

Draft - Rebuilding analysis for copper rockfish (*Sebastes caurinus*) in U.S. waters off the coast of California south of Point Conception based on the 2021 stock assessment

by
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Summary

This rebuilding analysis is for the stock of copper rockfish (*Sebastes caurinus*) in waters off California, south of Point Conception. The analysis is based on the 2021 stock assessment. The 2021 assessment model estimated the copper rockfish south of Point Conception to be at 18.1 percent of the unexploited equilibrium spawning output at the beginning of 2021. This rebuilding analysis compares the results of applying a suite of potential management actions to the stock for 2023 and beyond.

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 2033. The estimated generation time for copper rockfish was estimated to be 17 years. T_{MAX} is 2050 which is defined based on T_{MIN} plus the mean generation time. The SPR harvest rate of 0.589 generates a 50 percent probability of recovery by T_{MID} where T_{MID} was set equal to 2043, an intermediate year between T_{MIN} and T_{MAX} .

1 Introduction

The 2021 assessment of copper rockfish south of Point Conception in California documented that the stock had declined below the Minimum Stock Size Threshold (MSST), 25 percent of unfished spawning output for rockfish stocks, for the first time during the mid-1980s, remained below the MSST until 2011, increased above the MSST briefly between 2011-2016, but had fallen back below the MSST starting in 2017 (Wetzel et al. 2021). Based on the assumed stock productivity combined with the longevity of copper rockfish a range of alternative rebuilding approaches were examined where the stock rebuilt to or above the management target of 40 percent ranging between 2033 - 2050 based on various SPR harvest rates from 0.55 - 1.

2 Overview of the 2021 stock assessment

The 2021 assessment of copper rockfish assessed the stock as four separate sub-stocks along the U.S. west coast: south of Point Conception in California, north of Point Conception in California, Oregon, and Washington. This was the first assessment of copper rockfish conducted within Stock Synthesis that used catch and length composition data to inform model estimates around stock size and status. The previous assessment of copper rockfish conducted in 2013 was modeled using Extended Depletion-Based Stock Reduction Analysis (XDB-SRA), a delay-difference model, using catch, catch-per-unit-effort data, and prior distributions around biological parameters (Cope et al. 2013). The 2013 assessment estimated the stock at 76 percent of unfished spawning output based on fits to catch-per-unit-effort data and updated parameter distribution around biology (i.e., the posterior distributions). During model bridging between the 2013 to the 2021 assessment model, the large downward shift in estimated stock status in the new assessment was identified to be driven by the inclusion of the length data which implied a low relative stock size in recent years (Wetzel et al. 2021).

The stock assessment for the sub-stock south of Point Conception in California assumed two fishing fleets, a commercial and a recreational fleet, along with one survey fleet, the Northwest Fisheries Science Center Hook and Line Survey (NWFSC HKL Survey). The majority of the removals and length composition data within the model arose from the recreational fleet. Total removals of copper rockfish south of Point Conception peaked in the late 1970s and early 1980s, decreased from the late 1980s to mid-2000s but had high annual variability, and then increased in recent years (2013 - 2019). The stock was modeled using Stock Synthesis as a two-sex age-structured model. Area specific length-at-age and fecundity-at-length for copper rockfish south of Point Conception were estimated externally and then fixed within the model. Weight-at-length was estimated externally based upon observations by the NWFSC HKL and West Coast Groundfish Bottom Trawl Survey observations with the values fixed within the assessment model. Natural mortality and steepness were both fixed at the median or mean of the respective priors. The selectivity of both the commercial and recreational fishery were estimated to be domed-shape with the NWFSC HKL Survey selectivity fixed to

be asymptotic. The assessment model decision table explore uncertainty around stock size and status using lower and higher $\log(R_0)$ values relative to the base model.

3 Management performance under rebuilding

This is the first rebuilding plan for copper rockfish off the coast of California south of Point Conception.

4 Rebuilding calculations

This rebuilding analysis was conducted using software developed by A. Punt (version 3.12h, August 2021). The steps followed were:

- Define how equilibrium spawning output (SB_0) will be calculated.
- Define how future recruitment will be generated.
- Define the fishery selectivity and allocation to be applied during rebuilding.
- Decide how to include uncertainty in input parameters from the stock assessment in the rebuilding analysis.
- Calculate rebuilding reference points from the most current assessment results
 - Calculate the projected year in which the stock would rebuild with a 50 percent probability if all future fishing mortality was eliminated ($T_F=0$).
 - Calculate the projected year for a 50 percent probability of rebuilding from the year in which the stock was first declared overfished (T_{MIN}).
 - Calculate the mean generation time.
 - Calculate the maximum allowable rebuilding time (T_{MAX}).
- 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 relationship in order to be consistent with assessment model results. This level was estimated to be 233.04 millions of eggs in the base case assessment model, which dictates a rebuilding relative spawning output target ($SB_{40\%}$) of 93.22 millions of eggs (Table 1).

4.2 Generation of future recruitment

The estimated parameters of the stock recruitment relationship (unexploited equilibrium recruitment, $\log(R_0)$, and steepness, h) were used to generate future recruitments in the rebuilding analysis. The 2021 assessment model did not estimate annual recruitment deviations but uncertainty around future recruitments was generated by assuming a recruitment variability of $\sigma_R = 0.60$.

4.3 Population biology, fishery selectivity, and removal allocations

The biological parameters used for the rebuilding projections were based on the values from the Stock Synthesis assessment model. Biological parameters in the assessment were sex-specific and constant across time.

The selectivity used in the rebuilding analysis were obtained from 2021 assessment. Selectivity in the assessment model was constant across time for each fishing fleet. The relative allocation of catch among fleets in this rebuilding analysis was informed using the relative fishing mortality averaged over recent years (2015-2019).

4.4 Inclusion of uncertainty

Uncertainty was included in this rebuilding analysis via 1,200 random simulations of stochastic future recruitment strengths and integration over the three states of nature across stock size, $\log(R_0)$. The base model was given 50 percent of the weight and each alternative state of nature was given 25 percent of the weight.

4.5 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 selection of a T_{TARGET} (year for 50 percent probability of recovery). This rebuilding analysis presents the following alternate strategies spread among the approaches based on the selection of a SPR harvest rate or rebuilding by a selected target year:

- Apply a range of SPR values: 0.55, 0.60, 0.65, 0.70, and 0.75
- Eliminate all harvest, $F = 0$, beginning in the next management cycle, 2023, the same as setting a constant SPR harvest rate of 1.0.
- Apply the Annual Catch Limits (ACL) based on the 40:10 harvest control rule.
- Apply the Acceptable Biological Catch (ABC) with time-varying σ .
- Apply SPR harvest rates that are estimated to lead to a 50 percent probability of recovery by alternative target years: T_{MID} , T_{MAX} , and other years between T_{MIN} and T_{MAX}

All of the above rebuilding strategies were conducted assuming removals of 90.8 mt and 88.9 mt in 2021 and 2022.

