

## Depletion-Based Stock Reduction Analysis estimates of sustainable yield for cabezon (*Scorpaenichthys marmoratus*) in waters off Washington State.

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This report estimates yield for cabezon (*Scorpaenichthys marmoratus*) in waters off Washington State, using Depletion-Based Stock Reduction Analysis (DB-SRA) (Dick and MacCall 2011). This method requires annual removals, estimates of relative stock status for a given year  $y$  ( $SB_y/SB_0$ ), natural mortality ( $M$ ), the ratio of the fishing rate at maximum sustainable yield to  $M$  ( $F_{MSY}/M$ ) and age at maturity.

Annual catches (in numbers) from the Washington recreational fishery (1967, 1975-86, 1990-2016) were obtained from the Washington Department of Fish and Wildlife (WDFW). Given cabezon were still being recorded as landed in 1967, a linear interpolation was used to find landed values down to zero (year 1962) to fill in missing years (Table 1). Cabezon are also assumed to be caught and released, with a small fraction of those being released (7%; H. Reed (WDFW), pers. comm.) dying after capture. For years prior to 2002, a 10% discard rate was assumed (a value considered reasonable by WDFW staff), with the 7% post-released discard mortality rate being applied to all years. The sum of retained and dead released cabezon made up the total removal (in numbers) from the recreational fishery.

DB-SRA requires catches as biomass, so the numbers were converted to catch in weight (mt). Average weights for the recreational fishery were obtained for both Washington (short time series) and Oregon (longer times series) for comparison (Figure 1). The previous analysis in 2014 assumed 2.2 kg/fish for all years, which is closer to the averages in the earlier time series. There does appear to be a difference between the two time periods (pre- and post-2003; Figure 1) in Oregon, and the latter Oregon values seem closer to the Washington values. The Washington time series has an expectation around 2.5 kg/fish. Another consideration is using 2.2 kg/fish before 2003 and 2.5 kg/fish 2003 and after. These three catch histories do not produce large differences, but are used to explore DB-SRA sensitivity to recreational removals (Table 1).

Commercial catches in Washington are small relative to recreational removals (Table 1). Total removals are the summation of both the recreational and commercial fisheries, but driven mostly by the former. The stock status assumption also assumes low commercial removals, and was thus taken from the Oregon assessment based on years prior to the development of the commercial live-fish fishery in Oregon in the late 1990s. The DB-SRA model assumes that cabezon biomass off Washington in 1997 was 62% of unfished biomass on average, per the Oregon assessment (Cope and Key 2009). Other model inputs, such as life history parameters, are assumed equal to

values reported in the cabezon substock in Oregon waters (Cope and Key 2009; Table 2). DB-SRA was run 10,000 times to produce the OFL in 2019. The median value of the OFL in 2019 was then used as an input for further DB-SRA runs to obtain the 2020 OFL.

Results of the DB-SRA runs are provided in Table 3 and Figure 2 and Figure 3. The three removal histories based on different average catch assumptions were combined into a composite distribution of OFLs. This composite thus incorporates the uncertainty in the removal histories, and has been highlighted as the suggested OFL for management use. The ABC values are based on  $P^* = 0.45$  and  $\sigma = 1.44$ , which results in a buffer of 0.834. Only two years (i.e., enough for the next management cycle) are provided in this analysis to encourage further investigations beyond the 2019-2020 management cycle.

### **Acknowledgements**

We thank T. Tsou, H. Reed, J. Doerpinghaus (WDFW), and P. Mirick (ODFW) for providing data and consultation.

### **References**

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- Dick, E. J. and A. D. MacCall. 2011. Depletion-Based Stock Reduction Analysis: A catch-based method for determining sustainable yields for data-poor fish stocks. *Fisheries Research* 110: 331-341.

Table 1. Cabezon removals used in the DB-SRA analysis.

