DRAFT Rebuilding analysis for quillback rockfish (*Sebastes maliger*) in U.S. waters off the coast of California based on the 2021 stock assessment, incorporating November 2021 Council meeting requests

by
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Summary

This rebuilding analysis is for the sub-stock of quillback rockfish (*Sebastes maliger*) in waters off California. The analysis is based on the 2021 stock assessment (Langseth et al. 2021). The 2021 assessment model estimated the quillback rockfish population to be at 14% of the unexploited equilibrium spawning output at the start of 2021. This rebuilding analysis compares the results of applying a suite of potential management actions to the stock for 2023 and beyond.

This rebuilding analysis is an update of the one presented at the Pacific Fishery Management Council's (Council) November meeting, and incorporates the requests made by the Council during the November meeting. First, the assumed catch in 2022 was updated from 13.5 mt to 11.9 mt. Second, two SPR strategies were added, at SPR = 0.55 and SPR = 0.65, as were four strategies that delayed the application of constant SPR (at SPR = 0.6 and SPR = 0.7) until 2025. Third, the comparison between the base rebuilding analysis and the sensitivity rebuilding analyses with alternative assumptions about selectivity which was included in the November analysis was omitted for this report.

The results of the analysis show that the value for T_{MIN}, the median year for rebuilding to the target level in the absence of fishing since the year of declaration (2023), is 2040. The estimated generation time for quillback rockfish was 26 years. In conjunction with T_{MIN} and the mean generation time, T_{MAX} was estimated to be 2066. An SPR = 0.577 harvest rate leads to a 50% probability of recovery by T_{MID} where T_{MID} was 2053, an intermediate year between T_{MIN} and T_{MAX}.

1 Introduction

The 2021 assessment of quillback rockfish (*Sebastes maliger*) in California waters documented that the population of quillback rockfish was below the Minimum Stock Size Threshold (MSST), which is 25% of unfished spawning output for rockfish stocks, in 2021 (Langseth et al. 2021). The population declined below MSST starting in 1992, reached it lowest values in the mid-1990s, increased to near the MSST in the 2000s and early 2010s, and declined in recent years. The stock is expected to be declared overfished for 2023 in 2022. Given the assumed productivity of the stock combined with the longevity of quillback rockfish a range of alternative rebuilding approaches were examined, and are described in this report, with rebuilding ranging from 2040 - 2064 based on various SPR harvest rates from 0.5 to 1 (no harvest).

2 Overview of the 2021 stock assessment

The 2021 assessment of quillback rockfish assessed the stock as three separate sub-stocks along the U.S. west coast: Washington, Oregon, and California. These were the first assessments of quillback rockfish conducted within Stock Synthesis (Methot and Wetzel 2013) that used catch and length composition data to inform model estimates around stock size and status. The previous assessment of quillback rockfish, conducted in 2010, was a coastwide assessment modeled using Depletion-Based Stock Reduction Analysis (DB-SRA) to provide estimates of coastwide overfishing limits (OFLs) based on data and biological information (Dick and MacCall 2010). DB-SRA is a catch-only method and does not assess overfished status; the 2010 assessment assumed that current depletion was distributed around the management target of 40%. The 2010 assessment found there was a 52% chance that quillback rockfish was experiencing overfishing, as recent coastwide catch of quillback rockfish slightly exceeded the median coastwide OFL estimate at the time. Recent catches of quillback rockfish for the current assessment also exceed the annual catch limit (ACL) contributions for the species in all modeled areas.

Estimates of depletion in 2021 for the stocks off Washington and Oregon were above the MSST threshold, but the estimate of depletion for the stock off California was 14%. See Langseth et al. (2021) for additional results from the California quillback rockfish base model.

California quillback rockfish was assessed using a single-sex model with coastwide life history parameters combined across sexes. Life history parameters were estimated externally and then fixed within the model. Natural mortality and steepness were both fixed, at the median and mean of the priors, respectively. Annual recruitment deviations were estimated within the base model. The model for quillback rockfish in California waters included two fishing fleets, a commercial and a recreational fleet. The majority of the removals and length composition data arose from the recreational fleet. Recreational removals peaked in the late 1970s and early 1980s, with two years of large catches in 1984 and 1993. Removals declined sharply in 1994, but increased to levels similar to the late 1970s and early 1980s during the

mid 2000s and again in recent years. Commercial removals peaked in the mid to late 1990s, with one year of exceptionally large catches in 1991. Removals declined through the mid 2010s, but increased in recent years. Selectivity for the commercial and recreational fleets was specified to be asymptotic. The assessment model decision table explored uncertainty around stock size and status using lower ($M = 0.0464$ yr^{-1}) and higher ($M = 0.0744$ yr^{-1}) natural mortality (M) values relative to the base model.

Sensitivities to modeling choices, catch history, and parameter values were explored and showed general support for the base model estimates of stock status and depletion. Sensitivities to the von Bertalanffy growth coefficient (k, whether estimated on its own or along with L_∞) and natural mortality showed that model estimates of depletion were sensitive to these parameter choices.

3 Management performance under rebuilding

This is the first rebuilding plan for quillback rockfish in waters off the coast of California.

4 Rebuilding calculations

This rebuilding analysis was conducted in December, 2021 using software developed by A. Punt (version 3.12i, September 2021). The input file for the analysis is provided in Appendix A. The steps followed were:

1. Define how equilibrium spawning output (SB_0) will be calculated.
2. Define how future recruitment will be generated.
3. Define the biological information on which future projections will be based.
4. Define the fishery selectivity and allocation to be applied during rebuilding.
5. Decide how to include uncertainty in input parameters from the stock assessment in the rebuilding analysis.
6. Identification and analysis of alternative harvest strategies for rebuilding.

4.1 Definition of Equilibrium Spawning Output

The equilibrium spawning output (SB_0) used in this rebuilding analysis is calculated via the stock-recruitment, growth, maturity, and fecundity relationships from the 2021 assessment in order to be consistent with assessment model results. Equilibrium spawning output was estimated to be 55.08 millions of eggs in the assessment model, which dictates a rebuilding relative spawning output target ($SB_{40\%}$) of 22.035 millions of eggs (Table 1). Estimates of spawning output presented in this report are female spawning output only.

4.2 Generation of future recruitment

The estimated parameters of the stock recruitment relationship including the unexploited equilibrium recruitment (natural log of $R_0 = 3.168$), steepness ($h = 0.72$), and degree of recruitment variability ($\sigma_R = 0.60$) from the 2021 assessment were used to generate future recruitments in the rebuilding analysis.

4.3 Population biology

The biological parameters used for the rebuilding analysis were based on the values from the 2021 assessment. Biological parameters in the assessment were aggregated across sex and constant across time. The rebuilding analysis was based on a single sex model.

4.4 Fishery selectivity, and removal allocations

The selectivity used in the rebuilding analysis was obtained from the 2021 assessment. Selectivity in the assessment model was constant across time for each fishing fleet. The relative allocation of catch among fleets in the rebuilding analysis was informed using the relative fishing mortality from the assessment averaged over recent years (2017-2019). This choice provides some consistency between recent model results and forecasts from the rebuilding analysis, accounting for the unique dynamics in 2020 caused by the COVID-19 pandemic.