The rebuilding strategies were run without capping catches by the ABC in future projection years. In application rebuilding progress would be monitored through updated rebuilding analysis on a regular basis during rebuild that would evaluate the progress of the selected rebuilding strategy and associated SPR harvest rate limiting the probability of the rebuilding harvest exceeding the ABC in reality. An additional analysis was conducted that did limit the future catches by the ABC and is provided in Section 10.1 for comparison.

5 Results

5.1 Rebuilding reference points

All 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 10 years, corresponding to the stock being rebuilt by 2033, assuming the default removals for 2021 and 2022. The mean generation time was estimated to be 17 years. The maximum time allowed for rebuilding, T_{MAX} is defined as the T_{MIN} plus the mean generation time for stocks that are unable to rebuild in less than 10 years. The minimum rebuilding time for copper rockfish was 10 years, just above the cut-off of less than 10 years, so T_{MAX} was set to 2050.

5.2 Alternative harvest projections

T_{TARGET} and $\text{SPR}_{\text{TARGET}}$ are not specified since this is the first rebuilding plan for copper rockfish and these values have not been set via the Pacific Fishery Management Council (Council) process. A rebuilding strategy is presented below based on rebuilding target year termed T_{MID} which is set at 2043, mid-value between T_{MIN} and T_{MAX} , along with the associated SPR harvest rate. The Council may opt to select a T_{TARGET} earlier or later than this T_{MID} value based on fishery, economic, or other factors.

Summary results from the rebuilding alternatives assuming removals of 90.8 and 88.9 mt are presented in Table 2. Rebuilding alternatives based on various target years are presented in Table 3. Excluding the ABC Rule rebuilding strategy, the target rebuilding year based on the range of pre-specified SPR values between 0.55 - 0.75 ranged from 2036 - 2046 (Table 2). The probability of rebuilding by year steadily increased across the alternative SPR values with full rebuilding by 2046 when the lowest SPR of 0.55 was applied (Table 4 and Figure 1). The recommended removals in 2023, the first year of rebuilding, were low ranging between 8.91 - 18.66 mt across alternative SPR values (Table 5) with the recommended removals slowly increasing by year during the rebuilding period (Figure 2). The estimated ABCs for each rebuilding alternative is given in Table 6. The change in spawning output by year relative to the spawning output target, 40 percent of unfished, under each of the alternative SPR values are shown by year in Table 7 and Figure 3.

The ABC Rule projections were based on the adopted rockfish SPR target of 0.50 combined with a time-varying category 2 σ and P^* of 0.45. Under the ABC Rule catches the stock was estimated to rebuild by year 2044 with a probability of 0.81 of the stock being rebuilt by T_{MAX} (Table 2). Rebuilding by T_{MID} , 2043, was achieved using a SPR value of 0.589 with a 0.848 probability of rebuilding by T_{MAX} 2050 (2050, Table 2).

Alternative rebuilding analysis that examined a range of specific rebuilding target years generally fell within alternatives explored in the initial analysis (Table 3 versus Table 2) but provided additional granularity to see potential rebuilding timelines. The probability of rebuilding, median annual catches, median ABCs, and spawning output relative to the spawning output target (40 percent) by year are shown in Tables 8 - 11.

6 Acknowledgments

Thank you to Andre Punt for quickly updating the rebuild program to apply time-varying σ for the Acceptable Biological Catch scenarios and thank you for his assistance and guidance on application of the rebuilding program. This document was greatly improved based on feedback and review of Owen Hamel.

7 References

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8 Tables

8.1 Rebuilding reference points and summary of alternatives

Table 1: Summary of the rebuilding reference points.

Parameter	2021 Assessment Values
SB0 (millions of eggs)	233.04
SB40% (millions of eggs)	93.22
SB2021 (millions of eggs)	42.28
Year rebuilding begins	2023
Current year	2021
Tmin	2033
Mean generation time (years)	17
Tmax	2050
Ttarget	TBD
SPRtarget	TBD

Table 2: Results of rebuilding alternatives based on selection of an SPR target or year for 50 percent probability of recovery based on the assumed removals for 2021-22. The SPR value for the ABC Rule is lower than 0.50 since this value represents the average SPR value applied across the projection period based on the time-varying buffer.

	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021 Assumed Removals (mt)	90.8	90.8	90.8	90.8	90.8	90.8	90.8	90.8
2022 Assumed Removals (mt)	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9
2023 ACL (mt)	18.66	15.9	13.39	11.06	8.91	16.49	0	18.94
2024 ACL (mt)	20.9	17.97	15.25	12.69	10.29	18.6	0	21
SPR	0.55	0.6	0.65	0.7	0.75	0.589	1	0.545
Ttarget	2046	2042	2039	2038	2036	2043	2033	2044
Tmax	2050	2050	2050	2050	2050	2050	2050	2050
Probability of recovery by Tmax	0.697	0.876	0.949	0.984	0.997	0.848	1	0.81

Table 3: Results of rebuilding alternatives based on alternative target rebuilding years based on 50 percent probability of recovery.

	Yr = 2036.0	Yr = 2040.0	Yr = 2044.0	Yr = 2048.0	Yr = 2050.0
2021 Assumed Removals (mt)	90.8	90.8	90.8	90.8	90.8
2022 Assumed Removals (mt)	88.9	88.9	88.9	88.9	88.9
2023 ACL (mt)	9.44	14.47	17.92	20.21	21.13
2024 ACL (mt)	10.88	16.43	20.12	22.53	23.49
SPR	0.737	0.628	0.563	0.524	0.509
Ttarget	2036	2040	2044	2048	2050
Tmax	2050	2050	2050	2050	2050
Probability of recovery by Tmax	0.992	0.927	0.755	0.577	0.5

