

**Updated Rebuilding Analysis for Yelloweye Rockfish
Based on the Stock Assessment Update in 2007**

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by

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Introduction

The yelloweye rockfish (*Sebastes ruberrimus*) stock off the United States Pacific coast was declared to be in an “overfished” state in 2002 based on stock assessments by Wallace (2001) and Methot *et al.* (2002). Both assessments were length-based models and used an earlier version of the Stock Synthesis program (Methot 1990). The first assessment included data from two areas, California and Oregon (Wallace 2001). Washington catch and age data were incorporated by Methot *et al.* (2002) and the stock was treated as one single assemblage off the California, Oregon, and Washington (W-O-C) coast. Results from Methot *et al.* (2002) indicated that the stock was depleted at 24% of B_0 in 2002. A subsequent rebuilding analysis was conducted (Methot and Piner 2002) and the estimated rebuilding parameters were adopted by the Pacific Fishery Management Council in 2004 (PFMC 2004).

The stock assessment and rebuilding analysis were updated in 2005 (Wallace *et al.* 2005, Tsou and Wallace 2005). A full stock assessment was conducted the following year in order to incorporate new data sources and area-specific modeling in the assessment (Wallace *et al.* 2006). The rebuilding analysis was also updated (Tsou and Wallace, 2006) and the results were included in the revised rebuilding plan under Amendment 16-4 of the 2006 Pacific Coast Groundfish Fishery Management Plan (PFMC, 2006). The amendment re-evaluated and revised adopted rebuilding plans for seven depleted (overfished) groundfish species, including yelloweye rockfish, so that the rebuilding periods are as short as possible, taking into account the status and biology of the depleted species, the socioeconomic needs of West Coast fishing communities, and the interaction of the depleted species within the marine ecosystem.

The purpose of this document is to update the rebuilding analysis based on the most recent stock assessment update (Wallace 2007). The basic population estimates from previous assessments and rebuilding analyses as well as the 2007 assessment update are included in Table 1.

Summary of 2007 Updated Assessment

Landings, compositional data, and the catch per unit of effort (CPUE) time series were all updated through 2006 for the updated assessment. Some key issues identified in the update were: (1) correction of a technical error in the definition of age and length classes, (2) deleting Washington trawl-caught fish from hook-and-line age compositions, and (3) revising the natural mortality rate upwards from 0.036 to 0.043. The combination of these corrections led to an overall downward revision in the amount of spawning biomass and the level of depletion, relative to the 2006 assessment.

The update also considered the effect of including fishing trips that target halibut in the calculation of the Washington sport CPUE statistic, as well as the impact of dropping 2000 and 2001 from that particular time series. Neither of those two sensitivity analyses produced an appreciable effect on model outcome.

Rebuilding Calculations

Guidelines from John DeVore of the PFMC, (04 September 2007), and the SSC Default Rebuilding Analysis as implemented by Punt (September 2007, version 2.11) were used for these rebuilding calculations. The following steps were followed for this rebuilding analysis as requested by the Council:

- A. Define how virgin biomass (SB_0) is calculated.
- B. Define how future recruitment is generated.
- C. Recalculate rebuilding reference points from the most current assessment results
 - 1) Calculate the projected year in which the stock would rebuild with a 50% probability if all future fishing mortality was eliminated ($T_{F=0}$).
 - 2) Calculate the projected year for a 50% probability of rebuilding from the year in which the stock was first declared overfished (T_{MIN}).
 - 3) Calculate the mean generation time.
 - 4) Calculate the maximum allowable rebuilding time (T_{MAX}).
- D. Analysis of alternative harvest strategies for rebuilding.
- E. Results

A. Definition of SB_0

The equilibrium spawning biomass level (SB_0) used in this rebuilding analysis is calculated via the stock-recruitment relationship in order to be consistent with assessment model results. This level is estimated to be 3,062 mt in the base case assessment model ($M = 0.043$), which implies a rebuilding target ($SB_{40\%}$) of 1,225 mt (Table 1).

B. Generation of future recruitment

The parameters of the stock recruitment relationship (unexploited equilibrium recruitment [natural log of R_0], steepness [h], and the degree of recruitment variability [σ_r]) from the 2007 stock assessment update are used to generate future recruitments in the rebuilding analysis.

