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SEDAR48-DW-04

Black Grouper standardized catch rates from the Marine Recreational Fisheries Statistics Survey in south Florida, 1991-2015

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Recreational anglers catch Black Grouper, *Mycteroperca bonaci*, primarily in southern Florida from Tampa Bay to Cape Canaveral in the private/rental boat and charterboat fishing modes. While the Marine Recreational Information Program, formerly known as the Marine Recreational Fisheries Statistics Survey, (MRFSS/MRIP) is a fishery dependent survey, total catch including discards is reported in the intercepts and total catch rates can provide an indication of changes in the underlying population because they are less affected by changes in management regulations. In 1991, MRFSS/MRIP made several improvements to the survey and one of which was the linking of ancillary intercepts from the same fishing trip together and recording the total number of anglers in the party. MRFSS/MRIP also improved the training of field samplers which was particularly important for Black Grouper which is frequently confused with Gag, *Mycteroperca microlepis*. Therefore, the data for this analysis were constrained to MRFSS/MRIP intercepts from the 1991-2015 period in the private/rental boat and charterboat modes in offshore waters from southern Florida, Tampa Bay on the Gulf coast through to Cape Canaveral on the Atlantic coast of Florida (i.e., from Pinellas through Indian River counties).

There were 29,879 MRFSS/MRIP intercepts in the charterboat and private/rental boat modes in offshore waters (federal waters) and 33 species including black grouper occurred on at least 1% of those intercepts. In this analysis, those additional intercepts from the same fishing trip that caught fish but were unavailable to the sampler were linked back to the main intercept for the party. Over the 25 years from 1991 through 2015, there were 3,455 trips that caught Black Grouper in offshore waters from Tampa Bay to Cape Canaveral, FL (Table 1).

We used the same process in 2017 that was used in SEDAR 19 to estimate the recreational CPUE indices of abundance based on MRFSS/MRIP data. First, a hierarchical cluster analysis

(Shertzer and Williams 2008) was performed on presence-absence data of the landings (recreational landings in numbers) to identify those species caught in association with Black Grouper to include trips which could have caught Black Grouper (Figure 1). The hierarchical clustering procedure was used because it does not require the analyst to select a number of clusters in the data, and a Bray measure of similarity was used due to the data being presence-absence data.

Second, a hurdle approach with two generalized linear submodels (binomial and gamma distributions) was used to fit the data to produce an index of abundance time-series (Lo *et al.* 1992; Figure 2). The hurdle approach is the same method that was applied to the MRFSS index in SEDAR 19 (Muller 2009, SEDAR 19 DW-01). The index is the product of the probability that a Black Grouper was caught on a recreational trip and the number of Black Groupers that are caught on positive trips. The probability submodel used a binomial distribution with a logit link and the submodel for the number of Black Grouper caught on positive trips used a gamma distribution (with a log link). For these analyses, many potential explanatory variables including coast, region of Florida, year, two-month wave, fishing mode, whether nearshore or offshore, whether day or night fishing, hours fished, number of anglers, and the number of fishing trips in the past two months were evaluated for their inclusion in the final model. The variable selection process used a forward selection procedure starting with the null model to identify which combination of variables reduced the deviance (a measure of uncertainty) the most. To be included a variable had to be statistically significant, we used an alpha level of 0.05 and the variable had to reduce the mean deviance by at least 0.5%.

We used a Monte Carlo simulation approach to calculate the variability in the annual indices. Each iteration used the annual least-squares mean estimates on their linear scale and added uncertainty that was calculated by multiplying the standard error by a random normal deviate (μ=0, σ=1). As described above, these values were converted back from their linear scales and multiplied together and this product was calculated 10,000 times thus producing an empirical distribution for the index.

The submodel estimating the probability that a Black Grouper was observed at a station reduced the deviance by 5.5% and the variables in the final submodel, listed in decreasing order of importance, included the year, the area, and wave. The submodel estimating the number of

Black Grouper observed on successful trips with the gamma distribution reduced the deviance by 12.8%, and the variables in the final submodel, also listed in decreasing order of importance, included hours fished, year, area, and wave.

The MRFSS/MRIP index showed an increasing trend from 1996 through 2004 (with one low year, in 2002) and then started declining in 2005, reaching a low in 2006 (Figure 2). In 2007, the index increased again, but then declined thereafter through 2011, where it reached the lowest point in the time series (Figure 2). From 2011-2015 the MRFSS/MRIP index showed an increasing trend (Figure 2). The coefficients of variation were moderately high, ranging from 0.15 to 0.63. The nominal index had a similar shape as the standardized MRFSS/MRIP index (Figure 3). The 1991-2015 MRFSS/MRIP index was similar to the index used in SEDAR 19 (Figure 4). However, in SEDAR 19 the cluster of species was Yellowtail Snapper, Mutton Snapper and Gray Triggerfish (Muller, 2009), whereas our cluster of species differed (Figure 1). The differences seen between species clusters may have inflated the number of positive trips in this analysis, which may explain the differences seen between the two estimates of relative CPUE in the early years of the time series (Figure 4).

Literature Cited

Lo, N.C.N, L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on Delta-Lognormal models. Canadian Journal of Fishery and Aquatic Science 49:2515-2526.

Muller, R.G. 2009. Black grouper standardized catch rates from the Marine Recreational Fisheries Statistics Survey in south Florida, 1991-2008. SEDAR 19-DW-01. SEDAR. North Charleston, SC. 29 pp.

Shertzer, K. W. and E. H. Williams. 2008. Fish assemblages and indicator species: reef fishes of the southeastern United States. Fishery Bulletin 106:257-269.

Table 1. The MRFSS/MRIP index, its coefficient of variation, the number of intercepts, the proportion of positive trips (catching black grouper), the MRFSS/MRIP index scaled to its mean, nominal index, and the nominal index scaled to its mean.

