

MANAGEMENT ADVICE DERIVED USING ALTERNATIVE F_{MSY} PROXIES FOR GULF OF MEXICO GRAY SNAPPER: ASSOCIATED STOCK STATUS, OVERFISHING LIMIT AND ACCEPTABLE BIOLOGICAL CATCH.

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1. INTRODUCTION

At its January 2019 meeting in Orange Beach, Alabama, the Gulf of Mexico (Gulf) Fishery Management Council (Council) discussed Reef Fish Amendment 51: Establish Gray Snapper Status Determination Criteria and Modify Annual Catch Limits. The Council reviewed discussion by the Scientific and Statistical Committee (SSC), which recommended a maximum sustainable yield (MSY) proxy of $F_{30\%SPR}$ or greater. The Council expressed concern that the biology of gray snapper and other snapper species including red snapper are similar, yet the red snapper MSY proxy was set to $F_{SPR26\%}$. The Council requested the SSC evaluate an alternative which would set the MSY proxy at $F_{26\%SPR}$. A related motion was made to set the maximum fishing mortality threshold (MFMT) at $F_{26\%SPR}$. Following the changes to the minimum stock size threshold (MSST) modifications made in Reef Fish Amendment 44, the Council elected to set the MSST for gray snapper at $0.50 \cdot B_{MSY}$ (or proxy). With respect to annual catch limits, the Council added an alternative that would set ACL for gray snapper for the years 2019 through 2021 and beyond equal to the ABC yield stream using the MSY proxy of $F_{26\%SPR}$.

This document address the Council request described above. OFL and ABC yield streams for 2019 - 2021 are provided for Gulf gray snapper using the proposed MSY proxy of $F_{26\%SPR}$, as well as $F_{30\%SPR}$ and $F_{40\%SPR}$.

2. METHODS

The results presented in this paper were based on the 2018 benchmark assessment Gulf of Mexico gray snapper assessment (SEDAR 51). The assessment and associated projections were conducted using Stock Synthesis (SS: V3.24U²). 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 were also summarized by Methot (2000) and Methot and Wetzel (2013).

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² Stock Synthesis Version 3.24U was made available by Richard Methot (Richard.Methot@noaa.gov) on March 4, 2015. This version allows allocation fractions to vary annually during the projection.

Deterministic projections were run to evaluate stock status and associated retained yields for the specified scenarios. Projections were run from 2016 to equilibrium using the SEDAR 51 base model configuration, with the addition of assumed landings during 2016-2018³.

Assumed landings:

2016) Rec: 2,364,614 lbs; Com: 156,337 lbs

2017) Rec: 1,848,895 lbs; Com: 136,927 lbs

2018) Aggregate ACL 2,242,000 lbs

After 2018, constant F was projected at three alternative F_{MSY} proxies, F_{SPR26} , F_{SPR30} and F_{SPR40} . As requested by the Council, the results presented here are shown through 2021. Longer term projections are available upon request⁴.

To accomplish the desired projections, the 2016-2018 landings estimates were broken out into the appropriate fleets (COM: HL_Monroe, HL_notMonroe, LL; Rec: PB, CB+HB, Shore) using the proportions landed by each fleet during the three most recent years (**Tables 1-3**). When necessary, recreational landings were converted to numbers using annual fleet-specific average weights estimated internally by the stock assessment model.

To retain SEDAR 51 model structure, projected commercial landings were input in metric tons, and projected recreational landings in 1000s of fish (**Table 4**). Projections were run assuming that selectivity, discarding, and retention would continue as they had in the three most recent years (2013-2015). Forecast recruitments were assumed to continue at the average of the recent time period (i.e., 1990-2015).

The overfishing limit (OFL) and acceptable biological catch (ABC) were calculated as stipulated by the GMFMC SSC during their April 2018 meeting in Tampa, Florida. OFL was calculated as the median (50th percentile) of the probability density function (PDF) of retained yield (millions of lbs) using the projection of F_{MSY} (or proxy). At the Council's preferred $MSST = 0.5 * B_{MSY}$ (or proxy), none of the proxies considered led to an overfished stock status in 2015 (the terminal year of the assessment). Therefore, for all scenarios considered, the acceptable biological catch (ABC) was calculated at a P^* of 0.40 (the 40th percentile) of the PDF of retained yield using the projection of F_{MSY} (or proxy). A P^* of 0.40 implies a 40% probability of overfishing in any given year.

