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Attachment 3
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DRAFT Cowcod Rebuilding Analysis

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Introduction

The status of cowcod (*Sebastes levis*) in the Southern California Bight was first assessed by Butler et al. (1999), who concluded that spawning biomass in 1998 was 7% of the unfished biomass. The stock was declared overfished in 2000 and the first rebuilding plan was adopted under Amendment 16-3 (PFMC, 2004). The stock was assessed again in 2005 (Piner et al., 2006) and the original rebuilding plan parameters were supplanted by the rebuilding analysis of Piner (2006). The next assessment and rebuilding analysis were completed in 2007 and 2008, respectively (Dick et al., 2007; Dick and Ralston, 2008). Rebuilding reference points from previous analyses are provided in Table 1. This rebuilding analysis is based on the updated assessment by Dick et al. (2009) and uses rebuilding software developed by Dr. Andre Punt (version 2.11).

Simulation Model and Rebuilding Calculations

Estimation of Virgin Biomass (B_0)

The base model for the 2009 cowcod stock assessment assumes a Beverton-Holt stock-recruitment relationship with steepness fixed at 0.6. Virgin recruitment (R_0) is estimated at about 110,000 recruits. Spawning output is assumed to be directly proportional to spawning biomass. For each simulation, virgin biomass (B_0), is defined using the equation:

$$B_0 = 0.5 R_0 \sum_{a=a_{mat}}^{a_{last}} \phi_a e^{-\sum_{a'=a_{\min}}^{a-1} M_{a'}}$$

where a_{mat} is the minimum age-at-maturity, a_{last} is 5 times the last age group (to approximate the plus-group), $M_{a'}$ is the natural mortality rate at age a', and ϕ_a is fecundity at age a. Age-specific values for fecundity, weight, and other model inputs are given in Table 2. Estimates of spawning biomass (mt) presented in this document are female spawning biomass only.

Simulation of Future Recruitments

In each model run, 1000 simulated trajectories were generated with recruitment determined by a Beverton-Holt stock-recruitment (S-R) relationship. A major axis of uncertainty in the assessment was the assumed value of the steepness parameter in the S-R relationship. During the Science and Statistical Committee's review of the 2007 assessment, it was decided that the 2007 rebuilding analysis would represent uncertainty about steepness by using a discrete distribution of parameter values (Fig. 1). The relative frequency of each value of steepness approximated the prior probability distribution from a meta-analysis of multiple rockfish stocks (M. Dorn, pers. comm., 2007). Variability in future recruitment was expressed as a weighted set of twenty-one different states of nature (steepness values), rather than random deviations from an average S-R relationship (i.e. σ_R was fixed at zero). This rebuilding analysis follows the same approach as the 2007 rebuilding analysis because the 2009 cowcod assessment was an update assessment.

Mean Generation Time

Mean generation time for cowcod is estimated from the net maternity function and is 38 years. This is the same estimate for mean generation time as in the 2007 rebuilding analysis.

Recent Management Performance

Estimates of total cowcod mortality have not exceeded the OY in any year since 2002 (Table 3). Under the current SPR harvest rate ($F_{79\%}$) $T_{REBUILD}$ is 2071. This is 1 year earlier than the current estimate of T_{TARGET} (2072).

Description of Model Runs

Model runs presented in this document follow the SSC Terms of Reference for Groundfish Rebuilding Analysis (TOR) (draft revised version; PFMC, May 2008). All runs are based on output produced by the 2009 base model (Table ES2 in Dick et al., 2009). Rebuilding run numbers correspond to the list of requested runs in the TOR (p. 10, draft revised version; PFMC, May 2008). In all models, the catches for 2009 and 2010 were set to the OY for cowcod in the assessed area (2 mt for the region south of Point Conception). In recent years, the Council has set the statewide OY for cowcod equal to twice the OY for the area south of Pt. Conception (PFMC and NMFS, 2006).

The 2009-2010 SPR harvest control rule for cowcod was based on the Council's final preferred statewide OY alternative of 4 mt (2 mt south of Point Conception). The harvest control rule associated with this OY was incorrectly reported as 82.1% in the 2009-2010 Final Environmental Impact Statement (www.pcouncil.org/groundfish/gfspex/gfspex09-10.html). The correct value is 79% (see run D2 in Table 4 of Dick and Ralston, 2008).

The TOR lists the following minimum set of harvest policies for analysis:

1. The spawning potential ratio listed in the Rebuilding Plan in the FMP (Amendment 16-4 for the stocks that are currently overfished)
2. The spawning potential ratio corresponding to the optimum yields adopted for the current year (or biennium)
3. The spawning potential ratio on which the current optimum yields were based
4. The spawning potential ratio which will rebuild the stock to the target level with 0.5 probability by the T_{TARGET} specified in the FMP
5. The spawning potential ratio which will rebuild the stock to the target level with 0.5 probability by the T_{MAX} specified in the FMP
6. The spawning potential ratio which will rebuild the stock to the target level with 0.5 probability by the T_{MAX} calculated using the most recent biological and fishery information.
7. The ABC and 40:10 control rules.
8. No harvest after 2010.

Run 9 in the TOR is a request for a sequence of five runs based on spawning potential ratios which achieve recovery to the target level with 0.5 probability for years between $T_{F=0}$ and T_{MAX}. The runs are labeled 9a – 9e in this document, and correspond to the following set of target years:

Run 9a.	2060 (re-estimated $T_{F=0}$)
Run 9b.	2070
Run 9c.	2079
Run 9d.	2089
Run 9e.	2097 (re-estimated T_{MAX})

Results

The use of the discrete steepness distribution (Figure 1) causes some model trajectories to have a “step” pattern (Figures 2 and 3). As a result, proximal years often have the same probability of being above target and different catch streams appear to produce the same probability of rebuilding in a given year.

Rebuilding and biomass reference points for cowcod are shown in Table 4. A small change (1 year) in the value of T_{MIN} is likely due to revised estimates of historical recreational catch in the updated assessment (Dick et al., 2009).

Results of the updated rebuilding analysis differ little from the 2007 rebuilding analysis (Table 5). Run 4 (the spawning potential ratio which will rebuild the stock to the target level with 0.5 probability by the T_{TARGET} specified in the FMP) does not apply to cowcod because the stock rebuilds with 50% probability by 2060 in the absence of fishing, while T_{TARGET} in Amendment 16-4 of the FMP is 2039. Time series of probability of recovery, spawning biomass relative to target, and median catch from the updated rebuilding analysis are provided in Tables 6-10, and shown in Figures 2-7.

Literature cited

Butler, J. L., L. D. Jacobson and J.T. Barnes. 1999. Stock assessment of cowcod rockfish. In: Pacific Fishery Management Council. 1999. Appendix: Status of the Pacific Coast Groundfish Fishery through 1999 and recommended biological catches for 2000: Stock assessment and fishery evaluation. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon, 97201.

Dick, E.J., S. Ralston, and D. Pearson. 2007. Status of cowcod, *Sebastes levis*, in the Southern California Bight. Pacific Fishery Management Council, Portland, OR.

Dick, E.J. and S. Ralston. 2008. Cowcod Rebuilding Analysis. Pacific Fishery Management Council, Portland, OR.

Dick, E.J., S. Ralston, and D. Pearson. 2009. Updated status of cowcod, *Sebastes levis*, in the Southern California Bight. Document submitted to the PFMC, June 2009.

PFMC. 2004. Appendix F to amendment 16-3 to the pacific coast groundfish fishery management plan. Cowcod draft rebuilding plan. Adopted April 2004. Pacific Fishery Management Council.

PFMC (Pacific Fishery Management Council) and NMFS (National Marine Fisheries Service). 2006. Proposed Acceptable Biological Catch and Optimum Yield Specifications and Management Measures for the 2007-2008 Pacific Coast Groundfish Fishery, and Amendment 16-4: Rebuilding Plans For Seven Depleted Pacific Coast Groundfish Species; Final Environmental Impact Statement Including Regulatory Impact Review and Initial Regulatory Flexibility Analysis. Pacific Fishery Management Council, Portland, OR. October 2006.

PFMC. 2008. SSC Terms of Reference for Groundfish Rebuilding Analysis, Draft Revised Version (May 2008). Pacific Fishery Management Council, Portland. OR.

Piner, K. 2006. Cowcod Rebuilding Analysis 2005 Analysis of the Progress towards Rebuilding in the Southern California Bight. In Volume 1: Status of the Pacific Coast Groundfish Fishery Through 2005, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses. Portland, OR: Pacific Fishery Management Council.

Piner, K., E. J. Dick, and J. Field. 2006. 2005 Stock Status of Cowcod in the Southern California Bight and Future Prospects. In Volume 1: Status of the Pacific Coast Groundfish Fishery Through 2005, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses. Portland, OR: Pacific Fishery Management Council.

Table 1. Parameters from previous rebuilding analyses. * The harvest control rule for 2009-2010 was based on the Council's final preferred OY alternative of 4 mt (2 mt south of Point Conception). The harvest control rule associated with this OY was incorrectly reported as 82.1% in the 2009-2010 Final Environmental Impact Statement (FEIS). The correct value is 79%.

	Date of Analysis		
Rebuilding Parameter	**2004**	**2006**	**2008**
B_0 [female spawning biomass, mt]	1684	1523	2488
B_{MSY} [mt]	675	609	995
T_{MIN}	2062	2035	2060
T_{MAX}	2099	2074	2098
$T_{F=0}$	2062	2035	2061
P_{MAX}	60%	90.6%	66.2%
T_{TARGET}	2090	2039	2072
Harvest Control Rule	$F_{78\%}$	$F_{90\%}$	$F_{79\%}$*

Table 2. Age-specific quantities used in the 2009 rebuilding analysis.

