DRAFT Stock assessment update of blackgill rockfish, *Sebastes melanostomus*, in the Conception and Monterey INPFC areas for 2017

John C. Field and Xi He
Groundfish Analysis Team
Fisheries Ecology Division,
Southwest Fisheries Science Center
110 Shaffer Rd. Santa Cruz CA 95060
John.Field@noaa.gov

Table of Contents

B. Executive Summary

B.1 Stock

This assessment reports the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas, using data from 1950 through 2016. The resource is modeled as a single stock. Although the distribution of blackgill 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.

B.2 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.

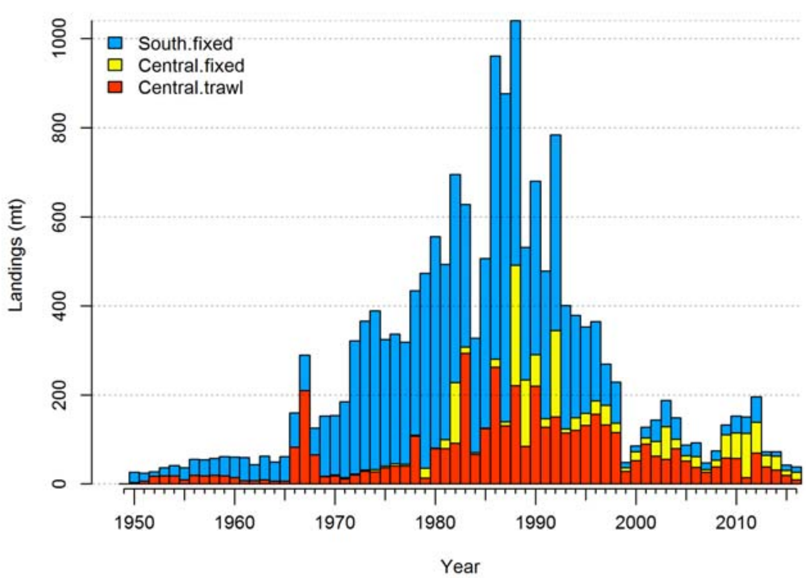

Figure B.1: Estimated catches by fleet from 1950-2016

Table B1: Recent commercial catches (mt, including discards) by fleet

	south fixed	central fixed	central trawl	total
2007	14.6	6.2	34.3	55.1
2008	20.2	17.3	41.7	79.2
2009	22.9	53	60.9	136.8
2010	37.5	57.3	57.5	152.3
2011	37.0	99.1	14.1	150.2
2012	56.6	69.4	69.4	195.4
2013	7.5	26.4	38.1	72
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

B.3 Data and Assessment

This 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 in that fishery following implementation of the trawl fishery rationalization program. The updated model does 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 includes new length composition data from 2010-2016 for all three fisheries (southern fixed gear, central CA fixed gear and central CA trawl), as well extends the NWFSC shelf and slope survey index from 2010 through 2016, with associated length and age data. The base case model uses the updated rockfish steepness prior (Thorson 2016) for rockfish of 0.718 (versus 0.76 in the 2011). The estimated natural mortality rate of 0.063 (females) and 0.065 (males) is unchanged from the 2011 assessment, and model results are highly sensitive to the assumed value for M. As in the 2011 model, recruitment is assumed to be deterministic.

B.4 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 nearly to the target level of 40% of the unfished larval output.

