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August 30, 3017

MEMORANDUM TO: Leann Bosarge
Chair, Gulf of Mexico Fishery Management Council

FROM: Bonnie J. Ponwith, Ph.D.
Science Director

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Date: 2017.08.30 13:26:45 -04'00'

SUBJECT: Request to conduct simulated carry-over for Gulf of Mexico red snapper with conditions

Please see the following report for requested simulations of carry-over for Gulf of Mexico red snapper.

cc:
Jack McGovern
Sue Gerhart
Adyan Rios
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Investigating the Impact of Carrying Over Multiple Theoretical Landings Underages on the Ability to Achieve Rebuilding Targets for Gulf of Mexico Red Snapper

Southeast Fisheries Science Center
August 28, 2017

Matthew W. Smith and Daniel R. Goethel

1. INTRODUCTION

At its June 2017 meeting the Gulf of Mexico Fisheries Management Council ("Council") requested that Council staff and the National Marine Fisheries Service conduct additional analyses to investigate the impact of carrying over unharvested red snapper quota from one year to the next. Previous analysis into the topic investigated the effect of a single, fleet-specific carryover event and demonstrated that even when 100% of the unharvested quota was carried over and removed the subsequent year, the stock would rebuild by the 2032 target date. The Council was concerned that this analysis was incomplete, because it did not account for the possibility of multiple carryover events or limitations to the quantity of unharvested quota that could be carried over. Specifically, the Council requested that the following issues be addressed with updated projections:

- Simulate carry-over events that are consecutive (but not cumulative) along with one-year and multi-year intervals between carry-overs
- Discount carryovers for natural mortality ("M adj.")
- Capping carryovers so that the resulting Acceptable Biological Catch (ABC) cannot exceed 95% of the annual OFL ("OFL cap")

Using the 2014 SEDAR 31 Update Stock Synthesis 3 model (terminal year 2014), several fixed catch projections were performed to investigate the impact of a series of theoretical underages occurring between 2017 and 2032.

2. METHODS

Deterministic projections conditioned on the base model from the SEDAR 31 Gulf of Mexico red snapper assessment (SEDAR, 2015) updated to include recent landings data (i.e., 2014, 2015 and 2016) were utilized to investigate the impact of multiple carryover events on rebuilding (26% gulf-wide SPR by 2032). Utilizing the base assessment model six projections were implemented using Stock Synthesis (SS3, V3.24U; Methot and Wetzel, 2013). Two of these projections were conducted to create time-series of ABC (Yield at $F_{REBUILD}$) and OFL (Yield at $F_{SPR26\%}$) that accounted for the additional landings data made available since the last assessment in 2014 (Table 1). The projected ABC yield stream established the total annual removals and the fleet-specific annual removals to which any underage or carry-over adjustment would be made. The OFL stream was used to enforce the OFL cap per the Council request. The four remaining projection scenarios were used to test the impact of carrying over unused quota with and without discounting for natural mortality and with and without applying the OFL cap.

An underage was input as a percent reduction in annual landings by management unit fleets ("SERO fleets", i.e., recreational private, recreational for-hire, and commercial; Table 1). The timing of an underage varied throughout the rebuilding timeseries to allow for one instance of a consecutive underage

for each SERO fleet and six total underages per fleet. An underage and subsequent carry-over was calculated and prepared for input into SS using the following approach:

1. The annual ABC (metric tons whole weight) was taken from the $F_{REBUILD}$ projection assuming a 0.51/0.49 commercial/recreational allocation and further apportioned 0.577/0.423 to the recreational private/recreational for-hire SERO fleets (Table 2).
2. An underage for each SERO fleet was calculated by multiplying the fleet-specific ABC by the annual percent underage for the corresponding fleet (listed in Table 1).
3. Recreational for-hire and private underages were further subdivided into eastern and western Gulf components using proportions derived from recent (2010 – 2014) landings data (72.2% of for-hire landings and 80.2% of private landings come from the eastern Gulf; Table 2).
4. To facilitate converting SERO recreational fleet underages into SS3 recreational fleet underages (MRIP_E, MRIP_W, HBT_E, and HBT_W), the average fleet composition of for-hire landings was calculated for the eastern and western Gulf using 2010 - 2014 landings data (Eastern Gulf, 69.3% charter boat and 30.7% headboat; Western Gulf, 24.3% charter boat and 75.7% from headboat).
5. Underages for the SS3 MRIP fleets were set equal to the SERO recreational private underage plus the charter boat proportion of the SERO for-hire fleet, while the SS headboat fleets (HBT_E and HBT_W) were assigned the remainder of the for-hire underage.
6. The amount of quota that was carried over to the next year (no implementation lag was assumed) was calculated assuming no cumulative carry-over (i.e., if there were subsequent underages it was assumed that all unused carryover was forfeited) for four test scenarios (no M adj. with no OFL cap, no M adj. with OFL cap, M adj. with no OFL cap, and M adj. with OFL cap; Tables 3-6).