8.2 Rebuilding alternative time series

Table 4: Probability of recovery by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	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
2023	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
2025	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
2027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2028	0.000	0.000	0.001	0.001	0.001	0.000	0.009	0.000
2029	0.001	0.001	0.002	0.006	0.007	0.001	0.048	0.001
2030	0.003	0.004	0.010	0.016	0.022	0.004	0.169	0.004
2031	0.005	0.013	0.025	0.043	0.068	0.010	0.313	0.018
2032	0.013	0.031	0.054	0.092	0.144	0.028	0.448	0.034
2033	0.028	0.058	0.098	0.152	0.223	0.049	0.580	0.070
2034	0.048	0.086	0.152	0.232	0.328	0.075	0.729	0.108
2035	0.068	0.128	0.220	0.315	0.422	0.112	0.825	0.154
2036	0.091	0.182	0.289	0.398	0.519	0.158	0.900	0.230
2037	0.135	0.242	0.352	0.492	0.616	0.210	0.948	0.282
2038	0.174	0.299	0.430	0.571	0.708	0.271	0.977	0.342
2039	0.212	0.351	0.498	0.665	0.783	0.321	0.989	0.404
2040	0.257	0.404	0.590	0.738	0.845	0.372	0.993	0.479
2041	0.300	0.467	0.663	0.792	0.884	0.428	0.998	0.554
2042	0.342	0.534	0.724	0.847	0.922	0.492	0.999	0.615
2043	0.390	0.606	0.764	0.881	0.947	0.552	0.999	0.674
2044	0.438	0.665	0.815	0.908	0.961	0.614	1.000	0.728
2045	0.495	0.703	0.845	0.931	0.975	0.664	1.000	0.760
2046	0.542	0.748	0.878	0.948	0.986	0.704	1.000	0.793
2047	0.586	0.776	0.900	0.962	0.991	0.739	1.000	0.815
2048	0.625	0.816	0.921	0.975	0.993	0.778	1.000	0.851
2049	0.657	0.848	0.938	0.982	0.995	0.807	1.000	0.886
2050	0.697	0.876	0.949	0.984	0.997	0.848	1.000	0.898
2051	0.737	0.899	0.960	0.987	0.998	0.873	1.000	0.918
2052	0.767	0.912	0.968	0.992	0.999	0.890	1.000	0.922
2053	0.792	0.928	0.971	0.993	0.999	0.903	1.000	0.937
2054	0.810	0.937	0.978	0.995	1.000	0.919	1.000	0.946
2055	0.832	0.943	0.987	0.996	1.000	0.927	1.000	0.952

Table 5: Median catches (mt) by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	90.80	90.80	90.80	90.80	90.80	90.80	90.8	90.80
2022	88.90	88.90	88.90	88.90	88.90	88.90	88.9	88.90
2023	18.66	15.90	13.39	11.06	8.91	16.49	0.0	8.57
2024	20.90	17.97	15.25	12.69	10.29	18.60	0.0	11.16
2025	22.88	19.82	16.92	14.17	11.55	20.48	0.0	14.05
2026	24.54	21.40	18.38	15.47	12.66	22.08	0.0	16.78
2027	25.54	22.37	19.31	16.33	13.44	23.06	0.0	19.33
2028	26.55	23.35	20.21	17.15	14.15	24.05	0.0	21.46
2029	27.40	24.20	21.02	17.88	14.82	24.91	0.0	23.02
2030	28.43	25.26	22.02	18.80	15.59	25.97	0.0	24.81
2031	29.41	26.11	22.87	19.56	16.26	26.84	0.0	26.37
2032	30.39	27.10	23.76	20.39	17.01	27.84	0.0	27.51
2033	31.42	28.09	24.69	21.24	17.76	28.83	0.0	28.97
2034	32.06	28.73	25.34	21.86	18.29	29.47	0.0	29.88
2035	32.84	29.55	26.13	22.57	18.90	30.28	0.0	30.89
2036	33.71	30.31	26.78	23.17	19.43	31.07	0.0	31.82
2037	34.54	31.15	27.60	23.90	20.07	31.91	0.0	32.97
2038	35.27	31.82	28.22	24.45	20.58	32.59	0.0	34.18
2039	36.09	32.62	28.98	25.14	21.14	33.40	0.0	35.83
2040	36.81	33.33	29.64	25.75	21.71	34.11	0.0	38.35
2041	37.51	33.95	30.20	26.28	22.17	34.77	0.0	41.11
2042	38.08	34.59	30.78	26.78	22.64	35.38	0.0	43.41
2043	38.76	35.19	31.33	27.31	23.07	36.02	0.0	44.71
2044	39.11	35.53	31.73	27.64	23.36	36.35	0.0	45.94
2045	39.23	35.70	31.88	27.81	23.56	36.48	0.0	45.82
2046	39.36	35.85	32.06	27.98	23.71	36.65	0.0	46.05
2047	40.19	36.58	32.62	28.40	24.04	37.40	0.0	46.23
2048	40.68	37.06	33.17	28.96	24.54	37.91	0.0	46.56
2049	41.02	37.41	33.46	29.23	24.71	38.24	0.0	47.01
2050	41.26	37.60	33.67	29.39	24.90	38.44	0.0	47.36
2051	41.56	37.86	33.83	29.55	25.03	38.69	0.0	47.46
2052	41.48	37.83	33.86	29.58	25.07	38.65	0.0	47.00
2053	41.63	38.00	34.04	29.74	25.17	38.82	0.0	47.02
2054	41.63	38.00	34.13	29.81	25.30	38.83	0.0	47.25
2055	42.28	38.56	34.53	30.22	25.66	39.41	0.0	47.53

Table 6: Median ABCs (mt) by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	23.47	23.47	23.47	23.47	23.47	23.47	23.47	23.47
2022	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33
2023	18.94	18.94	18.94	18.94	18.94	18.94	18.94	18.94
2024	21.01	21.19	21.36	21.51	21.65	21.15	22.23	21.67
2025	22.79	23.15	23.48	23.80	24.08	23.07	25.30	24.07
2026	24.21	24.76	25.27	25.73	26.16	24.64	27.99	25.98
2027	24.97	25.66	26.29	26.91	27.50	25.51	30.03	27.06
2028	25.73	26.51	27.28	28.00	28.66	26.34	31.83	27.96
2029	26.32	27.24	28.14	29.01	29.80	27.04	33.34	28.82
2030	27.00	28.15	29.15	30.15	31.05	27.90	35.24	29.47
2031	27.73	28.91	30.02	31.17	32.16	28.65	36.85	30.35
2032	28.36	29.65	30.87	32.07	33.25	29.37	38.38	31.23
2033	29.02	30.43	31.79	33.11	34.39	30.13	40.07	31.81
2034	29.34	30.84	32.31	33.72	35.08	30.53	41.28	32.13
2035	29.78	31.43	33.03	34.50	35.92	31.08	42.43	32.64
2036	30.48	32.16	33.76	35.29	36.81	31.80	43.67	33.27
2037	31.21	33.09	34.82	36.53	38.16	32.68	45.44	33.94
2038	31.88	33.77	35.61	37.32	39.08	33.38	46.88	34.58
2039	32.65	34.60	36.50	38.25	40.06	34.18	48.30	34.92
2040	33.25	35.30	37.33	39.28	41.13	34.87	49.54	35.36
2041	33.91	36.00	38.11	40.14	42.09	35.54	50.91	35.84
2042	34.42	36.69	38.85	40.92	42.94	36.19	52.12	35.97
2043	35.06	37.33	39.56	41.70	43.78	36.85	53.33	36.45
2044	35.38	37.70	40.05	42.23	44.38	37.19	54.18	36.52
2045	35.46	37.90	40.24	42.53	44.76	37.37	54.89	36.54
2046	35.58	38.02	40.38	42.64	44.94	37.49	55.44	36.54
2047	36.34	38.81	41.09	43.38	45.60	38.27	55.89	36.77
2048	36.78	39.35	41.81	44.21	46.51	38.80	57.30	37.16
2049	37.07	39.70	42.22	44.59	46.89	39.15	57.86	37.26
2050	37.27	39.92	42.43	44.89	47.23	39.33	58.24	37.30
2051	37.56	40.13	42.66	45.14	47.51	39.57	59.00	37.14
2052	37.47	40.13	42.70	45.18	47.61	39.56	59.01	37.10
2053	37.63	40.33	42.94	45.44	47.87	39.75	59.51	37.12
2054	37.63	40.33	43.02	45.54	48.10	39.73	59.64	37.11
2055	38.21	40.91	43.61	46.15	48.65	40.33	60.37	37.25

