NOAA FISHERIES

SEFSC

SEDAR 72: US Gulf of Mexico Gag Grouper Operational Assessment

Updated Projections

GMFMC SSC Presentation

November 18th 2021

NOAA Fisheries, Southeast Fisheries Science Center,
Sustainable Fisheries Division (SFD)

SEDAR 72 – GOM Gag Grouper

- Context behind the use of F_{max} with gag grouper
- Projections and rebuilding scenarios with updated 2021 red tide estimates
- GRFS ratio for adjusting projected catch

Context behind the use of F_{max} with gag grouper

Fmsy Proxy

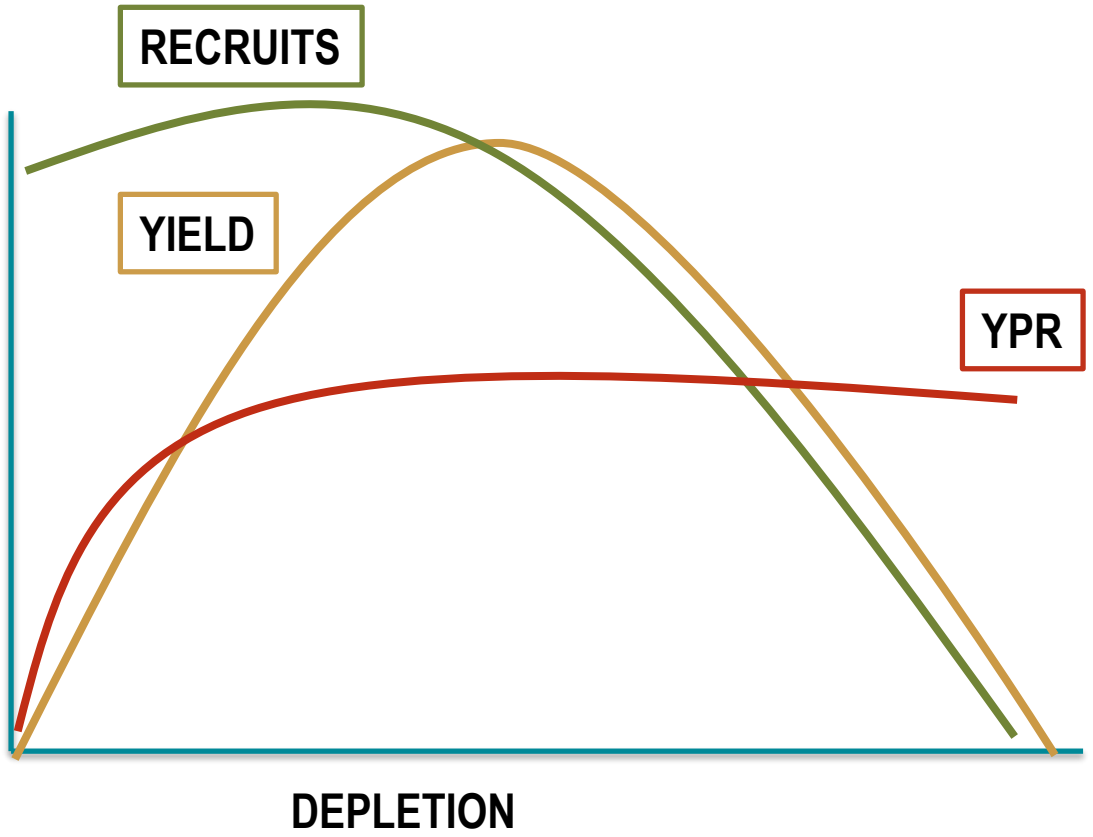
- Why F_{max}?
  - Source: Turner et al. 2001. Status of Gag in the Gulf of Mexico, Assessment 3.0. https://www.researchgate.net/publication/265279249_Status_of_Gag_in_the_Gulf_of_Mexico_Assessment_30
  - "**Because the female reproductive-potential function reaches a maximum at age 8, long-term fishing at F30% and F40% will generally result in the relatively low biomass levels of males.** The combination of the female reproductive function and the assumed selectivity pattern (see below) results in estimates of F30% and F40% which are much higher (about 2-3 times) than the assumed natural mortality rate. Because males are older; maximizing male biomass would require a lower fishing-mortality rate. **A bench mark that maximizes the yield from the entire population, given estimated recruitments, is Fmax**, the fishing mortality rate at which yield per recruit is maximized. Because of gag growth patterns and the female reproductive characteristics, Fmax is lower than both F30% and F40%. The obvious implication here is that **larger long term yields could be obtained at fishing mortality levels lower than F30% and F40%. Fmax was selected** as an additional reference fishing mortality rate **to provide some measure of the effects of lower fishing rates on both female and male gag**. /…/ An important point for the RFSAP to consider is the **choice of MSY proxies given the protogynous hermaphroditic life history of gag grouper**. As can be seen in Tables 31-36, **Fmax is typically about half of F30% while the female SSB at Fmax is about double the SSB at F30%.** This happens **because reproductive potential for the average female decreases rapidly after age 9** (Figure 41), **whereas the average weight per fish increases substantially.** Accordingly, **increasing F has a proportionally greater negative impact on the biomass of older fish**. Under the projected selectivity scenario's examined here, **an Fmax policy would achieve greater long-term yields and a higher SPR (43% - 65%) than would policies based on F30% or F40%**."