	Females				Fleet 1		Fleet 2	
Age	Fecundity	M	Init N	Init N Tmin	Weight	Selectivity	Weight	Selectivity
0	0	0.055	21.14480	12.12700	0	0	0	0
1	0	0.055	19.08350	10.92020	0	0	0.00021	0.002
2	0	0.055	17.17440	9.50210	0	0.00005	0.00227	0.009
3	0.00009	0.055	15.40280	8.50067	0.000	0.00059	0.01471	0.038
4	0.00126	0.055	13.75680	8.75935	0.004	0.00427	0.05404	0.105
5	0.00874	0.055	12.22690	8.39472	0.019	0.01840	0.13398	0.214
6	0.03501	0.055	10.80600	8.51984	0.060	0.05302	0.25695	0.349
7	0.09615	0.055	9.48871	7.57525	0.144	0.11464	0.41630	0.489
8	0.20397	0.055	8.27006	7.03875	0.277	0.20253	0.60222	0.618
9	0.36160	0.055	7.37078	5.94612	0.458	0.30968	0.80567	0.726
10	0.56415	0.055	6.62725	4.93306	0.679	0.42609	1.01990	0.812
11	0.80184	0.055	5.75479	4.06880	0.930	0.54175	1.24047	0.876
12	1.06323	0.055	5.13225	4.77038	1.199	0.64862	1.46472	0.921
13	1.33757	0.055	5.26342	5.01929	1.477	0.74137	1.69123	0.952
14	1.61611	0.055	5.01240	6.10020	1.755	0.81741	1.91931	0.972
15	1.89259	0.055	5.04995	6.46118	2.029	0.87650	2.14856	0.984
16	2.16318	0.055	4.45653	5.85213	2.296	0.92006	2.37873	0.991
17	2.42614	0.055	4.11206	4.50618	2.555	0.95053	2.60949	0.995
18	2.68117	0.055	3.45271	3.70317	2.806	0.97075	2.84044	0.997
19	2.92888	0.055	2.85021	2.68034	3.050	0.98348	3.07109	0.999
20	3.17027	0.055	2.34170	1.83116	3.289	0.99107	3.30088	0.999
21	3.40632	0.055	2.73746	1.18960	3.523	0.99537	3.52922	1
22	3.63780	0.055	2.87422	0.71499	3.752	0.99768	3.75554	1
23	3.86519	0.055	3.48807	0.40520	3.977	0.99887	3.97926	1
24	4.08867	0.055	3.69086	0.21926	4.199	0.99946	4.19989	1
25	4.30823	0.055	3.34083	0.11517	4.416	0.99974	4.41697	1
26	4.52370	0.055	2.57145	0.06016	4.63	0.99988	4.63008	1
27	4.73487	0.055	2.11272	0.03201	4.839	0.99994	4.83888	1
28	4.94148	0.055	1.52897	0.01774	5.043	0.99997	5.04307	1
29	5.14331	0.055	1.04448	0.01039	5.242	0.99999	5.24241	1
30	5.34016	0.055	0.67851	0.00651	5.437	0.99999	5.43668	1
31	5.53186	0.055	0.40780	0.00439	5.626	1	5.62574	1
32	5.71826	0.055	0.23111	0.00314	5.809	1	5.80945	1
33	5.89927	0.055	0.12506	0.00238	5.988	1	5.98774	1
34	6.07482	0.055	0.06569	0.00187	6.161	1	6.16054	1
35	6.24488	0.055	0.03431	0.00153	6.328	1	6.32784	1
36	6.40942	0.055	0.01826	0.00128	6.49	1	6.48963	1
37	6.56846	0.055	0.01012	0.00110	6.648	1	6.64799	1
38	6.72610	0.055	0.00592	0.00095	6.803	1	6.8028	1
39	6.87810	0.055	0.00371	0.00084	6.952	1	6.95201	1
40	7.02454	0.055	0.00250	0.00075	7.096	1	7.09569	1
41	7.16549	0.055	0.00179	0.00067	7.234	1	7.23394	1
42	7.30106	0.055	0.00136	0.00061	7.367	1	7.36686	1
43	7.43136	0.055	0.00107	0.00055	7.495	1	7.49457	1
44	7.55650	0.055	0.00087	0.00051	7.617	1	7.61718	1
45	7.67661	0.055	0.00073	0.00047	7.735	1	7.73483	1
46	7.79183	0.055	0.00063	0.00043	7.848	1	7.84764	1
47	7.90229	0.055	0.00054	0.00040	7.956	1	7.95577	1
48	8.00812	0.055	0.00048	0.00037	8.059	1	8.05935	1
49	8.10948	0.055	0.00043	0.00034	8.159	1	8.15852	1
50	8.20650	0.055	0.00038	0.00031	8.253	1	8.25342	1
51	8.29932	0.055	0.00035	0.00029	8.344	1	8.34421	1
52	8.38810	0.055	0.00032	0.00027	8.431	1	8.43102	1
53	8.47297	0.055	0.00029	0.00025	8.514	1	8.51399	1
54	8.55408	0.055	0.00027	0.00023	8.593	1	8.59327	1
55	8.63157	0.055	0.00025	0.00021	8.669	1	8.66899	1
56	8.70556	0.055	0.00023	0.00020	8.741	1	8.74129	1
57	8.77620	0.055	0.00021	0.00018	8.81	1	8.81031	1
58	8.84362	0.055	0.00019	0.00017	8.876	1	8.87617	1
59	8.90795	0.055	0.00018	0.00016	8.939	1	8.93899	1
60	8.96931	0.055	0.00016	0.00015	8.999	1	8.99892	1
61	9.02782	0.055	0.00015	0.00014	9.056	1	9.05605	1
62	9.08361	0.055	0.00014	0.00013	9.111	1	9.11052	1
63	9.13679	0.055	0.00013	0.00012	9.162	1	9.16243	1
64	9.18747	0.055	0.00012	0.00011	9.212	1	9.2119	1
65	9.23575	0.055	0.00011	0.00011	9.259	1	9.25903	1
66	9.28175	0.055	0.00010	0.00010	9.304	1	9.30392	1
67	9.32556	0.055	0.00010	0.00009	9.347	1	9.34667	1
68	9.36728	0.055	0.00009	0.00009	9.387	1	9.38738	1
69	9.40700	0.055	0.00008	0.00008	9.426	1	9.42614	1
70	9.44481	0.055	0.00008	0.00008	9.463	1	9.46303	1
71	9.48080	0.055	0.00007	0.00008	9.498	1	9.49814	1
72	9.51506	0.055	0.00007	0.00007	9.532	1	9.53156	1
73	9.54765	0.055	0.00006	0.00007	9.563	1	9.56335	1
74	9.57867	0.055	0.00006	0.00006	9.594	1	9.5936	1
75	9.60817	0.055	0.00006	0.00006	9.622	1	9.62238	1
76	9.63624	0.055	0.00005	0.00006	9.65	1	9.64975	1
77	9.66293	0.055	0.00005	0.00005	9.676	1	9.67579	1
78	9.68832	0.055	0.00005	0.00005	9.701	1	9.70055	1
79	9.71247	0.055	0.00005	0.00004	9.724	1	9.72409	1
80	9.73543	0.055	0.00059	0.00051	9.746	1	9.74648	1

Table 3. Recent estimates of cowcod catch relative to California statewide ABCs and OYs. The Council has defined the OY for the assessed area as one-half the statewide OY (PFMC and NMFS, 2006).

Year	Commercial (CalCOM)	Recreational (RecFIN)	Total Mortality Report	ABC	OY
2002	0.10	0.58	3.51	24	4.8
2003	0.05	--	0.32	24	4.8
2004	0.03	0.45	2.18	24	4.8
2005	0.04	0.15	1.27	24	4.2
2006	--	0.07	1.18	24	4.2
2007	0.40	0.20	3.20	36	4
2008	--	0.19	--	36	4

Table 4. Summary of rebuilding reference points for cowcod

Parameter	Values
Year declared overfished	2000
Current year	2009
First OY year	2011
T_{MIN} (re-estimated)	2059
Mean generation time (years)	38
T_{MAX} (re-estimated)	2097
$T_{F=0}$ (beginning in 2011)	2060
B_0 (female spawning biomass, mt)	2183
Rebuilding target ($B_{40\%}$) (mt)	873
Current SPR (2009-2010 cycle)	79%
Current T_{TARGET} (2009-2010 cycle)	2072
SB_{2009} (mt)	98

Table 5. Rebuilding reference points for requested model runs (see text for run descriptions).

	Run								
	1	2	3	4	5	6	7 (ABC)	7 (40:10)	8
SPR in 2011	90.0%	77.9%	79.0%	n/a	74.2%	59.7%	50%	100%	100%
50% prob. recovery by:	2064	2072	2071	n/a	2074	2097	2283	2215	2060
2011 OY (mt)	0.8	2	1.9	n/a	2.4	4.4	0	0	0
2011 ABC (mt)	6.2	6.2	6.2	n/a	6.2	6.2	6.2	6.2	6.2
2012 OY (mt)	0.9	2.1	2.0	n/a	2.5	4.5	0	0	0
2012 ABC (mt)	6.4	6.4	6.4	n/a	6.4	6.4	6.4	6.4	6.4
Probability of recovery by									
2059 (new Tmin)	46.7%	40.2%	40.2%	n/a	33.8%	27.6%	15.9%	21.6%	46.7%
2060 (old Tmin)	46.7%	40.2%	40.2%	n/a	40.2%	27.6%	15.9%	21.6%	52.5%
2072 (current Ttarget)	59.8%	53.3%	53.3%	n/a	46.7%	33.8%	22.2%	27.6%	59.8%
2097 (new Tmax)	72.4%	66.2%	66.2%	n/a	66.2%	50.0%	33.8%	40.2%	78.4%
2098 (old Tmax)	72.4%	66.2%	66.2%	n/a	66.2%	53.3%	33.8%	40.2%	78.4%

Table 5 (Continued). Rebuilding reference points for requested model runs (see text for run descriptions).

	Run				
	9a	9b	9c	9d	9e
SPR in 2011	100%	79.2%	69.5%	63.1%	59.7%
50% prob. recovery by:	2060	2070	2079	2089	2097
2011 OY (mt)	0	1.9	3.0	3.9	4.4
2011 ABC (mt)	6.2	6.2	6.2	6.2	6.2
2012 OY (mt)	0	2.0	3.1	4.0	4.5
2012 ABC (mt)	6.4	6.4	6.4	6.4	6.4
Probability of recovery by					
2059 (new Tmin)	46.7%	40.2%	33.8%	27.6%	27.6%
2060 (old Tmin)	52.5%	40.2%	33.8%	27.6%	27.6%
2072 (current Ttarget)	59.8%	53.3%	46.7%	40.2%	33.8%
2097 (new Tmax)	78.4%	66.2%	59.8%	53.3%	50.0%
2098 (old Tmax)	78.4%	66.2%	59.8%	53.3%	53.3%

Table 6. Probabilities of recovery for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2009	0	0	0	n/a	0	0	0	0	0
2010	0	0	0	n/a	0	0	0	0	0
2011	0	0	0	n/a	0	0	0	0	0
2012	0	0	0	n/a	0	0	0	0	0
2013	0	0	0	n/a	0	0	0	0	0
2014	0	0	0	n/a	0	0	0	0	0
2015	0	0	0	n/a	0	0	0	0	0
2016	0.005	0.005	0	n/a	0	0	0	0	0.005
2017	0.005	0.005	0.005	n/a	0.005	0	0	0	0.005
2018	0.005	0.005	0.005	n/a	0.005	0.002	0	0	0.005
2019	0.005	0.005	0.005	n/a	0.005	0.005	0	0	0.005
2020	0.005	0.027	0.005	n/a	0.005	0.005	0	0	0.027
2021	0.027	0.027	0.005	n/a	0.005	0.005	0.005	0.005	0.027
2022	0.027	0.027	0.027	n/a	0.027	0.005	0.005	0.005	0.027
2023	0.027	0.027	0.027	n/a	0.027	0.005	0.005	0.005	0.027
2024	0.027	0.027	0.027	n/a	0.027	0.005	0.005	0.005	0.062
2025	0.062	0.062	0.027	n/a	0.027	0.027	0.005	0.005	0.062
2026	0.062	0.062	0.062	n/a	0.027	0.027	0.005	0.005	0.062
2027	0.062	0.062	0.062	n/a	0.062	0.027	0.005	0.005	0.062
2028	0.062	0.062	0.062	n/a	0.062	0.027	0.005	0.007	0.107
2029	0.107	0.107	0.062	n/a	0.062	0.027	0.005	0.027	0.107
2030	0.107	0.107	0.062	n/a	0.062	0.027	0.027	0.027	0.159
2031	0.159	0.159	0.107	n/a	0.062	0.062	0.027	0.027	0.159
2032	0.159	0.159	0.107	n/a	0.107	0.062	0.027	0.027	0.159
2033	0.159	0.159	0.159	n/a	0.107	0.062	0.027	0.027	0.159
2034	0.159	0.159	0.159	n/a	0.147	0.062	0.027	0.027	0.159
2035	0.159	0.159	0.159	n/a	0.159	0.062	0.027	0.061	0.159
2036	0.159	0.159	0.159	n/a	0.159	0.062	0.027	0.062	0.159
2037	0.159	0.159	0.159	n/a	0.159	0.107	0.027	0.062	0.159
2038	0.159	0.159	0.159	n/a	0.159	0.107	0.062	0.062	0.216
2039	0.216	0.159	0.159	n/a	0.159	0.107	0.062	0.062	0.276
2040	0.216	0.216	0.159	n/a	0.159	0.12	0.062	0.062	0.276
2041	0.276	0.216	0.159	n/a	0.159	0.159	0.062	0.062	0.276
2042	0.276	0.276	0.216	n/a	0.159	0.159	0.062	0.107	0.276
2043	0.276	0.276	0.216	n/a	0.205	0.159	0.062	0.107	0.276
2044	0.276	0.276	0.276	n/a	0.216	0.159	0.062	0.107	0.276
2045	0.276	0.276	0.276	n/a	0.227	0.159	0.062	0.107	0.276
2046	0.276	0.276	0.276	n/a	0.276	0.159	0.107	0.138	0.276
2047	0.276	0.276	0.276	n/a	0.276	0.159	0.107	0.159	0.338
2048	0.276	0.276	0.276	n/a	0.276	0.159	0.107	0.159	0.338
2049	0.338	0.276	0.276	n/a	0.276	0.159	0.107	0.159	0.338
2050	0.338	0.276	0.276	n/a	0.276	0.159	0.107	0.159	0.388
2051	0.338	0.276	0.276	n/a	0.276	0.212	0.133	0.159	0.402
2052	0.338	0.338	0.276	n/a	0.276	0.216	0.159	0.159	0.402
2053	0.402	0.338	0.338	n/a	0.276	0.216	0.159	0.159	0.402

