Catch-only Update Assessment of Black Rockfish (*Sebastes melanops*) Off the U.S. West Coast in 2019

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Introduction

introduction

Stock

stock

This assessment reports the status of the Black Rockfish (*Sebastes melanops*) resource in U.S. waters off the West Coast using data through 2014, updated with catches through 2018 and with projected catches for 2019 and 2020.

The models described in this document apply to the black rockfish (Sebastes melanops) stocks that reside in the waters from Point Conception (3427' N latitude) in the south to the U.S. boundary with Canada (approximately 4830' 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 (4200' N latitude) and OR/WA border (4616' 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

catches

Information on historical landings of Black Rockfish are available back to xxxx... (Table l). Commercial landings were small during the years of World War II, ranging between 26 to 758 metric tons (mt) per year.

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 closed nearshore commercial fisheries in state water in late 1990's and never allowed the live-fish fishery to develop. 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.

(Figures a-h)
(Figure b)

Since 2000, annual total landings of Black Rockfish have ranged between 188-356 mt, with landings in 2014 totaling 356 mt.

Data and Assessment

data-and-assessment

This is a catch-only update of the assessment conducted in 2015. The assessment assumes three areas delineated by state borders, as was agreed upon at a pre-assessment and data workshop in March 2015. The current assessment use the same versions of Stock Synthesis 3 as in 2015. The Washington base-case assessment includes two commercial and a single recreational fleet, and a dockside and tag-based CPUE series. The Oregon assessment has three commercial fleets and two recreational fleets, and uses five surveys and an additional research study for biological compositions. California also has three commercial fleets and 1 recreational fleet with three surveys of abundance, all based on recreational fisheries. All three models include length compositions, and conditional age-at-length data.

Sigma analysis

sigma-analysis

One purpose of this assessment is to evaluate the effect of increasing the sigma value used to calculate P* buffers as the assessment ages, and the three models were each run with a series of buffers calculated from an increasing sigma. The Washington and California stocks are Category I stocks, and the models used buffers calculated from the 0.45 value of sigma. For the Oregon model, these were calculated according to the default Category II values. The timeseries of catches, projections and buffers used for this analysis were all provided by the Groundfish Management Team (GMT) of the Pacific Fishery Management Council (PFMC).

Ecosystem Considerations

ecosystem-considerations

Ecosystem considerations were not explicitly explored 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.

Unresolved Problems and Major Uncertainties

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 California and Washington base models instead use 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 fixing natural mortality as was necessary in the Oregon model.

The Oregon model also contained a step in female natural mortality, a specification not used in the California or Washington models. Another important issue is the highly uncertain historical time-series of removals in all states, which needs further consideration.

The development of fishery-dependent indices of abundance still requires 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 issue will likely rely on black rockfish-specific data.

Research and Data Needs

research-and-data-needs

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

1. **Movement**: 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 determine where they are?
2. **Mortality**: Appropriate natural mortality values for females and males will help resolve the extent to which dome-shaped age-based selectivity may be occurring for each.
3. **Historical Catch**: All states need improved historical catch reconstructions. The trawl fishery catches in particular require 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-border catch issues as well as standardize the approach to catch recommendations.

4. **Uncertainty**: 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. **Habitat**: The ODFW tagging study off Newport should continue and be 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. **Survey**: An independent nearshore survey should be supported in all states to avoid the reliance on fishery-based CPUE indices.

7. **Stock Structure**: Stock structure for black rockfish is a complicated topic that calls for 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.

Executive summary for the California Model

executive-summary-for-the-california-model

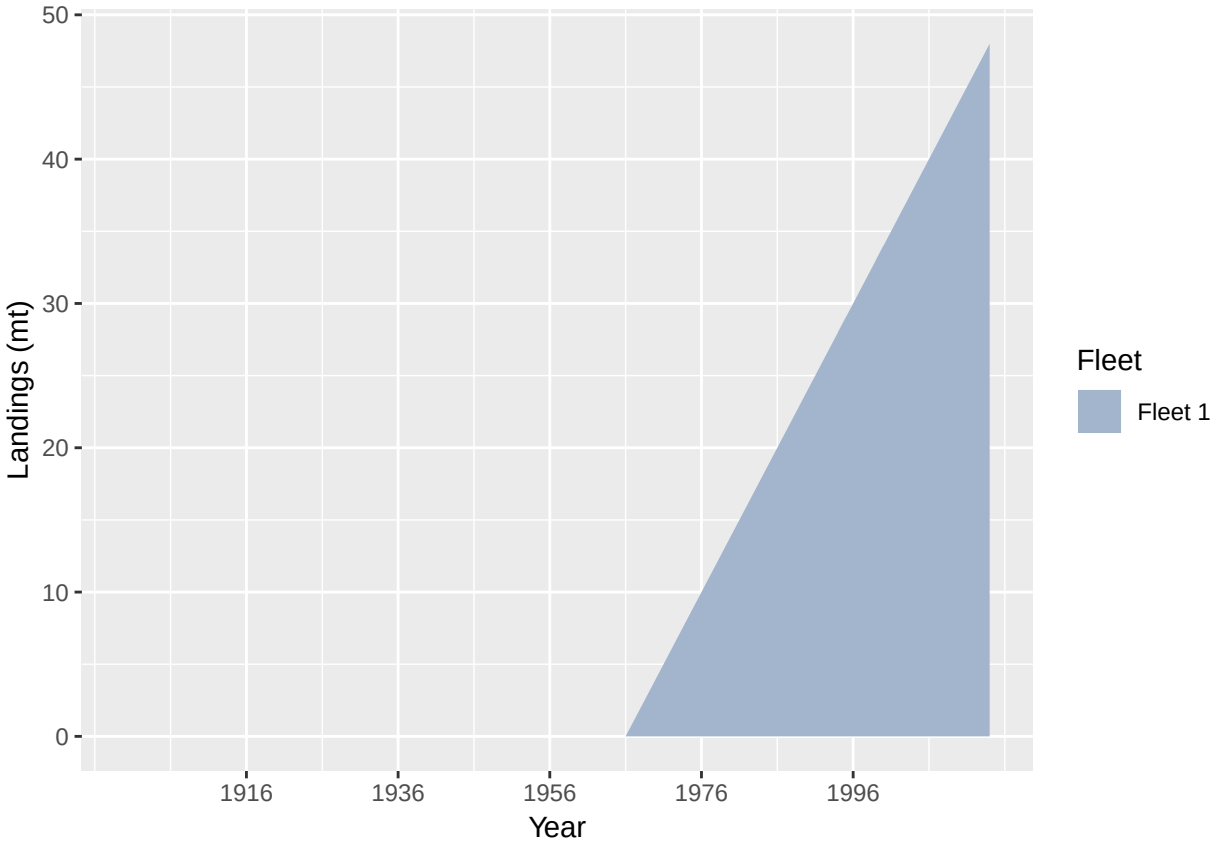

Figure a: Black Rockfish catch history for the CA recreational fleets. `fig:Exec_catch1`