Table 7: Median spawning output relative to the 40 percent of unfished spawning output target by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
2022	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2023	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2024	0.40	0.40	0.40	0.41	0.41	0.40	0.42	0.41
2025	0.43	0.43	0.44	0.44	0.45	0.43	0.46	0.45
2026	0.46	0.47	0.48	0.48	0.49	0.47	0.53	0.49
2027	0.49	0.51	0.52	0.53	0.54	0.50	0.60	0.54
2028	0.53	0.55	0.56	0.58	0.60	0.54	0.67	0.58
2029	0.56	0.59	0.61	0.63	0.65	0.58	0.74	0.63
2030	0.60	0.63	0.65	0.68	0.71	0.62	0.82	0.67
2031	0.63	0.67	0.70	0.73	0.76	0.66	0.90	0.71
2032	0.67	0.70	0.74	0.78	0.81	0.70	0.97	0.75
2033	0.70	0.74	0.78	0.82	0.86	0.73	1.05	0.79
2034	0.73	0.78	0.82	0.87	0.91	0.77	1.12	0.82
2035	0.75	0.81	0.86	0.91	0.96	0.80	1.20	0.85
2036	0.79	0.84	0.90	0.96	1.01	0.83	1.27	0.89
2037	0.81	0.87	0.93	1.00	1.05	0.86	1.33	0.91
2038	0.83	0.90	0.97	1.03	1.10	0.89	1.40	0.94
2039	0.86	0.93	1.00	1.07	1.14	0.91	1.46	0.96
2040	0.88	0.95	1.03	1.10	1.18	0.94	1.52	0.98
2041	0.90	0.98	1.06	1.14	1.21	0.96	1.58	1.00
2042	0.93	1.01	1.10	1.18	1.26	0.99	1.65	1.02
2043	0.95	1.03	1.12	1.21	1.29	1.01	1.70	1.03
2044	0.97	1.06	1.15	1.24	1.33	1.04	1.76	1.04
2045	0.99	1.09	1.18	1.28	1.37	1.07	1.82	1.05
2046	1.01	1.11	1.21	1.31	1.40	1.09	1.87	1.05
2047	1.03	1.13	1.23	1.33	1.43	1.11	1.91	1.06
2048	1.04	1.15	1.25	1.35	1.46	1.12	1.95	1.06
2049	1.06	1.16	1.27	1.37	1.48	1.14	1.99	1.07
2050	1.07	1.18	1.29	1.39	1.50	1.15	2.03	1.07
2051	1.08	1.19	1.30	1.41	1.52	1.16	2.06	1.08
2052	1.09	1.20	1.32	1.43	1.54	1.18	2.09	1.09
2053	1.10	1.22	1.34	1.45	1.57	1.20	2.13	1.09
2054	1.11	1.23	1.35	1.47	1.58	1.21	2.15	1.09
2055	1.12	1.24	1.36	1.48	1.60	1.22	2.17	1.09

8.3 Rebuilding alternative time series for target rebuilding years

Table 8: The probability of rebuilding by year for alternative rebuilding target years assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	Yr = 2036.0	Yr = 2040.0	Yr = 2044.0	Yr = 2048.0	Yr = 2050.0
2021	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00
2024	0.00	0.00	0.00	0.00	0.00
2025	0.00	0.00	0.00	0.00	0.00
2026	0.00	0.00	0.00	0.00	0.00
2027	0.00	0.00	0.00	0.00	0.00
2028	0.00	0.00	0.00	0.00	0.00
2029	0.01	0.00	0.00	0.00	0.00
2030	0.02	0.01	0.00	0.00	0.00
2031	0.06	0.02	0.01	0.00	0.00
2032	0.14	0.04	0.01	0.01	0.01
2033	0.21	0.08	0.04	0.02	0.01
2034	0.31	0.12	0.06	0.03	0.03
2035	0.40	0.17	0.08	0.05	0.04
2036	0.50	0.24	0.11	0.06	0.05
2037	0.59	0.30	0.16	0.08	0.06
2038	0.68	0.37	0.20	0.12	0.09
2039	0.76	0.44	0.25	0.16	0.12
2040	0.83	0.50	0.30	0.19	0.16
2041	0.87	0.57	0.34	0.23	0.19
2042	0.91	0.64	0.39	0.26	0.22
2043	0.94	0.71	0.44	0.30	0.24
2044	0.95	0.75	0.50	0.34	0.28
2045	0.97	0.80	0.56	0.37	0.32
2046	0.98	0.82	0.61	0.42	0.35
2047	0.99	0.86	0.65	0.46	0.39
2048	0.99	0.88	0.69	0.50	0.42
2049	0.99	0.91	0.72	0.54	0.47
2050	0.99	0.93	0.76	0.58	0.50
2051	1.00	0.94	0.79	0.61	0.53
2052	1.00	0.95	0.82	0.64	0.56
2053	1.00	0.95	0.84	0.67	0.59
2054	1.00	0.96	0.86	0.70	0.62
2055	1.00	0.97	0.88	0.73	0.65