Year	MRFSS/ MRIP Index	Coefficient of Variation	Number of Trips	Proportion of Positive Trips	Index Scaled to Mean	Nominal Index	Nominal Index Scaled to Mean
1991	0.55	0.38	27	10	1.19	0.59	0.99
1992	0.46	0.28	60	18	0.99	0.53	0.89
1993	0.41	0.31	66	16	0.89	0.45	0.76
1994	0.33	0.34	53	13	0.71	0.51	0.85
1995	0.39	0.28	70	18	0.84	0.44	0.74
1996	0.49	0.21	134	33	1.06	0.51	0.86
1997	0.59	0.19	114	40	1.27	0.75	1.25
1998	0.65	0.17	159	55	1.39	0.85	1.42
1999	0.60	0.17	150	52	1.29	0.77	1.29
2000	0.62	0.16	197	66	1.32	0.80	1.34
2001	0.71	0.15	217	86	1.52	0.87	1.46
2002	0.49	0.17	234	63	1.05	0.69	1.16
2003	0.72	0.15	267	86	1.54	1.01	1.70
2004	0.74	0.16	211	70	1.59	1.03	1.72
2005	0.43	0.18	179	56	0.92	0.58	0.97
2006	0.19	0.25	162	24	0.41	0.23	0.38
2007	0.54	0.18	179	52	1.15	0.69	1.15
2008	0.39	0.19	191	46	0.83	0.52	0.87
2009	0.24	0.26	138	23	0.52	0.28	0.47
2010	0.09	0.40	126	10	0.19	0.12	0.20
2011	0.09	0.63	112	5	0.19	0.09	0.15
2012	0.24	0.31	137	17	0.51	0.21	0.36
2013	0.15	0.33	102	14	0.32	0.16	0.26
2014	0.27	0.31	99	17	0.57	0.33	0.56
2015	0.43	0.26	101	23	0.92	0.45	0.75

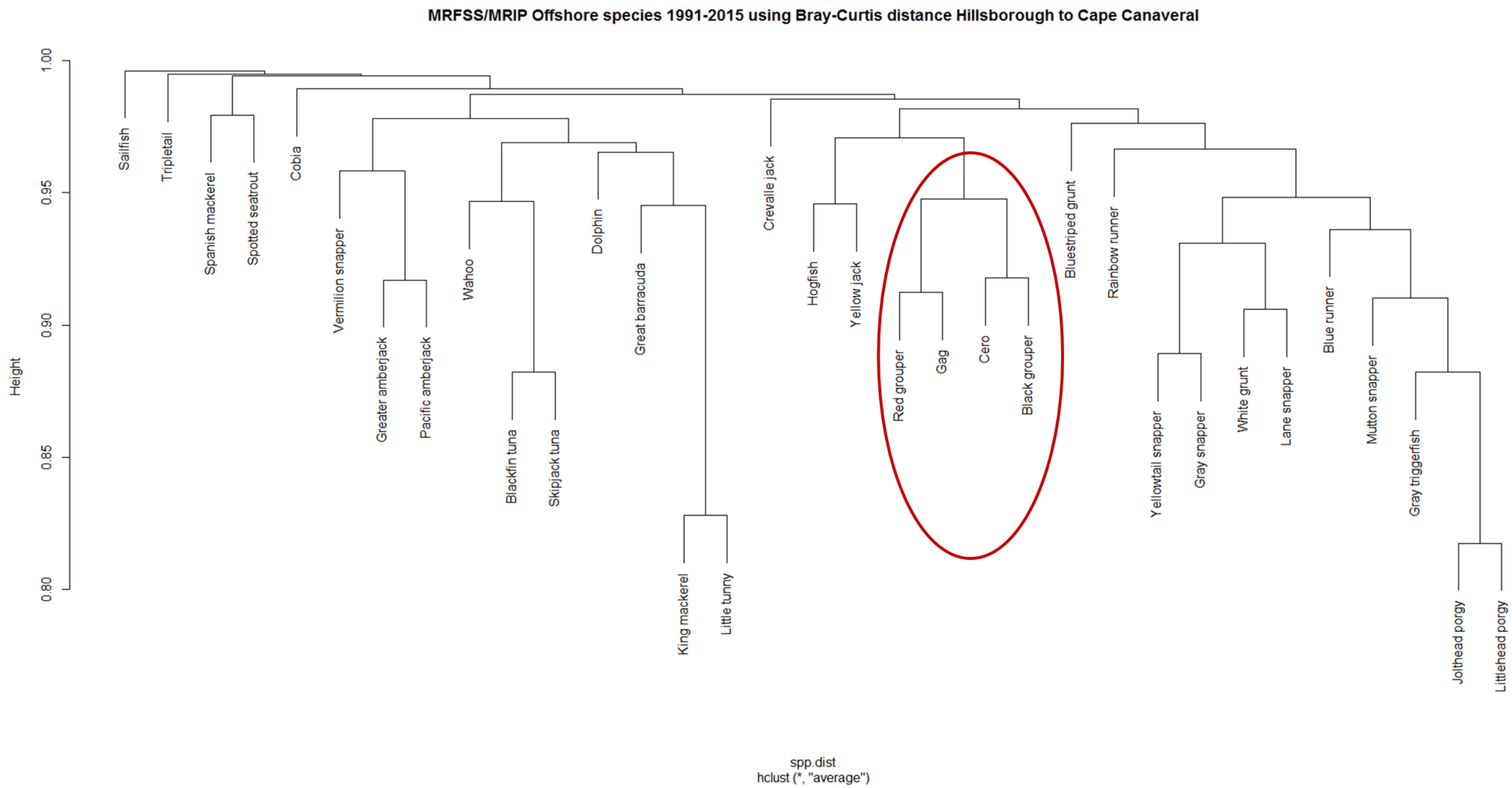

Figure 1. A hierarchical cluster diagram identified the three species caught in association with Black grouper in south Florida.