Fmsy Proxy

- F_{max} vs. $F_{\%SPR}$
  - 2001 assessment (VPA): $F_{max}^{SSB\ female} \sim F_{45-60\%SPR}$
  - SEDAR 10: $F_{max}^{SSB\ female} \sim F_{31-33\%SPR}$
  - SEDAR 33: $F_{max}^{SSB\ female} \sim F_{40\%SPR}$; $F_{max}^{SSB\ combined} \sim F_{30\%SPR}$
  - SEDAR 33 update: $F_{max}^{SSB\ female} \sim F_{29\%SPR}$
  - SEDAR 72: $F_{max}^{SSB\ female} \sim F_{30\%SPR}$; $F_{max}^{SSB\ combined} \sim F_{13\%SPR}$

The F_{max} search

- An F_{msy} search where raw catch is replaced by catch/recruits
- Given that the target value for F_{msy}/F_{max} is unknown, depletion is used as the proxy target
- F_{max} search is very **slow** and **unstable** (allocations and annual Fs can have a big impact on the search and different magnitudes of catch & recruitment can lead to very similar F_{max} if their ratio is similar)



Updated Projections

Projection Settings

Parameter	Value	Comment
Relative F	Average from 2017 - 2019	Average relative fishing mortality (apical F) over terminal three years of model (Red Tide F excluded)
Selectivity	2019	Fleet specific selectivity estimated in the terminal year of the model
Retention	2019	Fleet specific retention estimated in the terminal year of the model
Recruitment	Beverton-Holt stock-recruitment relationship	Derived from the model estimated Beverton-Holt stock-recruitment relationship
Interim Landings (2020-2022)	73.79/126.72/126.72 mt (Comm. Vertical Line) 133.69/97.41/97.41 mt (Comm. Longline) 2.61/2.54/2.54 thousands of fish (Headboat) 37.61/28.66/28.66 thousands of fish (Charter) 305.4/271.68/271.68 thousands of fish (Private)	Landings provided for 2020; For 2021-2022, used 3-year average of landings (2018-2020)
Allocation Ratio	39:61	Commercial:Recreational

Projection Scenarios – 2021 Red Tide

- Ecosystem model (updated with data up to the end of October) : $\widehat{M}_{2021\_redtide}$ =0.103; 95% CI (0.027,0.290)
- We take the **mean** estimate as the "Medium Red Tide" scenario and the limits of the **95% confidence interval** as the "Low" and "High" scenarios
- For SS, this translates into a red tide that is

Low = **6%** the strength of the 2005 red tide,

Med = **24%** the strength of the 2005 red tide,

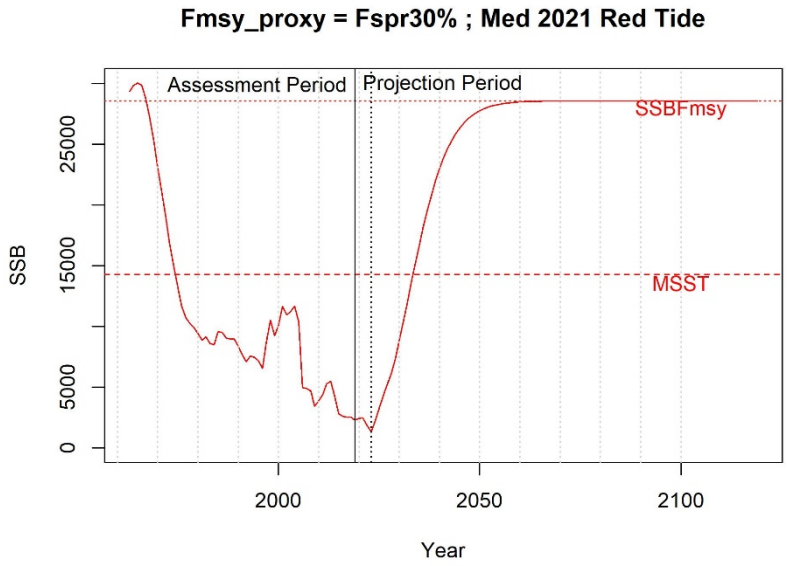
High = **68%** the strength of the 2005 red tide