Table 9: Median catches (mt) by year for alternative rebuilding target years assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	Yr = 2036.0	Yr = 2040.0	Yr = 2044.0	Yr = 2048.0	Yr = 2050.0
2021	90.80	90.80	90.80	90.80	90.80
2022	88.90	88.90	88.90	88.90	88.90
2023	9.44	14.47	17.92	20.21	21.13
2024	10.88	16.43	20.12	22.53	23.49
2025	12.22	18.21	22.10	24.60	25.58
2026	13.41	19.76	23.81	26.32	27.32
2027	14.24	20.78	24.88	27.41	28.39
2028	15.07	21.73	25.92	28.44	29.39
2029	15.63	22.51	26.60	29.15	30.14
2030	16.39	23.47	27.63	30.13	31.12
2031	17.08	24.27	28.54	31.12	32.08
2032	17.88	25.25	29.54	32.04	32.99
2033	18.65	26.22	30.58	33.13	34.11
2034	19.24	26.95	31.38	33.90	34.81
2035	19.87	27.67	32.05	34.60	35.56
2036	20.33	28.37	32.89	35.41	36.38
2037	21.01	29.16	33.64	36.22	37.15
2038	21.50	29.74	34.30	36.84	37.78
2039	22.14	30.60	35.24	37.83	38.74
2040	22.74	31.33	35.99	38.59	39.53
2041	23.23	31.89	36.63	39.25	40.19
2042	23.72	32.58	37.26	39.89	40.84
2043	24.11	33.01	37.78	40.38	41.31
2044	24.42	33.39	38.16	40.76	41.70
2045	24.67	33.63	38.45	41.03	41.96
2046	24.80	33.77	38.45	40.99	41.87
2047	25.15	34.38	39.29	41.85	42.80
2048	25.65	34.92	39.76	42.42	43.39
2049	25.85	35.18	40.04	42.68	43.63
2050	26.02	35.36	40.24	42.95	43.89
2051	26.22	35.68	40.70	43.33	44.26
2052	26.26	35.68	40.63	43.35	44.24
2053	26.42	35.92	40.83	43.44	44.39
2054	26.58	36.00	40.97	43.64	44.51
2055	26.87	36.46	41.42	44.17	45.15

Table 10: Median ABCs (mt) by year for alternative rebuilding target years assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	Yr = 2036.0	Yr = 2040.0	Yr = 2044.0	Yr = 2048.0	Yr = 2050.0
2021	23.47	23.47	23.47	23.47	23.47
2022	21.33	21.33	21.33	21.33	21.33
2023	18.94	18.94	18.94	18.94	18.94
2024	21.61	21.29	21.07	20.92	20.86
2025	24.04	23.38	22.92	22.62	22.50
2026	26.14	25.15	24.45	23.97	23.80
2027	27.48	26.18	25.31	24.74	24.51
2028	28.83	27.21	26.15	25.43	25.13
2029	29.61	27.80	26.57	25.82	25.52
2030	30.83	28.73	27.32	26.44	26.12
2031	31.85	29.50	28.04	27.05	26.66
2032	32.97	30.32	28.71	27.59	27.16
2033	34.11	31.24	29.42	28.26	27.82
2034	34.87	31.84	29.89	28.63	28.12
2035	35.69	32.36	30.26	28.96	28.47
2036	36.41	33.03	30.95	29.55	29.03
2037	37.57	34.01	31.67	30.21	29.64
2038	38.49	34.65	32.31	30.74	30.14
2039	39.61	35.68	33.17	31.57	30.91
2040	40.72	36.50	33.85	32.20	31.55
2041	41.61	37.22	34.46	32.77	32.07
2042	42.48	37.98	35.13	33.28	32.59
2043	43.22	38.48	35.53	33.70	32.96
2044	43.74	38.94	35.95	34.02	33.28
2045	44.24	39.26	36.16	34.23	33.48
2046	44.39	39.37	36.20	34.20	33.41
2047	45.07	40.02	37.02	34.91	34.16
2048	45.89	40.71	37.46	35.39	34.62
2049	46.30	41.05	37.74	35.61	34.81
2050	46.56	41.26	37.88	35.84	35.03
2051	46.90	41.61	38.30	36.16	35.32
2052	47.13	41.64	38.22	36.15	35.31
2053	47.37	41.94	38.42	36.27	35.42
2054	47.65	41.94	38.56	36.40	35.51
2055	48.13	42.55	39.01	36.88	36.03

Table 11: Median spawning output relative to the 40 percent of unfished spawning output target by year for alternative rebuilding targets assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	Yr = 2036.0	Yr = 2040.0	Yr = 2044.0	Yr = 2048.0	Yr = 2050.0
2021	0.45	0.45	0.45	0.45	0.45
2022	0.42	0.42	0.42	0.42	0.42
2023	0.38	0.38	0.38	0.38	0.38
2024	0.41	0.40	0.40	0.40	0.40
2025	0.44	0.43	0.43	0.42	0.42
2026	0.49	0.47	0.46	0.45	0.45
2027	0.54	0.52	0.50	0.49	0.48
2028	0.59	0.56	0.53	0.52	0.51
2029	0.65	0.60	0.57	0.55	0.54
2030	0.70	0.64	0.61	0.58	0.57
2031	0.75	0.69	0.64	0.62	0.61
2032	0.80	0.72	0.68	0.64	0.63
2033	0.85	0.76	0.71	0.67	0.66
2034	0.90	0.80	0.74	0.70	0.69
2035	0.95	0.84	0.77	0.73	0.71
2036	1.00	0.88	0.80	0.75	0.74
2037	1.04	0.91	0.83	0.78	0.76
2038	1.08	0.94	0.85	0.80	0.78
2039	1.12	0.97	0.88	0.82	0.80
2040	1.16	1.00	0.90	0.84	0.81
2041	1.19	1.02	0.92	0.86	0.84
2042	1.23	1.05	0.94	0.88	0.85
2043	1.27	1.08	0.97	0.90	0.87
2044	1.31	1.11	0.99	0.92	0.89
2045	1.34	1.14	1.02	0.94	0.91
2046	1.38	1.16	1.04	0.96	0.93
2047	1.40	1.19	1.05	0.97	0.94
2048	1.43	1.20	1.07	0.99	0.96
2049	1.46	1.23	1.09	1.00	0.97
2050	1.48	1.24	1.10	1.01	0.98
2051	1.49	1.25	1.11	1.02	0.99
2052	1.51	1.27	1.12	1.03	1.00
2053	1.53	1.28	1.13	1.04	1.01
2054	1.55	1.30	1.15	1.05	1.02
2055	1.57	1.31	1.16	1.06	1.02

