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Re-Analysis of Gag/Black Grouper Mis-Reporting Correction Factors in the Gulf of Mexico

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Introduction

Previous analyses by Chih and Turner (2006) and Chih (2013) developed correction factors to adjust landings of two grouper species, Gag (*Mycteroperca microlepis*) and Black Grouper (*Mycteroperca bonaci*), in the Gulf of Mexico for mis-reporting problems. The issue stems from some commercial fishers and dealers reporting catches of Gag as Black Grouper for marketing purposes, resulting in overestimates of landings for Black Grouper and underestimates of landings for Gag. The correction factors were the ratio of Gag to combined Gag and Black Grouper for different statistical areas around the Gulf of Mexico (**Fig. 1**), estimated from dockside intercept sampling of commercial catches (Trip Interview Program, TIP). These estimates of proportion Gag by statistical area were then multiplied by the corresponding combined landings of Gag and Black grouper to obtain the corrected landings for Gag (SEDAR 2014).

For SEDAR 33, correction factors were estimated for 1986-2009 TIP data (SEDAR 2014). Although available, 2010-2012 TIP data were excluded due to concerns that the mis-reporting situation may have fundamentally changed after implementation in 2010 of the Grouper-Tilefish Individual Fishing Quota (IFQ), encompassing Gag (species-specific) and Black Grouper (as part of a 4-species shallow-water grouper complex). Under IFQ, there is perhaps an incentive for fishers and dealers to report landings more accurately for the two species.

Correction factors for SEDAR 33 were estimated by pooling TIP data across all years (1986-2009) and gears (vertical line, bottom longline, other) within a given statistical area (SEDAR 2014). As pointed out by Chih and Turner (2006), the fundamental assumption for estimation was that TIP sampling was representative of commercial fleet catches. For a given statistical area, pooling data by years and gears has further assumptions, namely that the ratio of Gag to Black Grouper stock abundance for the exploited life stage (fish at or above legal size) was stable across the 24-year time period, and that the ratio of catchabilities q for the two species was the same for all gears. A potential concern for pooling data across years was that there have been a number of changes in minimum size regulations for the two species since the 1980s (**Table 1**). Each size change essentially redefines the age/size composition of the exploited life stage. While similar, the population dynamics of the two species with respect to age and growth, reproduction, etc., are not identical (c.f., Stevens et al. 2019); consequently, even if the stock abundances were stable, a change in minimum size would likely result in a change in the ratio of Gag to Black Grouper stock abundance.

Likewise, there are concerns for pooling data across gears. The two principal gears, vertical lines and bottom longlines, are hook-line gears, but the 'other' gear category is mostly comprised of traps and spears. Catchability concerns aside, the depth distributions vary among some of these gears. Vertical lines generally fish the full range of depth for the two species, but bottom longlines are restricted to 50 fathoms and deeper in the western GOM, and to 20-35 fathoms and deeper in the eastern GOM depending on the season. Most spearfishing likely occurs in depths shallower than 20 fathoms. The ratio of Gag to Black Grouper stock abundance may not be the same across all depths, and hence may differ among gears.

This study investigated two main issues potentially impacting the estimation of mis-reporting correction factors for Gag and Black Grouper:

(1) species mis-reporting pre- and post-implementation of IFQs; and,

(2) grouping years and gears for estimation within a given statistical area.

Methods

Data sources

The principal data for this study were lengths of individual Gag and Black Grouper recorded in TIP sampled catches from commercial fishing trips in the Gulf of Mexico during 1986-2019. Species-specific weights of individual fish were computed from weight-length relationships developed by Chih (2013), described in the **Appendix** below. Supplemental data from the Commercial Fisheries Logbook Program (CFLP) and Reef Fish Observer Program (RFOP) were utilized for corroborative analyses.

Statistical Estimation

Proportion Gag (p) in number or weight was respectively computed as the sum of Gag divided by the combined sum of Gag and Black Grouper. Standard error of p was calculated as

$$SE[p] = \sqrt{\left(\frac{s^2}{n}\right)} \ ,$$

where sample variance s^2 was computed using

$$s^2 = \left(\frac{n}{n-1}\right) p(1-p)$$

following Cochran (1977), where n was the number of TIP sampled trips.

Logbook (CFLP) and TIP data were evaluated to investigate potential changes in mis-reporting of Gag and Black Grouper before and after implementation of IFQ. Differences in proportion Gag estimates among gears were examined using TIP and observer program (RFOP) data. Data from TIP were used to determine the effects of changes in minimum size regulations on estimates of proportion Gag.

Results and Discussion

Estimates of proportion Gag for SEDAR 33 (SEDAR 2014) from TIP sampling showed distinct spatial patterns as summarized in **Fig. 1**. Analyses focused on statistical areas 2-5 where most of the overlap occurs between Gag and Black Grouper.

Issue #1: Species Mis-Reporting Pre- and Post-Implementation of IFQs

The logbook (CFLP) annual proportions of Gag to combined Gag and Black Grouper landings for two example statistical areas during 1986-2019 are shown for vertical lines in **Fig. 2** and bottom longlines in **Fig. 3**. Also shown are the proportion Gag estimates from TIP sampling during 1986-2009 (SEDAR 2014) in the statistical areas (horizontal dashed lines). In each case, the logbook proportion Gag was generally below the TIP observed proportion before implementation of IFQ, and then similar to TIP after implementation of IFQ. Time-series of annual estimates of the proportion of logbook trips reporting catches of both species on the same trip for these example statistical areas are shown for vertical lines in **Fig. 4** and bottom longlines in **Fig. 5**. There was a noticeable increase in this metric after implementation of IFQ in each case, suggesting IFQ may have created an incentive to distinguish these species in landings. The findings of Figs. 2-5 indicate there was no need to correct the Gag and Black Grouper landings for mis-reporting of the two species after implementation of IFQs in 2010.

