Rebuilding Analysis for Yelloweye Rockfish

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Farron Wallace
Marine Science WDFW
48 Devonshire Road
Montesano, Wa 98563

Introduction

Two separate assessments corresponding to yelloweye rockfish (*Sebastes ruberrimus*) found in waters off the northern California coast (PFMC areas 1B and 1C) and from waters off the Oregon coast were prepared for the PFMC in 2001 (Wallace, 2001). An assessment model was not developed for Washington due to limited length and age composition time series. However, Washington catch data was appended to the Oregon model to provide management with necessary information needed to base coastwide management decisions. Based on these stock assessments, the Pacific Fishery Management Council declared yelloweye to be overfished (for all modeled areas) in 2002. This document provides rebuilding projections for northern California, Oregon and Oregon-Washington coastal areas.

Projections in this document were performed using software developed by Punt (2002 version 2.0) and results are based on 1,000 Monte Carlo replicates. Analysis and documentation conforms to the SSC Terms of Reference for Groundfish Rebuilding Analysis.

Data Input

The analyses use data outputs generated from the length-based Stock Synthesis program developed by Methot (2000) for combined sexes. For each area, input of age specific data for ages 3-70+ include: 1) spawning output (product of the weight-at-age and % mature vectors) 2) natural mortality 3) weight (mid-year) 4) selectivity and 5) numbers of fish for year 2000 for each area (Tables 1-3). Vectors of annual recruitment (age 3 fish) and spawning biomass estimates were input for years 1970-2000 (Tables 4-6). Population projections were configured to begin in 2000 (last year of estimated recruitment) and catches were specified for three years beginning in 2000. Table 7 summarizes catch estimates and Table 8 details data source.

Selection of rebuilding

Two scenarios for estimating B_0 and generating recruitment during rebuild were considered. These two scenarios provide an evaluation of alternate assumptions of 1) density-dependent versus 2) environmentally driven recruitment on the calculation of stock reference points. The level of recruitment for yelloweye rockfish is relatively low throughout the time period and infrequently above replacement (Figure 1-3). In scenario

1, B_0 is based on an early time series of relatively high spawner biomass (1970-1985) and recruits-per-spawner data from 1970-1996 were used to generate recruitment. This scenario is consistent with a density-dependent hypothesis where recruitment is largely driven by spawner biomass. In Scenario 2, B_0 is based on the full time series (1970-2000) and recruitment data from 1970-1996 were used to generate recruitment. This scenario assumes that recruitment level is largely dependent on environmental conditions. There were too few data on which to adequately estimate recruitment past 1996, so these data are not included in estimates of recruitment or recruits-per-spawner.

Since median time to rebuild with no fishing was beyond 10 years in each scenario, total rebuilding time (T_{max}) is calculated as the minimum time to rebuild + one mean generation time. Mean generation time is calculated as the mean age weighted by the net maturity function.

Scenario 1

Rebuilding projections generated from these data result in extremely long rebuilding periods with low levels of catch. Unfished population size is well below the overfished threshold of $0.25B_0$ in all areas. The northern California population size is estimated to be 8% of the unfished stock; Oregon and Oregon-Washington stock size is 15% of the unfished stock.

Mean generation time is calculated to be 28 years for the northern California stock and 32 years for the Oregon and Oregon-Washington stock. Median time to rebuild for the northern California stock is 252 years. This compares to a median rebuild time of 112 years for the Oregon stock, and a 120-year median rebuild period for the Oregon-Washington stock (Table 9).

Scenario 2

Rebuilding projections generated from these data are much more optimistic compared to scenario 1. As a result, rebuilding periods are relatively shorter and allow for higher levels of catch. Current population size is well below the overfished threshold of $0.25B_0$ in all areas. The northern California population size is estimated to be 12% of the unfished stock; Oregon and Oregon-Washington stock size is 16% of the unfished stock.

Mean generation time is the same as that estimated in scenario 1. Median time to rebuild for the northern California stock is 42 years. This compares to a median rebuild time of 46 years for the Oregon and 47 years for the Oregon-Washington stock (Table 9).

Alternative rebuilding policies

For each scenario, estimates of fishing mortality, optimal yield, probability of recovery and median time to rebuild were computed for five rebuilding strategies. Rebuilding alternatives include 1) 50% probability of rebuilding by (T_{max}), 2) 60% probability of rebuilding by (T_{max}), 3) 70% probability of rebuild by (T_{max}), 4) F =0 harvest policy and 5) 40:10 harvest policy.

Scenario 1

The probability of recovery employing a F=0 policy is 66%, 86% and 85% for the northern California, Oregon and Oregon-Washington areas respectively. Corresponding median rebuild times are 224, 80 and 89 years. Given a 60% probability of recovery and a harvest of 0.1, 1.3 and 1.4 (metric tons), median rebuild time is 235, 102 and 110 years for the northern California, Oregon and Oregon-Washington areas respectively. Table 10 summarizes management values computed for other alternative rebuilding policies and

Scenario 2

Median rebuild time of recovery for the F=0 policy is 13, 14 and 14 years for the northern California, Oregon and Oregon-Washington areas respectively. With a 60% probability of recovery and a harvest of 11.2, 25.3 and 30.1 (metric tons) median rebuild time is 36, 40 and 42 years for the northern California, Oregon and Oregon-Washington areas respectively. Table 10 summarizes management values computed for other alternative rebuilding policies.

