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A catch-only update of the status of the Chilipepper Rockfish, *Sebastes goodei*, in the California Current for 2017

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Stock

The stock boundary for the 2007 chilipepper assessment, the 2015 update assessment, and this catch-only update, is the U.S./Mexico border in the south, to the Columbia River in the north.

Catches

This document represents a catch-only update to the 2015 chilipepper rockfish stock assessment update, to correct for errors in historical catch estimates from California fisheries between 1916 and 1968. Recent catches (2014-2016) are also updated, based on NWFSC total mortality reports for 2014-2015, and CalCOM landings estimates for 2016 multiplied by a ratio estimator (the ratio of CalCOM landings to NWFSC total mortality reports for the 2013-2015 period). Figure 1 shows the discrepancies between the catch estimates used in the 2015 assessment update and this 2017 catch-only update with corrected historical catches for California fisheries. The difference in total catch throughout that historical period is approximately 18,550 tons (all between 1916-1968), in the corrected catch history (now including 2015-2016), the total catch throughout the assessment period is 128,767 tons. No other data were added in the model. Figure 2 shows the catch estimates used in this 2017 catch only update, by fishery and gear type.

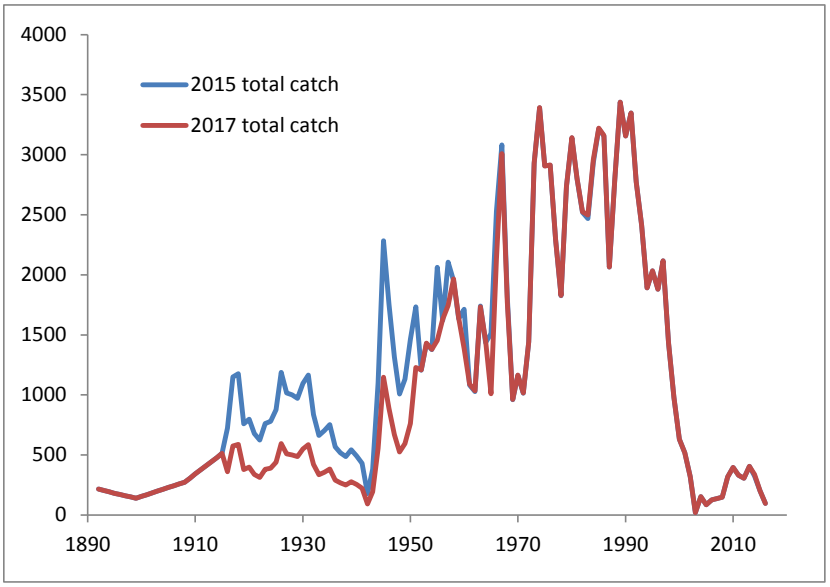

Figure 1: Catch estimates from the 2015 update and in this 2017 catch-only update with corrected historical catches

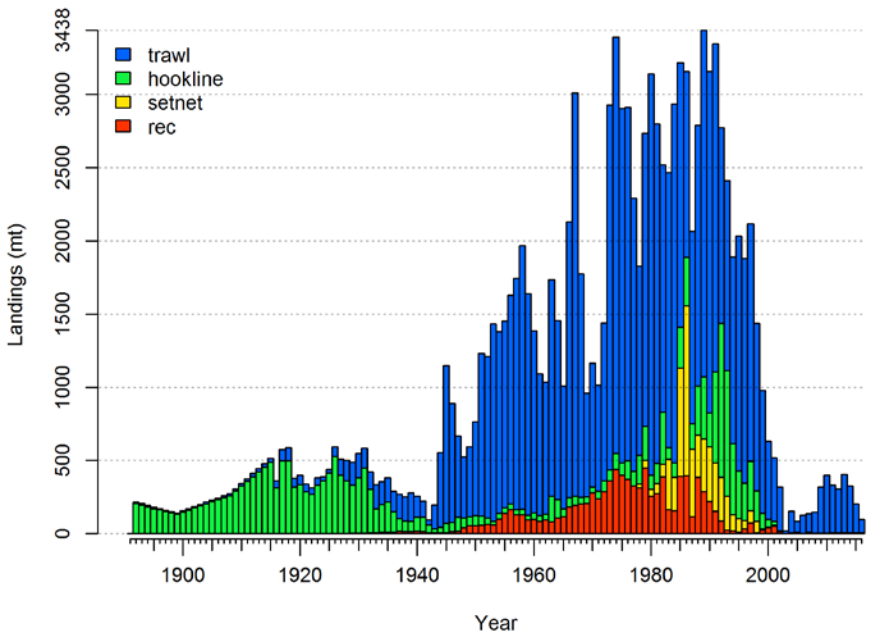

Figure 2: Catches by fishery for chilipepper rockfish over the past 120 years

Data and Assessment

The 2015 chilipepper update (which used Stock Synthesis version 3.24O, unchanged in this update) maintained the same fundamental model structure as the 2007 assessment, and that structure is unchanged in this 2017 catch only update. The corrected historical catch estimates, and the revised 2014 and new 2015-2016 catch estimates reflect the only change in model data. All other data are unchanged from the 2015 update. Steepness remains fixed at the point estimate used in the 2007 stock assessment (0.57). Sensitivity analyses comparing the model runs with old and new historical catch estimates show that the historical spawning output was estimated to be somewhat greater with the older catch history (consistent with the greater historical removals; Figure 3), with a greater impact of exploitation (more depletion) in the 1916-1968 time frame as a consequence (Figure 4).