Issue #2: Grouping Years and Gears for Estimation of Correction Factors

The noticeable increase in the proportion of logbook trips reporting both Gag and Black Grouper for the bottom longline gear after the Gag minimum size changed from 24 in TL to 22 in TL (**Fig. 5**) indicates a potential shift in the Gag:Black Grouper ratio, as hypothesized above. The proportion Gag estimated from observer data (RFOP) showed the same increasing trend from statistical areas 2 to 5 as the TIP estimates (**Table 2**); however, the RFOP estimates indicated potential differences between vertical line and bottom longline gears, especially in statistical areas of greatest overlap for the two species (areas 2 & 3).

Time period and gear effects on proportion Gag estimates were further examined, as illustrated in **Fig. 6**. Proportion Gag was estimated for vertical line and bottom longline gears for two time periods, 1990-1999 (min size 20 in TL) and 2000-2009 (min size 24 in TL), for statistical areas 2 through 5. Statistical comparisons were made within each statistical area. Some differences in proportion Gag ($p<0.05$) were observed between gears within a time period (red asterisks) and between time periods for a given gear (blue asterisks). Evaluation of two minor gears, traps and spears, indicated that the choice of pooling these into an 'other' category for reporting commercial landings was reasonable (**Fig. 7**). Our findings suggest that estimating proportion Gag by management time periods corresponding to changes in minimum size (**Table 1**) and by three gear categories (vertical line, bottom longline, other) within statistical areas may yield more accurate estimates and be more in line with the underlying fishery science assumptions compared to pooling TIP data for all years and gears within an area.

A related data pooling issue concerned statistical areas with proportion Gag close to 1.0 (100%). The previous analysis (SEDAR 2014) computed correction factors for statistical areas 1-11 separately, and for the combined areas 12-21; however, estimates for areas 6-11 all exceeded 0.97 and were similar to the combined estimate for 12-21 (0.963). Our analyses of four gears during 1990-1999 (**Fig. 7**) showed very high proportion Gag in statistical areas 6 and 7 irrespective of gear. Similarly, proportion Gag estimates ranged from 0.985 to 0.995 for vertical lines and bottom longlines in statistical area 6 and combined areas 7-21 for two management time periods (**Fig. 8**). These findings suggested that statistical areas 6-21, with very high proportions of Gag, could be combined for estimation of correction factors, albeit carrying out the estimation separately by management period and gear category.

Revised Correction Factors for 1986-2009

Proportion Gag in number and weight were estimated by gear category, statistical area, and management time period (**Table 3**). In some cases data were pooled across time periods within a gear-statistical area to overcome sparse TIP sampling, namely bottom longline in area 1 (**Table 3B**) and other gears in areas 4 and 5 (**Table 3C**). The revised estimates of Table 3 were used to correct pre-IFQ period Gag commercial landings (**Fig. 9**) and commercial discards (Smith et al. 2021). The revised correction factors by gear-area-time produced a slight decrease (0.92%) in the cumulative landings for 1986-2009 compared to the previous corrections based on area only. Correction factors for management time period 1986-1989 were applied to the pre-TIP sampling period landings for 1963-1985. This resulted in a minimal decrease in Gag cumulative landings (0.12%) compared to the previous corrections based on area only (Fig. 9).

For SEDAR 33, the area-only correction factors developed for 1986-2009 were applied to the post-IFQ time period 2010-2012 (SEDAR 2014). Application of the area-only approach in this study for the IFQ period 2010-2019 resulted in cumulative commercial landings that were 4.97%

lower than IFQ-reported landings; however, the uncorrected Gag cumulative landings for 2010-2019 were only 0.06% lower than IFQ-reported landings, i.e., nearly identical. Thus, the results of this study indicating that mis-reporting corrections are no longer necessary for the IFQ period (2010 and later) seem warranted.

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Table 1. Minimum total length regulations for Gag and Black Grouper for the GOM commercial fishery, 1986-2019. Size regulations are for both species unless indicated.

Time Period	Minimum Total Length, Inches
1986-1989	18
1990-1999	20
2000-2011	24
2012-2018	22, Gag 24, Black
2019	24

Table 2. Comparison of Gag proportion catch in number by statistical area between sampling programs (RFOP, Reef Fish Observer Program; TIP, Trip Interview Program) and gears. TIP estimates are from SEDAR (2014).

	Gag Proportion Catch in Number		
	RFOP, 2007-2019		TIP, 1986-2009
Statistical Area	Bottom Longline	Vertical Line	All Gears
6	1.000	0.998	0.991
5	0.994	0.989	0.977
4	0.977	0.974	0.947
3	0.852	0.954	0.874
2	0.346	0.605	0.576

Table 3. Revised estimates of proportion Gag in number and weight from TIP sampled trips by statistical area (Fig. 1) and management time period (Table 1) for **(A)** vertical line, **(B)** bottom longline, and **(C)** other gears. Estimation was carried out for pre-IFQ years only (1986-2009).

(A) Vertical Line

Statistical Area	Time Period	Trips (n)	Number of Fish		Proportion Gag, Number		Proportion Gag, Weight	
			Black	Gag	Mean	SE	Mean	SE
1	1986-89	10	46	0	0.0000	0.0000	0.0000	0.0000
1	1990-99	118	182	59	0.2448	0.0398	0.2350	0.0392
1	2000-09	20	44	5	0.1020	0.0694	0.1221	0.0751
2	1986-89	33	122	47	0.2781	0.0792	0.3794	0.0858
2	1990-99	100	272	297	0.5220	0.0502	0.5267	0.0502
2	2000-09	80	127	182	0.5890	0.0554	0.5921	0.0553
3	1986-89	4	8	59	0.8806	0.1872	0.8472	0.2077
3	1990-99	98	68	657	0.9062	0.0296	0.8271	0.0384
3	2000-09	50	34	338	0.9086	0.0412	0.8628	0.0492
4	1986-89	9	4	191	0.9795	0.0501	0.9430	0.0820
4	1990-99	149	107	1835	0.9449	0.0188	0.8895	0.0258
4	2000-09	170	40	1207	0.9679	0.0136	0.9309	0.0195
5	1986-89	47	7	1063	0.9935	0.0119	0.9843	0.0183
5	1990-99	234	141	6605	0.9791	0.0094	0.9776	0.0097
5	2000-09	223	42	2668	0.9845	0.0083	0.9711	0.0112
6-21	1986-89	33	7	172	0.9609	0.0343	0.9701	0.0301
6-21	1990-99	1517	131	21139	0.9938	0.0020	0.9894	0.0026
6-21	2000-09	1167	40	18432	0.9978	0.0014	0.9941	0.0022