Cabezon recreational removals											
Year	Retained	Released	Dead released	#s	mt <sup>1</sup>	mt <sup>2</sup>	mt <sup>3</sup>	Comm. Removals	Total removals (mt) <sup>1</sup>	Total removals (mt) <sup>2</sup>	Total removals (mt) <sup>3</sup>
1963	10	1	0	10	0.02	0.02	0.02	0.00	0.02	0.02	0.02
1964	31	3	0	31	0.07	0.07	0.08	0.00	0.07	0.07	0.08
1965	51	5	0	52	0.11	0.11	0.13	0.00	0.11	0.11	0.13
1966	72	7	1	73	0.16	0.16	0.18	0.00	0.16	0.16	0.18
1967	80	8	1	81	0.18	0.18	0.20	0.00	0.18	0.18	0.20
1968	114	11	1	115	0.25	0.25	0.29	0.00	0.25	0.25	0.29
1969	135	13	1	136	0.30	0.30	0.34	0.00	0.30	0.30	0.34
1970	156	16	1	157	0.34	0.34	0.39	0.00	0.34	0.34	0.39
1971	177	18	1	178	0.39	0.39	0.44	0.00	0.39	0.39	0.44
1972	197	20	1	199	0.44	0.44	0.50	0.00	0.44	0.44	0.50
1973	218	22	2	220	0.48	0.48	0.55	0.00	0.48	0.48	0.55
1974	239	24	2	241	0.53	0.53	0.60	0.00	0.53	0.53	0.60
1975	330	33	2	332	0.73	0.73	0.83	0.00	0.73	0.73	0.83
1976	316	32	2	318	0.70	0.70	0.80	0.00	0.70	0.70	0.80
1977	165	17	1	166	0.37	0.37	0.42	0.00	0.37	0.37	0.42
1978	449	45	3	452	0.99	0.99	1.13	0.11	1.11	1.11	1.25
1979	239	24	2	241	0.53	0.53	0.60	0.00	0.53	0.53	0.60
1980	390	39	3	393	0.86	0.86	0.98	0.00	0.86	0.86	0.98
1981	313	31	2	315	0.69	0.69	0.79	0.00	0.69	0.69	0.79
1982	473	47	3	476	1.05	1.05	1.19	0.00	1.05	1.05	1.19
1983	1029	103	7	1036	2.28	2.28	2.59	0.00	2.28	2.28	2.59
1984	1248	125	9	1257	2.76	2.76	3.14	0.02	2.79	2.79	3.17
1985	1153	115	8	1161	2.55	2.55	2.90	0.00	2.55	2.55	2.90
1986	1673	167	12	1685	3.71	3.71	4.21	0.02	3.72	3.72	4.23
1987	NA	NA	NA	NA				0.95	5.09	5.09	5.65
1988	NA	NA	NA	NA				1.10	5.66	5.66	6.28
1989	NA	NA	NA	NA				1.52	6.52	6.52	7.20

Linearly interpolated using years 1967, 1975-1982.

Assumes discard rate of 10%.

Assumes discard mortality rate of 7%.

<sup>1</sup> Average weights assumed 2.2 kg for all years

<sup>2</sup> Average weights assumed 2.2 (1963-2002) and 2.5 kg (2003-2016)

<sup>3</sup> Average weights assumed 2.5 kg for all years

Linearly interpolated using years

Table 1. continued.