Table 6 (Continued). Probabilities of recovery for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2054	0.402	0.338	0.338	n/a	0.276	0.216	0.159	0.159	0.402
2055	0.402	0.338	0.338	n/a	0.338	0.276	0.159	0.159	0.424
2056	0.402	0.338	0.338	n/a	0.338	0.276	0.159	0.159	0.467
2057	0.402	0.402	0.376	n/a	0.338	0.276	0.159	0.189	0.467
2058	0.402	0.402	0.402	n/a	0.338	0.276	0.159	0.216	0.467
2059	0.467	0.402	0.402	n/a	0.338	0.276	0.159	0.216	0.467
2060	0.467	0.402	0.402	n/a	0.402	0.276	0.159	0.216	0.525
2061	0.467	0.402	0.402	n/a	0.402	0.276	0.159	0.216	0.533
2062	0.467	0.402	0.402	n/a	0.402	0.276	0.159	0.217	0.533
2063	0.467	0.402	0.402	n/a	0.402	0.276	0.159	0.275	0.533
2064	0.532	0.462	0.467	n/a	0.402	0.276	0.159	0.276	0.533
2065	0.533	0.467	0.467	n/a	0.402	0.276	0.175	0.276	0.533
2066	0.533	0.467	0.467	n/a	0.402	0.292	0.216	0.276	0.598
2067	0.533	0.467	0.467	n/a	0.467	0.338	0.216	0.276	0.598
2068	0.533	0.467	0.467	n/a	0.467	0.338	0.216	0.276	0.598
2069	0.533	0.467	0.467	n/a	0.467	0.338	0.216	0.276	0.598
2070	0.533	0.467	0.48	n/a	0.467	0.338	0.216	0.276	0.598
2071	0.598	0.512	0.533	n/a	0.467	0.338	0.216	0.276	0.598
2072	0.598	0.533	0.533	n/a	0.467	0.338	0.222	0.276	0.598
2073	0.598	0.533	0.533	n/a	0.467	0.338	0.274	0.276	0.662
2074	0.598	0.533	0.533	n/a	0.501	0.394	0.276	0.276	0.662
2075	0.598	0.533	0.533	n/a	0.533	0.402	0.276	0.276	0.662
2076	0.598	0.533	0.533	n/a	0.533	0.402	0.276	0.301	0.662
2077	0.598	0.533	0.533	n/a	0.533	0.402	0.276	0.338	0.662
2078	0.598	0.533	0.541	n/a	0.533	0.402	0.276	0.338	0.662
2079	0.662	0.533	0.598	n/a	0.533	0.402	0.276	0.338	0.662
2080	0.662	0.598	0.598	n/a	0.533	0.402	0.276	0.338	0.662
2081	0.662	0.598	0.598	n/a	0.533	0.402	0.276	0.338	0.702
2082	0.662	0.598	0.598	n/a	0.533	0.402	0.276	0.338	0.724
2083	0.662	0.598	0.598	n/a	0.565	0.402	0.276	0.338	0.724
2084	0.662	0.598	0.598	n/a	0.598	0.402	0.276	0.338	0.724
2085	0.662	0.598	0.598	n/a	0.598	0.465	0.276	0.338	0.724
2086	0.662	0.598	0.598	n/a	0.598	0.467	0.276	0.338	0.724
2087	0.662	0.598	0.598	n/a	0.598	0.467	0.276	0.338	0.724
2088	0.662	0.598	0.607	n/a	0.598	0.467	0.276	0.345	0.724
2089	0.724	0.598	0.662	n/a	0.598	0.467	0.276	0.391	0.724
2090	0.724	0.598	0.662	n/a	0.598	0.467	0.285	0.402	0.724
2091	0.724	0.662	0.662	n/a	0.598	0.467	0.333	0.402	0.724
2092	0.724	0.662	0.662	n/a	0.598	0.467	0.338	0.402	0.783
2093	0.724	0.662	0.662	n/a	0.598	0.467	0.338	0.402	0.784
2094	0.724	0.662	0.662	n/a	0.598	0.467	0.338	0.402	0.784
2095	0.724	0.662	0.662	n/a	0.662	0.467	0.338	0.402	0.784
2096	0.724	0.662	0.662	n/a	0.662	0.467	0.338	0.402	0.784
2097	0.724	0.662	0.662	n/a	0.662	0.5	0.338	0.402	0.784
2098	0.724	0.662	0.662	n/a	0.662	0.533	0.338	0.402	0.784

Table 7. Probabilities of recovery for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0.005	0	0	0	0
2017	0.005	0.005	0.005	0	0
2018	0.005	0.005	0.005	0.005	0.002
2019	0.005	0.005	0.005	0.005	0.005
2020	0.027	0.005	0.005	0.005	0.005
2021	0.027	0.005	0.005	0.005	0.005
2022	0.027	0.027	0.005	0.005	0.005
2023	0.027	0.027	0.027	0.005	0.005
2024	0.062	0.027	0.027	0.027	0.005
2025	0.062	0.027	0.027	0.027	0.027
2026	0.062	0.062	0.027	0.027	0.027
2027	0.062	0.062	0.027	0.027	0.027
2028	0.107	0.062	0.062	0.027	0.027
2029	0.107	0.062	0.062	0.027	0.027
2030	0.159	0.062	0.062	0.062	0.027
2031	0.159	0.107	0.062	0.062	0.062
2032	0.159	0.107	0.062	0.062	0.062
2033	0.159	0.159	0.107	0.062	0.062
2034	0.159	0.159	0.107	0.062	0.062
2035	0.159	0.159	0.107	0.082	0.062
2036	0.159	0.159	0.159	0.107	0.062
2037	0.159	0.159	0.159	0.107	0.107
2038	0.216	0.159	0.159	0.11	0.107
2039	0.276	0.159	0.159	0.159	0.107
2040	0.276	0.159	0.159	0.159	0.12
2041	0.276	0.159	0.159	0.159	0.159
2042	0.276	0.216	0.159	0.159	0.159
2043	0.276	0.216	0.159	0.159	0.159
2044	0.276	0.276	0.159	0.159	0.159
2045	0.276	0.276	0.215	0.159	0.159
2046	0.276	0.276	0.216	0.159	0.159
2047	0.338	0.276	0.216	0.159	0.159
2048	0.338	0.276	0.276	0.159	0.159
2049	0.338	0.276	0.276	0.216	0.159
2050	0.388	0.276	0.276	0.216	0.159
2051	0.402	0.276	0.276	0.216	0.212
2052	0.402	0.276	0.276	0.276	0.216
2053	0.402	0.338	0.276	0.276	0.216

Table 7 (Continued). Probabilities of recovery for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2054	0.402	0.338	0.276	0.276	0.216
2055	0.424	0.338	0.276	0.276	0.276
2056	0.467	0.338	0.276	0.276	0.276
2057	0.467	0.394	0.282	0.276	0.276
2058	0.467	0.402	0.338	0.276	0.276
2059	0.467	0.402	0.338	0.276	0.276
2060	0.525	0.402	0.338	0.276	0.276
2061	0.533	0.402	0.338	0.276	0.276
2062	0.533	0.402	0.338	0.276	0.276
2063	0.533	0.402	0.398	0.338	0.276
2064	0.533	0.467	0.402	0.338	0.276
2065	0.533	0.467	0.402	0.338	0.276
2066	0.598	0.467	0.402	0.338	0.292
2067	0.598	0.467	0.402	0.338	0.338
2068	0.598	0.467	0.402	0.338	0.338
2069	0.598	0.467	0.402	0.35	0.338
2070	0.598	0.501	0.402	0.402	0.338
2071	0.598	0.533	0.466	0.402	0.338
2072	0.598	0.533	0.467	0.402	0.338
2073	0.662	0.533	0.467	0.402	0.338
2074	0.662	0.533	0.467	0.402	0.394
2075	0.662	0.533	0.467	0.402	0.402
2076	0.662	0.533	0.467	0.402	0.402
2077	0.662	0.533	0.467	0.402	0.402
2078	0.662	0.573	0.467	0.402	0.402
2079	0.662	0.598	0.5	0.467	0.402
2080	0.662	0.598	0.533	0.467	0.402
2081	0.702	0.598	0.533	0.467	0.402
2082	0.724	0.598	0.533	0.467	0.402
2083	0.724	0.598	0.533	0.467	0.402
2084	0.724	0.598	0.533	0.467	0.402
2085	0.724	0.598	0.533	0.467	0.465
2086	0.724	0.598	0.533	0.467	0.467
2087	0.724	0.598	0.533	0.467	0.467
2088	0.724	0.631	0.533	0.467	0.467
2089	0.724	0.662	0.533	0.5	0.467
2090	0.724	0.662	0.598	0.533	0.467
2091	0.724	0.662	0.598	0.533	0.467
2092	0.783	0.662	0.598	0.533	0.467
2093	0.784	0.662	0.598	0.533	0.467
2094	0.784	0.662	0.598	0.533	0.467
2095	0.784	0.662	0.598	0.533	0.467
2096	0.784	0.662	0.598	0.533	0.467
2097	0.784	0.662	0.598	0.533	0.5
2098	0.784	0.662	0.598	0.533	0.533

