Black grouper standardized catch rates from the Marine Recreational Fisheries Statistics Survey in south Florida, 1991-2008

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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 Fisheries Statistics Survey (MRFSS) 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 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 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 was constrained to MRFSS intercepts from the 1991-2008 period in the private/rental boat and charterboat modes in nearshore or 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 Volusia counties (Figure 1). Another analysis was conducted using just MRFSS intercepts from the Florida Keys.

There were 58,469 MRFSS intercepts in the charterboat and private/rental boat modes from nearshore (state waters) and offshore waters (federal waters) and 54 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 creel sampler were linked back to the main intercept for the party.

Over the 18 years from 1991 through 2008, there were 1,589 intercepts that caught black grouper in the near- and offshore waters from Tampa Bay to Cape Canaveral (Table 1, Figure 2). However, there was additional effort that could have caught black grouper and to identify that effort to include in the catch rate standardization process, I used Stephens and MacCall (2004) logistic regressions (S&M). The rationale is to identify a homogeneous group of intercepts that are believed to reflect the abundance of the target species. The S&M method is quite simple in that it uses a logistic regression of the total catch by species for all species on each intercept converted to presence or absence to predict whether the target species could be caught on the trip. Following Stephens and MacCall's example, I omitted species that occurred on less than 1% of the total number of intercepts. Dr. Calay of the Southeast Fisheries Center provided an R program to determine the threshold for selecting intercepts to include in the catch rate analysis and

that program was modified to use only those species with regression coefficients that were significant at $\alpha = 0.05$.

For the S&M method, the intercept data was rearranged to one record per intercept with the catch data for each of the 54 species. The catch numbers for a species were converted to presence or absence based on whether the total catch was one or more fish (1) or otherwise (0). The response variable in the logistic regression was the presence or absence of black grouper on each intercept and the predictor variables in the full model were the presence or absence of the other 53 species. There were 26 species whose regression coefficients were significant at the 0.05 level and those species were used in the final, reduced model. The species with significant regression coefficients are shown in Table 2 and Figure 3.

Potential thresholds for choosing whether to include an intercept in the catch rate analysis ranged from 0.01 to 0.99 and the critical value was based on the minimum absolute difference between observed number of intercepts with black grouper and the predicted number of intercepts. The smallest absolute difference occurred with a threshold of 0.145 (Figure 4). There were 1,585 intercepts that exceeded the 0.145 threshold and the regression correctly predicted 96% of the intercepts as to whether anglers caught black grouper or not on the selected intercepts. However, some of these intercepts were lacking necessary data such as the number of hours fished on the trip or the number of fishing trips that the angler completed in the past two months for avidity resulting in the selection of 1,561 intercepts with complete information.

Once the MRFSS intercepts for calculating the catch rates were selected, the total number of black grouper caught was calculated for each selected intercept and annual catch rates were estimated with a generalized linear model (GLM). I initially tried a Poisson distribution with a log link but the mean deviance (deviance/degrees of freedom) was 2.97 indicating that the data were over-dispersed, so I adopted an approach based on Lo et al. (1992) by dividing the data into two datasets: 1) presence or absence data (1,561 intercepts) and fit to a GLM with a binomial distribution with a logit link and 2) the total catch of black grouper on positive intercepts (405 of the 1,561 intercepts) were fit to a GLM with a gamma distribution with a log link. Potential explanatory variables were year, wave (two-month time period), mode (charterboat or private/rental boat), area (nearshore or offshore), region (southeast -- Volusia-Dade, Florida Keys -- Monroe, southwest -- Collier-Pinellas), avidity (0, 5, 10, 15, 20, 30, 40+ trips per wave), hours fished (0, 2, 4, 6, 8, 10, 12+ hr), and the number of anglers on the trip (1, 2, 3, 4, 5, 6, 7+). Potential variables were evaluated for inclusion in the GLM through a step-wise process. For eash step-wise level, provided that the variable with the lowest Akaike Information Criterion (AIC) value was also significant at the $\alpha = 0.05$ level (from twice the change in log-likelihood), that variable was added to the model for use in the calculations in the next step (Table 3).

The quantile plot and the distribution of standardized residuals from the GLM for the proportion of positive intercepts using a binomial distribution with a logit link seem reasonable (Figure 5); however, there were some departures from the expected at the

tails. The GLM explained 8.6% of the deviance with most of that being explained by region (7.4%, Table 3a), hours fished explained 0.6 %, and mode of fishing and two-month wave explained the remainder. Year was not significant ($P = 0.23$) and only explained 0.1% of the mean deviance and , therefore, was not included. The model for the total number of fish caught per intercept on positive intercepts using a gamma distribution with a log link explained 11.1% of the deviance with most of the deviance explained by year (3.9%), region (3.6%), and hours fished (3.6%) (Table 3b). The annual mean catch per intercept values (Table 1, Stephens and MacCall columns) were calculated with a Monte Carlo method based on the number of intercepts by region, fishing mode, two-month wave, and the time fished per year to determine the probability of a non-zero intercept multiplied by the mean number of black grouper caught per angler. Random variation was added to each outcome by multiplying the standard error of the proportion positive by a random, normal deviate and by multiplying the standard error of the number per intercept by a different random, deviate. After the random deviates were added to the terms, the terms were back-transformed to their original scales and multiplied together. This process was repeated for each of the 1,561 intercepts and the index was the mean of the outcomes by year (Figure 6).

A troubling aspect of the Stephens and MacCall approach for identifying intercepts to include in the calculation of catch rates is the high proportion of intercepts that were predicted to have caught black grouper but did not (false positives). In this case, out of 1,585 intercepts that were predicted to have caught black grouper, there were 1,177 false positives (74%). That the model predicted 96% of the intercepts correctly is misleading because the calculation is based on all intercepts and most (97%) of the intercepts did not catch black grouper. A better evaluation of the fit would be to examine the true positive intercepts, i.e., black grouper were caught on the intercept and the regression predicted that black grouper would be caught. With this criterion and using the 0.145 threshold, the correct prediction rate dropped to 26% (408 intercepts predicted to catch black grouper out of 1,589 intercepts that did catch black grouper). Therefore, I explored an alternative method to select intercepts based on species composition that was borrowed from community ecology, cluster analysis. Cluster analysis has been frequently applied to fish communities to identify species groupings (Mueter and Norcross 2000, Rooper 2008, and Shertzer and Williams 2008). The idea was to determine which species were frequently caught with black grouper and then to include any intercept that caught any member of the group.

