Agenda Item H.5
Attachment 16
September 2019

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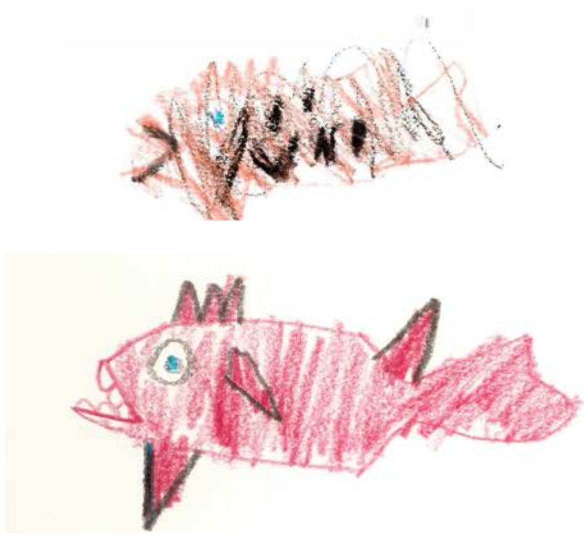
A 2019 catch-only update/projection from the 2017 assessment update of blackgill rockfish (*Sebastes melanostomus*) in the Conception and Monterey INPFC areas



Picture credit: Arlo Hamel

Owen S. Hamel[1]
Maia S. Kapur[2]

[1]Northwest Fisheries Science Center, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98112; owen.hamel@noaa.gov

[2]University of Washington, School of Aquatic and Fisheries Sciences, 1122 NE Boat St., Seattle, Washington 98105

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Executive Summary

Stock

This catch-only update/projection reports the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas, using available data from 1950 through 2016, catch information for 2017 and 2018, and catch projections for 2019 and 2020. The resource is modeled as a single stock. Although the distribution of blackgill rockfish extends north to at least Canadian waters and south into Mexican waters, the species becomes rare north of Cape Mendocino, CA, and data from Mexican waters are unavailable.

Catches

Historical catches of blackgill rockfish were largely made in southern California (south of Point Conception), where the species is the target of both directed and incidental catches from fixed gear (hook and line, and historically, gillnet). In recent years, a greater fraction of the total catch has come from central California waters, in fixed gear (hook and line, pot and trap, historically setnet) and trawl fisheries. Catch estimates from 2010 through 2015 were based on NWFSC total mortality reports and area/gear landings from the California Cooperative Groundfish Survey (CalCOM) database. Catches for 2016 were based on CalCOM catch estimates and averaged discard rates for the 2010-2015 period by fishery. Fleets in this model are identical to the 2011 model, including southern California fixed gear, central California fixed gear, and central California trawl. Recent catches from 2017 and 2018, as well as projected values for 2019 and 2020, were provided by the PFMC GMT.

Table a: Recent catch fixed and trawl gears (mt) used in the catch-only projection.

Year	South Fixed	Central Fixed	Trawl	Total
2009	22.6	52.1	57.9	132.6
2010	37.5	57.3	57.5	152.3
2011	37.0	99.2	14.1	150.3
2012	56.6	69.4	69.4	195.4
2013	7.5	26.4	38.1	72.0
2014	9.9	31.1	31.8	72.8
2015	12.9	10.9	19.0	42.8
2016	12.4	17.5	8.8	38.7
2017	11.9	16.2	24.5	51.6
2018	7.3	14.5	29.6	51.4