However, following the period of historical catches, and into the period for which index and demographic data are available (e.g., 1970s-2014), both the spawning output and relative depletion track very closely, with relative depletion nearly identical to the 2015 model estimate using the corrected historical catch data. The fits and likelihoods were also nearly identical between the two model runs (less than one unit likelihood difference, with the corrected catch history model providing a very slightly better fit to the data), as were parameter estimates, additive variance estimates and effective sample sizes, thus the model was not re-tuned and no other parameters were altered (beyond extending selectivity and growth time blocks through 2016). Recruitment estimates and relative exploitation estimates were also nearly indentical to the 2015 base model results for the data-informed period (1970-2016).

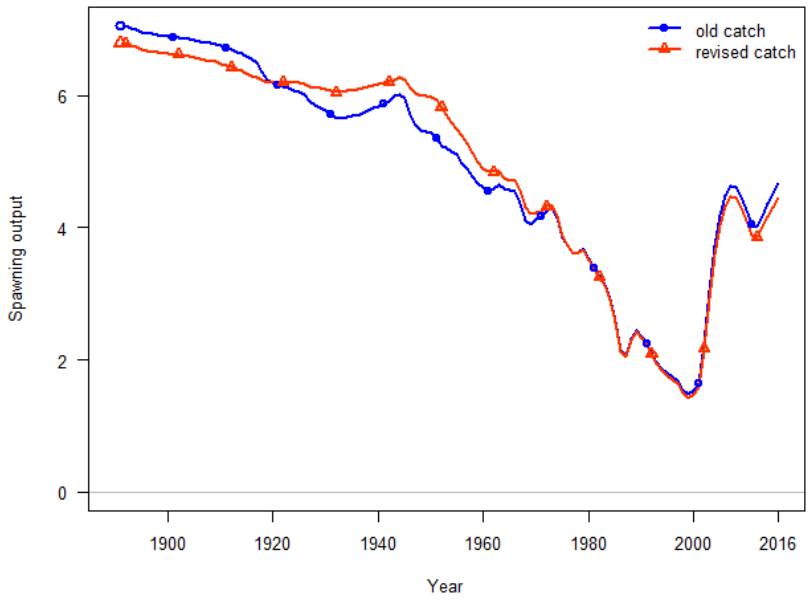

Figure 3: Spawning output estimates from the 2015 base model and this catch-only update

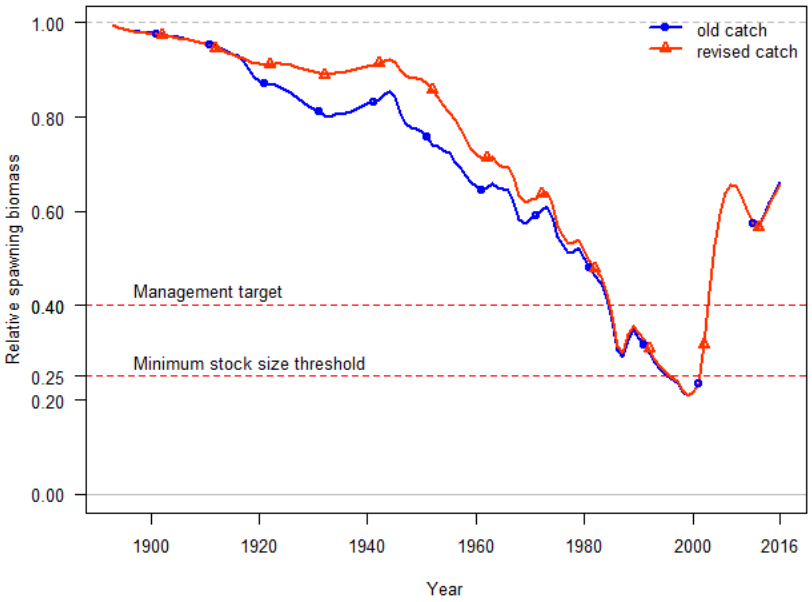

Figure 4: Relative depletion estimates from the 2015 base model and this catch-only update

Stock Spawning Output and Depletion

Spawning output is reported in the millions of larvae produced, rather than spawning stock biomass. Spawning output dipped very slightly below the current minimum stock size threshold in the late 1990s, as a result of a combination of high harvest rates and poor recruitment. However, a strong 1999 year class and reductions in harvest levels led to sharp population

increases and since the early 2000s spawning output has been maintained well above target levels (Figure 5). The estimated depletion in 2017 is 69.2% of the estimated unfished spawning output, well above the 40% target level. The entire time series for spawning output, summary biomass, recruitment, depletion, SPR, exploitation rate and total catch is provided in Table 7.

