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EVALUATING ALTERNATIVE ASSUMPTIONS USED FOR PROJECTIONS OF GULF OF MEXICO RED SNAPPER

INTRODUCTION

During the January 2015 Gulf of Mexico Fishery Management Council (Council) Standing and Special Reef Fish SSC meeting, the Southeast Fisheries Science Center presented the results of the 2014 Red Snapper assessment update. The Scientific and Statistical Committee (SSC) reviewed the update assessment and determined the acceptable biological catch (ABC) for Gulf of Mexico red snapper could be increased from 11 million pounds to 13 million pounds whole weight for 2015 with further increases over the next two years. The Council later requested the SSC to re-evaluate its ABC recommendations based on new information on 2014 red snapper landings. The quotas for red snapper were eventually set in a framework action to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico (FMP) prepared by the Council. The quotas for red snapper in the Gulf of Mexico for 2015, 2016, and 2017 were increased to 14.30, 13.96, and 13.74 million pounds whole weight, respectively.

The 2014 Red Snapper update assessment represents an update of the SEDAR 31 benchmark assessment of red snapper in the U.S. Gulf of Mexico using updated data inputs through 2013, and 2014 landings. In general, the update assessment follows the specifications of the model and data streams are identical to those of the base models identified in the SEDAR 31 final report. Two important changes were identified in the 2014 update assessment report (SEDAR Red Snapper 2014 Update Assessment). First, the recreational catch and discard estimates produced by the Marine Recreational Information Program (MRIP) were updated to reflect changes in MRIP protocols. The recalibration of the MRIP estimates led to an increase in the recreational landings and discards estimates from previous assessments. Second, the update assessment includes a new selectivity time-block (2011-2014) added to accommodate a recent increase in the size of red snapper landed in the recreational sector. The implications of these changes were explored by the Science Center through a series of sensitivity runs. The sensitivity runs revealed that both changes increased estimates of the overfishing limit (OFL), acceptable biological catch (ABC) and maximum sustainable yield (MSY) for the update assessment relative to the SEDAR 31 benchmark stock assessment (SEDAR 31).

The projections presented in the 2014 Red Snapper update assessment were run assuming that selectivity, discarding, and retention practices would continue as they had in the three most recent years (2011-2013). Model projections and subsequent ABC advice can be sensitive to these assumptions. Herein, we examine two important assumptions used in the projections presented in the 2014 Red Snapper update: recreational selectivity and discard mortality rate. In the update assessment, time-varying selectivity functions were estimated for recreational fisheries to allow for two changes, one due to a regulatory mandate requiring the use of circle-hooks beginning in 2007, and a second apparent change in fishing behavior resulting in a shift in age composition toward larger, older fish during 2011-2013 (SEDAR Red Snapper 2014 Update

Assessment; Figure 1). The Science Center assumed that the recent shift in the recreational fishery towards selection of larger fish would remain into the future. We explore alternative assumptions regarding recreational selectivity for the projection period and the implications this assumption has on management advice and stock status.

The second assumption we examine is that discard mortality rate will remain the same as the estimate used in the update assessment. The fraction of released red snapper that die (discard mortality rate) has been found to increase with depth of capture and decrease with venting. The release mortality rates used in the stock assessment were computed based on the average depth fished and whether or not venting was required (venting became mandatory in 2008). In the update assessment, discard mortality for the recreationally fleet in the Eastern Gulf of Mexico was estimated at 21% prior to 2008, and 10% for 2008-2014. In 2013, the requirement to possess and use venting tools in state and federal waters of the Gulf of Mexico was repealed. Thus, the discard mortality for the recreational fleet may have changed in recent years. We explore the sensitivity of stock status and management advice to alternative levels of discard mortality for the recreational fleet.

METHODS

The sensitivity runs examined are based on the 2014 update of the SEDAR 31 Gulf of Mexico red snapper assessment (SEDAR 31). Like the update assessment and associated projections, the sensitivities were conducted using Stock Synthesis (SS: V3.24U1). SS is an integrated statistical catch-at-age model, which is widely used for stock assessments in the United States and throughout the world. The model, and accompanying documentation and examples are available on the NOAA Toolbox website (NOAA 2011: http://nft.nefsc.noaa.gov/SS3.html). Descriptions of SS algorithms and options are summarized by Methot (2000) and Methot and Wetzel (2013).

Deterministic projections were run to evaluate stock status and associated retained yields for the specified sensitivity runs. Projections were run from 2015 to 2032 using the base model configuration with 2014 landings data. Similar to the update assessment, the expected fishing effort levels for the 6 bycatch fleets (shrimp, recreational closed season, and commercial without IFQ allocation) in 2015-2032 were assumed be the same as in 2013. Forecast recruitments were derived from the model estimated Beverton-Holt stock recruitment relationship, based on the recent time period (i.e., 1984-2013). Projections were run for a set of scenarios that included alternative assumptions regarding future selectivity patterns for the recreational red snapper fisheries as well as alternative assumptions regarding discard mortality from the recreational fisheries (Table 1). All of the assumptions made about the commercial fisheries in the update assessment were held constant for the set of sensitivities examined herein.

A total of eight projection scenarios were run and compared. The projection scenarios represent four assumptions about recreational selectivity and two levels of recreational discard mortality (Table 1). Four selectivity patterns were examined for each of the four recreational red snapper fisheries (MRIP East, MRIP West, Headboat East, and Headboat West): 1) selectivity patterns used in the 2014 update assessment base model, 2) estimated selectivity patterns for 2008-2013 when the second recreational time block (2011-2013) is removed, 3) estimated selectivity patterns for 2008-2010 for the projection period, and 4) the average selectivity from 2005-2013

for the projection period (Figure 2). For each of the four selectivity scenarios, the projections were run at two levels of discard mortality: 1) estimated discard mortality for 2008-2013 from the base model, 2) estimated discard mortality prior to 2008 from the base model (Table 1).