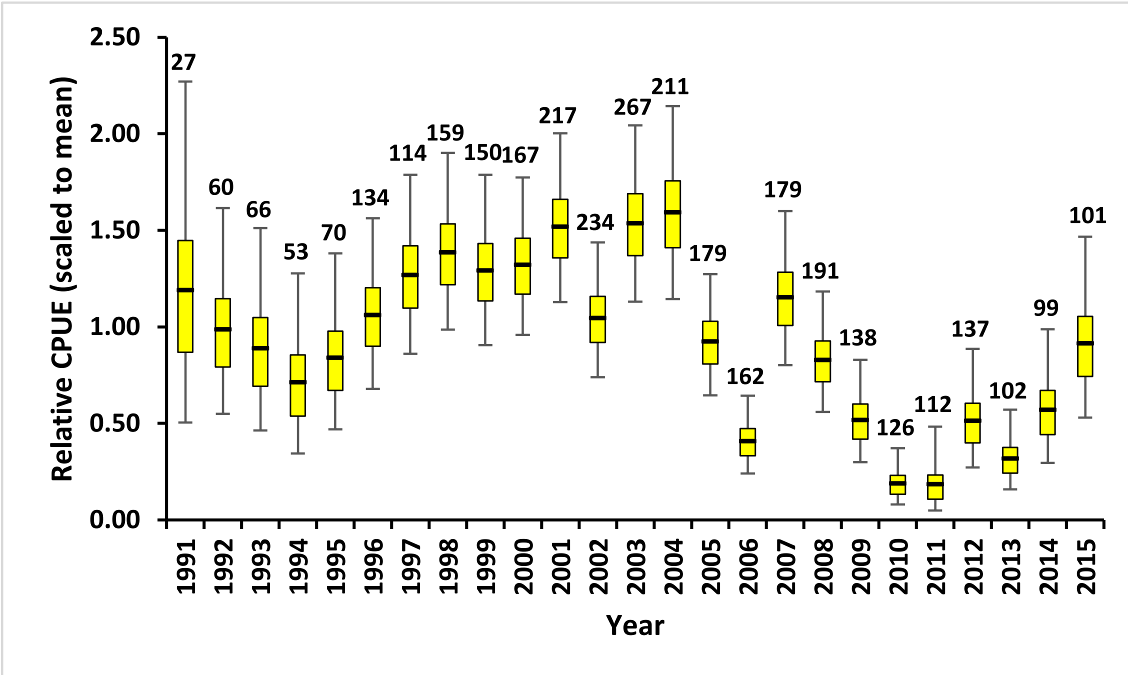

Figure 2. A box-whisker plot of the MRFSS/MRIP index by year. The horizontal line is the median estimate; the box is the inter-quartile range, and the vertical line is the 95% confidence interval. The number of interviews conducted each year is shown above the confidence interval.

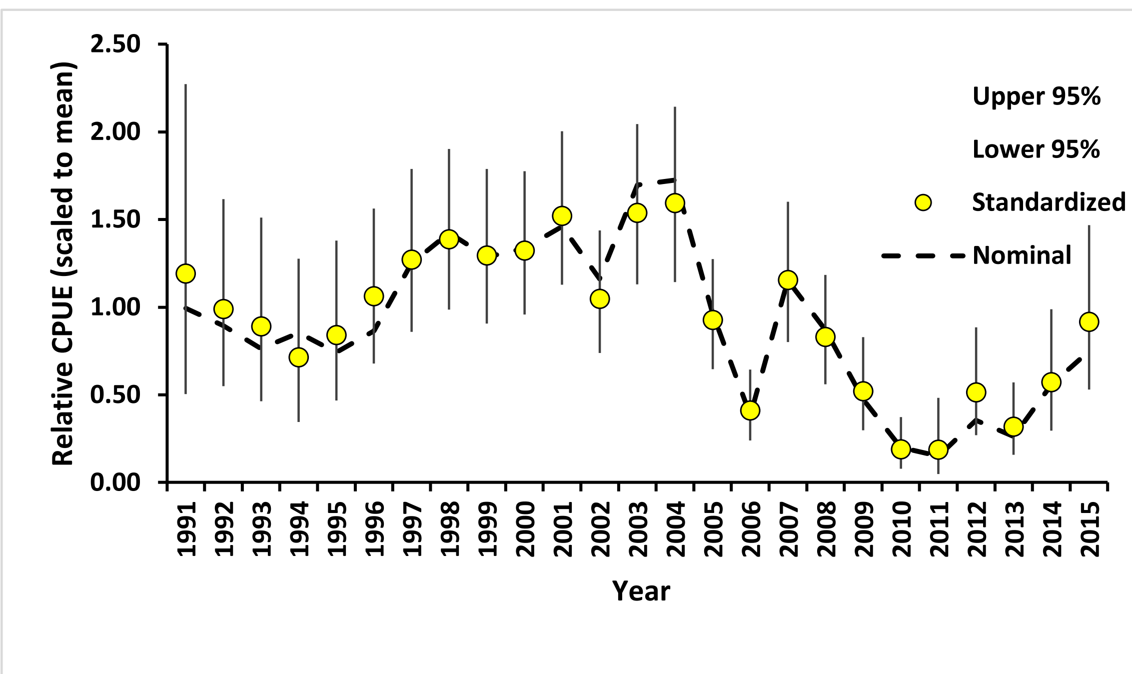

Figure 3. Comparison of standardized catch rates with their confidence intervals and nominal catch rates by year.

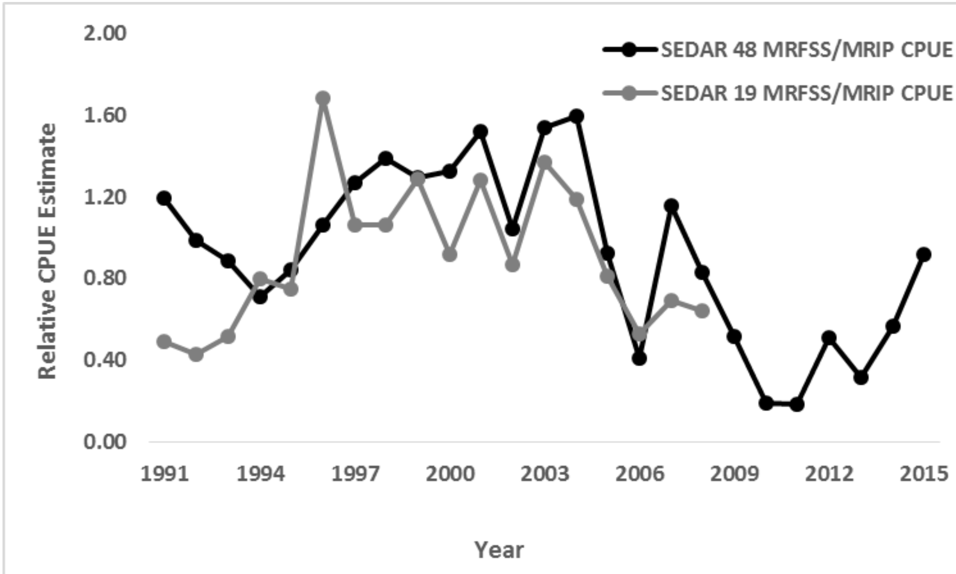

Figure 4. Comparison of relative CPUE estimates from this analysis (SEDAR 48) and the mean CPUE estimates used in SEDAR 19.

