Revised Rebuilding Analysis for Widow Rockfish for 2002

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Introduction

The Pacific Fishery Management Council (PFMC) adopted Amendment 11 to its Groundfish Management Plan in 1998. This amendment established an overfishing definition of 25% of the unfished biomass ($0.25B_0$). NMFS determined that a rebuilding plan was required for widow rockfish (*Sebastes entomelas*) in January 2001 based on the most recent stock assessment at that time (Williams *et al.* 2000). One aspect of a rebuilding plan is a rebuilding analysis to contrast alternative levels of fishing mortality and catch in terms of the probability of recovery to the B_{MSY} proxy of $0.4B_0$. The Scientific and Statistical Committee of the PFMC developed a set of guidelines for conducting rebuilding analyses, and the analyses of this document are based on those guidelines.

This document provides an update to the rebuilding analysis conducted by MacCall and Punt (2001) following the discovery of a minor error in the projection phase of the calculations. In addition to simply updating the calculations of MacCall and Punt (2001) to correct this minor error, this document also provides alternative rebuilding analyses that make use of the most recent information on catches since 1999. In general, the analyses of this paper are based on the same input parameters as those of MacCall and Punt (2001). The information on stock and recruitment and the age-structure of the population at the start of 1999 are taken from the assessment by Williams *et al.* (2000). The life history parameters are, consistent with the selections made by MacCall and Punt (2001), a simplification of the two-area, two-sex model with time-varying selectivity used in the assessment.

The calculations of this document were performed using the rebuilding software developed by Punt (2002a) and the results are based on 1000 Monte Carlo replicates (see below for the reason for this selection). The definition of "recovery by year y" in this document is that the spawning output reaches $0.4B_0$ by year y (even if it subsequently drops below this level again due to recruitment variability). The input to the rebuilding program for the 'preferred' rebuilding analysis is given as Appendix 1.

Selection of the rebuilding period

The maximum allowable rebuild period is defined as ten years (if the resource can be rebuilt to $0.4B_0$ in ten years or less) or the minimum possible rebuild period (rebuilding period in the absence of fishing mortality) plus one mean generation if the resource cannot be rebuilt to $0.4B_0$ in ten years. In order to determine the maximum allowable rebuild period, it is therefore necessary *inter alia* to define B_0, how future recruitments are to be generated, and the mean generation time. The mean generation time, 16 years, is calculated from the net maternity function (product of survivorship and fecundity at age,

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left panel of Figure 1) and rounding down to the nearest integer. MacCall and Punt (2001) based their estimate of B_0 (41872 million eggs) on the mean recruitment from 1965-79 and generated future recruitment by resampling recruits-per-spawning output ratios with replacement from those for the years 1983-96 (see the right panel of Figure 1). In the absence of new assessment data, there seems no good reason to change the approaches used to define B_0 and to generate future recruitment.

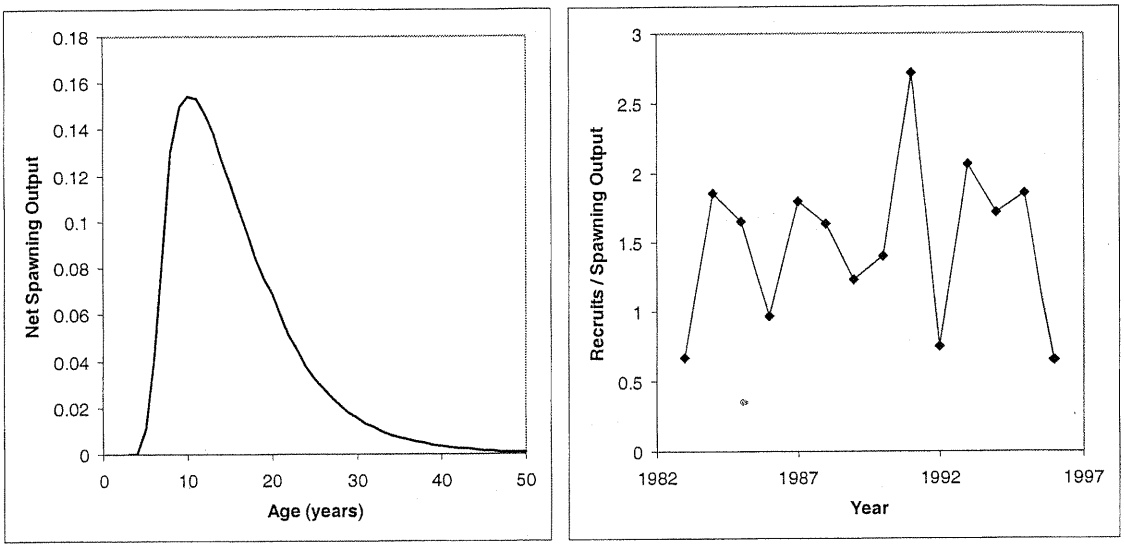

Figure 1. Net spawning output versus age (left panel) and the recruits-per-spawning output ratios used when generating future recruitment (right panel).

