A ratio-based method for calibrating GRFS and MRIP-FCAL estimates of total landings (numbers and pounds of fish), and releases (numbers of fish)

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Background

The Marine Recreational Information Program (MRIP) has provided vital statistics on recreational fishing effort and catch in the eastern U.S. Gulf of Mexico since 1981. In order to remain useful for regional stock assessments, the time-series has undergone several calibrations to account for the effects of survey design improvements in more recent years. Stock assessments require long-term time-series of landings and discards on an annual scale that are measured consistently through time. Regional stock assessments provide biological reference points, which are used by fisheries managers to set sustainable limits for fishery removals. For federally managed reef fish stocks, recreational fishing seasons and other restrictions are set with the goal of keeping fishery removals below a threshold limit, and precise and timely estimates are needed to track landings against prescribed annual catch limits (ACLs) and ensure overfishing is not occurring.

In response to a region-wide need for more precise and timely estimates of recreational catch, Florida's Gulf Reef Fish Survey (GRFS) was developed in collaboration with NOAA Fisheries alongside similar efforts in other states. The GRFS was implemented in May 2015, and is currently used by the Florida Fish and Wildlife Conservation Commission (FWC) to manage recreational harvest levels for Red Snapper off the Gulf coast of the state and track landings against a state-specific allocation of the Gulf-wide ACL. Detailed methodology of the GRFS is described in detail in Appendix A, *Results from the first year of an exempted fishing permit (18-SERO-01) for state management of Red Snapper recreational harvest in Florida*. Beginning July 1, 2020, the Gulf Reef Fish Survey was expanded statewide in Florida and is now known as the State Reef Fish Survey (SRFS). The GRFS runs concurrent with the MRIP survey in Florida and produces estimates that are consistently lower. A method is needed to convert catch advice derived from a stock assessment to the same currency as the GRFS. Historic MRIP estimates converted to the GRFS currency are also needed to integrate multiple MRIP-calibrated time-series from different surveys conducted in each state in order to provide one consistent set of estimates for use in regional assessments (NOAA Fisheries, 2019). A historic time-series converted to GRFS currency may also be useful on its own for assessing stocks in the eastern Gulf that occur primarily off the west coast of Florida (e.g. gag, red grouper).

Objectives

The objectives are to develop species-specific conversion factors that may be applied to annual, fully calibrated MRIP estimates, and produce a historic time series in the same currency as the GRFS. To accomplish this, an appropriate ratio with associated variance is developed from estimated landings (in numbers and pounds) and releases (numbers) for six species in both state and federal waters derived from two surveys conducted during recent overlapping years: the Florida Gulf Reef Fish Survey (GRFS) and the Marine Recreational Information Program

(MRIP). The estimated ratios and associated uncertainty are used to convert the historical MRIP time series to a common currency with GRFS.

Methods

This analysis used estimates of total landings (numbers and pounds of fish) and releases (numbers) derived from the GRFS and the MRIP from May 2015 through December 2019 when the two surveys overlapped. The two surveys use separate methods to calculate fishing effort (angler trips); however, catch estimates from the two surveys are not completely independent. To estimate catch-per-unit-effort (CPUE), the MRIP survey uses data from the Access Point Angler Intercept Survey (APAIS), whereas the GRFS uses a combination of data from the APAIS and supplemental reef fish angler intercepts. Assignments for both intercept surveys are drawn together so that sample weights are compatible (Foster, 2018).

Recreational harvest seasons for reef fishes off the Gulf coast of Florida have varied widely over recent years and across state and federal jurisdictions. For example, recreational harvest seasons for Red Snapper in the Gulf historically spanned 6-12 months, but during years that the GRFS and MRIP surveys overlap seasons have only been open for a limited number of weeks or days. In the past, season lengths were also consistent in state waters and federal jurisdictions, whereas in some recent years harvest has remained open longer in state waters. Rather than apply calibrations at a fine scale back in time (e.g. by month or area fished), it is more appropriate to quantify the overall differences between GRFS and FCAL estimates across the variable years and waves over which the two surveys overlap so that a single calibration factor may be applied to annual FCAL estimates back in time.