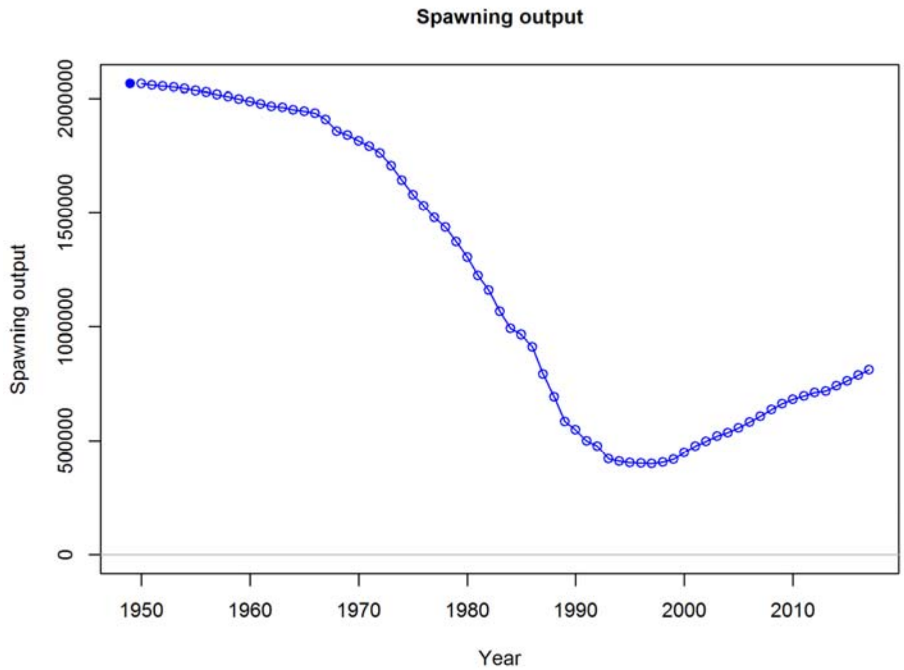

Figure B.2: Estimated spawning output (millions of larvae) from base model

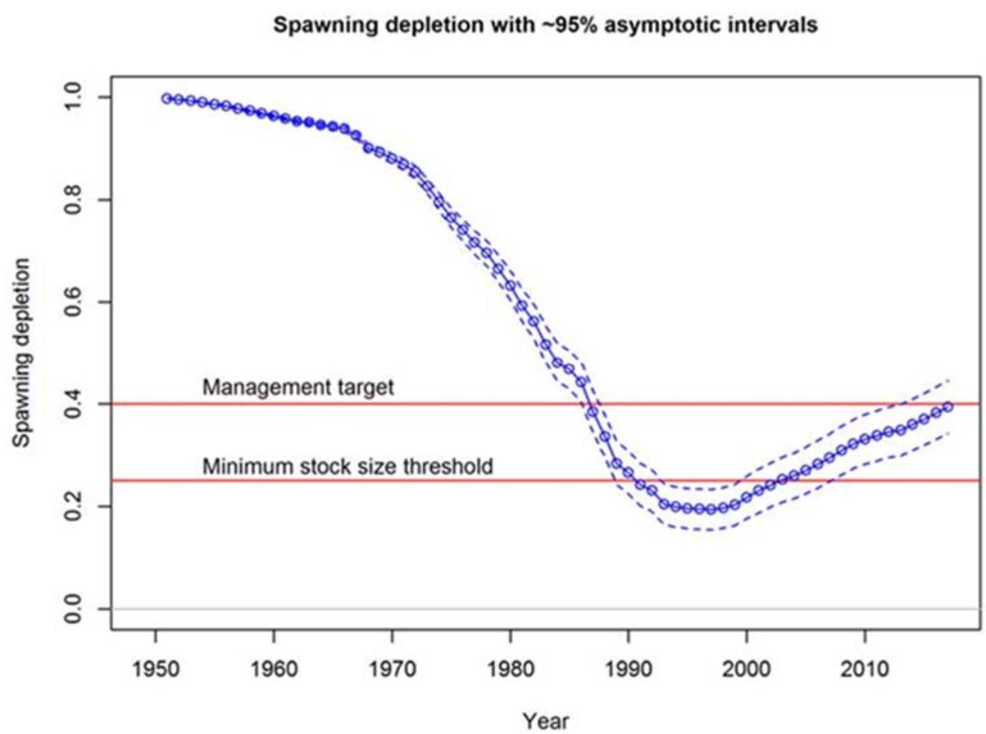

Figure B.3: Estimated relative depletion from base model

Table B.2: Recent trends in blackgill rockfish spawning output, recruitment and depletion

	Summary Biomass	Larval prod ($x10^9$)	Depletion	Recruit ($x 10^3$)
2008	7409	637	0.309	2124
2009	7461	663	0.321	2138
2010	7492	682	0.330	2150
2011	7521	697	0.338	2161
2012	7505	711	0.345	2167
2013	7596	720	0.349	2182
2014	7684	742	0.360	2197
2015	7796	763	0.370	2212
2016	7910	788	0.382	2227
2017	7917	812	0.394	2232

B.5 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.