The data used in the cluster analysis were the same MRFSS total catch information that was used in the S&M including the 1% cutoff value except that the catches were not converted to presence or absence but rather left as number of fish caught per intercept. Thus, each of the 58,469 intercepts included the total catch (MRFSS Types A, B1, and B2) for each of the 54 species. Following Kreb's (1999) recommendation for count data, the similarity of each pair of species was measured with the Morisita's Index of Similarity (vegdist function in the R vegan package, Oksanen 2008). Morisita's index, C_λ, between species j and k was calculated as

$$C_\lambda = \frac{2\sum X_{ij}X_{ik}}{(\lambda_1 + \lambda_2)N_j N_k}$$

where X_{ij} and X_{ik} are the number of intercepts for species j and k, N_j is the total number of species j and N_k is the total number of species k,

$$\lambda_1 = \frac{\sum X_{ij}(X_{ij}-1)}{N_j(N_j-1)} \quad \text{and} \quad \lambda_2 = \frac{\sum X_{ik}(X_{ik}-1)}{N_k(N_k-1)}.$$

The similarity matrix was input to a hierarchial clustering routine (hclust function in the R stats package, R Development Core Team. 2008) that used average linkage clustering.

Species in the cluster that contained black grouper included other reef species such as gray triggerfish, yellowtail snapper, and mutton snapper (Figure 7). Therefore, the intercept selection criterion for including a MRFSS intercept was whether it contained any of these four species.

There were 9,631 MRFSS intercepts that contained at least one member of the cluster. The cluster method selected all of the intercepts that caught black grouper (1,589) while the S&M method only selected 405 intercepts of those that caught black grouper. Catch rates were calculated with GLMs with the same potential explanatory variables: year, wave, area, mode, region, avidity, hours fished, and the number of anglers. Again, the Poisson distribution with a log link indicated that the data were over-dispersed (null model mean deviance = 1.73) and the proportion of positive intercepts was modeled separately from the number of black grouper caught on positive trips.

The fit of the proportion positive model was reasonable (Figure 8) and the model reduced the deviance by 13.3% (Table 4a) with most of that due to region (10.2%) and year (1.8%) with two-month wave (0.8%), mode of fishing (0.4%) and hours fished (0.1%). The fit of the number of black grouper caught per intercept for the 1,575 intercepts with positive catches was also reasonable (Table 4b, Figure 8 c and d). The model reduced the deviance by 10.5% with region accounting for 4.3%, hours fished (2.7%), year (1.9%), two-month wave (1.0%), and number of anglers (0.6%). Both measures of effort, hours fished and the number of anglers, were significant in determining the number of fosh caught on successful trips. The catch rates estimated by the GLM increased during the 1990s reaching a peak in 2003 and then declined to levels slightly above those in the beginning of the time series (Table 1, Figure 9).

The annual pattern of MRFSS catch rates from intercepts selected by cluster analysis not only was significant for year but was significantly correlated with the nominal annual catch rates ($r = 0.80$, $df = 16$, $P < 0.05$). Although the catch rates calculated from the intercepts selected by S&M were significantly correlated with those from cluster analysis ($r = 0.62$, $df = 16$, $P < 0.05$), they were not correlated ($r = 0.40$, $df = 16$, $P = 0.10$) with the nominal rates and their coefficients of variation were higher than those from cluster

analysis, therefore, I recommend using the index calculated from the intercepts that were selected by cluster analysis.

To determine the ages to which to apply the MRFSS index, I used the 95% range of lengths of black grouper in the measured by MRFSS samplers aggregated for 2000-2008 (n = 425 fish). The lower length was in the 525 mm TL category and the upper length was in the 925 mm TL category (Figure 10). Crabtree and Bullock (1998) estimated the von Bertalanffy growth for unsexed fish as

$$L_t = 1306(1 - e^{-0.169(t+0.768)})$$

and using that equation the corresponding age range would be 2 - 6 years.

The catch rates in the Florida Keys were substantially higher than the other two regions (Figure 11), and so the cluster analysis was repeated only using intercepts from the Florida Keys (Monroe county). The cluster analysis of the Keys MRFSS intercepts identified red grouper, *Epinephelus morio*, and gag, *Mycteroperca microlepis*, being caught together with black grouper (Figure 12) and 2,051 MRFSS intercepts were selected. As with the regional model, the GLM with a Poisson distribution was over-dispersed (mean deviance of 2.88) and so the analysis was split into two GLM models: the proportion positive and the total catch on positive intercepts (1,232 intercepts, gamma distribution and log link). The potential variables were the same as in the regional south Florida model.

Similarly, the fits of the GLM models appear reasonable (Figure 13). Without region, the GLM for the proportion positive only accounted for 6.0% of the deviance (Table 5a) with mode of fishing explained 4.2% of the deviance, year (1.6%), and area (0.2%). The GLM model for the total number caught per intercept accounted for 8.3% of the deviance (Table 5b), with hours fished accounting for 3.9% of the deviance, year (2.4%), two-month wave (1.4%), and number of anglers (0.6%).

The catch rates from the Florida Keys were higher in 1991-1993 bottoming out in 1995 and then slightly increasing to 2004 with a drop in 2005 and higher values in 2007 and 2008 (Figure 14). When the catch rates from the three models are superimposed on the same plot together with the nominal catch rate (Figure 15), there is general agreement after 1994. As a means of trying to simplify the patterns, I weighted each scaled index value by the inverse of its coefficient of variation and calculated a weighted average annual catch rate (the heavy line in the figure). The weighted average was variable but increased slightly until 2004 and then dropped to a low in 2006 and then has been higher afterwards.

I think the intercepts from the other regions should be included in the index and so I again recommend using the index with intercepts selected from cluster analysis for southern Florida and applying the index to ages 2 through 6.

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Table 1. Nominal and standardized total catch rates of black grouper from charterboat and private/rental boat MRFSS modes from nearshore and offshore waters from southern Florida using intercepts selected with the Stephens and MacCall logistic regression and with cluster analysis. The number of intercepts were the number of intercepts in the analysis where black grouper were caught.

