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.

Because gag were mis-identified as black grouper in the early years of the historic time series, i.e., 1982 – 1989, we calculated a simple ratio to characterize the difference between the FCAL landings estimates and the black grouper-adjusted FCAL landings estimates, e.g., black-grouper adjusted FCAL/FCAL), and then applied this ratio to the corresponding GRFS currency time

series. A simple ratio was utilized because we did not have the required error associated with the estimates to utilize the corrected data set in the delta method described above.

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). Landings estimates from the original FCAL time series excluding the Keys, the black grouper-adjusted FCAL times series, FCAL estimates converted to GRFS currency (from Table 2), the black grouper adjustment ratio for 1982-1989, and the final black-grouper-adjusted estimates in GRFS currency are given in Table 3.

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	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**

Table 2. Historic (MRIP-FCAL) estimates, and estimates converted to GRFS currency (GRFS) excluding the Keys for Gag. Associated standard error (PSE) is 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
1981	157,995	38.3	66,430	39.7	433,034	25.6	176,426	26.6	78,824	92.2	33,785	92.5
1982	1,206,268	22.6	507,183	24.9	7,274,923	31.6	2,963,933	32.4	380,792	34.9	163,211	35.6
1983	1,271,299	52.6	534,526	53.7	7,647,927	41.5	3,115,902	42.1	781,154	52.0	334,810	52.5
1984	252,169	38.3	106,026	39.7	872,531	37.3	355,485	38.0	95,823	5.0	41,071	8.6
1985	108,741	55.6	45,721	56.6	754,136	36.6	307,249	37.3	28,306	100.0	12,132	100.2
1986	55,446	44.4	23,313	45.6	246,540	34.9	100,445	35.6	15,409	49.1	6,605	49.6
1987	347,593	44.1	146,148	45.3	1,875,795	29.3	764,232	30.1	254,253	33.8	108,975	34.6
1988	360,412	37.7	151,538	39.1	307,752	28.0	125,384	28.9	194,653	34.3	83,430	35.0
1989	121,863	30.7	51,238	32.5	592,184	20.6	241,266	21.8	470,702	17.0	201,747	18.4
1990	533,966	30.7	224,510	32.4	4,897,579	22.1	1,995,361	23.2	845,307	32.6	362,306	33.3
1991	548,806	22.8	230,749	25.1	4,126,755	15.9	1,681,313	17.4	2,153,462	27.6	922,993	28.5
1992	441,076	17.4	185,454	20.3	3,039,982	12.5	1,238,543	14.4	1,379,078	18.8	591,085	20.1
1993	648,953	21.8	272,856	24.1	4,350,061	14.1	1,772,292	15.8	2,787,465	17.8	1,194,732	19.1