Catch data since 1999

The rebuilding analyses of MacCall and Punt (2001) were based on total catches (landed and discarded components) for 1999-2001 of 4363t, 4033t, and 2300t respectively. These catches have since been revised (Jim Hastie, NWFSC, pers. comm.) to 4894t, 4762t, and 2501t for 1999-2001. The 2002 OY selected by the PFMC was 856t.

The alternative rebuilding analyses

Even given the desire to make the same selections as MacCall and Punt (2001), a number of options exist concerning a revised rebuilding analysis.

- Should the revised catches be used in place of the catches on which the analyses of MacCall and Punt (2001) were based?
- Should the analyses assume that the 2002 catch will equal the 2002 OY already selected by the PFMC?
- Should the maximum allowable recovery period, T_{max}, be recalculated (this may be different from the 38 years (i.e. recovery by 2040) calculated by MacCall and Punt (2001)), given the revised catches and the selection of the 2002 OY?

Eight rebuilding analyses were considered based on all combinations of each of the three factors listed above (1999-2001 catches, 2002 catch, fix vs. estimate T_{max}; Table 1) to investigate the sensitivity of the results to these options. Cases 1 and 5 allow comparisons

to made with the previous rebuilding analysis of MacCall and Punt (2001), while cases 2 and 4 (and 6 and 8) permit the impact of the recent catches on the outcomes from the rebuilding analysis to be assessed.

Table 1. The specifications for the eight rebuilding analyses.

Case No	Catch series	2002 Catch	T_{max}
1	Original	Estimated	Re-estimated
2	Revised	Estimated	Re-estimated
3	Original	856 t	Re-estimated
4	Revised	856 t	Re-estimated
5	Original	Estimated	Fixed at 38 yrs
6	Revised	Estimated	Fixed at 38 yrs
7	Original	856 t	Fixed at 38 yrs
8	Revised	856 t	Fixed at 38 yrs

It is necessary to specify the number of Monte Carlo replicates to apply the rebuilding software. The rebuilding software was therefore run to calculate the coefficients of variation for the 2002 OYs (by replicating the process of conducting a rebuilding analysis 20 times). Figure 2 shows the trend in these coefficients of variation with the number of Monte Carlo replicates, as well as how the range for the 2002 OY changes with this number. Results are shown in Figure 2 for the rebuilding analysis closest to that conducted by MacCall and Punt (2002) [case 1] as well as that which uses all of the most recent information on catches and fixes T_{max} to the value already selected by the PFMC [case 8]. Figure 2 suggests that conducting 1000 Monte Carlo replicates should lead to estimates with sufficient precision, and that increasing this number has relatively little benefit in terms of precision. Punt (2002b) can be consulted for more details concerning the impacts of Monte Carlo uncertainty when conducting rebuilding analyses.