Estimates for state and federal waters were derived for six species: Gag, Gray Triggerfish, Greater Amberjack, Red Grouper, Red Snapper, and Vermilion Snapper. To assess overall differences between GRFS and FCAL estimates, the estimates ($\hat{E}$) and variances ($\hat{V}$) for each estimation method (*m: GRFS, FCAL*) were summed across years (*y*), two-month waves (*w*), and areas fished (*a*: federal or state waters) for each combination of species (*s*) and variable (*v*: number landed, pounds landed, number released) [1, 2].

$$\hat{E}_{m,s,v} = \sum_{m,s,v} \hat{E}_{y,w,a,m,s,v} \quad [1]$$

$$\hat{V}(\hat{E}_{m,s,v}) = \sum_{m,s,v} \hat{V}(\hat{E}_{y,w,a,m,s,v}) \quad [2]$$

This resulted in 18 pairs of GRFS and FCAL sums (3 variables x 6 species; Table 1). For each of the 18 paired sums, the ratio was calculated as the total GRFS estimate divided by total FCAL estimate [3].

$$\hat{R}_{s,v} = \frac{\hat{E}_{GRFS,s,v}}{\hat{E}_{FCAL,s,v}} \text{ [3]}$$

The delta method was used to approximate the variance of the ratios ($\hat{V}(\hat{R}_{s,v})$), and incorporates error associated with both the numerator (GRFS estimates) and denominator (FCAL estimates). The R statistical software package 'msm' (R Core Team 2018; Jackson 2011) was used to carry out variance calculations. Although GRFS and MRIP estimates are derived from survey data that are not completely independent, the strength of correlation between estimates from the two surveys is unknown. To evaluate the influence of correlation (ρ), we approximated variances at three levels: ρ = 0, ρ = 0.5, and ρ = 0.9. No correlation (ρ = 0) represents the most conservative approximation of variance if correlation between the two survey estimates is ignored. An upper limit of 90% correlation (ρ = 0.9) was selected based on linear regressions, and 50% (ρ = 0.5) assumes at least some correlation between estimates is explained by shared data that both surveys have in common.

Historic estimates were converted to GRFS currency by multiplying the annual FCAL estimate for each year, species, and variable type (number landed, pounds landed, number released) [4] with the corresponding ratio [3]:

$$\hat{E}_{GRFS-hind,y,s,v} = \hat{R}_{s,v}\hat{E}_{FCAL,y,s,v} \text{ [4]}$$

Variance was once again approximated using the delta method. No additional correlation was included in this calculation.

Some stock assessments require the Florida Keys data to be either included or excluded depending on the species being assessed. Because the GRFS provides catch estimates for Florida's Gulf waters excluding the Keys while MRIP provides estimates for west Florida that includes the Keys or excludes the Keys, we calculated a ratio calibration factor for both GRFS/FCAL with Keys and GRFS/FCAL without Keys, and provide the hindcast FCAL estimates in GRFS currency that both include and exclude the Keys. Depending on specific stock assessment needs, i.e. including or excluding the Keys, the appropriate calibrated time series can be utilized.

Findings and Conclusions

For the years in which the GRFS and MRIP overlap, annual Gag estimates derived from GRFS and FCAL and associated variances, observed ratios of summed GRFS to FCAL estimates and approximated variance for each level of correlation are provided in Table 1 (excluding the Keys). For Gag landings in pounds excluding the Keys, the ratio was 0.42 and the PSE of the ratio was 7.0 at 50% correlation.

The original FCAL time-series excluding the Keys, and corresponding FCAL estimates converted to GRFS currency with 50% correlation for Gag are shown in Figure 1. The degree of correlation assumed for the ratio variance calculation did not have a large influence on overall PSE's for calibrated estimates. When FCAL estimates for Gag were converted to GRFS currency, the PSEs differed by at most 6.6, between the lowest and highest levels of correlation assumed for the ratio calibration factor respectively, for estimates excluding the Keys. Under the varied assumptions of correlation, differences in PSEs for FCAL estimates calibrated to GRFS currency ranged from 1.7 – 6.6 for Gag landings in number of fish, 0.9 – 3.9 for landings in pounds, and 0.4 – 4.5 for releases in number of fish. Given that some dependence between the two surveys is known and the degree of correlation does not have a large impact on PSEs for final calibrated estimates, the ratio variance that assumes at least 50% correlation is recommended for use (Table 2).