All of the scenarios examined have the same data inputs as the 2014 update assessment. Scenario 1a represents the base model used in the 2014 update assessment (Table 1). All of the scenarios except 2a and 2b have the same estimates of historical and current stock size/status as the 2014 update assessment. Scenarios 2a and 2b require model parameters to be re-estimated due to the removal of the 2011-2013 recreational selectivity time block. This results in a slightly different picture of historical and current stock status. Scenarios 3a, 3b, 4a, and 4b are exactly the same as the 2014 update base model up until the projection period. For these scenarios, only the assumptions regarding the projection period (2015-2032) differ from the 2014 update assessment. All of the scenarios were projected forward at $F_{REBUILD}$. The projections at $F_{REBUILD}$ are set to achieve a gulf-wide spawning potential ratio (SPR) of 26% in 2032.

RESULTS AND DISCUSSION

All of the scenarios evaluated were projected forward at $F_{REBUILD}$ in order to achieve a gulf-wide spawning potential ratio of 26% in 2032 (Figure 3; top panel). This allowed for direct comparison of yield streams and forecasted stock status for the alterative models. All of the scenarios evaluated showed a similar pattern as SEDAR 31 and the SEDAR 31 update assessment; managing to achieve gulf-wide rebuilding goals results in the Western Gulf of Mexico stock rebuilding while the Eastern Gulf of Mexico stock declines to less than 5-8% of its estimated unfished stock size (Figure 3).

Of the scenarios examined, the SEDAR 31 update base model had the highest estimated retained yields at $F_{REBUILD}$ (Table 2, Figure 4). One of the reasons the base model had the highest estimated retained yields was that selectivity of the recreational fisheries in this scenario resulted in the largest predicted average size of fish captured. This leads to a larger average size of fish landed and the highest rate of retention of captured fish. The SEDAR 31 update base model predicts that 90% of fish captured by the recreational fishery are kept as legal fish during the projection period (Figure 5). Scenarios 3a and 4a are exactly the same as the 2014 update base model up until the projection period; the only difference is the selectivity of recreational fleets during the projection period (2015-2032). In Scenarios 3a and 4a, the selectivity patterns result in both a smaller average size of fish landed as well as higher discarding rates. If the recreational fishery selectivity were to shift towards smaller fish in the future, this would result in lower recreational landings in terms of biomass but greater total removals in terms of numbers of fish. However, both Scenarios 3a and 4a result in slightly higher spawning stock biomass in the Eastern Gulf compared the SEDAR 31 update base model.

Scenarios 2a and 2b had the lowest predicted stock status for the Eastern Gulf. In the SEDAR 31 base model, an increasing shift in selectivity toward older red snapper was estimated for 2008-2010 and 2011-2013. This shift was most apparent in the eastern recreational fisheries (Figure 1). Scenarios 2a and 2b represent an alternative hypothesis for the assessment model where the second time block for the recreational fishery (2011-2014) is removed and instead a single block for 2008-2013 is estimated. Changing the time blocks requires all model parameters to be re-

estimated and results in slightly lower estimate of stock productivity (R_0). A similar result was found in Appendix 1 of the SEDAR 31 update assessment; the addition of the second time block for the recreational fisheries increased estimates of OFL, ABC and MSY relative to the SEDAR 31 benchmark stock assessment (SEDAR 31 update). While the mechanism behind the shift in recreational selectivity in 2011 is unclear, the data do support the addition of the 2011-2013 selectivity time block into the assessment model (Table 4).

For each of the four alternative assumptions regarding recreational selectivity, two values of discard mortality were evaluated (0.10 and 0.21). These were the estimates used in both the SEDAR 31 benchmark and SEDAR update assessments to represent recreational discard mortality before (0.21) and after (0.10) venting requirements were mandated in 2008. In all of the scenarios with higher discard mortality, both the predicted yields and estimated stock size are lower. This result is expected as more fish are removed from the population as dead discards.

To further evaluate the assumption about discard mortality, model projections for the SEDAR 31 update base model (2015-2032) were run at two higher levels of discard morality (16% and 21%) but were forced to use the projected yield streams calculated from the SEDAR base model (which used a discard mortality of 10%) (Figure 6). While the Western Gulf stock shows almost no difference among runs, the Eastern Gulf stock is extremely sensitive to higher levels of discard mortality. Using the 21% discard mortality, the Eastern Gulf stock is eventually fished to extinction when following the yield streams from the SEDAR 31 base model (which used a discard mortality of 10%) (Figure 6). Of the 66 studies used in the meta-analysis to estimate recreational discard mortality for red snapper, 38 of the studies estimated recreational discard mortality at greater than 21% (Campbell et al. 2014). In 2013 the requirement to possess and use venting tools in state and federal waters of the Gulf of Mexico was repealed. The purpose of repealing this law was to allow fishermen the ability to choose methods or tools appropriate for their situation when releasing reef fish. However, venting is no longer mandated in the Gulf of Mexico and thus discard mortality rates may be higher than those used in the update assessment. The sensitivity of the Eastern Gulf of Mexico to recreational discard mortality suggests that large buffers between the OFL and ABC and ACL and ACT may be required for management of the recreational sector.