³ Estimated landings and ACL provided by SERO on March 4, 2019.

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3. RESULTS AND DISCUSSION

Each scenario considered used the preferred Council alternative for MSST ($MSST = 0.5 * B_{MSY}$ or proxy). Setting the F_{MSY} proxy and maximum fishing mortality threshold (MFMT) equal to $F_{SPR26\%}$ (the lower bound of proxies recommended by the Science Center) indicated that in 2015, the stock was not overfished ($SSB/MSST = 1.63$; **Table 5a and Figure 1**) but was experiencing a small degree of overfishing ($F/MFMT = 1.02$; **Table 6a and Figure 1**). Using the proxy $F_{SPR30\%}$ indicated that the stock was not overfished ($SSB/MSST = 1.41$) in 2015 (**Table 5b and Figure 2**), but was experiencing overfishing ($F/MFMT = 1.17$; **Table 6b and Figure 2**). Under the most conservative proxy considered, $F_{SPR40\%}$, the stock was not overfished ($SSB/MSST = 1.05$) in 2015 (**Table 5c and Figure 3**), but was experiencing overfishing ($F/MFMT = 1.61$; **Table 6c and Figure 3**). Under all scenarios considered, overfishing was eliminated by 2020 and stock biomass was expected to remain constant or increase throughout the time series.

It is important to note that using the Council's preferred MSST and MFMT definitions, a stock is not considered overfished until it reaches a level less than 50% of the biomass that produces MSY (or proxy) at equilibrium, while a stock is assumed to be undergoing overfishing when F exceeds F_{MSY} (or proxy). This selection of management references will often produce an outcome where a stock can be experiencing overfishing for a number of years ($F > F_{MSY}$), but will not yet have reached the level ($B < 50\% B_{MSY}$) that triggers an overfished designation.

The projected retained yield (in millions of pounds) varied depending on the proxy selected. The highest projected yield occurred when fishing at constant $F = F_{SPR26\%}$ during 2019-2021. Under this scenario, the projected yield (i.e. OFL) and acceptable biological catch ($P^* = 0.40$) were predicted to be somewhat higher than the recent landings (2015-2018; **Table 7 and Figure 4**). The lowest yields, OFL and ABC occurred when fishing at constant $F = F_{SPR40\%}$ during 2019-2021. Under this scenario, OFL was predicted to be about 20% lower than the recent landings (2015-2018; **Table 7 and Figure 4**).

Selected management reference points are shown in **Table 8**.

The results described in this report were dependent on a number of strong assumptions: that selectivity, discarding, and retention will continue as they have in the three most recent years (2013-2015); and that forecast recruitments continue at the average of the recent time period (i.e., 1990-2015). If any of these assumptions are violated (e.g. by a change in selectivity, retention/high-grading, environmentally driven recruitment fluctuations) the projected yields will be lower/higher than predicted.

4. ACKNOWLEDGMENTS

Stock assessment products depend on a large team of data providers and analysts. This assessment would not be possible without the substantial efforts of the SEDAR 51 data, assessment and review workshop participants and panelists.

5. LITERATURE CITED

Methot, R.D., 2000. Technical description of the Stock Synthesis assessment program. NOAA Tech Memo. NMFS-NWFSC-43. SEDAR. 2013.

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 Fisheries Toolbox, 2011. Stock Synthesis, Version 3.23b. <http://nft.nefsc.noaa.gov>

Table 1. Commercial landings estimates in 2016 and 2017 were broken out into the appropriate fleets (COM: HL_Monroe, HL_notMonroe, LL) using the proportions landed by each fleet during the three most recent years (2013-2015).

a) Commercial Landings (lbs):

YEAR	CHL_Monroe County	CHL_not Monroe County	CM_LL	SUM
2013	22,013	111,558	9,918	143,489
2014	7,932	173,722	16,964	198,619
2015	11,020	127,736	24,899	163,656
SUM	40,966	413,016	51,782	505,763

b) Proportion landed by commercial fleets:

YEAR	CHL_Monroe County	CHL_not Monroe County	CM_LL
2013-2015	=40,966/505,763	=413,016/505,763	=51,782/505,763
Prop (2013-2015)	0.0810	0.8166	0.1024

c) Estimated commercial landings by fleet during 2016-2017 (lbs):

YEAR	SERO Commercial Landings Estimate	CHL_Monroe County	CHL_not Monroe County	CM_LL	SUM
2016	156,337	12,663	127,668	16,006	156,337
2017	136,927	11,091	111,817	14,019	136,927