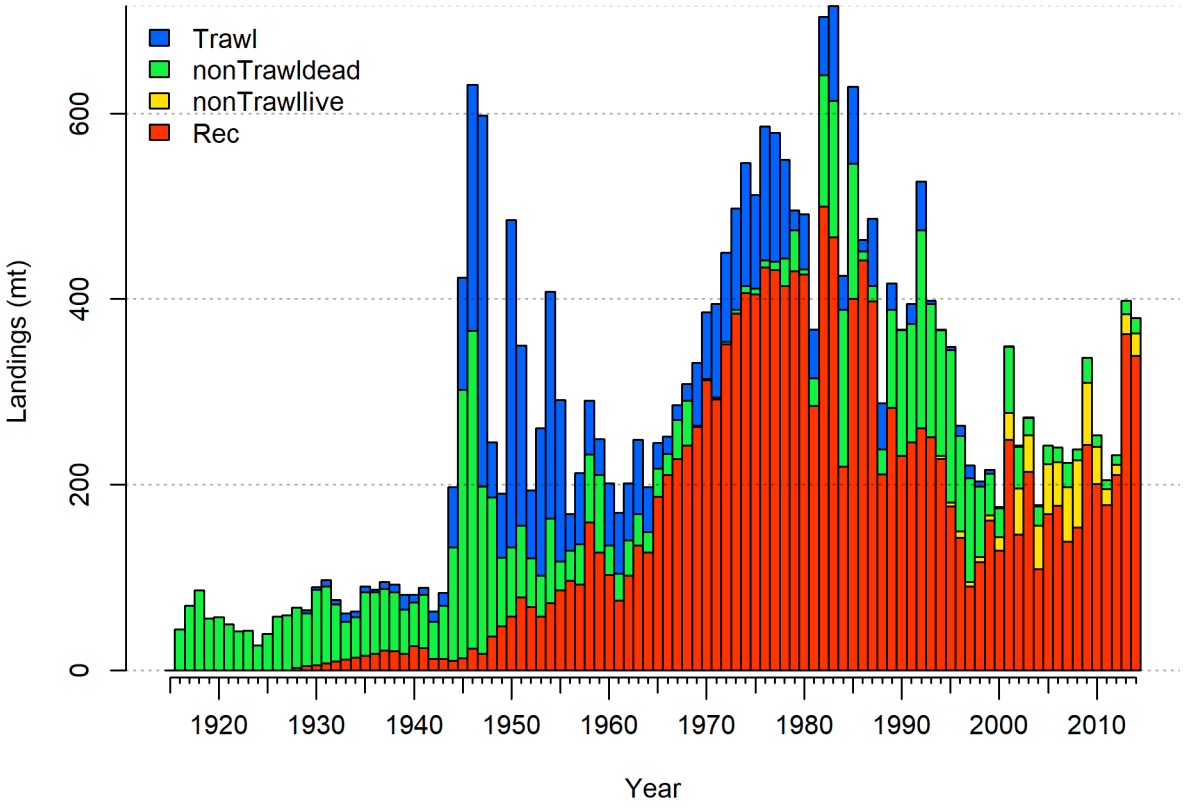

Figure b: Catch history of Black Rockfish in the California model. `fig:r4ss_catches`

Table a: Recent Black Rockfish landings (mt) by fleet.

tab:Exec_catch

Year	Landings 1	Landings 2	Landings 3	Landings 4	Landings 5	Total
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	-	-	-
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	-	-	-	-	-	-
2014	-	-	-	-	-	-

Stock Biomass

stock-biomass

(Figure c and Table b).

The 2014 estimated spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass at 33.3% (95% asymptotic interval: ± 18.9%-47.7%) (Figure d). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high.

Table b: Recent trend in beginning of the year spawning output and depletion for the California model for Black Rockfish.

tab:SpawningDeplete_mod1

Year	Spawning Output (million eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2006	227.850	(144.7-311)	0.215	(0.129-0.3)
2007	231.368	(145.32-317.41)	0.218	(0.131-0.305)
2008	241.187	(150.58-331.79)	0.227	(0.136-0.318)
2009	256.821	(159.31-354.33)	0.242	(0.145-0.339)
2010	267.775	(161.81-373.74)	0.252	(0.147-0.357)
2011	285.105	(169.54-400.67)	0.269	(0.155-0.383)
2012	305.208	(180.43-429.98)	0.288	(0.165-0.41)
2013	321.621	(189.4-453.84)	0.303	(0.174-0.431)
2014	329.401	(190.94-467.86)	0.310	(0.177-0.444)
2015	353.216	(203.75-502.69)	0.333	(0.189-0.477)

