-0.08
Yield with SPR_{proxy} at SB_{SPR} (mt)	311	275-346
Reference points based on estimated MSY values		
Spawning output at *MSY* (SB_{MSY})	294	267-322
SPR_{MSY}	0.274385	0.27-0.28
Exploitation rate corresponding to SPR_{MSY}	0.149	0.14-0.16
MSY (mt)	383	337-430

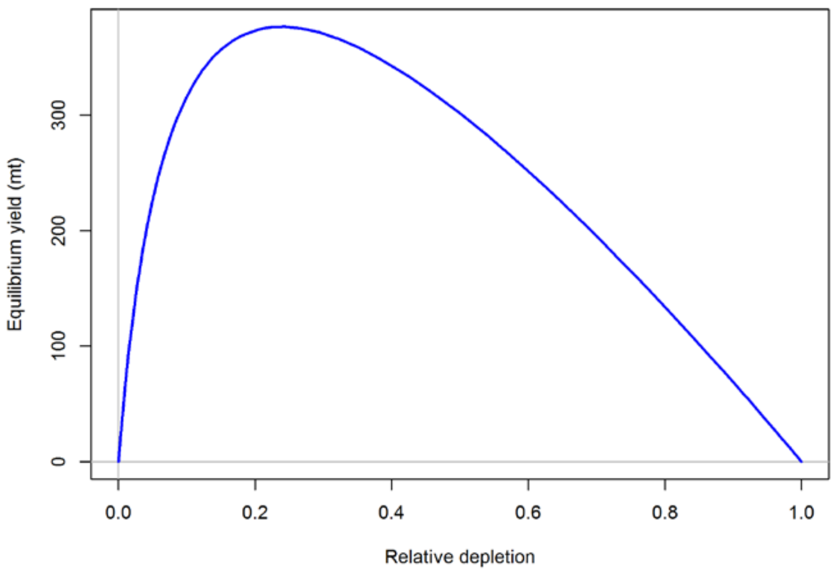

Figure ES-19. Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the California base case model. Values are based on 2014 fishery selectivity and distribution with steepness fixed at 0.773. The depletion is relative to unfished spawning biomass.

Figure ES-20. Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the Oregon base case model. Values are based on 2014 fishery selectivity and distribution with steepness fixed at 0.773. The depletion is relative to unfished spawning biomass.

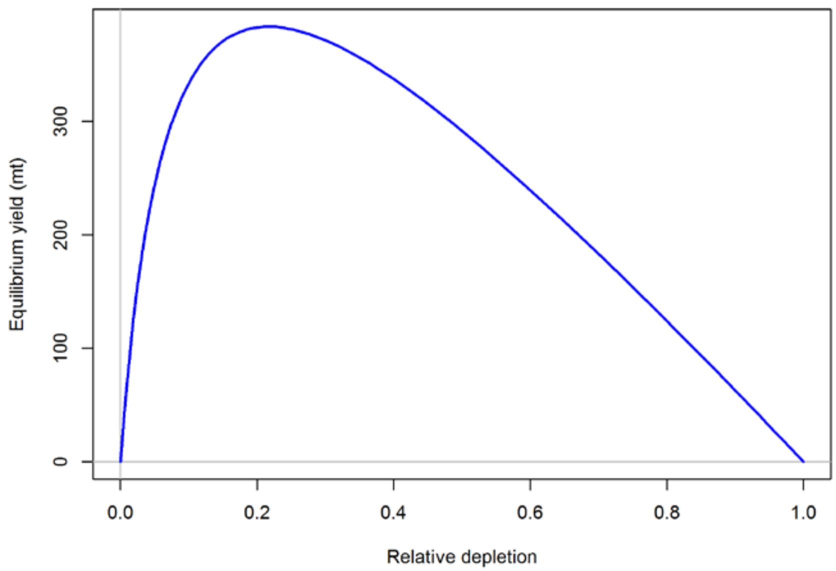

Figure ES-21. Equilibrium yield curve (derived from reference point values reported in Table ES-5) for the Washington base case model. Values are based on 2014 fishery selectivity and distribution with steepness fixed at 0.773. The depletion is relative to unfished spawning biomass.