	Nominal				Stephens and MacCall				Cluster analysis			
				Index				Index				Index
	Number of	Mean catch	Coefficient of	(scaled to	Number of	Mean catch	Coefficient of	(scaled to	Number of	Mean catch	Coefficient of	(scaled to
Year	intercepts	per trip	variation	mean)	intercepts	per trip	variation	mean)	intercepts	per trip	variation	mean)
1991	21	2.190	0.264	0.93	5	0.683	0.379	0.86	21	0.146	0.246	0.49
1992	38	1.789	0.132	0.76	5	0.453	0.564	0.57	38	0.128	0.241	0.43
1993	34	1.941	0.166	0.83	4	0.543	0.841	0.69	34	0.156	0.240	0.52
1994	37	2.838	0.208	1.21	11	0.410	0.590	0.52	37	0.237	0.217	0.80
1995	31	2.323	0.226	0.99	6	0.730	0.383	0.92	31	0.223	0.229	0.75
1996	53	3.396	0.265	1.44	18	0.714	0.670	0.90	53	0.499	0.224	1.68
1997	70	2.571	0.114	1.09	15	0.764	0.285	0.97	69	0.316	0.187	1.06
1998	91	2.231	0.094	0.95	24	0.841	0.359	1.07	90	0.314	0.149	1.06
1999	138	2.638	0.127	1.12	23	1.152	0.416	1.46	137	0.385	0.138	1.29
2000	137	2.080	0.094	0.88	25	0.629	0.364	0.80	136	0.274	0.129	0.92
2001	145	2.241	0.089	0.95	29	0.940	0.363	1.19	144	0.381	0.122	1.28
2002	128	2.398	0.114	1.02	39	1.005	0.404	1.27	128	0.258	0.142	0.87
2003	161	2.745	0.094	1.17	41	0.984	0.337	1.25	159	0.408	0.132	1.37
2004	134	2.694	0.147	1.15	34	0.974	0.339	1.23	131	0.353	0.149	1.19
2005	102	1.951	0.082	0.83	30	0.564	0.470	0.71	102	0.242	0.161	0.81
2006	66	1.727	0.091	0.73	19	0.533	0.375	0.67	65	0.156	0.178	0.53
2007	100	2.020	0.101	0.86	44	0.508	0.450	0.64	97	0.204	0.149	0.69
2008	103	2.107	0.109	0.90	33	0.820	0.311	1.04	103	0.190	0.170	0.64
Total	1589				405				1575			

Table 2. Species names and codes with significant regression coefficients ($\alpha = 0.05$) to predict whether black grouper were caught on MRFSS intercepts for charterboat and private/rental boat MRFSS modes from nearshore and offshore waters from southern Florida.

NODC code	Scientific name	Common name	Regression Coefficient	Std Error
		Intercept	-4.3254	0.0518
8835290101	Coryphaena hippurus	Dolphin	-0.4128	0.0841
8850030501	Scomberomorus cavalla	King mackerel	0.3579	0.0653
8850030102	Euthynnus alletteratus	Little tunny	-0.3423	0.0827
8837010104	Sphyraena barracuda	Great barracuda	0.6454	0.0665
8835360102	Lutjanus griseus	Gray snapper	0.2104	0.0729
8835020408	Epinephelus morio	Red grouper	0.8731	0.0733
8835400102	Haemulon plumieri	White grunt	-0.4850	0.0954
8835360401	Ocyurus chrysurus	Yellowtail snapper	1.2927	0.0623
8835020501	Mycteroperca microlepis	Gag	0.4284	0.0871
8850030502	Scomberomorus maculatus	Spanish mackerel	-0.3875	0.1246
8835360103	Lutjanus analis	Mutton snapper	1.1611	0.0690
8835440102	Cynoscion nebulosus	Spotted seatrout	-1.0594	0.3224
8860020201	Balistes capriscus	Gray triggerfish	-0.6672	0.1357
8835020301	Centropristis striata	Black sea bass	-0.9376	0.2657
8835280801	Seriola dumerili	Greater amberjack	0.8371	0.0981
8835021002	Diplectrum formosum	Sand perch	-0.7412	0.2769
8850030503	Scomberomorus regalis	Cero	1.4920	0.0812
8835250101	Pomatomus saltatrix	Bluefish	-1.0023	0.3609
8835010105	Centropomus undecimalis	Snook	-1.7128	0.5833
8777180202	Arius felis	Hardhead catfish	-1.9205	0.7099
8839010901	Lachnolaimus maximus	Hogfish	1.2199	0.1232
8707020101	Ginglymostoma cirratum	Nurse shark	0.6292	0.1553
8738020201	Megalops atlanticus	Tarpon	-1.0565	0.4628
8835400113	Haemulon sciurus	Bluestriped grunt	0.3776	0.1597
8762020101	Synodus foetens	Inshore lizardfish	-2.0472	1.0032
8747010000	Clupeidae	Herrings	-0.9445	0.3903