C. Recalculate reference points

The median year of recovery in the absence of future fishing, $T_{F=0}$, was calculated by not using the ramp-down strategy and having no fishing after 2009. The value for $T_{F=0}$ is 2049. The value for T_{MIN} , the median year for rebuilding to the target level in the absence of fishing since the year of declaration (2002) has not changed from 2046 given in Table 4-2 of Amendment 16-4 (PFMC 2006). The value for $T_{F=0}$ differs from T_{MIN} since the starting year of no fishing is seven years later.

The estimated mean generation time (MGT) decreased from 50 to 44 years resulting from a substantial increase in the rate of natural mortality used in the new model. The MGT is added to T_{MIN} to obtain an estimate of T_{MAX} , 2090. Since T_{MIN} did not change, this year is both the recalculated T_{MAX} (see guidelines under D-1 from J. DeVore) and the new T_{MAX} . All reference points from earlier rebuilding analyses and those recalculated here are summarized in Table 1.

D. Alternate harvest strategies for rebuilding

The yelloweye rockfish rebuilding plan specifies a harvest ramp-down strategy before resuming a constant harvest rate (SPR = 71.9%) in 2011 (Table 2a). The ramp-down strategy involves a declining Optimum Yield (OY) from 23 to 14 mt during the years 2007 to 2010 and was adopted by the PFMC in 2006 to mitigate impacts of the proposed OY reduction on small fishing entities. The ABC projections under the new rebuilding analysis are also shown in Table 2a. Table 2b shows similar information for the no ramp-down strategy.

E. Results

This rebuilding analysis presents a number of alternate harvest strategies. The alternatives are numbered as follows:

- 1) No fishing beginning in 2009
- 2) SPR = 0.8
- 3) The current rebuilding harvest rate target (SPR=0.719)
- 4) The harvest rate that achieves a 50% probability of recovery by T_{TARGET} from Amendment 16-4 (2084).
- 5) The harvest rate that achieves a 50% probability of recovery in the recalculated T_{MAX} (2090)
- 6) The harvest rate (SPR=0.595) which generates the 2007-08 OY's (under the ramp-down strategy).
- 7) The ABC harvest rate

Table 3a shows the new rebuilding parameters for the above scenarios. The SPR values for these scenarios range from 1.0 (no fishing) to 0.5 (the F_{MSY} proxy rate). In the former case, the median year to rebuild is 2049, however, in the latter case, rebuilding does not occur over any duration. Note that with the ramp-down strategy in place, when the SPR that produces the average 2007-08 OY is used, the median year to rebuild increases to 2181 which is not only greater than T_{TARGET} but T_{MAX} as well.

The median year to rebuild under the current harvest control rule of SPR fishing rate (71.9%) is 2082. Amendment 16-4's T_{Target} of 2084 gives a SPR of 71.2% and an OY of 14.4 mt in 2011. Alternative 5 shows the median year to rebuild of 2090. The OY for 2011 under this scenario is 15.6 mt and the fishing SPR is 69.3%. Solving for the SPR which gives the average OY for 2007 and 2008 (21.5 mt, under the ramp-down) gives a value of 59.5% and an OY of 23.1 in 2011.

Table 3b shows all the same scenarios without the ramp-down strategy. Note that the median times to rebuild do not change under the no ramp-down scenarios.

Figure 1 shows data from Table 3a graphically. It contours the percent probability of rebuilding for yelloweye by year and $1 - \text{SPR}$. If at least a 50% probability of rebuilding is desired then a position on or to the right of the 50% line is needed. Similarly, Figure 2 contours the OY's for the ramp-down strategy by year and $1 - \text{SPR}$.

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(http://www.pcouncil.org/bb/2007/0607/Groundfish_Assessments_E6/Yelloweye_Update_2007_Final.pdf)

Table 1. Summary of rebuilding reference points for yelloweye rockfish from the previous stock assessments and rebuilding analyses and recalculated values based on the current rebuilding analysis applied to the 2007 assessment results.