Carry-over amounts for the recreational fleets in Tables 3-6 were added to the annual fleet specific ABC's to get an adjusted yield stream for model forecasting. The annual commercial carryovers in Tables 3-6 were divided between the four commercial SS fleets (HL_E, HL_W, LL_E and LL_W) in proportion to their annual yield. Recreational ABCs were converted from weight to numbers in thousands of fish using the annual model estimated average weight by fleet and region.

Scenarios requiring a natural mortality adjustment were completed by discounting any carryover by the fraction of the fish that would die due to natural mortality over the course of the subsequent year (i.e., e^{-M}, where M was the age averaged natural mortality rate for red snapper of 0.094277). Scenarios requiring the OFL cap to be implemented were carried out by reducing proposed carry-over amounts until the annual ABC with carry-over was equal to 95% of the annual OFL. Carry-over was reduced in such a way that the relative proportions of each fleets contribution to the total original carry-over were maintained.

3. RESULTS

The carryover adjusted yield varied widely across years and forecasting scenario (Figure 1). Implementation of the OFL cap had the largest impact on carry-over adjusted yield, especially in the later years of the projections when the difference between the OFL and ABC was small (Table 1). Discounting future carry-over for loses due to natural mortality resulted in only modest reductions in carry-over adjusted yield due to the low natural mortality rate assumed for Gulf of Mexico red snapper. Under all scenarios tested the stock rebuilt prior to the 2032 target rebuilding date (Figure 2, Table 7). Scenarios implementing the OFL cap rebuilt the fastest due

to the heavily reduced carry-over adjusted yields resulting from the cap. Without the OFL cap in place the stock was still projected to rebuild by 2031. Including or excluding M adj. had little effect on rebuilding time

4. DISCUSSION

Given the results of the carry-over projections, it is expected that rebuilding timelines will not be impacted by a carry-over provision assuming that the carry-over is less than or equal to the underage and applied in a fleet-specific fashion. Although these results are expected to hold for underages less than our hypothesized potential maximum of 20%, it is unclear how well the stock can maintain its rebuilding schedule for values much larger than the projected underage level. Additionally, because the projected underage value is completely hypothetical, the results are not meant to be used as the basis of setting future catches for Gulf of Mexico red snapper. The carry-over was only projected on a fleet-specific basis, which means that these results only hold when a given underage is given back (in the form of a carry-over) to the fleet that didn't harvest its entire allocation. Given differences in selectivity and discarding patterns, reassigning carry-overs to fleets other than the one that originally observed an underage may lead to unexpected impacts on rebuilding.

Despite being explicitly requested by the council, performing post-hoc adjustments to the size of the carry-over is not required. In particular, because natural mortality is inherently accounted for within the SS3 ABC projections, it is unnecessary to perform additional adjustments to the quota that is carried over to the subsequent year. Performing adjustments to the carry-over quota to account for M essentially amounts to double counting the natural mortality. By catching less in the underage year, the stock is left better off than was accounted for in the ABC projection, which would allow the stock to then withstand the full amount of the ABC in addition to the underage (because the stock has grown by the size of the underage during the year of the underage). Both the ABC projection and the carry-over projections account for M explicitly and, therefore, it is unnecessary to further downgrade the carry-over quota by M. The same arguments can be made for capping the ABC in a carry-over year by the OFL assuming all of the stipulations of the current projections are met (i.e., that the carry-over does not exceed the underage and that each are applied in a fleet-specific manner). Additionally, because the error level propagated by SS3 is limited due to the way in which constant recruitment is forecasted for red snapper, the OFL is quite close to the ABC (particularly as $F_{rebuild}$ approaches $F_{SPR26\%}$) and may be overly restrictive.