Table 2. Recreational landings estimates in 2016 and 2017 were broken out into the appropriate fleets (Private, Shore, Charter+Headboat) using the proportions landed by each fleet during the three most recent years (2013-2015) after conversion from numbers of fish to weight landed.

a) Recreational Landings in *numbers*:

YEAR	Private	Shore	Charter+Headboat
2013	1,061,900	175,952	297,201
2014	1,285,510	324,448	327,376
2015	1,101,150	199,704	268,873

b) Average weight (lbs) internally estimated by assessment model:

YEAR	Private	Shore	Charter+Headboat
2013	1.306	0.842	1.136
2014	1.276	0.830	1.106
2015	1.313	0.856	1.148

c) Recreational Landings (*lbs*):

YEAR	Private	Shore	Charter+Headboat	SUM
2013	1,387,089	148,084	337,620	1,872,793
2014	1,639,677	269,449	362,195	2,271,321
2015	1,445,752	170,948	308,731	1,925,430
SUM	4,472,518	588,480	1,008,547	6,069,545

d) Proportion landed by recreational fleets:

YEAR	Private	Shore	Charter+Headboat
2013-2015	=4,472,518/6,069,595	=588,480/6,069,595	=1,008,547/6,069,595
Prop (2013-2015)	0.7369	0.0970	0.1662

e) Estimated commercial landings by fleet during 2016-2017 (lbs):

YEAR	SERO Commercial Landings Estimate	Private	Shore	Charter+Headboat	SUM
2016	2,364,614	1,742,433	229,264	392,916	2,364,614
2017	1,848,895	1,362,412	179,262	307,222	1,848,895

Table 3. The aggregated annual catch limit in 2018 was broken out into the appropriate recreational and commercial fleets using the proportions landed by each fleet during the three most recent years (2013-2015).

a) Landings by fleet in lbs (as summarized in Tables 1 and 2).

YEAR	CHL Monroe County	CHL not Monroe County	CM_LL	Private	Shore	CB+HB	SUM
2013	22,013	111,558	9,918	1,387,089	148,084	337,620	2,016,282
2014	7,932	173,722	16,964	1,639,677	269,449	362,195	2,469,939
2015	11,020	127,736	24,899	1,445,752	170,948	308,731	2,089,086
SUM	40,965	413,016	51,781	4,472,518	588,481	1,008,546	6,575,307

b) Proportion landed by fleet:

YEAR	CHL Monroe County	CHL not Monroe County	CM_LL	Private	Shore	CB+HB
2013-2015	=40,965 / 6,575,307	=413,016 / 6,575,307	=51,781 / 6,575,307	=4,472,518 / 6,575,307	=588,481 / 6,575,307	=1,008,546 / 6,575,307
Prop (2013-2015)	0.0062	0.0628	0.0079	0.6802	0.0895	0.1534

c) Estimated landings by fleet during 2018 (lbs):

YEAR	SERO ACL	CHL Monroe County	CHL not Monroe County	CM_LL	Private	Shore	CB+HB	SUM
2018	2,420,000	15,077	152,008	19,058	1,646,082	216,587	371,189	2,420,000

Table 4. To retain SEDAR 51 model structure, projected commercial landings were input in metric tons, and projected recreational landings in 1000s of fish (a). Recreational landings in weight (**Tables 2 and 3**) were converted to numbers of fish using annual average weight estimates computed internally by the assessment model (b).

a) Projection inputs in required units:

YEAR	Metric Tons			1000s of Fish		
	CHL Monroe County	CHL not Monroe County	CM_LL	Private	Shore	CB+HB
2016	5.74	57.91	7.26	1,372.81	277.48	357.07
2017	5.03	50.72	6.36	1,045.56	209.62	269.87
2018	6.76	68.13	8.54	1,203.62	246.44	310.13

b) Average weights (lbs) computed by the assessment model, by recreational fleet:

YEAR	Private	Shore	CB+HB
2016	1.2692	0.8262	1.1004
2017	1.3030	0.8552	1.1384
2018	1.3676	0.8788	1.1969

Table 5. Annual estimates of spawning stock biomass (SSB) in millions of pounds, SSB relative to the unfished condition (SSB/SSB_0), the SSB_{MSY} proxy ($SSB/SSB_{SPR26\%}$) and MSST ($SSB/MSST$).