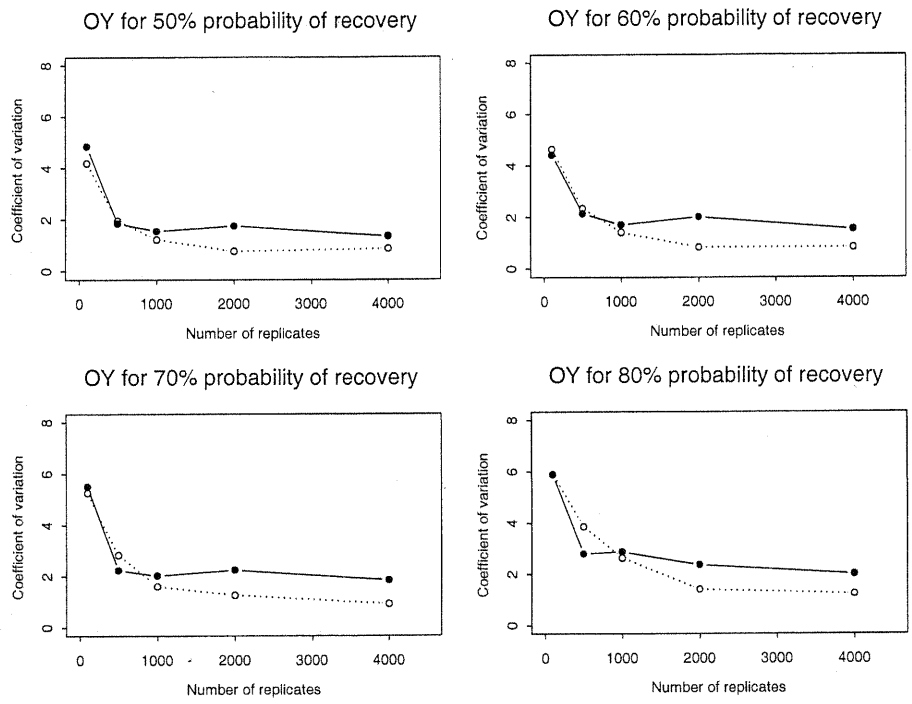

Figure 2(a). Coefficient of variation (%) for the 2002 OY (2003 OY for case 8) versus number of Monte Carlo replicates. Results are shown for case 1 (solid lines) and case 8 (dotted lines).

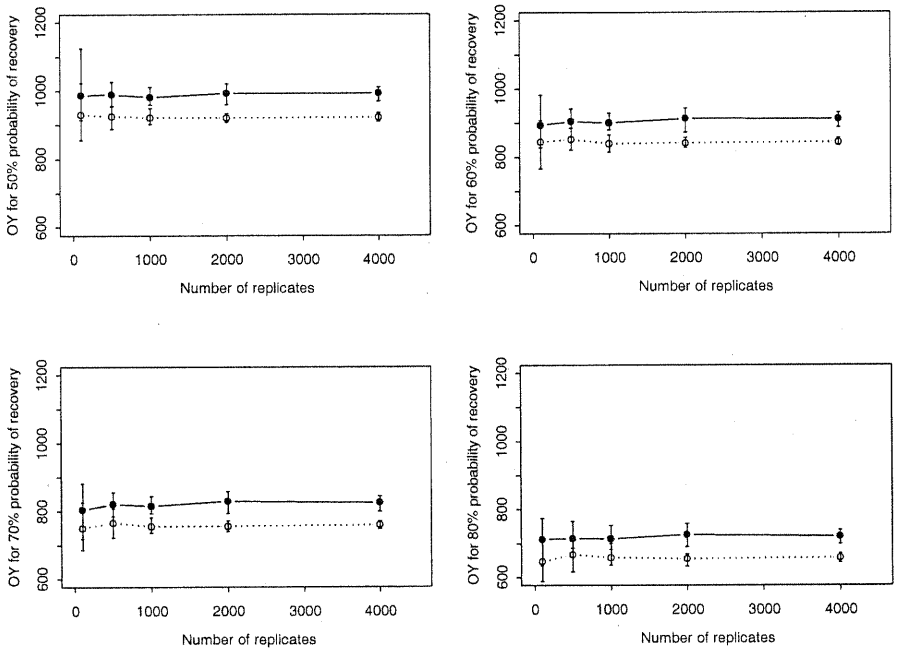

Figure 2(b). Mean and range for the 2002 OY (2003 OY for case 8) from 20 replications of the rebuilding analysis program versus the number of Monte Carlo replicates. Results are shown for case 1 (solid lines) and case 8 (dotted lines).

Results and discussion

Alternative rebuilding analyses

Table 2 lists the 2002 and 2003 OYs and the year by which recovery is expected to occur with the indicated probability, for the eight cases defined in Table 1. The 2002 OY for cases 3, 4, 7, and 8 is fixed at 856t, as this is one of the specifications for these cases. The 2002 OY selected by the PFMC was based on a 60% probability of recovery by 2040 so the discussion of Table 2 focuses on the OYs for 2003 for a 60% probability of recovery within the maximum allowable rebuild period, T_{max}. The 2003 OYs in Table 2 range from 903t (cases 3 and 7) to 832 t (case 8). Taking case 1 as a baseline, the 2003 OY for case 2 is lower than that for case 1 because the catches for 1999-2001 on which case 2 is based are larger (see above). In contrast, the 2003 OY for case 3 is larger than that for case 1 because the catch for 2002 for case 3 (856t) is less than that for case 1 (880t). Case 4 reflects the combination of the factors examined in cases 2 and 3, and consequently leads to a 2003 OY that is intermediate between those for cases 2 and 3. Fixing T_{max} to 38 (i.e. recovery to occur in 2040 with the pre-specified probability) leads to a lower 2003 OY for case 8 and a higher 2003 OY for case 5. This is because T_{max} for the corresponding cases that calculate T_{max} (cases 4 and 1) are one year greater and fewer than those for cases 8 and 5. The situation for case 4 is worth considering further. The value of T_{max} is higher for this case than for cases 1 and 2 because the population assessed to be more depleted at the start of 2003 given the higher catches for 1999-2000. It consequently takes longer to recover to $0.4B_0$ in the absence of catches.