1994	419,408	21.1	176,343	23.5	3,148,305	20.0	1,282,675	21.2	3,146,622	11.2	1,348,670	13.2
1995	854,066	24.6	359,098	26.7	6,029,501	17.7	2,456,526	19.1	3,981,660	14.3	1,706,575	15.9
1996	414,182	16.7	174,145	19.6	2,359,060	11.1	961,123	13.2	1,917,371	10.2	821,802	12.3
1997	788,173	18.2	331,393	20.9	5,141,640	14.5	2,094,796	16.2	3,427,308	11.1	1,468,975	13.1
1998	878,222	13.1	369,254	16.7	5,981,916	9.9	2,437,139	12.2	4,700,589	12.3	2,014,714	14.1
1999	1,098,285	10.1	461,781	14.5	7,370,527	7.3	3,002,884	10.1	4,010,739	9.7	1,719,038	12.0
2000	1,269,959	11.6	533,963	15.6	8,781,623	8.0	3,577,790	10.7	2,571,932	8.3	1,102,353	10.9
2001	998,009	11.7	419,619	15.6	8,450,130	8.0	3,442,733	10.7	4,848,993	12.8	2,078,321	14.6
2002	1,129,326	15.4	474,833	18.6	8,240,197	10.4	3,357,203	12.6	5,071,382	9.6	2,173,640	11.9
2003	862,380	11.0	362,593	15.1	5,877,651	7.8	2,394,660	10.5	6,263,309	8.2	2,684,510	10.8
2004	1,387,826	13.2	583,521	16.8	9,838,689	9.5	4,008,457	11.8	8,404,949	9.5	3,602,436	11.8
2005	1,058,617	18.4	445,103	21.1	7,966,043	13.3	3,245,508	15.0	4,875,672	9.6	2,089,756	11.9
2006	645,033	23.1	271,208	25.3	4,112,015	13.7	1,675,308	15.4	3,372,243	11.4	1,445,373	13.4
2007	507,962	13.8	213,576	17.2	4,277,749	11.4	1,742,831	13.4	4,121,561	9.1	1,766,537	11.5
2008	846,291	15.1	355,829	18.4	6,467,980	13.7	2,635,170	15.4	8,212,231	10.2	3,519,835	12.3
2009	382,960	13.8	161,018	17.3	2,620,161	10.0	1,067,500	12.2	5,319,745	9.0	2,280,090	11.5
2010	517,407	15.9	217,547	19.0	3,454,232	10.8	1,407,316	12.9	4,276,191	9.4	1,832,813	11.7
2011	300,773	23.2	126,462	25.4	1,919,984	15.9	782,236	17.4	3,223,163	16.3	1,381,476	17.7
2012	233,610	22.4	98,223	24.7	1,629,801	15.4	664,010	17.0	2,185,485	12.8	936,718	14.6
2013	441,048	16.9	185,441	19.8	3,174,166	11.3	1,293,212	13.3	2,121,606	12.3	909,339	14.2
2014	312,111	21.8	131,229	24.1	2,613,297	15.3	1,064,704	16.8	1,610,482	13.1	690,267	14.9
2015	263,761	24.4	110,900	26.5	2,239,482	18.2	912,405	19.5	961,197	11.6	411,978	13.6
2016	194,102	26.6	81,612	28.5	1,794,276	18.6	731,020	19.9	1,635,511	22.1	700,995	23.2
2017	253,921	22.9	106,763	25.1	2,190,390	15.2	892,404	16.8	2,949,294	15.2	1,264,093	16.8
2018	250,883	21.6	117,749	23.8	2,059,094	13.6	942,302	15.9	1,806,945	16.3	829,209	18.3
2019	216,639	29.5	92,492	31.7	1,861,196	21.4	823,744	23.1	1,665,827	17.0	722,632	18.3