Summary

The two recruitment scenarios result in substantially different rebuilding projections. The data are insufficient to completely dismiss either scenario at this time. The time series of recruitment data are extremely "noisy" and population projections are very imprecise.

Scenario 1 is consistent with the observation that recruitment has declined noticeably in the 1990's and recruits-per-spawner have not. The spawner-recruitment plots also indicate a somewhat linear relationship with 0-intercept (Figures 1-3). This provides strong evidence for supporting the density-dependent hypothesis. This model is most consistent with our current understanding of yelloweye population dynamics and represents the author's preferred model.

Conversely, rare large recruitment events every 10-15 years appear somewhat independent of stock size suggesting recruitment may be largely dependent on environmental conditions (Figures 1-3). The estimated rebuild time period in scenario 2, however may be underestimated and the fishing rate too aggressive. Future recruitment generated in scenario 2 does not adequately represent the recent low recruitment or the increasing recruitment as the stock rebuilds towards B_{40}. Scenario 2 is very optimistic in the short term because the recruits-per-spawner plots clearly show lower recruitment in recent years. Furthermore, unfished biomass estimates in scenario 2 (based on the entire time series) are lower than those derived in scenario 1 (based on the early time series). This is especially evident in the northern California model where unfished spawning biomass is 30% lower than that estimated in scenario 1 (Table 9) and is approximately half of the synthesis estimate.

Recruitment is likely driven by a combination of decreased abundance of spawners and changes in ocean conditions. Further investigation and information on this stock is needed to satisfactorily assess rebuilding for this species. There are currently two studies scheduled for 2002 that may give us additional insight regarding yelloweye abundance and life history. This includes enhanced rockfish data collection during the annual

International Pacific Halibut Commission halibut survey and submersible survey work in north coastal Washington waters. Until additional information is collected and analyzed it is difficult to establish a definitive time line to reassess this species. Parameterization of the selectivity function in the current assessment has been recently reviewed and alternate model configurations investigated. Results support current projections.

If yelloweye are not retained in the fisheries, our ability to collect biological information and conduct age-structured assessments for this species is extremely limited. Strong consideration should be given to maximizing the information from any minimal harvest that may occur.

References

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Methot R.D. 2000. Technical description of the stock synthesis program. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-43, 46p.

Wallace F.R. 2000. Status of the yelloweye rockfish resource in 2001 for northern California and Oregon waters. *In* Appendix to the Status of the Pacific Coast Groundfish Fishery Through 2001 and Recommended Acceptable Biological Catches for 2002 Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council 7700 NE Ambassador Pl, Ste. 200 Portland. Ore. 97220.

Table 1. Historical time series of spawning output, recruitment and yield for northern California.

Year	Biomass (mt) Total	Biomass (mt) Spawning	Recruits (3-year-old) 1,000's of fish	Exploitation	Total Yield
1970	2027	877	18	0.008	16.1
1971	2027	878	20	0.012	24.1
1972	1998	875	24	0.016	32.1
1973	1959	868	31	0.020	40.1
1974	1910	855	45	0.025	48.1
1975	1855	838	136	0.030	56.1
1976	1796	816	59	0.035	64.1
1977	1771	789	34	0.040	72.1
1978	1710	759	25	0.045	80.1
1979	1631	726	24	0.052	88.1
1980	1540	689	49	0.060	96.1
1981	1423	646	77	0.094	141.1
1982	1226	576	77	0.207	284.4
1983	1076	473	83	0.081	91.5
1984	1018	439	100	0.088	93.8
1985	959	406	34	0.109	110.2
1986	922	372	23	0.074	71.2
1987	865	351	30	0.112	102.5
1988	806	324	27	0.080	67.2
1989	752	307	16	0.121	96
1990	676	280	92	0.153	111.2
1991	568	245	18	0.238	152.1
1992	485	198	25	0.234	127.4
1993	420	164	15	0.132	58.7
1994	386	151	9	0.147	60.2
1995	350	137	14	0.141	52.5
1996	299	123	14	0.248	83.4
1997	236	98	6	0.293	79.7
1998	200	78	4	0.122	25.6
1999	187	74	4	0.099	19.3
2000	183	72	1	0.015	8.8

Table 2. Historical time series of spawning output, recruitment and yield for Oregon.