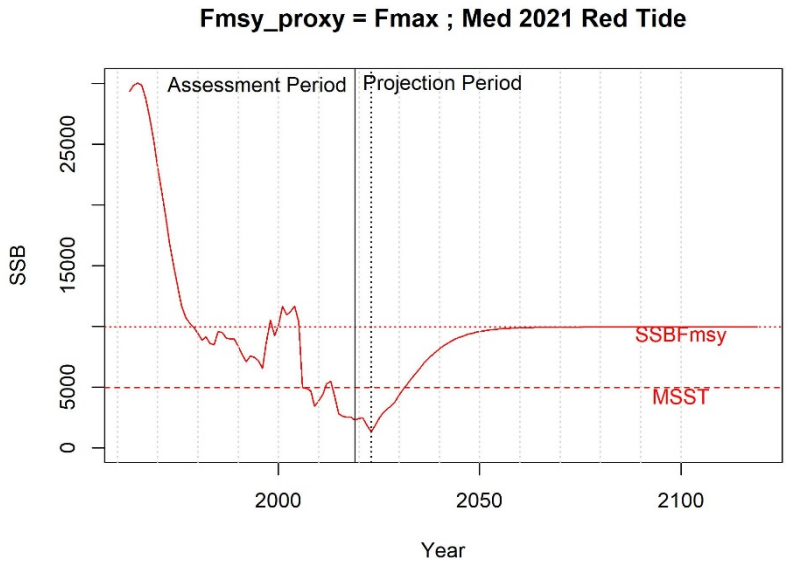
Projection Scenarios

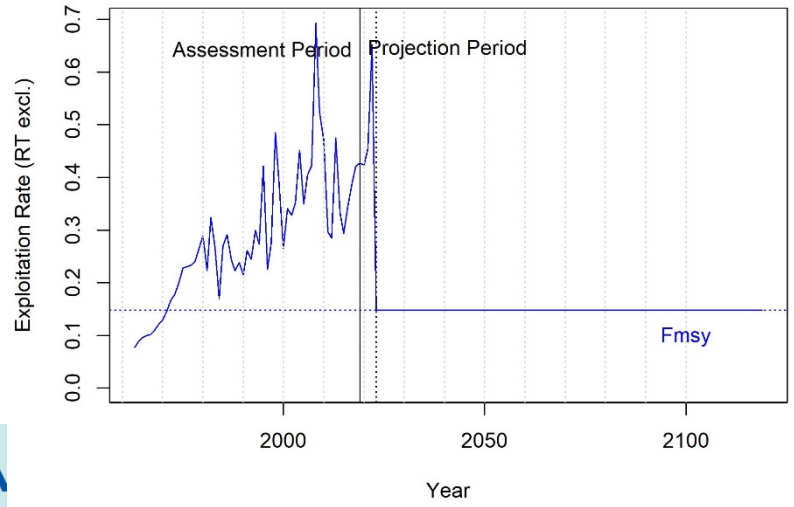
	Fspr30			Fmax		
	LOW	HIGH	MED	LOW	HIGH	MED
Base M	0.159	0.159	0.159	0.159	0.159	0.159
Steepness	0.855	0.855	0.855	0.855	0.855	0.855
R0	14319.2	14319.2	14319.2	14319.2	14319.2	14319.2
Generation Time	7.88	7.88	7.88	7.88	7.88	7.88
SSB0	106178	106178	106178	106178	106178	106178
Proxy	Fspr30	Fspr30	Fspr30	Fmax	Fmax	Fmax
Fmsy proxy	0.148	0.148	0.148	0.328	0.328	0.328
MFMT	0.148	0.148	0.148	0.328	0.328	0.328
%SPR equivalent of Fmsy proxy	30	30	30	**13**	**13**	**13**
Fcurrent	0.412	0.412	0.412	0.412	0.412	0.412
Fcurrent/MFMT	**2.784**	**2.784**	**2.784**	**1.256**	**1.256**	**1.256**
SSBmsy proxy	28559.6	28559.8	28559.4	9956.4	9956.53	9957.26
MSST	14279.8	14279.9	14279.7	4978.2	4978.265	4978.63
SSBcurrent	2296.24	2296.24	2296.24	2296.24	2296.24	2296.24
SSBcurrent/SSBFmsy_proxy	0.08	0.08	0.08	0.231	0.231	0.231
SSBcurrent/MSST	**0.161**	**0.161**	**0.161**	**0.461**	**0.461**	**0.461**
First year mgmt	2023	2023	2023	2023	2023	2023
Yr rebuilt at F=0	**2033**	**2035**	**2034**	**2028**	**2030**	**2029**
SSBcurrent/SSB0	0.022	0.022	0.022	0.022	0.022	0.022
SSByrrebuilt/SSB0	0.139	0.128	0.143	0.038	0.028	0.036

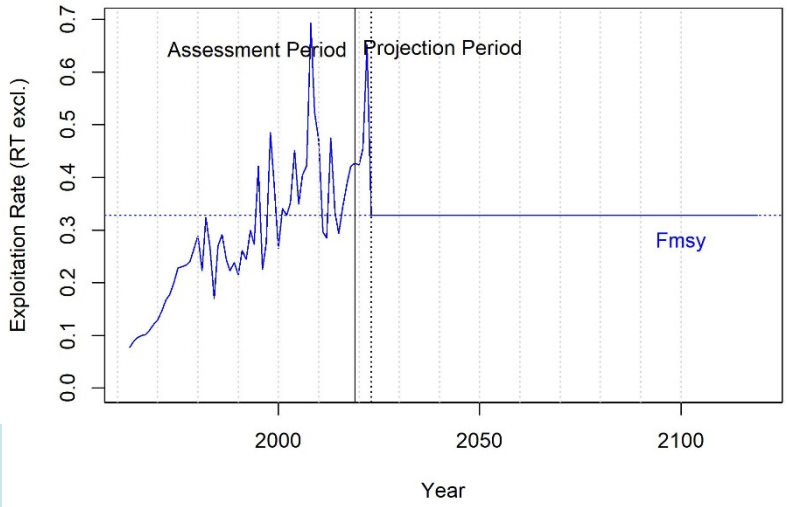
Fspr30%

Fmax


Fmsy_proxy = Fspr30% ; Med 2021 Red Tide
Assessment Period
Projection Period
SSBFmsy
MSST
SSB
0
5000
15000
25000
2000
2050
2100
Year


Fmsy_proxy = Fmax ; Med 2021 Red Tide
Assessment Period
Projection Period
SSBFmsy
MSST
SSB
0
5000
15000
25000
2000
2050
2100
Year


Assessment Period
Projection Period
Fmsy
Exploitation Rate (RT excl.)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2000
2050
2100
Year


Assessment Period
Projection Period
Fmsy
Exploitation Rate (RT excl.)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2000
2050
2100
Year

Frebuild

Calculate **Tmin**, the amount of time the stock is expected to take to rebuild to its MSY biomass level in the absence of any fishing mortality (**F=0**).

