Rebuilding Analysis for Yelloweye Rockfish: Update to Incorporate Results of Coastwide Assessment in 2002

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Summary

The rebuilding analysis for yelloweye rockfish was first conducted in 2002 based upon the 2001 assessment (Wallace 2002). This document updates those results based upon the new assessment (Methot et.al. 2002) that incorporates data from Washington State and age data from all 3 states.

The target spawning stock biomass is 40% of the unfished stock biomass (Bzero). Current spawning stock abundance was estimated at 24% of Bzero in 2002.

The mean generation time of yelloweye rockfish is 44 years and the estimated year to be rebuilt in the absence of fishing is 2027. This is shorter than estimated in the previous assessment due to a less depleted stock status in the newest assessment and due to a lesser decline in recruitment as the spawning stock declines.

The rate of rebuilding is based upon the estimated spawner-recruitment relationship with a steepness of 0.437 and sigma R =0.4. The following table lists resulting OY estimates for different rebuilding strategies.

Pr rebuilt by tmax	Median time to rebuild	OY in 2003
50%	67yrs	27mt
60%	64yrs	26mt
70%	59yrs	25mt
80%	55yrs	24mt
50% Pr rebuilt by tmid	48yrs	22mt

Introduction

This rebuilding analysis is based upon the new assessment of the yelloweye rockfish stock conducted in 2002 (Methot et al. 2002). The 2001 assessment and this update use the length-based version of the Synthesis model (Methot, 2000) to analyze the data. Substantial changes in the assessment involve inclusion of age data from all three states, inclusion of the Washington catch and data in the model, and an evaluation of several alternatives for combining, or leaving separate, the information from the three states. Considerable uncertainty remains about the estimates of recruitment and virgin recruitment. The rate of rebuilding will be sensitive to the estimated steepness of the spawner-recruit relationship and the estimate of B40% is sensitive to the estimates of virgin recruitment.

The purpose of this document is to use results from the most recent assessment (Methot et al. 2002) to update estimates of the potential rate of rebuilding of yelloweye rockfish. The basic results of this assessment are summarized in the Assessment Summary below. Rebuilding analyses were carried out using the rebuilding program developed by Punt (2002).

Assesment Summary

Model description

Analyses in this assessment were developed using the length-based version of Stock Synthesis (Methot, 2000). Important differences in model configuration from Wallace (2001) include:

1. inclusion of Washington data:
2. inclusion of age composition data from all three states as available and update of size composition data
3. inclusion of mean length-at-age data from each data source to aid in the simultaneous estimation of growth parameters and size-selectivity
4. allowing all fishery sectors to have dome-shaped selectivity
5. including emphasis on the spawner-recruitment curve and estimating the curvature (steepness) of this curve.
6. Starting in 1955 rather than 1970 to better allow for potential long-term patterns in recruitment
7. estimates of the Washington sport CPUE was done by the delta method and sport CPUE based on RecFIN estimates was excluded
8. Washington, Oregon and California was considered to be one stock
9. Re-examining evidence for age-specific natural mortality and concluding that baseline model should have constant natural mortality.

Results of the assessment indicated that the stock was overfished (24% of Bzero) but was in better condition than previously estimated. This was due in part to the inclusion of Washington state data and age composition data. The coastwide time series of catch is

shown in Figure 1. Additional information regarding the assessment result is found in the assessment document.

Rebuilding Calculations

The level of recruitment has declined from 169 thousand fish in an unfished state to around 80 thousand fish after 1990. The mean level of recruitment is estimated to correspond to the size of the spawning population and should therefore rebuild as the parental stock increases.

