

2009 Darkblotched Rockfish Rebuilding Analysis

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1. Introduction

The Pacific Fishery Management Council (PFMC) adopted Amendment 11 to its Groundfish Management Plan in 1998. This amendment established a definition for an overfished stock of 25% of the unfished spawning biomass ($0.25B_0$). Darkblotched rockfish (*Sebastes crameri*) was declared overfished in January 2001 based on the most recent stock assessment at that time (Rogers et al. 2000). Rebuilding analyses were first conducted in mid-year 2001 (Methot and Rogers 2001) and included a partial update of the 2000 stock assessment.

The stock assessment for darkblotched rockfish was updated in 2003 (Rogers 2003). Full assessments were conducted in 2005 (Rogers 2005) and 2007 (Hamel 2007), using Stock-Synthesis II. An assessment update was done in 2009 (Wallace and Hamel 2009) using version 3 of Stock-Synthesis. In 2005 the natural mortality rate used in the assessment was changed from the previously used value of 0.05 (based largely on Hoenig's method) to 0.07 (as a balance between Hoenig's method and Gunderson's method based on gonadosomatic index (GSI)). This latter value was used in the 2007 assessment and the 2009 update as well. The largest change in assumptions between the 2005 and 2007 assessments was the value of stock-recruitment steepness. In 2005, steepness was estimated at 1.0, and was set at 0.95. In 2007, a good deal more age data was included in the assessment, largely as conditional age-at length compositions, and steepness was estimated (using the prior from Dorn's meta-analysis) at 0.6. That value of steepness was then fixed in the 2007 assessment and hence also used in the 2009 update.

The SPR chosen following the 2005 rebuilding analysis (0.607) corresponded to a T_{target} (median rebuilding year) of 2011, which was much earlier than for previous rebuilding analyses, due largely to the high value of steepness (and thus high productivity at low stock sizes) assumed in the 2005 assessment. Based on the 2007 rebuilding analysis, the darkblotched rockfish stock was projected to recover 19 years later (2030) than anticipated from the 2005 rebuilding analysis. This then led to the adoption by the Pacific Council of a new T_{TARGET} equal to 2028.

2. Specifications

2.1 Selection of B_0

As in 2007 the unfished spawning stock biomass, B_0 , was determined from the fitted stock-recruitment relationship in order to be consistent with the assumptions underlying the current stock assessment. This is in contrast to previous rebuilding analyses for darkblotched rockfish which used a range of estimated historical recruitments to estimate B_0 . The MPD estimate of B_0 is 32,800 mt.

2.2 Generation of future recruitment

Future recruitments are generated using the Beverton-Holt spawner recruit relationship with steepness = 0.6 and $\sigma_r = 0.8$ as estimated within the 2007 assessment (Hamel, 2007) and used in the 2009 update (Wallace and Hamel 2009). This is in contrast to rebuilding analyses previous to 2007 which re-sampled from a range of estimated historical recruitments. Again, this choice is consistent with the assumptions underlying the current stock assessment.

2.3 Methods used

The revised SSC default rebuilding analysis (Punt 2009) was used to find all rebuilding milestones, such as T_{MIN} and the mean generation time, in addition to the results for the various harvest strategies specified below. Darkblotched biological information can be found within the rebuilding analysis input file in Appendix A.

2.4 Harvest strategies

Table 1 shows darkblotched summary statistics by assessment year. Table 2 shows an assortment of projections, which include 1) the SPR of 0.607 listed in the rebuilding plan in the FMP (Amendment 16-4 2006), 2) the SPR corresponding to the 2009-10 OY, 3) the new SPR of 0.621 on which the current OY's are based, 4) the SPR for the 2009-10 revised T_{TARGET} of 2028, 5) the FMP T_{MAX} of 2033, 6) the FMP T_{TARGET} of 2011, 7) no harvest (SPR = 1.0), 8) three evenly spaced quartiles between $T_{F=0}$ and T_{MAX} , 9) the ABC rule (SPR = 0.5), and 10) the 40:10 rule.