Year	Biomass (mt) Total	Biomass (mt) Spawning	Recruits (3-year-old) 1,000's of fish	Exploitation	Total Yield
1970	2692	1128	44	0.008	22.6
1971	2693	1129	49	0.009	25.6
1972	2675	1128	55	0.012	31.6
1973	2651	1125	65	0.014	37.6
1974	2622	1118	83	0.016	43.6
1975	2590	1108	132	0.019	49.6
1976	2559	1095	198	0.021	55.6
1977	2545	1079	72	0.024	61.6
1978	2559	1060	56	0.026	67.6
1979	2507	1036	46	0.040	103.8
1980	2438	1000	38	0.037	91.9
1981	2351	969	33	0.054	130.4
1982	2269	930	35	0.033	76
1983	2127	900	49	0.107	241.2
1984	1975	823	46	0.051	103.6
1985	1888	794	48	0.059	115.2
1986	1805	761	117	0.051	94.5
1987	1727	733	52	0.059	105.6
1988	1666	699	224	0.069	119.6
1989	1545	653	166	0.114	187.1
1990	1522	593	55	0.046	72.2
1991	1511	569	33	0.087	137.2
1992	1400	520	24	0.132	197.4
1993	1248	454	21	0.155	208.3
1994	1130	397	17	0.103	121.7
1995	986	362	12	0.224	246.9
1996	826	296	9	0.177	158.8
1997	676	255	8	0.268	207.2
1998	572	207	8	0.105	62.8
1999	515	198	9	0.166	92.5
2000	480	182	54	0.026	12.5

Table 3. Historical time series of spawning output, recruitment and yield for Oregon-Washington.

Year	Biomass (mt) Total	Biomass (mt) Spawning	Recruits (3-year-old) 1,000's of fish	Exploitation	Total Yield
1970	3428	1446	59	0.009	29.6
1971	3422	1444	65	0.009	32.6
1972	3396	1440	74	0.011	38.6
1973	3365	1434	86	0.013	44.6
1974	3330	1424	109	0.015	50.6
1975	3293	1411	165	0.017	57.1
1976	3259	1395	259	0.019	64
1977	3244	1375	92	0.022	72.9
1978	3271	1352	73	0.022	74.2
1979	3221	1326	60	0.033	109.8
1980	3139	1288	49	0.039	125.5
1981	3039	1246	44	0.044	138.2
1982	2953	1207	46	0.028	84.7
1983	2791	1175	65	0.096	281.4
1984	2608	1086	60	0.051	136.3
1985	2488	1047	63	0.063	161.3
1986	2374	1000	154	0.050	121.4
1987	2267	964	68	0.063	149.1
1988	2177	915	264	0.074	167.2
1989	1984	846	229	0.141	301.3
1990	1906	746	71	0.060	116.7
1991	1876	706	43	0.098	191.5
1992	1725	638	30	0.140	257.3
1993	1525	552	27	0.166	273.1
1994	1373	477	23	0.106	151.8
1995	1213	437	16	0.203	271.7
1996	1036	368	11	0.169	189.3
1997	865	322	11	0.242	235.8
1998	746	270	11	0.099	77.2
1999	666	258	12	0.184	133.8
2000	607	232	54	0.048	29.8

Table 4. Biological parameters used for the northern California rebuilding analysis.