Addendum to the standardized catch rates of Black Grouper from the Marine Recreational Fisheries Statistics Survey in south Florida, 1991-2015

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At the Data Workshop for SEDAR 48 (held on 15-17 March, 2017 in St. Petersburg, FL) the MRFSS/MRIP Survey was discussed by the Index Committee. At that time, there was a discussion concerning whether to include gear as a potential explanatory variable or to consider only hook-and-line trips. There was a belief that spear fishing had increased in recent years. However, on further examination of the data, spear fishing only constituted a small portion of the interviews and we decided to develop an index using only hook-and-line trips. This addendum addresses the Index Committee's recommendation.

We used a similar process in 2017 to that used in SEDAR 19 to estimate the recreational CPUE indices of abundance based on MRFSS/MRIP data. First, a hierarchical cluster analysis (Shertzer and Williams 2008) was performed on presence-absence data of the landings (recreational landings in numbers) to identify those species caught in association with Black Grouper to include trips which potentially could have caught Black Grouper (Figure 1). In this analysis, we limited the landings data to trips made in the Keys only, as we found few positive trips in other regions. Also, we used Type A (retained) catch here (to avoid misidentification issues in reported landings and releases) and pulled landings data from May through December (i.e., there should be few, if any, positive trips during the closed season- January through April). Intercepts from the same fishing trip that caught fish were linked back to the main intercept for the party to form a unique trip identifier. In the revised analysis, there were 7,446 MRFSS/MRIP trips meeting the above criteria and 27 species including Black Grouper that occurred on at least 1% of those trips. The hierarchical clustering procedure was used because it does not require the analyst to define the number of clusters in the data, and a Bray-Curtis measure of similarity was used which is appropriate for presence-absence data.

Once the species caught in association with Black Grouper were identified (Red Grouper, *Epinephelus morio*, and Mutton Snapper, *Lutjanus analis*, Fig. 1.), we extracted all trips that caught (retained or released) any of the three species from any month, Pinellas County on the Gulf coast around to Indian River County on the Atlantic coast using trips from the Charterboat and Private/Rental boat modes in nearshore (state) and offshore (federal) waters.

After the recreational trip data were extracted, we used a hurdle approach with two generalized linear submodels (binomial and gamma distributions) to fit the data and produce an index of abundance time-series (Lo *et al.* 1992). The hurdle approach is the same method that was applied to the MRFSS index in SEDAR 19 (Muller 2009, SEDAR 19 DW-01). The index is the product of the probability that a Black Grouper was caught on a recreational trip and the number of Black Groupers that are caught on positive trips. The probability submodel used a binomial distribution with a logit link and the submodel for the number of Black Grouper caught on positive trips used a gamma distribution (with a log link). For these analyses, potential explanatory variables were the region of Florida, year, two-month wave, fishing mode, whether nearshore or offshore, day or night fishing, hours fished, number of anglers, and the number of fishing trips in the past two months (avidity) and each was evaluated for inclusion in the final model. The variable selection process used a forward selection procedure starting with the null model to identify which combination of variables reduced the deviance (a measure of uncertainty) the most. To be included a variable had to be statistically significant ($\alpha \leq 0.05$), and the including the variable in the model had to reduce the mean deviance by at least 0.5%.

We used a Monte Carlo simulation approach to calculate the variability in the annual indices. Each iteration used the annual least-squares mean estimates on their linear scale and added uncertainty that was calculated by multiplying the standard error by a random normal deviate (μ=0, σ=1). As described above, these values were converted back from their linear scales and multiplied together and this product was repeated 10,000 times to produce an empirical distribution for the index.

The binomial submodel estimating the probability that a Black Grouper was observed at a station reduced the deviance by 31.8% and the variables in the final submodel, listed in decreasing order of importance, included region (Indian River to Miami-Dade County, Keys (Monroe County), and Collier to Pinellas County) and year (Table 2). The standardized deviance residuals did not show a pattern with the significant variables, but they were distributed in a bimodal pattern (corresponding to positive and zero catches of Black Grouper; Figure 2c) and the q-q plot was not linear. The submodel estimating the number of Black Grouper observed on successful trips with the gamma distribution reduced the deviance by 7.9%, and the variables in the final submodel, listed in decreasing order of importance, were region, year, hours fished category, and wave (Table 3).

The MRFSS/MRIP index showed an increasing trend from 1996 through 2004 (with one low year, in 2002), and declining in 2005 to a low in 2006 (Figure 3). In 2007, the index increased again, but then declined thereafter through 2009, where it reached levels like those seen in the early 1990s (Figure 3). In 2011 the MRFSS/MRIP index peaked, but then declined in 2012 and has since remained low compared to previous years (Figure 3). The coefficients of variation were moderately high, ranging from 0.12 to 0.30. The nominal index had a similar shape as the standardized MRFSS/MRIP index (Figure 4). The 1991-2015 MRFSS/MRIP index was like the index used in SEDAR 19 (Figure 5) and the index developed for the SEDAR 48 DW. However, in SEDAR 19 the cluster of species was based on catch (retained and/or released) on trips from Tampa Bay to Cape Canaveral during all months of the year and included Yellowtail Snapper, Mutton Snapper and Gray Triggerfish (Muller, 2009), while the cluster of species found in this analysis differed (Figure 1) because of the different selection criteria used (retained catch from hook-and-line trips made only in the Keys from May to December). The criteria used are likely responsible for the differences seen in the new estimates of relative CPUE in the early years of the time series and SEDAR 19 (Figure 5). It is our view that the selection criteria are an improvement over the ones used for SEDAR 19 in that only retained catch is used for defining the trips eligible for clustering (removing the potential confusion in identification of “black groupers”), hook-and-line trips were selected, only months where Black Grouper were legal to retain in most years of the time series were eligible, and trips which were more likely to encounter Black Grouper (trips in the Florida Keys) were used to develop clusters of species for trip selection for the CPUE index.