Table 3a. Stepwise selection of variables to include in estimating the proportion of positive MRFSS intercepts (shaded lines) with a GLM (binomial distribution and logit link) selected with Stephens and MacCall logistic regression based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	1560	1787.282	1.1457				-893.641			1		1789.28
Year	1543	1760.320	1.1408	0.0049	0.4%		-880.160	-13.481	26.96	17	0.058622	1796.32
Wave	1555	1758.833	1.1311	0.0146	1.3%		-879.416	-14.225	28.45	5	2.97E-05	1770.83
Area	1559	1771.842	1.1365	0.0092	0.8%		-885.921	-7.720	15.44	1	8.51E-05	1775.84
Mode_fx	1559	1744.814	1.1192	0.0265	2.3%		-872.407	-21.234	42.47	1	7.18E-11	1748.81
Region	1558	1652.426	1.0606	0.0851	7.4%	7.4%	-826.213	-67.428	134.86	2	5.2E-30	1658.43
Avidity	1554	1768.646	1.1381	0.0076	0.7%		-884.323	-9.318	18.64	6	0.004824	1782.65
Hr fished	1554	1758.404	1.1315	0.0142	1.2%		-879.202	-14.439	28.88	6	6.42E-05	1772.40
Num anglers	1554	1779.619	1.1452	0.0005	0.0%		-889.810	-3.831	7.66	6	0.263863	1793.62
With region												
Year	1541	1627.777	1.0563	0.0043	0.4%		-813.889	-12.325	24.65	17	0.102842	1667.78
Wave	1553	1640.462	1.0563	0.0043	0.4%		-820.231	-5.982	11.96	5	0.035287	1656.46
Area	1557	1651.022	1.0604	0.0002	0.0%		-825.511	-0.702	1.40	1	0.235988	1659.02
Mode_fx	1557	1646.235	1.0573	0.0033	0.3%		-823.118	-3.096	6.19	1	0.012839	1654.24
Avidity	1552	1646.475	1.0609	-0.0003	0.0%		-823.237	-2.976	5.95	6	0.428611	1664.47
Hr fished	1552	1634.929	1.0534	0.0072	0.6%	8.1%	-817.464	-8.749	17.50	6	0.007618	1652.93
Num anglers	1552	1645.613	1.0603	0.0003	0.0%		-822.807	-3.407	6.81	6	0.338488	1663.61
With region and hr_fished												
Year	1535	1612.281	1.0503	0.0031	0.3%		-806.141	-11.324	22.65	17	0.161079	1664.28
Wave	1547	1622.576	1.0489	0.0045	0.4%		-811.288	-6.177	12.35	5	0.030258	1650.58
Area	1551	1634.360	1.0537	-0.0003	0.0%		-817.180	-0.284	0.57	1	0.450975	1654.36
Mode_fx	1551	1630.007	1.0509	0.0025	0.2%	8.3%	-815.004	-2.461	4.92	1	0.026529	1650.01
Avidity	1546	1629.183	1.0538	-0.0004	0.0%		-814.592	-2.873	5.75	6	0.452283	1659.18
Num anglers	1546	1630.134	1.0544	-0.001	-0.1%		-815.067	-2.397	4.79	6	0.570414	1660.13
With region, hr_fished, and mode_fx												
Year	1534	1609.757	1.0494	0.0015	0.1%		-804.878	-10.125	20.25	17	0.261613	1663.76
Wave	1546	1618.349	1.0468	0.0041	0.4%	8.6%	-809.175	-5.829	11.66	5	0.039787	1648.35
Area	1550	1629.990	1.0516	-0.0007	-0.1%		-814.995	-0.009	0.02	1	0.893864	1651.99
Avidity	1545	1625.150	1.0519	-0.001	-0.1%		-812.575	-2.428	7	6	0.320847	1657.15
Num anglers	1545	1624.304	1.0513	-0.0004	0.0%		-812.152	-2.852	7	6	0.320847	1656.30
With region, hr_fished, mode_fx, and wave												
Year	1529	1597.406	1.0447	0.0021	0.2%		-798.703	-10.472	20.94	17	0.228832	1661.41
Area	1545	1618.348	1.0475	-0.0007	-0.1%		-809.174	-0.001	0.00	1	0.968093	1650.35
Avidity	1540	1613.600	1.0478	-0.001	-0.1%		-806.800	-2.375	12	6	0.061969	1655.60
Num anglers	1540	1613.550	1.0478	-0.001	-0.1%		-806.775	-2.400	12	6	0.061969	1655.55

Table 3b. Stepwise selection of variables to include in estimating the total catch of black grouper on positive MRFSS intercepts (shaded lines) with a GLM (gamma distribution and log link) selected with Stephens and MacCall logistic regression based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	404	322.8151	0.7990				-857.751			2		1719.50
Year	387	290.6065	0.7509	0.0481	6.0%		-834.142	-23.609	47.22	17	0.000113	1706.28
Wave	399	313.2494	0.7851	0.0139	1.7%		-850.974	-6.778	13.56	5	0.018693	1715.95
Area	403	321.6533	0.7981	0.0009	0.1%		-856.938	-0.813	1.63	1	0.202146	1719.88
Mode_fx	403	320.8231	0.7961	0.0029	0.4%		-856.355	-1.396	2.79	1	0.094712	1718.71
Region	402	309.5968	0.7701	0.0289	3.6%	3.6%	-848.335	-9.416	18.83	2	8.14E-05	1704.67
Avidity	398	317.4358	0.7976	0.0014	0.2%		-853.963	-3.789	7.58	6	0.270743	1723.93
Hr fished	398	304.6056	0.7653	0.0337	4.2%		-844.684	-13.067	26.13	6	0.00021	1705.37
Num anglers	398	314.6446	0.7906	0.0084	1.1%		-851.974	-5.778	11.56	6	0.07266	1719.95
With region												
Year	385	280.0020	0.7273	0.0428	5.4%		-825.841	-22.494	44.99	17	0.000244	1693.68
Wave	397	301.9986	0.7607	0.0094	1.2%		-842.755	-5.580	11.16	5	0.048283	1703.51
Area	401	309.1883	0.7710	-0.0009	-0.1%		-848.039	-0.297	0.59	1	0.44103	1706.08
Mode_fx	401	309.3780	0.7715	-0.0014	-0.2%		-848.177	-0.159	0.32	1	0.572933	1706.35
Avidity	396	303.9356	0.7675	0.0026	0.3%		-844.190	-4.146	8.29	6	0.217522	1708.38
Hr fished	396	293.7186	0.7417	0.0284	3.6%	7.2%	-836.525	-11.810	23.62	6	0.000613	1693.05
Num anglers	396	302.4297	0.7637	0.0064	0.8%		-843.075	-5.260	10.52	6	0.104365	1706.15
With region and hours fished												
Year	379	269.3114	0.7106	0.0311	3.9%	11.1%	-817.174	-19.351	38.70	17	0.001966	1688.35
Wave	391	285.4123	0.7300	0.0117	1.5%		-830.112	-6.414	12.83	5	0.025051	1690.22
Area	395	293.1535	0.7422	-0.0005	-0.1%		-836.094	-0.431	0.86	1	0.353124	1694.19
Mode_fx	395	293.1042	0.7420	-0.0003	0.0%		-836.057	-0.469	0.94	1	0.332947	1694.11
Avidity	390	289.6324	0.7426	-0.0009	-0.1%		-833.391	-3.134	6.27	6	0.393848	1698.78
Num anglers	390	288.1504	0.7388	0.0029	0.4%		-832.245	-4.281	8.56	6	0.199788	1696.49
With region, hours fished, and year												
Wave	374	263.7187	0.7051	0.0055	0.7%		-812.513	-4.661	9.32	5	0.096882	1689.03
Area	378	269.1331	0.7120	-0.0014	-0.2%		-817.027	-0.147	0.29	1	0.587415	1690.05
Mode_fx	378	269.1804	0.7121	-0.0015	-0.2%		-817.066	-0.108	0.22	1	0.641951	1690.13
Avidity	373	266.8054	0.7153	-0.0047	-0.6%		-815.097	-2.077	4.15	6	0.655737	1696.19
Num anglers	373	262.4413	0.7036	0.0070	0.9%		-811.436	-5.739	11.48	6	0.074701	1688.87