Table 1: Spawning output, summary biomass and depletion for the base model in 2015

	Spawning Output (millions larvae)	CV Spawning Output	Summary Biomass (age 1+)	Depletion
2007	4477	0.150	53328	0.658
2008	4456	0.150	53298	0.655
2009	4316	0.150	51394	0.634
2010	4120	0.150	50266	0.606
2011	3904	0.150	50728	0.574
2012	3860	0.150	50878	0.567
2013	4011	0.150	49823	0.59
2014	4185	0.150	51058	0.615
2015	4324	0.160	52664	0.636
2016	4469	0.160	53972	0.657
2017	4707	0.160	33171	0.692

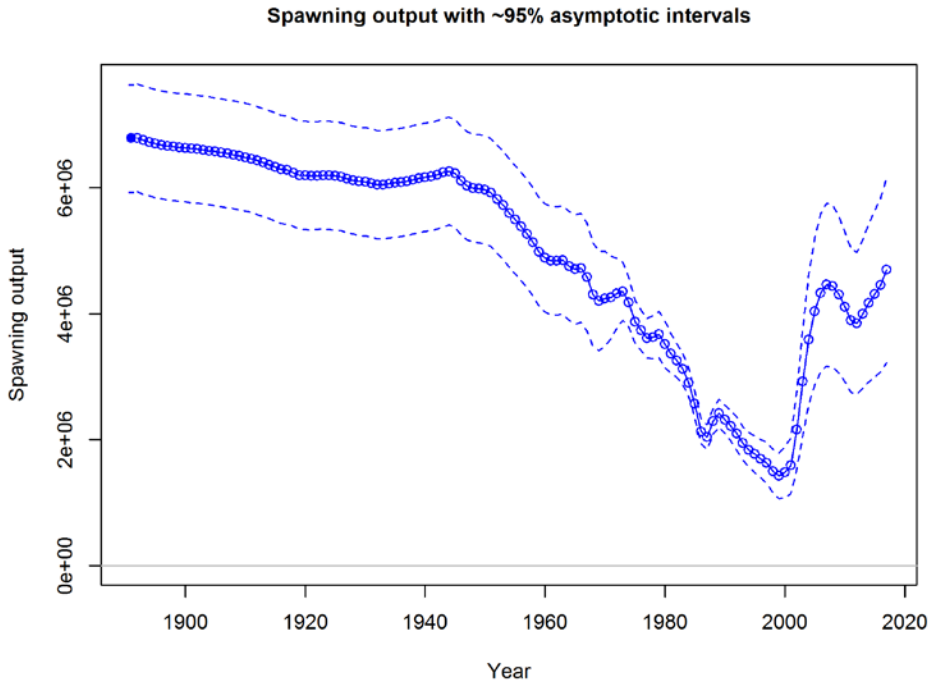

Figure 5: Spawning output (larvae, in 1000s) with approximate 95% confidence intervals

Recruitment

Recruitment for chilipepper rockfish is highly variable, with a small number of year classes tending to dominate the population (and catch) in any given fishery or region. As age and length data are only available for the late 1970s onward, estimates of year class strength are most

informative from the 1970s to the present. The 1984 and 1999 year classes were among the strongest in that time period (Figure 6), however several very strong year classes have been observed in recent years (2009-2010, 2013-2014) and are already leading to a fast rate of increase in abundance and larval production. Note that is this model was a catch only update from the 2015 model, recruitment deviations are not estimated beyond 2014 (as new length and age composition have not been included here), such that the 2015-2017 values reported here represent estimates based on the spawner-recruit relationship.

Table 2: Recruitment estimates and CV of recruitment estimates for the base model

	Recruitment (1000s)	CV Recruitment
2007	13856	0.24
2008	12277	0.27
2009	84492	0.19
2010	58495	0.21
2011	13148	0.32
2012	16948	0.32
2013	44748	0.32
2014	64330	0.77
2015	*26081*	*1.00*
2016	*31082*	*1.00*
2017	*37210*	*1.00*