Table 3 (cont.)
(B) Bottom Longline

Statistical Area	Time Period	Trips (n)	Number of Fish		Proportion Gag, Number		Proportion Gag, Weight	
			Black	Gag	Mean	SE	Mean	SE
1	1986-2009	12	28	47	0.6267	0.1458	0.4730	0.1505
2	1986-89	18	89	155	0.6353	0.1167	0.4701	0.1211
2	1990-99	201	822	1685	0.6721	0.0332	0.5258	0.0353
2	2000-09	283	1602	2058	0.5623	0.0295	0.4545	0.0297
3	1986-89	16	48	103	0.6821	0.1202	0.7350	0.1140
3	1990-99	89	179	1363	0.8839	0.0341	0.7502	0.0461
3	2000-09	192	251	1348	0.8430	0.0263	0.7456	0.0315
4	1986-89	15	3	337	0.9912	0.0250	0.9637	0.0500
4	1990-99	291	117	3097	0.9636	0.0110	0.9277	0.0152
4	2000-09	500	426	5226	0.9246	0.0118	0.8591	0.0156
5	1986-89	53	41	1072	0.9632	0.0261	0.9173	0.0382
5	1990-99	556	197	7271	0.9736	0.0068	0.9398	0.0101
5	2000-09	961	446	10872	0.9606	0.0063	0.9290	0.0083
6-21	1986-89	10	0	191	1.0000	0.0000	1.0000	0.0000
6-21	1990-99	256	34	4662	0.9928	0.0053	0.9911	0.0059
6-21	2000-09	482	33	6577	0.9950	0.0032	0.9908	0.0044

(C) Other Gears

Statistical Area	Time Period	Trips (n)	Number of Fish		Proportion Gag, Number		Proportion Gag, Weight	
			Black	Gag	Mean	SE	Mean	SE
1	1986-89	15	168	21	0.1111	0.0840	0.1518	0.0959
1	1990-99	29	323	6	0.0182	0.0253	0.0129	0.0214
1	2000-09	11	24	3	0.1111	0.0994	0.0778	0.0847
2	1986-89	13	171	5	0.0284	0.0480	0.0144	0.0343
2	1990-99	42	320	51	0.1375	0.0538	0.0953	0.0459
2	2000-09	25	340	62	0.1542	0.0737	0.1401	0.0708
3	1986-89	10	14	25	0.6410	0.1599	0.5836	0.1643
3	1990-99	14	5	44	0.8980	0.0840	0.9643	0.0515
3	2000-09	9	1	32	0.9697	0.0606	0.9766	0.0534
4	1986-2009	4	0	23	1.0000	0.0000	1.0000	0.0000
5	1986-99	6	1	62	0.9841	0.0559	0.9905	0.0435
5	2000-09	5	3	44	0.9362	0.1222	0.8821	0.1613
6-21	1986-99	58	6	935	0.9936	0.0105	0.9796	0.0187
6-21	2000-09	97	0	1089	1.0000	0.0000	1.0000	0.0000

Figure 1. Map of statistical fishing areas in the Gulf of Mexico, denoting areas with low to high proportion of Gag relative to Black Grouper in commercial catches from TIP sampling (SEDAR 2014).