Parameter	Source		
	2002 Full Assmt./ Rebuilding Anlys. (2004 Rebuilding Plan)	2006 Full Assmt. / Rebuilding Anlys. (Amendment 16-4)	2007 Updated Assessment/ Rebuilding Analysis
B_0	3,875 mt	3,322 mt	3,062 mt
B_{MSY}	1,550 mt	1,328 mt	1,225 mt
Depletion $B_{CURRENT}/B_0$	24% (2002)	17.7%	16.4%
T_{MIN}	2027	2046	2046
T_{MAX}	2071	2096	2090
T_{TARGET}	2058	2084	2084*
$T_{F=0}$	-	2048	2049
Harvest Control Rule	$F=0.0153$	$SPR=71.9\%$	$SPR=71.9\%$

* New T_{TARGET} shown unchanged from 2006 since the old T_{TARGET} is less than current T_{MAX} . (J. DeVore, personal communication)

Table 2a. OY and ABC projections for the harvest ramp-down strategy adopted by the Council. Years 2007-2010 show the ramp-down. The SPR of 71.9% is the constant harvest rate beginning in 2011.

Year	OY (mt)	ABC (mt)	SPR	1 - SPR
2007	23	29.8	0.574	0.426
2008	20	30.5	0.617	0.383
2009	17	31.1	0.663	0.337
2010	14	31.8	0.713	0.287
2011	13.9	32.5	0.719	0.281
2012	14.2	33.1	0.719	0.281
2013	14.5	33.8	0.719	0.281
2014	14.7	34.4	0.719	0.281
2015	15.0	34.9	0.719	0.281
2016	15.2	35.5	0.719	0.281
2017	15.5	36.1	0.719	0.281
2018	15.7	36.6	0.719	0.281
2019	15.9	37.1	0.719	0.281
2020	16.1	37.6	0.719	0.281

Table 2b. OY and ABC projections for harvest with no ramp-down. The SPR of 71.9% is kept as the constant harvest rate beginning now in 2009.

Year	OY (mt)	ABC (mt)	SPR	1 - SPR
2007	23	29.8	0.574	0.426
2008	20	30.5	0.617	0.383
2009	13.3	31.1	0.719	0.281
2010	13.6	31.9	0.719	0.281
2011	13.9	32.6	0.719	0.281
2012	14.2	33.3	0.719	0.281
2013	14.5	33.9	0.719	0.281
2014	14.8	34.5	0.719	0.281
2015	15.0	35.1	0.719	0.281
2016	15.3	35.7	0.719	0.281
2017	15.5	36.3	0.719	0.281
2018	15.7	36.8	0.719	0.281
2019	16.0	37.3	0.719	0.281
2020	16.2	37.9	0.719	0.281

Table 3a. Rebuilding parameters for ramp-down scenarios from no fishing mortality to fishing at the ABC, found by applying the *Rebuilding Analysis* program to the 2007 assessment update data.

Alternative	1. No Fishing Beginning in 2009	2. SPR = 0.800	3. SPR = 0.719 (From Amendment 16-4)	4. SPR that produces 50% prob. Recovery by $T_{TARGET} =$ 2084	5. SPR produces 50% prob. Recovery by new T_{MAX} =2090	6. SPR that produces current ave. OY for 2007-08	7. ABC harvest rate SPR=50% (after ramp down)
Ramp-Down Used	No	Yes	Yes	Yes	Yes	Yes	Yes
SPR	1.000	0.800	0.719	0.712	0.693	0.595	0.5
1 - SPR	0.000	0.200	0.281	0.288	0.307	0.405	0.5
2011 OY/ABC (mt)	0.0/ 33.2	9.1/ 32.5	13.9/ 32.5	14.4/ 32.5	15.6/ 32.5	23.1/ 32.5	32.5/ 32.5
2012 OY/ABC (mt)	0.0/ 34.2	9.3/ 33.2	14.2/ 33.1	14.7/ 33.1	15.9/ 33.1	23.5/ 32.9	32.7/ 32.7
Median Year to Rebuild	2049	2066	2082	2084	2090	2181	NA
Percent Prob. to Rebuild by: 2046 (T_{MIN})	27.8	0.1	0.0	0.0	0.0	0.0	0.0
2050	63.0	1.2	0.0	0.0	0.0	0.0	0.0
2060	98.0	24.5	2.6	1.8	0.8	0.0	0.0
2070	100.0	67.0	17.7	14.2	7.90	0.0	0.0
2080	100.0	90.4	45.1	38.9	26.9	0.2	0.0
2084 (T_{TARGET})	100.0	95.2	54.9	49.9	36.6	0.5	0.0
2090 (T_{MAX})	100.0	97.8	68.9	64.4	50.0	0.9	0.0

Table 3b. Rebuilding parameters for the no ramp-down scenarios from no fishing mortality to fishing at the ABC.