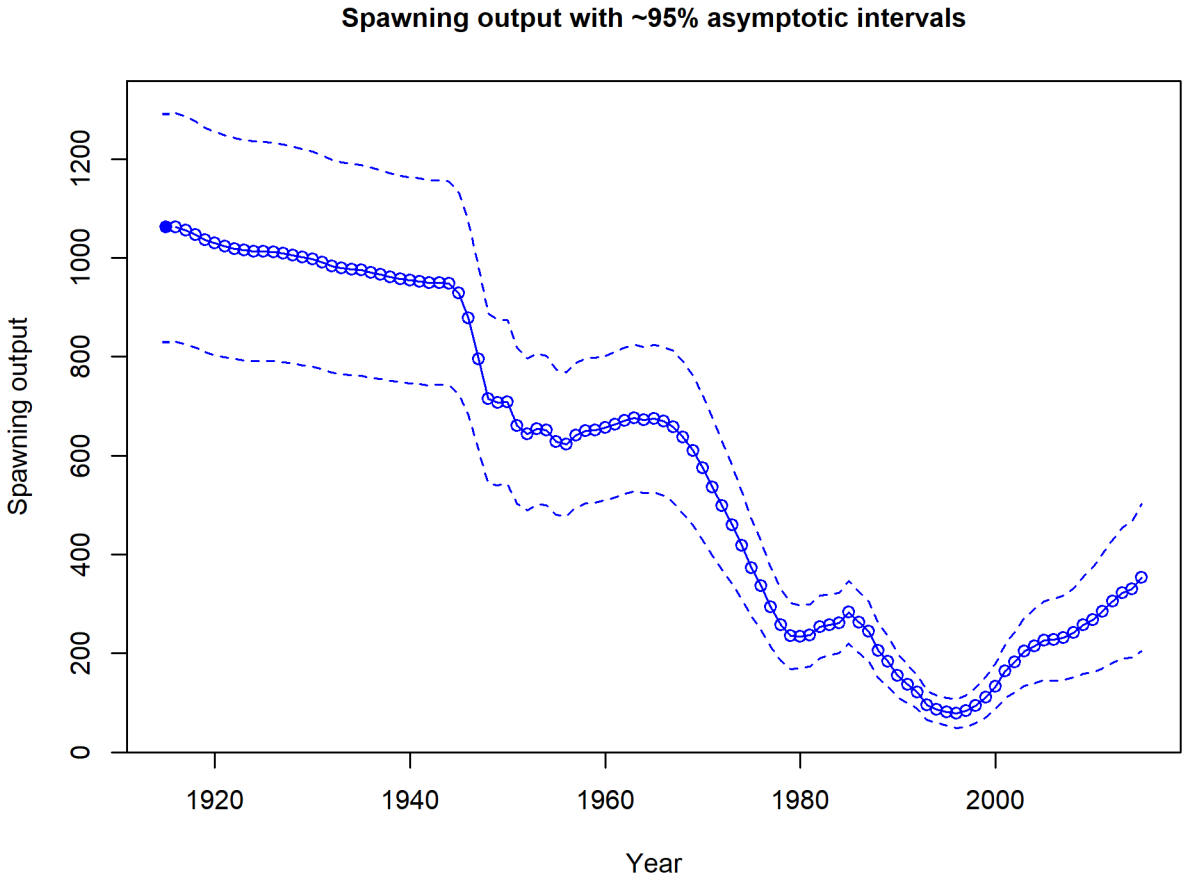

Figure c: Time series of spawning biomass trajectory (circles and line: median; light broken lines: 95% credibility intervals) for the base case assessment model. ⌜fig:Spawnbio_all

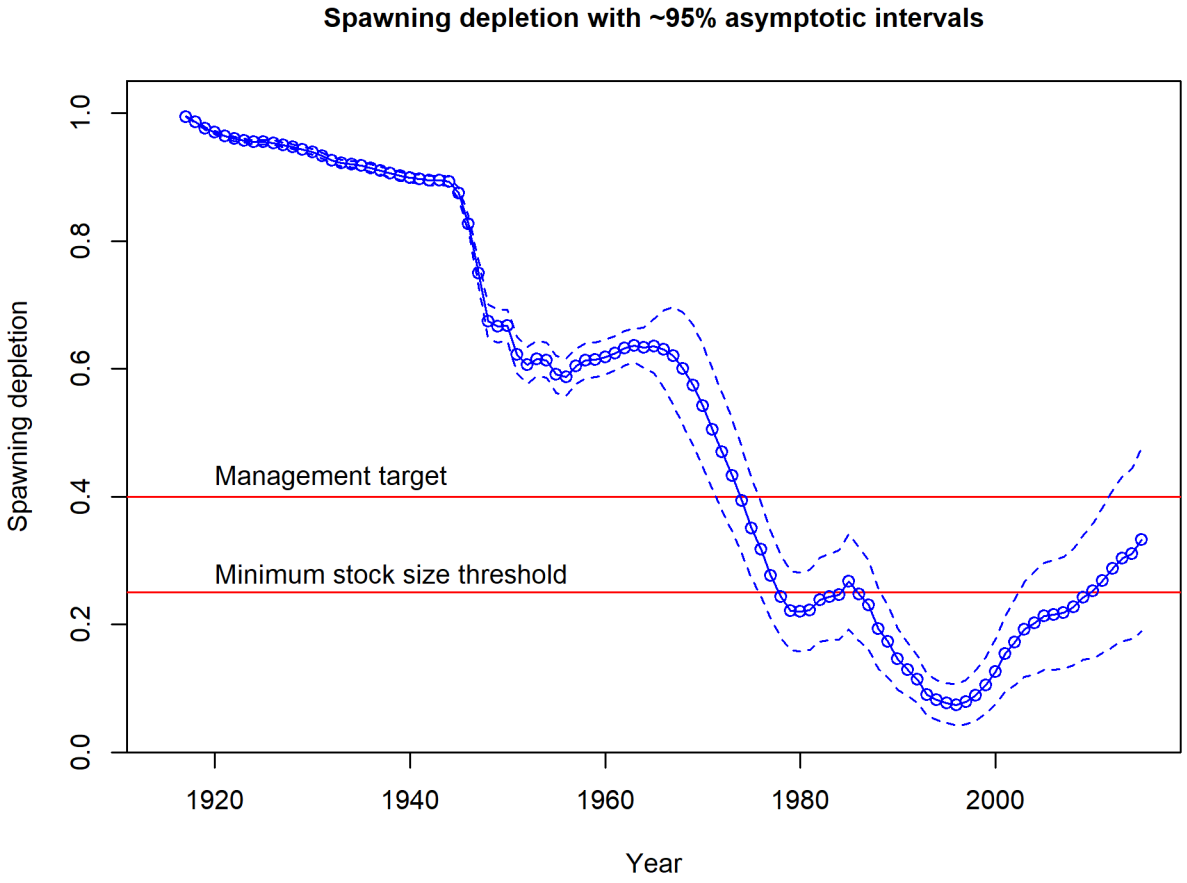

Figure d: Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model. `fig:RelDeplete_all`

Recruitment

recruitment

Recruitment deviations were estimated from xxxx-xxxx (Figure e and Table c).