Although these results are expected to hold for a variety of underage scenarios, it would not be expected that the opposite approach could be undertaken when an overage occurs (i.e., an overage cannot be offset by an equivalent underage in subsequent years) and still be able to maintain rebuilding. Unlike an underage where the resource is left better off and harvest is delayed allowing further growth, an overage will leave the resource worse off and will require underages greater than the overage to account for the potential growth that was removed earlier than expected by original projections. However, further investigations would need to be carried out to determine the exact extent of the subsequent underages that would be needed to account for a given overage.

5. ACKNOWLEDGEMENTS

These projections were based on the work accomplished by the stock assessment analytical team (Shannon Cass-Calay, Clay Porch, John Walter, and Jake Tezlaff), which in turn would not have been possible without the efforts of Refik Orhun, Neil Baertlein, Jessica Stephen and Andy Strelcheck (Commercial Catch), Vivian Matter (Recreational Catch and Discards), Kevin McCarthy (Commercial discards and CPUE), Adyan Rios (Recreational CPUE), Robert Allman, Beverley Barnett and Linda Lombari-Carlson (Life History), Adam Pollock and Walter Ingram (Fishery Independent CPUE), Rick Hart and Jeff Isely (Shrimp bycatch), Ching-Ping Chih (Size and Age composition), Sean Powers and John Walter (ROV age composition), Matthew Campbell (Discard mortality) Beverly Sauls and Alisha Gray (Headboat Discard Age Comp), and Elizabeth Scott-Denton (Shrimp Bycatch Age Composition).

6. LITERATURE CITED

Methot, R.D., and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish. Res. 42: 86-99.

SEDAR (Southeast Data, Assessment, and Review). 2015. Stock assessment of red snapper in the U.S. Gulf of Mexico 1872-2013 – with provisional 2014 landings. SEDAR, North Charleston, SC.

TABLES

Table 1. ABC and OFL yield streams (million pounds whole weight) derived from projections using the 2014 SEDAR 31 Update Stock Synthesis 3 model (SEDAR 2015) with updated 2014, 2015 and 2016 landings. The right hand panel provides the percent underage used in each year for each of the SERO management fleets (recreational private, recreational for-hire, and commercial) in each of the carryover projections.

			% underage by SERO Fleet		
Year	**ABC (Million Lbs)**	**OFL (Million. Lbs)**	**Rec. Private**	**Rec. For-Hire**	**Commercial**
2015	14.72	14.72	0	0	0
2016	14.33	14.33	0	0	0
2017	13.52	15.19	20	0	5
2018	13.36	14.60	10	20	0
2019	12.94	13.86	0	10	0
2020	12.61	13.35	0	0	0
2021	12.41	13.06	0	0	10
2022	12.30	12.89	10	20	0
2023	12.30	12.87	0	0	0
2024	12.34	12.88	10	0	10
2025	12.36	12.89	0	10	0
2026	12.39	12.90	0	0	0
2027	12.41	12.91	20	10	5
2028	12.43	12.92	0	0	10
2029	12.45	12.92	0	0	0
2030	12.46	12.93	20	20	20
2031	12.48	12.94	0	0	0
2032	12.49	12.94	0	0	0

Table 2. Forecasted fleet specific yield (left panel) and underages (right panel; metric tons. whole weight). East and West designations identify underages specific to the fleet operating in the eastern or western portion of the Gulf of Mexico roughly delimited by the Mississippi River outfall.