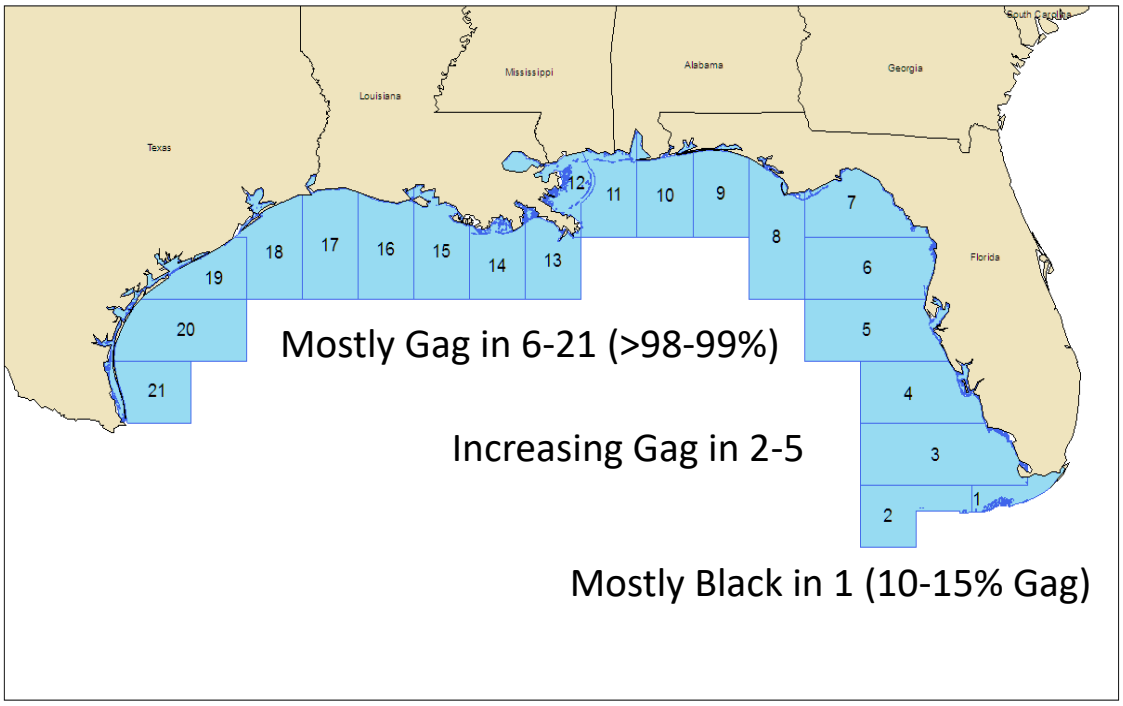


Figure 2. Vertical line annual proportion of Gag in combined Gag-Black Grouper landings reported in commercial logbooks for 1993-2019 for statistical areas 3 (top panel) and 5 (bottom panel). The horizontal dashed lines are the proportion Gag estimates from TIP sampling during 1986-2009 (SEDAR 2014) in the respective statistical areas. Also denoted is the implementation of IFQs in 2010 for both Gag and Black Grouper.

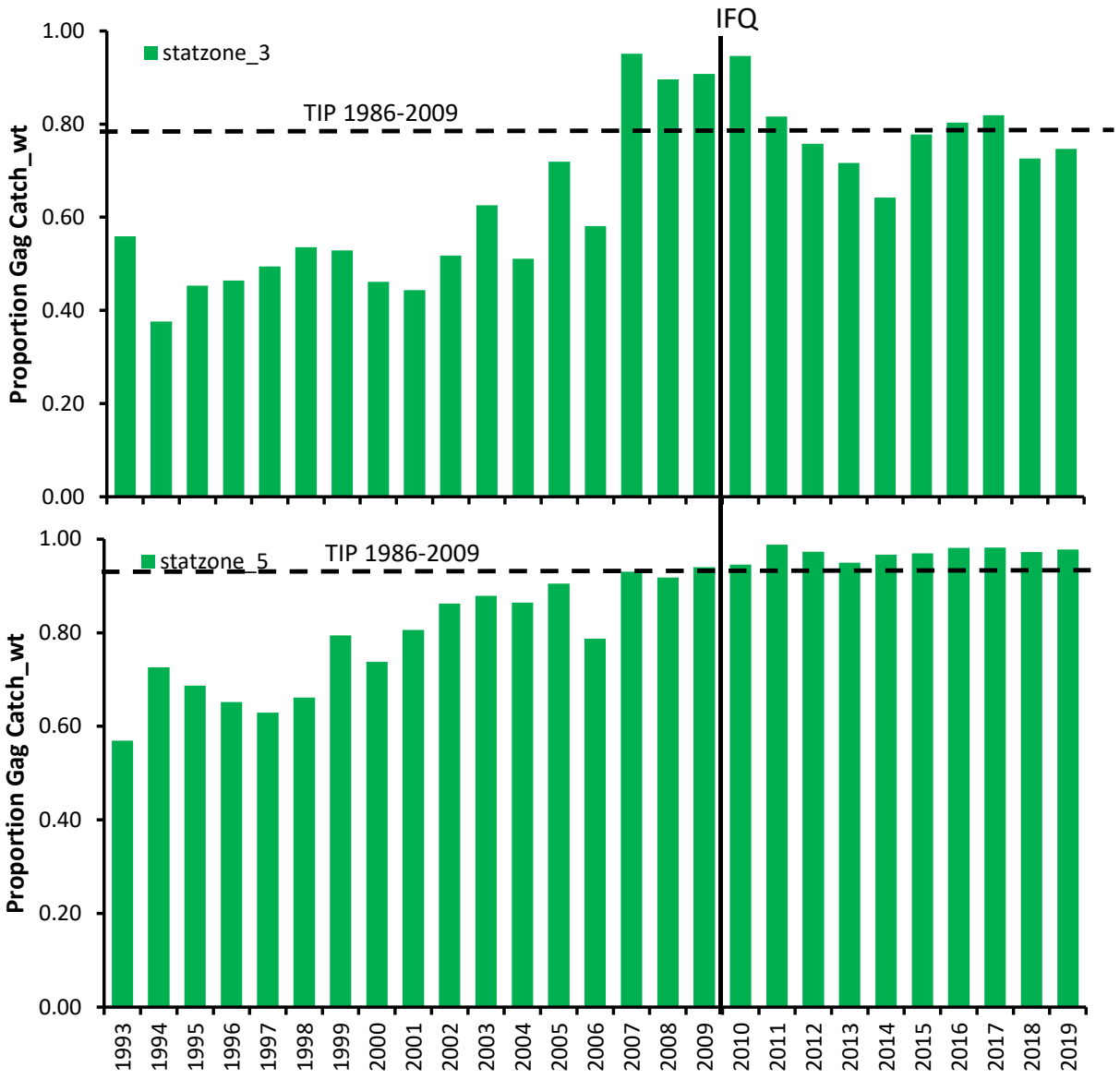


Figure 3. Bottom longline annual proportion of Gag in combined Gag-Black Grouper landings reported in commercial logbooks for 1993-2019 for statistical areas 3 (top panel) and 5 (bottom panel). The horizontal dashed lines are the proportion Gag estimates from TIP sampling during 1986-2009 (SEDAR 2014) in the respective statistical areas. Also denoted is the implementation of IFQs in 2010 for both Gag and Black Grouper.