Table 2. 2002 and 2003 OYs and the year by which recovery is expected to occur with the indicated probability, for the eight cases. Note that the value in the 2002 column for cases 3, 4, 7 and 8 is fixed at 856t.

Case	Catch Series	T_{max}	2002 OY				2003 OY			
			50%	60%	70%	80%	50%	60%	70%	80%
1	Original	Est=2039	965	880	794	687	952	870	787	682
2	Revised	Est=2040	921	839	758	666	913	833	755	665
3	Original	Est=2040	*856*	*856*	*856*	*856*	991	903	819	723
4	Revised	Est=2041	*856*	*856*	*856*	*856*	945	873	788	686
5	Original	2040	997	911	828	735	983	900	820	729
6	Revised	2040	921	839	758	666	913	833	755	665
7	Original	2040	*856*	*856*	*856*	*856*	991	903	819	723
8	Revised	2040	*856*	*856*	*856*	*856*	916	832	750	656

It is perhaps noteworthy that the 2002 OY for case 2 is lower than 856t. Therefore, the "benefit" of the revised rebuilding analysis evident from case 1 (a 2002 OY of 880t compared with 856t from the previous rebuilding analysis) is more than offset by the revisions to the catches for 1999-2001.

Detailed outputs for a preferred alternative

Choosing a preferred case involves selecting catches for 1999-2001, specifying how the 2002 catch will be determined, and deciding how to determine T_{max}. Guided by the need

to base decisions on the 'best' and most recent data, we believe that the focus should be on cases 4 and 8 as they use the most recent information on catches. The choice between these two cases is a policy decision. We concentrate here on case 8 because this paper reflects changes to the data on which the rebuilding analysis is based, not on policy decisions. For similar reasons, we focus on a 60% probability of recovery by 2040. It should be noted that allowing T_{max} to change given the new information on catches (i.e. case 4) implies *inter alia* that it is acceptable to increase the (agreed) maximum time to recovery because the estimates of historical removals were previously under-estimated.

Table 3 lists some key output statistics for five rebuild strategies (probabilities of recovery in the maximum allowable rebuild period of 50%, 60%, 70% and 80% and the strategy of setting future fishing mortality to zero). The probabilities of recovery are not exactly 50, 60, etc. because of the limited number of recruitments on which the projections are based and the accuracy of the numerical search procedure employed. Figure 3 contrasts the time-trajectory of the probability of recovery for each of the five rebuild strategies in Table 3 along with the envelopes (5%, 25%, 50%, 75% and 95%) of the time-trajectories for catch and the ratio of spawning output to $0.4B_0$ for a 60% rebuild probability. Appendix 2 lists the envelopes for the annual catch and the ratio of the spawning output to the target level for a 60% probability of rebuild. Note that this ratio is calculated each point in time – the probability of having reached $0.4B_0$ sometime before a given year is at least as great as that listed in Appendix 2 and shown in the right panel of Figure 3 for that year. Appendix 3 lists the median catches for rebuild probabilities of 50%, 60%, 70%, and 80% as well as for the 40:10 rule.

Table 3. Four management-related quantities for five rebuild strategies.

Fishing mortality rate	0.0298	0.0271	0.0244	0.0213	0
OY_{2003} (mt)	916	832	750	656	0
Probability of recovery by 2040	50.1	60.1	69.9	80.1	99.8
Median years to rebuild from 2003	37.0	34.7	32.6	30.4	21.2