- Tmin<10yrs
  - Tmin
    No fishing
  - 10yrs
  - Halfway in between Tmin and 10 years
- Tmin>10yrs
  - Tmin*2
  - Tmin+1 generation time
  - Amount of time stock expected to take to rebuild to Bmsy proxy if fished at 75% MFMT
- Tmin=10yrs
  No fishing

Fspr30_loRT

F=0*

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.454	3.10	2,484	0.09	0.17	3.07	0.02
2022	4,664	0.566	3.17	2,131	0.07	0.15	3.82	0.02
2023	3,992	0.000	0.00	1,712	0.06	0.12	0.00	0.02
2024	5,836	0.000	0.00	3,009	0.11	0.21	0.00	0.03
2025	7,583	0.000	0.00	4,837	0.17	0.34	0.00	0.05
2026	8,862	0.000	0.00	6,840	0.24	0.48	0.00	0.06
2027	9,766	0.000	0.00	8,851	0.31	0.62	0.00	0.08
2028	10,523	0.000	0.00	11,165	0.39	0.78	0.00	0.11
2029	11,218	0.000	0.00	14,120	0.49	0.99	0.00	0.13
2030	11,812	0.000	0.00	17,676	0.62	1.24	0.00	0.17
2031	12,288	0.000	0.00	21,676	0.76	1.52	0.00	0.20
2032	12,662	0.000	0.00	25,982	0.91	1.82	0.00	0.24
2033	12,956	0.000	0.00	30,503	1.07	2.14	0.00	0.29

*It takes exactly 10 yrs to rebuild in the absence of any fishing mortality

Fspr30_hiRT

F=0

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.455	3.09	2,484	0.09	0.17	3.07	0.02
2022	3,239	0.936	3.10	1,300	0.05	0.09	6.32	0.01
2023	1,751	0.000	0.00	623	0.02	0.04	0.00	0.01
2024	3,374	0.000	0.00	1,370	0.05	0.10	0.00	0.01
2025	5,166	0.000	0.00	2,481	0.09	0.17	0.00	0.02
2026	6,613	0.000	0.00	3,727	0.13	0.26	0.00	0.04
2027	7,608	0.000	0.00	4,870	0.17	0.34	0.00	0.05
2028	8,484	0.000	0.00	6,164	0.22	0.43	0.00	0.06
2029	9,449	0.000	0.00	8,070	0.28	0.57	0.00	0.08
2030	10,371	0.000	0.00	10,641	0.37	0.75	0.00	0.10
2031	11,144	0.000	0.00	13,751	0.48	0.96	0.00	0.13
2032	11,755	0.000	0.00	17,278	0.60	1.21	0.00	0.16
2033	12,236	0.000	0.00	21,171	0.74	1.48	0.00	0.20
2034	12,618	0.000	0.00	25,395	0.89	1.78	0.00	0.24
2035	12,920	0.000	0.00	29,878	1.05	2.09	0.00	0.28

Fspr30_hiRT

Frebuild Tmin*2

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.455	3.09	2,484	0.09	0.17	3.07	0.02
2022	3,239	0.936	3.10	1,300	0.05	0.09	6.32	0.01
2023	1,751	0.135	0.35	623	0.02	0.04	0.91	0.01
2024	3,101	0.135	0.63	1,230	0.04	0.09	0.91	0.01
2025	4,551	0.135	0.91	2,056	0.07	0.14	0.91	0.02
2026	5,665	0.135	1.05	2,867	0.10	0.20	0.91	0.03
2027	6,364	0.135	1.26	3,483	0.12	0.24	0.91	0.03
2028	6,969	0.135	1.58	4,103	0.14	0.29	0.91	0.04
2029	7,760	0.135	2.00	5,072	0.18	0.36	0.91	0.05
2030	8,606	0.135	2.48	6,374	0.22	0.45	0.91	0.06
2031	9,360	0.135	2.98	7,866	0.28	0.55	0.91	0.07
2032	9,981	0.135	3.52	9,437	0.33	0.66	0.91	0.09
2033	10,496	0.135	4.08	11,069	0.39	0.78	0.91	0.10
2034	10,930	0.135	4.66	12,773	0.45	0.89	0.91	0.12
2035	11,297	0.135	5.25	14,527	0.51	1.02	0.91	0.14
2036	11,603	0.135	5.82	16,280	0.57	1.14	0.91	0.15
2037	11,854	0.135	6.36	17,983	0.63	1.26	0.91	0.17
2038	12,060	0.135	6.87	19,599	0.69	1.37	0.91	0.18
2039	12,229	0.135	7.34	21,104	0.74	1.48	0.91	0.20
2040	12,367	0.135	7.77	22,484	0.79	1.57	0.91	0.21
2041	12,481	0.135	8.15	23,729	0.83	1.66	0.91	0.22
2042	12,574	0.135	8.49	24,838	0.87	1.74	0.91	0.23
2043	12,650	0.135	8.78	25,815	0.90	1.81	0.91	0.24
2044	12,712	0.135	9.04	26,666	0.93	1.87	0.91	0.25
2045	12,763	0.135	9.26	27,400	0.96	1.92	0.91	0.26
2046	12,805	0.135	9.44	28,027	0.98	1.96	0.91	0.26
2047	12,840	0.135	9.60	28,560	1.00	2.00	0.91	0.27

Fspr30_hiRT

F fixed at 75%MFMT

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.455	3.09	2,484	0.09	0.17	3.07	0.02
2022	3,239	0.936	3.10	1,300	0.05	0.09	6.32	0.01
2023	1,751	0.111	0.29	623	0.02	0.04	0.75	0.01
2024	3,150	0.111	0.52	1,254	0.04	0.09	0.75	0.01
2025	4,660	0.111	0.76	2,128	0.07	0.15	0.75	0.02
2026	5,835	0.111	0.90	3,008	0.11	0.21	0.75	0.03
2027	6,588	0.111	1.10	3,703	0.13	0.26	0.75	0.03
2028	7,244	0.111	1.38	4,417	0.15	0.31	0.75	0.04
2029	8,072	0.111	1.76	5,515	0.19	0.39	0.75	0.05
2030	8,940	0.111	2.20	6,989	0.24	0.49	0.75	0.07
2031	9,706	0.111	2.68	8,695	0.30	0.61	0.75	0.08
2032	10,334	0.111	3.18	10,517	0.37	0.74	0.75	0.10
2033	10,850	0.111	3.71	12,430	0.44	0.87	0.75	0.12
2034	11,280	0.111	4.27	14,436	0.51	1.01	0.75	0.14
2035	11,638	0.111	4.82	16,505	0.58	1.16	0.75	0.16
2036	11,934	0.111	5.37	18,579	0.65	1.30	0.75	0.17
2037	12,175	0.111	5.89	20,603	0.72	1.44	0.75	0.19
2038	12,372	0.111	6.38	22,533	0.79	1.58	0.75	0.21
2039	12,533	0.111	6.84	24,339	0.85	1.70	0.75	0.23
2040	12,664	0.111	7.26	26,003	0.91	1.82	0.75	0.24
2041	12,771	0.111	7.63	27,514	0.96	1.93	0.75	0.26
2042	12,859	0.111	7.97	28,867	1.01	2.02	0.75	0.27