The purpose of this report was to establish an accepted method for producing converted FCAL estimates for fisheries management and potential use in future stock assessments. Results presented in this report include data collected over 56 months (through December 2019). The two surveys continue to run concurrently in Florida. Since this analysis was conducted, estimates for 2020 have become available. Once this method is established, calibration factors that include the complete available time-series of overlapping data may be routinely updated and shared as needed.

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Table 1. Annual and summed FCAL and GRFS estimates and variances excluding the Keys, ratios of GRFS to FCAL estimates, and PSEs for ratios at 50correlation for Gag.

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	262,005	4,132,192,094		
		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	250,883	2,925,769,116		
		2019	90,827	222,017,384	216,639	4,071,388,424		
		TOTAL	**509,515**	**2,314,185,211**	**1,177,549**	**17,157,094,974**	**0.43**	**10.4**
	Landings (pounds)	2015	1,227,712	33,456,660,644	2,228,640	165,015,175,863		
		2016	653,631	7,368,434,736	1,794,276	111,291,988,053		
		2017	825,872	7,451,471,807	2,190,390	111,232,027,155		
		2018	791,494	3,740,339,737	2,059,094	78,815,032,702		
		2019	803,166	7,141,127,496	1,861,196	158,296,579,682		
		TOTAL	**4,301,875**	**59,158,034,420**	**10,133,595**	**624,650,803,455**	**0.42**	**7.0**
	Releases (no. fish)	2015	454,495	4,672,558,463	787,310	11,456,637,756		
		2016	787,806	6,743,433,279	1,635,511	131,109,179,831		
		2017	1,092,567	11,115,115,076	2,949,294	202,153,295,353		
		2018	810,794	8,961,298,440	1,806,945	87,229,243,957		
		2019	783,244	12,063,046,379	1,665,827	79,855,383,543		
		TOTAL	**3,928,906**	**43,555,451,637**	**8,844,887**	**511,803,740,439**	**0.44**	**7.1**

Table 2. Historic (MRIP-FCAL) estimates, and estimates converted to GRFS currency (GRFS) excluding the Keys for Gag. Associated PSEs are presented for the 50% correlation used to calculate variance for the calibration factor (ratio of GRFS to FCAL).