4.5 Inclusion of uncertainty

Model and parameter uncertainty is included in the rebuilding analysis via 1,000 random simulations of stochastic future recruitment strengths and integration over alternative low (M = 0.0464 yr^{-1}) and high ($M = 0.0744$ yr^{-1}) states of nature for values of natural mortality (M). Other potential states of nature were explored for the assessment, including for low and high ln(R_0) and high and low L_∞, but alternative values of natural mortality encapsulated a slightly wider range of depletion estimates compared to the other states of natures. The base model was given 50% of the weight (500 simulations) and each alternative natural mortality state of nature was given 25% (250 simulations) of the weight.

4.6 Alternate rebuilding strategies analyzed

Assuming that a constant rate of harvest will be applied throughout a rebuilding period, the basis for rebuilding alternatives can be divided into two approaches: 1) strategies based on selection of a constant harvest rate (SPR rate), or 2) strategies based on selection of a T_{TARGET} (year for 50% probability of recovery). This rebuilding analysis presents the

following alternate strategies, which are a combination of those specified in the rebuilding Terms of Reference (TOR; PFMC (2020)) and additional strategies. The additional strategies are based on the selection of a SPR harvest rate, rebuilding by a selected target year, or by delaying a SPR harvest rate for a specified number of years.

1. Eliminate all harvest, F = 0, starting in the next management cycle, 2023, the same as setting a constant SPR harvest rate of 1.0.
2. Apply the harvest rate that would generate the ACL contributions specified for the current year (i.e., the latest year specified in regulations).
3. Apply a range of SPR values:
   (a) SPR = 0.50,
   (b) SPR = 0.55
   (c) SPR = 0.60,
   (d) SPR = 0.65,
   (e) SPR = 0.70,
   (f) SPR = 0.80, and
   (g) SPR = 0.90.
4. Apply a range of SPR values to start in 2025 to allow a ramp down in fishing pressure from 2023-2025 based on varying fixed catch in 2023 and 2024:
   (a) Lower fixed 2023-2024 catch approach
      i. SPR = 0.60, and
      ii. SPR = 0.7.
   (b) Higher fixed 2023-2024 catch approach
      i. SPR = 0.60, and
      ii. SPR = 0.7.
5. Apply SPR harvest rates that are estimated to lead to a 50% probability of recovery by alternative target years:
   (a) by T_{MAX} from the current cycle, and
   (b) by T_{MID} from the current cycle, which is the year midway between T_{MIN} and T_{MAX}.
6. Apply the default harvest policy based on the 40:10 harvest control rule with time-varying sigma ($\sigma = 1.0$ as the basis for the time-varying sigmas) and $P^* = 0.45$.
7. Apply the ABC harvest rate with time-varying sigma ($\sigma = 1.0$ as the basis for the time-varying sigmas) and $P^* = 0.45$.

The sum of ACL contributions for quillback rockfish from the southern management area and the percent allocation for California (28.7%) in the northern management area as provided by the Groundfish Management Team (GMT) were larger than the catch resulting from applying an SPR of 0.5, implying an SPR rate of below 0.5 for this run, so results from this strategy are not provided in this report. Similarly, the SPR rate that led to a 50% probability of recovery by T_{MAX} was less than 0.5 so results from the T_{MAX} strategy are not presented in this report.

No current rebuilding plan exists for quillback rockfish in California waters so the alternatives related to the results of a previous rebuilding plan as specified in the rebuilding TOR could not be done. These include:

- Apply the spawning potential ratio or relevant harvest control run in the current rebuilding plan.
- Apply the harvest rate that is estimated to lead to a 50% probability of recovery by the current T_{TARGET}.
- Apply the harvest rate that is estimated to lead to a 50% probability of recovery by the T_{MAX} from the previous cycle.

All of the above rebuilding strategies were conducted assuming removals of 13.5 mt in 2021 and 11.9 mt in 2022 as recommended by the GMT.

4.6.1 Ramp strategies

The Council requested "ramp-down" strategies be explored that gradually reduced catches from 2022 values over a three year period. Four strategies were explored, divided into two approaches each reaching constant SPR = 0.6 and SPR = 0.7 rates starting in 2025.

For the first approach, catch in 2023 was set equal to the catch in 2023 indicated under the ABC harvest rate strategy. Catches in 2024 were iteratively set to be approximately midway between the 2023 ABC-based catch value and the preliminary estimated catch in 2025 based on applying the corresponding SPR strategy (SPR = 0.6 or SPR = 0.7) starting in 2024, and therefore approximating a linear ramp in catch between 2023-2025. Catch in 2024 was further adjusted as necessary, to ensure a declining ramp, meaning that the change in catch between 2023-2024 was greater than or equal to the change in catch between 2024-2025.

For the second approach, catch in 2023 was set at a value higher than that indicated by the standard P^* sigma ABC harvest rate strategy, but below the 2023 OFL value. This approach mitigates the effect of reduced catch on the fishery by allowing higher catch than the first ramp-down approach, and reflects a reasonable upper range for ramp-down scenarios. We used a 2023 catch value of 2.05 mt because it reflects a small but not negligible (~3%) buffer

from the 2023 OFL (2.11 mt). Catch in 2024 was then chosen to reflect a near constant geometric increase in the buffer fraction between 2023 and 2025 (depending on the SPR rate) up to the same buffer in 2025 as the original corresponding non-ramp SPR strategy while ensuring a monotonically decreasing catch across the three years. Catch in 2024 was set to 2.05 mt for the SPR = 0.6 strategy, and 2.00 mt for the SPR = 0.7 strategy. Using these catch values results in a buffer between catch and OFL that geometrically increases over the period of the ramp by approximately a factor of 3 for the SPR = 0.6 strategy, and by approximately a factor of 4 for the SPR = 0.7 strategy.

5 Results

5.1 Rebuilding reference points

Reference points calculated based on this rebuilding analysis are given in Table 1. The minimum time required for rebuilding, T_{MIN}, with no fishing (F=0) starting in 2023 was estimated to be 17 years, corresponding to the stock being rebuilt by 2040, assuming the default removals for 2021 and 2022. The mean generation time was estimated to be 26 years. The maximum time allowed for rebuilding, T_{MAX}, is defined as the T_{MIN} plus the mean generation time for stocks that require more than 10 years to rebuild. Quillback rockfish was unable to rebuild within 10 years so the estimated T_{MAX} was 2066. T_{TARGET}, and SPR_{TARGET} are not specified since this is the first rebuilding plan for quillback rockfish and these values have not been set via the Council's process.

A rebuilding strategy is presented below and includes a rebuilding target year termed T_{MID}, which equals 2053 and is the mid-point between T_{MIN} and T_{MAX}. The Council may opt to select a T_{TARGET} earlier or later than this T_{MID} value based on fishery, economic, or other factors.

5.2 Alternative harvest policy projections

Summary results from the rebuilding alternatives are presented in Table 2. Results from the ramp-down strategies are presented in Table 3. In Tables 2 and 3, non-fixed catch values for 2023-2025 are labeled as ACL values. Detailed results for all runs are presented in Tables 4-7 and Figures 1-4.