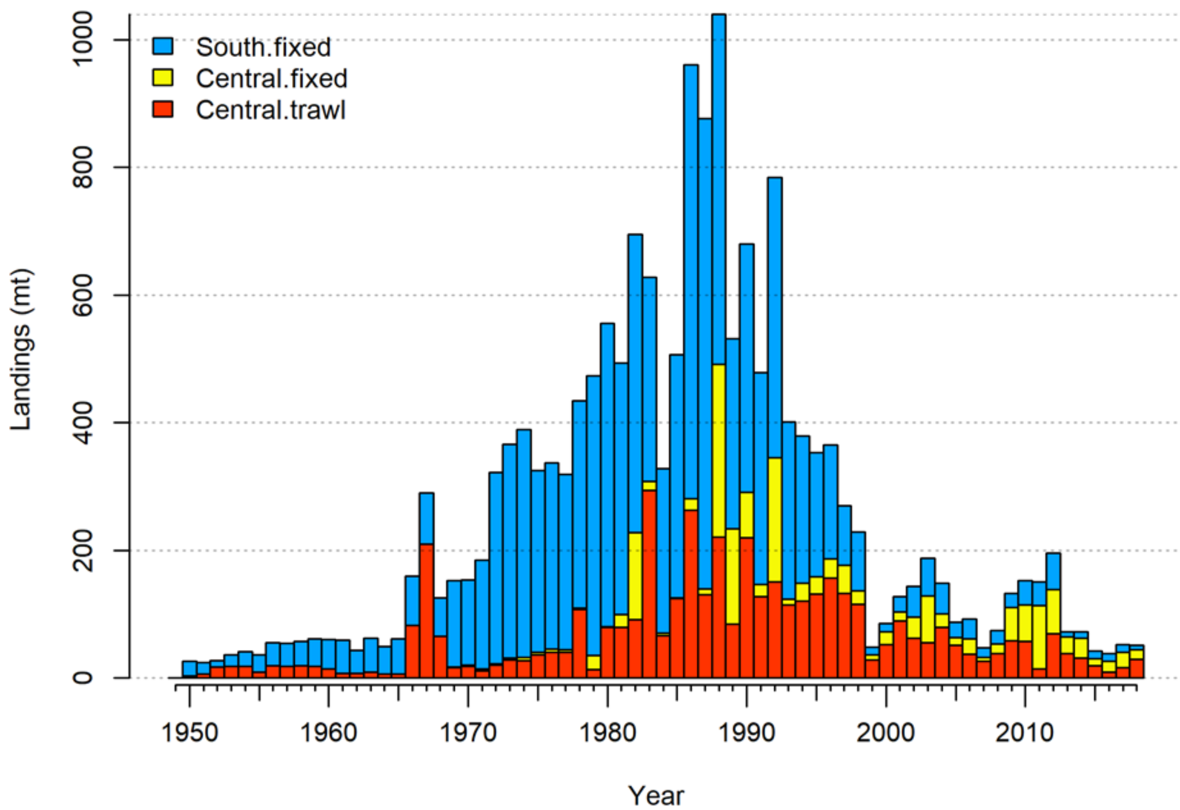

Figure a: Landings of blackgill rockfish from 1950 to 2018 for the trawl and fixed gear fisheries.

Data and assessment

This catch-only update assessment uses the Stock Synthesis 3 (SS3, version 3.24u) integrated length and age structured model, and includes both length frequency and conditional length-at-age data from all three commercial fisheries. The basic structure (fleets, estimated parameters) is unchanged from the 2011 model; the only new parameter is from a selectivity time block added to the trawl fishery to account for full retention of blackgill rockfish in that fishery following implementation of the trawl fishery rationalization program. The 2017 updated model did incorporate new life history data (maturity and fecundity) developed and published since the 2011 assessment, and nearly 2000 new age observations from the NWFSC bottom trawl survey to inform growth (estimated internally). The model also included new length composition data from 2010-2016 for all three fisheries (southern fixed gear, central CA fixed gear and central CA trawl), as well extended the NWFSC shelf and slope survey index from 2010 through 2016, including associated length and age data. The 2017 base model and this catch-only update use the updated rockfish steepness prior (Thorson 2016) for rockfish of 0.718. The estimated natural mortality rates of 0.063 (females) and 0.065 (males) are unchanged from the 2011 assessment, and model results are highly sensitive to the assumed values for M. As in the 2011 model and 2017 update, recruitment is assumed to be deterministic.

Stock biomass

The assessment uses a size-dependent fecundity relationship, and the model suggests that the spawning output of blackgill rockfish was at high levels in the mid-1970s; began to decline steeply in the late 1970s through the 1980s (consistent with the rapid development and growth of the targeted fishery); and reached a low point of approximately 20% of the unfished level in the mid-1990s. Since that time, catches have declined sharply and spawning output has increased, such that the current estimated larval production is now above the target level of 40% of the unfished larval output.