Cabezon recreational removals											
Year	Retained	Released	Dead released	#s	mt <sup>1</sup>	mt <sup>2</sup>	mt <sup>3</sup>	Comm. Removals	Total removals (mt) <sup>1</sup>	Total removals (mt) <sup>2</sup>	Total removals (mt) <sup>3</sup>
1990	2447	245	17	2464	5.42	5.42	6.16	0.59	6.01	6.01	6.75
1991	1923	192	13	1936	4.26	4.26	4.84	0.20	4.46	4.46	5.04
1992	3207	321	22	3229	7.10	7.10	8.07	0.34	7.44	7.44	8.41
1993	2755	276	19	2774	6.10	6.10	6.94	0.75	6.85	6.85	7.68
1994	1924	192	13	1937	4.26	4.26	4.84	0.21	4.48	4.48	5.06
1995	2069	207	14	2083	4.58	4.58	5.21	0.11	4.69	4.69	5.31
1996	2236	224	16	2252	4.95	4.95	5.63	0.00	4.95	4.95	5.63
1997	2601	260	18	2619	5.76	5.76	6.55	0.00	5.76	5.76	6.55
1998	2043	204	14	2057	4.53	4.53	5.14	0.00	4.53	4.53	5.14
1999	1962	196	14	1976	4.35	4.35	4.94	0.00	4.35	4.35	4.94
2000	1941	194	14	1955	4.30	4.30	4.89	0.53	4.83	4.83	5.41
2001	2443	244	17	2460	5.41	5.41	6.15	0.00	5.41	5.41	6.15
2002	3106	515	36	3142	6.91	7.86	7.86	0.00	6.91	7.86	7.86
2003	3047	734	51	3098	6.82	7.75	7.75	0.00	6.82	7.75	7.75
2004	3301	1036	73	3374	7.42	8.43	8.43	0.06	7.48	8.49	8.49
2005	3962.98	1016	71	4034	8.88	10.09	10.09	0.03	8.90	10.11	10.11
2006	2647.57	644	45	2693	5.92	6.73	6.73	0.00	5.93	6.74	6.74
2007	2433.7	768	54	2487	5.47	6.22	6.22	0.18	5.65	6.40	6.40
2008	2008.43	587	41	2050	4.51	5.12	5.12	0.01	4.52	5.14	5.14
2009	3067.69	593	41	3109	6.84	7.77	7.77	0.00	6.84	7.78	7.78
2010	3084.53	958	67	3152	6.93	7.88	7.88	0.01	6.95	7.89	7.89
2011	3666.22	985	69	3735	8.22	9.34	9.34	0.03	8.25	9.37	9.37
2012	2834.68	849	59	2894	6.37	7.24	7.24	0.12	6.48	7.35	7.35
2013	2477.41	954	67	2544	5.60	6.36	6.36	0.00	5.60	6.36	6.36
2014	2164.81	1523	107	2271	5.00	5.68	5.68	0.00	5.00	5.68	5.68
2015	2046.58	1108	78	2124	4.67	5.31	5.31	0.03	4.71	5.35	5.35
2016	1899.08	1248	87	1986	4.37	4.97	4.97	0.01	4.38	4.98	4.98
2017	NA	NA	NA	NA	NA	NA	NA	NA	3.80	3.80	3.80
2018	NA	NA	NA	NA	NA	NA	NA	NA	4.00	4.00	4.00

Assumes discard rate of 10%.  
 Assumes discard mortality rate of 7%.

<sup>1</sup> Average weights assumed 2.2 kg for all years

<sup>2</sup> Average weights assumed 2.2 (1963-2002) and 2.5 kg (2003-2016)

<sup>3</sup> Average weights assumed 2.5 kg for all years

Harvest specifications ACLs

Table 2. Parameter values/distributions used in the DB-SRA analysis for cabezon in Washington. Means are arithmetic means, standard deviations with an \* are log-scale standard deviations. Fixed values (assumed known without error) are shown in parentheses.

Parameter/Qty.	Distribution	Mean	SD	Bounds
M	lognormal	0.25	0.4*	0,Inf
F <sub>MSY</sub> /M	lognormal	0.8	0.1*	0,Inf
B <sub>MSY</sub> /B <sub>0</sub>	beta	0.4	0.05	0.05,0.95
1-Δ	beta	0.3814	0.1	0.01,0.99
Δ year	-	1997	-	-
Age at maturity	-	4	-	-

Table 3. OFL and ACL (83.4% of the OFL) values from the DB-SRA analysis for the Washington substock of cabezon. Bolded values are proposed values for use in management.

Year	Avg. wt. run	OFL					ACL
		2.5%	25%	50%	75%	97.5%	
2019	2.2 kg	0.08	2.93	5.38	8.33	16.80	4.49
2019	2.2 & 2.5 kg	0.02	2.49	4.87	7.88	16.94	4.06
2019	2.5 kg	0.19	3.33	6.27	9.64	18.85	5.23
<b>2019</b>	<b>Composite</b>	<b>0.08</b>	<b>2.90</b>	<b>5.52</b>	<b>8.69</b>	<b>17.68</b>	<b>4.60</b>
2020	2.2 kg	0.00	2.72	5.24	8.21	16.70	4.37
2020	2.2 & 2.5 kg	0.00	2.32	4.81	7.88	17.00	4.01
2020	2.5 kg	0.00	3.03	6.06	9.46	18.67	5.05
<b>2020</b>	<b>Composite</b>	<b>0.00</b>	<b>2.67</b>	<b>5.37</b>	<b>8.56</b>	<b>17.55</b>	<b>4.48</b>