Of key importance to rebuilding is the estimate of steepness of the S/R relationship. The estimate of S/R steepness was 0.437 and indicates relatively low stock productivity at small sizes. Meta-analysis indicates that rockfish typically have steepness around 0.7 (Myers 1999; Dorn 2000). A source of uncertainty in the steepness estimate is the unknown role of long-term trends in the ocean climate. Various studies have identified shifts in recruitment for other species (McFarlane et al, 2000) that correspond in timing to changes in the ocean climate, particularly near 1977 and 1989 (Mantua and Hare, 2002). From the yelloweye rockfish recruitment-spawner information it is not possible at this time to determine the degree to which the lower average recruitments during the 1990's are strictly due to long-term average spawner-recruitment steepness versus a period of climate-induced reduction in recruitment. Therefore, the steepness of 0.437 has a broad confidence range and it seems reasonable to use the range of 0.35 to 0.70 to bracket the uncertainty when conducting projections.

To impart year to year variability around the estimate of recruits, a lognormal variability (with a value of 0.4) around the S/R curve was used to generate future recruitment. This method is used in lieu of resampling year specific recruits or recruitment deviations. This seems like the most logical choice given that the estimates of year specific recruitment strength are based on very little data and probably not estimated well. The lognormal variability captures the scale of the observed recruitment variability without restricting the future values to the particular values estimated from the past. The sensitivity analysis compares the parametric S/R approach to a resampling of recruitments and to a resampling of recruits per spawner.

ABC, Overfishing and Fmsy

The Council's current policy for the calculation of an ABC is to apply an exploitation rate based on F50%. This would be 52 mt in 2003. For stocks below 40% of Bzero, a correction factor (40-10) is applied to reduce the OY linearly with spawning biomass. This would be in a 2003 limit of 42 mt. For stock below 25% of Bzero the harvest rate applied is that which would have a specified probability of at least 50% to rebuild the stock to 40% Bzero in no more than the time it would take the stock to rebuild in the absence of fishing plus one mean generation time (tmax). Those values along with the 2003 removal corresponding to Tmid are listed in Table 1. The probability distributions for time to rebuilding are shown in Figure 2. There is very little practical difference in 2003 catch over the various rebuilding strategies. The trade-off between short-term OY (corresponding to a constant harvest rate) and time to 50% probability of rebuilding is shown in Figure 3.

Table 1. The OY and median time to rebuild associated with different rebuilding strategies

Pr rebuilt by tmax	Median time to rebuild	OY
50%	67yrs	27mt
60%	64yrs	26mt
70%	59yrs	25mt
80%	55yrs	24mt
50% Pr rebuilt by tmid	48yrs	22mt

Additional rebujilding calculations (Table 2) were made using alternative methods in order to better understand the robustness of the baseline result presented above. The rebuilding runs at steepness levels of 0.35 and 0.70 started from assessment runs with these fixed steepness levels and not from the baseline run with steepness estimated at 0.437. The rebuilding runs based upon resampling of recruits or recruits per spawner used a range of years that corresponded to the time period in which the stock had fallen below the 50% biomass level. This is a small sample of years for such a non-parametric approach, but the results are basically similar to those from the parametric approach. The low steepness run (0.35) produces a result that is similar to the R/S resampling because both reproduce the low recruitments observed during the 1990's. These two pessimistic forecasts indicate that the status quo catch level (13 mt OY in 2002) would allow rebuilding with 80% probability even if the low steepness level prevails in the future.

Table 2. Sensitivity of rebuilding calculations to the level of S/R steepness and to alternative methods of generating future recruitment levels. The rebuilding runs at steepness levels of 0.35 and 0.70 started from assessment runs with these fixed steepness levels and not from the baseline run with steepness estimated at 0.437.