The target rebuilding year based on the various rebuilding strategies ranged from 2040 - 2064 (Tables 2 and 3). The probability of rebuilding by year steadily increased across the alternative SPR values with full rebuilding (reaching a probability of greater than 50%) by 2064 when the lowest SPR of 0.50 was applied (Table 4 and Figure 1). The recommended removals in 2023, the first year of rebuilding, were low ranging between 0.12 - 2.11 mt across

strategies excluding the no-harvest strategy (Table 5), with the recommended removals slowly increasing by year during the rebuilding period (Figure 2). The estimated overfishing limits (OFLs) for each rebuilding alternative are given in Table 6. The change in spawning output by year relative to the spawning output target, 40% of unfished, under each of the alternatives are shown by year in Table 7 and Figure 3. The harvest rate to obtain a 50% probability of recovery by T_{MAX} corresponds to an SPR that is lower than 0.5, which represents catch that is greater than the OFL, so is not provided in the tables.

6 Acknowledgements

Andre Punt (University of Washington) updated the rebuilder program to apply time-varying σ for the Acceptable Biological Catch and 40-10 scenarios. Andre Punt and Owen Hamel (NOAA) provided assistance in understanding and applying the rebuilder program. Owen Hamel provided comments on drafts of the analysis.

7 References

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8 Tables

8.1 Rebuilding reference points and policy projections

Table 1: Summary of the rebuilding reference points.

Quantity	2021 Assessment Values
SB0 (millions of eggs)	55.08
SB40 (millions of eggs)	22.03
SB2021 (millions of eggs)	7.75
Year rebuilding begins	2023
Current year	2021
T_{MIN}	2040
Mean generation time (years)	26
T_{MAX}	2066
$T_{F=0}$	2040
T_{TARGET}	TBD
SPR_{TARGET}	TBD
Current SPR (2021)	0.12

Table 2: Results of rebuilding alternatives based on alternative SPR targets for 50 percent probability of recovery based on the assumed removals for 2021-22. SPR for the ABC and 40-10 strategies is provided as a dash (-) because these strategies do not have a constant SPR value.

Quantity	SPR= .500	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2021 Assumed Removals (mt)	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
2022 Assumed Removals (mt)	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
2023 ACL (mt)	2.11	1.76	1.46	1.2	0.97	0.58	0.26	1.59	0	0.12	1.84
2024 ACL (mt)	2.3	1.93	1.61	1.33	1.08	0.65	0.29	1.76	0	0.41	2
SPR	0.5	0.55	0.6	0.65	0.7	0.8	0.9	0.58	1	-	-
T_{TARGET}	2064	2057	2051	2048	2046	2043	2041	2053	2040	2051	2055
T_{MAX}	2066	2066	2066	2066	2066	2066	2066	2066	2066	2066	2066
Probability of recovery by T_{MAX}	0.536	0.788	0.905	0.948	0.98	0.999	1	0.851	1	0.906	0.83

Table 3: Results of rebuilding alternatives for ramp-down strategy approaches (ramp1 and ramp2) based on applying alternative SPR targets starting in 2025 for 50 percent probability of recovery based on assumed removals for 2021-22 and fixed removals in 2023-24. Non-ramp strategies are copied from Table 2 and included for comparison. Catches (labeled ACLs) in 2023-2024 for non-ramp strategies were estimated based on the specified SPR value, and were not fixed.

Quantity	Ramp1 SPR = .600	Ramp2 SPR = .600	SPR = .600	Ramp1 SPR = .700	Ramp2 SPR = .700	SPR = .700
2021 Assumed Removals (mt)	13.5	13.5	13.5	13.5	13.5	13.5
2022 Assumed Removals (mt)	11.9	11.9	11.9	11.9	11.9	11.9
2023 Fixed Removals (mt), (2023 ACL for non-ramp)	1.84	2.05	1.46	1.84	2.05	0.97
2024 Fixed Removals (mt), (2024 ACL for non-ramp)	1.8	2.05	1.61	1.5	2	1.08
2025 ACL (mt)	1.76	1.75	1.78	1.17	1.16	1.2
SPR in 2023	0.54	0.51	0.6	0.54	0.51	0.7
SPR in 2024	0.57	0.53	0.6	0.62	0.54	0.7
SPR in 2025	0.6	0.6	0.6	0.7	0.7	0.7
T_{TARGET}	2051	2051	2051	2046	2046	2046
Probability of recovery by T_{MAX} = 2066	0.896	0.896	0.905	0.979	0.979	0.98

8.2 Rebuilding time series

Table 4: Probability of recovery by year for rebuilding strategies, including ramp strategies. Probabilities represent the proportion of simulations that reach the target biomass by the specified year.

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2029	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.005	0.000	0.000
2030	0.000	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.003	0.007	0.011	0.001	0.018	0.001	0.001
2031	0.001	0.002	0.003	0.004	0.004	0.004	0.010	0.010	0.010	0.018	0.042	0.003	0.080	0.003	0.002
2032	0.002	0.003	0.008	0.010	0.010	0.014	0.020	0.022	0.020	0.053	0.111	0.005	0.163	0.006	0.003
2033	0.004	0.009	0.016	0.022	0.022	0.031	0.048	0.050	0.048	0.104	0.175	0.012	0.220	0.013	0.009
2034	0.009	0.017	0.033	0.040	0.039	0.055	0.081	0.086	0.083	0.161	0.211	0.027	0.236	0.028	0.018
2035	0.014	0.033	0.050	0.052	0.052	0.073	0.115	0.121	0.119	0.191	0.235	0.042	0.256	0.048	0.034
2036	0.023	0.039	0.063	0.072	0.071	0.102	0.154	0.153	0.153	0.216	0.251	0.052	0.283	0.057	0.046
2037	0.028	0.052	0.085	0.087	0.087	0.131	0.174	0.175	0.172	0.238	0.287	0.065	0.325	0.074	0.055
2038	0.031	0.061	0.102	0.106	0.106	0.158	0.191	0.193	0.191	0.273	0.332	0.083	0.386	0.094	0.071
2039	0.034	0.072	0.123	0.130	0.128	0.177	0.234	0.234	0.228	0.318	0.387	0.102	0.455	0.114	0.085
2040	0.045	0.091	0.143	0.152	0.150	0.217	0.284	0.279	0.275	0.366	0.438	0.118	0.530	0.142	0.102
2041	0.055	0.104	0.181	0.185	0.184	0.257	0.321	0.311	0.306	0.414	0.504	0.146	0.602	0.177	0.117
2042	0.069	0.132	0.208	0.214	0.212	0.292	0.358	0.353	0.350	0.455	0.575	0.169	0.663	0.210	0.149
2043	0.081	0.149	0.244	0.246	0.244	0.331	0.402	0.390	0.387	0.518	0.631	0.201	0.708	0.248	0.166
2044	0.095	0.173	0.283	0.282	0.280	0.364	0.435	0.430	0.425	0.575	0.675	0.231	0.742	0.285	0.198
2045	0.109	0.197	0.319	0.321	0.319	0.406	0.470	0.464	0.459	0.621	0.722	0.263	0.764	0.321	0.229

Table 4: Probability of recovery by year for rebuilding strategies, including ramp strategies. Probabilities represent the proportion of simulations that reach the target biomass by the specified year. *(continued)*