AGE	Mean Weight	Percent Mature	Spawning Output	Natural Mortality	N-A-A 2000	Selectivity
3	0.321	0.018	0.006	0.040	0.6	0.199
4	0.410	0.046	0.018	0.040	4.2	0.259
5	0.509	0.095	0.046	0.040	3.4	0.329
6	0.618	0.164	0.097	0.040	4.4	0.405
7	0.734	0.250	0.176	0.040	9.3	0.482
8	0.856	0.344	0.284	0.040	8.1	0.555
9	0.983	0.439	0.418	0.040	4.6	0.623
10	1.115	0.529	0.572	0.040	6.6	0.683
11	1.250	0.610	0.742	0.040	8.9	0.735
12	1.387	0.681	0.922	0.040	5.2	0.780
13	1.526	0.742	1.105	0.042	21	0.817
14	1.665	0.791	1.290	0.044	2.9	0.848
15	1.804	0.832	1.473	0.045	4	0.874
16	1.943	0.866	1.652	0.047	3.6	0.895
17	2.081	0.892	1.826	0.049	2.2	0.913
18	2.218	0.914	1.995	0.051	2.6	0.927
19	2.352	0.931	2.158	0.052	6.4	0.939
20	2.484	0.944	2.314	0.054	4.4	0.948
21	2.614	0.955	2.465	0.056	3.3	0.956
22	2.741	0.963	2.610	0.058	2.7	0.963
23	2.864	0.970	2.749	0.060	1.4	0.968
24	2.985	0.976	2.883	0.061	0.6	0.972
25	3.102	0.980	3.011	0.063	0.5	0.976
26	3.216	0.983	3.135	0.065	0.6	0.979
27	3.326	0.986	3.253	0.067	0.9	0.982
28	3.433	0.989	3.367	0.068	1.7	0.984
29	3.536	0.990	3.477	0.070	0.5	0.986
30	3.636	0.992	3.582	0.072	0.3	0.987
31	3.732	0.993	3.682	0.074	0.2	0.989
32	3.824	0.994	3.779	0.075	0.1	0.990
33	3.913	0.995	3.871	0.077	0.1	0.991
34	3.999	0.996	3.960	0.079	0.4	0.992
35	4.081	0.996	4.045	0.081	0.3	0.992
36	4.160	0.997	4.127	0.083	0.3	0.993
37	4.235	0.997	4.205	0.084	0.3	0.994
38	4.308	0.997	4.279	0.086	0.2	0.994
39	4.377	0.998	4.350	0.088	0.2	0.994
40	4.444	0.998	4.418	0.090	0.2	0.995
41	4.507	0.998	4.483	0.091	0.2	0.995
42	4.568	0.998	4.546	0.093	0.2	0.995
43	4.626	0.999	4.605	0.095	0.1	0.996
44	4.682	0.999	4.662	0.097	0.1	0.996
45	4.735	0.999	4.716	0.098	0.1	0.996
46	4.785	0.999	4.767	0.100	0.1	0.996
47	4.833	0.999	4.816	0.102	0.1	0.997
48	4.879	0.999	4.863	0.104	0.1	0.997
49	4.923	0.999	4.908	0.105	0.1	0.997
50	4.965	0.999	4.950	0.107	0.1	0.997
51	5.005	0.999	4.991	0.109	0.1	0.997
52	5.042	0.999	5.030	0.111	0	0.997
53	5.078	0.999	5.066	0.113	0	0.997
54	5.113	0.999	5.101	0.114	0	0.997
55	5.145	0.999	5.134	0.116	0	0.997
56	5.176	0.999	5.166	0.118	0	0.998
57	5.206	1.000	5.196	0.120	0	0.998
58	5.234	1.000	5.224	0.121	0	0.998
59	5.261	1.000	5.251	0.123	0	0.998
60	5.286	1.000	5.277	0.125	0	0.998
61	5.310	1.000	5.302	0.127	0	0.998
62	5.333	1.000	5.325	0.128	0	0.998
63	5.355	1.000	5.347	0.130	0	0.998
64	5.375	1.000	5.368	0.132	0	0.998
65	5.395	1.000	5.388	0.134	0	0.998
66	5.414	1.000	5.407	0.136	0	0.998
67	5.431	1.000	5.425	0.137	0	0.998
68	5.448	1.000	5.442	0.139	0	0.998
69	5.464	1.000	5.458	0.141	0	0.998
70	5.542	1.000	5.540	0.143	0	0.998

Table 5. Biological parameters used for the Oregon rebuilding analysis.

AGE	Mean Weight	Percent Mature	Spawning Output	Natural Mortality	N-A-A 2000	Selectivity
3	0.308	0.002	0.001	0.040	54	0.137
4	0.387	0.005	0.002	0.040	8.9	0.176
5	0.481	0.013	0.006	0.040	7.3	0.245
6	0.585	0.032	0.018	0.040	6.6	0.336
7	0.697	0.067	0.045	0.040	6.5	0.432
8	0.816	0.124	0.097	0.040	8.1	0.522
9	0.941	0.202	0.184	0.040	10.4	0.601
10	1.070	0.297	0.308	0.040	11.2	0.670
11	1.203	0.399	0.466	0.040	10.9	0.729
12	1.338	0.499	0.651	0.040	12.9	0.780
13	1.475	0.591	0.852	0.041	18.2	0.822
14	1.613	0.672	1.060	0.042	45.2	0.856
15	1.752	0.739	1.269	0.043	50.3	0.884
16	1.890	0.794	1.473	0.044	9.6	0.907
17	2.028	0.838	1.671	0.045	17.8	0.925
18	2.164	0.873	1.859	0.046	6.1	0.940
19	2.299	0.900	2.038	0.047	4.8	0.951
20	2.432	0.921	2.208	0.048	4.3	0.960
21	2.562	0.937	2.370	0.049	2.6	0.968
22	2.689	0.950	2.523	0.050	2.1	0.973
23	2.814	0.959	2.670	0.051	2	0.978
24	2.935	0.967	2.810	0.052	2.1	0.982
25	3.054	0.973	2.943	0.053	2.2	0.984
26	3.169	0.978	3.071	0.054	2.5	0.987
27	3.280	0.982	3.193	0.055	6	0.989
28	3.388	0.985	3.310	0.056	3.5	0.990
29	3.493	0.987	3.422	0.057	2	0.992
30	3.594	0.989	3.529	0.058	1.4	0.993
31	3.691	0.991	3.632	0.059	1	0.994
32	3.785	0.992	3.731	0.060	0.8	0.994
33	3.875	0.993	3.826	0.061	0.7	0.995
34	3.962	0.994	3.917	0.062	1.1	0.996
35	4.046	0.995	4.003	0.063	1	0.996
36	4.126	0.995	4.087	0.064	0.9	0.996
37	4.203	0.996	4.166	0.065	0.8	0.997
38	4.277	0.996	4.242	0.066	0.8	0.997
39	4.347	0.997	4.315	0.067	0.7	0.997
40	4.415	0.997	4.385	0.068	0.6	0.998
41	4.480	0.997	4.451	0.069	0.6	0.998
42	4.542	0.997	4.515	0.070	0.5	0.998
43	4.601	0.998	4.576	0.071	0.5	0.998
44	4.658	0.998	4.634	0.072	0.5	0.998
45	4.712	0.998	4.689	0.073	0.4	0.998
46	4.763	0.998	4.742	0.074	0.4	0.998
47	4.812	0.998	4.792	0.075	0.4	0.999
48	4.859	0.998	4.840	0.076	0.3	0.999
49	4.904	0.999	4.885	0.077	0.3	0.999
50	4.947	0.999	4.929	0.078	0.3	0.999
51	4.987	0.999	4.971	0.079	0.3	0.999
52	5.026	0.999	5.010	0.080	0.2	0.999
53	5.063	0.999	5.048	0.081	0.2	0.999
54	5.098	0.999	5.083	0.082	0.2	0.999
55	5.131	0.999	5.117	0.083	0.2	0.999
56	5.163	0.999	5.150	0.084	0.2	0.999
57	5.193	0.999	5.180	0.085	0.1	0.999
58	5.222	0.999	5.210	0.086	0.1	0.999
59	5.249	0.999	5.237	0.087	0.1	0.999
60	5.275	0.999	5.264	0.088	0.1	0.999
61	5.300	0.999	5.289	0.088	0.1	0.999
62	5.323	0.999	5.313	0.089	0.1	0.999
63	5.345	0.999	5.335	0.090	0.1	0.999
64	5.366	0.999	5.357	0.091	0.1	0.999
65	5.386	0.999	5.377	0.092	0.1	0.999
66	5.406	0.999	5.397	0.093	0.1	0.999
67	5.424	0.999	5.415	0.094	0.1	0.999
68	5.441	0.999	5.433	0.095	0	0.999
69	5.457	0.999	5.449	0.096	0	0.999
70	5.558	0.999	5.554	0.097	0.4	0.999