In August 2015, the Gulf of Mexico Fishery Management Council approved modifications to the commercial and recreational sector allocations for red snapper in Amendment 28 to the Fishery Management Plan for Reef Fish Fishery of the Gulf of Mexico (FMP) (GMFMC 2015). The analyses run for this report assumed the current commercial and recreational red snapper allocation of 51:49 percent, respectively, would remain into the future. Preferred Alternative 8 from Amendment 28 would result in a 48.5 percent commercial and 51.5 percent recreational allocation. Given this change in allocation among fleets, an additional set of sensitivity analyses were run to evaluate the impact of reallocation on the results presented herein. Reallocation of yield from 51:49 percent to 48.5:51.5 percent had no impact on the general conclusions of the results presented (Figure 7). Increasing the recreational allocation from 49% to 51.5% led to a slight increase in estimates of yield at $F_{REBUILD}$ (Table 4) but decreased the projected stock size in the Eastern Gulf. Reallocation of yield would decrease the Eastern Gulf spawning stock biomass by approximately 5% compared to the current allocation scenario of 51:49 (Figure 8). If discard mortality is greater than 10% in the Eastern Gulf, then reallocation would further exacerbate the

Eastern Gulf decline (Figure 8). This result is consistent with results from Appendix 2 in the SEDAR 31 update assessment which found the greater the shift in allocation towards the recreational sector, the lower the spawning potential ratio of the Eastern Gulf stock (SEDAR 31 update).

LITERATURE CITED

Campbell, M.D., W.B. Driggers III, B. Sauls, and J.F. Walter. 2014. Release mortality in the red snapper (*Lutjanus campechanus*) fishery: a meta-analysis of 3 decades of research. Fish. Bull. 112:283-296.

GMFMC 2015. Amendment 28 to the Reef Fish Management Plan for the Reef Fish resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council. Tampa, Florida.

Method, R.D. 2000. Technical description of the Stock Synthesis assessment program. NOAA tech. Memo. NMFS-NWFSC-43.

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.

NOAA. 2011. Stock Synthesis, Version 3.23b. Available online at: http://nft.nefsc.noaa.gov

SEDAR 31. 2013. Gulf of Mexico Red Snapper Stock Assessment Report. Southeast Data, Assessment, and Review. North Charleston, SC. 1103 pp.

SEDAR 31 Update. 2014. Stock Assessment of Red Snapper in the Gulf of Mexico 1872-2013 – With Provisional 2014 Landings. Southeast Data, Assessment, and Review. North Charleston, SC.

TABLES

Table 1. Alternative projection scenarios (sensitivity runs for SEDAR 31 update base model). All scenarios used the same data inputs as the SEDAR 31 update assessment. Scenarios 1, 3, and 4 are the exact same model but have different assumptions regarding selectivity during the projection period. In Scenario 2, a selectivity time-block for the recreational fishery was removed and all model parameters were re-estimated.

Projection scenarios		Recreational selectivity	Discard mortality
1a	SEDAR 31 update base	2011-2013	2008-2013 (d=0.10)
1b	SEDAR 31 update base, higher discard mortality (d)	2011-2013	Pre 2008 (d=0.21)
2a	Remove 2011-2014 recreational time block	2008-2013	2008-2013 (d=0.10)
2b	Remove 2011-2014 recreational time block, higher d	2008-2013	Pre 2008 (d=0.21)
3a	Assume 2008-2010 selectivity for projections	2008-2010	2008-2013 (d=0.10)
3b	Assume 2008-2010 selectivity for projections, higher d	2008-2010	Pre 2008 (d=0.21)
4a	Assume average selectivity from 2005-2013	Average from 2005-2013	2008-2013 (d=0.10)
4b	Assume average selectivity from 2005-2013, higher d	Average from 2005-2013	Pre 2008 (d=0.21)

Table 2. Retained yield at $F_{REBUILD}$ (retained yield in millions of lbs whole weight) for the base model (1a) and seven alternative sensitivity runs for 2015-2020. $F_{REBUILD}$ is set to achieve a gulf-wide spawning potential ratio (SPR) of 26% in 2032.

		Scenarios							
Year	Landings	1a	2a	3a	4a	1b	2b	3b	4b
2007	8.95								
2008	6.52								
2009	8.06								
2010	6.01								
2011	10.30								
2012	11.52								
2013	15.11								
2014	9.39								
2015		14.52	12.27	14.47	14.34	13.75	11.56	14.22	14.01
2016		14.15	11.98	13.86	13.80	13.38	11.22	13.68	13.54
2017		13.93	11.90	13.12	13.16	13.15	11.09	13.00	12.96
2018		13.58	11.87	12.47	12.63	12.79	11.00	12.40	12.46
2019		13.04	11.69	11.90	12.12	12.26	10.78	11.85	11.98
2020		12.66	11.58	11.62	11.84	11.88	10.65	11.59	11.70
Equilibrium		12.55	11.90	11.62	11.71	11.77	10.90	11.62	11.60

Table 3. Retained yield at $F_{REBUILD}$ (retained yield in millions of lbs whole weight) for the base model and eight alternative sensitivity runs given reallocation of yield (48.5% commercial fisheries, 51.5% recreational fisheries). $F_{REBUILD}$ is set to achieve a gulf-wide spawning potential ratio (SPR) of 26% in 2032.

		Scenarios with reallocation (48.5% commercial, 51.5% recreational)							
Year	NMFS base	1a	2a	3a	4a	1b	2b	3b	4b
2015	14.52	14.75	12.37	14.63	14.50	13.91	11.66	14.40	14.17
2016	14.15	14.33	12.07	13.97	13.93	13.51	11.30	13.80	13.66
2017	13.93	14.09	11.98	13.20	13.25	13.26	11.16	13.10	13.04
2018	13.58	13.72	11.95	12.54	12.70	12.89	11.06	12.48	12.52
2019	13.04	13.17	11.75	11.95	12.18	12.35	10.83	11.91	12.03
2020	12.66	12.77	11.64	11.67	11.88	11.96	10.69	11.64	11.74
Equilibrium	12.55	12.64	11.94	11.64	11.73	11.82	10.92	11.64	11.61

Table 4. AIC table comparing model runs with different recreational selectivity time blocks.