Literature Cited

Lo, N.C.N, L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on Delta-Lognormal models. Canadian Journal of Fishery and Aquatic Science 49:2515-2526.

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Table 1. The MRFSS/MRIP index, its coefficient of variation, the number of intercepts, the proportion of positive trips (catching Black Grouper), the MRFSS/MRIP index scaled to its mean, nominal index, and the nominal index scaled to its mean.

Year	MRFSS/ MRIP Index	Coefficient of Variation	Number of Trips	Proportion of Positive Trips	Index Scaled to Mean	Nominal Index	Nominal Index Scaled to Mean
1991	0.16	0.30	160	20	0.89	0.28	0.83
1992	0.09	0.24	393	32	0.51	0.15	0.46
1993	0.09	0.26	299	28	0.48	0.18	0.53
1994	0.16	0.24	266	32	0.88	0.33	1.01
1995	0.13	0.27	257	26	0.73	0.25	0.74
1996	0.23	0.20	291	48	1.23	0.58	1.74
1997	0.16	0.18	348	62	0.88	0.48	1.44
1998	0.22	0.15	494	83	1.19	0.38	1.15
1999	0.35	0.12	739	132	1.87	0.48	1.45
2000	0.23	0.12	645	134	1.26	0.44	1.32
2001	0.27	0.12	679	138	1.47	0.47	1.40
2002	0.18	0.13	747	119	0.99	0.39	1.19
2003	0.29	0.12	735	152	1.59	0.58	1.76
2004	0.28	0.13	840	127	1.54	0.42	1.25
2005	0.23	0.14	666	96	1.22	0.29	0.87
2006	0.12	0.17	396	62	0.64	0.28	0.84
2007	0.15	0.15	468	89	0.84	0.40	1.21
2008	0.13	0.14	712	100	0.71	0.30	0.91
2009	0.10	0.20	565	44	0.54	0.15	0.45
2010	0.12	0.17	573	61	0.66	0.23	0.68
2011	0.22	0.17	479	67	1.21	0.40	1.21
2012	0.16	0.15	586	88	0.88	0.28	0.84
2013	0.09	0.18	554	57	0.47	0.18	0.53
2014	0.12	0.19	816	52	0.65	0.16	0.49
2015	0.09	0.19	735	49	0.48	0.13	0.40

Table 2. Stepwise selection of variables to include in estimating the proportion of positive Black Grouper trips (shaded lines) with a GLM (binomial distribution and logit link).

Explanatory variable	Degrees of freedom	Deviance	Mean deviance	Chi-square degrees of freedom	Chi-square	Probability of null hypothesis	Percent reduction in deviance	Converged	Cumulative percent reduction in mean deviance
Null	13442	10945.71	0.81	.	.	.	.	Conv	
region	13440	7663.61	0.57	2	3282.09	0.00	29.97	Conv	29.97
mode	13441	10275.50	0.76	1	670.20	0.00	6.12	Conv	
wave	13437	10411.97	0.77	5	533.73	0.00	4.84	Conv	
year	13418	10704.14	0.80	24	241.57	0.00	2.03	Conv	
avidity	13438	10722.43	0.80	4	223.28	0.00	2.01	Conv	
hours fished	13435	10872.13	0.81	7	73.57	0.00	0.62	Conv	
area fished	13441	10879.56	0.81	1	66.14	0.00	0.60	Conv	
party size	13437	10900.03	0.81	5	45.67	0.00	0.38	Conv	
time category	13441	10934.43	0.81	1	11.28	0.00	0.10	Conv	
region	13440	7663.61	0.57	.	.	.	.	Conv	
region year	13416	7484.81	0.56	24	178.80	0.00	1.51	Conv	31.48
region wave	13435	7577.93	0.56	5	85.68	0.00	0.76	Conv	
region mode	13439	7596.99	0.57	1	66.63	0.00	0.60	Conv	
region avidity	13436	7626.56	0.57	4	37.06	0.00	0.32	Conv	
region area fished	13439	7640.76	0.57	1	22.85	0.00	0.20	Conv	
region hours fished	13433	7651.95	0.57	7	11.66	0.11	0.07	Conv	
region party size	13435	7656.98	0.57	5	6.63	0.25	0.04	Conv	
region time cat	13439	7661.63	0.57	1	1.99	0.16	0.01	Conv	
region year	13416	7484.81	0.56	.	.	.	.	Conv	
region year wave	13411	7429.42	0.55	5	55.39	0.00	0.48	Conv	
region year mode	13415	7449.12	0.56	1	35.70	0.00	0.32	Conv	
region year avidity	13412	7462.46	0.56	4	22.35	0.00	0.18	Conv	
region year area fished	13415	7479.57	0.56	1	5.25	0.02	0.04	Conv	
region year hours fished	13409	7479.72	0.56	7	5.09	0.65	0.01	Conv	
region year time cat	13415	7484.07	0.56	1	0.74	0.39	0.00	Conv	
region year party size	13411	7482.86	0.56	5	1.96	0.86	-0.01	Conv	

Table 3 continued. Stepwise selection of variables to include in estimating the number of Black Grouper landed on positive Black Grouper trips (shaded lines) with a GLM (gamma distribution and log link).