Table c: Recent recruitment for the California model.

tab:Recruit_mod1

Year	Estimated Recruitment (1,000s)	~ 95% confidence interval
2006	984.26	(585.85 - 1653.62)
2007	1326.80	(756.15 - 2328.1)
2008	4508.71	(2710.76 - 7499.17)
2009	4323.29	(2318.79 - 8060.6)
2010	2997.05	(1493.29 - 6015.09)
2011	1764.55	(798.38 - 3899.95)
2012	1700.52	(1273.7 - 2270.38)
2013	1719.46	(1292.47 - 2287.52)
2014	1727.92	(1299.38 - 2297.79)
2015	1751.93	(1322.75 - 2320.36)

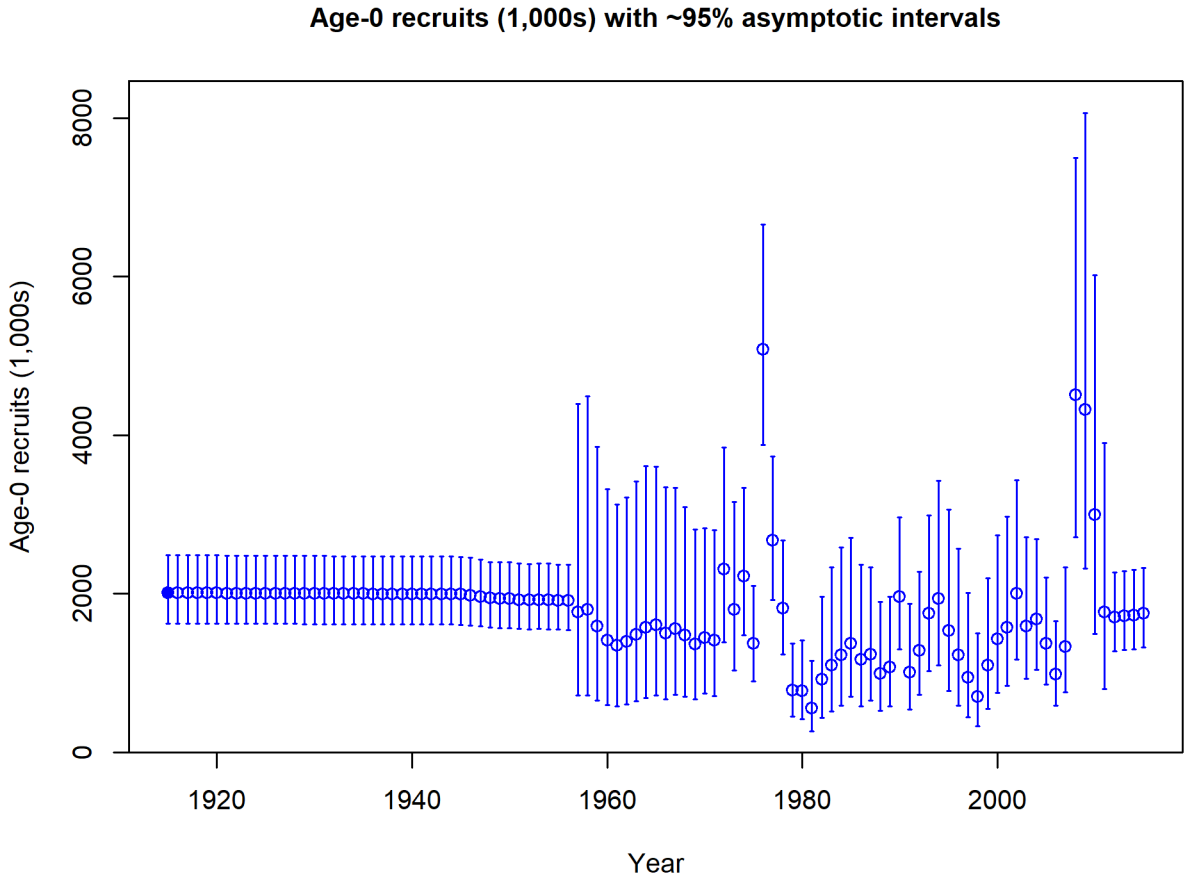

Figure e: Time series of estimated Black Rockfish recruitments for the base-case model with 95% confidence or credibility intervals. `fig:Recruits_all`

Exploitation status

exploitation-status

Harvest rates estimated by the base model ..... management target levels (Table d and Figure f).

Table d: Recent trend in spawning potential ratio and exploitation for Black Rockfish in the California model. Fishing intensity is (1-SPR) divided by 50% (the SPR target) and exploitation is F divided by F_{SPR}.

tab:SPR_Exploit_mod1

Year	Fishing intensity	~ 95% confidence interval	Exploitation rate	~ 95% confidence interval
2005	1.20	(0.96-1.44)	0.09	(0.06-0.12)
2006	1.15	(0.91-1.4)	0.08	(0.06-0.11)
2007	1.06	(0.81-1.31)	0.08	(0.05-0.1)
2008	1.06	(0.81-1.31)	0.08	(0.05-0.1)
2009	1.30	(1.04-1.55)	0.10	(0.07-0.14)
2010	1.12	(0.85-1.38)	0.08	(0.05-0.11)
2011	0.92	(0.67-1.18)	0.06	(0.04-0.08)
2012	0.89	(0.65-1.14)	0.05	(0.03-0.07)
2013	1.14	(0.88-1.41)	0.08	(0.05-0.11)
2014	1.07	(0.8-1.33)	0.07	(0.05-0.1)

