Some Issues Related to Conducting Rebuilding Analyses for Overfished Groundfish Resources

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Background

The rebuilding analyses for overfished groundfish species are based on conducting projections into the future for a range of different levels of constant fishing mortality or constant catch. The projections all start from the best estimates of the age-structure of the population based on the most recent assessment. Future recruitment is determined by either generating a recruitment from a sub-set of historical estimates or by generating a recruits/spawner ratio from a sub-set of the historical estimates and multiplying this by the spawner stock size for the year for which a recruitment is needed. A large number of simulations are conducted for a range of fishing mortalities / constant catches to identity the levels that correspond to a set of pre-specified probabilities of the spawner stock size exceeding the target level of 40% of the virgin spawner stock size in some future year (10 years after the species was first declared overfished or the minimum time to rebuild plus one mean generation).

Although the algorithm for conducting rebuilding analyses is fully specified, it involves Monte Carlo simulation so a rebuilding analysis should be considered to be a form of estimation rather than of calculation. This is because there is some (Monte Carlo) uncertainty associated with the outcomes from a rebuilding analysis due to the fact that it is not feasible to conduct projections for every combination of year and recruits/spawner ratio for example. The extent of Monte Carlo uncertainty would be greater if aspects of the rebuilding analysis, other than just future recruitment (e.g. the initial age-structure), were considered uncertain.

Implications of Monte Carlo uncertainty

Table 1 lists 2002 OYs for widow rockfish for a range of recovery probabilities from 50% to 80% and illustrates the sensitivity of the results to the number of simulations, N, from 100 (the value on which the original widow rockfish rebuilding analysis was based) to 1000. Ten analyses for each choice of N are shown in Table 1. The key result in this table is that the 2002 OYs differ among runs due to Monte Carlo uncertainty. As expected, the extent of Monte Carlo uncertainty, as quantified by the coefficient of variation (CV) of the 2002 OY, is reduced when the number of simulations, N is increased from 100 to 1000 (although the reduction in CV once N reaches 500 is perhaps not as large as expected, several of the CVs actually increase when N is increased from 500 to 1000). It is pleasing to note that the average values for the 2002 OYs for the three values for N are very similar, as expected.

It should be noted that the generation of future recruitment when selecting the fishing mortalities / constant catches is not the only source of Monte Carlo uncertainty in Table 1. Another source for this uncertainty is the calculation of the minimum rebuild time, which is also determined using Monte Carlo methods. Therefore, the values in the rows in Table 1 may differ slightly (by 1 year) because the minimum time to rebuild differs.

The Widow Rockfish Rebuilding Analysis

The results in Table 1 differ quite substantially from those presented in MacCall and Punt (2001). For example, the 2002 OY for a 50% probability of recovery is 921 mt in MacCall and Punt (2001), which is lower than any of the values in Table 1 for this quantity. Detailed examination of the computer code used for the calculations in MacCall and Punt (2001) [an early version of the rebuilding software] revealed a computational problem when conducting the Monte Carlo simulations, which meant that the number of simulations actually conducted was less than intended.

Recommendations

1. Quantification of the extent of Monte Carlo uncertainty should be a standard component of all rebuilding analyses. The software developed to conduct rebuilding analyses has been modified to allow this source of uncertainty to be quantified in a relatively straightforward fashion.
2. The SSC should consider specifying the number of simulations chosen to ensure that the CV for the key output quantities is less than a pre-specified value (noting that the CV for the 2002 OY is sensitive to the probability of recovery).
3. The rebuilding analysis for widow rockfish should be replaced by one based on the most recent version of the rebuilding software.
4. All existing rebuilding analyses should be repeated to determine the extent of Monte Carlo uncertainty associated with the 'key model outputs'. The SSC needs to specify these 'key model outputs'.

Reference

MacCall, A.D. and A.E. Punt. 2001. Revised rebuilding analysis for widow rockfish. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220-1384 (9pp).

Table 1. 2002 OYs for widow rockfish based on 10 applications of the rebuilding analysis software for each of three choices for the number of simulations, *N*. Results are shown for rebuilding probabilities of 50%, 60%, 70% and 80%.

	Probability of recovery											
	N=100				*N*=500				*N*=1000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	1028	928	783	678	977	891	791	691	965	879	794	686
2	1016	954	828	684	1004	918	824	720	1009	938	835	725
3	1036	918	834	729	1009	919	848	747	1005	918	840	736
4	1013	901	842	767	986	906	822	713	999	912	828	717
5	986	875	772	691	981	889	809	713	978	886	798	705
6	1000	862	787	708	1024	931	838	741	1021	930	834	747
7	936	882	835	724	989	898	821	739	1009	911	823	724
8	990	890	835	718	1008	904	817	709	986	886	792	688
9	990	936	847	719	1018	936	864	769	1001	921	832	726
10	976	895	792	695	990	920	809	697	963	877	788	681
Average	997	904	815	711	999	911	824	724	994	906	816	714
SD	28.9	29.1	28.4	26.4	16.2	16.1	21.0	24.3	19.7	22.1	20.9	22.5
CV	2.90	3.22	3.48	3.71	1.62	1.77	2.55	3.35	1.98	2.44	2.56	3.15