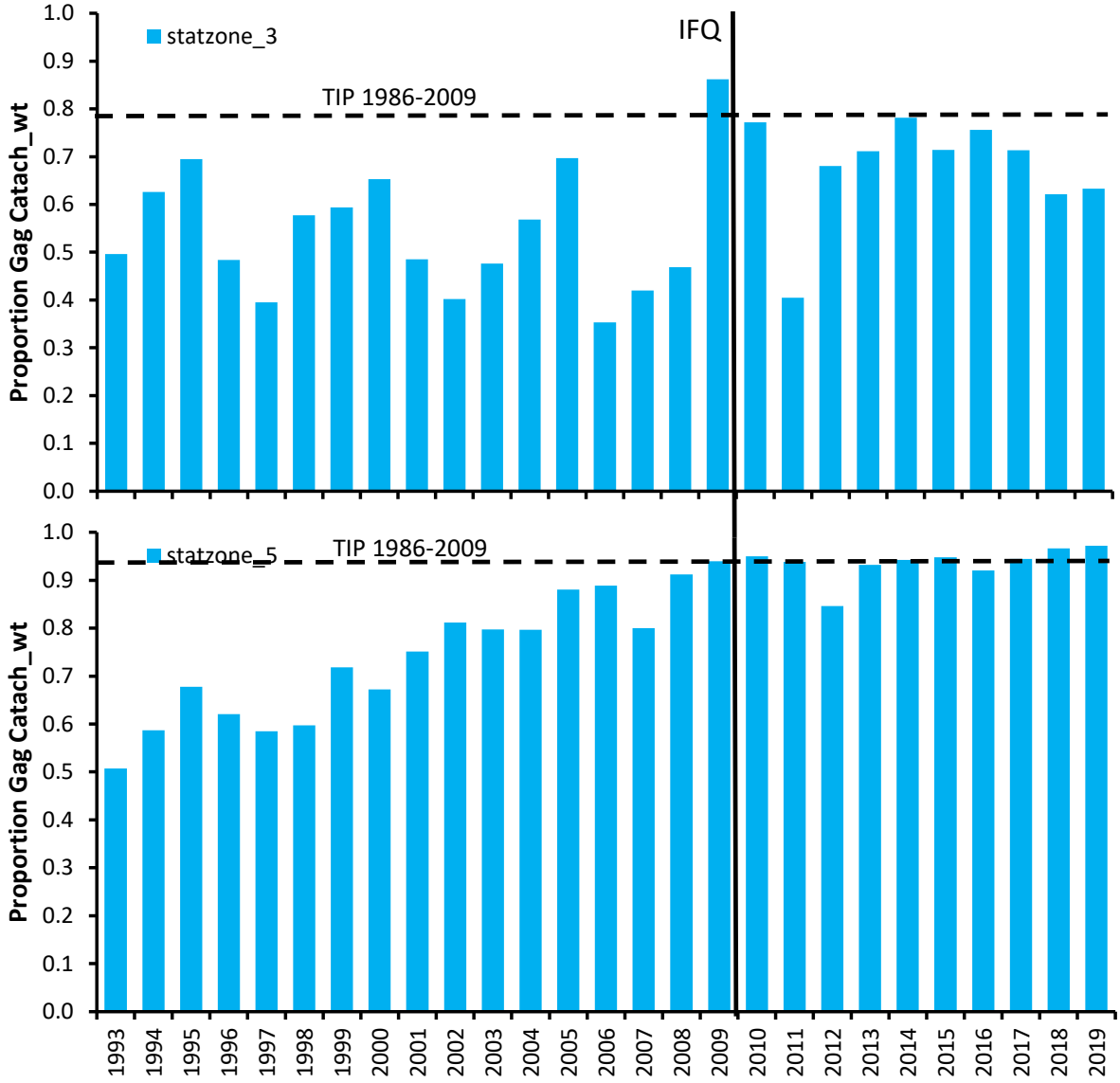


Figure 4. Annual proportion of vertical line logbook trips reporting catch of both Gag and Black Grouper for 1993-2019 for statistical areas 3 (top panel) and 5 (bottom panel). The implementation of IFQs in 2010 is denoted.