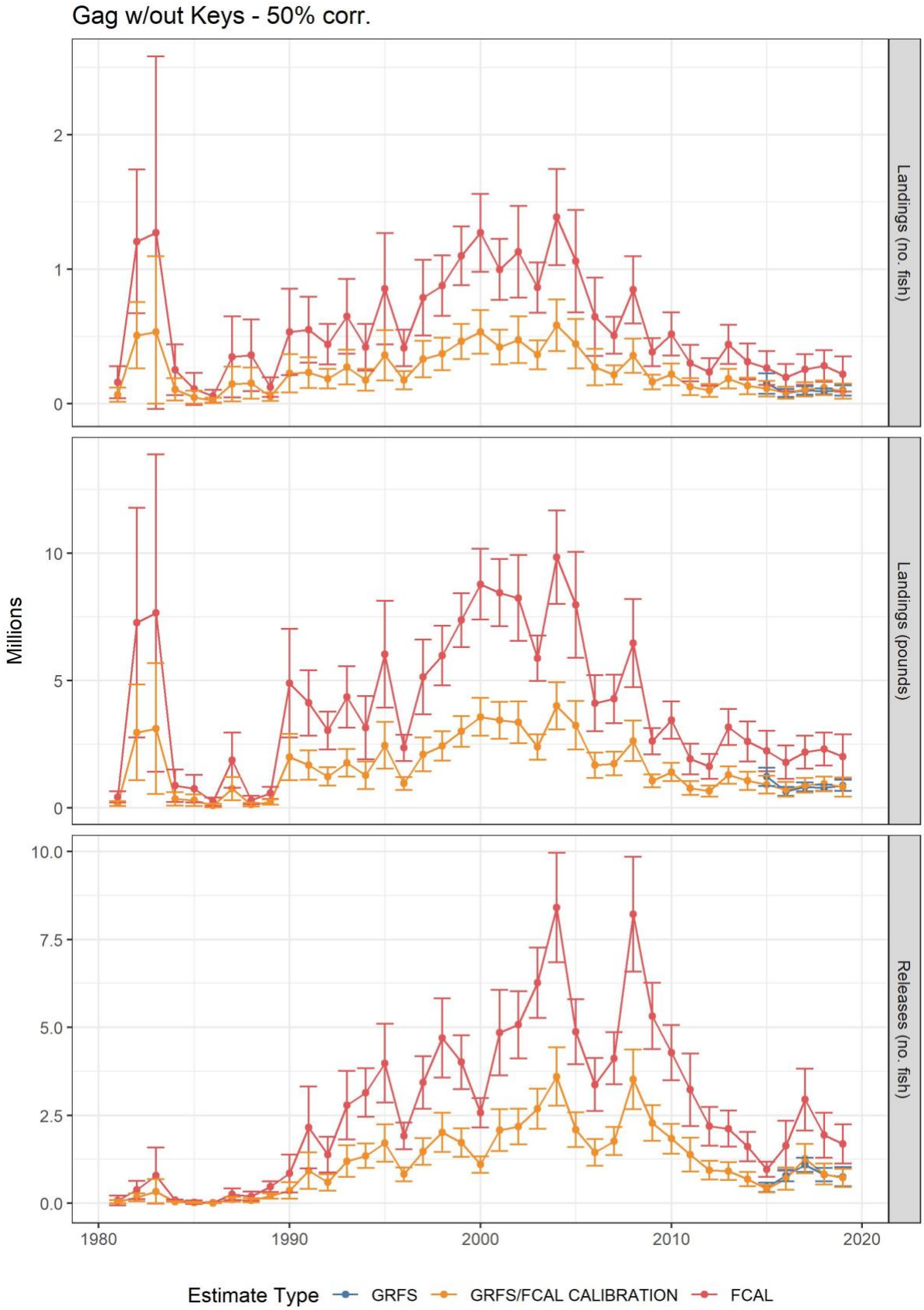

Figure 1. Gag hindcast estimates excluding the Keys from: GRFS, FCAL, and FCAL converted to GRFS currency (GRFS/FCAL CALIBRATION). The 95% confidence intervals were calculated assuming 50% correlation between the two survey estimates.

Table 3. Historic (MRIP – FCAL) estimates, black grouper-adjusted estimates (MRIP-BG Adjusted), estimates converted to GRFS currency (GRFS), black grouper adjustment ratio calculated as MRIP-BG Adjusted divided by MRIP-FCAL estimates, and estimates converted to GRFS currency with black grouper correction (BG-Adjusted GRFS) excluding the Keys for Gag. Associated percent standard errors (PSE) are given for the 50% correlation used to calculate variance for the calibration factor (ratio of GRFS to FCAL). The black grouper adjusted MRIP estimates were provided without error estimates, hence PSE and standard error calculations are missing for those estimates as well as the black grouper adjustment ratio, and the final black grouper adjusted GRFS estimates.