Explanatory variable	Degrees of freedom	Deviance	Mean deviance	Chi-square degrees of freedom	Chi-square	Probability of null hypothesis	Percent reduction in deviance	Converged	Cumulative percent reduction in mean deviance
Null	1897	1265.78	0.67	.	3405.50		.	Conv	
region	1895	1227.06	0.65	2	64.67	0.00	2.96	Conv	2.96
year	1873	1213.79	0.65	24	87.28	0.00	2.88	Conv	
hours fished	1890	1230.89	0.65	7	58.20	0.00	2.40	Conv	
wave	1892	1250.15	0.66	5	25.89	0.00	0.97	Conv	
avidity	1893	1255.56	0.66	4	16.90	0.00	0.60	Conv	
party size	1892	1255.30	0.66	5	17.33	0.00	0.57	Conv	
time category	1896	1265.03	0.67	1	1.24	0.27	0.01	Conv	
mode	1896	1265.51	0.67	1	0.44	0.51	-0.03	Conv	
area fished	1896	1265.75	0.67	1	0.06	0.81	-0.05	Conv	
region	1895	1227.06	0.65	.	3158.07	.	.	Conv	
region year	1871	1178.44	0.63	24	83.92	0.00	2.65	Conv	5.61
region hours fished	1888	1195.89	0.63	7	53.45	0.00	2.12	Conv	
region party size	1890	1215.04	0.64	5	20.47	0.00	0.70	Conv	
region wave	1890	1216.31	0.64	5	18.30	0.01	0.60	Conv	
region avidity	1891	1218.11	0.64	4	15.22	0.18	0.50	Conv	
region time category	1894	1225.21	0.65	1	3.14	0.28	0.10	Conv	
region mode	1894	1225.36	0.65	1	2.88	0.63	0.08	Conv	
region area fished	1894	1226.33	0.65	1	1.24	0.27	0.01	Conv	
region year	1871	1178.44	0.63	.	2625.95	.	.	Conv	
region year hours fished	1864	1154.20	0.62	7	43.06	0.00	1.60	Conv	7.20
region year wave	1866	1165.23	0.62	5	23.37	0.00	0.81	Conv	
region year party size	1866	1168.54	0.63	5	17.49	0.00	0.54	Conv	
region year avidity	1867	1171.32	0.63	4	12.56	0.01	0.37	Conv	
region year time cat.	1870	1176.29	0.63	1	3.80	0.05	0.12	Conv	
region year area fished	1870	1177.33	0.63	1	1.95	0.16	0.04	Conv	
region year mode	1870	1177.81	0.63	1	1.11	0.29	0.00	Conv	

Table 3 (Continued). Stepwise selection of variables to include in estimating the proportion of positive Black Grouper trips (shaded lines) with a GLM (binomial distribution and logit link).

Explanatory variable	Degrees of freedom	Deviance	Mean deviance	Chi-square degrees of freedom	Chi-square	Probability of null hypothesis	Percent reduction in deviance	Converged	Cumulative percent reduction in mean deviance
region year hours fish	1864	1154.20	0.62	.	2438.81	.	.	Conv	
region year hours fished wave	1859	1142.32	0.61	5	21.39	0.00	0.71	Conv	7.91
region year hours fished party size	1859	1144.82	0.62	5	16.88	0.00	0.51	Conv	
region year hours fished avidity	1860	1148.50	0.62	4	10.23	0.04	0.26	Conv	
region year hours fished area fish	1863	1150.81	0.62	1	6.09	0.01	0.22	Conv	
region year hours fished mode	1863	1152.42	0.62	1	3.19	0.07	0.09	Conv	
region year hours fished time cat.	1863	1152.46	0.62	1	3.13	0.08	0.09	Conv	
region year hours fish wave	1859	1142.32	0.61	.	2406.72	.	.	Conv	
region year hours fish wave party sz	1854	1133.75	0.61	5	15.58	0.00	0.01	Conv	
region year hours fish wave avidity	1855	1137.58	0.61	4	8.61	0.00	0.07	Conv	
region year hours fish wave area fish	1858	1139.93	0.61	1	4.34	0.04	0.04	Conv	
region year hours fish wave time cat.	1858	1140.08	0.61	1	4.07	0.01	0.04	Conv	
region year hours fished wave mode	1858	1140.76	0.61	1	2.83	0.07	0.09	Conv	