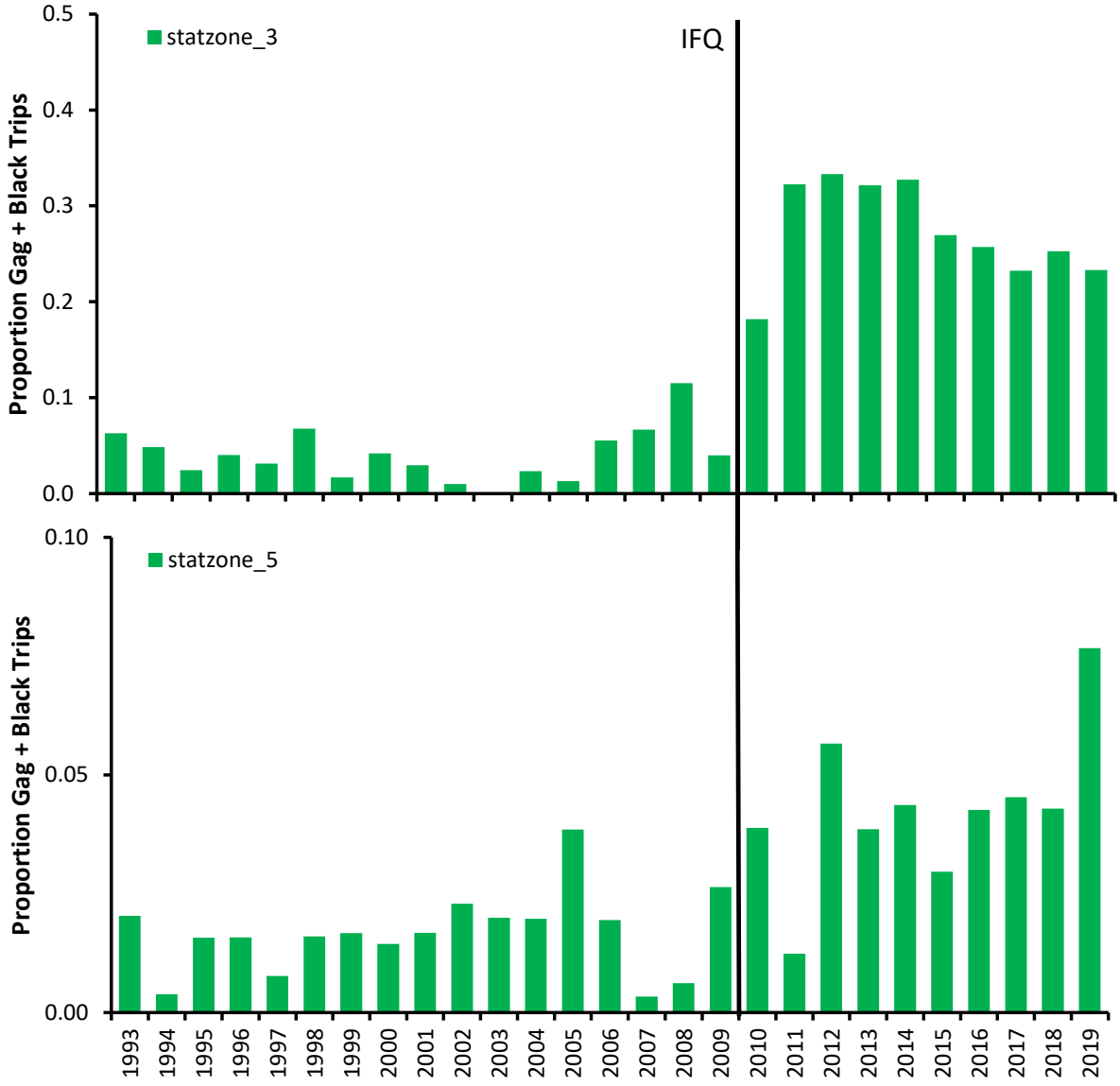


Figure 5. Annual proportion of bottom longline logbook trips reporting catch of both Gag and Black Grouper for 1993-2019 for statistical areas 3 (top panel) and 5 (bottom panel). The implementation of IFQs in 2010 and Gag minimum size change from 24" TL to 22" TL in 2012 are denoted.

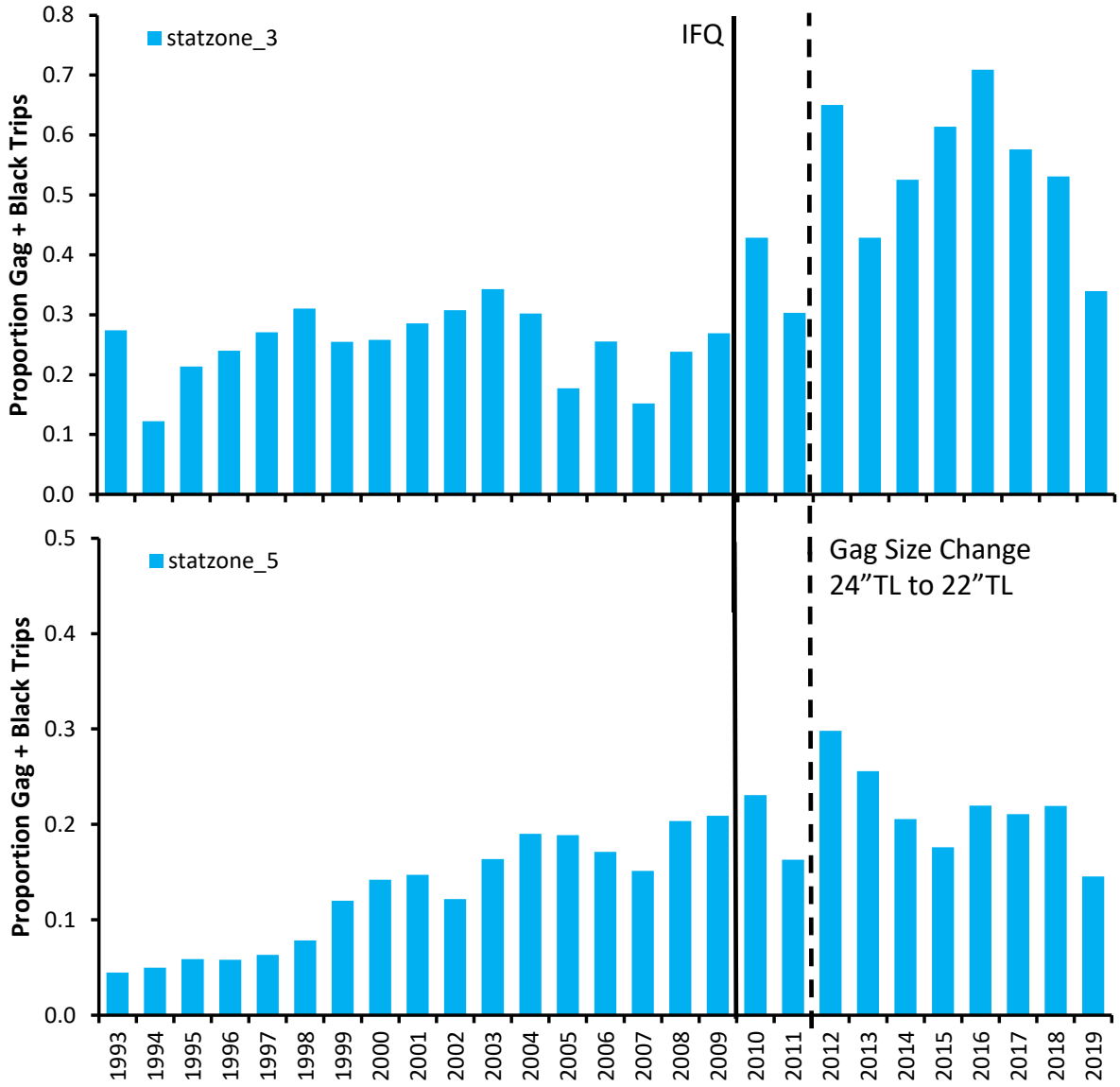


Figure 6. Gear (Handline, Longline) and management time period (1990-1999, 2000-2009) comparisons of proportion Gag for statistical areas 2-5. Within a given statistical area, red asterisks denote statistical differences between gears within a given time period; blue asterisks denote statistical differences between time periods for a given gear.