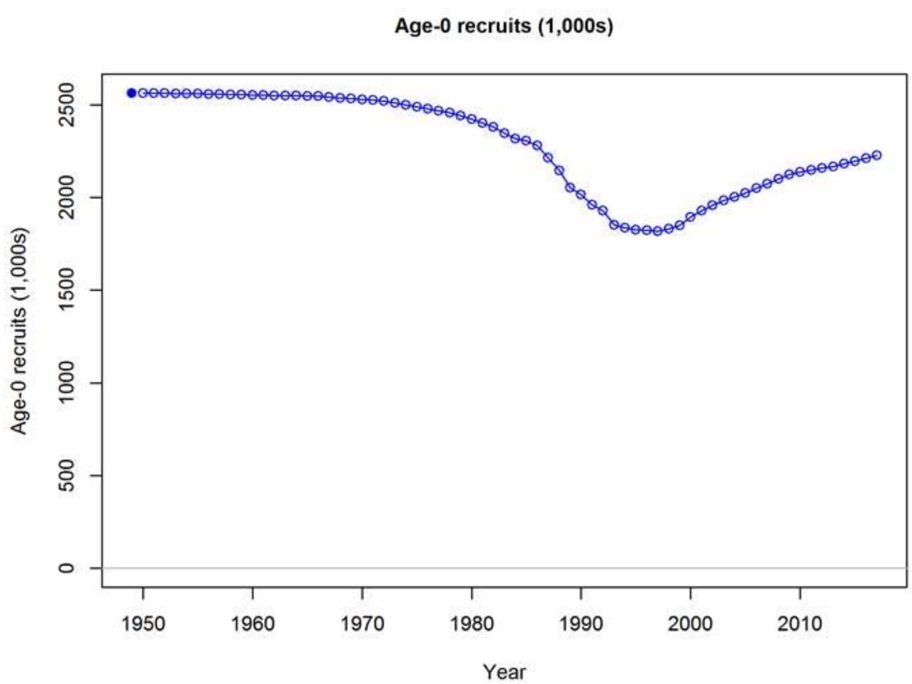

Figure B.4: Estimates of recruitment based on deterministic S/R relationship

B.6 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 0.70 and 0.82, corresponding to exploitation rates roughly half of the overfishing limit (0.50).

Table B.4: Recent catches, estimated SPR and relative exploitation rates

	Catches	*Summary Biomass*	*SPR*	*Exploitation rate*
2008	74	7409	0.677	0.010
2009	133	7461	0.531	0.018
2010	152	7492	0.498	0.020
2011	150	7521	0.503	0.020
2012	195	7505	0.432	0.026
2013	72	7596	0.701	0.009
2014	73	7684	0.702	0.009
2015	43	7796	0.810	0.005
2016	39	7910	0.827	0.005
2017	n/a	7917	n/a	n/a