a) $F_{SPR26\%}$

YEAR	LCI	SSB	UCI	SSB/S0	SSB/SSB_SPR26	SSB/MSST
2015	8.35	10.27	12.20	0.21	0.81	1.63
2016	8.90	10.90	12.89	0.22	0.86	1.73
2017	9.36	11.43	13.51	0.23	0.91	1.81
2018	10.40	12.63	14.85	0.26	1.00	2.00
2019	10.61	13.13	15.66	0.27	1.04	2.08
2020	10.05	13.25	16.45	0.27	1.05	2.10
2021	9.09	13.26	17.42	0.27	1.05	2.10

b) $F_{SPR30\%}$

YEAR	LCI	SSB	UCI	SSB/S0	SSB/SSB_SPR30	SSB/MSST
2015	8.35	10.27	12.20	0.21	0.70	1.41
2016	8.90	10.90	12.89	0.22	0.75	1.49
2017	9.36	11.43	13.51	0.23	0.78	1.57
2018	10.40	12.63	14.85	0.26	0.86	1.73
2019	10.61	13.14	15.66	0.27	0.90	1.80
2020	10.33	13.55	16.77	0.28	0.93	1.86
2021	9.63	13.84	18.04	0.28	0.95	1.90

c) $F_{SPR40\%}$

YEAR	LCI	SSB	UCI	SSB/S0	SSB/SSB_SPR40	SSB/MSST
2015	8.35	10.27	12.20	0.21	0.53	1.05
2016	8.90	10.90	12.89	0.22	0.56	1.12
2017	9.36	11.43	13.51	0.23	0.59	1.17
2018	10.40	12.63	14.85	0.26	0.65	1.29
2019	10.61	13.14	15.66	0.27	0.67	1.35
2020	10.84	14.11	17.37	0.29	0.72	1.45
2021	10.67	14.97	19.26	0.31	0.77	1.53

Table 6. Annual estimates of fishing mortality (F), and F relative to the MFMT ($=F_{MSY}$ or proxy).

a) $F_{SPR26\%}$

YEAR	LCI	F	UCI	F/MFMT
2015	0.1146	0.1347	0.1548	1.02
2016	0.1173	0.1325	0.1476	1.01
2017	0.0938	0.1073	0.1209	0.82
2018	0.0947	0.1256	0.1564	0.95
2019	0.0972	0.1325	0.1678	1.01
2020	0.0911	0.1319	0.1728	1.00
2021	0.0856	0.1317	0.1778	1.00

b) $F_{SPR30\%}$

YEAR	LCI	F	UCI	F/MFMT
2015	0.1146	0.1347	0.1548	1.17
2016	0.1173	0.1325	0.1476	1.15
2017	0.0938	0.1073	0.1209	0.93
2018	0.0947	0.1255	0.1563	1.09
2019	0.0845	0.1155	0.1465	1.00
2020	0.0797	0.1151	0.1505	1.00
2021	0.0756	0.1150	0.1545	1.00

c) $F_{SPR40\%}$

YEAR	LCI	F	UCI	F/MFMT
2015	0.1146	0.1347	0.1548	1.61
2016	0.1173	0.1325	0.1476	1.59
2017	0.0938	0.1073	0.1209	1.29
2018	0.0947	0.1255	0.1563	1.50
2019	0.0608	0.0836	0.1063	1.00
2020	0.0581	0.0835	0.1088	1.00
2021	0.0559	0.0835	0.1111	1.00

Table 7. Landings estimates (shaded) and projected retained yield, OFL and ABC. OFL was calculated as the median (50th percentile) of the probability density function (PDF) of retained yield (millions of lbs) using the projection of F_{MSY} (or proxy). ABC was calculated at a P* of 0.40 (the 40th percentile) of the PDF of retained yield using the projection of F_{MSY} (or proxy).

a) F_{SPR26%}

YEAR	LCI	Retained Yield (millions of lbs)	UCI	OFL	ABC @ P =0 .40
2015		1.956			
2016		2.521			
2017		1.986			
2018		2.420			
2019	2.229	2.587	2.945	2.587	2.516
2020	2.257	2.575	2.893	2.575	2.512
2021	2.274	2.564	2.854	2.564	2.507

b) F_{SPR30%}

YEAR	LCI	Retained Yield (millions of lbs)	UCI	OFL	ABC @ P =0 .40
2015		1.956			
2016		2.521			
2017		1.986			
2018		2.420			
2019	1.942	2.257	2.573	2.257	2.195
2020	2.007	2.291	2.575	2.291	2.235
2021	2.057	2.320	2.582	2.320	2.268

c) F_{SPR40%}

YEAR	LCI	Retained Yield (millions of lbs)	UCI	OFL	ABC @ P =0 .40
2015		1.956			
2016		2.521			
2017		1.986			
2018		2.420			
2019	1.402	1.635	1.867	1.589	1.635
2020	1.504	1.720	1.937	1.677	1.720
2021	1.591	1.796	2.001	1.755	1.796