Alternative	1. No Fishing Beginning in 2009	2. SPR = 0.800	3. SPR = 0.719 (From Amendment 16-4)	4. SPR that produces 50% prob. Recovery by $T_{TARGET} =$ 2084	5. SPR produces 50% prob. Recovery by new T_{MAX} =2090	6. SPR that produces current ave. OY for 2007-08	7. ABC harvest rate SPR=50% (after ramp down)
Ramp-Down Used	No	No	No	No	No	No	No
SPR	1.000	0.800	0.719	0.712	0.693	0.595	0.5
1 - SPR	0.000	0.200	0.281	0.288	0.307	0.405	0.5
2009 OY/ABC (mt)	0.0/ 33.2	8.7/ 31.1	13.3/ 31.1	13.8/ 31.1	15.0/ 30.5	22.1/ 31.1	31.1/ 31.1
2010 OY/ABC (mt)	0.0/ 34.2	9.0/ 32.0	13.6/ 33.8	14.1/ 31.9	15.3/ 31.1	22.5/ 31.7	31.5/ 31.5
Median Year to Rebuild	2049	2066	2082	2084	2090	2181	NA
Percent Prob. to Rebuild by: 2046 (T_{MIN})	27.8	0.1	0.0	0.0	0.0	0.0	0.0
2050	63.0	1.4	0.0	0.0	0.0	0.0	0.0
2060	98.0	26.2	2.7	1.8	0.8	0.0	0.0
2070	100.0	68.1	18.3	14.4	7.8	0.0	0.0
2080	100.0	91.1	45.7	38.9	26.9	0.2	0.0
2084 (T_{TARGET})	100.0	95.8	55.8	50.1	36.3	0.5	0.0
2090 (T_{MAX})	100.0	98.0	69.5	64.4	49.9	0.9	0.0