					Underage by SERO fleet and region (metric tons)				
Year	**ABC**	**Comm. Yield**	**Rec. For-hire Yield**	**Rec. Private Yield**	**Commercial**	**For-Hire East**	**For-Hire West**	**Private East**	**Private West**
2015	6678.9	3406.3	1384.3	1888.3	0	0	0	0	0
2016	6500.9	3315.4	1347.4	1838.0	0	0	0	0	0
2017	6130.8	3126.7	1270.7	1733.4	156.3	0	0	278.1	68.6
2018	6060.1	3090.6	1256.1	1713.4	0	181.6	69.6	137.4	33.9
2019	5868.8	2993.1	1216.4	1659.3	0	87.9	33.7	0	0
2020	5720.5	2917.5	1185.7	1617.4	0	0	0	0	0
2021	5630.5	2871.5	1167.0	1591.9	287.2	0	0	0	0
2022	5579.6	2845.6	1156.5	1577.5	0	167.2	64.1	126.5	31.2
2023	5581.1	2846.4	1156.8	1577.9	0	0	0	0	0
2024	5595.4	2853.7	1159.8	1582.0	285.4	0	0	126.9	31.3
2025	5607.7	2860.0	1162.3	1585.5	0	84.0	32.2	0	0
2026	5618.7	2865.5	1164.6	1588.6	0	0	0	0	0
2027	5628.2	2870.4	1166.6	1591.3	143.5	84.3	32.3	255.3	63.0
2028	5636.8	2874.8	1168.3	1593.7	287.5	0	0	0	0
2029	5645.1	2879.0	1170.1	1596.0	0	0	0	0	0
2030	5652.6	2882.8	1171.6	1598.1	576.6	169.4	64.9	256.4	63.3
2031	5659.5	2886.3	1173.0	1600.1	0	0	0	0	0
2032	5666.3	2889.8	1174.4	1602.0	0	0	0	0	0

Table 3. Adjustments made to the annual ABC of the stock assessment model fleets (metric tons whole weight) when forecasting the stock assuming **no reduction in carry-over due to natural mortality or OFL cap**. Underages are highlighted in red and carry-overs in green. When underages occur in consecutive years, the underage or carryover in the most recent year was calculated relative to the original ABC (given that any unused carry-over is forfeited). Commercial underages and carry-overs were divided between the assessment model fleets (HL_E, HL_W, LL_E, and LL_W) in proportion to the fleet-specific landings for each year.

Year	Commercial	MRIP_E	MRIP_W	HBT_E	HBT_W
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	-156.3	-278.1	-68.6	0	0
2018	156.3	-263.3	-50.8	-55.7	-52.7
2019	0	76.5	25.7	-27.0	-25.5
2020	0	61.0	8.2	27.0	25.5
2021	-287.2	0	0	0	0
2022	287.2	-242.5	-46.8	-51.3	-48.5
2023	0	242.5	46.8	51.3	48.5
2024	-285.4	-126.9	-31.3	0	0
2025	285.4	68.6	23.5	-25.8	-24.4
2026	0	58.3	7.8	25.8	24.4
2027	-143.5	-313.7	-70.8	-25.9	-24.5
2028	-287.5	313.7	70.8	25.9	24.5
2029	287.5	0	0	0	0
2030	-576.6	-373.8	-79.1	-52.0	-49.1
2031	576.6	373.8	79.1	52.0	49.1
2032	0	0	0	0	0

Table 4. Adjustments made to the annual ABC of the stock assessment model fleets (mt whole weight) when forecasting the stock assuming **no reduction in carry-over due to natural mortality with the OFL cap applied**. Underages are highlighted in red and carry-overs in green. When underages occur in consecutive years, the underage or carryover in the most recent year was calculated relative to the original ABC (given that any unused carry-over is forfeited). Commercial underages and carry-overs were divided between the assessment model fleets (HL_E, HL_W, LL_E, and LL_W) in proportion to the fleet-specific landings for each year.

Year	Commercial	MRIP_E	MRIP_W	HBT_E	HBT_W
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	-156.3	-278.1	-68.6	0	0
2018	156.3	-263.3	-50.8	-55.7	-52.7
2019	0	76.5	25.7	-27.0	-25.5
2020	0	15.2	2.0	6.7	6.4
2021	-287.2	0	0	0	0
2022	287.2	-242.5	-46.8	-51.3	-48.5
2023	0	0	0	0	0
2024	-285.4	-126.9	-31.3	0	0
2025	0	0	0	-25.8	-24.4
2026	0	0	0	0	0
2027	-143.5	-313.7	-70.8	-25.9	-24.5
2028	-287.5	156.1	35.3	12.9	12.2
2029	0	0	0	0	0
2030	-576.6	-373.8	-79.1	-52.0	-49.1
2031	0	0	0	0	0
2032	0	0	0	0	0

Table 5. Adjustments made to the annual ABC of the stock assessment model fleets (mt whole weight) when forecasting the stock assuming **carry-over reduced for natural mortality and no OFL cap**. Underages are highlighted in red and carry-overs in green. When underages occur in consecutive years, the underage or carry-over in the most recent year was calculated relative to the original ABC (given that any unused carry-over is forfeited). Commercial underages and carry-overs were divided between the assessment model fleets (HL_E, HL_W, LL_E, and LL_W) in proportion to the fleet-specific landings for each year.