Table 8. Relevant management reference points.

a) $F_{SPR26\%}$

Reference	Definition	Value	Units
SSB_0	SSB_Unfished	48.943	Million LBS
R_0	Recr_Unfished	10,683,000	numbers
SSB_MSY	SSB_SPR26	12.633	Million LBS
F_MSY	Fstd_SPR26	0.132	Fraction of stock removed
MSY	Eq. Retained Yield_SPR26	2.470	Million LBS

b) $F_{SPR30\%}$

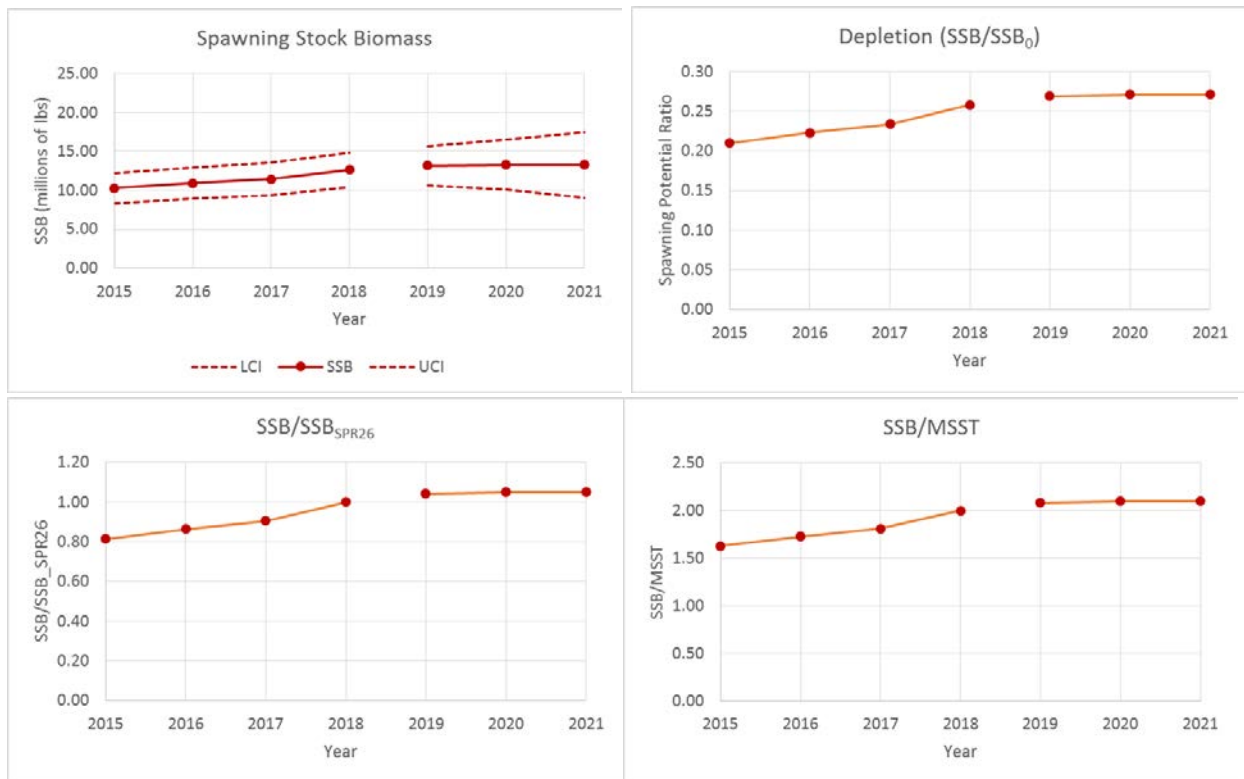
Reference	Definition	Value	Units
SSB_0	SSB_Unfished	48.943	Million LBS
R_0	Recr_Unfished	10,683,000	numbers
SSB_MSY	SSB_SPR30	14.596	Million LBS
F_MSY	F_SPR30	0.115	Fraction of stock removed
MSY	Eq. Retained Yield_SPR30	2.402	Million LBS

c) $F_{SPR40\%}$

Reference	Definition	Value	Units
SSB_0	SSB_Unfished	48.943	Million LBS
R_0	Recr_Unfished	10,683,000	numbers
SSB_MSY	SSB_SPR40	19.503	Million LBS
F_MSY	Fstd_SPR40	0.083	Fraction of stock removed
MSY	Eq. Retained Yield_SPR40	2.178	Million LBS