Model Run	Neg Log Like	N Parm	N Data	AIC	AICc	Delta AICc
SEDAR 31 Base model	5281.61	1306	10877	13175.22	13531.95	0
Scenario 2	5372.85	1271	10877	13287.7	13624.34	92.39

FIGURES

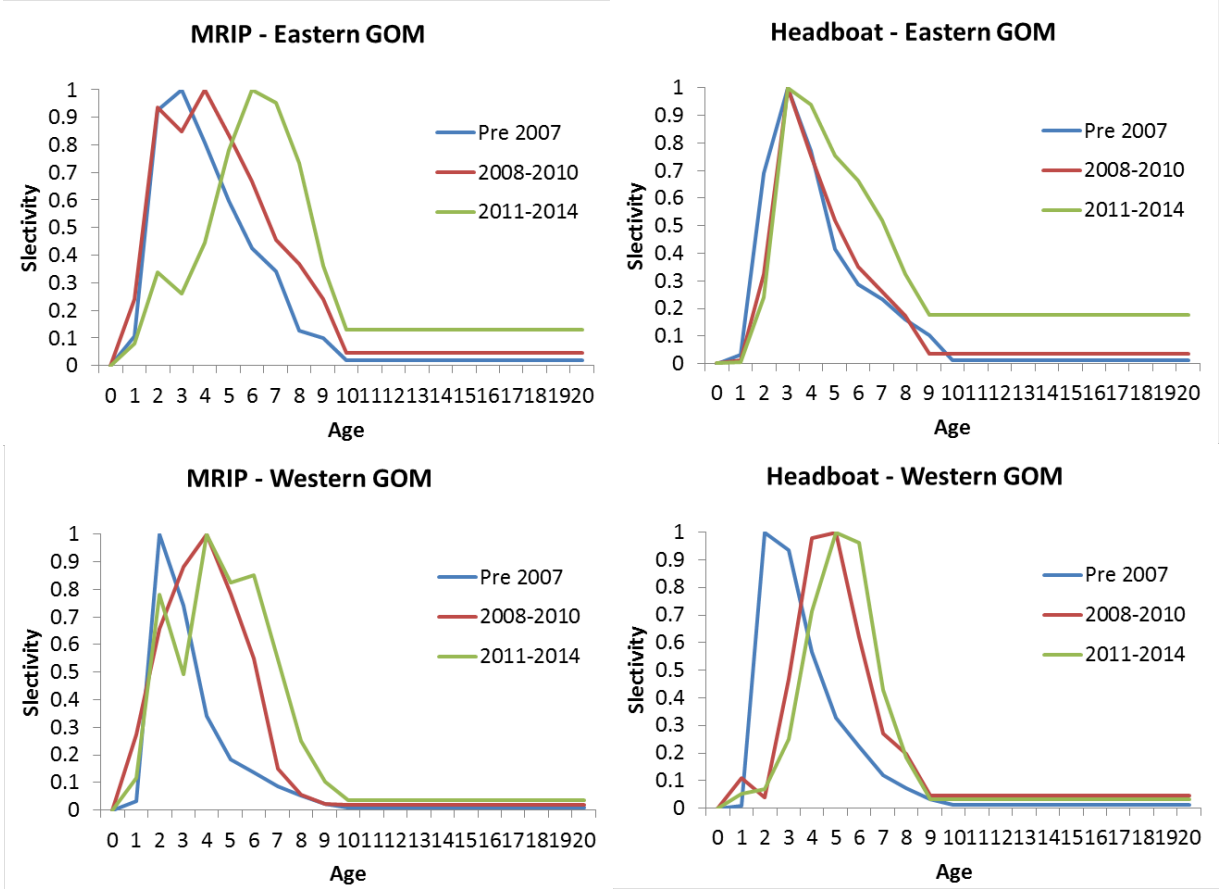


Figure 1. Selectivity patterns estimated for the four recreational fleets in the 2014 Red Snapper Update Assessment.