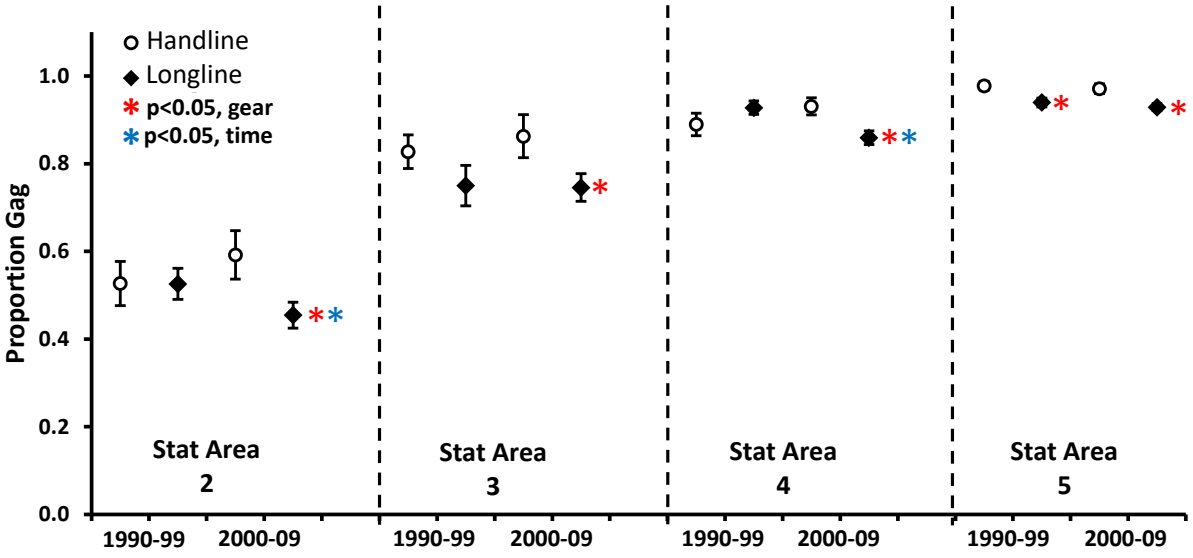


Figure 7. Comparison of proportion Gag for spear and trap gears with the two principal gears, vertical line (handline) and bottom longline. Estimates are shown for statistical areas during the 1990-1999 time period where there was sufficient data for all four gears. For statistical area 1, spear and trap gag proportions were similar to each other, but different (p<0.05) from vertical line and bottom longline. Gag proportions for all gears were similar in statistical areas 6 and 7.

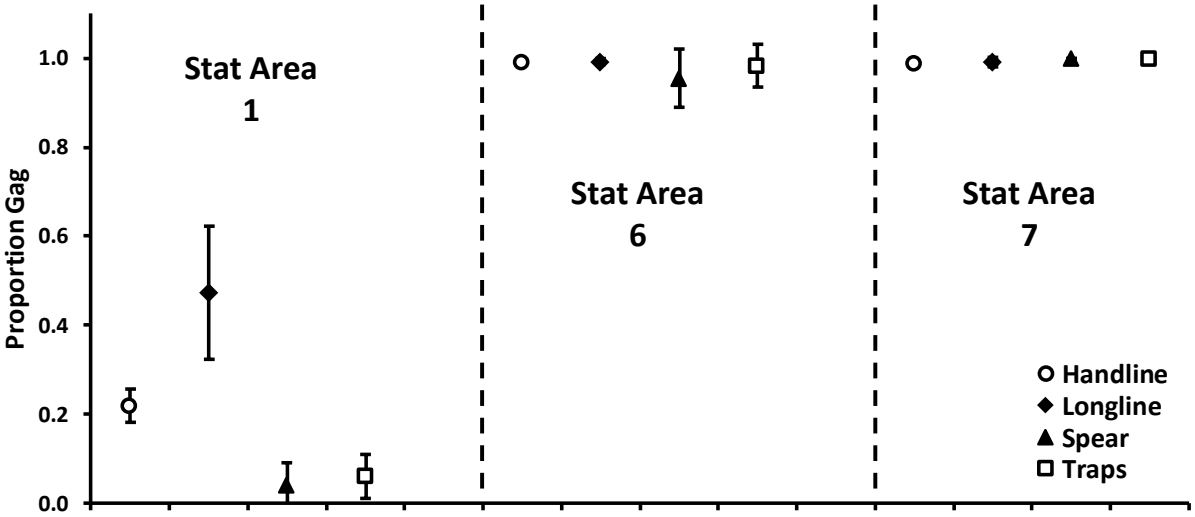


Figure 8. Comparison of proportion Gag between statistical area 6 and the combined statistical areas 7-21 for two gears and two time periods. All estimates ranged between 0.985 and 0.995.