Table 6. Biological parameters used for the Oregon-Washington rebuilding analysis.

AGE	Mean Weight	Percent Mature	Spawning Output	Natural Mortality	N-A-A 2000	Selectivity
3	0.308	0.002	0.001	0.040	54	0.136
4	0.387	0.005	0.002	0.040	11.3	0.175
5	0.481	0.013	0.006	0.040	9.4	0.243
6	0.585	0.032	0.018	0.040	8.4	0.333
7	0.697	0.067	0.045	0.040	8.3	0.429
8	0.816	0.124	0.097	0.040	10.3	0.518
9	0.941	0.202	0.184	0.040	13.2	0.598
10	1.070	0.297	0.308	0.040	14	0.667
11	1.203	0.399	0.466	0.040	13.6	0.726
12	1.338	0.499	0.651	0.040	16.2	0.777
13	1.475	0.591	0.852	0.041	22.9	0.819
14	1.613	0.672	1.060	0.042	61.6	0.854
15	1.752	0.739	1.269	0.043	58.8	0.882
16	1.890	0.794	1.473	0.044	12.5	0.906
17	2.028	0.838	1.671	0.045	23.6	0.924
18	2.164	0.873	1.859	0.046	7.9	0.939
19	2.299	0.900	2.038	0.047	6.3	0.950
20	2.432	0.921	2.208	0.048	5.7	0.959
21	2.562	0.937	2.370	0.049	3.4	0.967
22	2.689	0.950	2.523	0.050	2.7	0.973
23	2.814	0.959	2.670	0.051	2.6	0.977
24	2.935	0.967	2.810	0.052	2.7	0.981
25	3.054	0.973	2.943	0.053	2.9	0.984
26	3.169	0.978	3.071	0.054	3.2	0.987
27	3.280	0.982	3.193	0.055	7.9	0.989
28	3.388	0.985	3.310	0.056	4.4	0.990
29	3.493	0.987	3.422	0.057	2.6	0.991
30	3.594	0.989	3.529	0.058	1.8	0.993
31	3.691	0.991	3.632	0.059	1.4	0.994
32	3.785	0.992	3.731	0.060	1.1	0.994
33	3.875	0.993	3.826	0.061	0.9	0.995
34	3.962	0.994	3.917	0.062	1.4	0.995
35	4.046	0.995	4.003	0.063	1.2	0.996
36	4.126	0.995	4.087	0.064	1.1	0.996
37	4.203	0.996	4.166	0.065	1	0.997
38	4.277	0.996	4.242	0.066	1	0.997
39	4.347	0.997	4.315	0.067	0.9	0.997
40	4.415	0.997	4.385	0.068	0.8	0.997
41	4.480	0.997	4.451	0.069	0.7	0.998
42	4.542	0.997	4.515	0.070	0.7	0.998
43	4.601	0.998	4.576	0.071	0.6	0.998
44	4.658	0.998	4.634	0.072	0.6	0.998
45	4.712	0.998	4.689	0.073	0.5	0.998
46	4.763	0.998	4.742	0.074	0.5	0.998
47	4.812	0.998	4.792	0.075	0.5	0.998
48	4.859	0.998	4.840	0.076	0.4	0.999
49	4.904	0.999	4.885	0.077	0.4	0.999
50	4.947	0.999	4.929	0.078	0.4	0.999
51	4.987	0.999	4.971	0.079	0.3	0.999
52	5.026	0.999	5.010	0.080	0.3	0.999
53	5.063	0.999	5.048	0.081	0.3	0.999
54	5.098	0.999	5.083	0.082	0.2	0.999
55	5.131	0.999	5.117	0.083	0.2	0.999
56	5.163	0.999	5.150	0.084	0.2	0.999
57	5.193	0.999	5.180	0.085	0.2	0.999
58	5.222	0.999	5.210	0.086	0.2	0.999
59	5.249	0.999	5.237	0.087	0.2	0.999
60	5.275	0.999	5.264	0.088	0.1	0.999
61	5.300	0.999	5.289	0.088	0.1	0.999
62	5.323	0.999	5.313	0.089	0.1	0.999
63	5.345	0.999	5.335	0.090	0.1	0.999
64	5.366	0.999	5.357	0.091	0.1	0.999
65	5.386	0.999	5.377	0.092	0.1	0.999
66	5.406	0.999	5.397	0.093	0.1	0.999
67	5.424	0.999	5.415	0.094	0.1	0.999
68	5.441	0.999	5.433	0.095	0.1	0.999
69	5.457	0.999	5.449	0.096	0.1	0.999
70	5.559	0.999	5.556	0.097	0.5	0.999