Fspr30_hiRT

Frebuild Tmin + 1 generation

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.455	3.09	2,484	0.09	0.17	3.07	0.02
2022	3,239	0.936	3.10	1,300	0.05	0.09	6.32	0.01
2023	1,751	0.119	0.31	623	0.02	0.04	0.80	0.01
2024	3,134	0.119	0.56	1,246	0.04	0.09	0.80	0.01
2025	4,624	0.119	0.81	2,104	0.07	0.15	0.80	0.02
2026	5,778	0.119	0.96	2,960	0.10	0.21	0.80	0.03
2027	6,513	0.119	1.16	3,628	0.13	0.25	0.80	0.03
2028	7,151	0.119	1.45	4,309	0.15	0.30	0.80	0.04
2029	7,968	0.119	1.85	5,362	0.19	0.38	0.80	0.05
2030	8,829	0.119	2.30	6,776	0.24	0.47	0.80	0.06
2031	9,591	0.119	2.79	8,408	0.29	0.59	0.80	0.08
2032	10,217	0.119	3.30	10,142	0.36	0.71	0.80	0.10
2033	10,733	0.119	3.85	11,955	0.42	0.84	0.80	0.11
2034	11,165	0.119	4.41	13,855	0.49	0.97	0.80	0.13
2035	11,526	0.119	4.98	15,812	0.55	1.11	0.80	0.15
2036	11,825	0.119	5.54	17,772	0.62	1.24	0.80	0.17
2037	12,070	0.119	6.07	19,681	0.69	1.38	0.80	0.19
2038	12,270	0.119	6.57	21,498	0.75	1.51	0.80	0.20
2039	12,433	0.119	7.03	23,196	0.81	1.62	0.80	0.22
2040	12,567	0.119	7.46	24,757	0.87	1.73	0.80	0.23
2041	12,676	0.119	7.83	26,171	0.92	1.83	0.80	0.25
2042	12,766	0.119	8.17	27,435	0.96	1.92	0.80	0.26
2043	12,839	0.119	8.46	28,552	1.00	2.00	0.80	0.27
2044	12,900	0.148	10.83	29,528	1.03	2.07	1.00	0.28

Fspr30_medRT

F=0

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.454	3.10	2,484	0.09	0.17	3.07	0.02
2022	4,221	0.652	3.15	1,849	0.06	0.13	4.40	0.02
2023	3,312	0.000	0.00	1,337	0.05	0.09	0.00	0.01
2024	5,134	0.000	0.00	2,458	0.09	0.17	0.00	0.02
2025	6,927	0.000	0.00	4,057	0.14	0.28	0.00	0.04
2026	8,274	0.000	0.00	5,824	0.20	0.41	0.00	0.05
2027	9,226	0.000	0.00	7,573	0.27	0.53	0.00	0.07
2028	10,035	0.000	0.00	9,591	0.34	0.67	0.00	0.09
2029	10,808	0.000	0.00	12,257	0.43	0.86	0.00	0.12
2030	11,483	0.000	0.00	15,557	0.54	1.09	0.00	0.15
2031	12,029	0.000	0.00	19,340	0.68	1.35	0.00	0.18
2032	12,458	0.000	0.00	23,471	0.82	1.64	0.00	0.22
2033	12,795	0.000	0.00	27,865	0.98	1.95	0.00	0.26
2034	13,061	0.000	0.00	32,449	1.14	2.27	0.00	0.31

Fspr30_medRT

Frebuild Tmin*2

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.454	3.10	2,484	0.09	0.17	3.07	0.02
2022	4,221	0.652	3.15	1,849	0.06	0.13	4.40	0.02
2023	3,312	0.135	0.66	1,337	0.05	0.09	0.91	0.01
2024	4,753	0.135	1.02	2,190	0.08	0.15	0.91	0.02
2025	6,195	0.135	1.39	3,325	0.12	0.23	0.91	0.03
2026	7,255	0.135	1.65	4,430	0.16	0.31	0.91	0.04
2027	7,974	0.135	1.98	5,370	0.19	0.38	0.91	0.05
2028	8,595	0.135	2.41	6,354	0.22	0.44	0.91	0.06
2029	9,267	0.135	2.92	7,660	0.27	0.54	0.91	0.07
2030	9,912	0.135	3.48	9,244	0.32	0.65	0.91	0.09
2031	10,466	0.135	4.05	10,965	0.38	0.77	0.91	0.10
2032	10,918	0.135	4.64	12,721	0.45	0.89	0.91	0.12
2033	11,288	0.135	5.22	14,477	0.51	1.01	0.91	0.14
2034	11,593	0.135	5.79	16,217	0.57	1.14	0.91	0.15
2035	11,845	0.135	6.33	17,915	0.63	1.25	0.91	0.17
2036	12,053	0.135	6.84	19,536	0.68	1.37	0.91	0.18
2037	12,223	0.135	7.32	21,049	0.74	1.47	0.91	0.20
2038	12,363	0.135	7.75	22,437	0.79	1.57	0.91	0.21
2039	12,477	0.135	8.13	23,691	0.83	1.66	0.91	0.22
2040	12,571	0.135	8.47	24,808	0.87	1.74	0.91	0.23
2041	12,648	0.135	8.77	25,792	0.90	1.81	0.91	0.24
2042	12,711	0.135	9.02	26,649	0.93	1.87	0.91	0.25
2043	12,763	0.135	9.25	27,389	0.96	1.92	0.91	0.26
2044	12,805	0.135	9.43	28,022	0.98	1.96	0.91	0.26
2045	12,840	0.135	9.59	28,560	1.00	2.00	0.91	0.27