YELLOWEYE ROCKFISH REBUILDING RESULTS

Prob to rebuild by Tmax:	50%	60%	70%	80%	100%
	baseline; S/R steepness = 0.437				
Fishing Rate	0.0173	0.0167	0.0161	0.0153	0
2003 OY (mt)	27	26	25	24	0
Median Year to Rebuild	2070	2067	2062	2058	2026
	steep=0.35				
Fishing Rate	0.0108	0.0103	0.0097	0.0091	0
2003 OY (mt)	17	16	15	14	0
Median Year to Rebuild	2078	2074	2070	2065	2034
	steep=0.70				
Fishing Rate	0.0337	0.0328	0.0321	0.0312	0
2003 OY (mt)	59	57	56	54	0
Median Year to Rebuild	2060	2055	2052	2048	2016
	resamp R/S in 89-99				
Fishing Rate	0.0115	0.0112	0.0108	0.0104	0
2003 OY (mt)	18	18	17	16	0
Median Year to Rebuild	2076	2073	2070	2067	2032
	resamp R in 89-99				
Fishing Rate	0.0208	0.0200	0.0191	0.0180	0
2003 OY (mt)	33	31	30	28	0
Median Year to Rebuild	2066	2059	2054	2048	2022

Table 3. The age specific vectors of fecundity, mortality, weigh and selectivity used in the rebuilding analysis.

	fecundity at age	mortality at age	weight at age	selectivity at age	Init N at age
3	0.0002	0.045	0.2748	0.0155	84.4
4	0.0008	0.045	0.3578	0.0311	85.6
5	0.0026	0.045	0.4511	0.0559	51.8
6	0.008	0.045	0.5543	0.087	50.6
7	0.0213	0.045	0.6648	0.1273	55.6
8	0.0498	0.045	0.779	0.1677	74
9	0.1017	0.045	0.895	0.2112	63.7
10	0.1839	0.045	1.0123	0.2516	52.6
11	0.2992	0.045	1.1307	0.295	50.9
12	0.445	0.045	1.2504	0.3416	64.3
13	0.6149	0.045	1.371	0.3944	77
14	0.8004	0.045	1.4926	0.4534	92.8
15	0.9935	0.045	1.6149	0.5155	79.2
16	1.1878	0.045	1.7375	0.5776	77.1
17	1.3787	0.045	1.8603	0.6429	78.2
18	1.5633	0.045	1.9827	0.705	51.8
19	1.7408	0.045	2.1046	0.764	42.9
20	1.9104	0.045	2.2256	0.8168	44.1
21	2.0727	0.045	2.3449	0.8602	28.5
22	2.2278	0.045	2.4623	0.9006	21.3
23	2.3767	0.045	2.5772	0.9317	15.5
24	2.5195	0.045	2.6893	0.9565	15.1
25	2.6572	0.045	2.7983	0.9752	21
26	2.7898	0.045	2.9037	0.9876	21.1
27	2.9177	0.045	3.0054	0.9969	7.4
28	3.0415	0.045	3.1031	1	6.7
29	3.1611	0.045	3.1968	1	23.9
30	3.2767	0.045	3.2867	0.9938	8.6
31	3.3886	0.045	3.3723	0.9876	6.5
32	3.4967	0.045	3.4541	0.9814	8.7
33	3.6011	0.045	3.5321	0.9689	5.2
34	3.7022	0.045	3.6066	0.9565	3.5
35	3.7996	0.045	3.6774	0.9441	2.7
36	3.8937	0.045	3.7448	0.9286	2.1
37	3.9843	0.045	3.809	0.913	2
38	4.0717	0.045	3.8704	0.8975	2
39	4.1559	0.045	3.9288	0.882	1.9
40	4.2368	0.045	3.9845	0.8665	2.2
41	4.3146	0.045	4.0376	0.8509	2.9
42	4.3893	0.045	4.0883	0.8354	2.7
43	4.4611	0.045	4.1367	0.8199	2
44	4.53	0.045	4.1831	0.8043	1.7