Table 4a. Stepwise selection of variables to include in estimating the proportion of positive MRFSS intercepts (shaded lines) with a GLM (binomial distribution and logit link) selected by cluster analysis based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	9630	8580.9235	0.8911				-4290.46			1		8582.92
Year	9613	8391.5473	0.8729	0.0182	2.0%		-4195.77	-94.688	189.38	17	3.87E-31	8427.55
Wave	9625	8327.2048	0.8652	0.0259	2.9%		-4163.60	-126.859	253.72	5	8.75E-53	8339.20
Area	9629	8425.0095	0.8750	0.0161	1.8%		-4212.50	-77.957	155.91	1	8.84E-36	8429.01
Mode_fx	9629	8110.3778	0.8423	0.0488	5.5%		-4055.19	-235.273	470.55	1	2.4E-104	8114.38
Region	9628	7706.5930	0.8004	0.0907	10.2%	10.2%	-3853.30	-437.165	874.33	2	1.4E-190	7712.59
Avidity	9624	8453.9139	0.8784	0.0127	1.4%		-4226.96	-63.505	127.01	6	5.48E-25	8467.91
Hr fished	9624	8505.3400	0.8838	0.0073	0.8%		-4252.67	-37.792	75.58	6	2.91E-14	8519.34
Num anglers	9624	8509.2649	0.8842	0.0069	0.8%		-4254.63	-35.829	71.66	6	1.87E-13	8523.27
With region												
Year	9611	7539.2145	0.7844	0.0160	1.8%	12.0%	-3769.61	-83.689	167.38	17	9.27E-27	7579.21
Wave	9623	7609.3970	0.7908	0.0096	1.1%		-3804.70	-48.598	97.20	5	2.06E-19	7625.40
Area	9627	7673.1451	0.7970	0.0034	0.4%		-3836.57	-16.724	33.45	1	7.32E-09	7681.15
Mode_fx	9627	7605.9503	0.7901	0.0103	1.2%		-3802.98	-50.321	100.64	1	1.1E-23	7613.95
Avidity	9622	7677.4296	0.7979	0.0025	0.3%		-3838.71	-14.582	29.16	6	5.67E-05	7695.43
Hr fished	9622	7681.9496	0.7984	0.0020	0.2%		-3840.97	-12.322	24.64	6	0.000397	7699.95
Num anglers	9622	7694.8563	0.7997	0.0007	0.1%		-3847.43	-5.868	11.74	6	0.068105	7712.86
With region and year												
Wave	9606	7466.3480	0.7773	0.0071	0.8%	12.8%	-3733.17	-36.433	72.87	5	2.59E-14	7516.35
Area	9610	7532.8798	0.7839	0.0005	0.1%		-3766.44	-3.167	6.33	1	0.011839	7574.88
Mode_fx	9610	7490.6707	0.7795	0.0049	0.5%		-3745.34	-24.272	48.54	1	3.23E-12	7532.67
Avidity	9605	7522.0711	0.7831	0.0013	0.1%		-3761.04	-8.572	17.14	6	0.00877	7574.07
Hr fished	9605	7523.8490	0.7833	0.0011	0.1%		-3761.92	-7.683	15.37	6	0.017596	7575.85
Num anglers	9605	7534.9188	0.7845	-0.0001	0.0%		-3767.46	-2.148	4.30	6	0.636715	7586.92
With region, year, and wave												
Area	9605	7458.5751	0.7765	0.0008	0.1%		-3729.29	-3.886	7.77	1	0.005304	7510.58
Mode_fx	9605	7431.2529	0.7737	0.0036	0.4%	13.2%	-3715.63	-17.548	35.10	1	3.14E-09	7483.25
Avidity	9600	7454.4456	0.7765	0.0008	0.1%		-3727.22	-5.951	11.90	6	0.064182	7516.45
Hr fished	9600	7451.6970	0.7762	0.0011	0.1%		-3725.85	-7.325	14.65	6	0.023152	7513.70
Num anglers	9600	7461.9808	0.7773	0.0000	0.0%		-3730.99	-2.184	4.37	6	0.627115	7523.98
With region, year, wave, and mode_fx												
Area	9604	7430.0710	0.7736	0.0001	0.0%		-3715.04	-0.591	1.18	1	0.27699	7484.07
Avidity	9599	7426.9647	0.7737	0.0000	0.0%		-3713.48	-2.144	4.29	6	0.637765	7490.96
Hr fished	9599	7418.2387	0.7728	0.0009	0.1%	13.3%	-3709.12	-6.507	13.01	6	0.042811	7482.24
Num anglers	9599	7423.9326	0.7734	0.0003	0.0%		-3711.97	-3.660	7.32	6	0.292247	7487.93
With region, year, wave, and mode_fx												
Area	9598	7417.6783	0.7728	0.0000	0.0%		-3708.84	-0.280	0.56	1	0.454099	7483.68
Avidity	9593	7413.4462	0.7728	0.0000	0.0%		-3706.72	-2.396	4.79	6	0.570702	7489.45
Num anglers	9593	7411.2253	0.7726	0.0002	0.0%		-3705.61	-3.507	7.01	6	0.319628	7487.23