Figure 1 shows this information in one succinct picture. Shown is the estimated probability of rebuilding darkblotched by year and $1 - SPR$. The current T_{TARGET} of 2028 is highlighted along with the new model's corresponding SPR of 0.596.

3. Evaluation

$T_{REBUILD}$, the new time to rebuild at the current SPR_{TARGET} , is 2027 which is one year earlier than the currently adopted T_{TARGET} of 2028. $T_{REBUILD}$ is also substantially below the new T_{MAX} of 2037, as can be seen graphically in Figure 1.

References

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- Rogers, J.B. 2005. Status of the Darkblotched Rockfish (*Sebastes crameri*) Resource in 2005. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97201.
- Rogers, J.B. 2003. Darkblotched rockfish (*Sebastes crameri*) 2003 stock status and rebuilding update, appendix to Status of the Pacific coast groundfish fishery through 2003 and recommended acceptable biological catches for 2004. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97201.
- Rogers, J.B., R.D. Methot, T.L. Builder, K. Piner, and M. Wilkins. 2000. Status of the Darkblotched Rockfish (*Sebastes crameri*) Resource in 2000, appendix to Status of the Pacific coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97201.
- Wallace, J.W., Hamel, O.S. 2009. Status and future prospects for the darkblotched rockfish resource in waters off Washington, Oregon and California as assessed in 2009. Pacific Fishery Management Council, Portland, OR.

Table 1. Summary statistics for darkblotched rockfish by assessment year. The sum of the catch divided by the sum of the OY for years 2001-2007 is 97.0%.

Value	2001	2002	2003	2004	2005	2006	2007	2008	2009
ABC	302-349	187	205	240	269	294	456	487	437
OY	130	168	172	240	269	200	290	330	285
Landings (mt)	173	113	80	189	98	109	145	117	
Catch (mt)	274	179	127	252	129	200	264	213	
1+ Biomass ^T	6,382	7,231	8,266	9,326	10,204	11,142	11,899	12,423	12,836
Sp. Output ^T (10^8 eggs)	3,099	3,252	3,572	3,999	4,466	5,230	6,166	7,090	7,940
Sp. Output-Relative to Target ^T	26.9%	28.2%	31.0%	34.7%	38.7%	45.4%	53.5%	61.5%	68.9%
Recruits (10^3) ^T	986	968	2,346	2,817	2,478	545	46	2,002	2,104
B_0 (mt) (1+ Biomass)							34,509		32,783
1+ Biomass at B_{40}							16,528		15,763
Year declared overfished	X								
T_{MIN}	2014		2011		2009		2015		2012
$T_{F=0}$ (beginning 2 years after the assessment year)							2018		2016
Mean generation time	33 yrs		33 yrs		24 yrs		25 yrs		25 yrs
T_{MAX}	2047		2044		2033		2040		2037
Adopted T_{TARGET}	2030		2019		2011		2028		
Adopted SPR_{TARGET}					0.607		0.621		
$T_{REBUILD}$, new time to rebuild at current SPR_{TARGET}									2027
2009-2010 OY SPR									0.649

^T2009 assessment results and projection (for the 2009 recruits)

Table 2. Darkblotched projections. The vertical double lines demarcate the evenly spaced quartile increments. Note that if an integer year is wanted for the year in which 50% probability is achieved, then, given the yearly nature of fishery management, that number should only be “rounded up” to the next highest integer.