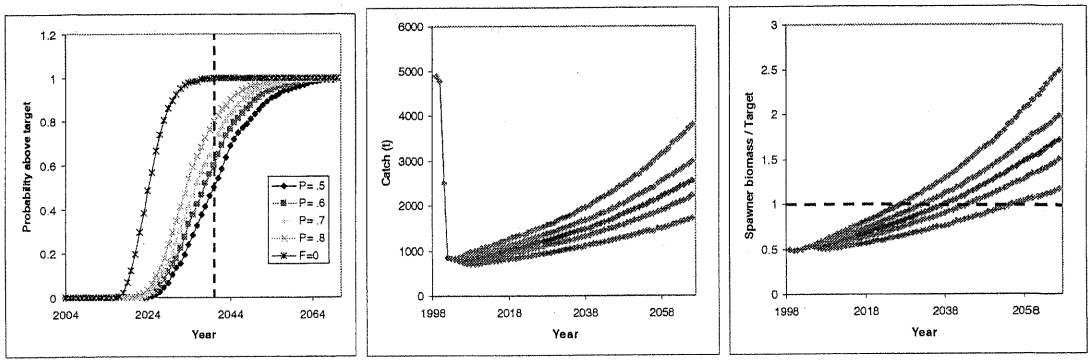

Figure 3. Time trajectories of the probability of recovery for five rebuild strategies, of the catch for a 0.6 probability of recovery, and of the spawning output expressed relative to $0.4B_0$ for a 0.6 probability of recovery. The vertical line in the first plot corresponds to the year in which recovery with the pre-specified probability is to occur and the horizontal line in the third panel is the target level.

References

MacCall, A. D. and A. E. Punt. 2001. Revised rebuilding analysis for widow rockfish. Pacific Fishery Management Council. Portland, OR.

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Punt, A. E. 2002b. An exploration of Monte Carlo uncertainty for rebuilding analyses for four overfished groundfish resources. Pacific Fishery Management Council, Portland, OR.

Williams, E. H., A. D. MacCall, S. V. Ralston, and D. E. Pearson. 2000. Status of the widow rockfish resource in Y2K. In: Appendix to Status of the Pacific coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001. Stock assessment and fishery evaluation. Pacific Fishery Management Council. Portland, OR.

Acknowledgements

Dr Jim Hastie (NWFSC, NMFS, NOAA) is thanked for providing the revised estimates of widow rockfish catch for 1999-2001 and the widow rockfish OY estimate for 2002. John DeVore (PFMC) is thanked for his comments on a draft of this document.