Table 4b. Stepwise selection of variables to include in estimating the total catch of black grouper on positive MRFSS intercepts (shaded lines) with a GLM (gamma distribution and log link) selected by cluster analysis based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	1574	1069.1975	0.6793				-2827.95			2		5659.89
Year	1557	1032.3518	0.6630	0.0163	2.4%		-2797.62	-30.324	60.65	17	8.21E-07	5633.25
Wave	1569	1051.7460	0.6703	0.0090	1.3%		-2813.71	-14.240	28.48	5	2.93E-05	5641.41
Area	1573	1067.9699	0.6789	0.0004	0.1%		-2826.95	-0.995	1.99	1	0.158404	5659.90
Mode_fx	1573	1066.1864	0.6778	0.0015	0.2%		-2825.51	-2.442	4.88	1	0.027116	5657.01
Region	1572	1022.3759	0.6504	0.0289	4.3%	4.3%	-2789.24	-38.705	77.41	2	1.55E-17	5586.48
Avidity	1568	1058.3414	0.6750	0.0043	0.6%		-2819.11	-8.833	17.67	6	0.007123	5654.23
Hr fished	1568	1025.5499	0.6540	0.0253	3.7%		-2791.92	-36.030	72.06	6	1.54E-13	5599.83
Num anglers	1568	1058.8786	0.6753	0.0040	0.6%		-2819.55	-8.394	16.79	6	0.010095	5655.11
With region												
Year	1555	985.3265	0.6337	0.0167	2.5%		-2757.44	-31.805	63.61	17	2.63E-07	5556.87
Wave	1567	1011.0059	0.6452	0.0052	0.8%		-2779.60	-9.646	19.29	5	0.001696	5577.19
Area	1571	1022.3733	0.6508	-0.0004	-0.1%		-2789.24	-0.002	0.00	1	0.945926	5588.48
Mode_fx	1571	1022.0419	0.6506	-0.0002	0.0%		-2788.96	-0.282	0.56	1	0.452653	5587.92
Avidity	1566	1012.0466	0.6463	0.0041	0.6%		-2780.48	-8.759	17.52	6	0.007558	5580.97
Hr fished	1566	989.5387	0.6319	0.0185	2.7%	7.0%	-2761.11	-28.134	56.27	6	2.57E-10	5542.21
Num anglers	1566	1009.4514	0.6446	0.0058	0.9%		-2778.27	-10.972	21.94	6	0.001239	5576.54
With region and hours fished												
Year	1549	959.1465	0.6192	0.0127	1.9%	8.8%	-2734.29	-26.820	53.64	17	1.13E-05	5522.57
Wave	1561	978.1829	0.6266	0.0053	0.8%		-2751.18	-9.931	19.86	5	0.001327	5532.35
Area	1565	988.5457	0.6317	0.0002	0.0%		-2760.24	-0.864	1.73	1	0.188641	5542.49
Mode_fx	1565	988.7134	0.6318	0.0001	0.0%		-2760.39	-0.718	1.44	1	0.230755	5542.78
Avidity	1560	980.6454	0.6286	0.0033	0.5%		-2753.34	-7.768	15.54	6	0.016472	5538.68
Num anglers	1560	978.2617	0.6271	0.0048	0.7%		-2751.25	-9.861	19.72	6	0.003102	5534.49
With region, hours fished, and year												
Wave	1544	945.7788	0.6126	0.0066	1.0%	9.8%	-2722.24	-12.047	24.09	5	0.000208	5508.48
Area	1548	958.1446	0.6190	0.0002	0.0%		-2733.39	-0.897	1.79	1	0.180343	5522.78
Mode_fx	1548	959.0470	0.6195	-0.0003	0.0%		-2734.20	-0.089	0.18	1	0.673098	5524.40
Avidity	1543	952.2623	0.6171	0.0021	0.3%		-2728.10	-6.184	12.37	6	0.054229	5522.21
Num anglers	1543	949.3491	0.6153	0.0039	0.6%		-2725.47	-8.814	17.63	6	0.007233	5516.95
With region, hours fished, and year												
Area	1543	945.1804	0.6126	0.0000	0.0%		-2721.70	-0.543	1.09	1	0.297359	5509.39
Mode_fx	1543	945.6013	0.6128	-0.0002	0.0%		-2722.08	-0.161	0.32	1	0.570408	5510.16
Avidity	1538	938.7809	0.6104	0.0022	0.3%		-2715.87	-6.370	12.74	6	0.04737	5507.74
Num anglers	1538	935.4276	0.6082	0.0044	0.6%	10.5%	-2712.80	-9.437	18.87	6	0.00438	5501.61
With region, hours fished, year, num_anglers												
Area	1537	935.0833	0.6084	-0.0002	0.0%		-2712.49	-0.316	0.63	1	0.426915	5502.97
Mode_fx	1537	935.4248	0.6086	-0.0004	-0.1%		-2712.80	-0.003	0.01	1	0.942514	5503.60
Avidity	1532	929.3721	0.6066	0.0016	0.2%		-2707.24	-5.566	11.13	6	0.084381	5502.47

Table 5a. Stepwise selection of variables to include in estimating the proportion of positive MRFSS intercepts (shaded lines) with a GLM (binomial distribution and logit link) selected by cluster analysis from the Florida Keys based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	2050	2759.5546	1.3461				-1379.777			1		2761.55
Year	2033	2632.4268	1.2948	0.0513	3.8%		-1316.213	-63.564	127.128	17	6.68291E-19	2668.43
Wave	2045	2729.1472	1.3345	0.0116	0.9%		-1364.574	-15.204	30.407	5	1.22606E-05	2741.15
Area	2049	2698.1436	1.3168	0.0293	2.2%		-1349.072	-30.706	61.411	1	4.63215E-15	2702.14
Mode_fx	2049	2642.8790	1.2898	0.0563	4.2%	4.2%	-1321.440	-58.338	116.676	1	3.3808E-27	2646.88
Avidity	2044	2709.3350	1.3255	0.0206	1.5%		-1354.668	-25.110	50.220	6	4.24782E-09	2723.34
Hr fished	2044	2736.4567	1.3388	0.0073	0.5%		-1368.228	-11.549	23.098	6	0.000764376	2750.46
Num anglers	2044	2738.9681	1.3400	0.0061	0.5%		-1369.484	-10.293	20.586	6	0.002176286	2752.97
With mode_fx												
Year	2032	2576.9632	1.2682	0.0216	1.6%	5.8%	-1288.482	-32.958	65.916	17	1.07558E-07	2614.96
Wave	2044	2638.0775	1.2906	-0.0008	-0.1%		-1319.039	-2.401	4.802	5	0.44057003	2652.08
Area	2048	2633.2568	1.2858	0.0040	0.3%		-1316.628	-4.811	9.622	1	0.001922393	2639.26
Avidity	2043	2638.3583	1.2914	-0.0016	-0.1%		-1319.179	-2.260	4.521	6	0.606592922	2654.36
Hr fished	2043	2636.2955	1.2904	-0.0006	0.0%		-1318.148	-3.292	6.583	6	0.36109607	2652.30
Num anglers	2043	2636.5824	1.2905	-0.0007	-0.1%		-1318.291	-3.148	6.297	6	0.390797973	2652.58
With mode_fx and year												
Wave	2027	2572.0968	1.2689	-0.0007	-0.1%		-1286.048	-2.433	4.866	5	0.432401729	2620.10
Area	2031	2570.5743	1.2657	0.0025	0.2%	6.0%	-1285.287	-3.194	6.389	1	0.011484265	2610.57
Avidity	2026	2572.3928	1.2697	-0.0015	-0.1%		-1286.196	-2.285	4.570	6	0.599967298	2622.39
Hr fished	2026	2571.1344	1.2691	-0.0009	-0.1%		-1285.567	-2.914	5.829	6	0.442638908	2621.13
Num anglers	2026	2570.4865	1.2687	-0.0005	0.0%		-1285.243	-3.238	6.477	6	0.37194737	2620.49
With mode_fx, year, and area												
Wave	2026	2565.2249	1.2662	-0.0005	0.0%		-1282.612	-2.675	5.350	5	0.374719705	2613.22
Avidity	2025	2565.9856	1.2672	-0.0015	-0.1%		-1282.993	-2.294	4.589	6	0.597524403	2615.99
Hr fished	2025	2564.7846	1.2666	-0.0009	-0.1%		-1282.392	-2.895	5.790	6	0.447144145	2614.78
Num anglers	2025	2565.1373	1.2667	-0.0010	-0.1%		-1282.569	-2.719	5.437	6	0.489079204	2615.14