Figure 1. $F_{SPR26\%}$: Annual estimates of spawning stock biomass (SSB) and fishing mortality (F), and SSB and F relative to relevant management references. Note: The constant $F_{SPR26\%}$ projection begins in 2019. During 2016-2018 fixed catches were assumed. This change is indicated by a break in the time series.

a) Spawning Stock Biomass



b) Fishing Mortality

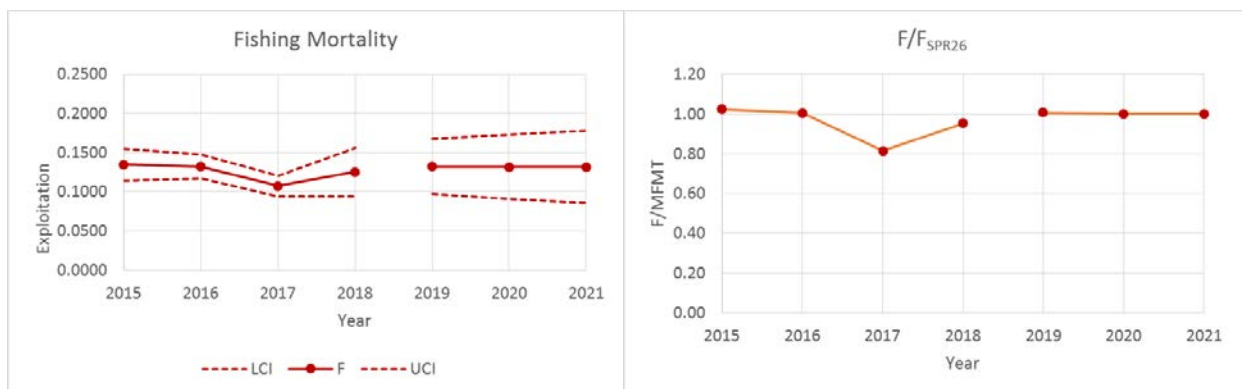


Figure 2. $F_{SPR30\%}$: Annual estimates of spawning stock biomass (SSB) and fishing mortality (F), and SSB and F relative to relevant management references. Note: The constant $F_{SPR30\%}$ projection begins in 2019. During 2016-2018 fixed catches were assumed. This change is indicated by a break in the time series.