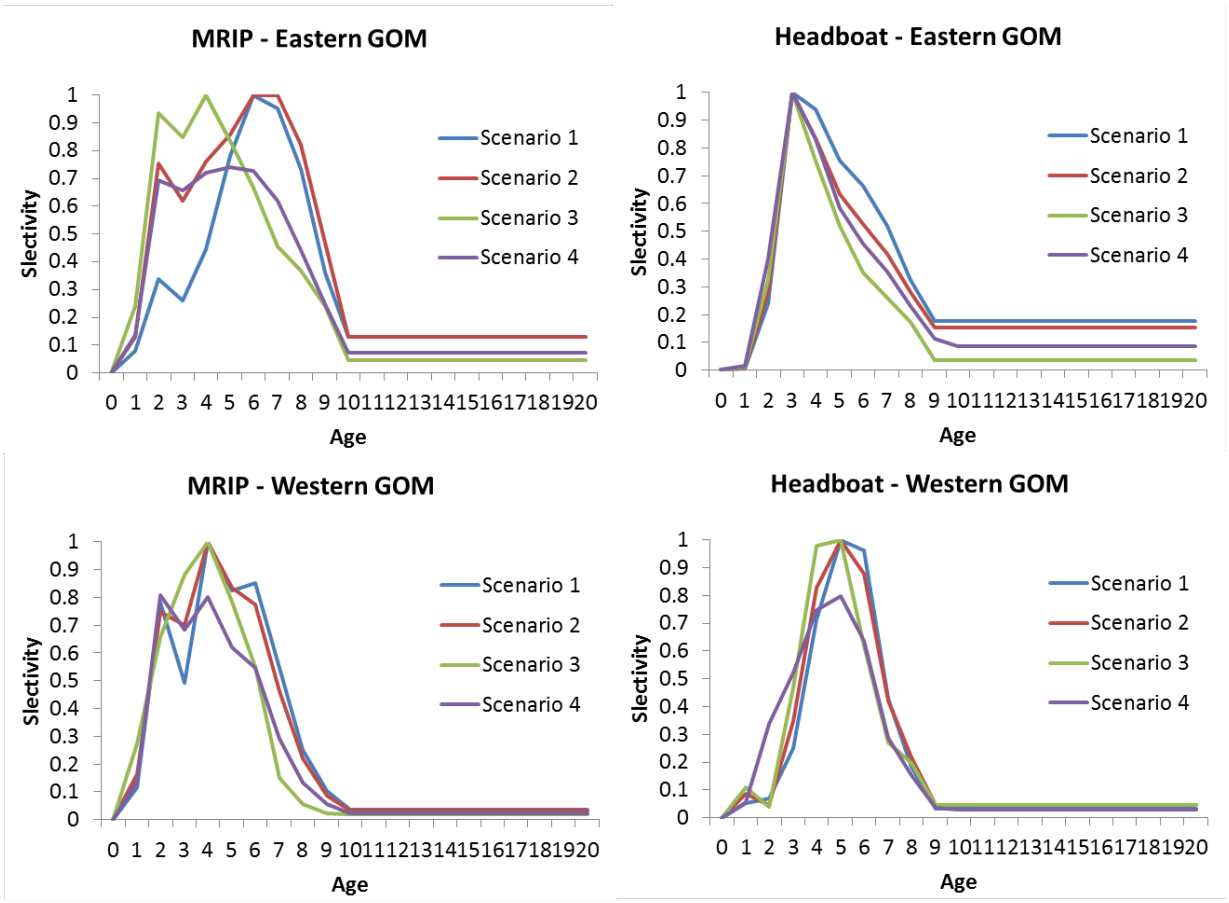


Figure 2. Selectivity patterns of recreational fleets used for alternative projection scenarios. Scenarios 1, 3, and 4 are estimated from the 2014 Red Snapper Update Assessment. Scenario 2 was estimated after removing the 2011-2014 recreational time block that was used in the 2014 Update Assessment.

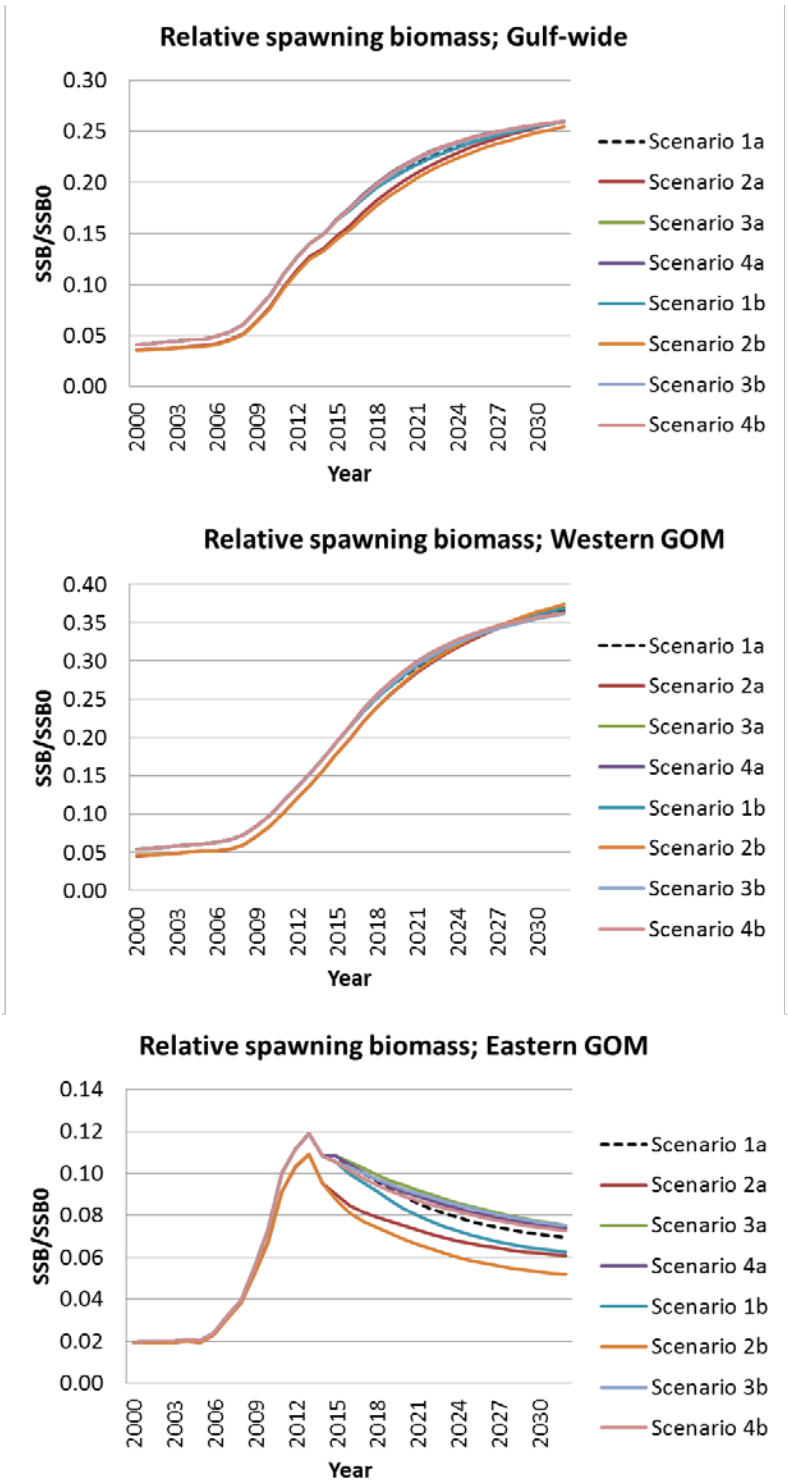


Figure 3. Annual estimates of spawning stock biomass relative to unfished levels for the entire Gulf of Mexico (top), Western Gulf of Mexico (middle), and Eastern Gulf of Mexico under the eight alternative projection scenarios.