Table 7. Catch estimates for northern California, Oregon and Oregon-Washington coastal waters.

Catch Estimates input to Rebuilding Model

Year	Recreational	Commercial	Total
Northern California			
2000	8.0	0.8	8.8
2001	5.1	2.8	7.9
2002	0.9	0.0	0.9
Oregon			
2000	8.2	4.3	12.5
2001	2.0	6.8	8.8
2002	3.8	0.0	3.8
Oregon-Washington			
2000	25.3	4.5	29.8
2001	12.5	0.8	13.3
2002	8.1	0.0	8.1

Table 8. Data source for estimated catches input into rebuilding model.

Catch Data Source

Year	Recreational	Commercial
Northern California		
2000	MRFSS[1]	PacFIN
2001	MRFSS	PacFIN
2002	Set to Council/GMT allocation proposal.	
Oregon		
2000	ODFW	PacFIN
2001	MRFSS	PacFIN
2002	Set to Council/GMT allocation proposal.	
Oregon-Washington		
2000	ODFW+WDFW	PacFIN
2001	MRFSS+WDFW	PacFIN
2002	Set to Council/GMT allocation proposal.	

[1] *Recently updated MRFSS estimate (5-6-02).*

Table 9. Comparison of management reference points between Scenario 1 and Scenario 2.

	Northern California		Oregon		Oregon-Washington	
Outputs	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**
FMSY proxy	0.042	0.042	0.037	0.037	0.034	0.034
FMSY SPR / SPR(F=0)	0.5	0.5	0.5	0.5	0.5	0.5
Virgin SPR	16.5	16.5	18.7	18.7	18.7	18.7
Generation time	28	28	32	32	32	32
Minimum Rebuild Time	225	15	81	15	89	16
Maximum Rebuild Time	252	42	112	46	120	47
Selected rebuild time	252	42	112	46	120	47
Year for rebuild	2255	2045	2115	2049	2123	2050
Virgin Spawning Output	860	602	1223	1119	1596	1440
Target Spawning Output	344	241	489	448	638	576
Current Spawning Output	72.4	72.4	184.6	184.6	236.1	236.1
B/B_0	0.08	0.12	0.15	0.16	0.15	0.16

Table 10. Estimates of fishing mortality, optimal yield, probability of recovery and median time to rebuild for six rebuilding strategies.

Northern California

Scenario 1						
Fishing rate	0.0009	0.0004	0	0	0	0
OY_{2003} (mt)	0.1	0.1	0	0	0	0
Prob of recovery by 2255	50.1	60	65.6	65.6	65.7	0
Median time to rebuild	251.8	234.5	224.3	224.3	224.2	na
Scenario 2						
Fishing rate	0.0708	0.0679	0.0643	0.0605	0	0
OY_{2003} (mt)	11.7	11.2	10.6	10	0	0.7
Prob of recovery by 2045	49.9	60	70	80	100	100
Median time to rebuild	42.1	36.1	31.9	28.5	13.3	16.1

Oregon

Scenario 1						
Fishing rate	0.0039	0.0029	0.0019	0.0008	0	0
OY_{2003} (mt)	1.7	1.3	0.8	0.4	0	0
Prob of recovery by 2115	50	60	70	80.1	85.9	0
Median time to rebuild	112	101.5	93.7	85.3	80	na
Scenario 2						
Fishing rate	0.0605	0.0577	0.055	0.0514	0	0
OY_{2003} (mt)	26.5	25.3	24.2	22.6	0	4.7
Prob of recovery by 2049	49.9	60.1	69.9	80.1	100	99.9
Median time to rebuild	46	40	35.1	30.9	13.7	18