9 Figures

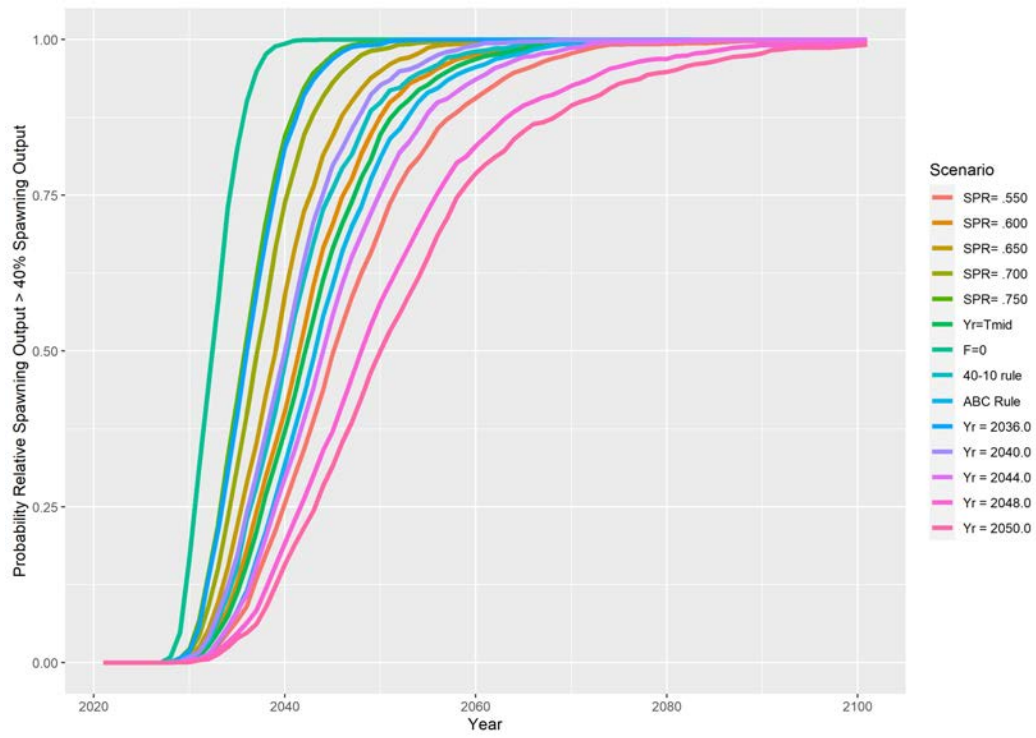


Figure 1: Probability of rebuilding by year for alternative rebuilding strategies.

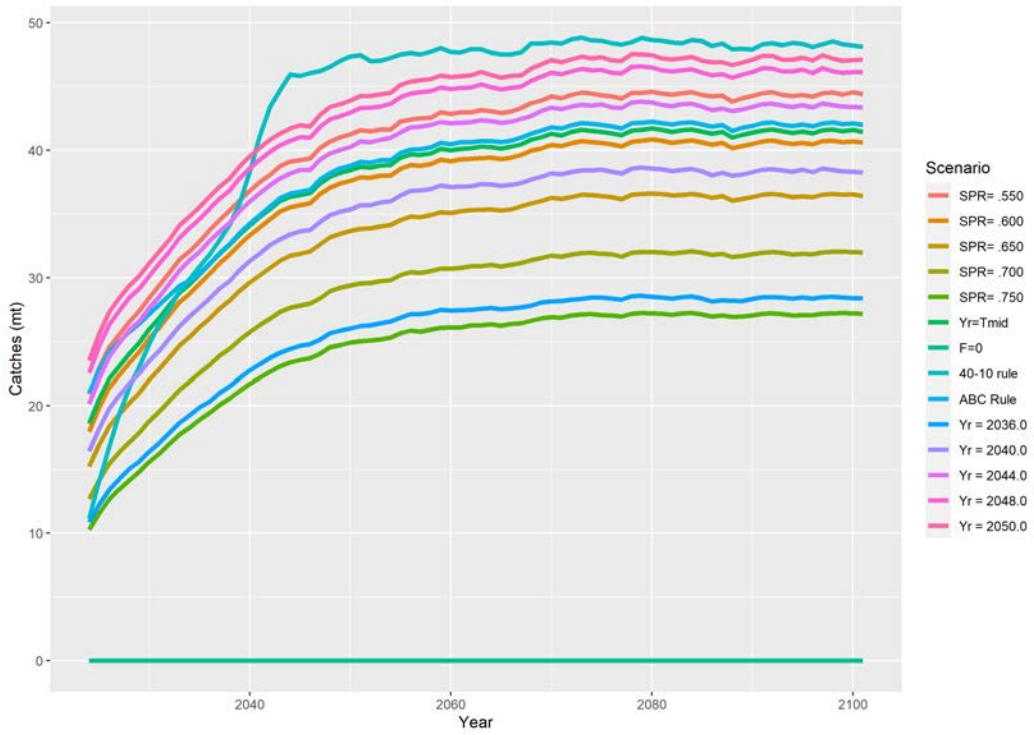


Figure 2: Catches (mt) by year for alternative rebuilding strategies.

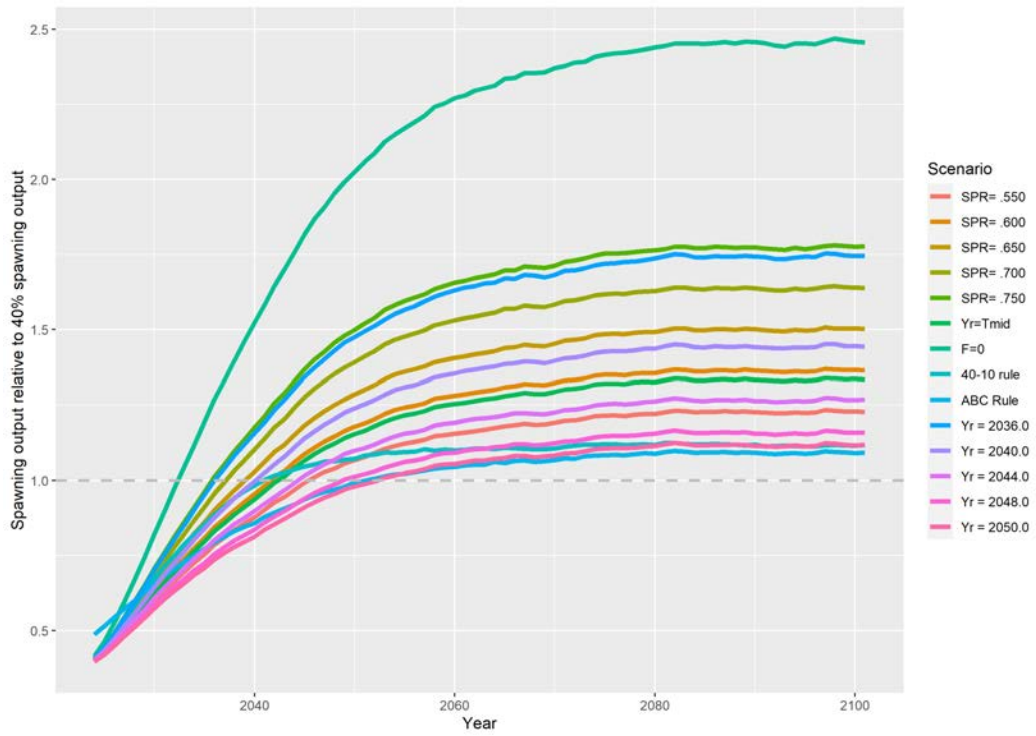


Figure 3: Spawning output relative to the management target of 40 percent of unfished spawning output by year for alternative rebuilding strategies.