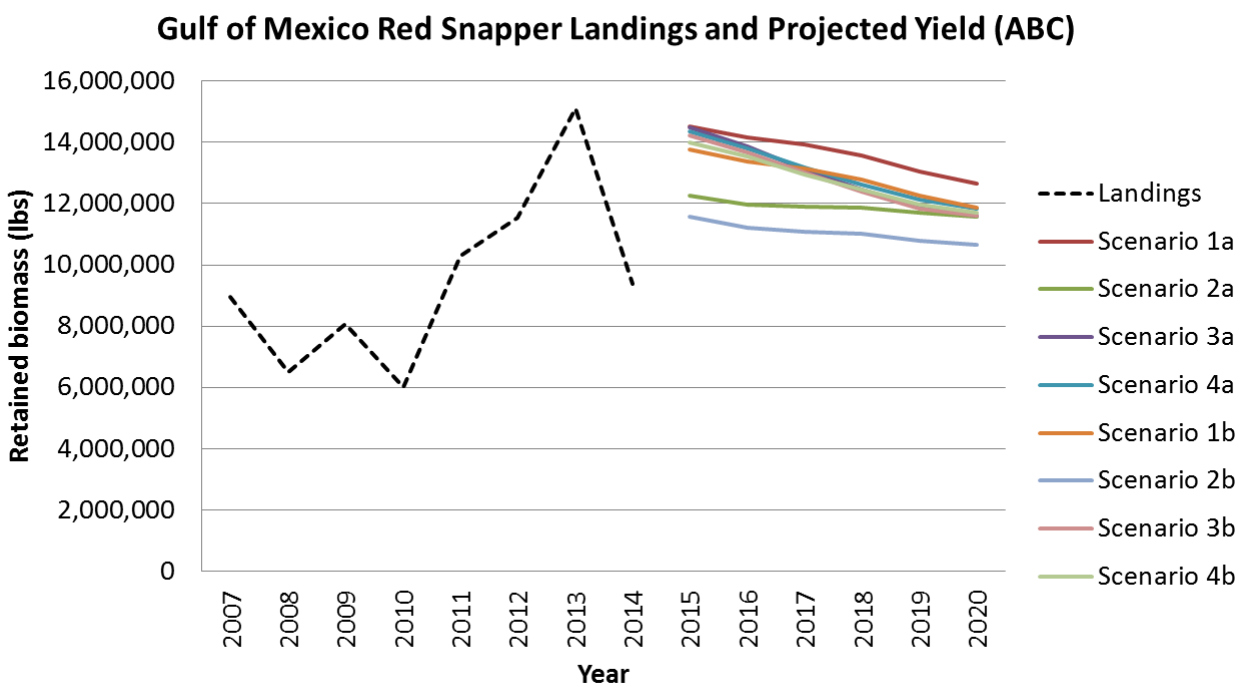


Figure 4. Retained yield at $F_{REBUILD}$ (retained yield in millions of lbs whole weight) for the base model (Scenario 1a) and seven alternative sensitivity runs. $F_{REBUILD}$ is set to achieve a gulf-wide spawning potential ratio (SPR) of 26% in 2032. Dotted line represents recent landings.

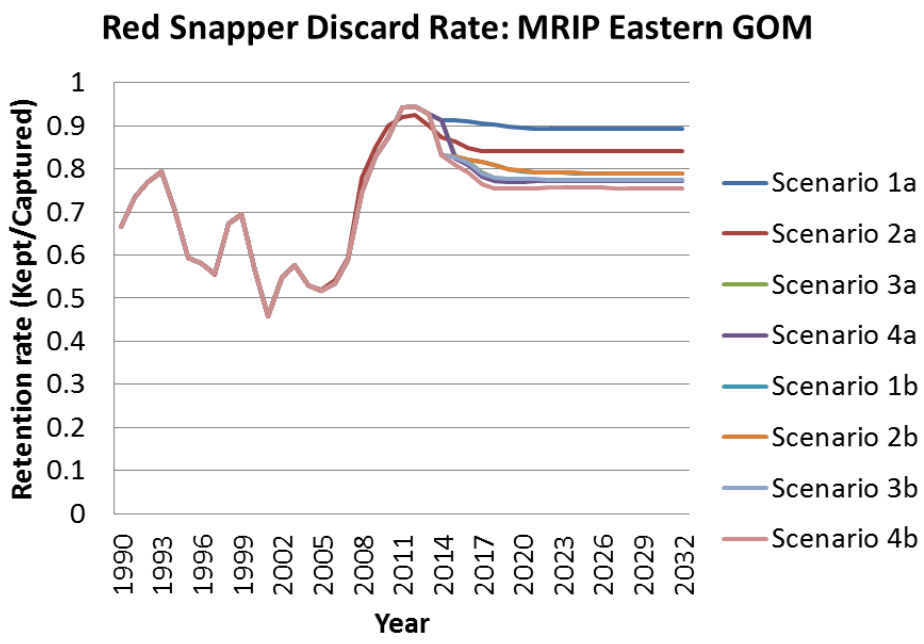


Figure 5. Retention rates (fish kept / fish captured) for the Eastern Gulf private recreational fisheries (1990-2032).