	OLD FMP SPR	2009- 2010 OY SPR	SPR on which current OY's are based	Current T _{target} , Yr = 2028	FMP T _{MAX} = 2033	FMP T _{Target} = 2011 & F = 0	Yr = 2021	Yr = 2026	Yr = 2031	New T _{MAX} = 2037	ABC Rule	40-10 rule
SPR (target)	0.607	0.649	0.621	0.596	0.551	1.000	0.719	0.629	0.564	0.528	0.500	0.507-0.526 [†]
50% Prob Yr	2027.0	2024.4	2026.1	2028.0	2033.0	2015.5	2021.3	2025.6	2031.0	2037.0	2045.5	2040.7
OY (2011)	349.2	297.6	331.5	363.6	427.1	0.0	221.6	322.0	407.1	461.4	507.8	465.7
ABC (2011)	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8
OY (2012)	346.1	296.1	329.0	360.0	421.6	0.0	221.8	319.9	401.6	453.3	497.0	465.2
ABC (2012)	503.3	505.3	504.0	502.7	500.1	517.1	508.3	504.3	501.0	499.8	497.0	498.7
Probability of Recovery by Year (See the '50% Prob Yr' row above for the year of 50% probability of recovery.)												
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
2020	11.2	19.0	13.5	10.1	5.6	100.0	38.5	15.1	6.6	4.4	3.1	3.8
2024	35.4	47.7	39.8	31.9	20.8	100.0	70.3	41.9	23.6	7.3	12.2	13.9
2028	53.6	66.3	58.0	50.0	36.2	100.0	84.6	59.5	40.8	22.5	21.4	25.0
2032	66.4	78.5	70.9	62.9	48.0	100.0	91.4	73.1	52.7	37.9	30.3	34.3
2036	74.9	85.2	78.8	71.4	57.2	100.0	95.1	80.3	62.8	48.8	37.6	42.5
2040	80.7	90.0	85.1	78.3	64.5	100.0	97.3	86.5	68.6	55.9	42.9	48.7

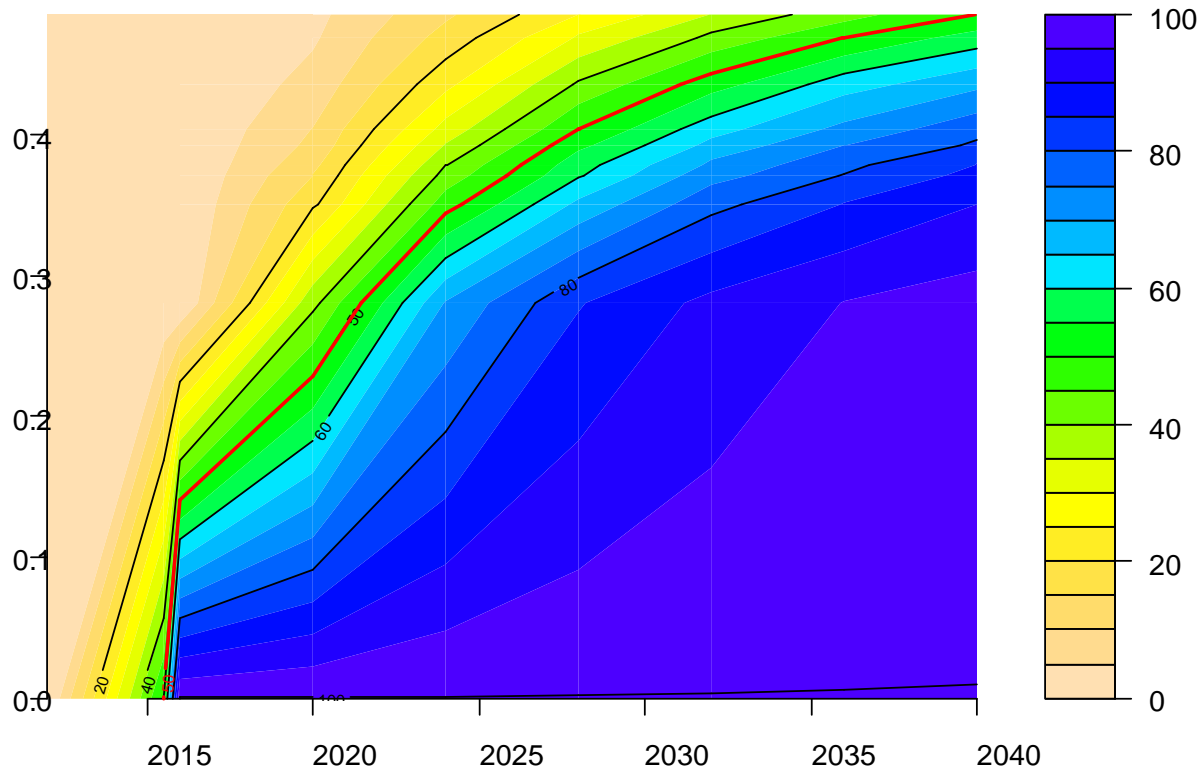
[†] Range of the 40-10 rule SPR is for years 2011-2040.