Year	Commercial	MRIP_E	MRIP_W	HBT_E	HBT_W
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	-156.3	-278.1	-68.6	0	0
2018	142.3	-263.3	-50.8	-55.7	-52.7
2019	0	69.6	23.4	-27.0	-25.5
2020	0	55.5	7.5	24.5	23.2
2021	-287.2	0	0	0	0
2022	261.3	-242.5	-46.8	-51.3	-48.5
2023	0	220.6	42.6	46.7	44.1
2024	-285.4	-126.9	-31.3	0	0
2025	259.7	62.5	21.4	-25.8	-24.4
2026	0	53.0	7.1	23.5	22.2
2027	-143.5	-313.7	-70.8	-25.9	-24.5
2028	-287.5	285.5	64.5	23.5	22.3
2029	261.6	0	0	0	0
2030	-576.6	-373.8	-79.1	-52.0	-49.1
2031	524.7	340.2	71.9	47.3	44.7
2032	0	0	0	0	0

Table 6. Adjustments made to the annual ABC of the stock assessment model fleets (mt whole weight) when forecasting the stock assuming **carry-over reduced for natural mortality with the OFL cap applied**. Underages are highlighted in red and carry-overs in green. When underages occur in consecutive years, the underage or carryover in the most recent year was calculated relative to the original ABC (given that any unused carry-over is forfeited). Commercial underages and carry-overs were divided between the assessment model fleets (HL_E, HL_W, LL_E, and LL_W) in proportion to the fleet-specific landings for each year.

Year	Commercial	MRIP_E	MRIP_W	HBT_E	HBT_W
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	-156.3	-278.1	-68.6	0	0
2018	142.3	-263.3	-50.8	-55.7	-52.7
2019	0	69.6	23.4	-27.0	-25.5
2020	0	13.9	1.9	6.1	5.8
2021	-287.2	0	0	0	0
2022	261.3	-242.5	-46.8	-51.3	-48.5
2023	0	0	0	0	0
2024	-285.4	-126.9	-31.3	0	0
2025	0	0	0	-25.8	-24.4
2026	0	0	0	0	0
2027	-143.5	-313.7	-70.8	-25.9	-24.5
2028	-287.5	142.1	32.1	11.7	11.1
2029	0	0	0	0	0
2030	-576.6	-373.8	-79.1	-52.0	-49.1
2031	0	0	0	0	0
2032	0	0	0	0	0

Table 7. Time-series of Gulfwide red snapper SPR obtained from projections of $F_{REBUILD}$ (Rebuild) along with the four carry-over projections assuming no adjustment for natural mortality and no OFL cap (No_M_No_Cap), no adjustment for natural mortality and enforcing the OFL cap (No_M_Cap), adjustment made for natural mortality and no OFL cap (M_No_Cap), adjustment made for natural mortality and enforcing the OFL cap (M_Cap). The year in which the rebuild target of SPR 26% was reached is highlighted in yellow for all runs.

Year	Rebuild	No_M_No_Cap	No_M_Cap	M_No_Cap	M_Cap
2015	0.155	0.155	0.155	0.155	0.155
2016	0.166	0.166	0.166	0.166	0.166
2017	0.177	0.177	0.177	0.177	0.177
2018	0.188	0.190	0.190	0.190	0.190
2019	0.198	0.200	0.200	0.200	0.200
2020	0.206	0.208	0.208	0.208	0.208
2021	0.213	0.216	0.216	0.216	0.216
2022	0.220	0.223	0.224	0.223	0.224
2023	0.226	0.230	0.230	0.230	0.230
2024	0.232	0.234	0.236	0.235	0.236
2025	0.237	0.240	0.242	0.241	0.242
2026	0.241	0.244	0.247	0.244	0.247
2027	0.245	0.247	0.251	0.248	0.251
2028	0.248	0.252	0.256	0.253	0.256
2029	0.252	0.255	0.260	0.256	0.260
2030	0.255	0.258	0.263	0.258	0.263
2031	0.257	0.263	0.269	0.264	0.270
2032	0.260	0.263	0.272	0.264	0.273