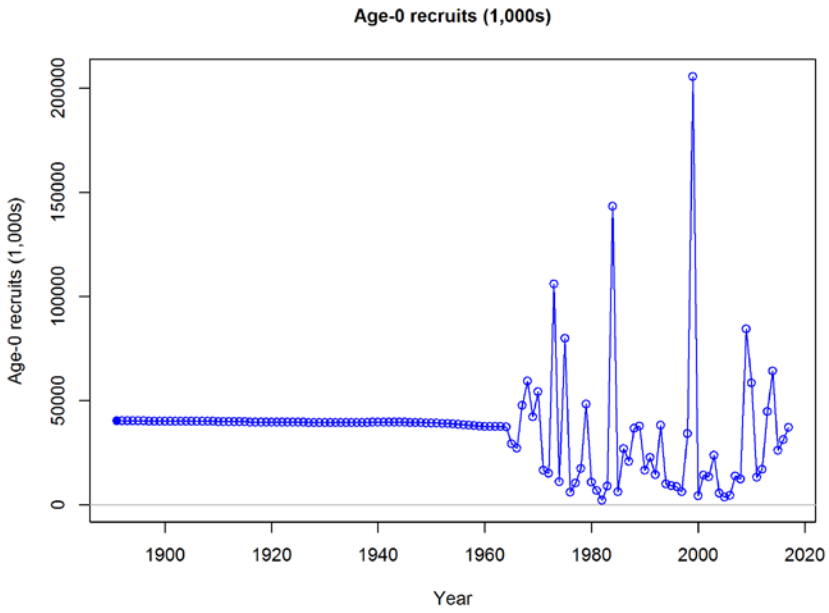

Figure 6: Recruitment estimates for the base model

Reference Points

Reference points, including estimates of yield under target SPR and relative biomass target levels, are reported in Table 3. The model estimated an unfished larval production (spawning

biomass) (SSB_0) of 6.8 billion larvae, an unfished summary biomass of 51,079 tons, and a mean unfished recruitment (R_0) of 40,333 (thousands of fish). Estimates of equilibrium yields in this catch update are slightly below, but very comparable to those in the 2015 update, ranging from 2042-2091 tons depending on the proxy used (relative to a range from 2113 to 2165 metric tons in the 2015 model). These values are also consistent with those from the 2007 assessment (2099 to 2165 metric tons).

Table 3: Reference Points for the 2015 Base Model

	Estimate	St.Dev	Lower ~95% CL	Upper ~95% CL
SSB_Unfished (millions larvae)	6803	440	6363	7243
SmryBio_Unfished	51079	3354	47725	54433
Recr_Unfished	40333	2604	37729	42937

	Yield	Depletion	SSB	SPR	F
Btarget	2064	0.377	2721	0.484	0.082
SPR target	2042	0.421	2863	0.500	0.078
MSY	2091	0.339	2307	0.437	0.095

Exploitation Status and Management Performance

Since 2007, total catches have been well below the established ABC/OY (pre-2011) and ACL/OFL (post 2010) levels, and SPR and exploitation rates have been correspondingly low through this period (Figures 7-8).

Table 4: Exploitation status and Management Performance, 2007- 2018

	OFL (ABC pre-2011, south 40 10 from 2011 onward)	ACL (OY pre-2011) south of 40 10 from 2011 onward	Contribution to minor shelf rock north (OFL), 2011 onward	Total Catch	Catch as % of combined OFL	SPR	Exploitation Rate
2007	2700	2000		137	0.050	0.962	0.003
2008	2700	2000		148	0.050	0.960	0.003
2009	3037	2885		318	0.100	0.914	0.006
2010	2576	2447		397	0.150	0.887	0.008
2011	2073	1981	156	331	0.160	0.897	0.007
2012	1872	1789	141	307	0.160	0.900	0.006
2013	1768	1690	133	405	0.230	0.875	0.008
2014	1722	1647	130	325	0.190	0.905	0.006
2015	1703	1628	*130*	203	0.110	0.942	0.004
2016	1694	1619	*130*	97	0.050	*0.973*	0.002
2017	2726.7	2606.8	205.2				
2018	2622.6	2507.2	197.4				

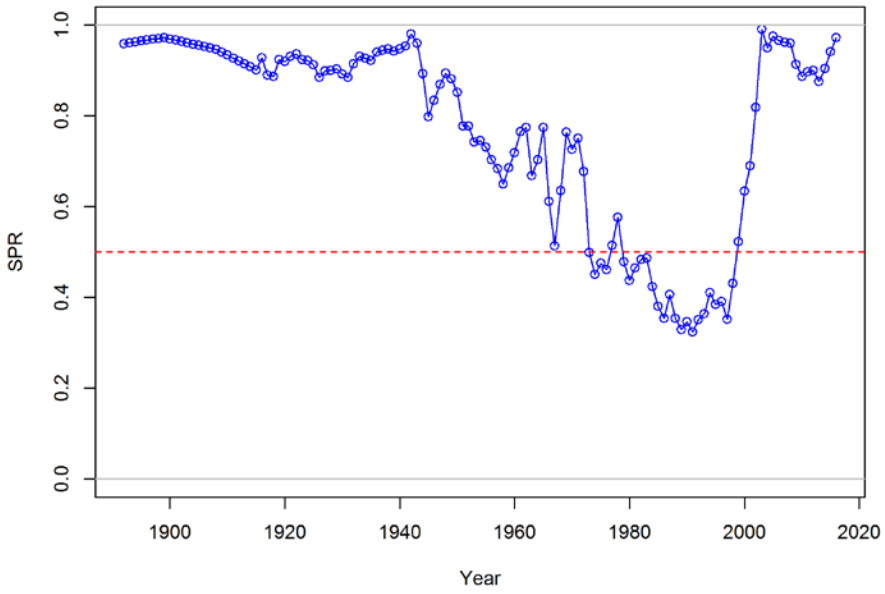

Figure 7: Model estimated Spawning Potential Ratio (SPR)