Table 2. cont.

	OLD FMP SPR	2009- 2010 OY SPR	SPR on which current OY's are based	Current T _{target} , Yr = 2028	FMP T _{MAX} = 2033	FMP T _{Target} = 2011 & F = 0	Yr = 2021	Yr = 2026	Yr = 2031	New T _{MAX} = 2037	ABC Rule	40-10 rule	
SSB / Target by Year													
2009	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	
2010	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	
2011	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	
2012	0.841	0.844	0.842	0.840	0.835	0.865	0.850	0.843	0.837	0.833	0.830	0.833	
2016	0.884	0.903	0.891	0.879	0.857	1.015	0.931	0.894	0.864	0.845	0.830	0.841	
2020	0.902	0.933	0.912	0.893	0.856	1.133	0.980	0.918	0.868	0.838	0.813	0.830	
2024	0.949	0.991	0.964	0.938	0.888	1.275	1.056	0.971	0.904	0.863	0.829	0.852	
2028	1.006	1.06	1.024	0.992	0.929	1.434	1.146	1.034	0.949	0.899	0.857	0.884	
2032	1.059	1.124	1.081	1.041	0.967	1.587	1.227	1.093	0.991	0.931	0.883	0.910	
2036	1.099	1.173	1.123	1.079	0.993	1.709	1.291	1.136	1.020	0.952	0.897	0.927	
2040	1.126	1.21	1.154	1.104	1.012	1.829	1.345	1.170	1.040	0.966	0.906	0.929	
ABC by Year												40-10 SPR	
2009	483.5	483.5	483.5	483.5	483.5	483.5	483.5	483.5	483.5	483.5	483.5	483.5	0.648
2010	500.7	500.7	500.7	500.7	500.7	500.7	500.7	500.7	500.7	500.7	500.7	500.7	0.651
2011	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	507.8	0.526
2012	503.3	505.3	504.0	502.7	500.1	517.1	508.3	504.3	501.0	498.8	497.0	498.7	0.521
2016	499.2	508.2	502.3	496.7	485.6	563.1	521.8	503.9	489.2	480.0	472.3	477.7	0.519
2020	521.7	536.5	526.7	517.6	499.8	630.8	559.1	529.4	505.4	490.9	478.6	487.2	0.521
2024	556.3	577.1	563.4	550.6	526.2	712.7	609.1	567.2	534.1	513.9	497.5	509.1	0.518
2028	588.0	614.4	596.4	581.4	551.1	790.6	655.4	601.5	560.8	535.6	514.5	526.5	0.513
2032	610.5	641.4	620.8	602.7	566.7	857.6	690.5	626.5	578.2	548.9	525.1	536.7	0.510
2036	627.3	662.8	639.4	617.5	576.4	914.4	719.9	645.6	589.3	556.5	529.4	541.8	0.508
2040	636.9	675.0	649.7	626.9	583.1	956.3	735.9	656.6	597.1	561.4	532.6	546.9	0.508

Table 2. cont.