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2046	0.125	0.228	0.353	0.352	0.352	0.433	0.528	0.513	0.505	0.659	0.750	0.307	0.798	0.355	0.265
2047	0.141	0.260	0.378	0.377	0.375	0.474	0.559	0.553	0.549	0.700	0.780	0.336	0.837	0.389	0.304
2048	0.153	0.293	0.409	0.405	0.402	0.517	0.601	0.597	0.594	0.739	0.815	0.363	0.863	0.429	0.330
2049	0.170	0.324	0.442	0.442	0.440	0.555	0.633	0.627	0.621	0.776	0.849	0.388	0.898	0.455	0.354
2050	0.194	0.347	0.481	0.481	0.480	0.582	0.675	0.658	0.654	0.812	0.879	0.417	0.925	0.491	0.381
2051	0.216	0.371	0.507	0.504	0.502	0.614	0.717	0.710	0.699	0.840	0.910	0.447	0.940	0.524	0.415
2052	0.232	0.405	0.535	0.534	0.534	0.658	0.759	0.742	0.737	0.868	0.921	0.479	0.961	0.554	0.442
2053	0.250	0.432	0.565	0.556	0.555	0.700	0.790	0.775	0.768	0.889	0.940	0.500	0.975	0.589	0.471
2054	0.280	0.453	0.598	0.591	0.586	0.733	0.819	0.803	0.801	0.910	0.962	0.525	0.981	0.635	0.494
2055	0.298	0.477	0.640	0.627	0.625	0.768	0.845	0.829	0.823	0.925	0.976	0.555	0.989	0.665	0.517
2056	0.321	0.497	0.668	0.659	0.657	0.797	0.865	0.854	0.852	0.943	0.977	0.604	0.993	0.700	0.554
2057	0.339	0.533	0.694	0.688	0.687	0.825	0.887	0.873	0.870	0.958	0.987	0.637	0.997	0.722	0.588
2058	0.361	0.566	0.725	0.717	0.713	0.846	0.901	0.895	0.891	0.967	0.992	0.660	1.000	0.761	0.622
2059	0.386	0.597	0.754	0.740	0.737	0.865	0.926	0.912	0.908	0.971	0.996	0.689	1.000	0.781	0.650
2060	0.405	0.624	0.771	0.765	0.761	0.889	0.935	0.929	0.926	0.982	0.997	0.712	1.000	0.802	0.677
2061	0.429	0.649	0.805	0.793	0.788	0.898	0.949	0.939	0.937	0.988	0.998	0.740	1.000	0.824	0.707
2062	0.459	0.684	0.831	0.822	0.814	0.916	0.955	0.950	0.947	0.995	0.999	0.762	1.000	0.849	0.730
2063	0.479	0.703	0.855	0.847	0.843	0.921	0.963	0.959	0.957	0.997	0.999	0.791	1.000	0.868	0.756
2064	0.502	0.726	0.872	0.863	0.862	0.935	0.965	0.964	0.962	0.998	0.999	0.824	1.000	0.884	0.788
2065	0.511	0.754	0.888	0.878	0.876	0.942	0.973	0.968	0.966	0.998	0.999	0.840	1.000	0.899	0.815
2066	0.536	0.788	0.905	0.896	0.896	0.948	0.980	0.979	0.979	0.999	1.000	0.851	1.000	0.906	0.830

Table 5: Catches (mt) by year for rebuilding strategies, including ramp strategies. Catches in 2021-2022 for all strategies were set at values recommended by the Groundfish Management Team. Catches in 2023-2024 for the ramp strategies were fixed as described in the text.

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2021	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.5	13.50	13.50
2022	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.9	11.90	11.90
2023	2.11	1.76	1.46	1.84	2.05	1.20	0.97	1.84	2.05	0.58	0.26	1.59	0.0	0.12	1.84
2024	2.30	1.93	1.61	1.80	2.05	1.33	1.08	1.50	2.00	0.65	0.29	1.76	0.0	0.41	2.00
2025	2.52	2.13	1.78	1.76	1.75	1.47	1.20	1.17	1.16	0.72	0.33	1.93	0.0	0.75	2.18
2026	2.74	2.32	1.95	1.94	1.92	1.62	1.32	1.30	1.28	0.80	0.37	2.12	0.0	1.09	2.36
2027	2.94	2.51	2.12	2.10	2.09	1.77	1.45	1.42	1.41	0.88	0.41	2.30	0.0	1.42	2.52
2028	3.14	2.69	2.28	2.26	2.25	1.90	1.56	1.54	1.53	0.96	0.45	2.46	0.0	1.71	2.67
2029	3.32	2.85	2.43	2.41	2.40	2.04	1.68	1.65	1.64	1.03	0.48	2.62	0.0	1.98	2.81
2030	3.50	3.02	2.58	2.57	2.55	2.17	1.79	1.77	1.76	1.11	0.52	2.78	0.0	2.23	2.95
2031	3.66	3.18	2.72	2.71	2.70	2.30	1.90	1.88	1.87	1.19	0.56	2.93	0.0	2.46	3.08
2032	3.84	3.34	2.88	2.86	2.85	2.43	2.02	2.00	1.98	1.26	0.59	3.09	0.0	2.69	3.21
2033	4.00	3.50	3.01	3.00	2.99	2.56	2.13	2.10	2.09	1.34	0.63	3.23	0.0	2.90	3.33
2034	4.18	3.66	3.16	3.15	3.14	2.69	2.25	2.22	2.21	1.42	0.67	3.39	0.0	3.10	3.46
2035	4.34	3.82	3.31	3.30	3.29	2.83	2.36	2.34	2.33	1.50	0.71	3.55	0.0	3.30	3.59
2036	4.52	3.98	3.46	3.44	3.43	2.96	2.47	2.45	2.43	1.57	0.75	3.70	0.0	3.52	3.73
2037	4.68	4.13	3.60	3.58	3.57	3.08	2.59	2.56	2.55	1.65	0.79	3.84	0.0	3.76	3.88
2038	4.82	4.27	3.73	3.72	3.71	3.20	2.69	2.67	2.66	1.72	0.83	3.98	0.0	3.95	4.02
2039	4.95	4.40	3.85	3.84	3.83	3.32	2.79	2.77	2.76	1.79	0.86	4.10	0.0	4.12	4.14
2040	5.08	4.53	3.98	3.96	3.95	3.43	2.89	2.87	2.86	1.87	0.90	4.24	0.0	4.31	4.28
2041	5.21	4.66	4.10	4.09	4.07	3.54	2.99	2.97	2.96	1.93	0.93	4.36	0.0	4.46	4.40
2042	5.38	4.81	4.24	4.22	4.21	3.67	3.10	3.08	3.07	2.01	0.97	4.50	0.0	4.65	4.55
2043	5.49	4.93	4.35	4.34	4.33	3.77	3.20	3.18	3.17	2.08	1.01	4.62	0.0	4.82	4.67
2044	5.64	5.07	4.49	4.47	4.47	3.89	3.30	3.28	3.27	2.15	1.05	4.76	0.0	4.98	4.81