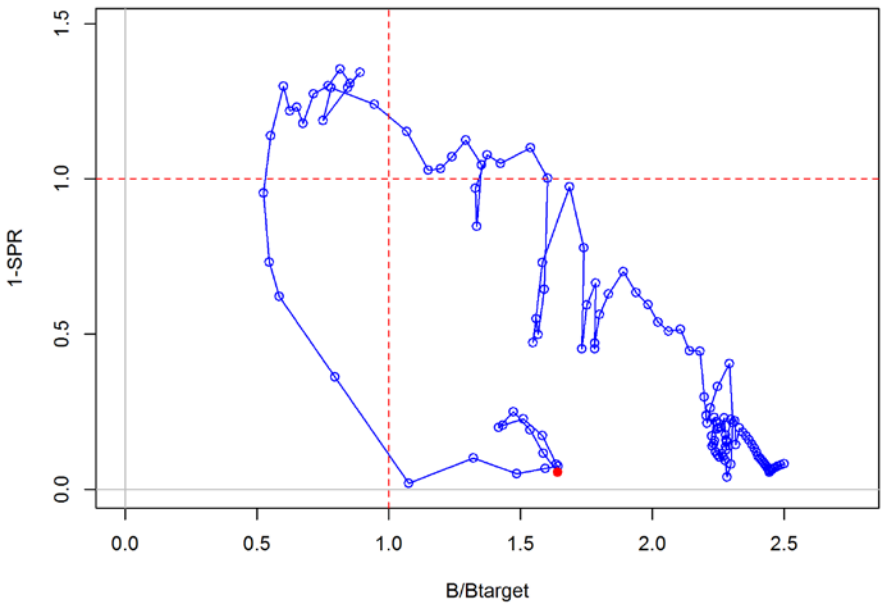

Figure 8: Phase plot of relative stock status and relative SPR

Forecast

The current spawning output is above target levels, recent catches have been well below target levels, and several strong year classes are contributing to a forecast for high and increasing biomass in the near future. In estimating forecast values into the future, we did not adopt the typical pattern of using the 2017-2018 adopted ACLs as "fixed" catches and projecting ACLs and OFLs from 2019 onward, as a key output of this update was perceived to be the "corrected" estimate of the ACL and OFL for the 2017-18 management cycle, in order to evaluate whether the adopted values are above those in the base model with the corrected time series (as discussed in the forecast section). We assumed that chilipepper will remain a category 1 stock with a P* = 0.45 (translating to a 4.4% buffer for the ACL relative to the OFL).

As anticipated, the correction to the historical catch did result in a modest decline in the equilibrium sustainable harvest levels (e.g., MSY at SPR 50% or SSB 40%), of approximately 100 tons. However, the current ("uncorrected") ACLs and OFLs for the 2017-2018 cycle were estimated with the assumption that the 2015-16 ACLs would be achieved, and as realized catches in those years were considerably less than the adopted ACLs, the estimated 2017-2018 ACL and OFL values from this "corrected" model are actually moderately greater than those adopted for the 2017-18 management cycle based on the 2015 update. This is because the relative abundance was estimated to be greater, as a result of the large biomass of fish that were not removed from the population. Specifically, the 2015 model estimated 2017 and 2018 ACLs of 2803 and 2707, respectively, while the "corrected" model with realized 2015-16 catches estimated ACLs of 3033 and 2873, respectively. For OFLs, the 2015 model estimated 2932 and 2820 for 2017 and 2018 respectively, while the "corrected" model estimated OFLs of 3173 and 2993 tons, respectively. These values do not represent the apportionment between the areas north and south of Point Conception (for which the ratio used for the 2015 assessment was 0.93:0.07, south and north of 40°10' N).