a) Spawning Stock Biomass



b) Fishing Mortality

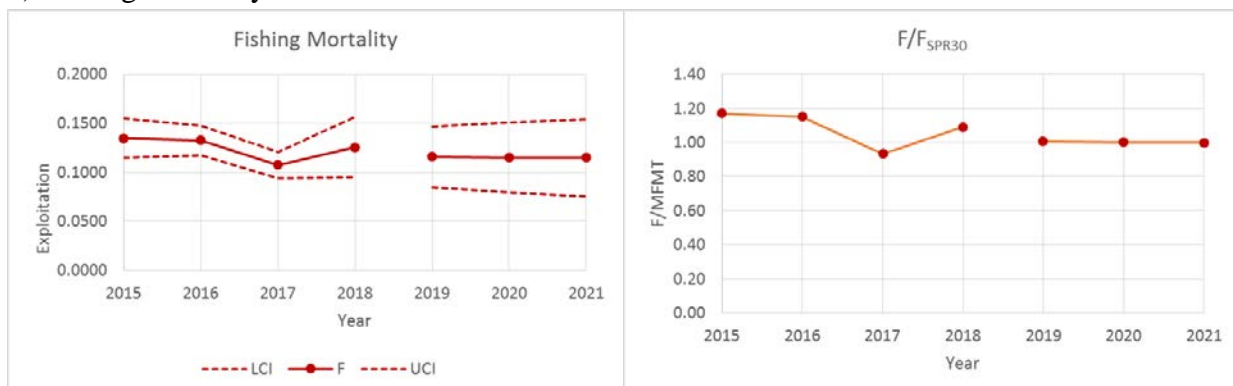
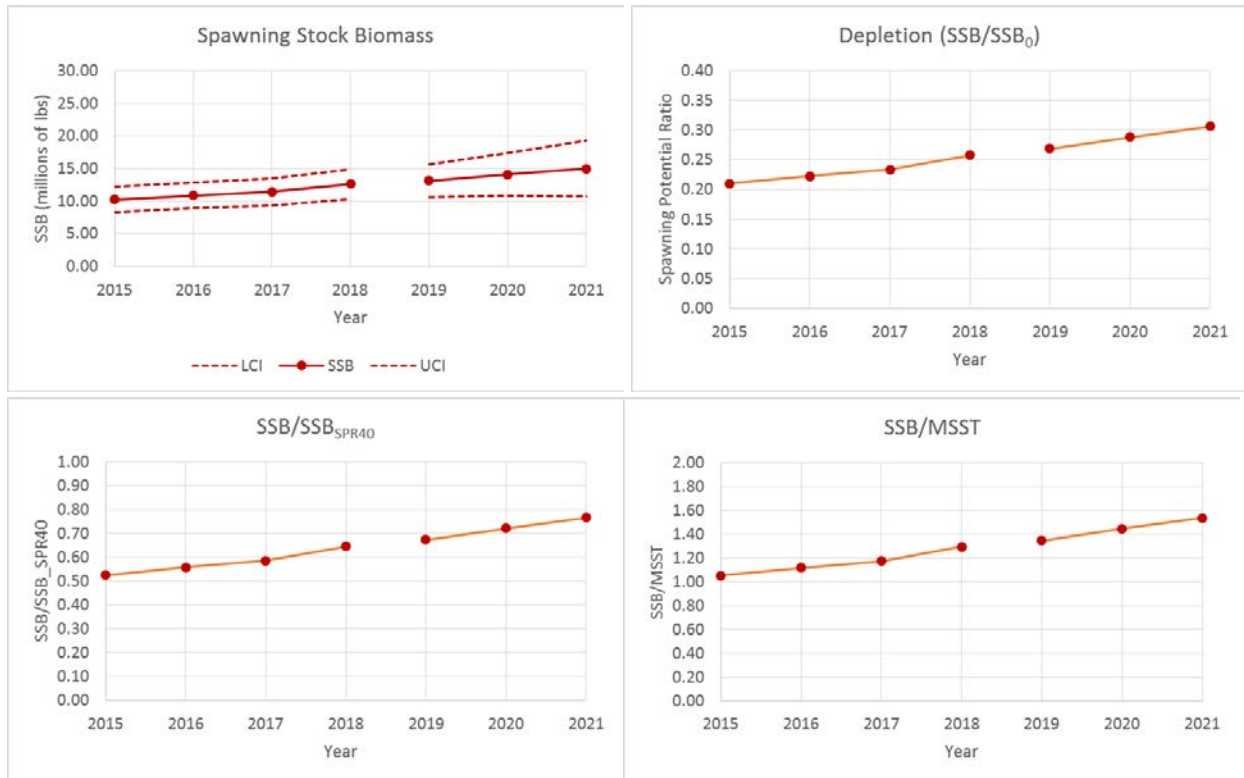


Figure 3. $F_{SPR40\%}$: Annual estimates of spawning stock biomass (SSB) and fishing mortality (F), and SSB and F relative to relevant management references. Note: The constant $F_{SPR40\%}$ projection begins in 2019. During 2016-2018 fixed catches were assumed. This change is indicated by a break in the time series.