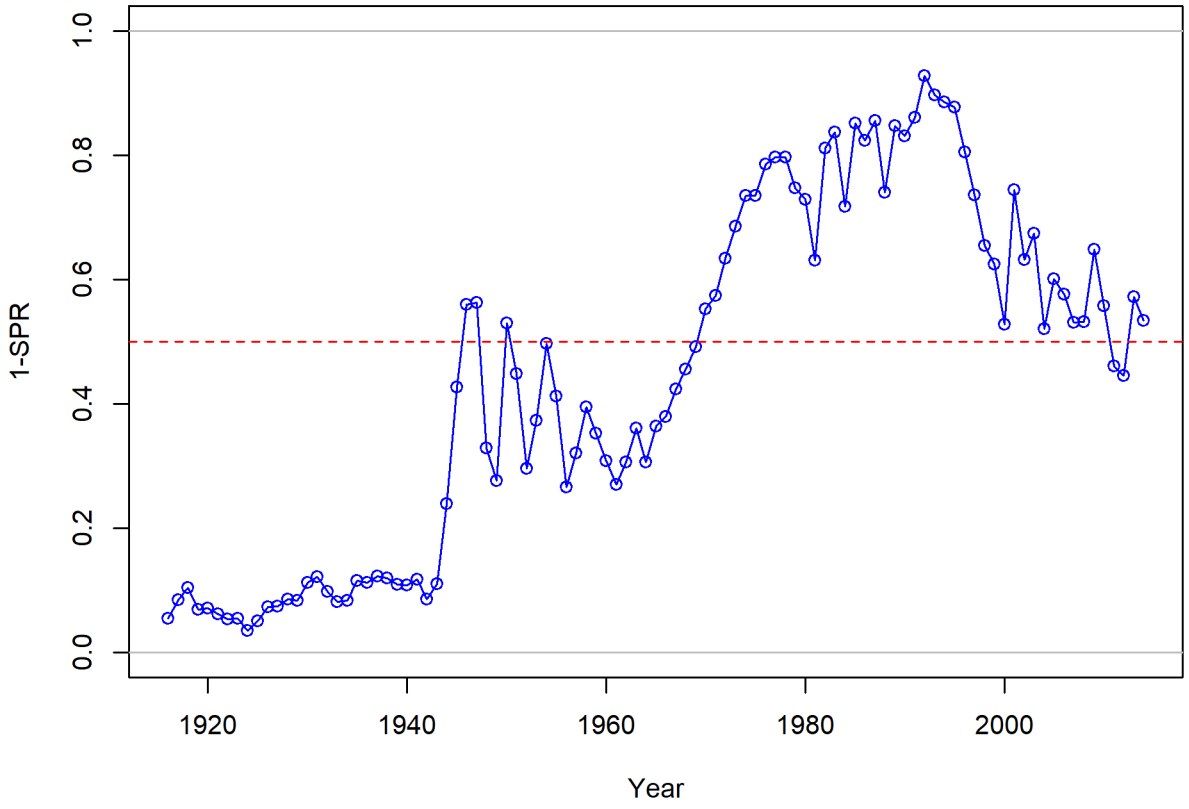

Figure f: Estimated spawning potential ratio (SPR) for the base-case model. One minus SPR is plotted so that higher exploitation rates occur on the upper portion of the y-axis. The management target is plotted as a red horizontal line and values above this reflect harvests in excess of the overfishing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

Reference Points

reference-points

This stock assessment estimates that Black Rockfish in the California model is below the biomass target ($SB_{40\%}$), and well above the minimum stock size threshold ($SB_{25\%}$). The estimated relative depletion level for the base model in 2015 is 33.3% (95% asymptotic interval: ± 18.9%-47.7%, corresponding to an unfished spawning biomass of 353.216 million eggs (95% asymptotic interval: 203.75-502.69 million eggs) of spawning biomass in the base model (Table e). Unfished age 1+ biomass was estimated to be 9,540 mt in the base case model. The target spawning biomass ($SB_{40\%}$) is 425 million eggs, which corresponds with an equilibrium yield of 343 mt. Equilibrium yield at the proxy F_{MSY} harvest rate corresponding to $SPR_{50\%}$ is 319 mt (Figure g).

Table e: Summary of reference points and management quantities for the base case California model.

tab:Ref_pts_mod1

Quantity	**Estimate**	**Low 2.5% limit**	**High 2.5% limit**
Unfished spawning output (million eggs)	1,062	830	1,293
Unfished age 1+ biomass (mt)	9,540	8,862	10,219
Unfished recruitment (R_0)	2,010	1,580	2,440
Spawning output(2014 million eggs)	329	191	468
Depletion (2014)	0.31	0.177	0.444
Reference points based on SB$_{40\%}$			
Proxy spawning output ($B_{40\%}$)	425	332	517
SPR resulting in $B_{40\%}$ ($SPR_{B40\%}$)	0.444	0.444	0.444
Exploitation rate resulting in $B_{40\%}$	0.075	0.07	0.081
Yield with $SPR_{B40\%}$ 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	0.059	0.069
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	0.287	0.303
Exploitation rate at MSY	0.117	0.107	0.126
MSY (mt)	376	345	408

Management Performance

management-performance

Table f

Table f: 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.

tab:mnmgt_perform

Year	OFL (mt; ABC prior to 2011)	ABC (mt)	ACL (mt; OY prior to 2011)	Estimated total catch (mt)
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

186 # Decision Table

decision-table

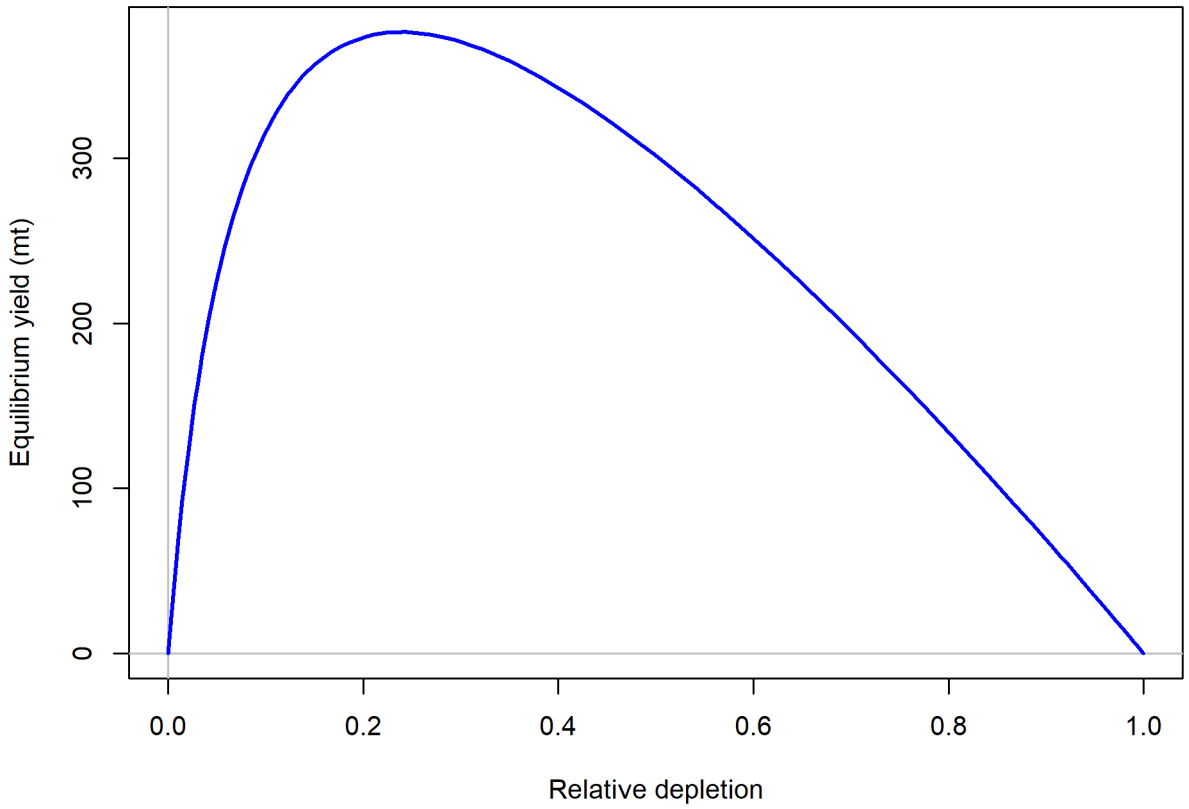

Figure g: Equilibrium yield curve for the base case model. Values are based on the 2014 fishery selectivity and with steepness fixed at 0.718. ⌜fig:Yield_all