	Gag											
	MRIP - FCAL		GRFS		MRIP - FCAL		GRFS		MRIP - FCAL		GRFS	
Year	Landings (no. fish)	PSE	Landings (no. fish)	PSE 50% corr	Landings (pounds)	PSE	Landings (pounds)	PSE 50% corr	Releases (no. fish)	PSE	Releases (no. fish)	PSE 50% corr
1982	1,206,268	22.6	521,941	24.9	7,274,923	31.6	3,088,322	32.4	380,792	34.9	169,148	35.6
1983	1,271,299	52.6	550,080	53.7	7,647,927	41.5	3,246,669	42.1	781,154	52.0	346,989	52.5
1984	252,169	38.3	109,111	39.7	872,531	37.3	370,404	38.0	95,823	5.0	42,565	8.7
1985	108,741	55.6	47,051	56.6	754,136	36.6	320,143	37.3	28,306	100.0	12,574	100.3
1986	55,446	44.4	23,991	45.6	246,540	34.9	104,660	35.6	15,409	49.1	6,845	49.6
1987	347,593	44.1	150,400	45.3	1,875,795	29.3	796,305	30.1	254,253	33.8	112,939	34.6
1988	360,412	37.7	155,947	39.1	307,752	28.0	130,646	28.9	194,653	34.3	86,465	35.0
1989	121,863	30.7	52,729	32.5	592,184	20.6	251,392	21.8	470,702	17.0	209,086	18.4
1990	533,966	30.7	231,043	32.4	4,897,579	22.1	2,079,101	23.2	845,307	32.6	375,486	33.3
1991	548,806	22.8	237,463	25.1	4,126,755	15.9	1,751,874	17.4	2,153,462	27.6	956,570	28.5
1992	441,076	17.4	190,850	20.3	3,039,982	12.5	1,290,522	14.4	1,379,078	18.8	612,587	20.1
1993	648,953	21.8	280,796	24.1	4,350,061	14.1	1,846,671	15.8	2,787,465	17.8	1,238,194	19.1
1994	419,408	21.1	181,474	23.5	3,148,305	20.0	1,336,506	21.2	3,146,622	11.2	1,397,732	13.3
1995	854,066	24.6	369,547	26.7	6,029,501	17.7	2,559,621	19.1	3,981,660	14.3	1,768,657	16.0
1996	414,182	16.7	179,213	19.6	2,359,060	11.1	1,001,459	13.2	1,917,371	10.2	851,698	12.4
1997	788,173	18.2	341,035	20.9	5,141,640	14.5	2,182,709	16.1	3,427,308	11.1	1,522,413	13.2
1998	878,222	13.1	379,999	16.7	5,981,916	9.9	2,539,420	12.1	4,700,589	12.3	2,088,005	14.2
1999	1,098,285	10.1	475,218	14.5	7,370,527	7.3	3,128,908	10.1	4,010,739	9.7	1,781,574	12.1
2000	1,269,959	11.6	549,500	15.6	8,781,623	8.0	3,727,941	10.6	2,571,932	8.3	1,142,455	10.9
2001	998,009	11.7	431,830	15.6	8,450,130	8.0	3,587,217	10.6	4,848,993	12.8	2,153,927	14.6
2002	1,129,326	15.4	488,650	18.6	8,240,197	10.4	3,498,097	12.5	5,071,382	9.6	2,252,712	12.0
2003	862,380	11.0	373,144	15.1	5,877,651	7.8	2,495,158	10.4	6,263,309	8.2	2,782,167	10.8
2004	1,387,826	13.2	600,500	16.8	9,838,689	9.5	4,176,682	11.8	8,404,949	9.5	3,733,485	11.9
2005	1,058,617	18.4	458,054	21.1	7,966,043	13.3	3,381,714	15.0	4,875,672	9.6	2,165,778	12.0
2006	645,033	23.1	279,100	25.3	4,112,015	13.7	1,745,617	15.4	3,372,243	11.4	1,497,953	13.5
2007	507,962	13.8	219,790	17.2	4,277,749	11.4	1,815,973	13.3	4,121,561	9.1	1,830,801	11.6
2008	846,291	15.1	366,183	18.4	6,467,980	13.7	2,745,762	15.4	8,212,231	10.2	3,647,880	12.4
2009	382,960	13.8	165,703	17.3	2,620,161	10.0	1,112,301	12.2	5,319,745	9.0	2,363,035	11.5
2010	517,407	15.9	223,878	19.0	3,454,232	10.8	1,466,377	12.9	4,276,191	9.4	1,899,487	11.8
2011	300,773	23.2	130,142	25.4	1,919,984	15.9	815,064	17.4	3,223,163	16.3	1,431,732	17.7
2012	233,610	22.4	101,081	24.7	1,629,801	15.4	691,877	16.9	2,185,485	12.8	970,794	14.7
2013	441,048	16.9	190,838	19.8	3,174,166	11.3	1,347,485	13.3	2,121,606	12.3	942,419	14.2
2014	312,111	21.8	135,048	24.1	2,613,297	15.3	1,109,387	16.8	1,610,482	13.1	715,378	14.9
2015	263,761	24.4	114,127	26.5	2,239,482	18.2	950,696	19.4	961,197	11.6	426,965	13.6
2016	194,102	26.6	83,986	28.5	1,794,276	18.6	761,699	19.9	1,635,511	22.1	726,496	23.2
2017	253,921	22.9	109,869	25.1	2,190,390	15.2	929,856	16.7	2,949,294	15.2	1,310,079	16.8
2018	250,883	21.6	108,555	23.9	2,059,094	13.6	874,119	15.3	1,806,945	16.3	802,646	17.8
2019	216,639	29.5	93,738	31.2	1,861,196	21.4	790,108	22.5	1,665,827	17.0	739,962	18.4