Table 8. Spawning biomass relative to target for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2009	0.112	0.112	0.112	n/a	0.112	0.112	0.112	0.112	0.112
2010	0.117	0.117	0.117	n/a	0.117	0.117	0.117	0.117	0.117
2011	0.123	0.123	0.123	n/a	0.123	0.123	0.123	0.123	0.123
2012	0.130	0.129	0.129	n/a	0.129	0.128	0.126	0.130	0.130
2013	0.136	0.135	0.135	n/a	0.134	0.132	0.130	0.137	0.137
2014	0.143	0.141	0.141	n/a	0.141	0.137	0.134	0.145	0.145
2015	0.151	0.148	0.148	n/a	0.147	0.142	0.138	0.153	0.153
2016	0.159	0.155	0.155	n/a	0.154	0.147	0.142	0.161	0.161
2017	0.167	0.162	0.163	n/a	0.160	0.153	0.146	0.170	0.170
2018	0.175	0.170	0.170	n/a	0.168	0.159	0.151	0.179	0.179
2019	0.184	0.178	0.178	n/a	0.175	0.165	0.156	0.189	0.189
2020	0.194	0.186	0.187	n/a	0.183	0.171	0.161	0.199	0.199
2021	0.204	0.195	0.196	n/a	0.192	0.178	0.166	0.210	0.210
2022	0.214	0.204	0.205	n/a	0.201	0.185	0.172	0.221	0.221
2023	0.225	0.213	0.215	n/a	0.210	0.192	0.178	0.232	0.232
2024	0.236	0.223	0.224	n/a	0.219	0.200	0.184	0.245	0.245
2025	0.247	0.233	0.235	n/a	0.229	0.208	0.190	0.257	0.257
2026	0.259	0.244	0.245	n/a	0.239	0.216	0.197	0.270	0.270
2027	0.272	0.255	0.256	n/a	0.249	0.224	0.203	0.283	0.284
2028	0.284	0.266	0.268	n/a	0.260	0.232	0.210	0.295	0.298
2029	0.298	0.278	0.280	n/a	0.271	0.241	0.217	0.308	0.312
2030	0.312	0.290	0.292	n/a	0.282	0.250	0.224	0.321	0.328
2031	0.326	0.302	0.304	n/a	0.294	0.259	0.231	0.334	0.343
2032	0.341	0.315	0.317	n/a	0.306	0.268	0.238	0.347	0.359
2033	0.356	0.328	0.331	n/a	0.319	0.278	0.245	0.360	0.376
2034	0.371	0.341	0.344	n/a	0.331	0.287	0.253	0.373	0.394
2035	0.387	0.355	0.358	n/a	0.344	0.297	0.260	0.386	0.411
2036	0.404	0.369	0.373	n/a	0.358	0.307	0.268	0.399	0.430
2037	0.421	0.384	0.387	n/a	0.371	0.317	0.276	0.412	0.449
2038	0.439	0.398	0.402	n/a	0.385	0.328	0.284	0.425	0.468
2039	0.456	0.414	0.418	n/a	0.400	0.338	0.292	0.437	0.488
2040	0.475	0.429	0.434	n/a	0.414	0.349	0.300	0.450	0.509
2041	0.493	0.445	0.450	n/a	0.429	0.360	0.308	0.463	0.530
2042	0.513	0.461	0.466	n/a	0.444	0.371	0.316	0.476	0.551
2043	0.532	0.477	0.483	n/a	0.460	0.383	0.325	0.489	0.573
2044	0.552	0.494	0.500	n/a	0.475	0.394	0.333	0.502	0.596
2045	0.572	0.511	0.517	n/a	0.491	0.406	0.342	0.514	0.619
2046	0.593	0.528	0.535	n/a	0.507	0.418	0.350	0.527	0.642
2047	0.614	0.546	0.552	n/a	0.524	0.430	0.359	0.539	0.666
2048	0.635	0.564	0.571	n/a	0.540	0.442	0.368	0.551	0.690
2049	0.657	0.581	0.589	n/a	0.557	0.454	0.377	0.563	0.714
2050	0.679	0.600	0.607	n/a	0.574	0.466	0.386	0.575	0.739
2051	0.701	0.618	0.626	n/a	0.592	0.478	0.395	0.587	0.764
2052	0.724	0.637	0.645	n/a	0.609	0.491	0.404	0.599	0.790
2053	0.746	0.655	0.664	n/a	0.626	0.503	0.413	0.610	0.816

Table 8 (Continued). Spawning biomass relative to target for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2054	0.769	0.674	0.684	n/a	0.644	0.516	0.422	0.622	0.842
2055	0.792	0.693	0.703	n/a	0.662	0.529	0.432	0.633	0.868
2056	0.816	0.713	0.723	n/a	0.680	0.541	0.441	0.644	0.895
2057	0.839	0.732	0.742	n/a	0.698	0.554	0.450	0.655	0.921
2058	0.862	0.751	0.762	n/a	0.716	0.567	0.459	0.665	0.948
2059	0.886	0.770	0.781	n/a	0.734	0.579	0.468	0.675	0.975
2060	0.910	0.790	0.801	n/a	0.752	0.592	0.478	0.685	1.002
2061	0.933	0.809	0.821	n/a	0.770	0.605	0.487	0.695	1.029
2062	0.957	0.829	0.841	n/a	0.788	0.618	0.496	0.705	1.056
2063	0.981	0.848	0.861	n/a	0.806	0.631	0.505	0.714	1.084
2064	1.005	0.867	0.881	n/a	0.824	0.643	0.514	0.724	1.111
2065	1.028	0.887	0.900	n/a	0.842	0.656	0.524	0.733	1.138
2066	1.052	0.906	0.920	n/a	0.860	0.669	0.533	0.742	1.165
2067	1.076	0.925	0.940	n/a	0.878	0.681	0.542	0.750	1.192
2068	1.099	0.944	0.959	n/a	0.896	0.694	0.551	0.759	1.219
2069	1.122	0.963	0.979	n/a	0.913	0.706	0.560	0.767	1.246
2070	1.145	0.982	0.998	n/a	0.931	0.719	0.568	0.775	1.273
2071	1.169	1.001	1.017	n/a	0.949	0.731	0.577	0.783	1.299
2072	1.191	1.020	1.036	n/a	0.966	0.743	0.586	0.790	1.325
2073	1.214	1.038	1.055	n/a	0.983	0.755	0.595	0.797	1.352
2074	1.237	1.056	1.074	n/a	1.000	0.767	0.603	0.805	1.378
2075	1.259	1.074	1.092	n/a	1.017	0.779	0.612	0.811	1.403
2076	1.281	1.092	1.110	n/a	1.034	0.791	0.620	0.818	1.429
2077	1.303	1.110	1.128	n/a	1.050	0.802	0.629	0.825	1.454
2078	1.324	1.128	1.146	n/a	1.066	0.814	0.637	0.831	1.478
2079	1.346	1.145	1.164	n/a	1.082	0.825	0.645	0.837	1.503
2080	1.366	1.162	1.181	n/a	1.098	0.836	0.653	0.843	1.527
2081	1.387	1.179	1.199	n/a	1.114	0.847	0.661	0.849	1.551
2082	1.407	1.195	1.215	n/a	1.129	0.858	0.669	0.854	1.575
2083	1.428	1.212	1.232	n/a	1.144	0.869	0.677	0.859	1.598
2084	1.447	1.228	1.249	n/a	1.159	0.879	0.684	0.865	1.621
2085	1.467	1.243	1.265	n/a	1.174	0.889	0.692	0.870	1.643
2086	1.486	1.259	1.280	n/a	1.188	0.899	0.699	0.875	1.665
2087	1.505	1.274	1.296	n/a	1.202	0.909	0.706	0.879	1.687
2088	1.523	1.289	1.311	n/a	1.216	0.919	0.713	0.884	1.709
2089	1.541	1.304	1.326	n/a	1.230	0.929	0.721	0.888	1.730
2090	1.559	1.318	1.341	n/a	1.244	0.939	0.728	0.893	1.750
2091	1.577	1.332	1.356	n/a	1.257	0.948	0.734	0.897	1.771
2092	1.594	1.346	1.370	n/a	1.270	0.957	0.741	0.901	1.790
2093	1.611	1.360	1.384	n/a	1.282	0.966	0.748	0.904	1.810
2094	1.627	1.373	1.397	n/a	1.295	0.975	0.754	0.908	1.829
2095	1.643	1.386	1.410	n/a	1.307	0.983	0.760	0.912	1.847
2096	1.659	1.399	1.424	n/a	1.319	0.992	0.767	0.915	1.866
2097	1.674	1.411	1.436	n/a	1.330	1.000	0.773	0.918	1.884
2098	1.689	1.423	1.449	n/a	1.342	1.008	0.779	0.921	1.901

Table 9. Spawning biomass relative to target for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2009	0.112	0.112	0.112	0.112	0.112
2010	0.117	0.117	0.117	0.117	0.117
2011	0.123	0.123	0.123	0.123	0.123
2012	0.130	0.129	0.128	0.128	0.128
2013	0.137	0.135	0.134	0.133	0.132
2014	0.145	0.142	0.139	0.138	0.137
2015	0.153	0.148	0.145	0.143	0.142
2016	0.161	0.155	0.152	0.149	0.147
2017	0.170	0.163	0.158	0.155	0.153
2018	0.179	0.170	0.165	0.161	0.159
2019	0.189	0.179	0.172	0.168	0.165
2020	0.199	0.187	0.180	0.174	0.171
2021	0.210	0.196	0.188	0.182	0.178
2022	0.221	0.205	0.196	0.189	0.185
2023	0.232	0.215	0.204	0.197	0.192
2024	0.245	0.225	0.213	0.205	0.200
2025	0.257	0.235	0.222	0.213	0.208
2026	0.270	0.246	0.232	0.222	0.216
2027	0.284	0.257	0.242	0.230	0.224
2028	0.298	0.268	0.252	0.239	0.232
2029	0.312	0.280	0.262	0.248	0.241
2030	0.328	0.292	0.272	0.258	0.250
2031	0.343	0.305	0.283	0.268	0.259
2032	0.359	0.318	0.295	0.278	0.268
2033	0.376	0.331	0.306	0.288	0.278
2034	0.394	0.345	0.318	0.298	0.287
2035	0.411	0.359	0.330	0.309	0.297
2036	0.430	0.373	0.342	0.320	0.307
2037	0.449	0.388	0.355	0.331	0.317
2038	0.468	0.403	0.368	0.342	0.328
2039	0.488	0.418	0.381	0.353	0.338
2040	0.509	0.434	0.394	0.365	0.349
2041	0.530	0.450	0.408	0.377	0.360
2042	0.551	0.467	0.422	0.389	0.371
2043	0.573	0.483	0.436	0.402	0.383
2044	0.596	0.501	0.450	0.414	0.394
2045	0.619	0.518	0.465	0.427	0.406
2046	0.642	0.536	0.479	0.440	0.418
2047	0.666	0.553	0.494	0.452	0.430
2048	0.690	0.572	0.510	0.466	0.442
2049	0.714	0.590	0.525	0.479	0.454
2050	0.739	0.608	0.540	0.492	0.466
2051	0.764	0.627	0.556	0.506	0.478
2052	0.790	0.646	0.572	0.519	0.491
2053	0.816	0.665	0.588	0.533	0.503

Table 9 (Continued). Spawning biomass relative to target for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2054	0.842	0.685	0.604	0.547	0.516
2055	0.868	0.704	0.620	0.561	0.529
2056	0.895	0.724	0.636	0.575	0.541
2057	0.921	0.744	0.652	0.589	0.554
2058	0.948	0.763	0.669	0.602	0.567
2059	0.975	0.783	0.685	0.616	0.579
2060	1.002	0.803	0.701	0.631	0.592
2061	1.029	0.823	0.718	0.644	0.605
2062	1.056	0.843	0.734	0.658	0.618
2063	1.084	0.862	0.750	0.673	0.631
2064	1.111	0.882	0.767	0.687	0.643
2065	1.138	0.902	0.783	0.700	0.656
2066	1.165	0.922	0.799	0.714	0.669
2067	1.192	0.942	0.815	0.728	0.681
2068	1.219	0.961	0.832	0.742	0.694
2069	1.246	0.981	0.847	0.756	0.706
2070	1.273	1.000	0.863	0.769	0.719
2071	1.299	1.019	0.879	0.783	0.731
2072	1.325	1.038	0.895	0.796	0.743
2073	1.352	1.057	0.910	0.809	0.755
2074	1.378	1.076	0.926	0.822	0.767
2075	1.403	1.094	0.941	0.835	0.779
2076	1.429	1.113	0.956	0.848	0.791
2077	1.454	1.131	0.971	0.861	0.802
2078	1.478	1.149	0.985	0.873	0.814
2079	1.503	1.167	1.000	0.886	0.825
2080	1.527	1.184	1.014	0.898	0.836
2081	1.551	1.201	1.028	0.910	0.847
2082	1.575	1.218	1.042	0.922	0.858
2083	1.598	1.235	1.056	0.934	0.869
2084	1.621	1.251	1.069	0.945	0.879
2085	1.643	1.268	1.083	0.957	0.889
2086	1.665	1.283	1.096	0.968	0.899
2087	1.687	1.299	1.108	0.979	0.909
2088	1.709	1.314	1.121	0.989	0.919
2089	1.730	1.329	1.133	1.000	0.929
2090	1.750	1.344	1.146	1.011	0.939
2091	1.771	1.359	1.158	1.021	0.948
2092	1.790	1.373	1.169	1.031	0.957
2093	1.810	1.387	1.181	1.040	0.966
2094	1.829	1.401	1.192	1.050	0.975
2095	1.847	1.414	1.203	1.060	0.983
2096	1.866	1.427	1.213	1.069	0.992
2097	1.884	1.440	1.224	1.078	1.000
2098	1.901	1.452	1.234	1.087	1.008