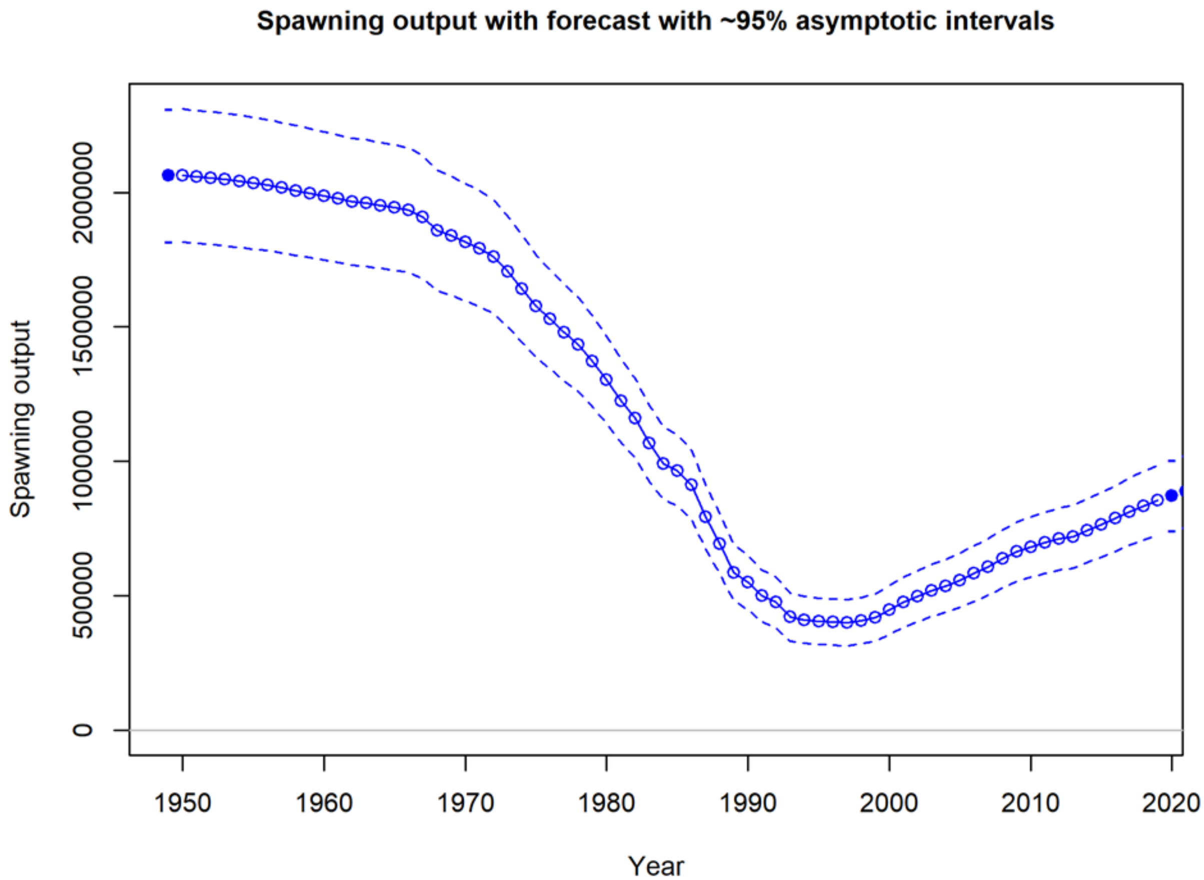

Figure b: Estimated female spawning biomass time-series from the base model (solid line) with an approximate asymptotic 95% confidence interval (dashed lines). Filled in point is at 2019.

Table b: Recent trend in estimated female spawning output and relative depletion of the spawning output.

Year	Spawning Output	~95% confidence interval	Estimated depletion	~95% confidence interval
2010	681,851	570,210–793,492	33.0	28.2–37.9
2011	697,066	583,719–810,413	33.8	28.9–38.7
2012	711,385	596,349–826,421	34.5	29.5–39.4
2013	719,854	603,339–836,369	34.9	29.9–39.8
2014	742,127	623,522–860,732	36.0	31.0–41.0
2015	763,487	642,837–884,137	37.0	32.0–42.0
2016	788,106	665,287–910,925	38.2	33.1–43.3
2017	812,499	687,540–937,458	39.4	34.3–44.5
2018	834,403	707,403–961,393	40.4	35.3 – 45.6
2019	855,984	726,996 – 984,972	41.5	36.3 – 46.7

Recruitment

In the assessment, the Beverton-Holt model was used to describe the stock-recruitment relationship. The log of the unexploited recruitment level was treated as an estimated parameter; recruits were taken deterministically from the stock-recruit curve. Recruitment deviations were not estimated, as the lack of obvious cohorts in either age or length data and the high degree of ageing uncertainty make plausible estimates unlikely. The estimated recruitment is projected to be at relatively high levels due to the fixed value of steepness.

Table c: Recent estimated trend in rougheye rockfish recruitment with approximate 95% confidence intervals determined from the base model.

Year	Estimated recruitment (1,000's)	~95% confidence interval
2010	2,138	1,942–2,354
2011	2,150	1,955–2,365
2012	2,161	1,966–2,374
2013	2,167	1,972–2,380
2014	2,182	1,989–2,394
2015	2,196	2,004–2,407
2016	2,212	2,021–2,421
2017	2,227	879–5,640
2018	2,240	36-4,444
2019	2,252	36-4,467

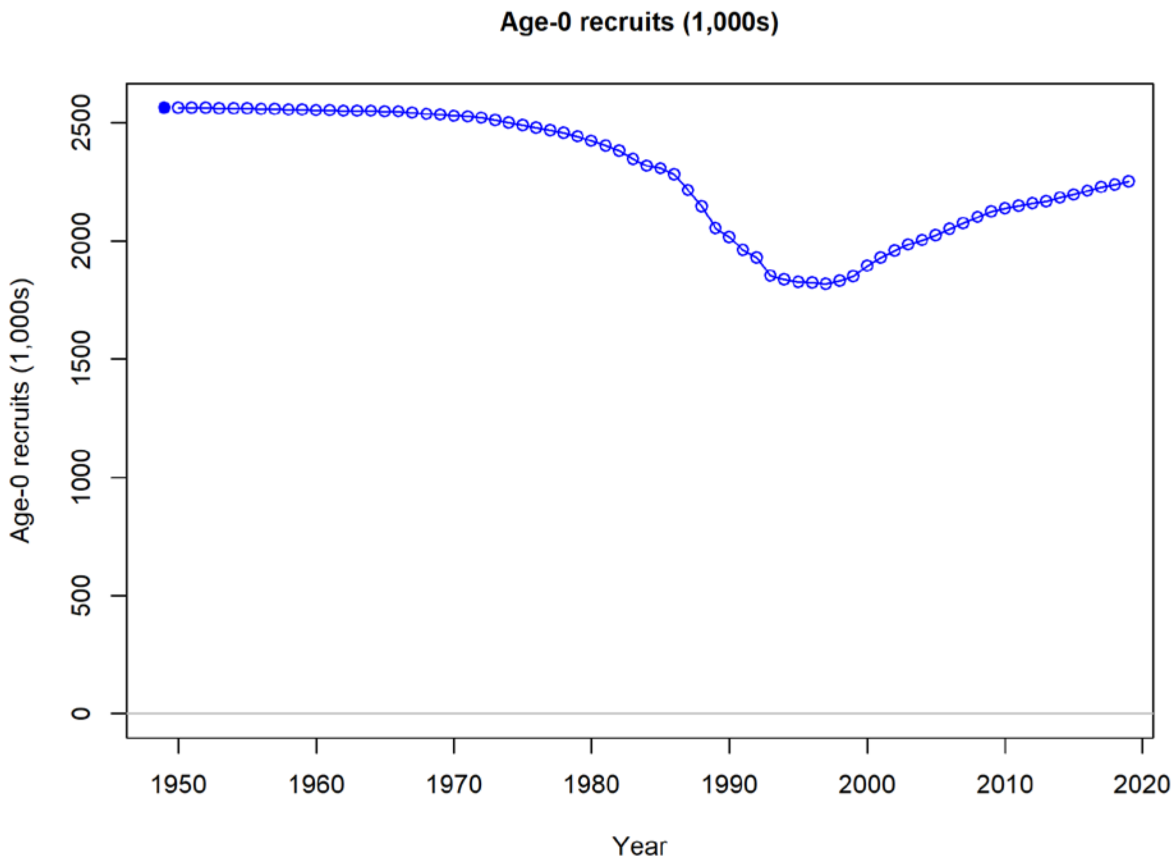

Figure c: Time-series of estimated recruitments for the base case model. There are no recruitment deviations estimated in the blackgill rockfish assessment, thus recruits are directly from the Spawner-Recruit curve.