10 Appendix

10.1 Rebuilding strategies with catches constrained by the ABC

Alternative rebuilding alternative that cap the potential removals across alternative strategies by the ABC Rule with time-varying σ values. Capping removals by the ABC in this manner impacts both the $\text{SPR} = 0.55$ and the T_{MID} ($\text{SPR} = 0.545$) rebuilding strategies where projected catches from these strategies equal those from the ABC Rule. The intermediate rebuilding strategies, SPR between 0.60 - 0.75, are not impacted by applying a removal cap tied to the ABC values.

Table 12: Summary of the rebuilding reference points.

Parameter	2021 Assessment Values
SB0 (millions of eggs)	233.04
SB40% (millions of eggs)	93.22
SB2021 (millions of eggs)	42.28
Year rebuilding begins	2023
Current year	2021
Tmin	2033
Mean generation time (years)	17
Tmax	2050
Ttarget	TBD
SPRtarget	TBD

Table 13: Results of rebuilding alternatives based on selection of an SPR target or year for 50 percent probability of recovery based on the assumed removals for 2021-22. The SPR value provided under the ABC Rule is the realized average applied SPR across projection years based on time-varying sigmas and the applied buffer where the ABC Rule is based initially on an SPR value of 0.50.

	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021 Assumed Removals (mt)	90.8	90.8	90.8	90.8	90.8	90.8	90.8	90.8
2022 Assumed Removals (mt)	88.9	88.9	88.9	88.9	88.9	88.9	88.9	88.9
2023 ACL (mt)	18.66	15.9	13.39	11.06	8.91	15.92	0	18.94
2024 ACL (mt)	20.9	17.97	15.25	12.69	10.29	17.98	0	21
SPR	0.55	0.6	0.65	0.7	0.75	0.6	1	0.545
Ttarget	2044	2042	2039	2038	2036	2042	2033	2044
Tmax	2050	2050	2050	2050	2050	2050	2050	2050
Probability of recovery by Tmax	0.81	0.876	0.949	0.984	0.997	0.875	1	0.81

Table 14: Probability of recovery by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	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
2023	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
2025	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
2027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2028	0.000	0.000	0.001	0.001	0.001	0.000	0.009	0.000
2029	0.001	0.001	0.002	0.006	0.007	0.001	0.048	0.001
2030	0.003	0.004	0.010	0.016	0.022	0.004	0.169	0.004
2031	0.005	0.013	0.025	0.043	0.068	0.013	0.313	0.018
2032	0.014	0.031	0.054	0.092	0.144	0.031	0.448	0.034
2033	0.034	0.058	0.098	0.152	0.223	0.058	0.580	0.070
2034	0.058	0.086	0.152	0.232	0.328	0.086	0.729	0.108
2035	0.084	0.128	0.220	0.315	0.422	0.128	0.825	0.154
2036	0.117	0.182	0.289	0.398	0.519	0.181	0.900	0.230
2037	0.165	0.242	0.352	0.492	0.616	0.242	0.948	0.282
2038	0.211	0.299	0.430	0.571	0.708	0.299	0.977	0.342
2039	0.264	0.351	0.498	0.665	0.783	0.350	0.989	0.404
2040	0.320	0.404	0.590	0.738	0.845	0.403	0.993	0.479
2041	0.374	0.467	0.663	0.792	0.884	0.467	0.998	0.554
2042	0.429	0.534	0.724	0.847	0.922	0.533	0.999	0.615
2043	0.491	0.606	0.764	0.881	0.947	0.605	0.999	0.674
2044	0.556	0.665	0.815	0.908	0.961	0.664	1.000	0.728
2045	0.607	0.703	0.845	0.931	0.975	0.703	1.000	0.760
2046	0.660	0.748	0.878	0.948	0.986	0.746	1.000	0.793
2047	0.699	0.776	0.900	0.962	0.991	0.775	1.000	0.815
2048	0.733	0.816	0.921	0.975	0.993	0.814	1.000	0.851
2049	0.775	0.848	0.938	0.982	0.995	0.847	1.000	0.886
2050	0.810	0.876	0.949	0.984	0.997	0.875	1.000	0.898
2051	0.841	0.899	0.960	0.987	0.998	0.899	1.000	0.918
2052	0.856	0.912	0.968	0.992	0.999	0.912	1.000	0.922
2053	0.879	0.928	0.971	0.993	0.999	0.928	1.000	0.937
2054	0.901	0.937	0.978	0.995	1.000	0.937	1.000	0.946
2055	0.915	0.943	0.987	0.996	1.000	0.943	1.000	0.952

Table 15: Median catches (mt) by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	90.80	90.80	90.80	90.80	90.80	90.80	90.8	90.80
2022	88.90	88.90	88.90	88.90	88.90	88.90	88.9	88.90
2023	18.66	15.90	13.39	11.06	8.91	15.92	0.0	8.57
2024	20.90	17.97	15.25	12.69	10.29	17.98	0.0	11.16
2025	22.79	19.82	16.92	14.17	11.55	19.83	0.0	14.05
2026	24.22	21.40	18.38	15.47	12.66	21.41	0.0	16.78
2027	24.99	22.37	19.31	16.33	13.44	22.38	0.0	19.33
2028	25.78	23.35	20.21	17.15	14.15	23.35	0.0	21.46
2029	26.41	24.20	21.02	17.88	14.82	24.22	0.0	23.02
2030	27.17	25.26	22.02	18.80	15.59	25.27	0.0	24.81
2031	27.92	26.11	22.87	19.56	16.26	26.12	0.0	26.37
2032	28.64	27.10	23.76	20.39	17.01	27.11	0.0	27.51
2033	29.38	28.09	24.69	21.24	17.76	28.10	0.0	28.97
2034	29.77	28.73	25.34	21.86	18.29	28.74	0.0	29.88
2035	30.33	29.55	26.13	22.57	18.90	29.56	0.0	30.86
2036	31.10	30.31	26.78	23.17	19.43	30.32	0.0	31.69
2037	31.96	31.15	27.60	23.90	20.07	31.17	0.0	32.72
2038	32.67	31.82	28.22	24.45	20.58	31.83	0.0	33.83
2039	33.51	32.62	28.98	25.14	21.14	32.63	0.0	34.75
2040	34.25	33.33	29.64	25.75	21.71	33.35	0.0	35.49
2041	34.92	33.95	30.20	26.28	22.17	33.96	0.0	36.32
2042	35.58	34.59	30.78	26.78	22.64	34.59	0.0	36.88
2043	36.25	35.19	31.33	27.31	23.07	35.20	0.0	37.47
2044	36.60	35.53	31.73	27.64	23.36	35.55	0.0	37.77
2045	36.75	35.70	31.88	27.81	23.56	35.71	0.0	38.03
2046	36.92	35.85	32.06	27.98	23.71	35.86	0.0	38.00
2047	37.73	36.58	32.62	28.40	24.04	36.59	0.0	38.64
2048	38.22	37.06	33.17	28.96	24.54	37.07	0.0	39.21
2049	38.58	37.41	33.46	29.23	24.71	37.42	0.0	39.40
2050	38.78	37.60	33.67	29.39	24.90	37.61	0.0	39.61
2051	39.08	37.86	33.83	29.55	25.03	37.87	0.0	39.78
2052	39.04	37.83	33.86	29.58	25.07	37.84	0.0	39.77
2053	39.23	38.00	34.04	29.74	25.17	38.01	0.0	39.89
2054	39.23	38.00	34.13	29.81	25.30	38.02	0.0	39.90
2055	39.82	38.56	34.53	30.22	25.66	38.57	0.0	40.48