Table 5: Catches (mt) by year for rebuilding strategies, including ramp strategies. Catches in 2021-2022 for all strategies were set at values recommended by the Groundfish Management Team. Catches in 2023-2024 for the ramp strategies were fixed as described in the text. *(continued)*

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2045	5.76	5.18	4.59	4.58	4.57	3.99	3.39	3.37	3.36	2.21	1.08	4.87	0.0	5.13	4.92
2046	5.91	5.33	4.73	4.72	4.71	4.12	3.51	3.49	3.48	2.29	1.12	5.01	0.0	5.29	5.06
2047	6.03	5.46	4.86	4.85	4.84	4.23	3.61	3.59	3.58	2.36	1.15	5.15	0.0	5.45	5.20
2048	6.14	5.56	4.96	4.95	4.94	4.32	3.69	3.67	3.66	2.43	1.19	5.24	0.0	5.59	5.30
2049	6.26	5.68	5.07	5.06	5.05	4.44	3.79	3.77	3.76	2.49	1.22	5.36	0.0	5.71	5.42
2050	6.34	5.76	5.15	5.14	5.14	4.51	3.86	3.84	3.84	2.54	1.25	5.44	0.0	5.80	5.50
2051	6.41	5.84	5.22	5.21	5.20	4.58	3.93	3.91	3.90	2.60	1.28	5.51	0.0	5.87	5.57
2052	6.51	5.95	5.32	5.31	5.30	4.67	4.00	3.98	3.97	2.65	1.30	5.62	0.0	5.96	5.69
2053	6.61	6.03	5.43	5.42	5.41	4.76	4.08	4.06	4.05	2.70	1.33	5.71	0.0	6.04	5.78
2054	6.68	6.10	5.48	5.47	5.46	4.82	4.14	4.13	4.12	2.75	1.36	5.77	0.0	6.10	5.84
2055	6.74	6.16	5.53	5.52	5.51	4.87	4.19	4.18	4.17	2.79	1.39	5.82	0.0	6.16	5.90
2056	6.84	6.25	5.61	5.61	5.60	4.95	4.26	4.24	4.24	2.83	1.41	5.91	0.0	6.26	5.98
2057	6.91	6.32	5.68	5.67	5.67	5.01	4.32	4.30	4.29	2.88	1.43	5.98	0.0	6.33	6.06
2058	7.00	6.41	5.77	5.76	5.76	5.09	4.39	4.37	4.36	2.92	1.45	6.07	0.0	6.40	6.15
2059	7.06	6.48	5.84	5.84	5.83	5.16	4.45	4.44	4.43	2.97	1.48	6.14	0.0	6.46	6.21
2060	7.14	6.57	5.92	5.92	5.91	5.23	4.51	4.50	4.49	3.02	1.50	6.22	0.0	6.52	6.31
2061	7.17	6.58	5.95	5.94	5.93	5.26	4.55	4.54	4.53	3.06	1.53	6.25	0.0	6.54	6.33
2062	7.20	6.64	5.99	5.97	5.97	5.30	4.59	4.58	4.57	3.08	1.54	6.30	0.0	6.58	6.38
2063	7.27	6.67	6.04	6.04	6.03	5.35	4.63	4.62	4.61	3.11	1.56	6.34	0.0	6.63	6.42
2064	7.30	6.72	6.08	6.07	6.07	5.39	4.67	4.66	4.65	3.15	1.58	6.38	0.0	6.64	6.46
2065	7.36	6.78	6.14	6.13	6.13	5.44	4.71	4.70	4.70	3.18	1.59	6.44	0.0	6.69	6.53
2066	7.39	6.83	6.19	6.18	6.18	5.48	4.74	4.74	4.73	3.20	1.61	6.48	0.0	6.74	6.57

Table 6: OFLs (mt) by year for rebuilding strategies, including ramp strategies.

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2021	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
2022	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	2.30	2.32	2.34	2.31	2.31	2.34	2.35	2.31	2.31	2.37	2.38	2.32	2.39	2.38	2.31
2025	2.52	2.54	2.57	2.56	2.53	2.59	2.61	2.57	2.53	2.65	2.67	2.57	2.70	2.67	2.54
2026	2.74	2.78	2.83	2.80	2.78	2.86	2.89	2.84	2.80	2.94	2.98	2.80	3.02	2.97	2.77
2027	2.94	3.01	3.07	3.04	3.02	3.12	3.15	3.10	3.08	3.23	3.29	3.04	3.34	3.25	3.00
2028	3.14	3.22	3.29	3.27	3.25	3.36	3.41	3.36	3.34	3.52	3.59	3.27	3.66	3.51	3.21
2029	3.32	3.41	3.51	3.49	3.46	3.58	3.66	3.61	3.58	3.78	3.89	3.46	3.97	3.74	3.40
2030	3.50	3.62	3.73	3.70	3.69	3.83	3.91	3.86	3.84	4.06	4.19	3.68	4.30	3.99	3.61
2031	3.66	3.80	3.94	3.91	3.90	4.05	4.16	4.11	4.07	4.33	4.49	3.88	4.62	4.21	3.80
2032	3.84	4.01	4.16	4.13	4.12	4.28	4.41	4.36	4.33	4.62	4.79	4.08	4.94	4.45	4.00
2033	4.00	4.19	4.35	4.33	4.31	4.50	4.64	4.59	4.57	4.89	5.09	4.28	5.27	4.65	4.19
2034	4.18	4.38	4.57	4.54	4.53	4.75	4.90	4.85	4.82	5.18	5.41	4.48	5.61	4.89	4.39
2035	4.34	4.58	4.78	4.77	4.76	4.97	5.15	5.10	5.08	5.47	5.73	4.69	5.96	5.10	4.60
2036	4.52	4.77	4.99	4.97	4.96	5.21	5.40	5.35	5.31	5.73	6.03	4.90	6.29	5.32	4.79
2037	4.68	4.95	5.19	5.18	5.15	5.44	5.64	5.59	5.57	6.03	6.35	5.09	6.63	5.53	4.99
2038	4.82	5.12	5.39	5.37	5.35	5.64	5.87	5.82	5.80	6.30	6.66	5.27	6.98	5.71	5.17
2039	4.95	5.27	5.57	5.54	5.53	5.84	6.09	6.04	6.02	6.56	6.95	5.42	7.30	5.89	5.32
2040	5.08	5.42	5.75	5.73	5.71	6.04	6.31	6.26	6.23	6.81	7.26	5.60	7.63	6.04	5.50
2041	5.21	5.58	5.93	5.90	5.89	6.23	6.53	6.48	6.45	7.06	7.52	5.77	7.93	6.21	5.66
2042	5.38	5.76	6.12	6.11	6.08	6.47	6.77	6.72	6.70	7.33	7.83	5.95	8.28	6.39	5.85
2043	5.49	5.91	6.29	6.27	6.26	6.65	6.98	6.94	6.92	7.60	8.14	6.12	8.61	6.53	6.00
2044	5.64	6.08	6.48	6.47	6.45	6.85	7.20	7.16	7.13	7.85	8.43	6.30	8.93	6.70	6.18
2045	5.76	6.20	6.63	6.62	6.61	7.02	7.40	7.35	7.34	8.08	8.69	6.44	9.23	6.86	6.32
2046	5.91	6.38	6.84	6.83	6.80	7.26	7.65	7.62	7.60	8.37	9.00	6.62	9.55	7.02	6.50