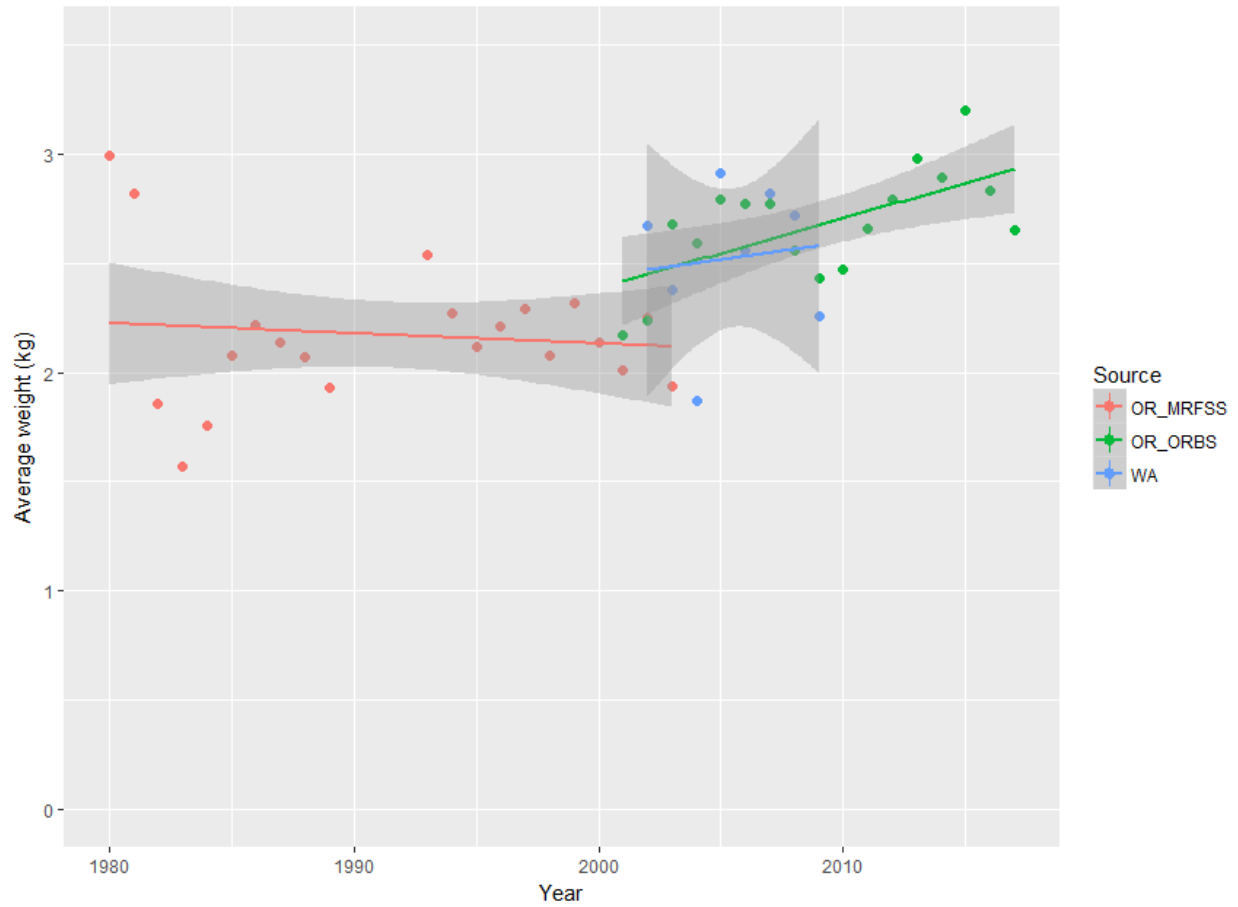


Figure 1. Average landed cabezon weights by year from three recreational fishery data sources. OR\_MRFSS = Oregon MRFSS. OR\_ORBS = Oregon ORBS. WA = Washington recreational sampling.