Table 10. Median catch for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2009	2	2	2	2	2	2	2	2	2
2010	2	2	2	2	2	2	2	2	2
2011	0.8	2.0	1.9	n/a	2.4	4.4	6.2	0	0
2012	0.9	2.1	2.0	n/a	2.5	4.6	6.4	0	0
2013	0.9	2.2	2.1	n/a	2.6	4.8	6.6	0	0
2014	0.9	2.3	2.2	n/a	2.8	4.9	6.8	0	0
2015	1.0	2.4	2.3	n/a	2.9	5.1	7.0	0	0
2016	1.0	2.5	2.4	n/a	3.0	5.3	7.2	0	0
2017	1.1	2.6	2.5	n/a	3.1	5.5	7.4	0	0
2018	1.2	2.8	2.6	n/a	3.3	5.7	7.6	0	0
2019	1.2	2.9	2.7	n/a	3.4	5.9	7.9	0	0
2020	1.3	3.0	2.8	n/a	3.6	6.1	8.2	0	0
2021	1.3	3.2	3.0	n/a	3.8	6.4	8.4	0	0
2022	1.4	3.3	3.1	n/a	3.9	6.6	8.7	0	0
2023	1.5	3.5	3.3	n/a	4.1	6.9	9.0	0	0
2024	1.5	3.6	3.4	n/a	4.3	7.2	9.3	0	0
2025	1.6	3.8	3.6	n/a	4.5	7.5	9.6	0.5	0
2026	1.7	4.0	3.7	n/a	4.7	7.7	10.0	1.3	0
2027	1.8	4.1	3.9	n/a	4.9	8.0	10.3	2.2	0
2028	1.9	4.3	4.1	n/a	5.1	8.3	10.6	3.1	0
2029	2.0	4.5	4.3	n/a	5.3	8.6	11.0	3.9	0
2030	2.0	4.7	4.4	n/a	5.5	9.0	11.3	4.8	0
2031	2.1	4.9	4.6	n/a	5.8	9.3	11.7	5.7	0
2032	2.2	5.1	4.8	n/a	6.0	9.6	12.1	6.5	0
2033	2.3	5.3	5.0	n/a	6.2	10.0	12.4	7.4	0
2034	2.4	5.5	5.2	n/a	6.5	10.3	12.8	8.3	0
2035	2.5	5.7	5.5	n/a	6.7	10.7	13.2	9.2	0
2036	2.7	6.0	5.7	n/a	7.0	11.0	13.6	10.0	0
2037	2.8	6.2	5.9	n/a	7.3	11.4	14.0	10.9	0
2038	2.9	6.4	6.1	n/a	7.5	11.8	14.4	11.8	0
2039	3.0	6.7	6.4	n/a	7.8	12.1	14.8	12.6	0
2040	3.1	6.9	6.6	n/a	8.1	12.5	15.2	13.5	0
2041	3.2	7.0	6.8	n/a	8.4	12.9	15.6	14.4	0
2042	3.4	7.2	7.1	n/a	8.7	13.3	16.0	15.3	0
2043	3.5	7.3	7.3	n/a	9.0	13.7	16.4	16.1	0
2044	3.6	7.4	7.6	n/a	9.3	14.1	16.9	17.0	0
2045	3.8	7.5	7.9	n/a	9.6	14.6	17.3	17.8	0
2046	3.9	7.6	8.1	n/a	9.9	15.0	17.7	18.7	0
2047	4.0	7.8	8.4	n/a	10.3	15.4	18.2	19.5	0
2048	4.2	8.0	8.7	n/a	10.6	15.8	18.6	20.3	0
2049	4.3	8.3	9.0	n/a	10.9	16.3	19.1	21.1	0
2050	4.5	8.6	9.2	n/a	11.2	16.7	19.5	21.9	0
2051	4.6	8.8	9.5	n/a	11.6	17.2	20.0	22.7	0
2052	4.8	9.1	9.8	n/a	11.9	17.6	20.5	23.5	0
2053	4.9	9.3	10.1	n/a	12.3	18.1	20.9	24.3	0

Table 10 (Continued). Median catch for model runs 1-8 (see text for descriptions of individual runs).

	Run								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7 (ABC)**	**7 (40:10)**	**8**
2054	5.1	9.6	10.4	n/a	12.6	18.5	21.4	25.1	0
2055	5.2	9.9	10.7	n/a	13.0	19.0	21.8	25.8	0
2056	5.4	10.1	11.0	n/a	13.3	19.4	22.3	26.6	0
2057	5.5	10.3	11.3	n/a	13.6	19.9	22.8	27.3	0
2058	5.7	10.4	11.6	n/a	14.0	20.3	23.2	28.0	0
2059	5.8	10.5	11.9	n/a	14.4	20.8	23.7	28.7	0
2060	6.0	10.5	12.2	n/a	14.7	21.2	24.2	29.4	0
2061	6.1	10.6	12.5	n/a	15.1	21.7	24.6	30.0	0
2062	6.3	10.7	12.8	n/a	15.4	22.2	25.1	30.7	0
2063	6.4	10.8	13.1	n/a	15.8	22.6	25.6	31.3	0
2064	6.6	10.9	13.4	n/a	16.1	23.1	26.0	31.9	0
2065	6.7	11.0	13.7	n/a	16.5	23.5	26.5	32.5	0
2066	6.9	11.2	14.0	n/a	16.8	24.0	27.0	33.1	0
2067	7.1	11.4	14.3	n/a	17.2	24.4	27.4	33.7	0
2068	7.2	11.7	14.6	n/a	17.5	24.9	27.9	34.3	0
2069	7.4	11.9	14.9	n/a	17.9	25.3	28.3	34.8	0
2070	7.5	12.2	15.2	n/a	18.2	25.8	28.8	35.4	0
2071	7.7	12.5	15.5	n/a	18.5	26.2	29.2	35.9	0
2072	7.8	12.7	15.7	n/a	18.9	26.6	29.6	36.4	0
2073	8.0	13.0	16.0	n/a	19.2	27.1	30.1	36.9	0
2074	8.1	13.2	16.3	n/a	19.5	27.5	30.5	37.4	0
2075	8.3	13.5	16.6	n/a	19.9	27.9	31.0	37.8	0
2076	8.4	13.8	16.9	n/a	20.2	28.3	31.4	38.3	0
2077	8.5	14.0	17.1	n/a	20.5	28.8	31.8	38.7	0
2078	8.7	14.3	17.4	n/a	20.8	29.2	32.2	39.1	0
2079	8.8	14.6	17.7	n/a	21.1	29.6	32.6	39.6	0
2080	9.0	14.8	17.9	n/a	21.5	30.0	33.0	39.9	0
2081	9.1	15.1	18.2	n/a	21.8	30.4	33.4	40.3	0
2082	9.2	15.3	18.5	n/a	22.1	30.7	33.8	40.7	0
2083	9.4	15.6	18.7	n/a	22.4	31.1	34.2	41.1	0
2084	9.5	15.9	19.0	n/a	22.6	31.5	34.6	41.4	0
2085	9.6	16.1	19.2	n/a	22.9	31.9	35.0	41.8	0
2086	9.7	16.4	19.4	n/a	23.2	32.2	35.4	42.1	0
2087	9.9	16.6	19.7	n/a	23.5	32.6	35.7	42.4	0
2088	10.0	16.9	19.9	n/a	23.8	32.9	36.1	42.7	0
2089	10.1	17.2	20.1	n/a	24.0	33.3	36.4	43.0	0
2090	10.2	17.3	20.4	n/a	24.3	33.6	36.8	43.3	0
2091	10.3	17.3	20.6	n/a	24.5	34.0	37.1	43.6	0
2092	10.4	17.4	20.8	n/a	24.8	34.3	37.5	43.8	0
2093	10.5	17.5	21.0	n/a	25.0	34.6	37.8	44.1	0
2094	10.7	17.5	21.2	n/a	25.3	34.9	38.1	44.3	0
2095	10.8	17.6	21.4	n/a	25.5	35.2	38.4	44.6	0
2096	10.9	17.6	21.6	n/a	25.7	35.5	38.8	44.8	0
2097	11.0	17.7	21.8	n/a	26.0	35.8	39.1	45.0	0
2098	11.1	17.7	22.0	n/a	26.2	36.1	39.4	45.2	0

Table 11. Median catch for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2009	2	2	2	2	2
2010	2	2	2	2	2
2011	0	1.9	3.0	3.9	4.4
2012	0	2.0	3.1	4.0	4.6
2013	0	2.0	3.3	4.2	4.8
2014	0	2.1	3.4	4.4	4.9
2015	0	2.2	3.5	4.5	5.1
2016	0	2.3	3.7	4.7	5.3
2017	0	2.5	3.9	4.9	5.5
2018	0	2.6	4.0	5.1	5.7
2019	0	2.7	4.2	5.3	5.9
2020	0	2.8	4.4	5.5	6.1
2021	0	3.0	4.6	5.7	6.4
2022	0	3.1	4.8	6.0	6.6
2023	0	3.2	5.0	6.2	6.9
2024	0	3.4	5.2	6.5	7.2
2025	0	3.5	5.4	6.7	7.5
2026	0	3.7	5.6	7.0	7.7
2027	0	3.9	5.9	7.3	8.0
2028	0	4.0	6.1	7.6	8.3
2029	0	4.2	6.4	7.9	8.6
2030	0	4.4	6.6	8.2	9.0
2031	0	4.6	6.9	8.5	9.3
2032	0	4.8	7.2	8.8	9.6
2033	0	5.0	7.4	9.1	10.0
2034	0	5.2	7.7	9.4	10.3
2035	0	5.4	8.0	9.8	10.7
2036	0	5.6	8.3	10.1	11.0
2037	0	5.8	8.6	10.5	11.4
2038	0	6.1	8.9	10.8	11.8
2039	0	6.3	9.3	11.2	12.1
2040	0	6.5	9.6	11.5	12.5
2041	0	6.8	9.9	11.9	12.9
2042	0	7.0	10.3	12.3	13.3
2043	0	7.3	10.6	12.7	13.7
2044	0	7.5	10.9	13.1	14.1
2045	0	7.8	11.3	13.5	14.6
2046	0	8.1	11.7	13.9	15.0
2047	0	8.3	12.0	14.3	15.4
2048	0	8.6	12.4	14.7	15.8
2049	0	8.9	12.8	15.1	16.3
2050	0	9.2	13.1	15.6	16.7
2051	0	9.5	13.5	16.0	17.2
2052	0	9.7	13.9	16.4	17.6
2053	0	10.0	14.3	16.8	18.1

Table 11 (Continued). Median catch for model runs 9a – 9e (see text for descriptions of individual runs).