	OLD FMP SPR	2009- 2010 OY SPR	SPR on which current OY's are based	Current T_{target} , Yr = 2028	FMP T_{MAX} = 2033	FMP T_{Target} = 2011 & F = 0	Yr = 2021	Yr = 2026	Yr = 2031	New T_{MAX} = 2037	ABC Rule	40-10 rule
	OY (Annual Catch) by Year											
2009	285.0	285	285.0	285.0	285.0	285.0	285.0	285.0	285.0	285.0	285.0	285.0
2010	291.0	291	291.0	291.0	291.0	291.0	291.0	291.0	291.0	291.0	291.0	291.0
2011	349.2	297.6	331.5	363.6	428.1	0.0	221.6	322.0	407.1	461.4	507.8	465.7
2012	346.1	296.1	329.0	360.0	421.6	0.0	221.8	319.9	401.6	453.3	497.0	465.2
2016	343.3	297.8	327.8	355.6	409.3	0.0	227.6	319.6	392.2	436.1	472.3	447.6
2020	358.7	314.4	343.8	370.6	421.2	0.0	243.9	335.7	405.2	446.0	478.6	455.6
2024	382.5	338.2	367.7	394.2	443.4	0.0	265.8	359.7	428.1	466.9	497.5	480.3
2028	404.4	360	389.3	416.3	464.5	0.0	286.0	381.5	449.6	486.7	514.5	507.3
2032	419.8	375.9	405.2	431.5	477.5	0.0	301.2	397.3	463.6	498.7	525.1	519.4
2036	431.4	388.4	417.4	442.1	485.7	0.0	314.1	409.5	472.4	505.6	529.4	529.7
2040	438.0	395.5	424.0	448.9	491.3	0.0	321.0	416.3	478.7	510.1	530.4	532.6




```
# Definition of the 40-10 rule
10 40
# 37) Calculate coefficients of variation (1=Yes)
0
# Number of replicates to use
10
# Random number seed
-99004
# File with multiple parameter vectors
rebuild.SSO
# User-specific projection (1=Yes); Output replaced (1->9)
1 6
# 42) Catches and Fs (Year; 1/2/3 (F or C or SPR); value); Final row is -1
2011 3 0.649
-1 -1 -1
# Fixed catch project (1=Yes); Output replaced (1->9); Approach (-1=Read in else 1-9)
0 2 -1
# Split of Fs
2009 0.0191475
-1 1
# 45) Yrs to define T_target for projection type 4 (a.k.a. 5 pre-specified inputs)
2011 2021 2028 2033 2040
# Eight years for probability of recovery
2012 2016 2020 2024 2028 2032 2036 2040
# Time varying weight-at-age (1=Yes;0=No)
0
# File with time series of weight-at-age data
none
# Use bisection (0) or linear interpolation (1)
1
# Target Depletion
0.4
# CV of implementation error
0
```

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Supplement

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Table 2 supplement. 2011 OY of 130 mt with continuation of the implied SPR of 0.818 .

	2011 OY of 130 mt
SPR (target)	0.818
50% Prob Yr	2018.0
OY (2011)	130.4
ABC (2011)	507.8
OY (2012)	131.4
ABC (2012)	511.9

Probability of Recovery by Year	
(See the '50% Prob Yr' row above for the year of 50% probability of recovery.)	
2012	0.0
2016	0.3
2020	81.0
2024	93.0
2028	96.7
2032	99.0
2036	99.7
2040	99.8

Table 2 supplement. cont.

	2011 OY of 130 mt
	<u>SSB / Target by Year</u>
2009	0.689
2010	0.748
2011	0.801
2012	0.856
2016	0.965
2020	1.040
2024	1.141
2028	1.256
2032	1.363
2036	1.448
2040	1.525
	<u>ABC by Year</u>
2009	483.5
2010	500.7
2011	507.8
2012	511.9
2016	538.5
2020	587.5
2024	649.1
2028	707.4
2032	754.1
2036	795.4
2040	818.4
	<u>OY (Annual Catch) by Year</u>
2009	285.0
2010	291.0
2011	130.4
2012	131.4
2016	138.2
2020	150.8
2024	166.6
2028	181.6
2032	193.6
2036	204.1
2040	210.1