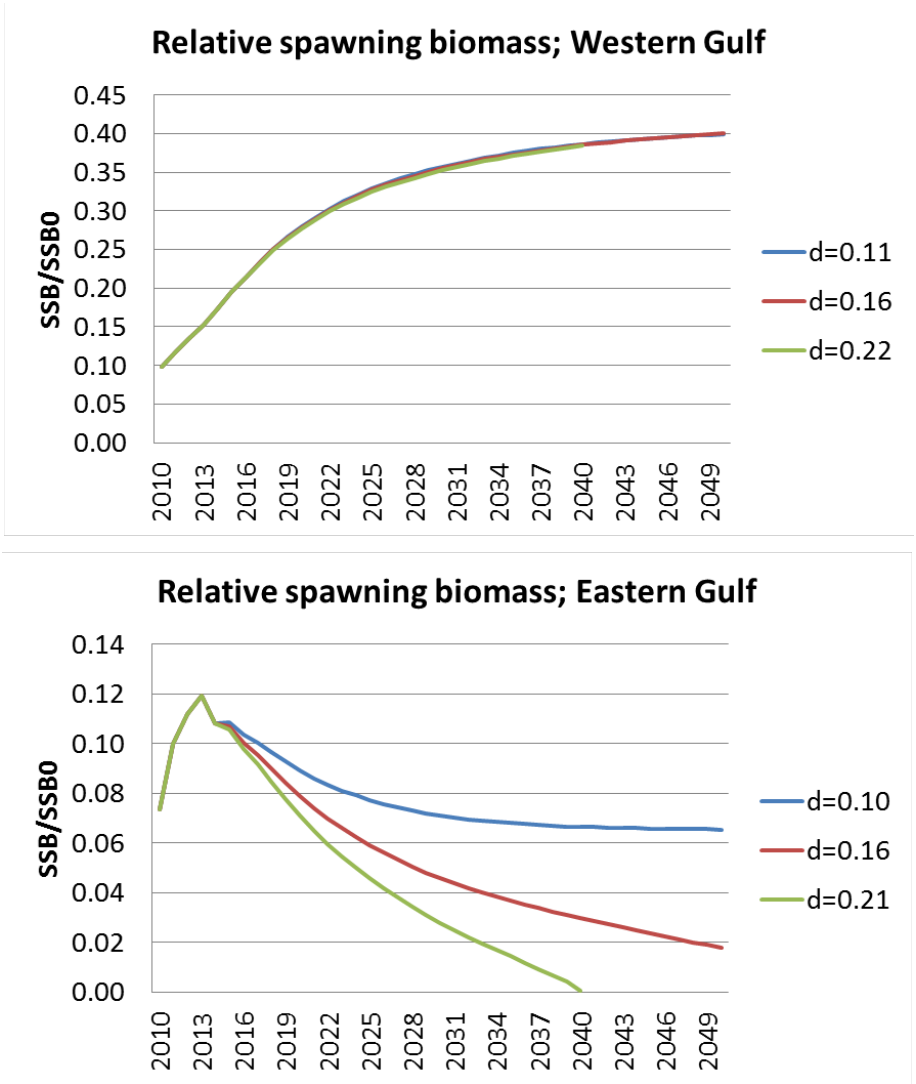
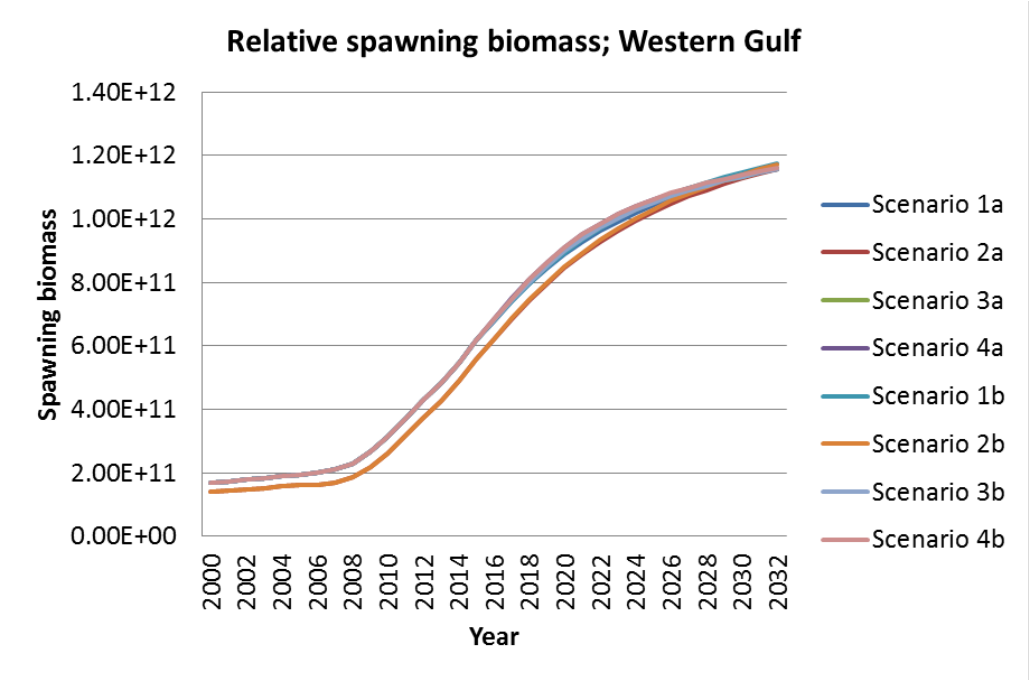


Figure 6. Annual estimates of spawning stock biomass relative to unfished levels for the Western Gulf of Mexico (top) and Eastern Gulf of Mexico (bottom) for three levels of discard mortality when forcing projections with yield streams from the SEDAR 31 update base model using $F_{REBUILD}$.