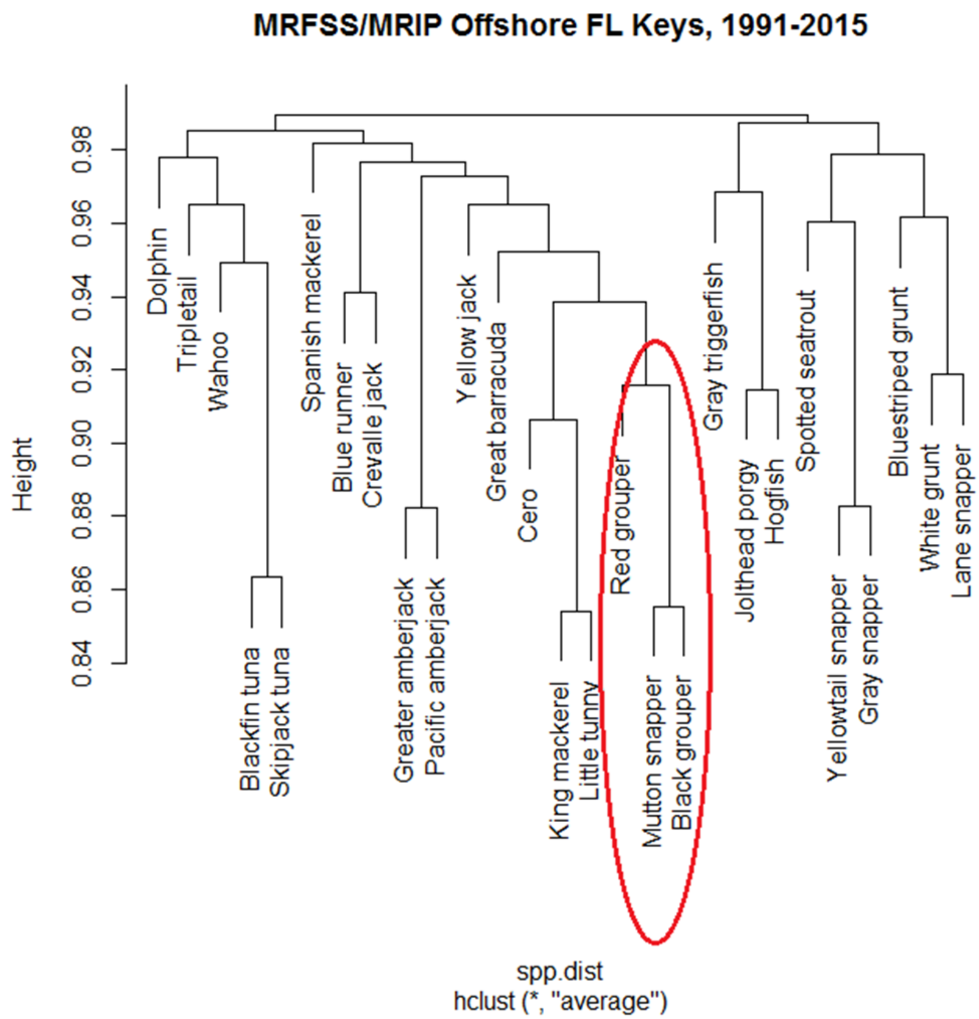

Figure 1. Hierarchical cluster diagram identified the two additional species associated with Black Grouper in south Florida.

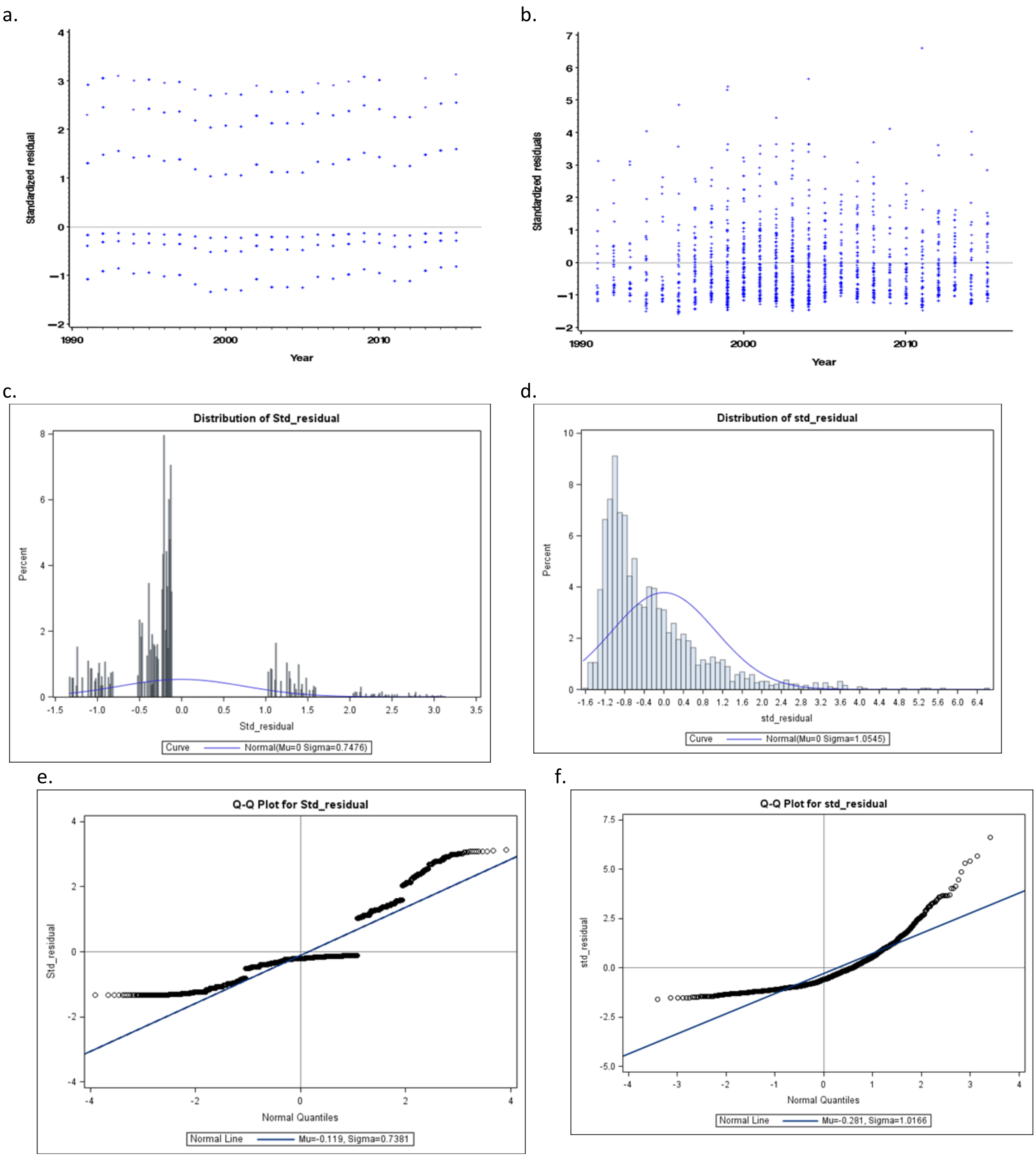

Figure 2. Diagnostic plots for the probability of landing a Black Grouper fit using a binomial distribution, standardized deviance residuals, a and c, and q-q plot, e; and for the number of Black Grouper landed on a trip using a gamma distribution, standardized deviance residuals, b and d, and q-q plot, f.