Exploitation status

The base model estimates that the spawning potential ratio (SPR) was below the current target (of 50% of the unfished level) from the late 1970s through the 1990s, and in several years of the 2000s. However, average SPR rates have been near or above target levels since the very late 1990s, corresponding to an apparent increase in stock abundance. Over the past four years, SPR rates have ranged between 0.78 and 0.83, corresponding to less than half of the overfishing limit SPR (0.50). The exploitation rates reported here reflect catch divided by the summary (age 1+) biomass.

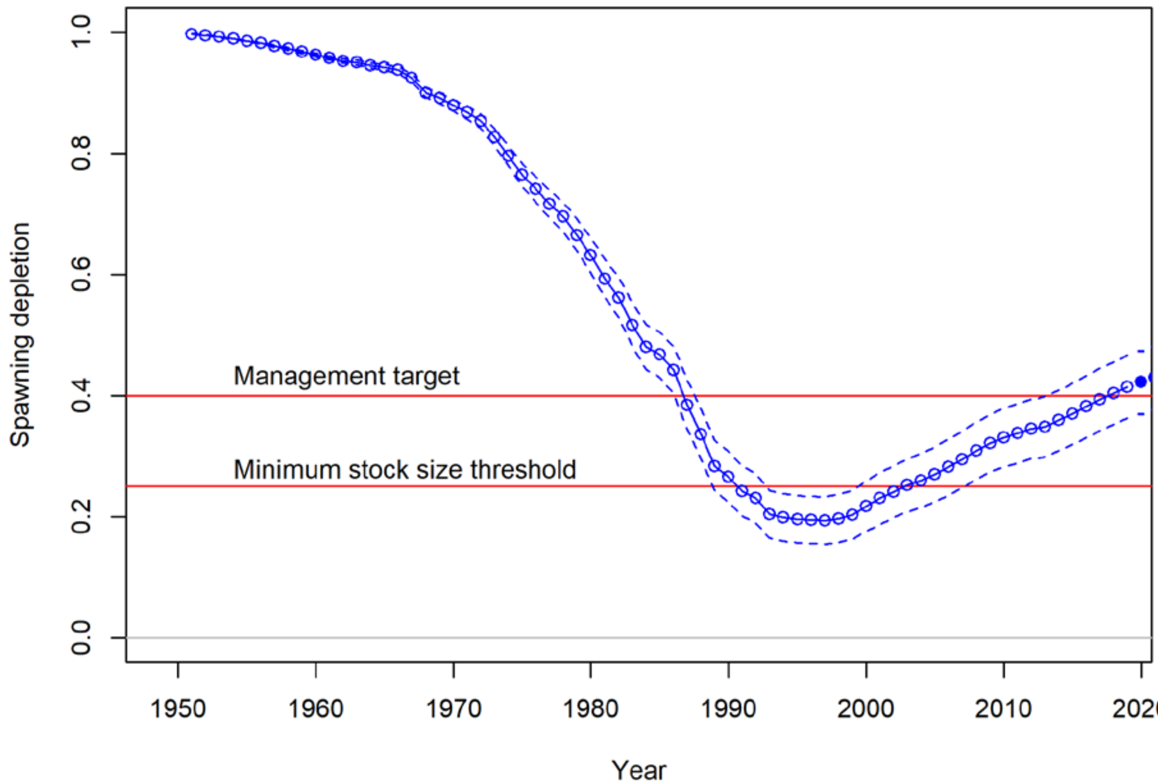

Figure d. Estimated relative depletion with approximate 95% asymptotic confidence intervals (dashed lines) for the base case assessment model.

Table d. Recent trend in spawning potential ratio (entered as 1-SPR) and summary exploitation rate.

Year	Estimated (1-SPR)/(1-SPR$_{50\%}$) (%)	~95% confidence interval	Harvest rate	~95% confidence interval
2009	93.81	83.14–104.47	0.657	0.540–0.774
2010	100.36	89.73–110.98	0.806	0.663–0.949
2011	99.31	88.58–110.05	0.796	0.652–0.940
2012	113.59	103.19–123.99	1.359	1.103–1.615
2013	59.85	51.74–67.95	0.478	0.383–0.574
2014	59.63	51.53–67.73	0.454	0.367–0.541
2015	37.98	32.46–43.51	0.309	0.249–0.368
2016	34.62	29.37–39.88	0.235	0.192–0.277
2017	44.11	37.76–50.46	0.305	0.250–0.359
2018	42.39	36.44-48.33	0.337	0.270–0.404