Fspr30_medRT

F fixed at 75%MFMT

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.454	3.10	2,484	0.09	0.17	3.07	0.02
2022	4,221	0.652	3.15	1,849	0.06	0.13	4.40	0.02
2023	3,312	0.111	0.54	1,337	0.05	0.09	0.75	0.01
2024	4,822	0.111	0.85	2,237	0.08	0.16	0.75	0.02
2025	6,327	0.111	1.17	3,448	0.12	0.24	0.75	0.03
2026	7,441	0.111	1.42	4,656	0.16	0.33	0.75	0.04
2027	8,204	0.111	1.72	5,715	0.20	0.40	0.75	0.05
2028	8,864	0.111	2.11	6,842	0.24	0.48	0.75	0.06
2029	9,560	0.111	2.58	8,333	0.29	0.58	0.75	0.08
2030	10,218	0.111	3.10	10,143	0.36	0.71	0.75	0.10
2031	10,776	0.111	3.64	12,127	0.42	0.85	0.75	0.11
2032	11,230	0.111	4.19	14,177	0.50	0.99	0.75	0.13
2033	11,598	0.111	4.75	16,247	0.57	1.14	0.75	0.15
2034	11,899	0.111	5.30	18,312	0.64	1.28	0.75	0.17
2035	12,146	0.111	5.82	20,336	0.71	1.42	0.75	0.19
2036	12,348	0.111	6.32	22,279	0.78	1.56	0.75	0.21
2037	12,513	0.111	6.78	24,104	0.84	1.69	0.75	0.23
2038	12,648	0.111	7.20	25,788	0.90	1.81	0.75	0.24
2039	12,758	0.111	7.59	27,320	0.96	1.91	0.75	0.26
2040	12,848	0.111	7.92	28,694	1.00	2.01	0.75	0.27

Fspr30_medRT

Frebuild Tmin + 1 generation

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.09	0.17	2.86	0.02
2021	5,170	0.454	3.10	2,484	0.09	0.17	3.07	0.02
2022	4,221	0.652	3.15	1,849	0.06	0.13	4.40	0.02
2023	3,312	0.124	0.60	1,337	0.05	0.09	0.84	0.01
2024	4,785	0.124	0.95	2,212	0.08	0.15	0.84	0.02
2025	6,256	0.124	1.29	3,381	0.12	0.24	0.84	0.03
2026	7,341	0.124	1.55	4,533	0.16	0.32	0.84	0.04
2027	8,080	0.124	1.87	5,527	0.19	0.39	0.84	0.05
2028	8,719	0.124	2.28	6,575	0.23	0.46	0.84	0.06
2029	9,403	0.124	2.77	7,964	0.28	0.56	0.84	0.08
2030	10,054	0.124	3.32	9,648	0.34	0.68	0.84	0.09
2031	10,611	0.124	3.88	11,486	0.40	0.80	0.84	0.11
2032	11,064	0.124	4.45	13,373	0.47	0.94	0.84	0.13
2033	11,433	0.124	5.02	15,267	0.53	1.07	0.84	0.14
2034	11,736	0.124	5.58	17,151	0.60	1.20	0.84	0.16
2035	11,986	0.124	6.12	18,992	0.67	1.33	0.84	0.18
2036	12,192	0.124	6.63	20,753	0.73	1.45	0.84	0.20
2037	12,360	0.124	7.10	22,402	0.78	1.57	0.84	0.21
2038	12,497	0.124	7.52	23,919	0.84	1.68	0.84	0.23
2039	12,610	0.124	7.91	25,292	0.89	1.77	0.84	0.24
2040	12,702	0.124	8.25	26,520	0.93	1.86	0.84	0.25
2041	12,777	0.124	8.55	27,604	0.97	1.93	0.84	0.26
2042	12,839	0.124	8.81	28,552	1.00	2.00	0.84	0.27
2043	12,890	0.148	10.78	29,372	1.03	2.06	1.00	0.28

Fmax_loRT

F=0

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.38	0.02
2022	4,664	0.566	3.17	2,131	0.21	0.43	1.73	0.02
2023	3,992	0.000	0.00	1,712	0.17	0.34	0.00	0.02
2024	5,836	0.000	0.00	3,009	0.30	0.60	0.00	0.03
2025	7,583	0.000	0.00	4,837	0.49	0.97	0.00	0.05
2026	8,862	0.000	0.00	6,840	0.69	1.37	0.00	0.06
2027	9,766	0.000	0.00	8,851	0.89	1.78	0.00	0.08
2028	10,523	0.000	0.00	11,165	1.12	2.24	0.00	0.11