Table 5: Base model estimates of 2017-2028 ACL and OFL levels

	ACL	OFL	Depletion (assuming ACL catches)
2017	3033	3173	*0.69*
2018	2873	2993	*0.65*
2019	2749	2852	*0.62*
2020	2622	2711	*0.59*
2021	2504	2581	*0.56*
2022	2407	2476	*0.54*
2023	2333	2395	*0.52*
2024	2274	2331	*0.51*
2025	2226	2278	*0.49*
2026	2185	2233	0.48
2027	2149	2194	0.47
2028	2116	2159	0.47

Unresolved Problems and Major Uncertainties

A number of technical issues discussed in the review of the 2007 model were not resolved in the 2015 update, as resolution required changes to model structure outside of the terms of reference for assessment updates. These include how weightings were assigned for length and age composition data, how the time varying growth is estimated, the length bin structure, and selectivity parameterization issues for both fisheries and fishery independent surveys. Steepness remains a key uncertainty. When profiled or estimated with a prior, the model has a slightly better fit with lower steepness values (approximately 0.4), which was in contrast to the results of the 2007 model, which had a better fit (based on the likelihood profile) with higher steepness values. This was the basis for maintaining the steepness prior point estimate from the 2007 model (a decision made for the 2015 update).

The results from the convergence tests with randomly jittered starting parameter values continue to indicate that the likelihood surface is very irregular, which was true in both the 2007 model and the 2015 update. However, biomass trajectories and other critical results do not appear to be sensitive to these differences.

Decision Table

The decision table follows the 2015 update (and 2007 assessment) format, with the two alternative states of nature equating to low (steepness set to 0.34) and high (steepness set to 0.81) productivity assumptions. Catches are based on either the status quo for the "low" catch scenario (average catch over the 5 year period used in the 2015 assessment), on the default harvest control rule (0.954% of the OFL) from 2017 onward, and on the base model OFL for 2017 onward. We did not use the 2017-2018 adopted ACLs as a key output of this update was perceived to be the "corrected" estimate of the ACL and OFL for the 2017-18 management cycle, in order to evaluate whether the adopted values are above those in the base model with the corrected time series (as discussed in the forecast section). As chilipepper is considered a category 1 stock with a P* = 0.45 in recent years (translating to a 4.4% buffer for the ACL to be set below the OFL), the difference between ACL and OFL catch streams is minor. Under the base and high productivity scenarios, none of these catch streams lead to conservation concerns, however under the low productivity scenario (h=0.34), the stock rebuilds to target levels with status quo catches, but declines below the overfished threshold by 2019 with ACL or OFL catches.

Table 6: Decision Table

		State 1 (h=0.34)		Base (h=0.57)		State 2 (h=0.81)	
Year	Status quo catches	larvae (millions)	depletion	larvae (millions)	depletion	larvae (millions)	depletion
2017	346	3082	0.36	4707	0.69	5162	0.85
2018	346	3108	0.36	4843	0.71	5292	0.87
2019	346	3130	0.36	4947	0.73	5379	0.88
2020	346	3161	0.36	5032	0.74	5434	0.89
2021	346	3206	0.37	5110	0.75	5472	0.90
2022	346	3265	0.38	5185	0.76	5499	0.90
2023	346	3334	0.38	5256	0.77	5519	0.91
2024	346	3409	0.39	5325	0.78	5533	0.91
2025	346	3489	0.40	5391	0.79	5544	0.91
2026	346	3572	0.41	5453	0.80	5552	0.91
2027	346	3655	0.42	5513	0.81	5559	0.91
2028	346	3740	0.43	5569	0.82	5565	0.91
	ACL catches	larvae (millions)	depletion	larvae (millions)	depletion	larvae (millions)	depletion
2017	3033	3082	0.36	4707	0.69	5162	0.85
2018	2873	2704	0.31	4454	0.65	4905	0.81
2019	2749	2382	0.28	4215	0.62	4648	0.76
2020	2622	2113	0.25	3998	0.59	4401	0.72
2021	2504	1898	0.22	3814	0.56	4179	0.69
2022	2407	1725	0.20	3664	0.54	3988	0.65
2023	2333	1577	0.18	3543	0.52	3826	0.63
2024	2274	1442	0.17	3443	0.51	3690	0.61
2025	2226	1310	0.15	3360	0.49	3576	0.59
2026	2185	1178	0.14	3290	0.48	3481	0.57
2027	2149	1044	0.12	3229	0.47	3401	0.56
2028	2116	907	0.11	3176	0.47	3335	0.55
	OFL catches	larvae (millions)	depletion	larvae (millions)	depletion	larvae (millions)	depletion
2017	3173	3082	0.36	4707	0.69	5162	0.85
2018	2993	2697	0.31	4434	0.65	4882	0.80
2019	2852	2360	0.27	4179	0.61	4609	0.76
2020	2711	2079	0.24	3950	0.58	4349	0.71
2021	2581	1855	0.21	3756	0.55	4118	0.68
2022	2476	1675	0.19	3599	0.53	3920	0.64
2023	2395	1522	0.18	3472	0.51	3754	0.62
2024	2331	1381	0.16	3369	0.50	3615	0.59
2025	2278	1243	0.14	3282	0.48	3499	0.57
2026	2233	1105	0.13	3209	0.47	3404	0.56
2027	2194	965	0.11	3146	0.46	3324	0.55
2028	2159	822	0.10	3091	0.45	3259	0.53