Table 5b. Stepwise selection of variables to include in estimating the total catch of black grouper on positive MRFSS intercepts (shaded lines) with a GLM (gamma distribution and log link) selected by cluster analysis from the Florida Keys based on lowest AIC values. The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the Akaike Information Criterion (AIC).

| Variables	df	Deviance	Mean dev	Δ mean dev	% expl	Cum %	log like	Δ log like	Chi sq	df	Prob Ho	AIC
Null	1231	872.1446	0.7085				-2300.264			2		4604.53
Year	1214	831.0690	0.6846	0.0239	3.4%		-2267.543	-32.721	65.441	17	1.29E-07	4573.09
Wave	1226	857.3432	0.6993	0.0092	1.3%		-2288.640	-11.624	23.248	5	0.000303	4591.28
Area	1230	872.0383	0.7090	-0.0005	-0.1%		-2300.181	-0.083	0.166	1	0.684052	4606.36
Mode_fx	1230	871.7051	0.7087	-0.0002	0.0%		-2299.922	-0.343	0.685	1	0.40787	4605.84
Avidity	1225	862.5167	0.7041	0.0044	0.6%		-2292.724	-7.540	15.081	6	0.019639	4601.45
Hr fished	1225	833.9890	0.6808	0.0277	3.9%	3.9%	-2269.918	-30.346	60.692	6	3.26E-11	4555.84
Num anglers	1225	860.5386	0.7025	0.0060	0.8%		-2291.165	-9.099	18.198	6	0.005756	4598.33
With hr_fished												
Year	1208	801.9274	0.6638	0.0170	2.4%	6.3%	-2243.413	-26.505	53.011	17	1.42E-05	4536.83
Wave	1220	821.1442	0.6731	0.0077	1.1%		-2259.414	-10.504	21.008	5	0.000807	4544.58
Area	1224	833.2657	0.6808	0.0000	0.0%		-2269.331	-0.588	1.175	1	0.278376	4556.66
Mode_fx	1224	832.5000	0.6801	0.0007	0.1%		-2268.708	-1.210	2.420	1	0.119795	4555.42
Avidity	1219	826.4495	0.6780	0.0028	0.4%		-2263.771	-6.147	12.295	6	0.05571	4555.54
Num anglers	1219	824.0397	0.6760	0.0048	0.7%		-2261.795	-8.123	16.246	6	0.012493	4551.59
With hr_fished and year												
Wave	1203	786.7187	0.6540	0.0098	1.4%	7.7%	-2230.496	-12.917	25.834	5	9.61E-05	4520.99