Table 16: Median ABCs (mt) by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	23.47	23.47	23.47	23.47	23.47	23.47	23.47	23.47
2022	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33
2023	18.94	18.94	18.94	18.94	18.94	18.94	18.94	18.94
2024	21.01	21.19	21.36	21.51	21.65	21.19	22.23	21.67
2025	22.79	23.15	23.48	23.80	24.08	23.15	25.30	24.07
2026	24.22	24.76	25.27	25.73	26.16	24.76	27.99	25.98
2027	24.99	25.66	26.29	26.91	27.50	25.66	30.03	27.06
2028	25.78	26.51	27.28	28.00	28.66	26.51	31.83	27.96
2029	26.41	27.24	28.14	29.01	29.80	27.23	33.34	28.82
2030	27.17	28.15	29.15	30.15	31.05	28.14	35.24	29.47
2031	27.92	28.91	30.02	31.17	32.16	28.90	36.85	30.35
2032	28.64	29.65	30.87	32.07	33.25	29.65	38.38	31.23
2033	29.38	30.43	31.79	33.11	34.39	30.42	40.07	31.81
2034	29.77	30.84	32.31	33.72	35.08	30.84	41.28	32.13
2035	30.33	31.43	33.03	34.50	35.92	31.43	42.43	32.73
2036	31.10	32.16	33.76	35.29	36.81	32.16	43.67	33.39
2037	31.96	33.09	34.82	36.53	38.16	33.08	45.44	34.07
2038	32.67	33.77	35.61	37.32	39.08	33.77	46.88	34.78
2039	33.51	34.60	36.50	38.25	40.06	34.59	48.30	35.42
2040	34.25	35.30	37.33	39.28	41.13	35.30	49.54	35.87
2041	34.92	36.00	38.11	40.14	42.09	35.99	50.91	36.57
2042	35.58	36.69	38.85	40.92	42.94	36.68	52.12	37.02
2043	36.25	37.33	39.56	41.70	43.78	37.33	53.33	37.54
2044	36.60	37.70	40.05	42.23	44.38	37.70	54.18	37.84
2045	36.75	37.90	40.24	42.53	44.76	37.88	54.89	38.10
2046	36.92	38.02	40.38	42.64	44.94	38.01	55.44	38.12
2047	37.73	38.81	41.09	43.38	45.60	38.81	55.89	38.69
2048	38.22	39.35	41.81	44.21	46.51	39.34	57.30	39.22
2049	38.58	39.70	42.22	44.59	46.89	39.70	57.86	39.42
2050	38.78	39.92	42.43	44.89	47.23	39.91	58.24	39.67
2051	39.08	40.13	42.66	45.14	47.51	40.12	59.00	39.78
2052	39.04	40.13	42.70	45.18	47.61	40.12	59.01	39.80
2053	39.23	40.33	42.94	45.44	47.87	40.32	59.51	39.93
2054	39.23	40.33	43.02	45.54	48.10	40.32	59.64	39.92
2055	39.82	40.91	43.61	46.15	48.65	40.90	60.37	40.51

Table 17: Median pawning output relative to the 40 percent of unfished spawning output target by year for rebuilding SPR alternatives assuming removals of 90.8 and 88.9 mt in 2021 and 2022, respectively.

Year	SPR= .550	SPR= .600	SPR= .650	SPR= .700	SPR= .750	Yr=Tmid F=0	40-10 rule	ABC Rule
2021	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
2022	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
2023	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2024	0.40	0.40	0.40	0.41	0.41	0.40	0.42	0.41
2025	0.43	0.43	0.44	0.44	0.45	0.43	0.46	0.45
2026	0.46	0.47	0.48	0.48	0.49	0.47	0.53	0.49
2027	0.49	0.51	0.52	0.53	0.54	0.51	0.60	0.54
2028	0.53	0.55	0.56	0.58	0.60	0.55	0.67	0.58
2029	0.56	0.59	0.61	0.63	0.65	0.59	0.74	0.63
2030	0.60	0.63	0.65	0.68	0.71	0.63	0.82	0.67
2031	0.64	0.67	0.70	0.73	0.76	0.67	0.90	0.71
2032	0.67	0.70	0.74	0.78	0.81	0.70	0.97	0.75
2033	0.70	0.74	0.78	0.82	0.86	0.74	1.05	0.79
2034	0.74	0.78	0.82	0.87	0.91	0.78	1.12	0.82
2035	0.77	0.81	0.86	0.91	0.96	0.81	1.20	0.85
2036	0.80	0.84	0.90	0.96	1.01	0.84	1.27	0.89
2037	0.83	0.87	0.93	1.00	1.05	0.87	1.33	0.91
2038	0.86	0.90	0.97	1.03	1.10	0.90	1.40	0.94
2039	0.88	0.93	1.00	1.07	1.14	0.93	1.46	0.97
2040	0.91	0.95	1.03	1.10	1.18	0.95	1.52	0.99
2041	0.94	0.98	1.06	1.14	1.21	0.98	1.58	1.01
2042	0.97	1.01	1.10	1.18	1.26	1.01	1.65	1.03
2043	0.99	1.03	1.12	1.21	1.29	1.03	1.70	1.05
2044	1.01	1.06	1.15	1.24	1.33	1.06	1.76	1.08
2045	1.04	1.09	1.18	1.28	1.37	1.09	1.82	1.10
2046	1.06	1.11	1.21	1.31	1.40	1.11	1.87	1.12
2047	1.08	1.13	1.23	1.33	1.43	1.13	1.91	1.13
2048	1.10	1.15	1.25	1.35	1.46	1.15	1.95	1.15
2049	1.12	1.16	1.27	1.37	1.48	1.16	1.99	1.16
2050	1.13	1.18	1.29	1.39	1.50	1.18	2.03	1.17
2051	1.14	1.19	1.30	1.41	1.52	1.19	2.06	1.19
2052	1.16	1.20	1.32	1.43	1.54	1.20	2.09	1.20
2053	1.17	1.22	1.34	1.45	1.57	1.22	2.13	1.21
2054	1.18	1.23	1.35	1.47	1.58	1.23	2.15	1.21
2055	1.19	1.24	1.36	1.48	1.60	1.24	2.17	1.22

10.2 Rebuilding data file

The rebuild.dat file used for the SPR alternative analysis has been provided as a separate file.