Management performance

Removals have been below the equivalent ABC-ACL since the prior assessment (Table ES-6), but those specified ABCs from the 2007 assessments are higher than those coming from the current assessment models. Removals over the last few years have or may have exceeded the newly estimated ABC-ACL values in some years for both California and Washington. The differences in the treatment of natural mortality between the previous and current assessments are the biggest reason for this discrepancy.

Table ES-6. Recent trend in total catch and commercial landings (mt) relative to the management guidelines. Estimated total catch reflect the commercial landings plus estimated discarded biomass.

	OFL (mt)		ABC/ACL (mt)		Removals (mt)	
Year	CA + OR	WA	CA + OR	WA	CA + OR	WA
2007	722	540	722	540	577	287
2008	722	540	722	540	593	222
2009	1469	490	1000	490	784	251
2010	1317	464	1000	464	650	219
2011	1163	426	1000	426	523	232
2012	1117	415	1000	415	563	282
2013	1108	411	1000	411	845	325

2014	1115	409	1000	409	865	356

Unresolved problems and major uncertainties

The most significant uncertainty for all models is the treatment and value of natural mortality and the form of fleet selectivity (e.g., length-based asymptotic vs. age-based dome-shaped selectivity). Data-driven selection between the extreme “kill” (using a ramping of M) or “hide” hypotheses are not currently resolvable. The current base models of the California and Washington stocks instead uses a form of the “kill” hypothesis by not implementing the age-based selectivity (“hide” hypothesis) and estimating female and male natural mortality, thus avoiding a fixed ramping of natural mortality. Another important uncertainty is that the historical time-series of removals are highly uncertain for all states and need further consideration. The development of fishery-dependent indices of abundance still needs further attention. Steepness, while fixed, is still highly uncertain for rockfishes and currently is mismatched to the MSY proxy. And while the steepness profile shows low sensitivity in several derived quantities, steepness strongly defines the yield capacity of stocks, and therefore could cause major uncertainty in the recommended management quantities. Stock structure and its relationship to the current political/management boundaries are also not fully understood, both within U.S. jurisdiction and between the U.S. and Canada. While this is a common challenge faced in most west coast stock assessments, further improvement on this topic will likely rely on black rockfish-specific data.

Harvest projections and decision tables

Black rockfish assessments for California and Washington are considered category 1 stock assessments, thus harvest projections and decision tables are based on using P*=0.45 and sigma = 0.36, resulting in a multiplier on the OFL of 0.956. This is combined with the rockfish MSY proxy of F_{SPR}=50% MSY and the 40-10 harvest control rule to calculate OFLs, ABCs and ACLs. Projections for each state are provided in Table ES-7 to Table ES-9. Uncertainty in management quantities for the California and Washington models was characterized by exploring various model specifications. Initial exploration included natural mortality and steepness values, and uncertainty in historical trawl catches. There was very little sensitivity to steepness and trawl catches. Natural mortality produced the most sensitive results of predicted population scale and status. Discussion with the STAR panel resulted in high and low states of nature +/- 0.03 from the base case natural mortality values for females and males. High and low catch streams (rows) were determined by the forecasts, as described above, for each state of nature. Thus the low catch stream is based on the forecast from the low state of nature. Resultant decision tables are provided in Table ES-10 to Table ES-12.

Table ES-7. Harvest projection of potential OFL and prescribed removals, summary biomass (age-3 and older), spawning output, and depletion for the California base case model projected with total catch equal to the 420 mt for 2015 and 2016. The predicted OFL is the calculated total catch determined by F_{SPR}=50%.