Fmax_loRT

Frebuild 10 years

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.38	0.02
2022	4,664	0.566	3.17	2,131	0.21	0.43	1.73	0.02
2023	3,992	0.231	1.38	1,712	0.17	0.34	0.70	0.02
2024	5,118	0.231	1.94	2,446	0.25	0.49	0.70	0.02
2025	6,265	0.231	2.45	3,390	0.34	0.68	0.70	0.03
2026	7,069	0.231	2.79	4,215	0.42	0.85	0.70	0.04
2027	7,590	0.231	3.18	4,845	0.49	0.97	0.70	0.05
2028	8,035	0.231	3.67	5,460	0.55	1.10	0.70	0.05
2029	8,540	0.231	4.24	6,261	0.63	1.26	0.70	0.06
2030	9,046	0.231	4.82	7,198	0.72	1.45	0.70	0.07
2031	9,488	0.231	5.38	8,161	0.82	1.64	0.70	0.08
2032	9,854	0.231	5.93	9,085	0.91	1.82	0.70	0.09
2033	10,160	0.231	6.45	9,964	1.00	2.00	0.70	0.09

Fmax_loRT

Halfway between Tmin and 10 yrs

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.38	0.02
2022	4,664	0.566	3.17	2,131	0.21	0.43	1.73	0.02
2023	3,992	0.149	0.89	1,712	0.17	0.34	0.45	0.02
2024	5,381	0.149	1.33	2,642	0.27	0.53	0.45	0.02
2025	6,747	0.149	1.76	3,865	0.39	0.78	0.45	0.04
2026	7,730	0.149	2.08	5,031	0.51	1.01	0.45	0.05
2027	8,401	0.149	2.47	6,027	0.61	1.21	0.45	0.06
2028	8,977	0.149	2.95	7,061	0.71	1.42	0.45	0.07
2029	9,576	0.149	3.51	8,372	0.84	1.68	0.45	0.08
2030	10,141	0.149	4.10	9,906	0.99	1.99	0.45	0.09
2031	10,623	0.328	10.29	11,532	1.16	2.32	1.00	0.11

Fmax_hiRT

F=0

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.455	3.09	2,484	0.25	0.50	1.39	0.02
2022	3,239	0.936	3.10	1,300	0.13	0.26	2.85	0.01
2023	1,751	0.000	0.00	623	0.06	0.13	0.00	0.01
2024	3,374	0.000	0.00	1,370	0.14	0.28	0.00	0.01
2025	5,166	0.000	0.00	2,481	0.25	0.50	0.00	0.02
2026	6,613	0.000	0.00	3,727	0.37	0.75	0.00	0.04
2027	7,608	0.000	0.00	4,870	0.49	0.98	0.00	0.05
2028	8,484	0.000	0.00	6,164	0.62	1.24	0.00	0.06
2029	9,449	0.000	0.00	8,070	0.81	1.62	0.00	0.08
2030	10,371	0.000	0.00	10,641	1.07	2.14	0.00	0.10

Fmax_hiRT

Frebuild 10 years

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.455	3.09	2,484	0.25	0.50	1.39	0.02
2022	3,239	0.936	3.10	1,300	0.13	0.26	2.85	0.01
2023	1,751	0.158	0.41	623	0.06	0.13	0.48	0.01
2024	3,054	0.158	0.72	1,207	0.12	0.24	0.48	0.01
2025	4,446	0.158	1.03	1,989	0.20	0.40	0.48	0.02
2026	5,503	0.158	1.19	2,737	0.27	0.55	0.48	0.03
2027	6,151	0.158	1.41	3,285	0.33	0.66	0.48	0.03
2028	6,706	0.158	1.74	3,823	0.38	0.77	0.48	0.04
2029	7,461	0.158	2.18	4,681	0.47	0.94	0.48	0.04
2030	8,283	0.158	2.68	5,837	0.59	1.17	0.48	0.05
2031	9,021	0.158	3.21	7,148	0.72	1.44	0.48	0.07
2032	9,632	0.158	3.75	8,508	0.85	1.71	0.48	0.08
2033	10,142	0.158	4.33	9,908	1.00	1.99	0.48	0.09
2034	10,578	0.328	10.15	11,365	1.14	2.28	1.00	0.11

Fmax_hiRT

Halfway between Tmin and 10 yrs

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.455	3.09	2,484	0.25	0.50	1.39	0.02
2022	3,239	0.936	3.10	1,300	0.13	0.26	2.85	0.01
2023	1,751	0.124	0.33	623	0.06	0.13	0.38	0.01
2024	3,123	0.124	0.58	1,241	0.12	0.25	0.38	0.01
2025	4,600	0.124	0.84	2,089	0.21	0.42	0.38	0.02
2026	5,741	0.124	0.99	2,930	0.29	0.59	0.38	0.03
2027	6,466	0.124	1.19	3,581	0.36	0.72	0.38	0.03
2028	7,093	0.124	1.49	4,242	0.43	0.85	0.38	0.04
2029	7,901	0.124	1.90	5,267	0.53	1.06	0.38	0.05
2030	8,758	0.124	2.36	6,645	0.67	1.33	0.38	0.06
2031	9,517	0.124	2.85	8,230	0.83	1.65	0.38	0.08
2032	10,142	0.124	3.38	9,911	1.00	1.99	0.38	0.09
2033	10,658	0.328	10.31	11,664	1.17	2.34	1.00	0.11

Fmax_medRT

F=0

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.39	0.02
2022	4,221	0.652	3.15	1,849	0.19	0.37	1.99	0.02
2023	3,312	0.000	0.00	1,337	0.13	0.27	0.00	0.01
2024	5,134	0.000	0.00	2,458	0.25	0.49	0.00	0.02
2025	6,927	0.000	0.00	4,057	0.41	0.81	0.00	0.04
2026	8,274	0.000	0.00	5,824	0.58	1.17	0.00	0.05
2027	9,226	0.000	0.00	7,573	0.76	1.52	0.00	0.07
2028	10,035	0.000	0.00	9,591	0.96	1.93	0.00	0.09
2029	10,808	0.000	0.00	12,257	1.23	2.46	0.00	0.12