Table g: Projections of potential OFL (mt) for each model, using the base model forecast. tab:OFL_projection

Year	OFL
2015	353.54
2016	359.25
2017	366.23
2018	374.73
2019	382.01
2020	380.61
2021	379.09
2022	373.80
2023	369.34
2024	365.90
2025	363.12
2026	361.05
2027	359.56
2028	358.51
2029	357.83
2030	357.23
2031	356.89

Table h: Summary of 10-year projections beginning in 2016 for alternate states of nature based on an axis of uncertainty for the California model. Columns range over low, mid, and high states of nature, and rows range over different assumptions of catch levels. An entry of "–" indicates that the stock is driven to very low abundance under the particular scenario.

tab:Decision_table_mod1

			States of nature					
			Low M 0.05		Base M 0.07		High M 0.09	
	Year	Catch	Spawning Output	Depletion	Spawning Output	Depletion	Spawning Output	Depletion
40-10 Rule, Low M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
40-10 Rule, High M	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-
Average Catch	2019	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	-
	2021	-	-	-	-	-	-	-
	2022	-	-	-	-	-	-	-
	2023	-	-	-	-	-	-	-
	2024	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	-
	2026	-	-	-	-	-	-	-
	2027	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	-

Table i: Base case results summary.

tab:base_summary1

Quantity	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Landings (mt)										
Total Est. Catch (mt)										
OFL (mt)										
ACL (mt)										
(1-SPR)(1-$SPR_{50\%}$)	1.15	1.06	1.06	1.30	1.12	0.92	0.89	1.14	1.07	
Exploitation rate	0.08	0.08	0.08	0.10	0.08	0.06	0.05	0.08	0.07	
Age 1+ biomass (mt)	2987.38	3142.51	3315.26	3456.33	3496.33	3446.74	3974.90	4713.79	5346.04	5610.33
Spawning Output	227.8	231.4	241.2	256.8	267.8	285.1	305.2	321.6	329.4	353.2
95% CI	(144.7-311)	(145.32-317.41)	(150.58-331.79)	(159.31-354.33)	(161.81-373.74)	(169.54-400.67)	(180.43-429.98)	(189.4-453.84)	(190.94-467.86)	(203.75-502.69)
Depletion	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
95% CI	(0.129-0.3)	(0.131-0.305)	(0.136-0.318)	(0.145-0.339)	(0.147-0.357)	(0.155-0.383)	(0.165-0.41)	(0.174-0.431)	(0.177-0.444)	(0.189-0.477)
Recruits	984.26	1326.80	4508.71	4323.29	2997.05	1764.55	1700.52	1719.46	1727.92	1751.93
95% CI	(585.85 - 1653.62)	(756.15 - 2328.1)	(2710.76 - 7499.17)	(2318.79 - 8060.6)	(1493.29 - 6015.09)	(798.38 - 3899.95)	(1273.7 - 2270.38)	(1292.47 - 2287.52)	(1299.38 - 2297.79)	(1322.75 - 2320.36)

Executive summary for the Oregon Model

executive-summary-for-the-oregon-model

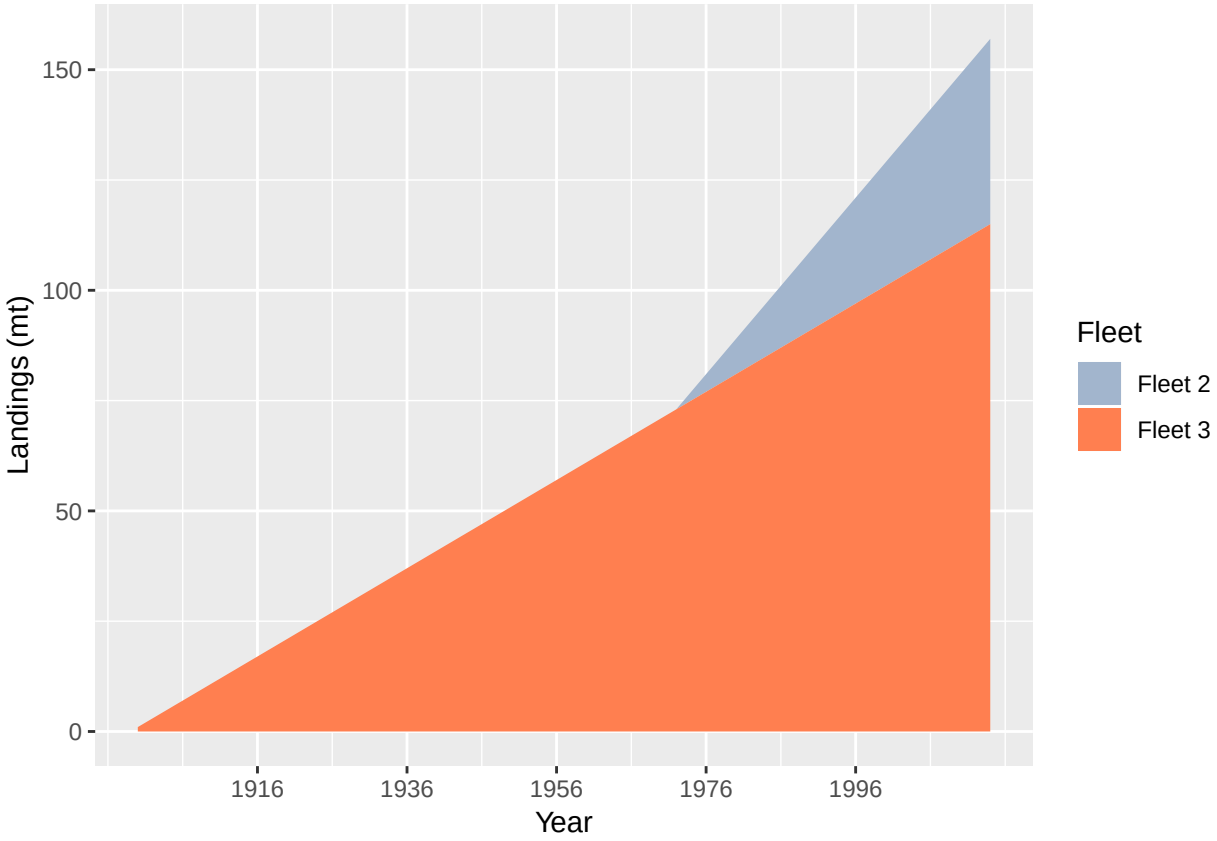

Figure h: Stacked line plot of Black Rockfish catch history for the commercial fleets. fig:Exec_catch2