45	4.596	0.045	4.2273	0.7919	1.6
46	4.6592	0.045	4.2695	0.7764	1.8
47	4.7197	0.045	4.3099	0.764	2.3
48	4.7775	0.045	4.3485	0.7516	2.8
49	4.8329	0.045	4.3855	0.7391	2.9
50	4.8858	0.045	4.4208	0.7267	2.4
51	4.9365	0.045	4.4548	0.7143	2.3
52	4.9848	0.045	4.4871	0.7019	2.3
53	5.0308	0.045	4.5181	0.6925	2.2
54	5.0748	0.045	4.5477	0.6832	2.2
55	5.1167	0.045	4.5761	0.6739	2.1
56	5.1567	0.045	4.6032	0.6646	2.1
57	5.1948	0.045	4.6292	0.6553	2
58	5.2311	0.045	4.654	0.646	2
59	5.2657	0.045	4.6778	0.6398	1.9
60	5.2986	0.045	4.7005	0.6304	1.9
61	5.33	0.045	4.7222	0.6242	1.8
62	5.3599	0.045	4.743	0.618	1.8
63	5.3886	0.045	4.763	0.6118	1.8
64	5.4156	0.045	4.782	0.6056	1.7
65	5.4414	0.045	4.8002	0.5994	1.7
66	5.466	0.045	4.8175	0.5932	1.6
67	5.4893	0.045	4.8341	0.587	1.6
68	5.5115	0.045	4.85	0.5839	1.5
69	5.5327	0.045	4.8651	0.5776	1.5
70	5.758	0.045	4.9912	0.5311	37.8