Table 6: OFLs (mt) by year for rebuilding strategies, including ramp strategies. *(continued)*

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2047	6.03	6.54	7.02	7.01	6.99	7.46	7.87	7.83	7.80	8.62	9.28	6.81	9.88	7.16	6.68
2048	6.14	6.66	7.16	7.15	7.13	7.61	8.06	8.02	7.99	8.87	9.56	6.94	10.22	7.28	6.81
2049	6.26	6.80	7.33	7.31	7.30	7.81	8.28	8.23	8.21	9.09	9.83	7.10	10.53	7.39	6.97
2050	6.34	6.90	7.44	7.43	7.42	7.94	8.42	8.39	8.37	9.29	10.08	7.20	10.80	7.48	7.07
2051	6.41	6.99	7.54	7.53	7.52	8.07	8.57	8.53	8.52	9.49	10.30	7.29	11.04	7.58	7.16
2052	6.51	7.12	7.69	7.67	7.66	8.21	8.71	8.69	8.66	9.67	10.51	7.44	11.29	7.69	7.31
2053	6.61	7.22	7.84	7.83	7.81	8.39	8.89	8.87	8.84	9.88	10.75	7.56	11.57	7.79	7.43
2054	6.68	7.31	7.90	7.90	7.89	8.48	9.04	9.00	8.98	10.05	10.96	7.63	11.80	7.85	7.51
2055	6.74	7.38	7.99	7.98	7.97	8.57	9.14	9.11	9.10	10.21	11.21	7.71	12.07	7.92	7.58
2056	6.84	7.48	8.11	8.10	8.08	8.71	9.29	9.27	9.25	10.35	11.34	7.81	12.26	8.05	7.69
2057	6.91	7.57	8.20	8.19	8.19	8.83	9.41	9.40	9.37	10.53	11.54	7.92	12.49	8.14	7.79
2058	7.00	7.67	8.33	8.33	8.32	8.96	9.56	9.55	9.52	10.67	11.70	8.03	12.69	8.23	7.90
2059	7.06	7.76	8.44	8.43	8.42	9.09	9.70	9.68	9.67	10.87	11.93	8.12	12.92	8.30	7.98
2060	7.14	7.87	8.55	8.55	8.53	9.22	9.83	9.81	9.79	11.03	12.12	8.24	13.14	8.38	8.11
2061	7.17	7.88	8.59	8.57	8.57	9.27	9.92	9.90	9.88	11.17	12.30	8.26	13.33	8.41	8.14
2062	7.20	7.94	8.66	8.62	8.62	9.33	10.00	9.97	9.97	11.26	12.43	8.34	13.50	8.46	8.20
2063	7.27	7.99	8.73	8.73	8.71	9.42	10.10	10.08	10.06	11.38	12.56	8.39	13.68	8.52	8.25
2064	7.30	8.05	8.78	8.77	8.77	9.49	10.18	10.15	10.15	11.49	12.72	8.44	13.84	8.53	8.30
2065	7.36	8.12	8.86	8.86	8.86	9.58	10.28	10.26	10.24	11.61	12.83	8.52	13.98	8.60	8.39
2066	7.39	8.17	8.93	8.93	8.92	9.64	10.35	10.33	10.32	11.70	12.97	8.57	14.15	8.66	8.44

Table 7: Spawning output relative to the 40 percent of unfished spawning output target by year for rebuilding strategies, including ramp strategies.

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2021	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
2022	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2023	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
2024	0.28	0.29	0.29	0.28	0.28	0.29	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.29	0.28
2025	0.31	0.31	0.32	0.31	0.31	0.32	0.32	0.32	0.31	0.33	0.33	0.32	0.33	0.33	0.31
2026	0.34	0.34	0.35	0.35	0.34	0.35	0.36	0.35	0.35	0.37	0.37	0.35	0.38	0.37	0.34
2027	0.37	0.38	0.38	0.38	0.38	0.39	0.40	0.39	0.38	0.41	0.41	0.38	0.42	0.41	0.37
2028	0.40	0.41	0.42	0.41	0.41	0.42	0.43	0.43	0.42	0.45	0.46	0.41	0.47	0.45	0.41
2029	0.42	0.43	0.45	0.44	0.44	0.46	0.47	0.46	0.46	0.48	0.50	0.44	0.51	0.48	0.43
2030	0.44	0.46	0.48	0.47	0.47	0.49	0.50	0.49	0.49	0.52	0.54	0.47	0.55	0.51	0.46
2031	0.47	0.49	0.51	0.50	0.50	0.52	0.54	0.53	0.52	0.56	0.58	0.50	0.60	0.54	0.49
2032	0.49	0.51	0.53	0.53	0.53	0.55	0.57	0.56	0.56	0.60	0.62	0.52	0.64	0.57	0.51
2033	0.51	0.54	0.56	0.56	0.56	0.58	0.60	0.60	0.59	0.64	0.67	0.55	0.69	0.60	0.54
2034	0.54	0.56	0.59	0.59	0.58	0.61	0.63	0.63	0.62	0.67	0.71	0.58	0.73	0.63	0.57
2035	0.56	0.59	0.62	0.62	0.62	0.65	0.67	0.66	0.66	0.71	0.75	0.61	0.78	0.66	0.59
2036	0.58	0.62	0.65	0.65	0.64	0.68	0.71	0.70	0.69	0.75	0.80	0.63	0.83	0.69	0.62
2037	0.60	0.64	0.68	0.67	0.67	0.71	0.74	0.73	0.73	0.79	0.84	0.66	0.88	0.72	0.65
2038	0.63	0.67	0.70	0.70	0.70	0.74	0.77	0.76	0.76	0.83	0.88	0.69	0.92	0.75	0.67
2039	0.64	0.69	0.73	0.73	0.73	0.77	0.80	0.80	0.79	0.87	0.92	0.71	0.97	0.77	0.70
2040	0.66	0.71	0.75	0.75	0.75	0.79	0.83	0.83	0.82	0.90	0.96	0.73	1.02	0.79	0.72
2041	0.68	0.73	0.78	0.77	0.77	0.82	0.86	0.86	0.85	0.94	1.00	0.75	1.06	0.82	0.74
2042	0.70	0.75	0.80	0.80	0.80	0.85	0.89	0.89	0.88	0.97	1.04	0.78	1.11	0.84	0.76
2043	0.71	0.77	0.83	0.83	0.82	0.88	0.92	0.92	0.92	1.01	1.09	0.80	1.15	0.86	0.79
2044	0.73	0.79	0.85	0.85	0.84	0.90	0.95	0.95	0.94	1.05	1.13	0.82	1.20	0.88	0.81
2045	0.75	0.81	0.87	0.87	0.87	0.93	0.98	0.98	0.97	1.08	1.17	0.85	1.24	0.90	0.83

Table 7: Spawning output relative to the 40 percent of unfished spawning output target by year for rebuilding strategies, including ramp strategies. *(continued)*