	Gag									
	MRIP - FCAL		MRIP – BG Adjusted		GRFS		BG Ratio Adjustment		BG-Adjusted GRFS	
Year	Landings (no. fish)	PSE	Landings (pounds)	PSE	Landings (no. fish)	PSE 50% corr	MRIP-BG/MRIP-FCAL	Std. Err.	Landings (no. fish)	Std. Err.
1981	157,995	38.3	591,078	NA	66,430	39.7	3.74	NA	248,523	NA
1982	1,206,268	22.6	1,900,492	NA	507,183	24.9	1.58	NA	799,074	NA
1983	1,271,299	52.6	3,967,738	NA	534,526	53.7	3.12	NA	1,668,261	NA
1984	252,169	38.3	516,540	NA	106,026	39.7	2.05	NA	217,183	NA
1985	108,741	55.6	823,884	NA	45,721	56.6	7.58	NA	346,407	NA
1986	55,446	44.4	762,790	NA	23,313	45.6	13.76	NA	320,720	NA
1987	347,593	44.1	872,083	NA	146,148	45.3	2.51	NA	366,673	NA
1988	360,412	37.7	899,614	NA	151,538	39.1	2.5	NA	378,249	NA
1989	121,863	30.7	727,597	NA	51,238	32.5	5.97	NA	305,923	NA
1990	533,966	30.7	533,966	NA	224,510	32.4	1	NA	224,510	72,801
1991	548,806	22.8	548,806	NA	230,749	25.1	1	NA	230,749	57,842
1992	441,076	17.4	441,076	NA	185,454	20.3	1	NA	185,454	37,576
1993	648,953	21.8	648,953	NA	272,856	24.1	1	NA	272,856	65,805
1994	419,408	21.1	419,408	NA	176,343	23.5	1	NA	176,343	41,444
1995	854,066	24.6	854,066	NA	359,098	26.7	1	NA	359,098	95,998
1996	414,182	16.7	414,182	NA	174,145	19.6	1	NA	174,145	34,164
1997	788,173	18.2	788,173	NA	331,393	20.9	1	NA	331,393	69,315
1998	878,222	13.1	878,222	NA	369,254	16.7	1	NA	369,254	61,714
1999	1,098,285	10.1	1,098,285	NA	461,781	14.5	1	NA	461,781	66,924
2000	1,269,959	11.6	1,269,959	NA	533,963	15.6	1	NA	533,963	83,044
2001	998,009	11.7	998,009	NA	419,619	15.6	1	NA	419,619	65,469
2002	1,129,326	15.4	1,129,326	NA	474,833	18.6	1	NA	474,833	88,166
2003	862,380	11.0	862,380	NA	362,593	15.1	1	NA	362,593	54,835
2004	1,387,826	13.2	1,387,826	NA	583,521	16.8	1	NA	583,521	97,742
2005	1,058,617	18.4	1,058,617	NA	445,103	21.1	1	NA	445,103	93,902
2006	645,033	23.1	645,033	NA	271,208	25.3	1	NA	271,208	68,613
2007	507,962	13.8	507,962	NA	213,576	17.2	1	NA	213,576	36,806
2008	846,291	15.1	846,291	NA	355,829	18.4	1	NA	355,829	65,297
2009	382,960	13.8	382,960	NA	161,018	17.3	1	NA	161,018	27,838
2010	517,407	15.9	517,407	NA	217,547	19.0	1	NA	217,547	41,279
2011	300,773	23.2	300,773	NA	126,462	25.4	1	NA	126,462	32,091
2012	233,610	22.4	233,610	NA	98,223	24.7	1	NA	98,223	24,237
2013	441,048	16.9	441,048	NA	185,441	19.8	1	NA	185,441	36,729
2014	312,111	21.8	312,111	NA	131,229	24.1	1	NA	131,229	31,667
2015	263,761	24.4	263,761	NA	110,900	26.5	1	NA	110,900	29,383
2016	194,102	26.6	194,102	NA	81,612	28.5	1	NA	81,612	23,264
2017	253,921	22.9	253,921	NA	106,763	25.1	1	NA	106,763	26,807
2018	250,883	21.6	280,049	NA	117,749	23.8	1	NA	117,749	27,983
2019	216,639	29.5	219,981	NA	92,492	31.7	1	NA	92,492	29,335