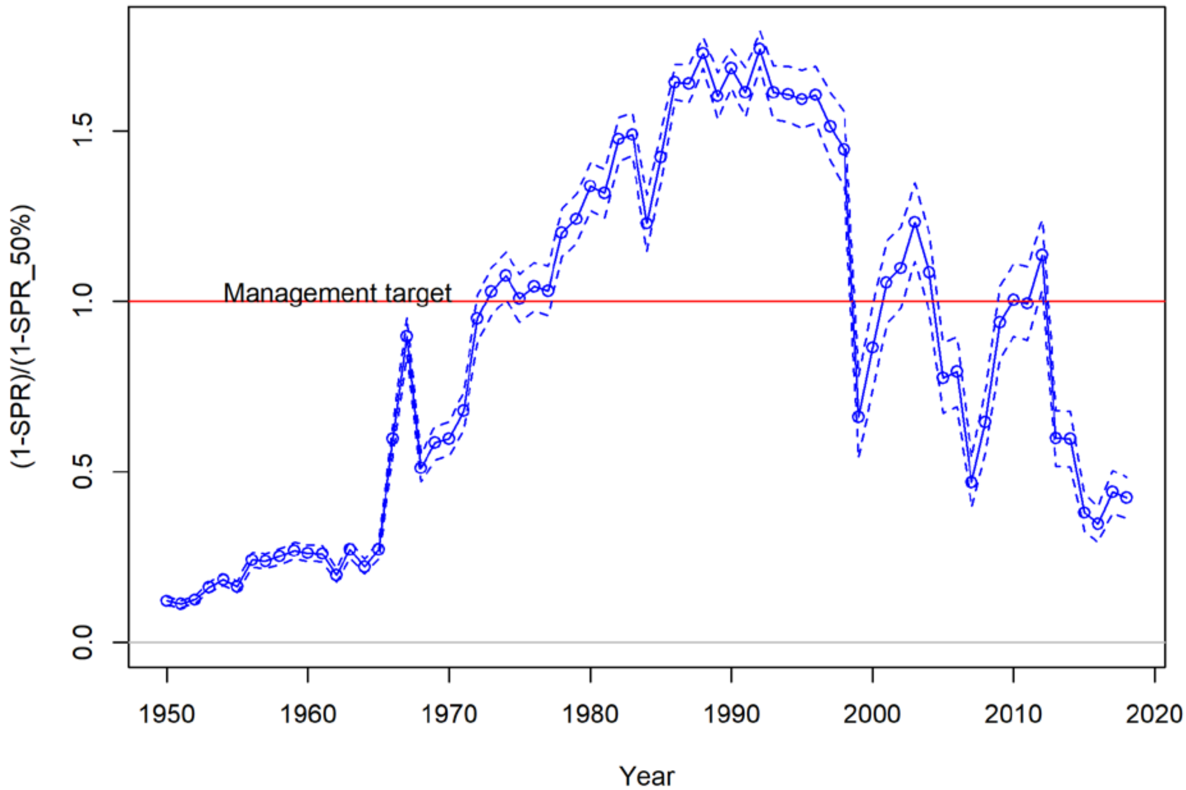

Figure e. Time-series of estimated relative harvest rate (1-SPR)/(1-SPR50%) for the base case model (round points) with approximate 95% asymptotic confidence intervals. The red line is the harvest rate at the overfishing proxy using SPR$_{50\%}$. The last year shown is 2018.

Ecosystem considerations

Blackgill rockfish are among the most deeply distributed of all of the California Current *Sebastes*, living at the edge of the low oxygen (hypoxic) conditions that characterize the slope waters of the California Current. As a shoaling (expansion into shallower waters) of this low oxygen habitat has already been observed in the California Current, and is predicted to be a likely or plausible response to future climate change, this species could be vulnerable to climate induced changes in distribution and productivity in the future. Key predators for this stock include sablefish and shortspine thornyheads, which have themselves undergone shifts in abundance in response to fishing, potentially altering predation mortality. However, neither of these ecosystem considerations are explicitly accounted for in this stock assessment.