	Run				
Year	**9a**	**9b**	**9c**	**9d**	**9e**
2054	0	10.3	14.7	17.3	18.5
2055	0	10.6	15.1	17.7	19.0
2056	0	10.9	15.5	18.2	19.4
2057	0	11.2	15.9	18.6	19.9
2058	0	11.5	16.3	19.0	20.3
2059	0	11.8	16.6	19.5	20.8
2060	0	12.1	17.0	19.9	21.2
2061	0	12.4	17.4	20.4	21.7
2062	0	12.7	17.8	20.8	22.2
2063	0	13.0	18.2	21.2	22.6
2064	0	13.3	18.6	21.7	23.1
2065	0	13.6	19.0	22.1	23.5
2066	0	13.9	19.4	22.6	24.0
2067	0	14.2	19.8	23.0	24.4
2068	0	14.5	20.2	23.4	24.9
2069	0	14.8	20.6	23.9	25.3
2070	0	15.1	21.0	24.3	25.8
2071	0	15.3	21.4	24.7	26.2
2072	0	15.6	21.7	25.1	26.6
2073	0	15.9	22.1	25.5	27.1
2074	0	16.2	22.5	26.0	27.5
2075	0	16.5	22.9	26.4	27.9
2076	0	16.8	23.2	26.8	28.3
2077	0	17.0	23.6	27.2	28.8
2078	0	17.3	23.9	27.6	29.2
2079	0	17.6	24.3	28.0	29.6
2080	0	17.8	24.6	28.3	30.0
2081	0	18.1	25.0	28.7	30.4
2082	0	18.3	25.3	29.1	30.7
2083	0	18.6	25.6	29.5	31.1
2084	0	18.8	26.0	29.8	31.5
2085	0	19.1	26.3	30.2	31.9
2086	0	19.3	26.6	30.5	32.2
2087	0	19.5	26.9	30.9	32.6
2088	0	19.8	27.2	31.2	32.9
2089	0	20.0	27.5	31.5	33.3
2090	0	20.2	27.8	31.9	33.6
2091	0	20.4	28.1	32.2	34.0
2092	0	20.6	28.4	32.5	34.3
2093	0	20.9	28.6	32.8	34.6
2094	0	21.1	28.9	33.1	34.9
2095	0	21.3	29.2	33.4	35.2
2096	0	21.5	29.4	33.7	35.5
2097	0	21.6	29.7	34.0	35.8
2098	0	21.8	29.9	34.3	36.1

Fig. 1. Frequency distribution for twenty-one fixed steepness values used to characterize uncertainty in rebuilding projections. Steepness values are the midpoints of the bins.

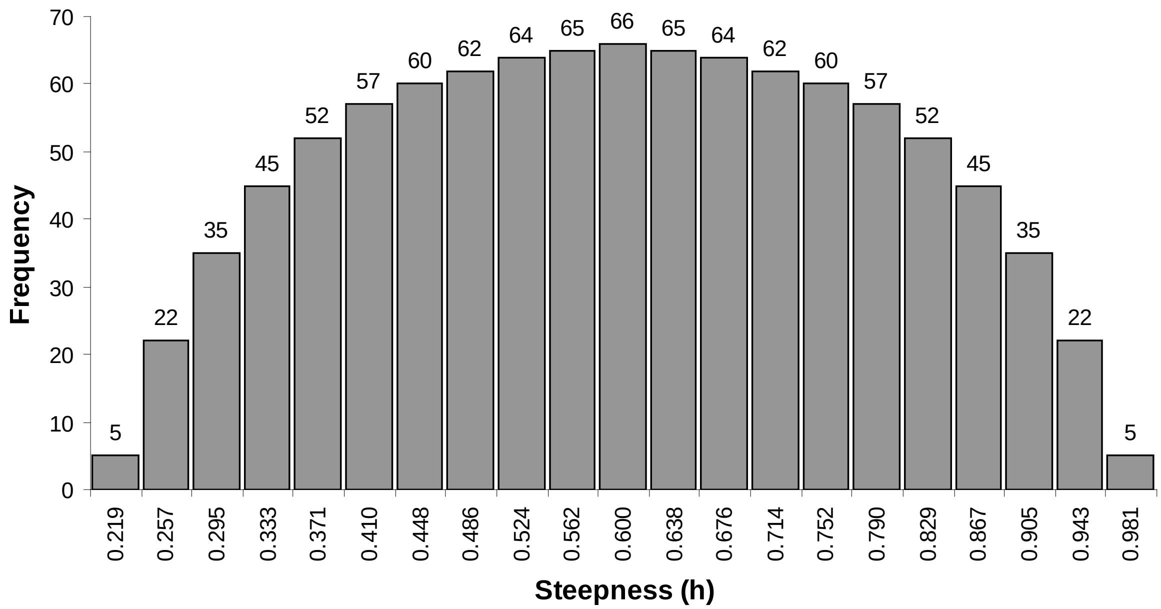


Fig. 2. Projected probability of being above target biomass, runs 1-8.

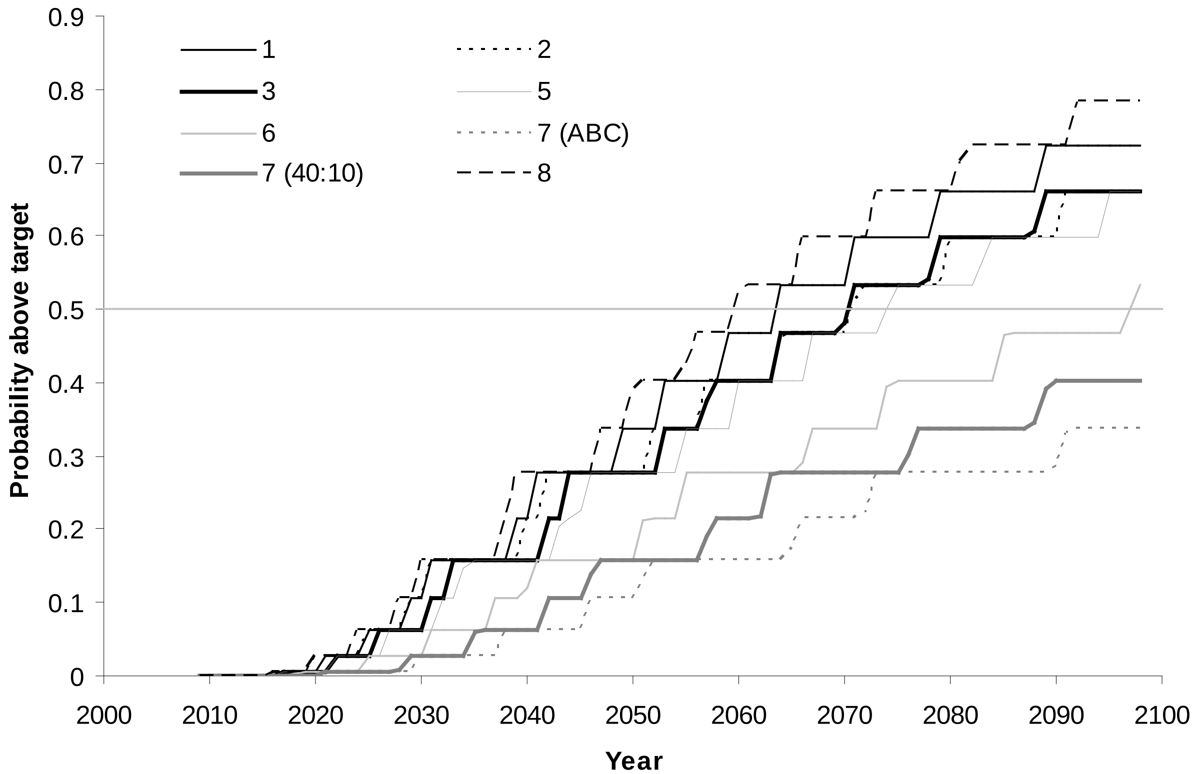


Fig. 3. Projected probability of being above target biomass, runs 9a – 9e.

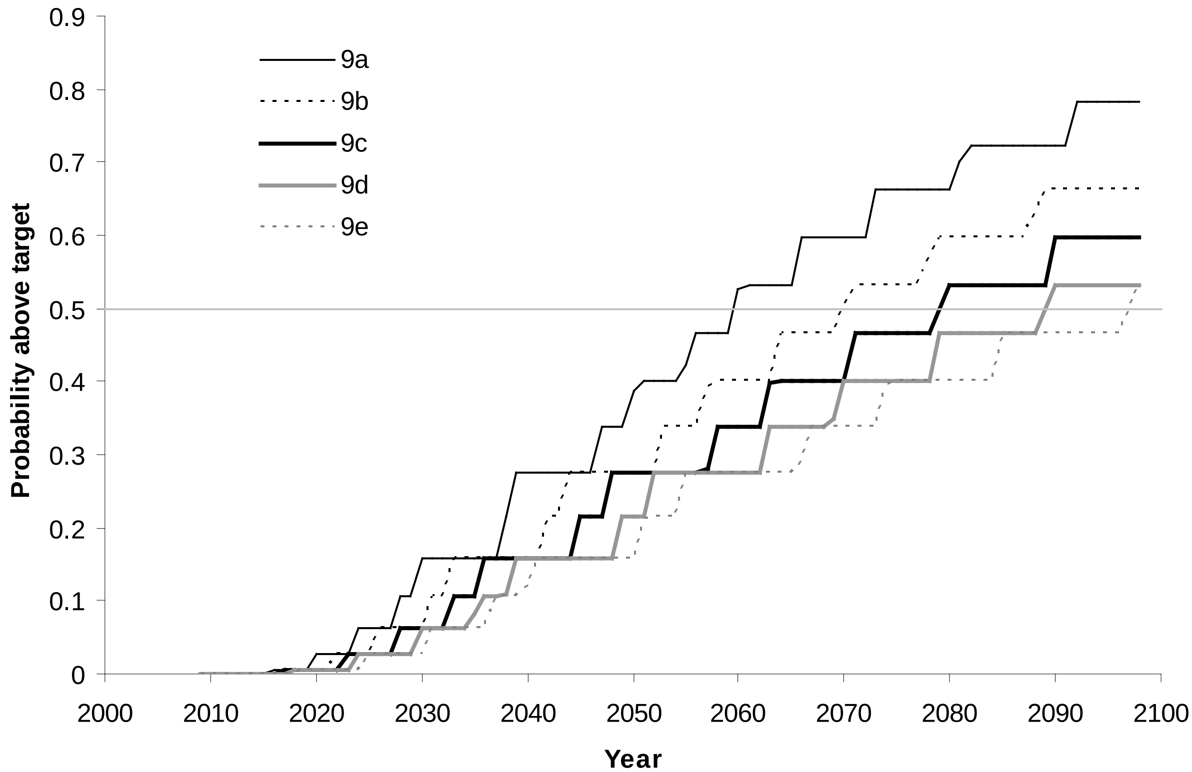


Fig. 4. Projections of median spawning biomass relative to target biomass for runs 1-8