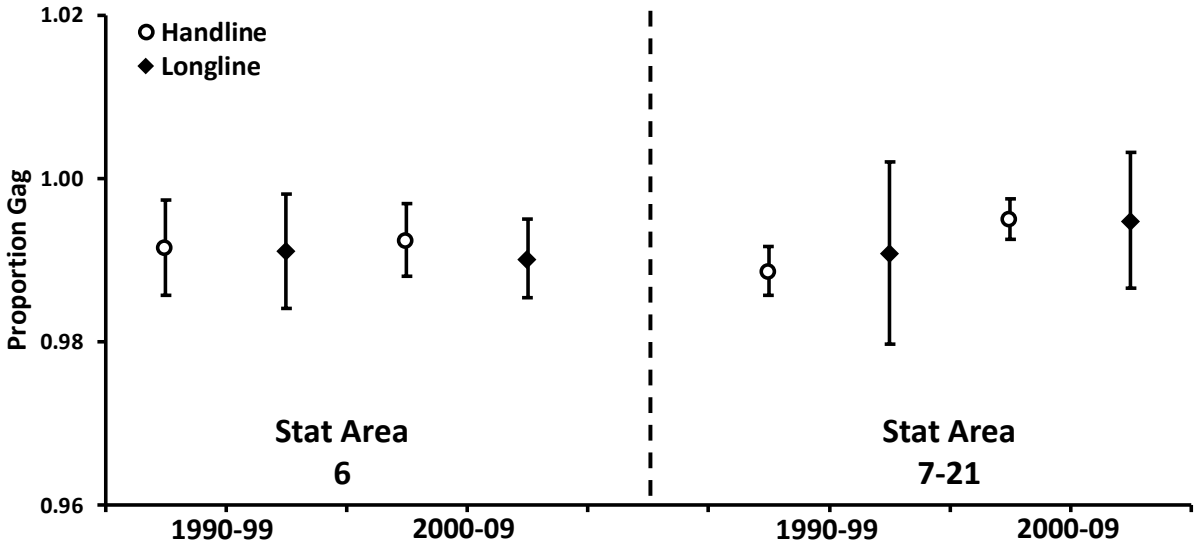
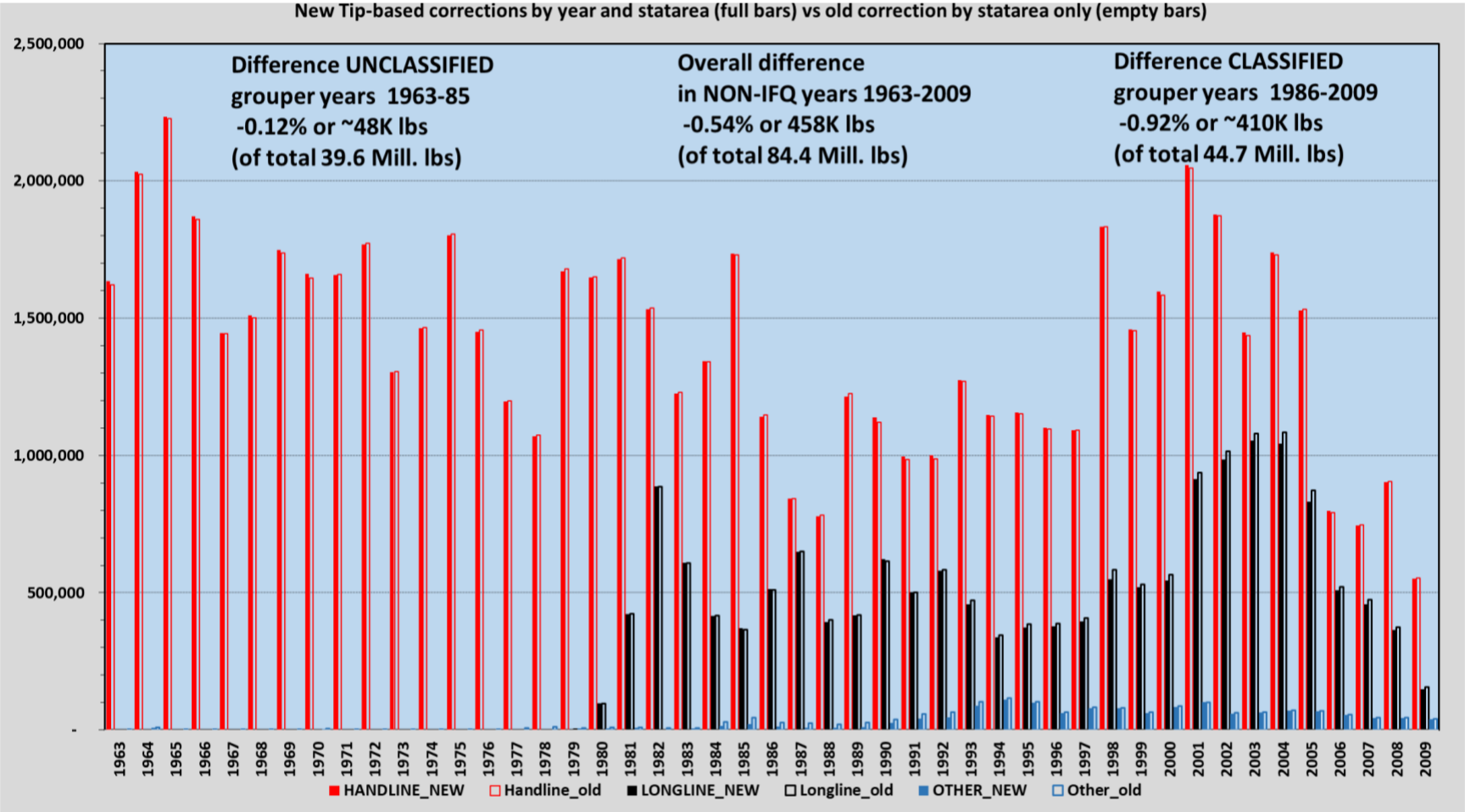


Figure 9. Comparison of Gag commercial landings 1963-2009 using correction factors based on gear-statistical area-time period (solid bars), as reported in Table 3, vs. using corrections based on area alone (open bars), as reported in SEDAR (2014).



Appendix. Weight-length relationships developed by Chih (2013).

Length to weight conversion equations estimated from TIP data (length in inches, weight in pounds):

Gag

Gutted weight=0.0004265 x (fork length)$^{3.027}$, n=14291, r^2=0.98

Gutted weight=0.0004465 x (total length)$^{2.989}$, n=1254, r^2=0.95

Black Grouper

Gutted weight=0.0002847 x (fork length)$^{3.176}$, n=1481, r^2=0.98

Gutted weight=0.0003328 x (total length)$^{3.111}$, n=224, r^2=0.98