Year	Predicted OFL	Projected removals	Age 3+ biomass	Spawning output	Depletion (%)
2015	354	420	5,773	353	33%
2016	354	420	5,800	396	37%
2017	349	334	5,754	450	42%
2018	347	332	5,747	503	47%
2019	344	329	5,716	538	51%
2020	341	326	5,677	555	52%
2021	338	323	5,640	558	53%
2022	336	321	5,608	554	52%
2023	334	319	5,583	547	52%
2024	333	318	5,565	539	51%
2025	332	318	5,550	532	50%
2026	332	317	5,540	526	50%

Table ES-8. Harvest projection of potential OFL and prescribed removals, summary biomass (age-3 and older), spawning output, and depletion for the Oregon base case model projected with total catch equal to the 420 mt for 2015 and 2016. The predicted OFL is the calculated total catch determined by F_{SPR}=50%.

Year	Predicted OFL	Projected removals	Age 3+ biomass	Spawning output	Depletion (%)
2015					
2016					
2017					
2018					
2019					
2020					
2021					
2022					
2023					
2024					
2025					
2026					

Table ES-9. Harvest projection of potential OFL and prescribed removals, summary biomass (age-3 and older), spawning output, and depletion for the Washington base case model projected with total catch equal to the 420 mt for 2015 and 2016. The predicted OFL is the calculated total catch determined by F_{SPR}=50%.

Year	Predicted OFL	Projected removals	Age 3+ biomass	Spawning output	Depletion (%)
2015	319	283	5,645	582	43%
2016	320	283	5,652	610	45%
2017	319	305	5,651	632	47%
2018	315	301	5,629	643	47%
2019	312	299	5,615	646	48%
2020	311	297	5,609	644	48%
2021	311	297	5,610	640	47%
2022	311	297	5,616	636	47%
2023	311	297	5,625	634	47%
2024	312	298	5,635	632	47%
2025	312	299	5,645	632	47%
2026	313	299	5,655	632	47%

Table ES-10. Summary decision table of 12-year projections for the California model beginning in 2017 for alternate states of nature based on natural mortality. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels corresponding to the forecast catches from each state of nature. Catches in 2015 and 2016 are determined from the percentage of landings for each fleet in 2014.

California			**State of nature**					
			Low M_{female} = 0.15 ; M_{male} = 0.10		Base case M_{female} = 0.18; M_{male} = 0.13		High M_{female} = 0.21 ; M_{male} = 0.16	
Relative probability of states of nature			0.25		0.5		0.25	
Management decision	Year	Catch (mt)	Spawning output	Stock status	Spawning output	Stock status	Spawning output	Stock status
Low catch	2017	185	325	27%	450	42%	589	62%
	2018	207	378	31%	517	49%	668	70%
	2019	222	418	34%	567	53%	721	76%
	2020	232	446	37%	598	56%	748	79%
	2021	240	463	38%	613	58%	754	79%
	2022	246	474	39%	620	58%	748	79%
	2023	251	482	40%	621	59%	736	77%
	2024	255	488	40%	620	58%	722	76%
	2025	259	493	41%	617	58%	707	74%
	2026	262	498	41%	615	58%	694	73%
Base catch	2017	334	325	27%	450	42%	589	62%
	2018	332	364	30%	503	47%	654	69%
	2019	329	389	32%	538	51%	694	73%
	2020	326	402	33%	555	52%	708	74%
	2021	323	406	33%	558	53%	703	74%
	2022	321	406	33%	554	52%	689	72%
	2023	319	404	33%	547	52%	670	70%
	2024	318	401	33%	539	51%	651	68%
	2025	318	400	33%	532	50%	634	67%
	2026	317	400	33%	526	50%	619	65%
High catch	2017	478	325	27%	450	42%	589	62%
	2018	461	350	29%	490	46%	641	67%
	2019	444	360	30%	510	48%	666	70%
	2020	428	357	29%	512	48%	666	70%
	2021	415	348	29%	503	47%	650	68%
	2022	404	335	28%	489	46%	626	66%
	2023	395	322	27%	473	45%	600	63%
	2024	388	311	26%	458	43%	576	60%
	2025	382	303	25%	446	42%	555	58%
	2026	377	296	24%	437	41%	538	56%

Table ES-11. Summary decision table of 12-year projections for the Oregon model beginning in 2017 for alternate states of nature based on natural mortality. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels corresponding to the forecast catches from each state of nature. Catches in 2015 and 2016 are determined from the percentage of landings for each fleet in 2014.