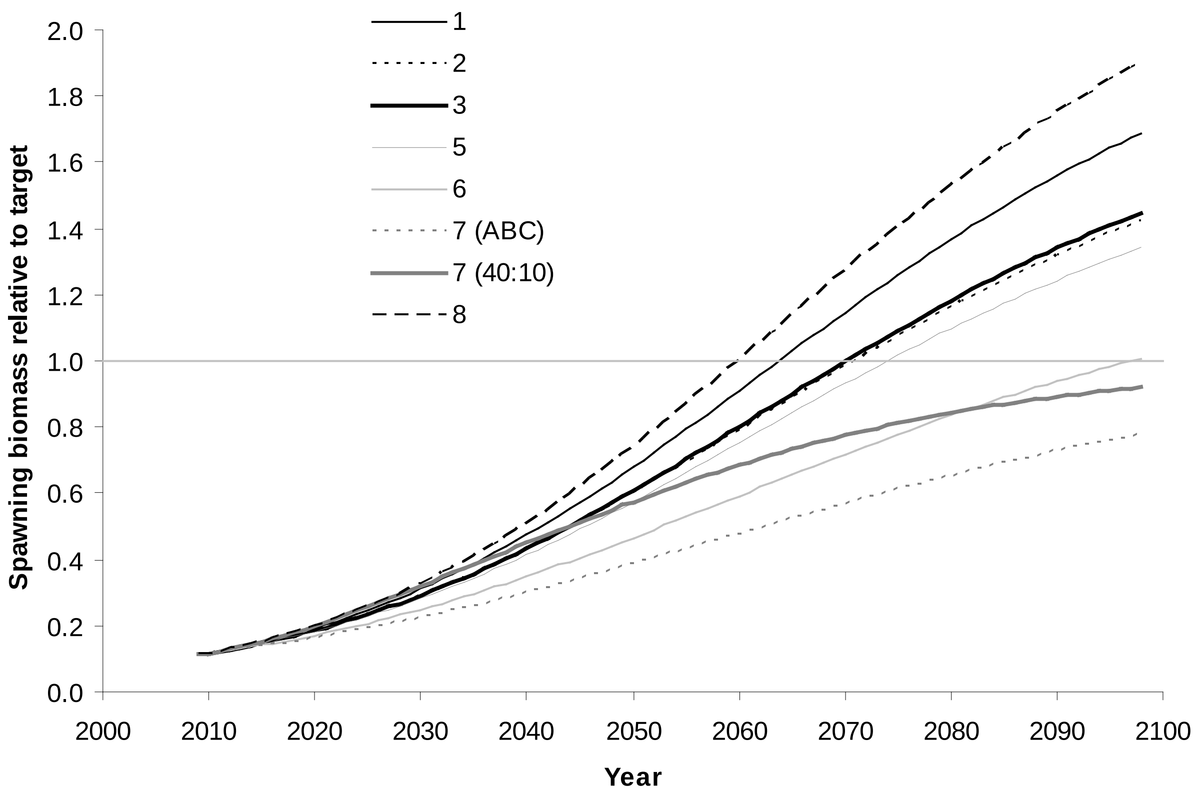


Fig. 5. Projections of median spawning biomass relative to target biomass for runs 9a – 9e.

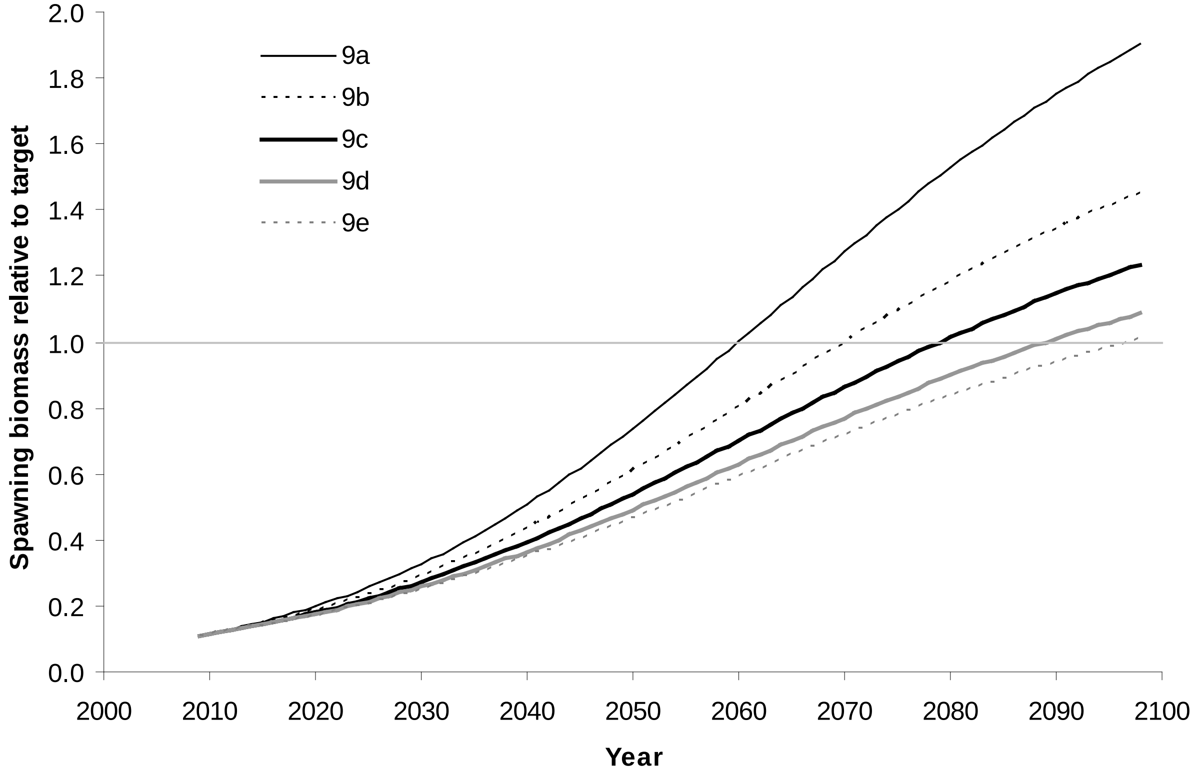


Fig. 6. Projections of median catch for runs 1-8

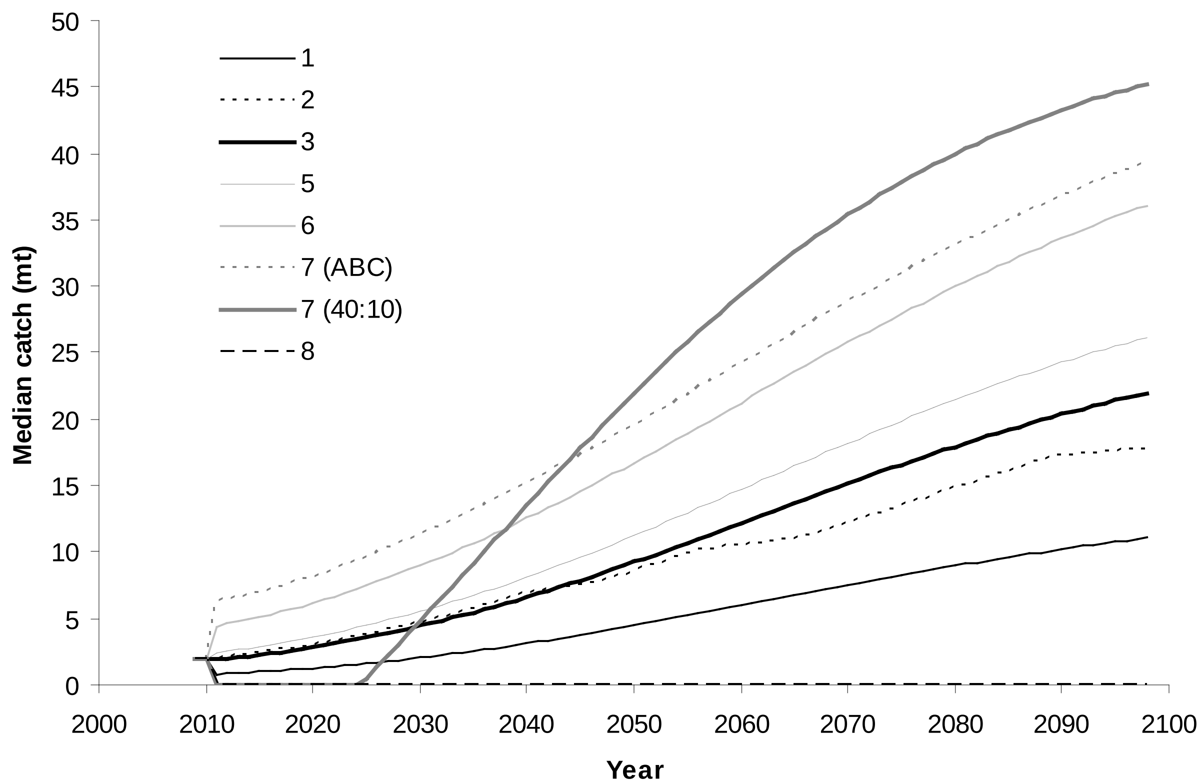
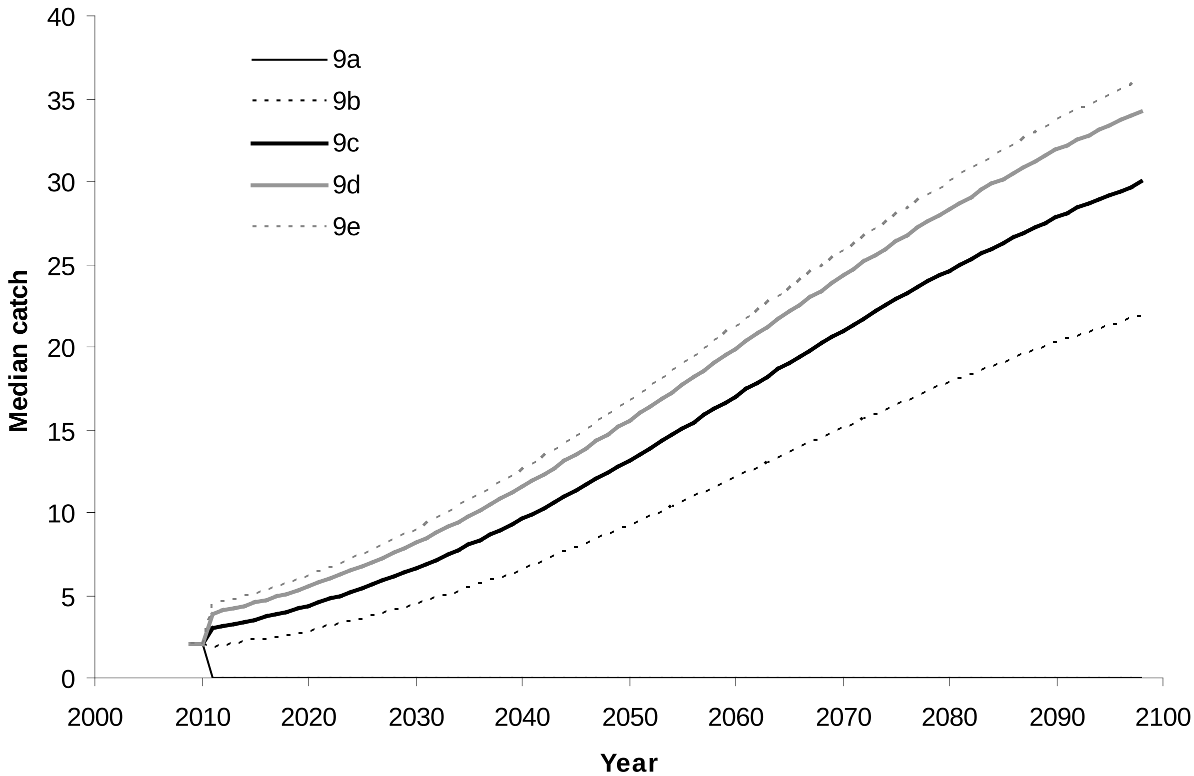


Fig. 7. Projections of median catch for runs 9a – 9e.