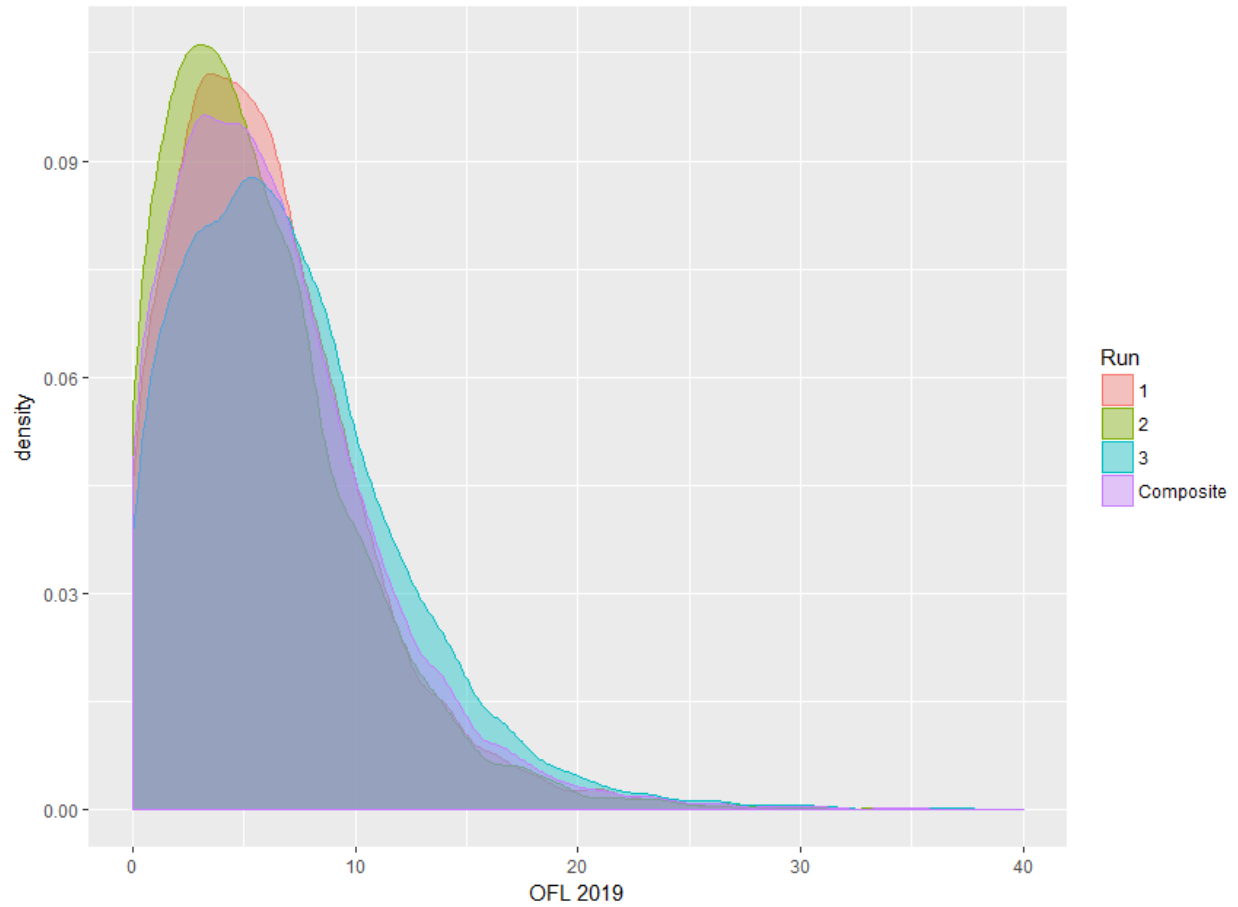


Figure 2 . Distribution of 2019 OFL values for cabezon in Washington for 3 different catch scenarios and the composite of all 3 catch scenarios. Run 1 = average catch assume 2.2 kg/fish; Run 2 = average catch assume 2.2 kg/fish (1963-2002) and 2.5 kg/fish (2003-2016); Run 3 = average catch assume 2.5 kg/fish.