FIGURES

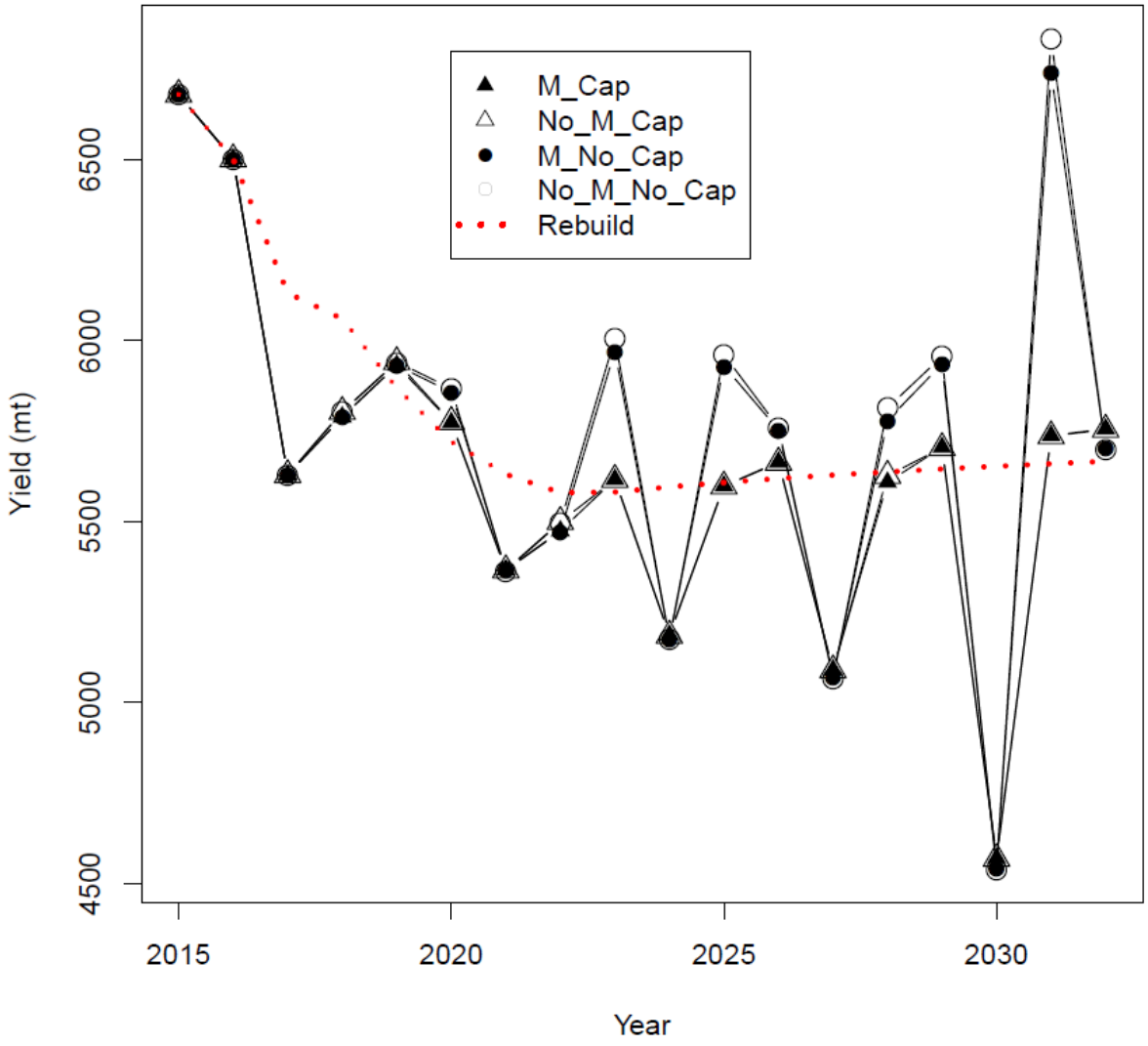

Figure 1. Adjusted annual removals used to forecast stock rebuilding status under the four tested carry-over scenarios (no adjustment for natural mortality and no OFL cap, No_M_No_Cap, no adjustment for natural mortality and enforcing the OFL cap, No_M_Cap, adjustment made for natural mortality and no OFL cap, M_No_Cap, and adjustment made for natural mortality and enforcing the OFL cap, M_Cap). The annual removals associated with the baseline rebuilding plan are shown in red for reference.