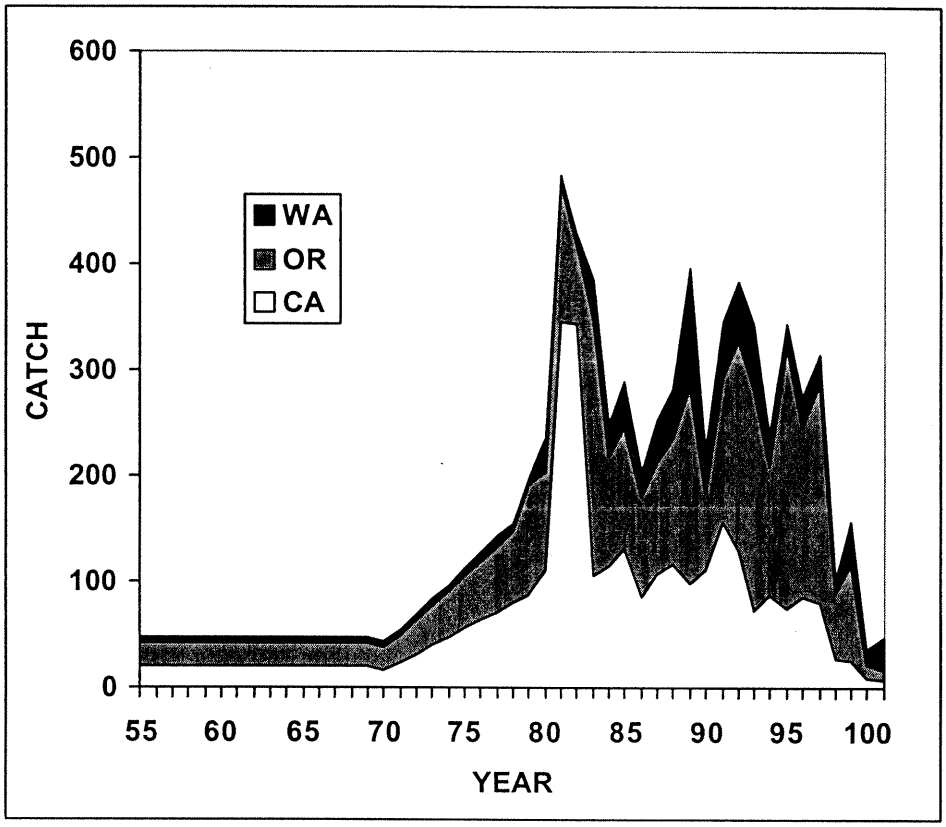

Figure 1. The time series of catch taken from each state from 1955-2001

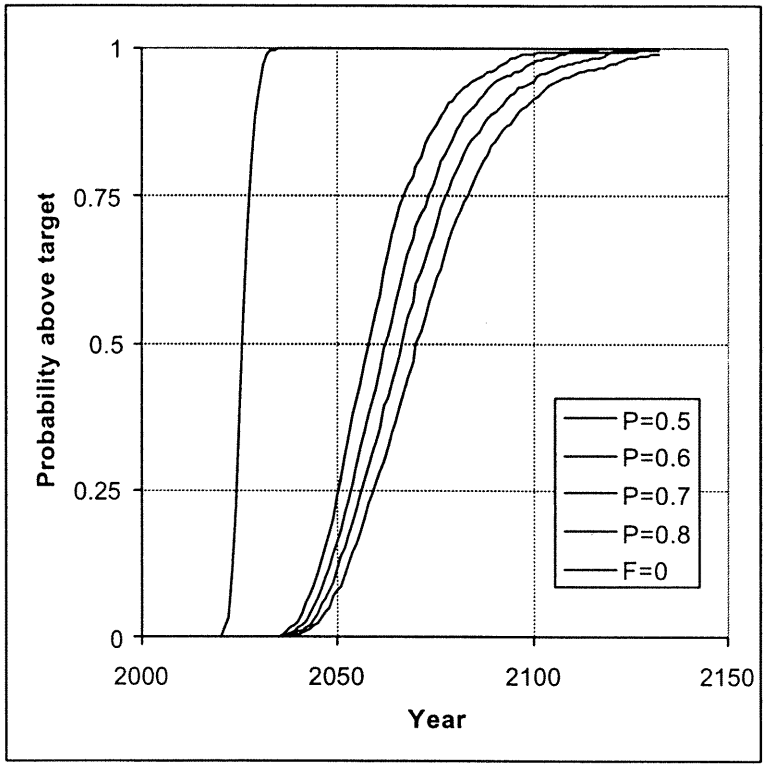

Figure 2. The probability of yelloweye rockfish being above B40% over time under different rebuilding strategies is given.

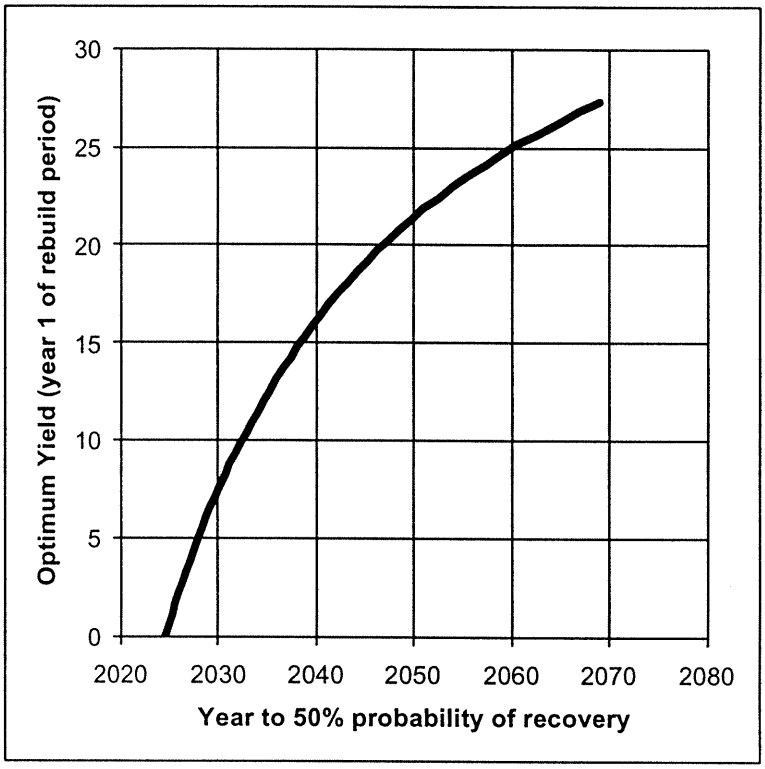

Figure 3. Relationship between short-term harvest level and the year to 50% probability of rebuilding.