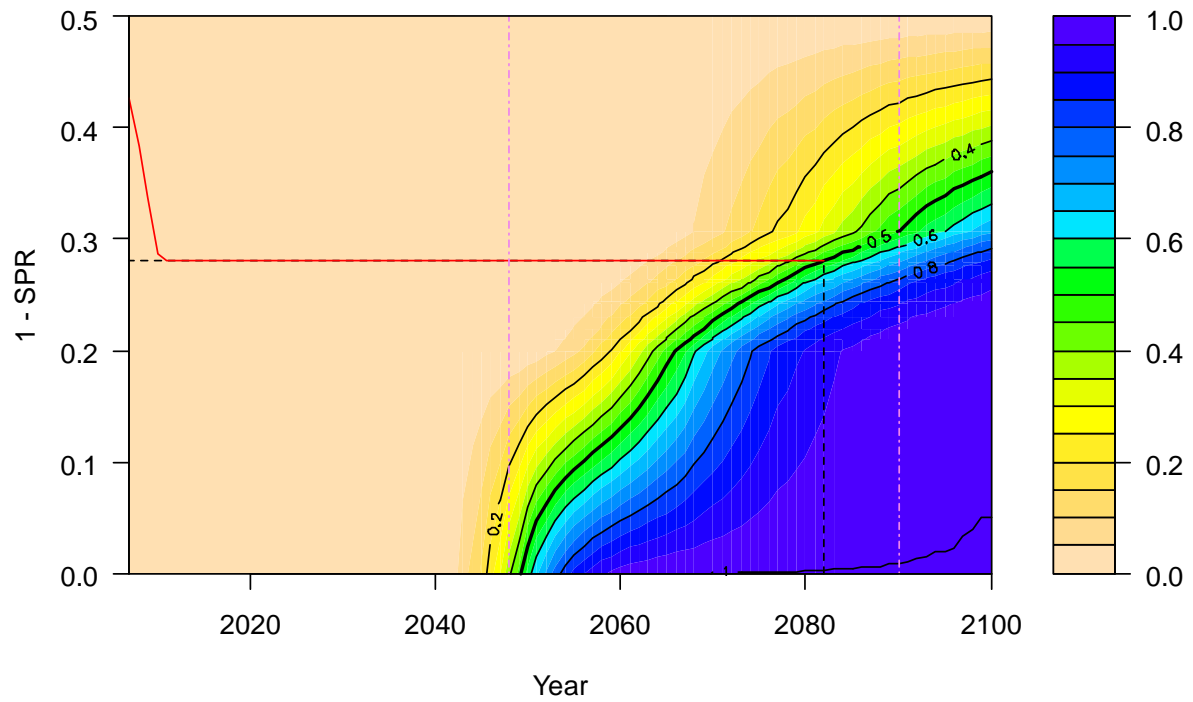


Figure 1. Estimated percent probability of rebuilding for yelloweye by year and $1 - \text{SPR}$. Fishing increases as $1 - \text{SPR}$ increases. The black dashed lines show a SPR of 71.9% intersecting with the 50% median year to rebuild of 2082. The solid red (mostly horizontal) line shows the ramp-down strategy. The violet dashed-dotted lines show the limits of T_{MIN} (2046) and the new T_{MAX} of 2090.

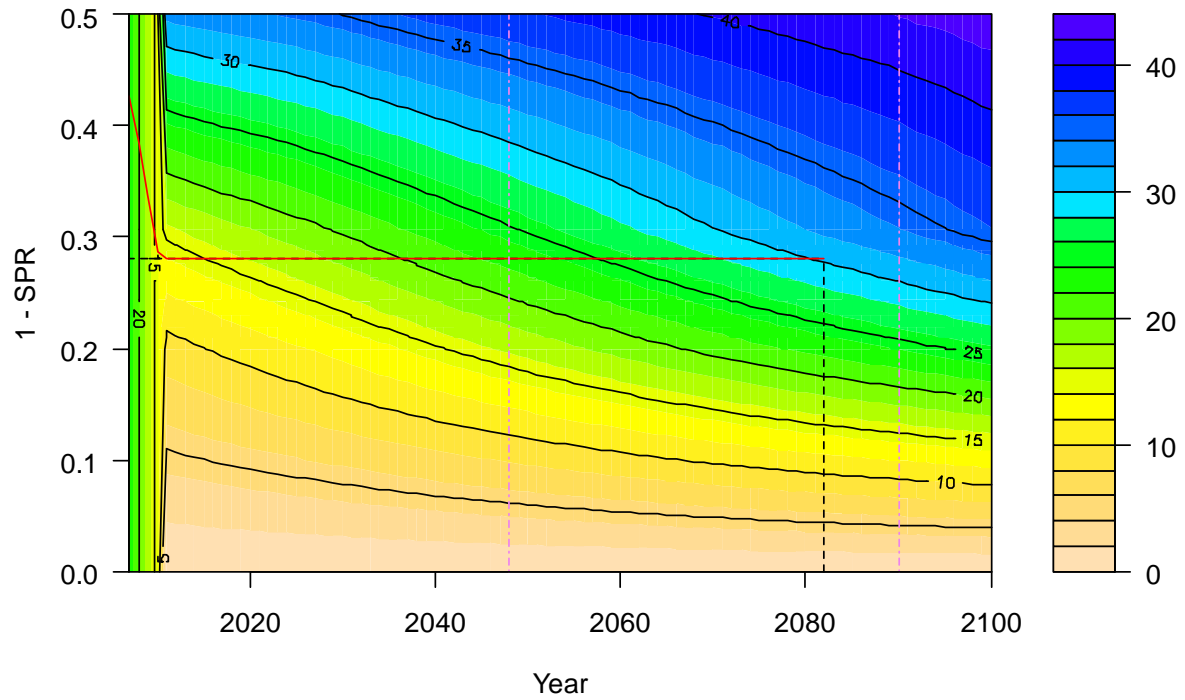


Figure 2. Estimated OY (with ramp-down) for yelloweye by year and $1 - \text{SPR}$. Fishing increases as $1 - \text{SPR}$ increases. The black dashed lines show a SPR of 71.9% intersecting with the 50% median year to rebuild of 2082. The solid red (mostly horizontal) line shows the ramp-down strategy. The violet dashed-dotted lines show the limits of T_{MIN} (2046) and the new T_{MAX} of 2090.