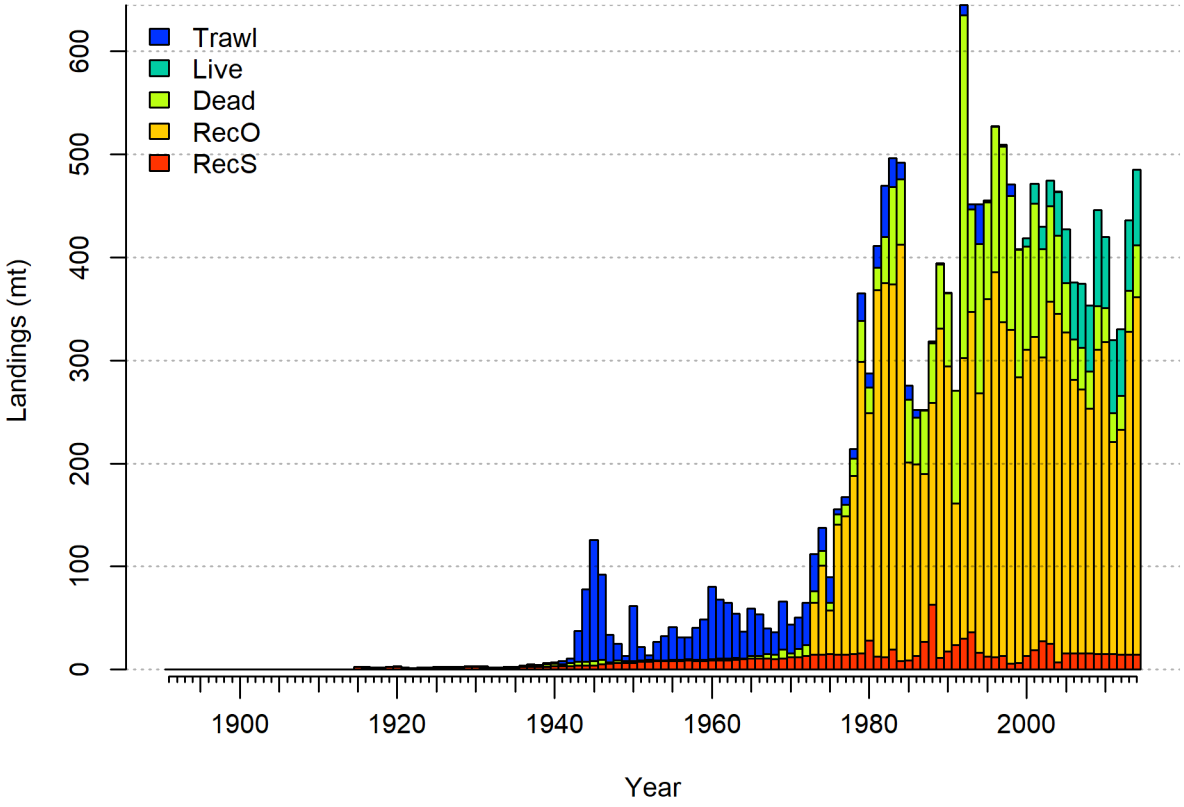

Figure i: Catch history of Black Rockfish in the California model. `fig:r4ss_catches2`

Table j: Recent Black Rockfish landings (mt) by fleet.

tab:Exec_catch

Year	Landings 1	Landings 2	Landings 3	Landings 4	Landings 5	Total
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	-	-	-
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	-	-	-	-	-	-
2014	-	-	-	-	-	-

Stock Biomass

stock-biomass-1

(Figure **??** and Table k).

The 2014 estimated spawning biomass relative to unfished equilibrium spawning biomass is above the target of 40% of unfished spawning biomass at 60.3% (95% asymptotic interval: ± 18.9%-47.7%) (Figure d). Approximate confidence intervals based on the asymptotic variance estimates show that the uncertainty in the estimated spawning biomass is high.

Table k: Recent trend in beginning of the year spawning output and depletion for the Oregon model for Black Rockfish.

tab:SpawningDeplete_mod2

Year	Spawning Output (million eggs)	~ 95% confidence interval	Estimated depletion	~ 95% confidence interval
2006	776.596	(676.31-876.88)	0.589	(0.575-0.604)
2007	778.375	(678.43-878.32)	0.590	(0.576-0.605)
2008	781.352	(681.55-881.15)	0.593	(0.578-0.607)
2009	786.954	(687.07-886.84)	0.597	(0.583-0.611)
2010	785.401	(685.38-885.42)	0.596	(0.582-0.61)
2011	785.753	(685.59-885.92)	0.596	(0.582-0.61)
2012	793.377	(692.97-893.79)	0.602	(0.588-0.616)
2013	800.964	(700.14-901.79)	0.608	(0.594-0.621)
2014	800.461	(699.23-901.69)	0.607	(0.593-0.621)
2015	794.603	(693.2-896.01)	0.603	(0.588-0.617)