Fmax_medRT

Frebuild 10 years

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.39	0.02
2022	4,221	0.652	3.15	1,849	0.19	0.37	1.99	0.02
2023	3,312	0.214	1.03	1,337	0.13	0.27	0.65	0.01
2024	4,523	0.214	1.53	2,039	0.20	0.41	0.65	0.02
2025	5,756	0.214	1.99	2,942	0.30	0.59	0.65	0.03
2026	6,637	0.214	2.28	3,752	0.38	0.75	0.65	0.04
2027	7,203	0.214	2.63	4,369	0.44	0.88	0.65	0.04
2028	7,689	0.214	3.09	4,976	0.50	1.00	0.65	0.05
2029	8,265	0.214	3.64	5,809	0.58	1.17	0.65	0.05
2030	8,851	0.214	4.23	6,818	0.68	1.37	0.65	0.06
2031	9,367	0.214	4.80	7,882	0.79	1.58	0.65	0.07
2032	9,794	0.214	5.37	8,925	0.90	1.79	0.65	0.08
2033	10,151	0.214	5.93	9,936	1.00	2.00	0.65	0.09
2034	10,455	0.328	9.91	10,926	1.10	2.19	1.00	0.10

Fmax_medRT

Halfway between Tmin and 10 yrs

Year	R (1000s)	F	Yield (mp gwt)	SSB (mt)	SSB/ SSBFmsy	SSB/ MSST	F/ MFMT	SSB/ SSB0
2020	5,098	0.424	3.31	2,432	0.24	0.49	1.29	0.02
2021	5,170	0.454	3.10	2,484	0.25	0.50	1.39	0.02
2022	4,221	0.652	3.15	1,849	0.19	0.37	1.99	0.02
2023	3,312	0.159	0.77	1,337	0.13	0.27	0.48	0.01
2024	4,683	0.159	1.18	2,143	0.22	0.43	0.49	0.02
2025	6,061	0.159	1.59	3,204	0.32	0.64	0.49	0.03
2026	7,067	0.159	1.87	4,213	0.42	0.85	0.49	0.04
2027	7,740	0.159	2.21	5,044	0.51	1.01	0.49	0.05
2028	8,321	0.159	2.66	5,898	0.59	1.18	0.49	0.06
2029	8,966	0.159	3.20	7,040	0.71	1.41	0.49	0.07
2030	9,597	0.159	3.78	8,423	0.85	1.69	0.49	0.08
2031	10,143	0.159	4.37	9,911	1.00	1.99	0.49	0.09
2032	10,591	0.328	10.19	11,413	1.15	2.29	1.00	0.11

GRFS ratio for adjusting projected catch

GRFS

- FWC quantifies the overall differences between GRFS and FCAL estimates across the variable *years* and *waves* over which the GRFS and MRIP surveys overlap (May 2015- Dec 2019) so that a **single calibration factor** may be applied to annual FCAL estimates back in time (1981-2014)

Species	Estimate Type	Year	GRFS sum	GRFS variance	FCAL sum	FCAL variance	Ratio	50% corr.
Gag	Landings (no. fish)	2015	148,854	1,501,594,176	263,761	4,135,276,672		
		2016	80,435	234,456,235	194,102	2,656,239,068		
		2017	98,295	246,164,449	253,921	3,371,506,271		
		2018	91,104	109,952,966	280,049	3,585,707,642		
		2019	90,827	222,017,384	219,981	4,347,408,565		
		TOTAL	**509,515**	**2,314,185,211**	**1,211,814**	**18,096,138,218**	**0.42**	**10.4**
	Landings (pounds)	2015	1,227,712	33,456,660,644	2,239,482	165,223,441,144		
		2016	653,631	7,368,434,736	1,794,276	111,291,988,053		
		2017	825,872	7,451,471,807	2,190,390	111,232,027,154		
		2018	791,494	3,740,339,737	2,312,865	108,962,506,309		
		2019	803,166	7,141,127,496	2,021,866	197,695,252,120		
		TOTAL	**4,301,875**	**59,158,034,420**	**10,133,595**	**694,405,214,780**	**0.41**	**7.0**
	Releases (no. fish)	2015	454,495	4,672,558,463	961,197	12,446,118,627		
		2016	787,806	6,743,433,279	1,635,511	130,873,839,849		
		2017	1,092,567	11,115,115,076	2,949,294	202,153,295,351		
		2018	810,794	8,961,298,440	1,934,651	106,267,810,729		
		2019	783,244	12,063,046,379	1,685,994	81,416,873,738		
		TOTAL	**3,928,906**	**43,555,451,637**	**9,166,647**	**533,157,938,295**	**0.43**	**7.0**

GRFS

- FWC provided the time series of **Private mode FL** catches and discards in GRFS currency from 1981 to 2019
- In SEDAR 72, the PRIVATE+SHORE FLEET is composed of Private mode, Shore mode and mixed Private/Shore (from LA) and additional states (AL, TX, LA, MS
- For the sensitivity run, we replaced ***just*** the Private mode FL portion of the catches/discards with GRFS and retained the other sources of reported catch/discards (shore, private/shore, AL, TX, LA, MS)
- That is why the catches from the PRIVATE+SHORE FLEET are ***not exactly*** equal to the GRFS time series (though close since PRIVATE FL make up 95+% of catches)

Adjusting projected catch

- Adjusting projected catch for Private mode
  - Could use the GRFS ratio of **0.41**
  - Could calculate a ratio from the last 3, 5, 10 (?) years of the time series of the expected PRIVATE+SHORE FLEET retained catches from base run vs. GRFS sensitivity run (ratios: 0.40, 0.41, 0.44 for the last 3, 5, 10 years)
- Adjusting projected catch for Charterboat and Headboat?