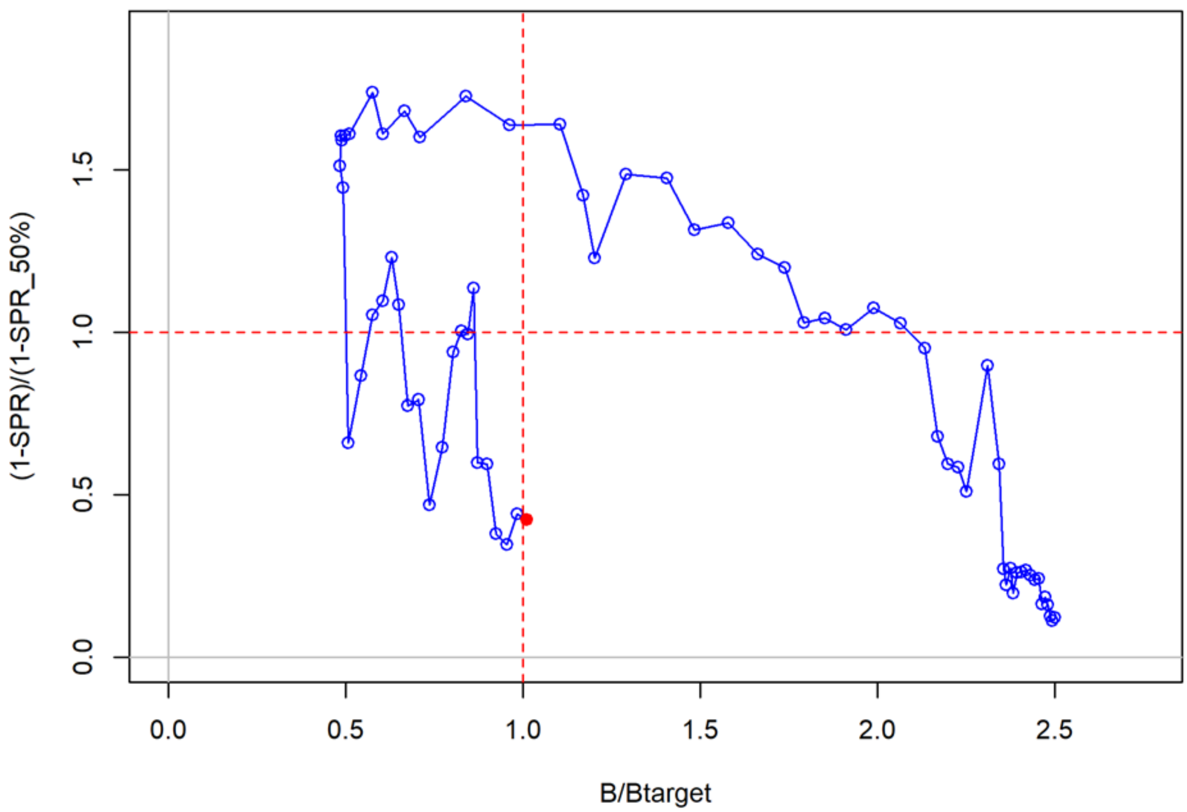

Figure f. Phase plot of estimated relative (1-SPR) vs. relative spawning biomass for the base case model. The relative (1-SPR) is (1-SPR) divided by 0.5 (one minus the SPR target). Relative depletion is the annual spawning biomass divided by the spawning biomass corresponding to 40% of the unfished spawning biomass. The red point indicates the year 2018.

Reference points

The unfished larval production was estimated to be 2.064 trillion larvae, corresponding to a total (summary, age 1+) biomass of 14,187 tons (within a model estimated range of 13,313 to 15,061 tons). The overfishing limit is 25% of the unfished spawning output, and the estimated spawning output is well above that level at the current time. The target stock size of 40% of the unfished level is associated with a summary biomass of 8037 tons and a yield of 188 tons (relative to 192 in the 2011 assessment, and considerably greater than recent catches). It should be emphasized that this biomass estimate is inclusive of immature fish and mature fish too small to be vulnerable to current fisheries. Estimated maximum yields vary relatively modestly (across a range of 31 tons) over the $SSB_{40\%}$.

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

Quantity	Estimate	~95% Confidence Interval
Unfished spawning output (M larvae)	2,063,690	1,816,062–2,311,318
Unfished age 1+ biomass (mt)	14,187	13,331–15,044
Unfished recruitment (R0, thousands)	855,984	726,998–984,970
Spawning output (2019)	2,564	2,398–2,730
Depletion (2019)	41.48	36.30–46.65
Reference points based on $SB_{40\%}$		
Proxy spawning output ($SB_{40\%}$)	825,476	726,425–924,527
SPR resulting in $SB_{40\%}$	45.9%	0.459–0.459
Exploitation rate resulting in $SB_{40\%}$	1.3%	0.011–0.015
Yield with *SPR* based on $SB_{40\%}$ (mt)	189	174–204
Reference points based on SPR proxy for MSY		
Spawning output	919,497	809,164–1,029,830
SPR_{proxy}	50%	NA
Exploitation rate corresponding to SPR_{proxy}	1.1%	0.009–0.013
Yield with SPR_{proxy} at SB_{SPR} (mt)	179	164–193
Reference points based on estimated MSY values		
Spawning output at *MSY* (SB_{MSY})	493,443	434,347–552,539
SPR_{MSY}	31.4%	0.309–0.319
Exploitation rate corresponding to SPR_{MSY}	2.2%	0.019–0.026
MSY (mt)	209	192–226

Management performance

Estimated total catches have been well below ACL and OFL levels for the past decade, typically less than 50% of the adopted levels.

Unresolved problems and major uncertainties

This assessment is not as data rich as an age structured model would ideally be. Catch data are generally reliable for most of the time period, although there is significant uncertainty in catch data prior to the late 1970s and early 1980s as species composition data are unavailable and the fishery was undergoing a spatial expansion into deeper and more offshore waters. Ageing is very difficult for this species, which appears to have highly variable size at age, as well as apparent regional differences in growth rates and potentially other life history traits. There is some suggestion in the diagnostics of differences in age estimates between fish aged for the 2011 assessment and those aged for this update. The growing time series for the NWFSC bottom trawl survey is increasingly important to assess population trends, however the lack of survey effort in the Cowcod Conservation Areas (CCAs) presents current and future challenges to interpretation of both fishery and survey data. Recruitment is not estimated in the current model, although survey data for recent years suggest possible recent pulses in recruitment.

Decision table

The base model was projected forward 12 years, with catches in the first two years (2019-2020) based on advice from the Groundfish Management Team, and subsequent harvests based on either status quo projected harvests, the base model ABC removal projections, or values similar to those used in the 2017 update assessment for the high catch stream. No 40:10 adjustment is applied given that the stock is projected to be above 40% of the unfished larval production in 2019. As in the 2011 and 2017 update assessments, the natural mortality rate is considered to be the greatest source of uncertainty for this stock, and scenarios designed to bracket uncertainty (alternative states of nature) were based on the standard deviations from a prior on natural mortality (M) used in the 2011 assessment. The base model values for the natural mortality rate are 0.063 and 0.065 for females and males, respectively. The low M values used in the decision table are 0.046 and 0.048 for females and males, respectively, while the high M values are 0.086 and 0.089.