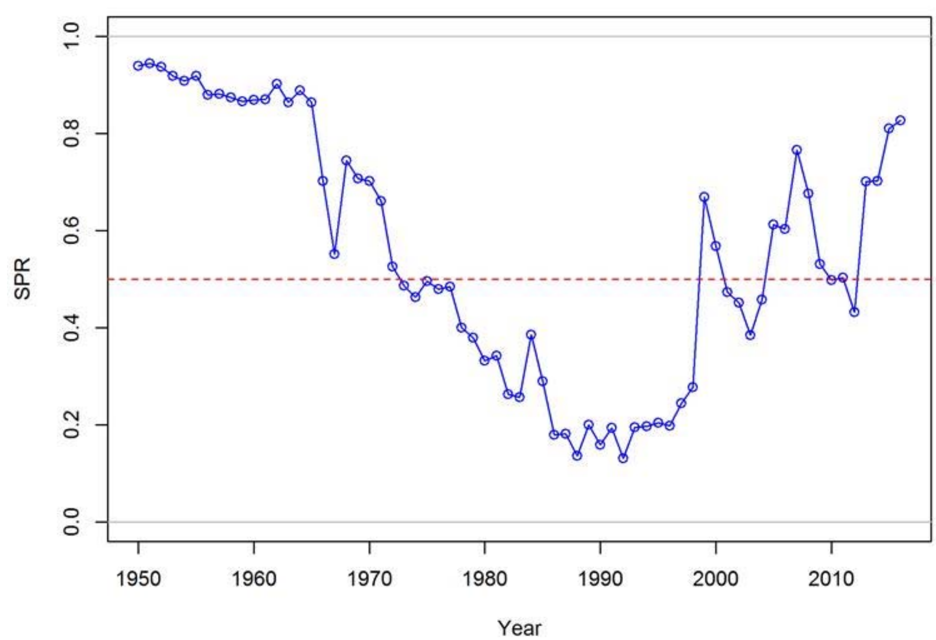

Figure B.5: Time series of estimated SPR rate for the base case model.

B.7 Ecosystem Considerations

Blackgill are among the deepest distribution 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.

B.8 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 stock 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 $SSB_{40\%}$, $SPR_{50\%}$ and MSY estimates.

Table B3: Key reference points for blackgill rockfish

		95% Confidence Limits	
Unfished Stock	Estimate	Lower	Upper
Summary (1+) Biomass (tons)	14187	13313	15061
Spawning Output (billions larvae)	2064	1812	2316
Equilibrium recruitment (1000s)	2564	2394	2733

	Yield reference Points		
	$SSB_{40\%}$	$SPR_{50\%}$	MSY est.
SPR	0.459	0.500	0.314
Exploitation rate	0.025	0.022	0.044
Yield	188	178	209
Spawning output	826	919	493
Summary biomass	8037	8590	5815
SSB/SSB_0	0.400	0.507	0.213

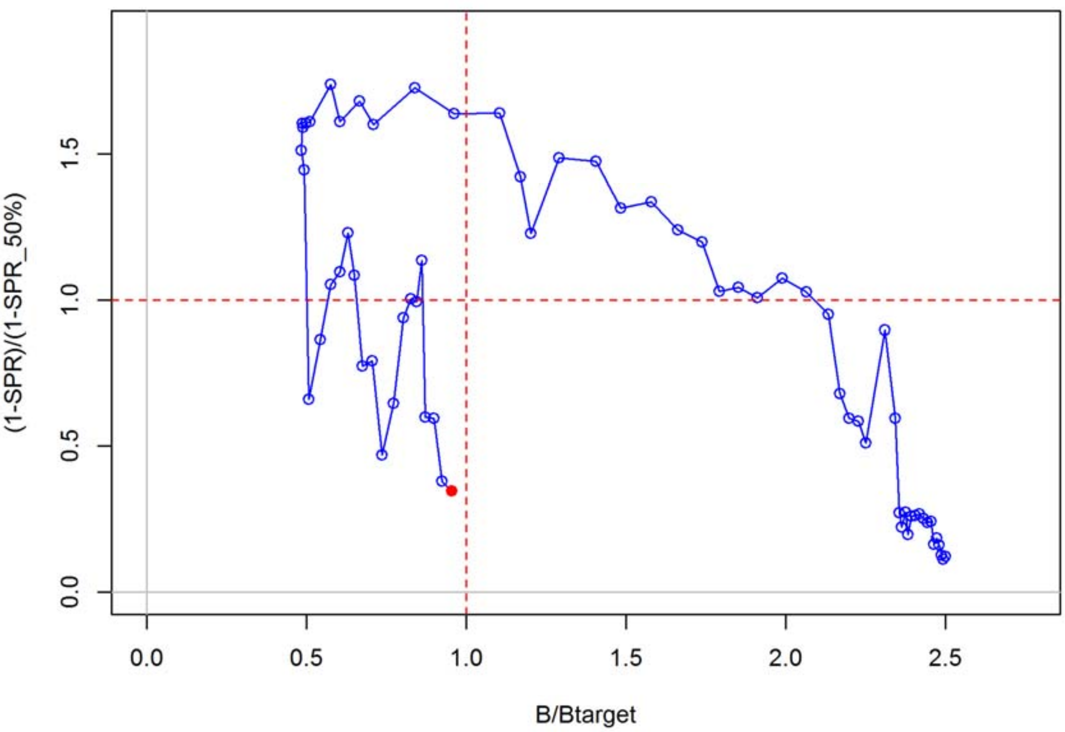

Figure B.6: Phase plot of relative depletion against estimated SPR rate (red point represents the end year of 2016).