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206 Executive summary for the Washington Model

executive-summary-for-the-washington-model

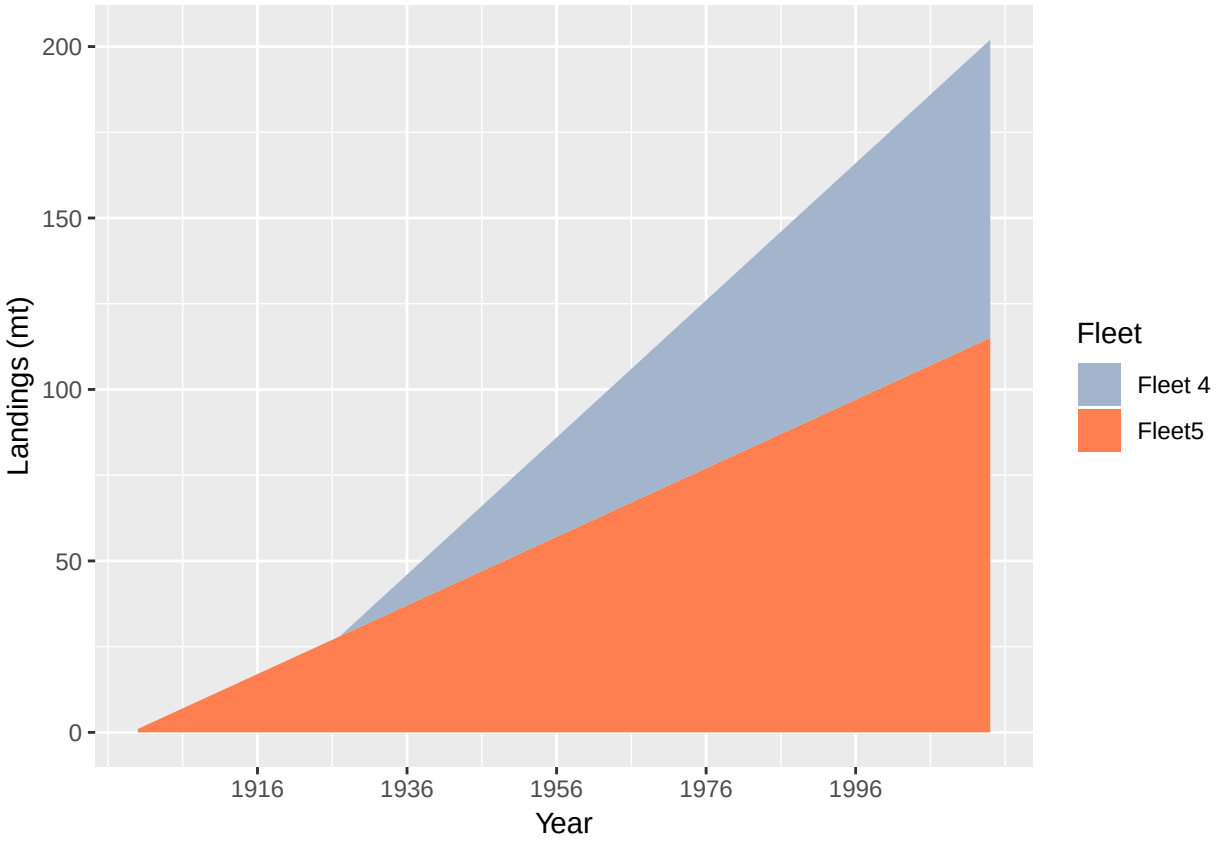

Figure j: Black Rockfish catch history for the recreational fleets. `fig:Exec_catch3`

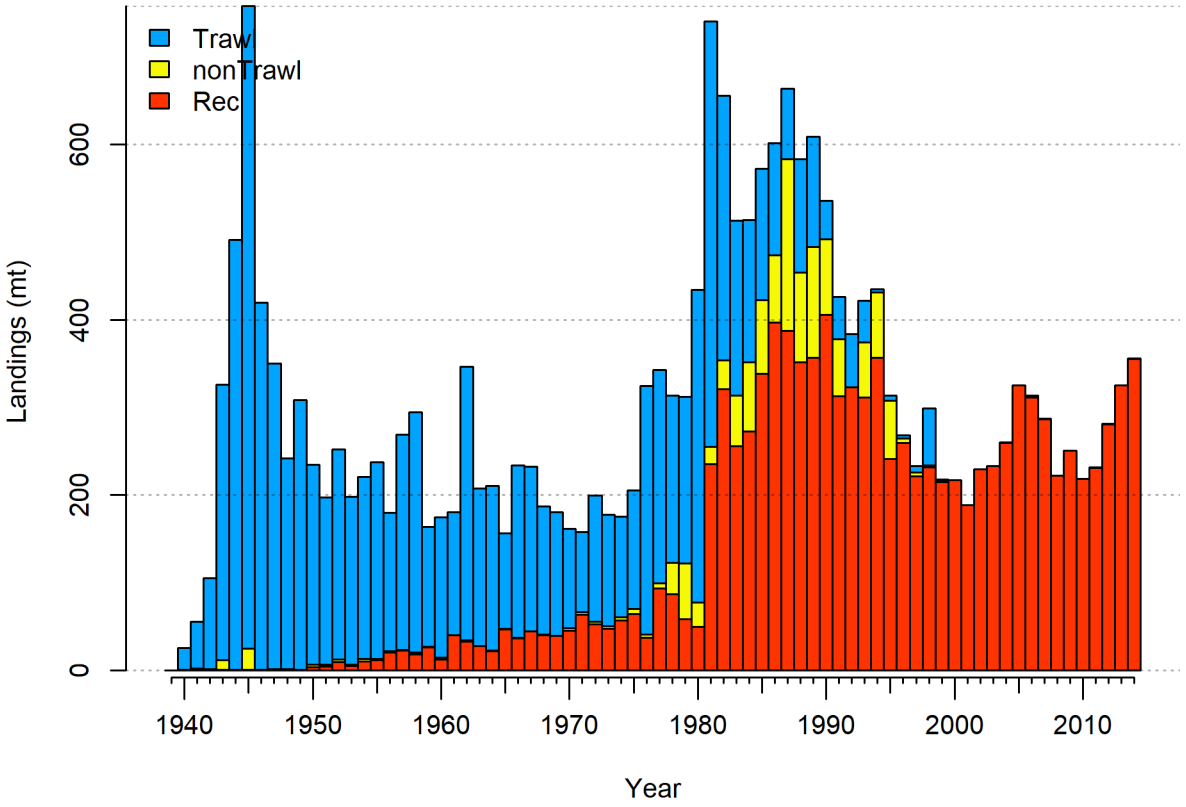

Figure k: Catch history of Black Rockfish in the Washington model. [fig:r4ss_catches3

Table l: Recent Black Rockfish landings (mt) by fleet.

tab:Exec_catch

Year	Landings 1	Landings 2	Landings 3	Landings 4	Landings 5	Total
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	-	-	-
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	-	-	-	-	-	-
2014	-	-	-	-	-	-

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References

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