Table f. Projection of potential OFL, landings, and catch, summary biomass (age-10 and older), spawning biomass, and depletion for the base case model projected with total catch 2019 and 2020 (*in italics*) based on the GMT spreadsheet and recent discard rates, and equal to the predicted ABC afterwards. The predicted OFL is the calculated total catch determined by $F_{SPR=50\%}$.

Year	Predicted OFL (mt)	ABC/ Catch (mt)	Spawning output	Depletion (%)
2019		*81*	855,984	41.5%
2020		*92*	872,841	42.3%
2021	206	177	887,648	43.0%
2022	205	174	890,815	43.2%
2023	205	172	893,398	43.3%
2024	204	170	895,499	43.4%
2025	203	168	897,208	43.5%
2026	203	166	898,584	43.6%
2027	202	164	899,725	43.6%
2028	202	162	900,699	43.6%
2029	201	160	901,536	43.7%
2030	201	158	902,316	43.8%

Table g. Summary table of 10-year projections beginning in 2021 for alternate states of nature based on the axis of uncertainty. Columns range over low, mid, and high state of nature, and rows range over different assumptions of total catch levels (discards + retained).

			State of nature					
			Low *M*=0.046(F), 0.048(M)		Base case *M* =0.063(F),0.065(M)		High *M=0.086(F),0.089(M)*	
Relative probability of ln(SB_2013)			0.25		0.5		0.25	
Management decision	Year	Catch (mt)	Spawning output	Depletion	Spawning output	Depletion	Spawning output	Depletion
Continue constant projections from 2019 and 2020	2021	86	678,426	0.3	887,648	0.43	1,133,030	0.59
	2022	86	691,370	0.31	902,922	0.44	1,147,600	0.6
	2023	86	703,766	0.32	917,558	0.44	1,161,450	0.61
	2024	86	715,655	0.32	931,602	0.45	1,174,630	0.61
	2025	86	727,077	0.33	945,098	0.46	1,187,190	0.62
	2026	86	738,070	0.33	958,086	0.46	1,199,160	0.62
	2027	86	748,673	0.34	970,601	0.47	1,210,600	0.63
	2028	86	758,917	0.34	982,673	0.48	1,221,520	0.64
	2029	86	768,837	0.34	994,333	0.48	1,231,960	0.64
	2030	86	778,456	0.35	1,005,600	0.49	1,241,940	0.65
ABC	2021	177	678,426	0.3	887,648	0.43	1,133,020	0.59
	2022	174	678,926	0.3	890,815	0.43	1,136,270	0.59
	2023	172	678,805	0.3	893,398	0.43	1,139,020	0.59
	2024	170	678,166	0.3	895,499	0.43	1,141,370	0.59
	2025	168	677,095	0.3	897,208	0.43	1,143,420	0.6
	2026	166	675,654	0.3	898,584	0.44	1,145,200	0.6
	2027	164	673,950	0.3	899,725	0.44	1,146,810	0.6
	2028	162	672,057	0.3	900,699	0.44	1,148,310	0.6
	2029	160	670,012	0.3	901,536	0.44	1,149,720	0.6
	2030	158	667,904	0.3	902,316	0.44	1,151,120	0.6
Near average catch from 2013 high catch stream.	2021	265	678,426	0.3	887,648	0.43	1,133,020	0.59
	2022	265	666,798	0.3	879,014	0.43	1,125,230	0.59
	2023	265	653,868	0.29	869,254	0.42	1,116,600	0.58
	2024	265	639,787	0.29	858,520	0.42	1,107,300	0.58
	2025	265	624,709	0.28	846,965	0.41	1,097,460	0.57
	2026	265	608,784	0.27	834,735	0.4	1,087,210	0.57
	2027	265	592,155	0.27	821,962	0.4	1,076,690	0.56
	2028	265	574,967	0.26	808,778	0.39	1,065,990	0.56
	2029	265	557,351	0.25	795,299	0.39	1,055,220	0.55
	2030	265	539,436	0.24	781,639	0.38	1,044,470	0.54

Research and data needs

Age estimates are highly uncertain, and this species has proven very difficult to age. There is some indication of aging bias between ages developed for the 2011 assessment and for this update, despite the fact that they were aged by the same reader, using the same criteria. Conducting cross reads with other laboratories, as well as additional age validation, are important factors for future efforts.

Histology studies have shown that this species is slow to mature and often undergoes abortive maturation, particularly at younger ages (smaller sizes), complicating maturity estimates. There also appear to be latitudinal clines in growth, maturity and potentially other life history parameters that are not accounted for in the model.

Despite considerable investment in catch reconstruction efforts, historical catches remain uncertain for this stock due to the lack of historical species composition data and spatial patterns of fishery development in California waters. Efforts to analyze spatially explicit historical catch data have indicated that fisheries for this and other rockfish species tended to fish deeper waters, further offshore, in more inclement weather over time, suggesting that historical catches of this deeply distributed species that are derived from species compositions from later in the time series may be overestimated.

A large fraction of blackgill rockfish habitat is currently closed to both fishing and survey effort in the Cowcod Conservation Areas (CCAs), complicating efforts to interpret both catch and survey data. Alternative means of exploring relative or absolute abundance in this region is a key research priority.

