Exhibit E.7
Supplemental Attachment 1
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An Exploration of Monte Carlo Uncertainty for Rebuilding Analyses for Four 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 identify 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 (Punt, 2002a), 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.

Four of the rebuilding analyses on which Council decisions have been based (those for widow rockfish, Pacific Ocean Perch, lingcod, and darkblotched rockfish) were conducted using software (Punt, 2002a) developed to implement the guidelines for conducting rebuilding analyses developed by the PFMC Scientific and Statistical Committee[1]. This document examines the impact of Monte Carlo uncertainty for the rebuilding analyses for these four species.

Results and Discussion

Table 1 lists 2002 OYs corresponding to rebuilding probabilities of 50%, 60%, 70% and 80% for the four groundfish species based on 10 applications of the rebuilding analysis software. Results are shown separately for the northern and southern populations of lingcod as the rebuilding analysis software is applied to each separately, and the results combined to provide advice for the whole stock. The sensitivity of the results to the number of simulations, N, is examined by conducting analyses for N=100, 1000 and 2000. The results for the 10 applications for each choice of N are summarized by the mean, standard deviation and coefficient of variation in Table 1. Table 2 summarizes the results for the four species in terms of the means and coefficients of variation for each choice for N. This table also lists the 2002 OYs from the most recent rebuilding analyses available to the Council.

[1] The rebuilding analyses for the remaining species (bocaccio, cowcod, and canary rockfish) have been conducted using custom-developed software.

Tables 1 and 2 confirm several expectations concerning Monte Carlo uncertainty.

- The mean OYs are essentially independent of *N* and the coefficients of variation drop as the value of *N* is increased.
- The extent of Monte Carlo uncertainty is case-specific (the 2002 OYs for darkblotched rockfish tend to be the most precise while those for Pacific Ocean Perch tend to be the least precise).
- The extent of Monte Carlo uncertainty differs among quantities, being lowest for the 2002 OYs corresponding to a 50% probability of recovery and highest for an 80% probability of recovery – this is not unexpected because the high probabilities correspond to results in the tails of the distribution.

As expected from Punt (2002b), the 2002 OYs for widow rockfish based on the most recent rebuilding analysis presented to the council are outside the intervals based solely on Monte Carlo uncertainty. However, the 2002 OYs presented to the Council for the remaining species correspond fairly closely with the means reported in Tables 1 and 2.

Conclusions

- It is not possible to specify a 'best' value for *N* because the extent of Monte Carlo uncertainty depends on the specifics of the species concerned as well as the quantity of interest.
- A prescribed standard deviation or coefficient of variation may be more appropriate if a standard / guideline is needed. However, for some species (e.g. Pacific Ocean Perch) achieving very low coefficients of variation may lead to prohibitively large numbers of simulations.
- Although the previous OYs for widow rockfish differ noticeably from those obtained using the most recent version of the rebuilding software, this is not the case for Pacific Ocean Perch, darkblotched rockfish, and lingcod.

References

Punt, A.E. 2002a. SSC default rebuilding analysis: Technical specifications and User Manual (18pp).

Punt, A.E. 2002b. Some issues related to conducting rebuilding analyses for overfished groundfish resources. Pacific Fishery Management Council. 2130 SW Fifth Avenue, Suite 224, Portland, OR 97201 (3pp).

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Table 1. 2002 OYs for four groundfish species (results are presented separately for the northern and southern populations of lingcod) 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%.

(a) Widow rockfish

	Probability of recovery											
	N=100				*N*=1000				*N*=2000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	1028	928	783	678	965	879	794	686	996	917	835	733
2	1017	954	828	684	1009	939	835	727	1009	935	841	734
3	1036	918	834	729	1005	918	841	737	976	893	817	718
4	1013	901	842	767	999	912	828	717	990	907	826	722
5	986	875	774	691	978	886	798	705	987	896	809	707
6	1000	870	788	708	1021	930	834	747	1009	925	830	744
7	936	882	835	724	1009	911	823	724	1017	928	831	731
8	991	892	834	721	986	886	792	690	1001	912	826	721
9	990	936	847	719	1001	922	832	726	1005	923	834	725
10	976	895	792	695	963	879	789	682	994	917	837	735
Average	997	905	816	712	994	906	817	714	998	915	829	727
SD	28.89	27.90	27.93	26.32	19.71	22.12	20.72	22.33	12.16	13.47	9.65	10.48
CV	2.90	3.08	3.43	3.70	1.98	2.44	2.54	3.13	1.22	1.47	1.16	1.44

(Table 1 Continued)

(b) Pacific Ocean Perch

	Probability of recovery											
	N=100				*N*=1000				*N*=2000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	480	415	347	296	457	402	339	277	468	412	349	291
2	480	419	367	315	471	415	365	314	465	411	362	301
3	449	370	318	279	450	398	337	285	460	406	350	291
4	471	420	365	276	472	420	359	302	465	408	349	294
5	482	419	377	270	465	412	351	291	465	411	354	292
6	470	405	319	265	467	409	351	288	470	413	357	290
7	441	389	306	248	448	397	348	277	455	407	351	286
8	444	386	344	295	462	405	365	306	470	415	366	305
9	490	407	360	296	465	410	344	281	467	416	355	287
10	439	359	286	247	465	410	354	284	463	409	352	286
Average	465	399	339	279	462	408	351	290	465	411	354	292
SD	19.52	21.86	30.03	22.19	8.31	7.32	9.62	12.66	4.43	3.34	5.55	6.43
CV	4.20	5.48	8.86	7.97	1.80	1.80	2.74	4.36	0.95	0.81	1.57	2.20