Oregon and Washington

Scenario 1						
Fishing rate	0.0033	0.0025	0.0016	0.0006	0	0
OY_{2003} (mt)	1.8	1.4	0.9	0.3	0	0
Prob of recovery by 2123	49.9	60.1	70	80	85	0
Median time to rebuild	120.1	110.2	101.3	93.6	88.9	na
Scenario 2						
Fishing rate	0.0562	0.0539	0.0511	0.0481	0	0
OY_{2003} (mt)	31.4	30.1	28.6	26.9	0	4.9
Prob of recovery by 2050	49.9	60.1	69.9	80.1	100	99.9
Median time to rebuild	47.1	41.5	36.1	31.9	14.2	18.3

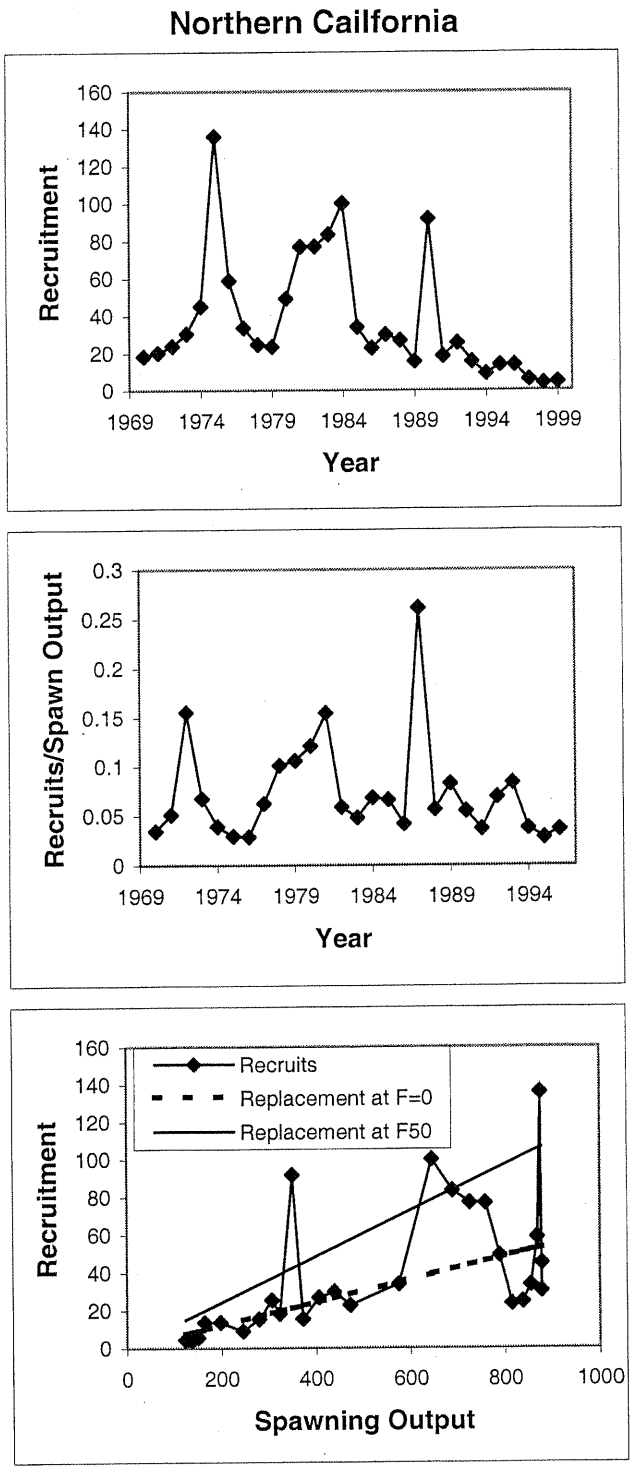

Figure 1. Time series of recruitment for yelloweye rockfish in northern California waters.