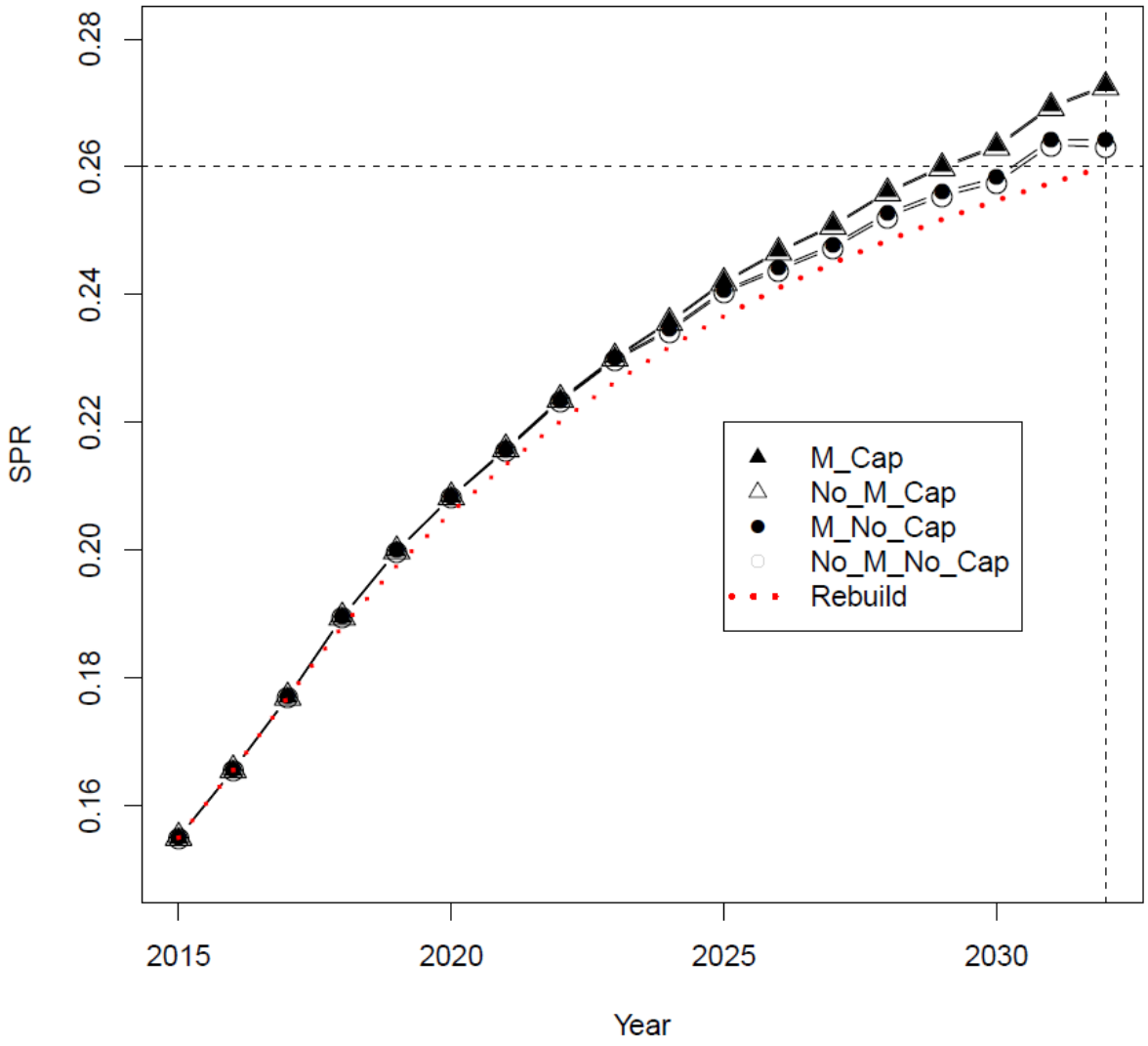

Figure 2. Annual spawning potential ratio under the four tested carry-over scenarios (no adjustment for natural mortality and no OFL cap, No_M_No_Cap, no adjustment for natural mortality and enforcing the OFL cap, No_M_Cap, adjustment made for natural mortality and no OFL cap, M_No_Cap, adjustment made for natural mortality and enforcing the OFL cap, M_Cap). The SPR forecasted from the baseline rebuilding plan was shown in red for reference.