Oregon			**State of nature**					
			Low		Base case		High	
Relative probability of states of nature			0.25		0.5		0.25	
Management decision	Year	Catch (mt)	Spawning output	Stock status	Spawning output	Stock status	Spawning output	Stock status
Low catch	2017							
	2018							
	2019							
	2020							
	2021							
	2022							
	2023							
	2024							
	2025							
	2026							
Base catch	2017							
	2018							
	2019							
	2020							
	2021							
	2022							
	2023							
	2024							
	2025							
	2026							
High catch	2017							
	2018							
	2019							
	2020							
	2021							
	2022							
	2023							
	2024							
	2025							
	2026							

Table ES-12. Summary decision table of 12-year projections for the Washington model beginning in 2017 for alternate states of nature based on natural mortality. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels corresponding to the forecast catches from each state of nature. Catches in 2015 and 2016 are determined from the percentage of landings for each fleet in 2014.

Washington			**State of nature**					
			Low M_{female}= 0.133 ; M_{male} = 0.115		Base case M_{female}= 0.163 ; M_{male} = 0.145		High M_{female}= 0.193 ; M_{male} = 0.175	
Relative probability of states of nature			0.25		0.5		0.25	
Management decision	Year	Catch (mt)	Spawning output	Stock status	Spawning output	Stock status	Spawning output	Stock status
Low catch	2017	193	498	34%	632	47%	844	59%
	2018	200	525	36%	660	49%	871	61%
	2019	206	545	38%	679	50%	886	62%
	2020	210	559	38%	692	51%	894	63%
	2021	215	569	39%	701	52%	899	63%
	2022	218	578	40%	709	52%	905	64%
	2023	221	585	40%	716	53%	912	64%
	2024	224	593	41%	724	53%	919	65%
	2025	226	600	41%	731	54%	927	65%
	2026	228	607	42%	737	54%	935	66%
Base catch	2017	305	498	34%	632	47%	844	59%
	2018	301	508	35%	643	47%	855	60%
	2019	299	511	35%	646	48%	855	60%
	2020	297	508	35%	644	48%	849	60%
	2021	297	504	35%	640	47%	843	59%
	2022	297	499	34%	636	47%	839	59%
	2023	297	494	34%	634	47%	837	59%
	2024	298	491	34%	632	47%	838	59%
	2025	299	489	34%	632	47%	840	59%
	2026	299	487	34%	632	47%	843	59%
High catch	2017	464	498	34%	632	47%	844	59%
	2018	448	483	33%	619	46%	831	58%
	2019	436	461	32%	599	44%	810	57%
	2020	428	436	30%	576	42%	785	55%
	2021	423	409	28%	553	41%	761	53%
	2022	419	385	27%	532	39%	742	52%
	2023	417	363	25%	514	38%	728	51%
	2024	415	344	24%	500	37%	718	50%
	2025	414	327	23%	488	36%	711	50%
	2026	413	313	22%	478	35%	706	50%

Research and data needs

Recommended avenues for research to help improve future black rockfish stock assessments:

1. Further investigation into the movement and behavior of older (> age 10) females to reconcile their absence in fisheries data. If the females are currently inaccessible to fishing gear, can we find where they are?
2. Appropriate natural mortality values for females and males. This will help resolve the extent to which dome-shaped age-based selectivity may be occurring for each.
3. All states needed improved historical catch reconstructions. The trawl fishery catches in particular need particular attention. Given the huge historical removals of that fleet in each state, the assessment is very sensitive to the assumed functional form of selectivity. A synoptic catch reconstruction is recommended, where states work together to resolve cross-state catch issues as well as standardize the approach to catch recommendations.
4. Identifying stanzas or periods of uncertainty in the historical catch series will aid in the exploration of catch uncertainty in future assessment sensitivity runs.
5. The ODFW tagging study off Newport should be continued and expanded to other areas. To provide better prior information on the spatial distribution of the black rockfish stock, further work should be conducted to map the extent of black rockfish habitat and the densities of black rockfish residing there.
6. An independent nearshore survey should be supported in all states to avoid the reliance on fishery-based CPUE indices.
7. Stock structure for black rockfish is a complicated topic that needs further analysis. How this is determined (e.g., exploitation history, genetics, life history variability, biogeography, etc.) and what this means for management units needs to be further refined. This is a general issue for all nearshore stocks that likely have significant and small scale stock structure among and within states, but limited data collections to support small-scale management.

Table ES-13. Summary table of the result for each state assessment model for black rockfish.

California

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Landings (mt)	257	258	233	248	359	265	216	239	414
Total removals (mt)	261	261	237	252	365	269	219	243	421
OFL (mt)	753	736	722	722	1469	1317	1163	1117	1108
ACL (mt)	753	736	722	722	1000	1000	1000	1000	1000
1-SPR	0.60	0.58	0.53	0.53	0.65	0.56	0.46	0.45	0.57
Exploitation rate (catch/ age 3+ biomass)	0.09	0.08	0.07	0.07	0.10	0.08	0.06	0.05	0.08
Age 3+ biomass (mt)	2987	3143	3315	3456	3496	3447	3975	4714	5346
Spawning Output	226	228	231	241	257	268	285	305	322
~95% CI	146-306	145-311	145-317	151-332	159-354	162-374	170-401	180-430	189-454
Recruitment	1371	984	1327	4509	4323	2997	1765	1701	1719
~95% CI	714-2029	465-1504	565-2088	2176-6842	1560-7086	841-5153	306-3223	1206-2195	1226-2213
Depletion (%)	0.21	0.21	0.22	0.23	0.24	0.25	0.27	0.29	0.30
~95% CI	0.13-0.3	0.13-0.3	0.13-0.31	0.14-0.32	0.14-0.34	0.15-0.36	0.15-0.38	0.17-0.41	0.17-0.43

Oregon

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2
Landings (mt)										
Total removals (mt)										
OFL (mt)										
ACL (mt)										
1-SPR										
Exploitation rate (catch/ age 3+ biomass)										
Age 3+ biomass (mt)										
Spawning Output										
~95% CI										
Recruitment										
~95% CI										
Depletion (%)										
~95% CI										

Washington

	2005	2006	2007	2008	2009	2010	2011	2012	2013	20
Landings (mt)	321	307	283	219	247	216	228	277	321	35
Total removals (mt)	325	312	287	222	251	219	232	282	325	35
OFL (mt)	540	540	540	540	490	464	426	415	411	40
ACL (mt)	540	540	540	540	490	464	426	415	411	40
1-SPR	0.54	0.54	0.52	0.45	0.48	0.44	0.45	0.49	0.52	0.
Exploitation rate (catch/ age 3+ biomass)	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.05	0.06	0.
Age 3+ biomass (mt)	4984	4899	4814	4779	4980	5119	5427	5550	5699	56
Spawning Output	594	576	564	557	558	551	550	552	557	56
~95% CI	482-706	466-686	455-672	449-665	450-665	444-657	444-656	446-658	449-664	456-
Recruitment	1371	984	1327	4509	4323	2997	1765	1701	1719	17
~95% CI	714-2029	465-1504	565-2088	2176-6842	1560-7086	841-5153	306-3223	1206-2195	1226-2213	12 22
Depletion (%)	0.44	0.42	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.
~95% CI	0.36-0.51	0.35-0.5	0.35-0.49	0.34-0.48	0.34-0.48	0.34-0.47	0.34-0.47	0.34-0.47	0.34-0.48	0.35-