Year	SPR= .500	SPR= .550	SPR= .600	Ramp1 SPR= .600	Ramp2 SPR= .600	SPR= .650	SPR= .700	Ramp1 SPR= .700	Ramp2 SPR= .700	SPR= .800	SPR= .900	Yr= T_{MID}	F=0	40-10 rule	ABC Rule
2046	0.77	0.83	0.90	0.89	0.89	0.96	1.01	1.00	1.00	1.11	1.20	0.87	1.28	0.92	0.85
2047	0.78	0.85	0.92	0.92	0.92	0.98	1.04	1.03	1.03	1.15	1.24	0.89	1.33	0.94	0.87
2048	0.80	0.87	0.94	0.94	0.94	1.01	1.07	1.06	1.06	1.18	1.28	0.91	1.38	0.96	0.90
2049	0.81	0.89	0.96	0.96	0.96	1.03	1.09	1.09	1.09	1.21	1.32	0.93	1.41	0.97	0.91
2050	0.83	0.91	0.98	0.98	0.98	1.05	1.12	1.11	1.11	1.25	1.36	0.95	1.46	0.99	0.93
2051	0.84	0.92	1.00	0.99	0.99	1.07	1.14	1.14	1.14	1.27	1.39	0.96	1.50	1.00	0.95
2052	0.85	0.93	1.02	1.01	1.01	1.09	1.16	1.16	1.16	1.30	1.42	0.98	1.53	1.02	0.96
2053	0.86	0.95	1.03	1.03	1.03	1.11	1.18	1.18	1.18	1.33	1.45	0.99	1.57	1.03	0.98
2054	0.87	0.96	1.04	1.04	1.04	1.13	1.20	1.20	1.19	1.35	1.48	1.01	1.60	1.04	0.99
2055	0.88	0.97	1.06	1.06	1.06	1.15	1.23	1.22	1.22	1.37	1.51	1.02	1.63	1.06	1.00
2056	0.90	0.99	1.08	1.07	1.07	1.16	1.24	1.24	1.24	1.40	1.54	1.03	1.67	1.07	1.02
2057	0.91	1.00	1.09	1.09	1.09	1.18	1.26	1.26	1.26	1.42	1.57	1.05	1.70	1.08	1.03
2058	0.92	1.01	1.11	1.10	1.10	1.20	1.28	1.28	1.27	1.44	1.60	1.06	1.74	1.09	1.04
2059	0.93	1.03	1.12	1.12	1.12	1.21	1.30	1.30	1.29	1.46	1.62	1.08	1.76	1.11	1.06
2060	0.94	1.04	1.14	1.14	1.13	1.23	1.32	1.31	1.31	1.49	1.65	1.09	1.79	1.11	1.07
2061	0.94	1.04	1.15	1.15	1.15	1.25	1.34	1.33	1.33	1.51	1.67	1.10	1.83	1.12	1.08
2062	0.95	1.06	1.16	1.16	1.16	1.26	1.35	1.35	1.34	1.53	1.69	1.11	1.85	1.13	1.09
2063	0.96	1.07	1.17	1.17	1.16	1.27	1.36	1.36	1.35	1.55	1.71	1.12	1.87	1.14	1.10
2064	0.96	1.07	1.18	1.18	1.17	1.28	1.38	1.37	1.37	1.56	1.73	1.13	1.90	1.15	1.11
2065	0.97	1.08	1.19	1.19	1.18	1.29	1.39	1.39	1.38	1.58	1.76	1.14	1.92	1.15	1.12
2066	0.98	1.09	1.20	1.20	1.20	1.30	1.40	1.40	1.40	1.60	1.78	1.15	1.95	1.16	1.13

9 Figures

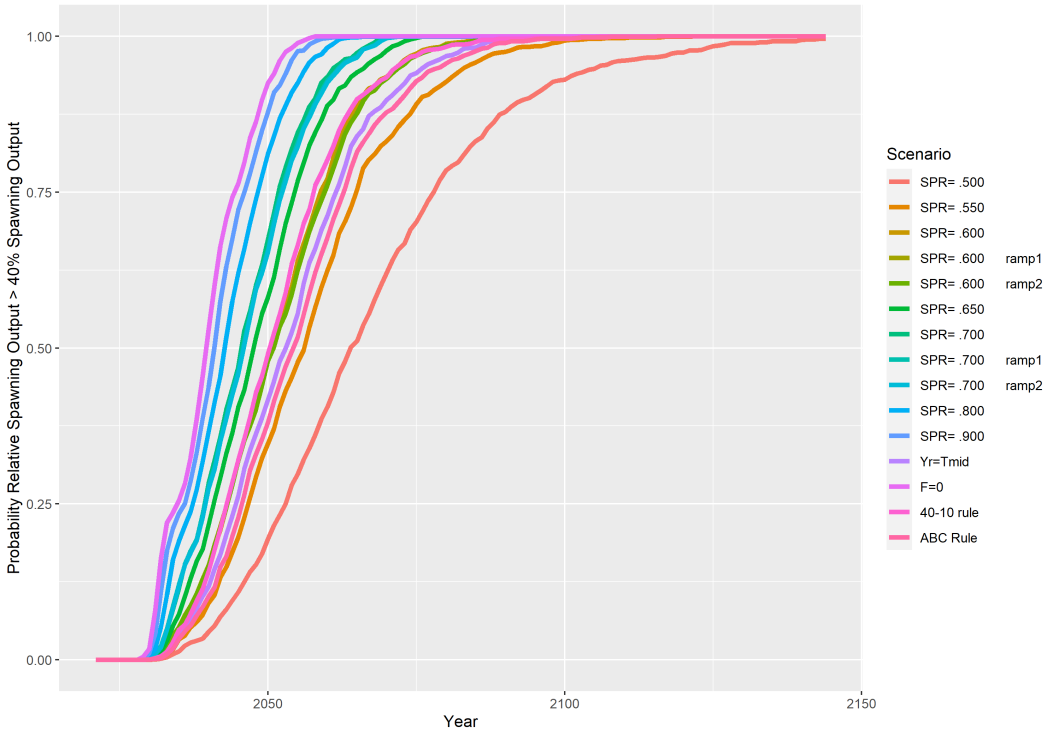

Figure 1: Probability of rebuilding by year for the alternative rebuilding strategies, including ramp strategies.