Table 7: Base model output

	Larval Output (millions larvae)	Std dev larval Output	Summary Biomass (age 1+)	Recruits (1000s)	SPR	Exploitation rate	Depletion	Total Catch
Virgin	6803	439	51079	40333	1	0	1	
Initial	6803	439	51079	40333	1	0	1	
1892	6803	439	51079	40333	0.959	0.004	1	217
1893	6768	439	51155	40294	0.961	0.004	0.995	205
1894	6738	439	51233	40261	0.963	0.004	0.991	193
1895	6713	439	51320	40232	0.965	0.004	0.987	180
1896	6693	439	51380	40209	0.967	0.003	0.984	171
1897	6676	439	51456	40189	0.969	0.003	0.981	160
1898	6662	439	51518	40174	0.970	0.003	0.979	151
1899	6652	439	51597	40161	0.972	0.003	0.978	140
1900	6644	439	51487	40153	0.970	0.003	0.977	155
1901	6635	439	51384	40142	0.967	0.003	0.975	169
1902	6624	439	51267	40129	0.964	0.004	0.974	185
1903	6612	439	51156	40115	0.961	0.004	0.972	200
1904	6598	439	51046	40099	0.958	0.004	0.97	215
1905	6584	439	50943	40082	0.955	0.004	0.968	229
1906	6568	439	50832	40064	0.952	0.005	0.966	244
1907	6552	439	50721	40044	0.949	0.005	0.963	259
1908	6535	439	50610	40024	0.947	0.005	0.961	274
1909	6517	439	50373	40002	0.940	0.006	0.958	307
1910	6495	439	50122	39976	0.934	0.007	0.955	342
1911	6470	439	49871	39946	0.927	0.008	0.951	377
1912	6442	439	49627	39912	0.921	0.008	0.947	411
1913	6411	439	49382	39874	0.914	0.009	0.942	445
1914	6377	439	49137	39832	0.908	0.01	0.938	479
1915	6342	439	48884	39788	0.901	0.011	0.932	514
1916	6304	439	49897	39740	0.928	0.007	0.927	362
1917	6294	439	48440	39727	0.890	0.012	0.925	574
1918	6251	439	48320	39674	0.887	0.012	0.919	588
1919	6211	439	49728	39621	0.924	0.008	0.913	380
1920	6206	439	49589	39616	0.920	0.008	0.912	399
1921	6200	439	50018	39607	0.931	0.007	0.911	339
1922	6203	439	50214	39611	0.936	0.006	0.912	312
1923	6210	439	49727	39621	0.924	0.008	0.913	380
1924	6206	439	49665	39615	0.922	0.008	0.912	390
1925	6201	439	49320	39608	0.913	0.009	0.912	439
1926	6187	439	48245	39591	0.885	0.012	0.91	595
1927	6151	439	48784	39544	0.900	0.01	0.904	508
1928	6132	439	48811	39518	0.901	0.01	0.902	501
1929	6116	439	48891	39497	0.903	0.01	0.899	487
1930	6104	439	48452	39481	0.891	0.011	0.897	549
1931	6083	439	48205	39453	0.885	0.012	0.894	586
1932	6058	439	49331	39419	0.914	0.009	0.891	422
1933	6060	440	49939	39423	0.931	0.007	0.891	336
1934	6077	440	49793	39445	0.927	0.007	0.893	357
1935	6089	440	49606	39461	0.922	0.008	0.895	383
1936	6096	440	50296	39470	0.940	0.006	0.896	290
1937	6116	440	50459	39497	0.944	0.005	0.899	268
1938	6138	440	50593	39526	0.948	0.005	0.902	251
1939	6161	440	50389	39556	0.943	0.006	0.906	278
1940	6177	440	50585	39577	0.947	0.005	0.908	255
1941	6195	440	50839	39601	0.954	0.004	0.911	223