B.8 Management performance

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

Table B.5: Recent catches relative to OFL (ABC) and ACL (OY) targets for recent years.

	Catch	ACL	ABC	OFL	% of ABC	% of OFL
2008	74	292	292	292	0.25	0.25
2009	132.7	282	282	282	0.47	0.47
2010	152.3	282	282	282	0.54	0.54
2011	150.3	279	282	282	0.53	0.53
2012	195.4	275	282	282	0.69	0.69
2013	72	113.8	118.7	130	0.6	0.55
2014	72.8	117.2	122.3	134	0.59	0.54
2015	42.8	120.2	125.1	137	0.34	0.31
2016	38.7	123	127.8	140	0.3	0.27
2017			130.6	143		
2018			133	146		

B.9 Unresolved problems and major uncertainties

This assessment is not as data rich as an age structure 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 in particular are suggestive of potential recent pulses in recruitment.

B.10 Forecast of model results and decision table

The base model was projected forward 12 years, with catches in the first two years (2017-2018) based on the currently adopted ACLs and subsequent harvests based on either status quo harvests, the base model ABC removal projections, or the OFL harvest rates. No 40:10 adjustment is applied given that the stock is projected to be above 40% of the unfished larval production by 2019. As in the 2011 assessment, 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 used in the 2011 assessment.

Table B.6: Base model projected ABC and OFL values, assuming ABC attainment

	ABC	OFL
2017	131	
2018	133	
2019	159	174
2020	159	174
2021	159	174
2022	159	174
2023	159	174
2024	159	173
2025	158	173
2026	158	173
2027	158	173
2028	158	173

Table B.7: Decision Table, based on status quo (2014-2016) catches and alternative assumptions on natural mortality rates.

		Low M model		Base model		High M model	
status quo catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	812	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	51	630	0.28	835	0.40	1083	0.56
2020	51	648	0.29	855	0.41	1103	0.58
2021	51	665	0.30	875	0.42	1122	0.59
2022	51	683	0.31	895	0.43	1141	0.59
2023	51	700	0.31	914	0.44	1159	0.60
2024	51	716	0.32	933	0.45	1176	0.61
2025	51	733	0.33	951	0.46	1193	0.62
2026	51	749	0.34	969	0.47	1209	0.63
2027	51	764	0.34	986	0.48	1225	0.64
2028	51	780	0.35	1003	0.49	1240	0.65

		Low M model		Base model		High M model	
ABC catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	812	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	159	630	0.28	835	0.40	1083	0.56
2020	159	633	0.28	841	0.41	1089	0.57
2021	159	635	0.29	846	0.41	1094	0.57
2022	159	637	0.29	850	0.41	1099	0.57
2023	159	638	0.29	854	0.41	1103	0.58
2024	159	638	0.29	857	0.42	1107	0.58
2025	158	638	0.29	860	0.42	1110	0.58
2026	158	637	0.29	862	0.42	1113	0.58
2027	158	636	0.29	864	0.42	1116	0.58
2028	158	635	0.28	866	0.42	1118	0.58

		Low M model		Base model		High M model	
OFL catches		Sp.out	depletion	Sp.out	depletion	Sp.out	depletion
2017	*131*	613	0.28	813	0.39	1060	0.55
2018	*133*	622	0.28	824	0.40	1072	0.56
2019	174	630	0.28	835	0.40	1083	0.56
2020	174	631	0.28	839	0.41	1087	0.57
2021	173	631	0.28	842	0.41	1090	0.57
2022	173	631	0.28	844	0.41	1093	0.57
2023	172	629	0.28	846	0.41	1096	0.57
2024	172	628	0.28	847	0.41	1098	0.57
2025	171	625	0.28	848	0.41	1099	0.57
2026	171	623	0.28	848	0.41	1101	0.57
2027	170	620	0.28	848	0.41	1102	0.57
2028	170	617	0.28	848	0.41	1103	0.58

B.11 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 may be overestimated.

A large fraction of blackgill 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 habitat will aid in evaluating threats to this species that may be posed by global climate change.