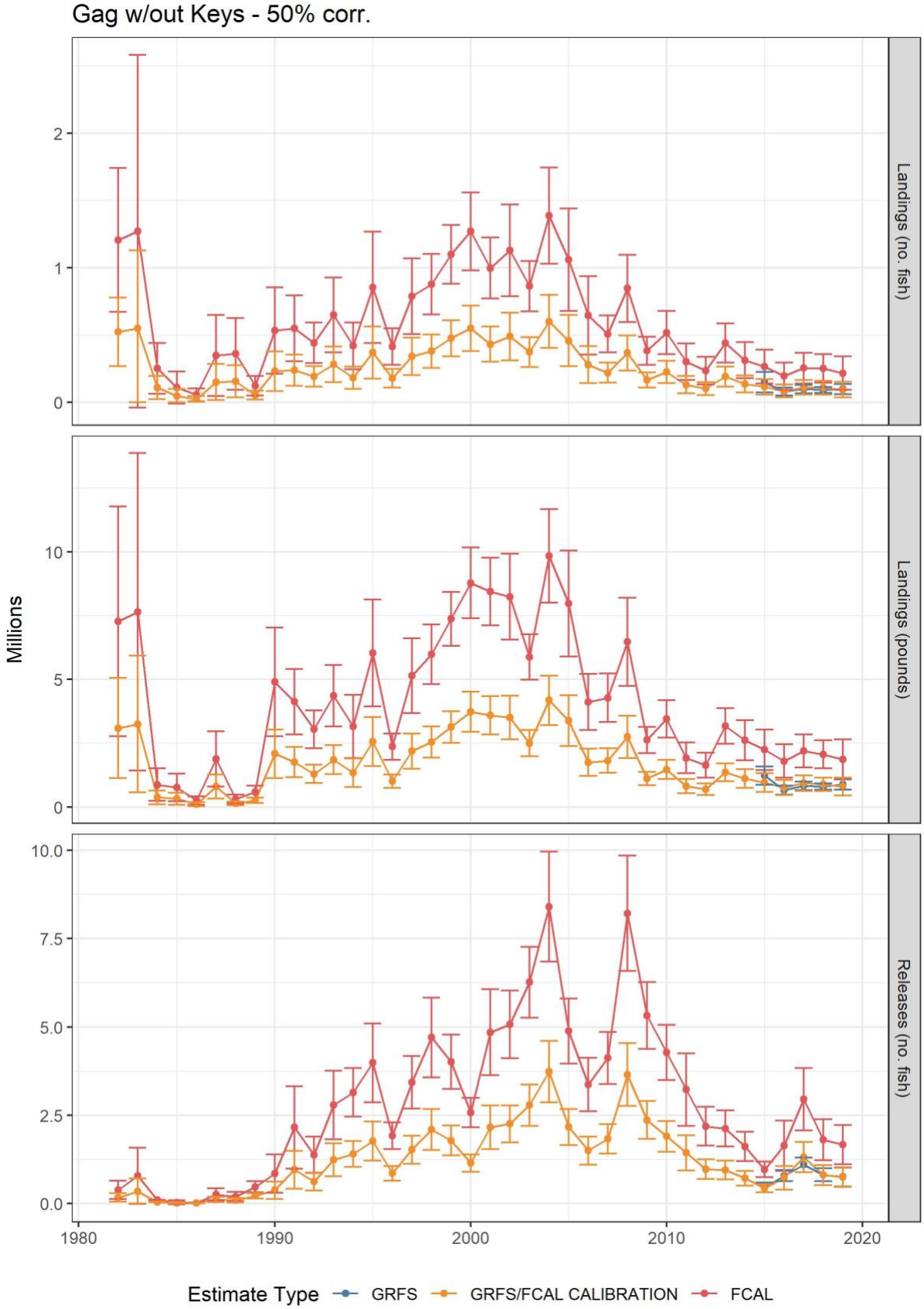

Figure 1. Gag hindcast estimates excluding the Keys from: GRFS, FCAL, and FCAL converted to GRFS currency (GRFS/FCAL CALIBRATION). The 95% confidence intervals were calculated assuming 50% correlation between the two survey estimates.