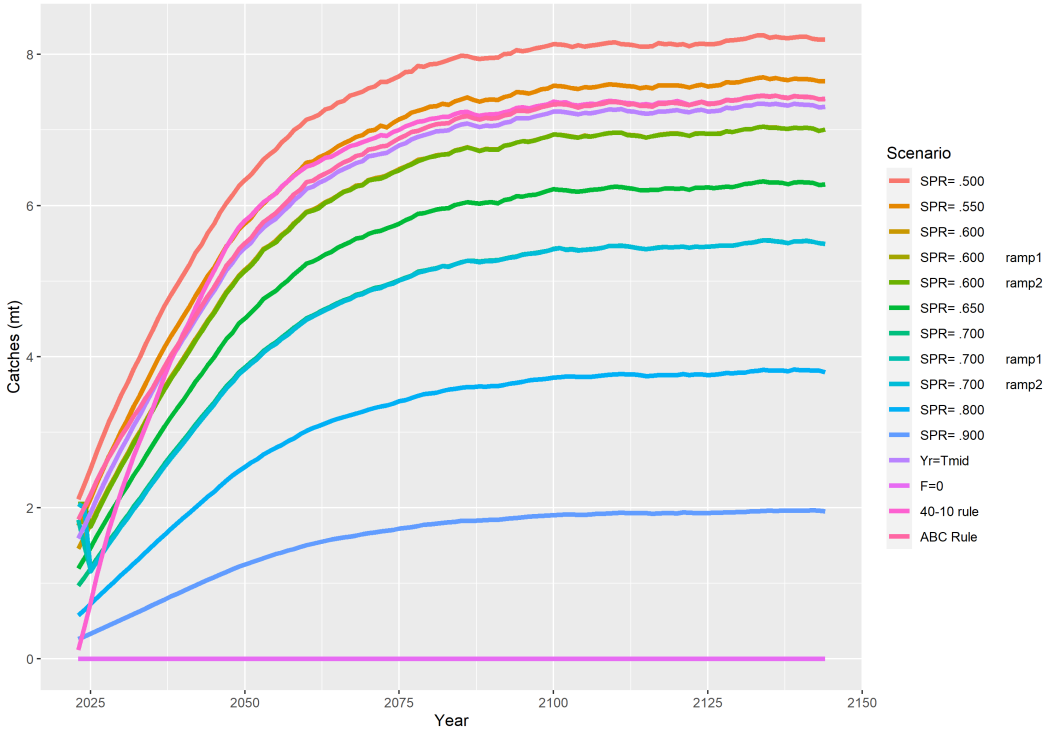

Figure 2: Catches (mt) by year, starting in 2023, for the alternative rebuilding strategies, including ramp strategies.

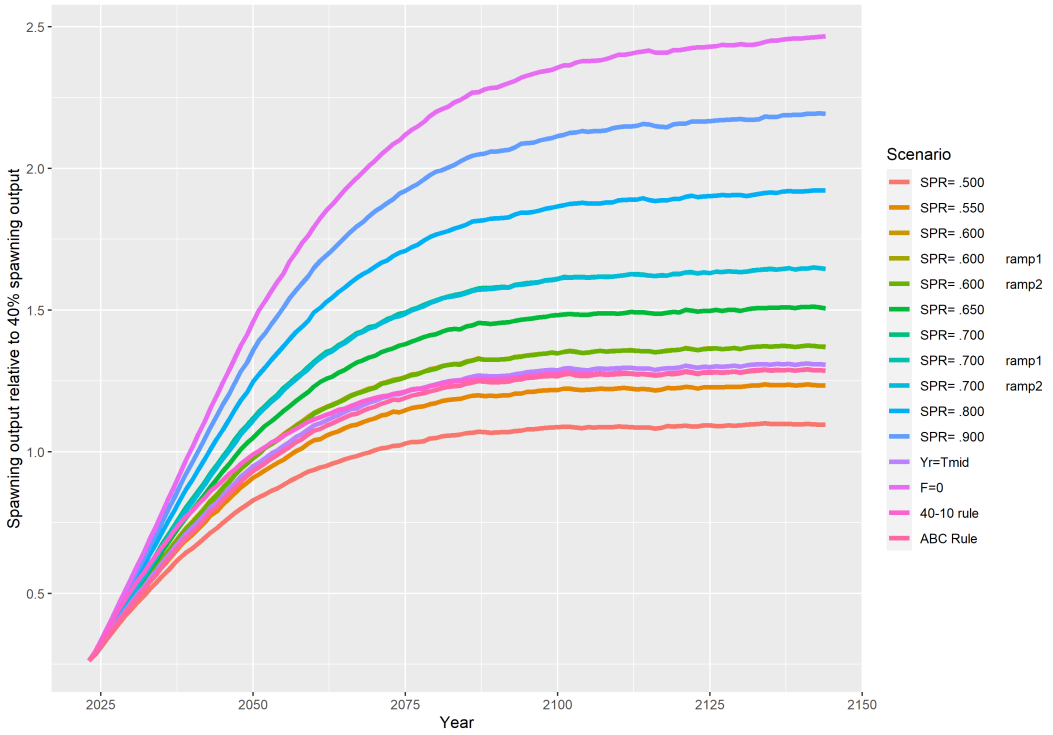

Figure 3: Spawning output relative to the management target of 40 percent of unfished spawning output by year, starting in 2023, for the alternative rebuilding strategies, including ramp strategies.

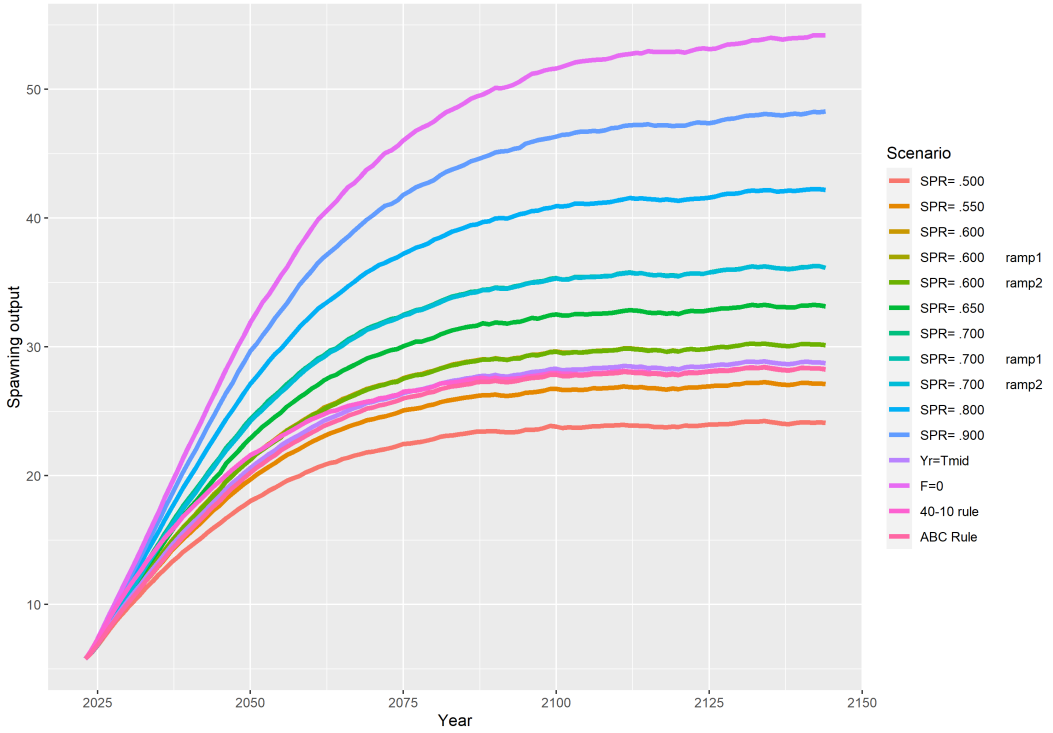

Figure 4: Spawning output by year, starting in 2023, for the alternative rebuilding strategies, including ramp strategies.

10 Appendix

10.1 Appendix A: Rebuilder data file.

The rebuild.dat file used for the base rebuilding analysis has been provided as a separate file.