Appendix 1: Data used in the rebuilding analysis (REBUILD.DAT file) – Case 8

```
#Title
Window rockfish - default assumptions
# Number of sexes
2
# Age range to consider (minimum age; maximum age)
3 20
# First year of projection
1999
# Year declared overfished
1999
# Is the maximum age a plus-group (1=Yes;2=No)
1
# Generate future recruitments using historical recruitments (1), historical recruits/spawner (2), or a stock-recruitment (3)
2
# Constant fishing mortality (1) or constant Catch (2) projections
1
# Pre-specify the year of recovery (or -1) to ignore
37
# Fecundity-at-age
# 3 4 5 6 7 8 9 10
 5.71571E-
05,0.000192238,0.014959075,0.06416152,0.161188109,0.276595084,0.36866541,0.441150816,0.508537268,0.566615354,0.6187650
39,0.665202145,0.706388539,0.74275911,0.774748748,0.802838386,0.827408957,0.883903028
# Age specific information (Females then males), M, weight, selectivity and numbers
# Females
 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000
0.150000 0.150000 0.150000 0.150000 0.150000
0.260608092 0.382403028 0.516070194 0.654578339 0.792170662 0.924895027 1.049946766 1.165864012 1.271881655
1.367769472 1.453797243 1.530488701 1.598486647 1.658533881 1.711419248 1.757704614 1.798297893 1.89163453
0.000593893 0.005686670 0.054780300 0.362629000 0.846479000 0.998077000 0.963625000 0.904980000 0.847668000
0.793880000 0.743284000 0.695263000 0.649123000 0.604100000 0.559340000 0.513919000 0.466977000 0.41801300
 2958.5 7588.5 6246.5 6863.0 2061.5 5577.5 2272.0 1669.5 1646 1334.5 542.5 675 517 141 171 386.5 239 935
# Males
 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000 0.150000
0.150000 0.150000 0.150000 0.150000 0.150000
0.303357216 0.410118829 0.515691806 0.615331188 0.706167139 0.787117388 0.857984578 0.919248338 0.971690941
1.016243337 1.053962138 1.085701311 1.112314822 1.134579656 1.153172796 1.168719902 1.181646637 1.20887895
0.000590021 0.005633680 0.054211900 0.359841000 0.844941000 0.998171000 0.962820000 0.902934000 0.844470000
0.789659000 0.738174000 0.689400000 0.642654000 0.597194000 0.552196000 0.506774000 0.460107000 0.41171100
 2958.5 7588.5 6246.5 6863.0 2061.5 5577.5 2272.0 1669.5 1646 1334.5 542.5 675 517 141 171 386.5 239 935
# Number of simulations
1000
# Recruitment and Spanwer biomasses
# Number of historical assessment years
32
# Historical data: Year, Recruitment, Spawner biomass, Used to compute B0, Used to project based
# on R, Used to project based on R/S
1968  29603 30662 1 0 0
1969  39748 30664 1 0 0
1970  37990 30668 1 0 0
1971  47532 30716 1 0 0
1972  39929 30910 1 0 0
1973 112579 31371 1 0 0
1974  42955 32096 1 0 0
1975  20667 33298 1 0 0
1976  11070 35254 1 0 0
1977  23596 37731 1 0 0
1978  39407 39189 1 0 0
1979  02219 39316 1 0 0
1980  73666 38032 1 0 0
1981  48325 32253 1 0 0
1982  24940 25329 1 0 0
1983  47876 19457 0 0 0
1984  62307 17592 0 0 0
1985  21667 17055 0 0 0
1986  13094 16665 0 1 1
```

```
1987  32540 16481 0 1 1
1988  28129 15782 0 1 1
1989  16110 14978 0 1 1
1990  29622 13019 0 1 1
1991  25813 11553 0 1 1
1992  18452 11079 0 1 1
1993  18265 10632 0 1 1
1994  31413 09860 0 1 1
1995   8327 09533 0 1 1
1996  21956 08985 0 1 1
1997  16901 08664 0 1 1
1998  17637 08261 0 1 1
1999   5917 08223 0 1 1
# Number of years with pre-specified catches
4
# catches for years with pre-specified catches
1999 4894
2000 4762
2001 2501
2002  856
# Number of future recruitments to override
2
# Process for overiding (-1 for average otherwise index in data list)
2000 -1
2001 28
# Which probability to product detailed results for (1=0.5,2=0.6,etc.)
2
# Steepness and sigma-R
0.5 0.5
# Target SPR rate (FMSY Proxy)
0.5
# Target SPR information: Use (1=Yes) and power
0 20
# Discount rate (for cumulative catch)
0.1
# Truncate the series when 0.4B0 is reached (1=Yes)
0
# Set F to FMSY once 0.4B0 is reached (1=Yes)
0
# Percentage of FMSY which defines Ftarget
0.9
# Conduct MacCall transition policy (1=Yes)
0
# Defintion of recovery (1=now only;2=now or before)
2
# Produce the risk-reward plots (1=Yes)
0
# Calculate coefficients of variation (1=Yes)
0
# Number of replicates to use
20
# First Random number seed
-89102
```

Appendix 2 : The envelopes (5%, 25%, 50%, 75% and 95% distribution points) for the annual catch and the annual ratio of the spawner output to $0.4B_0$. The results in this appendix pertain to case 8 and a 60% probability of recovery.