(Table 1 Continued)

(c) Darkblotched rockfish

	Probability of recovery											
	N=100				*N*=1000				*N*=2000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	188	177	170	160	188	176.5	166	154	188	178	167	155
2	188	183	177	165	189	178.9	169	156	189	178	167	155
3	191	181	171	152	191	179.4	171	157	190	179	169	155
4	194	186	179	164.	188	178.2	169	153	187	177	166	152
5	196	187	172	160	189	178.7	167	155	190	179	168	156
6	195	188	179	157	189	179.1	168	156	189	179	167	154
7	194	186	176	159	190	180	169	156	190	180	168	155
8	194	185	169	158	192	180.8	170	158	190	179	168	156
9	196	187	175	156	190	180	169	155	190	180	170	157
10	189	179	169	154	189	179	168	154	189	179	167	154
Average	192	184	174	159	189	179	168	155	189	179	168	155
SD	3.20	3.80	4.02	4.09	1.19	1.16	1.41	1.47	1.08	1.01	1.18	1.34
CV	1.66	2.07	2.32	2.58	0.63	0.65	0.84	0.95	0.57	0.57	0.70	0.86

(Table 1 Continued)

(d) Lingcod (north)

	Probability of recovery											
	N=100				*N*=1000				*N*=2000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	386	363	321	281	368	341	310	281	369	344	315	285
2	385	369	343	317	369	346	322	291	367	344	320	290
3	372	344	304	268	366	342	316	282	368	343	316	284
4	354	339	300	276	366	341	311	286	368	342	314	286
5	376	343	323	286	371	347	321	286	368	345	320	289
6	378	346	326	305	374	346	321	288	374	347	320	288
7	383	353	337	312	368	345	320	291	367	344	319	288
8	362	342	314	278	369	349	324	288	369	349	323	290
9	363	342	322	293	369	349	322	289	369	348	321	292
10	379	350	322	294	375	350	321	292	369	344	318	286
Average	374	349	321	291	369	346	319	287	369	345	319	288
SD	10.86	9.64	13.16	16.14	3.04	3.16	4.65	3.72	1.96	2.24	2.85	2.53
CV	2.90	2.76	4.10	5.55	0.82	0.92	1.46	1.29	0.53	0.65	0.89	0.88

(Table 1 Continued)

(e) Lingcod (south)

	Probability of recovery											
	N=100				N=1000				N=2000			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
1	271	244	219	180	253	230	196	166	253	229	197	165
2	261	230	191	158	261	236	211	177	260	234	208	173
3	260	235	211	179	253	227	202	169	253	227	200	167
4	243	221	183	156	249	222	198	169	254	229	200	171
5	276	255	221	174	259	230	202	169	257	230	204	172
6	264	238	195	169	257	231	202	169	256	229	201	170
7	261	230	195	165	259	234	204	172	258	234	204	169
8	257	227	198	164	254	231	201	172	254	231	201	167
9	246	220	190	167	255	228	198	166	252	225	196	166
10	249	220	208	185	253	225	199	172	257	230	202	173
Average	259	232	201	170	255	229	201	170	255	230	201	169
SD	10.65	11.31	12.97	9.59	3.75	4.13	4.15	3.33	2.61	2.86	3.44	2.81
CV	4.11	4.87	6.45	5.65	1.47	1.80	2.06	1.96	1.02	1.25	1.71	1.66

Table 2. 2002 OYs corresponding to rebuilding probabilities of 50%, 60%, 70% and 80% for four groundfish species (results are presented separately for the northern and southern populations of lingcod) based on 10 applications of the rebuilding analysis software for each of three choices for the number of simulations, *N*. The results are summarized by the means and coefficients of variation over the 10 applications for each choice of *N*. The row 'current' lists the 2002 OYs based on the most recent rebuilding analyses presented to the Council.

	Species / Probability of recovery											
	Widow rockfish				*Pacific Ocean Perch*				*Darkblotched rockfish*			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
Current	*921*	*856*	*777*	*726*	*464*	*410*	*353*	*290*	*190*	*181*	*169*	*158*
N=100	997	905	816	712	465	399	339	279	192	184	174	159
	2.90	3.08	3.43	3.70	4.20	5.48	8.86	7.97	1.66	2.07	2.32	2.58
N=1000	994	906	817	714	462	408	351	290	189	179	168	155
	1.98	2.44	2.54	3.13	1.80	1.80	2.74	4.36	0.63	0.65	0.84	0.95
N=2000	998	915	829	727	465	411	354	292	189	179	168	155
	1.22	1.47	1.16	1.44	0.95	0.81	1.57	2.20	0.57	0.57	0.70	0.86

	Species / Probability of recovery							
	Lingcod (north)				*Lingcod (south)*			
Run	**50**	**60**	**70**	**80**	**50**	**60**	**70**	**80**
Current	384	337	324	302	262	240	211	187
N=100	374	349	321	291	259	232	201	170
	2.90	2.76	4.10	5.55	4.11	4.87	6.45	5.65
N=1000	369	346	319	287	255	229	201	170
	0.82	0.92	1.46	1.29	1.47	1.80	2.06	1.96
N=2000	369	345	319	288	255	230	201	169
	0.53	0.65	0.89	0.88	1.02	1.25	1.71	1.66