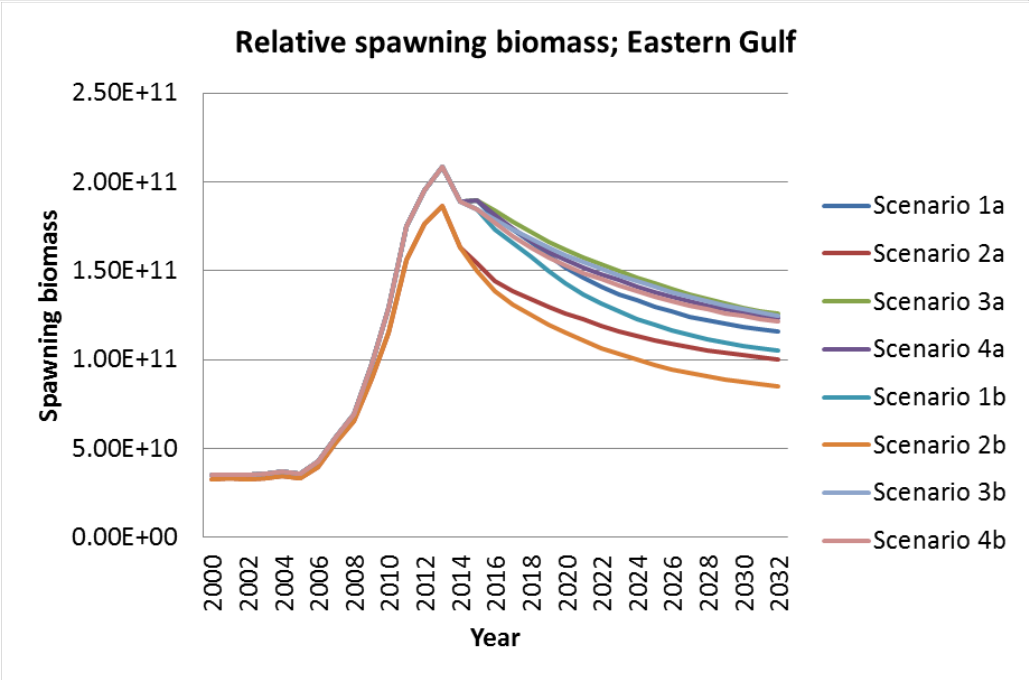


Figure 7. Annual estimates of spawning stock biomass relative to unfished levels for the Western Gulf of Mexico (top) and Eastern Gulf of Mexico under the eight alternative projection scenarios given reallocation of yield (48.5% commercial fisheries, 51.5% recreational fisheries).

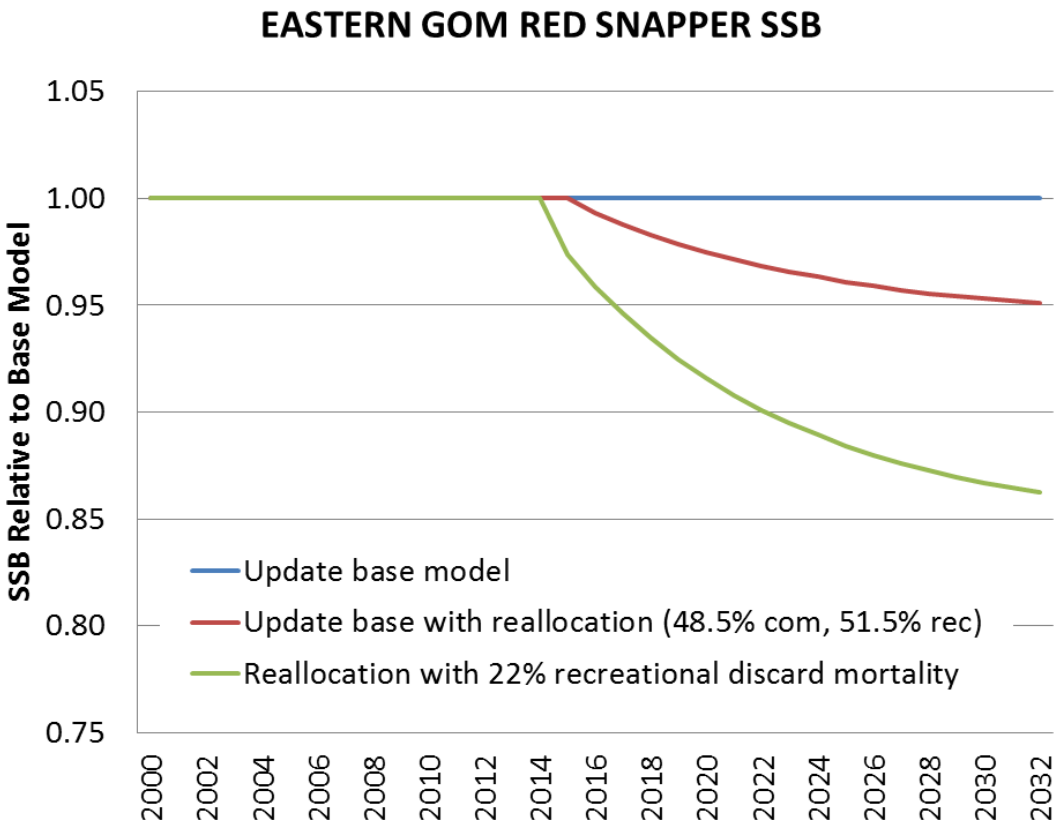


Figure 8. Spawning stock biomass relative to spawning stock biomass of the SEDAR 31 update base model (blue line) for two sensitivity runs: 1) reallocation of yield (48.5% commercial fisheries, 51.5% recreational fisheries; red line) and 2) reallocation of yield with a recreational discard mortality of 22% for the Eastern Gulf of Mexico (green line).