Year	Spawner output / $0.4B_0$					Annual catch (t)				
	5%	25%	50%	75%	95%	5%	25%	50%	75%	95%
1999	0.496	0.496	0.496	0.496	0.496	4894	4894	4894	4894	4894
2000	0.488	0.488	0.488	0.488	0.488	4762	4762	4762	4762	4762
2001	0.481	0.481	0.481	0.481	0.481	2501	2501	2501	2501	2501
2002	0.493	0.493	0.493	0.493	0.493	856	856	856	856	856
2003	0.512	0.512	0.512	0.512	0.512	832	832	832	832	833
2004	0.520	0.521	0.523	0.523	0.526	816	817	821	822	825
2005	0.519	0.523	0.530	0.533	0.540	776	785	808	814	839
2006	0.511	0.523	0.536	0.545	0.559	729	766	809	838	884
2007	0.504	0.527	0.545	0.561	0.580	707	774	823	867	924
2008	0.503	0.533	0.554	0.576	0.602	710	781	834	889	960
2009	0.502	0.540	0.564	0.590	0.621	712	790	848	907	989
2010	0.507	0.547	0.574	0.603	0.642	715	802	864	926	1011
2011	0.513	0.555	0.587	0.618	0.661	733	818	883	950	1043
2012	0.519	0.565	0.598	0.632	0.684	746	839	903	969	1074
2013	0.526	0.576	0.611	0.646	0.702	753	852	923	993	1098
2014	0.532	0.585	0.622	0.662	0.716	759	866	939	1014	1127
2015	0.538	0.596	0.634	0.677	0.738	775	882	958	1039	1152
2016	0.542	0.603	0.645	0.691	0.755	789	897	980	1068	1187
2017	0.548	0.610	0.657	0.706	0.771	801	911	1002	1089	1216
2018	0.557	0.620	0.672	0.720	0.795	811	932	1021	1112	1252
2019	0.565	0.630	0.684	0.733	0.813	827	946	1045	1139	1286
2020	0.572	0.641	0.698	0.750	0.835	838	962	1061	1159	1307
2021	0.581	0.650	0.707	0.766	0.852	853	977	1079	1182	1332
2022	0.585	0.659	0.722	0.784	0.870	862	990	1094	1215	1362
2023	0.594	0.672	0.733	0.799	0.890	867	1010	1118	1234	1402
2024	0.605	0.683	0.746	0.815	0.912	884	1026	1144	1264	1433
2025	0.612	0.695	0.761	0.830	0.927	907	1050	1168	1292	1466
2026	0.619	0.707	0.774	0.850	0.951	924	1066	1190	1320	1494
2027	0.628	0.718	0.789	0.867	0.975	931	1090	1213	1344	1533
2028	0.637	0.733	0.803	0.884	0.992	948	1122	1236	1374	1569
2029	0.643	0.748	0.817	0.901	1.014	954	1143	1261	1399	1596
2030	0.655	0.762	0.832	0.917	1.035	977	1159	1282	1418	1625
2031	0.662	0.773	0.846	0.934	1.060	993	1170	1311	1450	1669
2032	0.672	0.786	0.865	0.953	1.080	1014	1197	1334	1487	1712
2033	0.684	0.797	0.881	0.973	1.107	1035	1215	1361	1517	1741
2034	0.695	0.809	0.896	0.991	1.130	1050	1235	1387	1549	1784
2035	0.706	0.819	0.910	1.009	1.156	1056	1254	1414	1581	1826
2036	0.714	0.832	0.925	1.028	1.181	1065	1276	1435	1620	1876
2037	0.722	0.846	0.944	1.051	1.199	1072	1296	1464	1651	1912
2038	0.728	0.860	0.959	1.073	1.231	1106	1316	1483	1679	1963
2039	0.739	0.876	0.978	1.092	1.259	1136	1342	1505	1703	2009

Year	Spawner output / $0.4B_0$					Annual catch (t)				
	5%	25%	50%	75%	95%	5%	25%	50%	75%	95%
2040	0.754	0.890	0.993	1.106	1.287	1150	1370	1534	1738	2062
2041	0.768	0.905	1.007	1.127	1.315	1160	1391	1567	1776	2120
2042	0.775	0.922	1.027	1.150	1.348	1174	1419	1598	1814	2165
2043	0.790	0.937	1.043	1.175	1.378	1199	1446	1628	1844	2203
2044	0.800	0.954	1.063	1.200	1.412	1214	1475	1666	1884	2253
2045	0.806	0.972	1.089	1.220	1.449	1239	1501	1702	1932	2308
2046	0.820	0.989	1.106	1.234	1.478	1252	1517	1737	1966	2362
2047	0.827	0.999	1.130	1.266	1.511	1279	1547	1778	2014	2420
2048	0.840	1.012	1.153	1.294	1.551	1301	1575	1819	2049	2464
2049	0.859	1.031	1.174	1.319	1.571	1320	1606	1849	2105	2523
2050	0.872	1.050	1.194	1.347	1.600	1340	1632	1884	2138	2592
2051	0.883	1.067	1.220	1.371	1.642	1357	1677	1914	2194	2666
2052	0.897	1.086	1.240	1.399	1.675	1381	1707	1969	2233	2695
2053	0.907	1.107	1.259	1.426	1.715	1416	1733	2001	2277	2786
2054	0.924	1.126	1.279	1.452	1.765	1435	1765	2029	2320	2820
2055	0.937	1.144	1.308	1.480	1.799	1430	1791	2071	2361	2902
2056	0.950	1.163	1.327	1.514	1.846	1436	1823	2110	2411	2994
2057	0.961	1.178	1.354	1.544	1.890	1488	1857	2151	2481	3066
2058	0.966	1.195	1.384	1.579	1.931	1500	1892	2195	2535	3142
2059	0.982	1.222	1.401	1.612	1.962	1510	1926	2234	2590	3202
2060	0.993	1.247	1.423	1.649	2.010	1534	1969	2270	2641	3270
2061	1.002	1.268	1.446	1.677	2.066	1571	2012	2316	2694	3388
2062	1.018	1.286	1.477	1.707	2.120	1600	2047	2370	2744	3453
2063	1.038	1.310	1.513	1.743	2.178	1630	2072	2417	2779	3537
2064	1.044	1.329	1.538	1.771	2.225	1652	2109	2452	2843	3604
2065	1.064	1.356	1.565	1.810	2.274	1681	2165	2502	2909	3713
2066	1.077	1.387	1.588	1.841	2.311	1722	2213	2553	2978	3791
2067	1.097	1.419	1.619	1.882	2.354	1740	2256	2607	3053	3848
2068	1.117	1.446	1.646	1.919	2.414	1772	2299	2669	3103	3970
2069	1.125	1.457	1.678	1.955	2.465	1798	2328	2702	3158	4041
2070	1.153	1.481	1.711	1.984	2.540	1828	2366	2762	3190	4171
2071	1.171	1.502	1.746	2.015	2.595	1841	2395	2824	3273	4263