a) Spawning Stock Biomass



b) Fishing Mortality

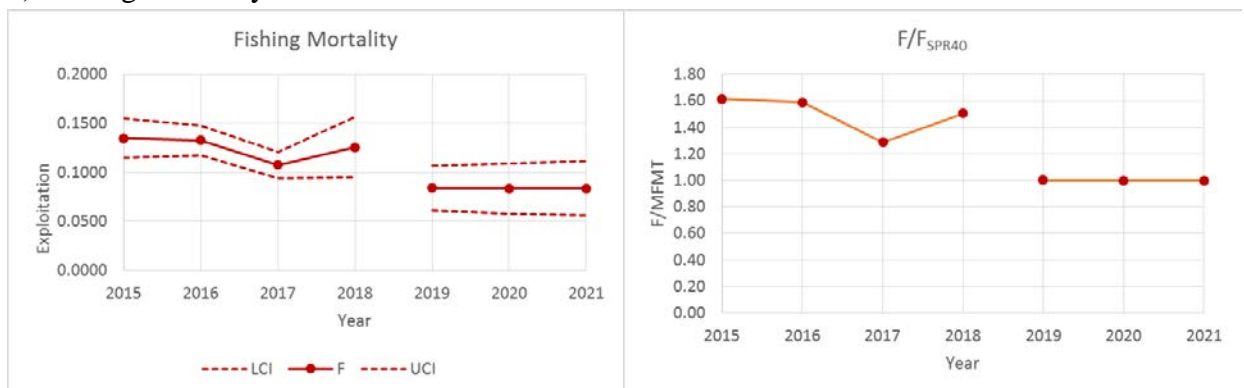
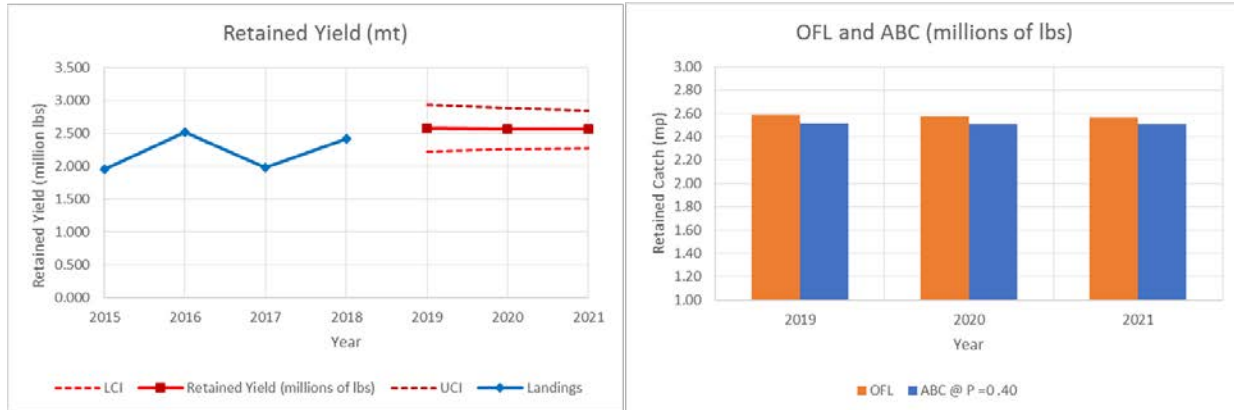
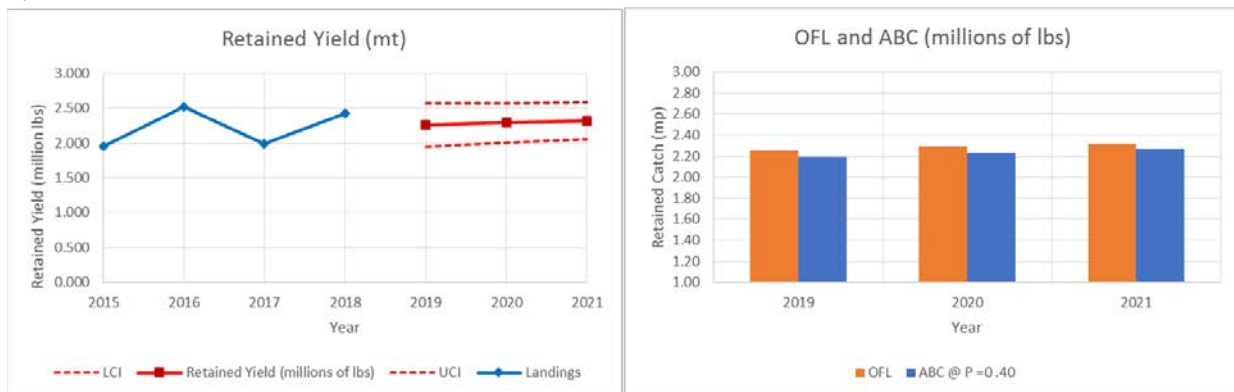


Figure 4. Landings estimates (blue) and projected retained yield, OFL and ABC. OFL was calculated as the median (50th percentile) of the probability density function (PDF) of retained yield (millions of lbs) using the projection of F_{MSY} (or proxy). ABC was calculated at a P^* of 0.40 (the 40th percentile) of the PDF of retained yield using the projection of F_{MSY} (or proxy).

a) $FS_{PR26\%}$



b) $FS_{PR30\%}$



c) $FS_{PR40\%}$