Rebuild.dat file for run 1

```
#Title #runnumber: 1 moo4_base.dat moo4_base.ctl 17.983 4366.67 206.34
Cowcod rebuilding analysis 2009 -- F90% harvest rate
# Number of sexes
1
# Age range to consider (minimum age; maximum age)
0 80
# Number of fleets
2
# First year of projection (Yinit)
2009
# First Year of rebuilding period (Ydecl)
2000
# 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)
3
# Constant fishing mortality (1) or constant Catch (2) projections
1
# Fishing mortality based on SPR (1) or actual rate (2)
1
# Pre-specify the year of recovery (or -1) to ignore
-1
# Fecundity-at-age
# 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 #runnumber: 1
moo4_base.dat moo4_base.ctl 17.983 4366.67 206.34
 0 1.27093e-007 3.34807e-006 9.01415e-005 0.00126286 0.00873566 0.0350091 0.0961502
0.203967 0.361596 0.564146 0.801836 1.06323 1.33757 1.61611 1.89259 2.16318 2.42614
2.68117 2.92888 3.17027 3.40632 3.6378 3.86519 4.08867 4.30823 4.5237 4.73487 4.94148
5.14331 5.34016 5.53186 5.71826 5.89927 6.07482 6.24488 6.40942 6.56846 6.7261 6.8781
7.02454 7.16549 7.30106 7.43136 7.5565 7.67661 7.79183 7.90229 8.00812 8.10948 8.2065
8.29932 8.3881 8.47297 8.55408 8.63157 8.70556 8.7762 8.84362 8.90795 8.96931 9.02782
9.08361 9.13679 9.18747 9.23575 9.28175 9.32556 9.36728 9.407 9.44481 9.4808 9.51506
9.54765 9.57867 9.60817 9.63624 9.66293 9.68832 9.71247 9.73543 #female fecundity;
weighted by N in year Y_init across morphs and areas
# Age specific selectivity and weight adjusted for discard and discard mortality
 #WEIGHT, THEN SELEX for gender,fleet: 1 1
 0 6.51084e-007 1.8565e-005 0.000370308 0.00359865 0.0185089 0.0603049 0.143815
0.276706 0.457794 0.679306 0.930275 1.19938 1.47677 1.75489 2.02877 2.29566 2.55461
2.80588 3.0503 3.28891 3.52259 3.75199 3.97741 4.19895 4.41649 4.62984 4.83876 5.04301
5.24237 5.43666 5.62573 5.80944 5.98773 6.16054 6.32784 6.48963 6.64799 6.8028 6.95201
7.09569 7.23394 7.36686 7.49457 7.61718 7.73483 7.84764 7.95577 8.05935 8.15852
8.25342 8.34421 8.43102 8.51399 8.59327 8.66899 8.74129 8.81031 8.87617 8.93899
8.99892 9.05605 9.11052 9.16243 9.2119 9.25903 9.30392 9.34667 9.38738 9.42614 9.46303
9.49814 9.53156 9.56335 9.5936 9.62238 9.64975 9.67579 9.70055 9.72409 9.74648
 0 3.85763e-006 5.02165e-005 0.000590347 0.00426779 0.0184032 0.053019 0.114639
0.202529 0.309685 0.426087 0.541752 0.648622 0.74137 0.817414 0.876498 0.920056
0.950529 0.970754 0.98348 0.991073 0.995371 0.997684 0.998874 0.999463 0.999745
0.999878 0.999941 0.999971 0.999985 0.999992 0.999996 0.999998 0.999999 0.999999
0.999999 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1
 #WEIGHT, THEN SELEX for gender,fleet: 1 2
 0 0.000209136 0.00226615 0.0147101 0.05404 0.133985 0.256955 0.416304 0.602218
0.805672 1.0199 1.24047 1.46472 1.69123 1.91931 2.14856 2.37873 2.60949 2.84044
3.07109 3.30088 3.52922 3.75554 3.97926 4.19989 4.41697 4.63008 4.83888 5.04307
5.24241 5.43668 5.62574 5.80945 5.98774 6.16054 6.32784 6.48963 6.64799 6.8028 6.95201
7.09569 7.23394 7.36686 7.49457 7.61718 7.73483 7.84764 7.95577 8.05935 8.15852
8.25342 8.34421 8.43102 8.51399 8.59327 8.66899 8.74129 8.81031 8.87617 8.93899
```

```
8.99892 9.05605 9.11052 9.16243 9.2119 9.25903 9.30392 9.34667 9.38738 9.42614 9.46303
9.49814 9.53156 9.56335 9.5936 9.62238 9.64975 9.67579 9.70055 9.72409 9.74648
 0 0.00161388 0.0088351 0.037502 0.105252 0.21417 0.34888 0.488771 0.617605 0.726343
0.812095 0.875988 0.921252 0.951846 0.971613 0.983838 0.991087 0.995219 0.99749 0.9987
0.999331 0.999654 0.999819 0.999904 0.999947 0.999971 0.999983 0.99999 0.999994
0.999996 0.999998 0.999998 0.999999 0.999999 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
# M and current age-structure in year Yinit: 2009
 # gender = 1
 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055 0.055
 21.1448 19.0835 17.1744 15.4028 13.7568 12.2269 10.806 9.48871 8.27006 7.37078
6.62725 5.75479 5.13225 5.26342 5.0124 5.04995 4.45653 4.11206 3.45271 2.85021 2.3417
2.73746 2.87422 3.48807 3.69086 3.34083 2.57145 2.11272 1.52897 1.04448 0.678515
0.407803 0.231105 0.125057 0.0656865 0.0343147 0.0182551 0.0101169 0.00592463
0.00371364 0.00250228 0.00179252 0.00135541 0.00106893 0.000872781 0.000731253
0.00062606 0.000544373 0.000479993 0.000427554 0.000384 0.000347519 0.000316405
0.000289754 0.000266115 0.000245033 0.000225788 0.000208404 0.000192702 0.000178214
0.000164867 0.000152563 0.000141212 0.000130783 0.000121177 0.000112346 0.000104333
9.69388e-005 9.03015e-005 8.41467e-005 7.84829e-005 7.32651e-005 6.85254e-005
6.41382e-005 6.02989e-005 5.68335e-005 5.36456e-005 5.0776e-005 4.82718e-005 4.57005e-
005 0.000594057
# Age-structure at Ydecl= 2000
 12.127 10.9202 9.5021 8.50067 8.75935 8.39472 8.51984 7.57525 7.03875 5.94612 4.93306
4.0688 4.77038 5.01929 6.1002 6.46118 5.85213 4.50618 3.70317 2.68034 1.83116 1.1896
0.714993 0.405197 0.219263 0.115169 0.0601645 0.032007 0.0177381 0.0103878 0.00651119
0.0043873 0.00314286 0.00237647 0.00187417 0.00153026 0.00128212 0.00109768 0.00095446
0.000841581 0.000749639 0.000673273 0.000609312 0.000554759 0.000508032 0.000466585
0.00042962 0.000395878 0.000365399 0.000337868 0.000312465 0.000289065 0.000267491
0.000247589 0.000229303 0.000212462 0.000196978 0.000182928 0.000169965 0.000158327
0.000147536 0.000137605 0.000128457 0.000120147 0.000112455 0.000105723 9.96472e-005
9.40578e-005 8.90265e-005 8.46358e-005 8.01274e-005 7.56147e-005 7.12938e-005
6.72185e-005 6.32869e-005 5.9189e-005 5.50573e-005 5.08816e-005 4.67632e-005 4.28267e-
005 0.000509439
# Year for Tmin Age-structure (set to Ydecl by SS2)
2000
# Number of simulations
1000
#  recruitment and biomass
# Number of historical assessment years
111
# Historical data
# year recruitment spawner in B0 in R project in R/S project
1899  1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915
1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932
1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949
1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
2001 2002 2003 2004 2005 2006 2007 2008 2009 #years (with first value representing R0)
96.4746  96.4746 96.4746 96.4558 96.4183 96.3622 96.2876 96.1942 96.0821 95.9509
95.8005 95.6304 95.44 95.229 94.9964 94.7416 94.4635 94.1611 93.8329 93.2552 92.719
92.4302 92.1097 91.8456 91.5911 91.2058 90.6299 89.9628 89.0522 88.3002 87.7506
87.2608 86.5766 85.5891 85.0122 84.6793 84.4565 84.406 84.6589 84.8774 85.1511 85.3937
85.6179 85.7885 86.1095 86.4058 86.7735 87.1073 87.3751 87.5798 87.6942 87.7382
87.7385 87.6967 87.7444 87.8297 87.799 87.7286 87.5586 87.4561 87.3473 87.269 87.1554
87.0198 86.9783 86.8661 86.7983 86.5878 86.3234 85.8425 85.3246 84.6098 84.1426
83.5682 82.5091 81.1772 79.6035 77.9098 75.9678 73.8118 71.2236 67.0995 63.1754
58.5732 49.5178 45.9435 37.1408 26.3676 16.8525 12.9168 9.2359 9.73371 10.5129 11.3989
```

```
11.3894 11.984 11.1031 10.9306 10.0288 10.6075 11.5377 12.127 12.8641 13.9587 15.0381
16.1002 17.143 18.1662 19.1715 20.1625 21.1448 #recruits; first value is R0 (virgin)
4366.67  4366.67 4366.66 4361.56 4351.41 4336.32 4316.35 4291.61 4262.19 4228.2
4189.77 4146.99 4100 4048.89 3993.79 3934.82 3872.06 3805.63 3735.63 3617.37 3512.91
3458.64 3399.95 3352.78 3308.3 3242.71 3148.42 3044.45 2910.93 2807.33 2735.13 2673.13
2590.01 2476.7 2413.86 2378.67 2355.53 2350.32 2376.53 2399.52 2428.78 2455.15 2479.9
2498.98 2535.48 2569.87 2613.53 2654.14 2687.41 2713.27 2727.89 2733.54 2733.57 2728.2
2734.33 2745.34 2741.38 2732.3 2710.57 2697.59 2683.93 2674.15 2660.07 2643.41 2638.34
2624.71 2616.51 2591.34 2560.24 2505.06 2447.59 2371.41 2323.48 2266.46 2166.48
2049.44 1922.25 1797.19 1666.89 1536.36 1396.35 1204.03 1049.03 894.355 652.744
574.627 412.525 257.575 148.789 109.678 75.7133 80.1689 87.2278 95.3812 95.2937
100.843 92.6442 91.0547 82.8301 88.0917 96.6711 102.187 109.174 119.738 130.379
141.074 151.801 162.548 173.328 184.177 195.155 #spbio; first value is S0 (virgin)
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  # in Bzero
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  0 0 0 # in R project
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  0 0 0 # in R/S project
# Number of years with pre-specified catches
2
# catches for years with pre-specified catches go next
2009 2
2010 2
# Number of future recruitments to override
0
# Process for overiding (-1 for average otherwise index in data list)
# Which probability to product detailed results for (1=0.5; 2=0.6; etc.)
2
# Steepness sigma-R Auto-correlation
0.6 0 0
# Target SPR rate (FMSY Proxy); manually change to SPR_MSY if not using SPR_target
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
0.75
# Maximum possible F for projection (-1 to set to FMSY)
-1
# Conduct MacCall transition policy (1=Yes)
0
# Defintion of recovery (1=now only;2=now or before)
2
# Results for rec probs by Tmax (1) or 0.5 prob for various Ttargets (2)
1
# Definition of the 40-10 rule
10 40
# Produce the risk-reward plots (1=Yes)
0
# Calculate coefficients of variation (1=Yes)
0
# Number of replicates to use
15
# Random number seed
```

```
-99004
# Conduct projections for multiple starting values (0=No;else yes)
1
# File with multiple parameter vectors
Dorn_2007corr.txt
# Number of parameter vectors: value is placeholder only, user needs to change it
1000
# User-specific projection (1=Yes); Output replaced (1->9)
1  2  0  0
# Catches and Fs (Year; 1/2/3 (F or C or SPR); value); Final row is -1
2011 3 0.9
-1 -1 -1
# Split of Fs
2009 1 1
-1 99 99
# Five pre-specified years (used to define Ttarget for projection type 4)
2011 2012 2013 2014 2015 # placeholder
# year for probability of recovery
2072
# Time varying weight-at-age (1=Yes;0=No)
0
# File with time series of weight-at-age data
none
# Use bisection (0) or linear interpolation (1)
1
# Target Depletion
0.4
# Project with Historical recruitments when computing Tmin (1=Yes)
0
# CV of implementation error
0
```