Appendix 3 : The median catches (t) for case 8 corresponding to rebuilding probabilities of 50, 60, 70, and 80%.

	Probability of recovery				
Year	P= .5	P= .6	P= .7	P= .8	40:10 Rule
1999	4894	4894	4894	4894	4894
2000	4762	4762	4762	4762	4762
2001	2501	2501	2501	2501	2501
2002	856	856	856	856	856
2003	916	832	750	656	1289
2004	902	821	741	650	1284
2005	886	808	730	642	1260
2006	886	809	733	645	1260
2007	900	823	746	657	1299
2008	912	834	757	667	1328
2009	926	848	770	680	1367
2010	943	864	786	694	1424
2011	963	883	804	710	1481
2012	984	903	822	727	1530
2013	1005	923	842	746	1575
2014	1020	939	856	760	1619
2015	1040	958	875	778	1653
2016	1062	980	896	797	1700
2017	1085	1002	917	816	1737
2018	1104	1021	936	834	1783
2019	1129	1045	959	856	1826
2020	1145	1061	974	871	1861
2021	1164	1079	993	889	1889
2022	1178	1094	1008	903	1910
2023	1203	1118	1031	925	1943
2024	1229	1144	1056	949	1974
2025	1254	1168	1079	971	2021
2026	1275	1190	1101	992	2053
2027	1298	1213	1123	1013	2076
2028	1322	1236	1146	1035	2115
2029	1347	1261	1169	1058	2164
2030	1369	1282	1191	1079	2178
2031	1397	1311	1219	1105	2199
2032	1420	1334	1243	1128	2211
2033	1448	1361	1269	1154	2237
2034	1473	1387	1295	1179	2251
2035	1500	1414	1321	1204	2297
2036	1521	1435	1342	1225	2302
2037	1549	1464	1371	1252	2334
2038	1567	1483	1390	1272	2326
2039	1589	1505	1413	1294	2336

Year	Probability of recovery				40:10 Rule
	P= .5	P= .6	P= .7	P= .8	
2040	1619	1534	1441	1321	2337
2041	1650	1567	1474	1354	2348
2042	1683	1598	1505	1383	2388
2043	1713	1628	1535	1414	2407
2044	1750	1666	1573	1449	2446
2045	1785	1702	1608	1485	2467
2046	1820	1737	1643	1518	2470
2047	1861	1778	1684	1558	2489
2048	1902	1819	1723	1597	2510
2049	1930	1849	1755	1628	2551
2050	1965	1884	1791	1664	2565
2051	1994	1914	1819	1693	2587
2052	2048	1969	1875	1746	2576
2053	2080	2001	1907	1777	2613
2054	2107	2029	1938	1810	2600
2055	2148	2071	1979	1850	2612
2056	2186	2110	2018	1889	2607
2057	2226	2151	2060	1931	2607
2058	2268	2195	2104	1975	2665
2059	2306	2234	2144	2015	2665
2060	2340	2270	2182	2053	2689
2061	2385	2316	2228	2099	2673
2062	2439	2370	2282	2153	2702
2063	2484	2417	2330	2201	2711
2064	2518	2452	2366	2237	2708
2065	2565	2502	2417	2290	2722
2066	2614	2553	2470	2343	2736
2067	2667	2607	2525	2398	2751
2068	2726	2669	2587	2459	2763
2069	2757	2702	2622	2495	2764
2070	2816	2762	2682	2555	2760
2071	2875	2824	2747	2622	2756