Table 7, continued: Base model output

	Spawning Output (millions larvae)	Std dev Spawning Output	Summary Biomass (age 1+)	Recruitment	SPR	Exploitation rate	Depletion	Total Catch
1942	6216	440	51875	39628	0.980	0.002	0.914	93
1943	6254	440	51055	39677	0.960	0.004	0.919	195
1944	6275	440	48386	39704	0.893	0.011	0.923	555
1945	6240	440	44546	39659	0.798	0.026	0.917	1148
1946	6118	440	46020	39500	0.834	0.019	0.9	889
1947	6043	440	47451	39400	0.869	0.014	0.888	669
1948	6007	440	48425	39351	0.894	0.011	0.883	526
1949	5996	440	47904	39336	0.881	0.012	0.882	596
1950	5978	440	46721	39310	0.852	0.016	0.879	763
1951	5936	440	43708	39252	0.778	0.028	0.873	1229
1952	5828	440	43688	39101	0.777	0.028	0.857	1209
1953	5732	440	42251	38960	0.743	0.034	0.843	1432
1954	5610	440	42365	38779	0.745	0.033	0.825	1381
1955	5505	440	41768	38617	0.731	0.035	0.809	1454
1956	5399	440	40599	38449	0.703	0.04	0.794	1630
1957	5276	440	39783	38246	0.683	0.044	0.776	1745
1958	5146	440	38388	38024	0.650	0.051	0.757	1966
1959	4993	440	39906	37754	0.686	0.041	0.734	1639
1960	4901	440	41276	37583	0.719	0.034	0.72	1386
1961	4853	441	43165	37492	0.765	0.025	0.713	1091
1962	4852	441	43558	37492	0.775	0.024	0.713	1036
1963	4862	442	39217	37509	0.668	0.044	0.715	1733
1964	4768	443	40659	37329	0.703	0.036	0.701	1455
1965	4720	443	43555	29382	0.774	0.023	0.694	1009
1966	4737	441	36770	27124	0.612	0.058	0.696	2130
1967	4590	438	32533	47849	0.514	0.093	0.675	3010
1968	4313	422	37753	59620	0.635	0.047	0.634	1773
1969	4212	404	43090	42348	0.764	0.022	0.619	960
1970	4250	386	41519	54439	0.726	0.028	0.625	1163
1971	4268	337	42207	16577	0.751	0.024	0.628	1015
1972	4335	286	38960	15029	0.678	0.037	0.637	1441
1973	4368	238	31322	106366	0.500	0.094	0.642	2929
1974	4194	201	29101	11106	0.451	0.117	0.617	3391
1975	3882	178	30101	80183	0.476	0.097	0.571	2907
1976	3748	165	29457	5887	0.462	0.099	0.551	2912
1977	3625	165	31688	10433	0.516	0.072	0.533	2293
1978	3641	176	34250	17344	0.577	0.053	0.535	1827
1979	3688	190	30116	48350	0.479	0.091	0.542	2736
1980	3530	194	28310	10675	0.439	0.111	0.519	3141
1981	3387	163	30378	6733	0.466	0.092	0.498	2800
1982	3271	141	31966	2095	0.485	0.079	0.481	2521
1983	3140	127	32665	8960	0.487	0.076	0.462	2469
1984	2918	118	29917	143377	0.425	0.098	0.429	2934
1985	2586	110	28189	6139	0.380	0.114	0.38	3217
1986	2138	103	27243	26965	0.353	0.116	0.314	3157
1987	2052	102	29847	20791	0.407	0.069	0.302	2065
1988	2304	107	27080	36742	0.354	0.103	0.339	2790
1989	2430	115	25914	37815	0.329	0.133	0.357	3438
1990	2327	117	26627	16403	0.346	0.119	0.342	3156
1991	2223	124	25454	22756	0.324	0.131	0.327	3347
1992	2098	136	27099	14340	0.351	0.102	0.309	2774
1993	1950	137	27380	38317	0.364	0.088	0.287	2412

Table 7, continued: Base model output

	Spawning Output (millions larvae)	Std dev Spawning Output	Summary Biomass (age 1+)	Recruitment	SPR	Exploitation rate	Depletion	Total Catch
1994	1840	141	29109	10036	0.411	0.065	0.271	1891
1995	1775	147	27539	9025	0.386	0.074	0.261	2034
1996	1703	157	27578	8612	0.392	0.068	0.25	1880
1997	1640	168	25634	6016	0.352	0.083	0.241	2116
1998	1506	178	29288	34114	0.432	0.049	0.221	1435
1999	1433	187	33098	206214	0.524	0.03	0.211	978
2000	1490	206	38206	4241	0.635	0.017	0.219	632
2001	1595	228	40858	14277	0.690	0.013	0.235	518
2002	2169	315	46636	13246	0.820	0.007	0.319	320
2003	2934	432	54022	23840	0.991	0	0.431	21
2004	3602	532	52507	5407	0.950	0.003	0.53	153
2005	4050	600	53655	3584	0.975	0.002	0.595	85
2006	4346	643	53441	4369	0.966	0.002	0.639	126
2007	4477	662	53328	13856	0.962	0.003	0.658	137
2008	4456	659	53298	12277	0.960	0.003	0.655	148
2009	4316	637	51394	84492	0.914	0.006	0.634	318
2010	4120	611	50266	58495	0.887	0.008	0.606	397
2011	3904	583	50728	13148	0.897	0.007	0.574	331
2012	3860	579	50878	16948	0.900	0.006	0.567	307
2013	4011	607	49823	44748	0.875	0.008	0.59	405
2014	4185	644	51058	64330	0.905	0.006	*0.615*	325
2015	4324	674	52664	26081	0.942	0.004	*0.636*	203
2016	4469	707	53972	31082	*0.973*	0.002	*0.657*	97
2017	4707	752	33171	37210	*0.502*	0	*0.692*	0