Greater investigation into the likely or plausible consequences of a shoaling of the oxygen minimum zone (OMZ) on blackgill rockfish habitat will aid in evaluating threats to this species that may be posed by global climate change.

Table h. Summary table of results for the assessment of rougheye rockfish. OFL values are for 2011 and 2012 were for rougheye specifically. Rougheye and blackspotted rockfish are managed within the minor slope rockfish complex, the OFL and ABC split between north and south of 40° 10’.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Estimated Total catch (mt)	132.6	152.3	150.3	195.4	72	72.8	42.8	38.7	51.6	51.4	NA
OFL (mt)	292	282	282	282	130	134	137	140	143	146	174
ACL (mt)	292	282	279	275			113.8	117.2	120.2	123	158.9
1-SPR	0.94	1	0.99	1.14	0.6	0.6	0.38	0.35	0.44	0.42	NA
Exploitation rate	0.66	0.81	0.8	1.36	0.48	0.45	0.31	0.23	0.3	0.34	NA
Age 1+ biomass (mt)	7,409	7,461	7,492	7,521	7,505	7,596	7,684	7,796	7,910	8,010	8,109
Spawning Biomass	663,439	681,851	697,066	711,385	719,854	742,127	763,487	788,106	812,499	834,403	855,984
~95% Confidence Interval	553,636–773,242	570,210–793,492	583,719–810,413	596,349–826,421	603,339–836,369	623,522–860,732	642,837–884,137	665,287–910,925	687,540–937,458	707,416–961,390	726,998–984,970
Recruitment	2,124	2,138	2,150	2,161	2,167	2,182	2,196	2,212	2,227	2,240	2,252
~95% Confidence Interval	1,927–2,341	1,942–2,354	1,955–2,365	1,966–2,374	1,972–2,380	1,989–2,394	2,004–2,407	2,021–2,421	879–5,640	884–5,672	889–5,702
Depletion (%)	32.1	33	33.8	34.5	34.9	36	37	38.2	39.4	40.4	41.5
~95% Confidence Interval	27.4–36.9	28.2–37.9	28.9–38.7	29.5–39.4	29.9–39.8	31.0–41.0	32.0–42.0	33.1–43.3	34.3–44.5	35.3–45.6	36.3–46.7

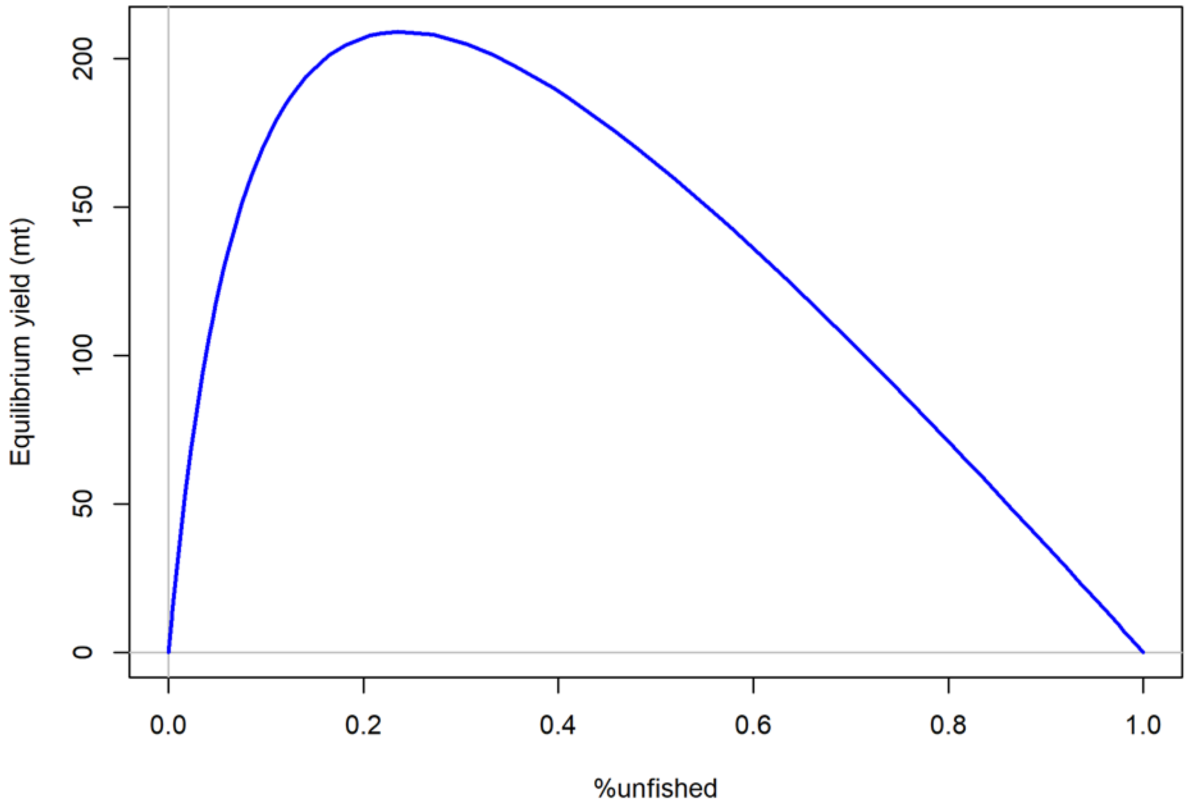

Figure g. Equilibrium yield curve for the base case mode.

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