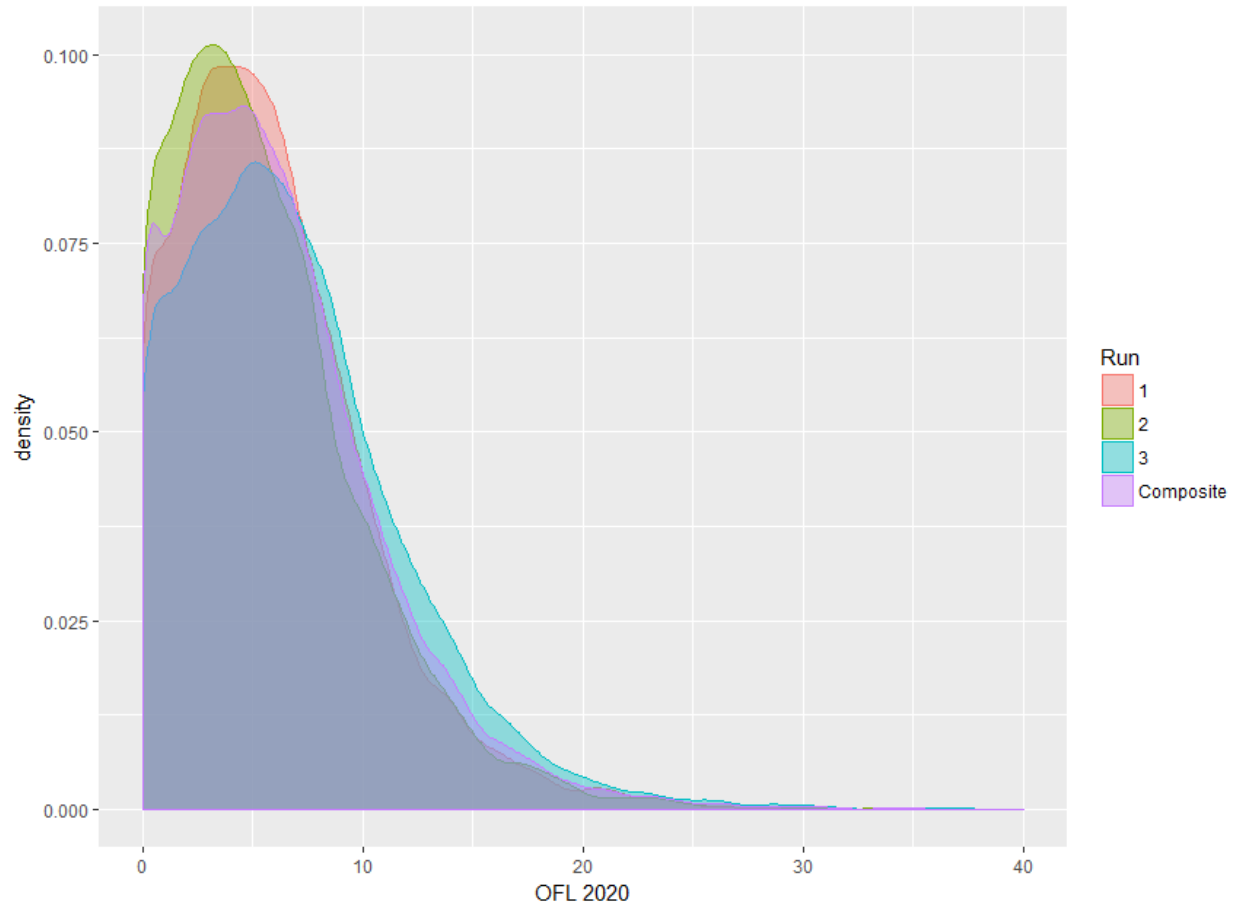


Figure 3. Distribution of 2020 OFL values for cabezon in Washington for 3 different catch scenarios and the composite of all 3 catch scenarios. Run 1 = average catch assume 2.2 kg/fish; Run 2 = average catch assume 2.2 kg/fish (1963-2002) and 2.5 kg/fish (2003-2016); Run 3 = average catch assume 2.5 kg/fish.