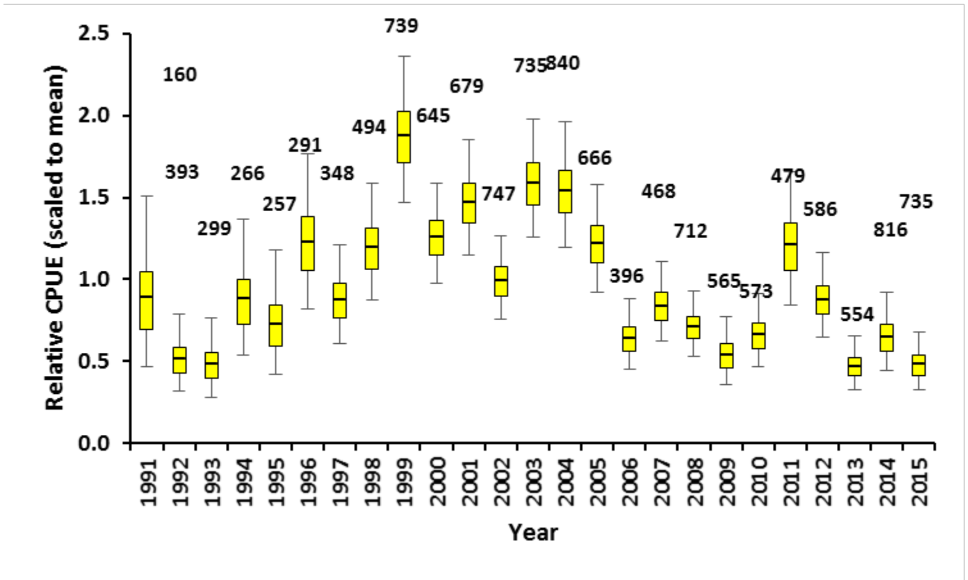

Figure 3. A box-whisker plot of the MRFSS/MRIP index by year. The horizontal line is the median estimate; the box is the inter-quartile range, and the vertical line is the 95% confidence interval. The number of interviews conducted each year is shown above the confidence interval.

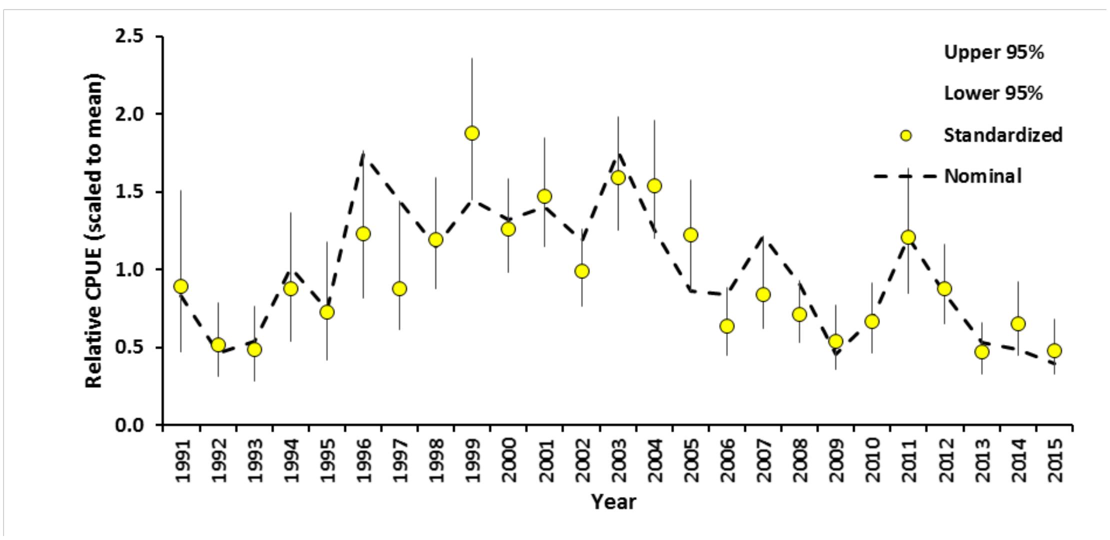

Figure 4. Comparison of standardized catch rates with their confidence intervals and nominal catch rates by year.

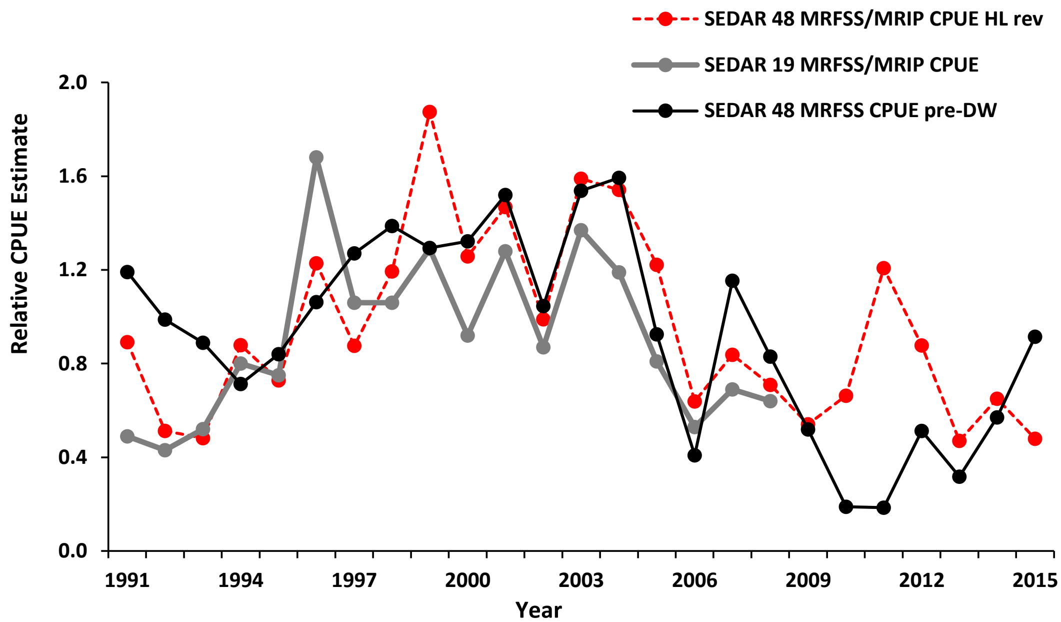

Figure 5. Comparison of relative CPUE estimates from this analysis (SEDAR 48 MRFSS/MRIP CPUE HL rev) using only the hook and line (HL) gear type (excludes spear fishing trips and is restricted to the species developed from cluster analysis using trips in the Florida Keys), the analysis conducted for the DW includes HL and spear fishing trips (SEDAR 48 MRFSS/MRIP CPUE pre-DW), and the mean CPUE estimates used in SEDAR 19. (SEDAR 19 MRFSS/MRIP CPUE).