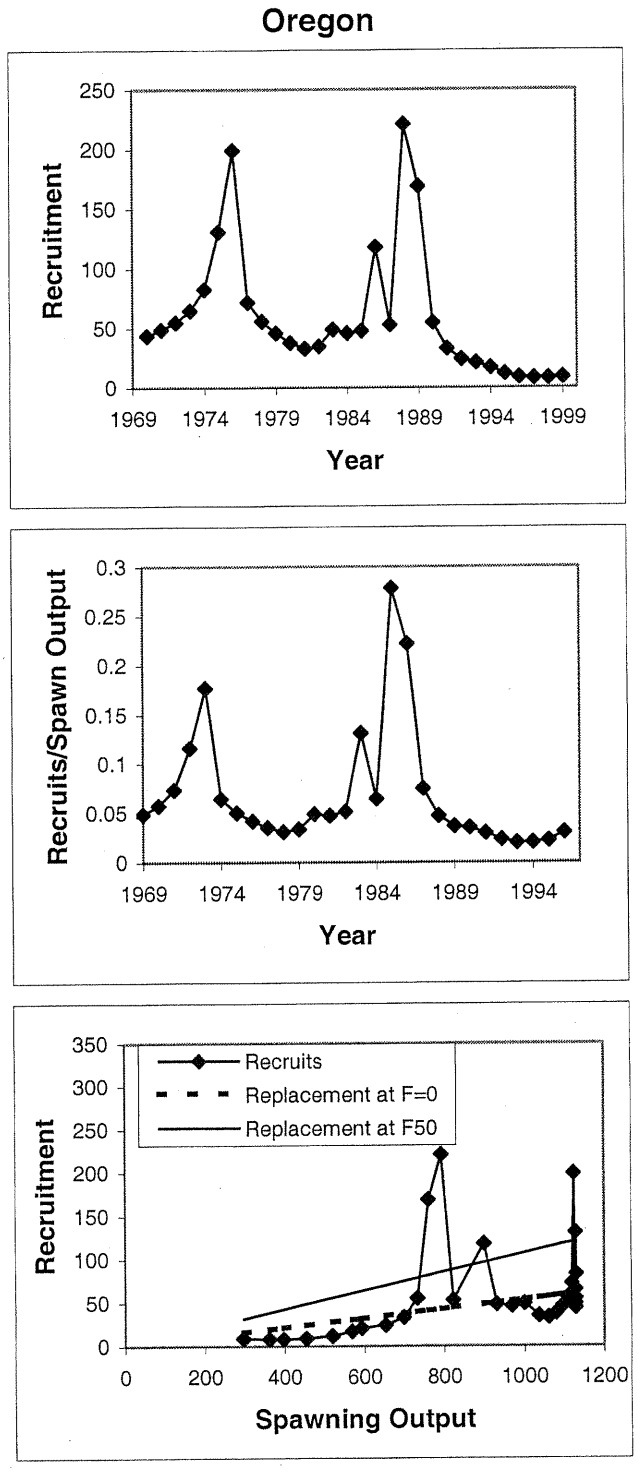

Figure 2. Time series of recruitment for yelloweye rockfish in Oregon waters.

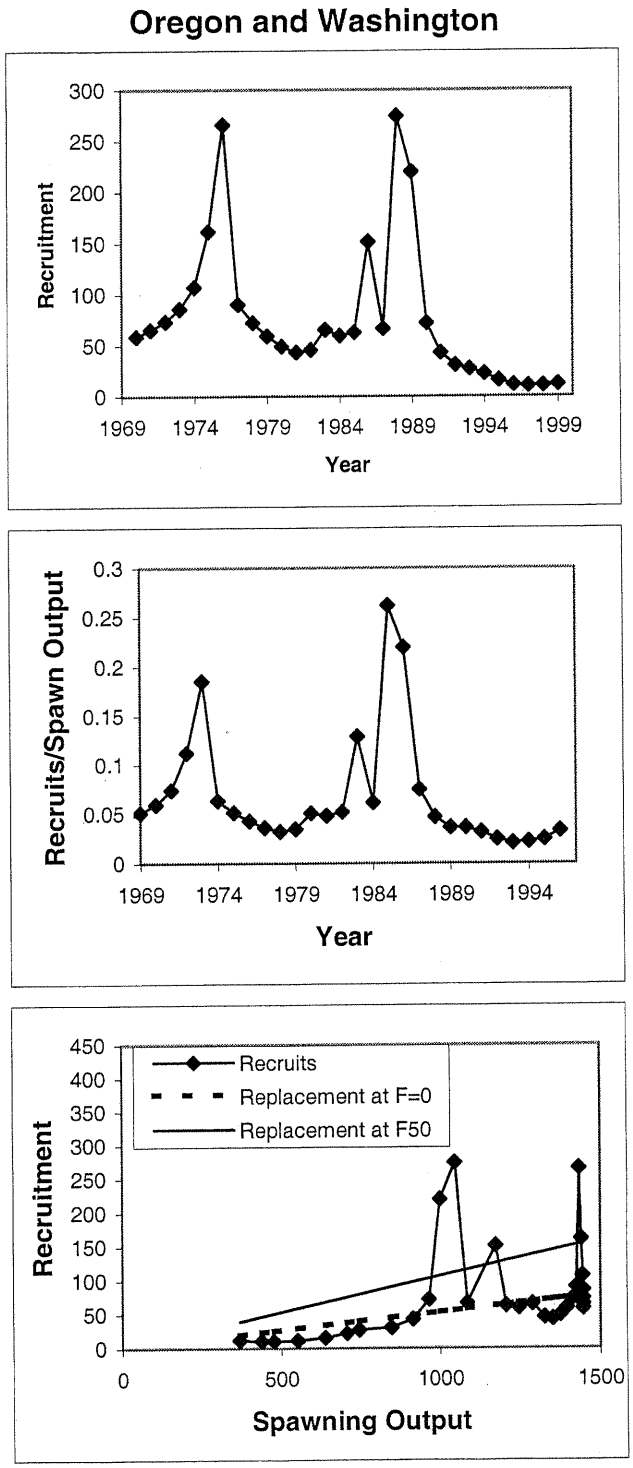

Figure 3. Time series of recruitment for yelloweye rockfish in Oregon and coastal Washington waters.