Area	1207	800.7181	0.6634	0.0004	0.1%		-2242.394	-1.019	2.037	1	0.153472	4536.79
Mode_fx	1207	800.8899	0.6635	0.0003	0.0%		-2242.539	-0.874	1.748	1	0.186154	4537.08
Avidity	1202	796.0290	0.6623	0.0015	0.2%		-2238.430	-4.983	9.965	6	0.126134	4538.86
Num anglers	1202	791.7310	0.6587	0.0051	0.7%		-2234.778	-8.635	17.269	6	0.008343	4531.56
With hr_fished, year, and wave												
Area	1202	786.0609	0.6540	0.0000	0.0%		-2229.932	-0.564	1.128	1	0.288245	4521.86
Mode_fx	1202	784.9472	0.6530	0.0010	0.1%		-2228.976	-1.520	3.039	1	0.081276	4519.95
Avidity	1197	780.3705	0.6519	0.0021	0.3%		-2225.036	-5.460	10.920	6	0.090874	4522.07
Num anglers	1197	777.4994	0.6495	0.0045	0.6%	8.3%	-2222.553	-7.943	15.886	6	0.01438	4517.11
With hr_fished, year, wave, and num_angl												
Area	1196	777.3119	0.6499	-0.0004	-0.1%		-2222.390	-0.162	0.325	1	0.568618	4518.78
Mode_fx	1196	776.4924	0.6492	0.0003	0.0%		-2221.680	-0.873	1.746	1	0.18638	4517.36
Avidity	1191	771.4814	0.6478	0.0017	0.2%		-2217.321	-5.232	10.464	6	0.106423	4518.64
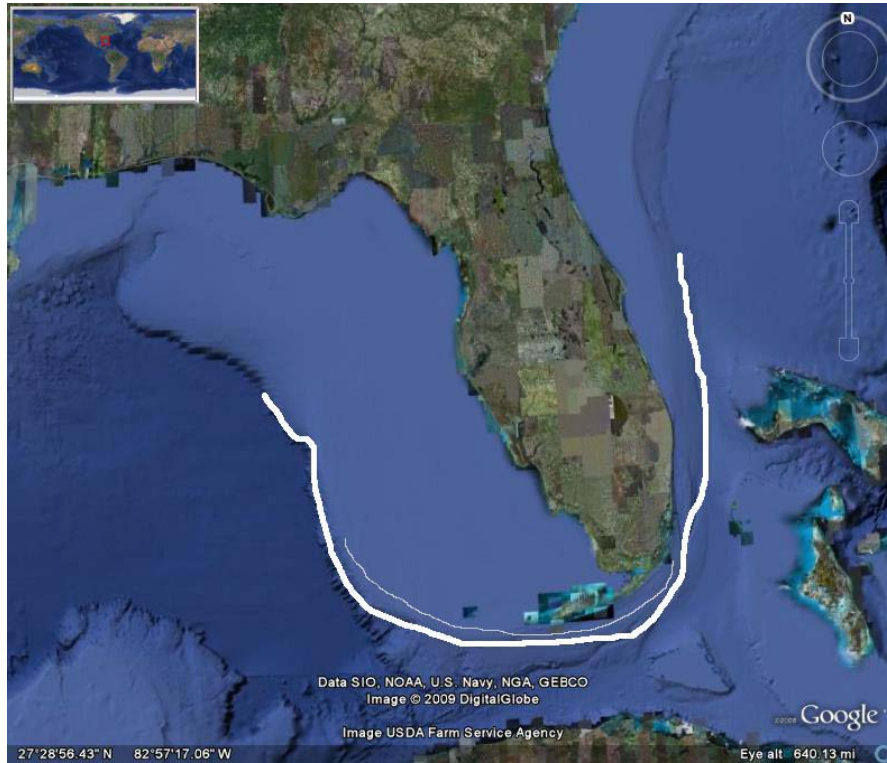
Figure 1. A map of Florida indicating the region from Tampa Bay to Cape Canaveral (thick line) and the Florida Keys (thin line).
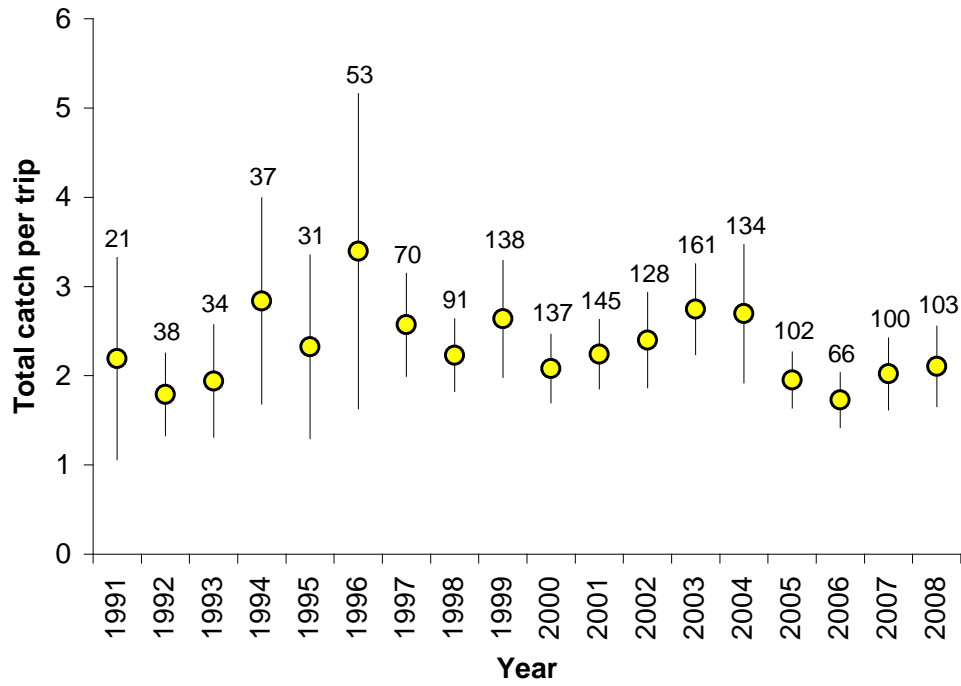
Figure 2. Nominal catch rate of black grouper by year from southern Florida. The vertical lines are the 95% confidence interval and the circle is the mean. The numbers above the figures are the number of intercepts in the private/rental and charterboat modes from southern Florida per year.
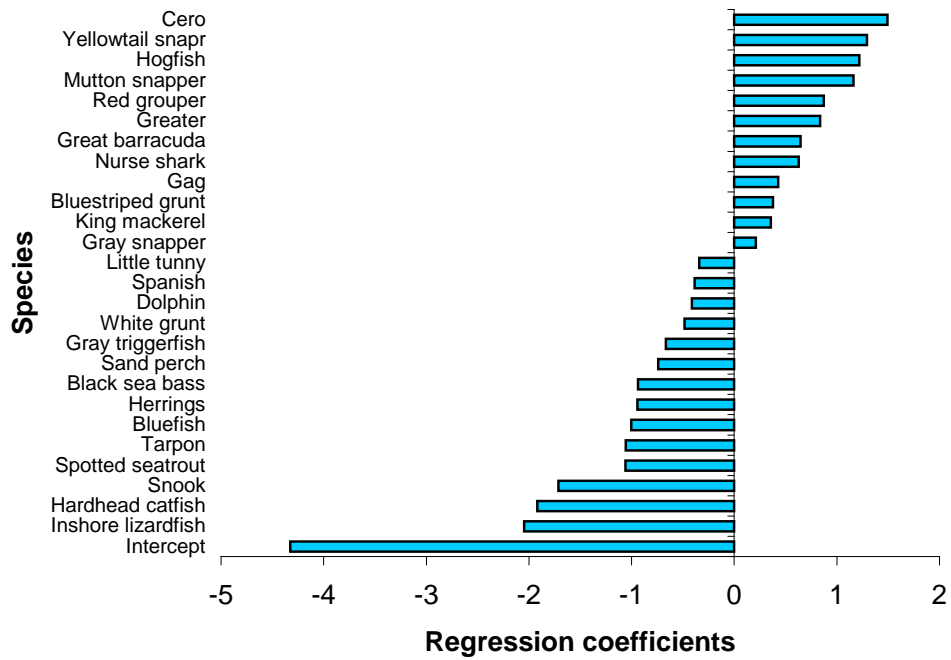
Figure 3. Species with significant logistic regression coefficients at the 0.05 level for determining whether a MRFSS intercept should be selected for calculating annual total catch rates using the Stephens and MacCall method.
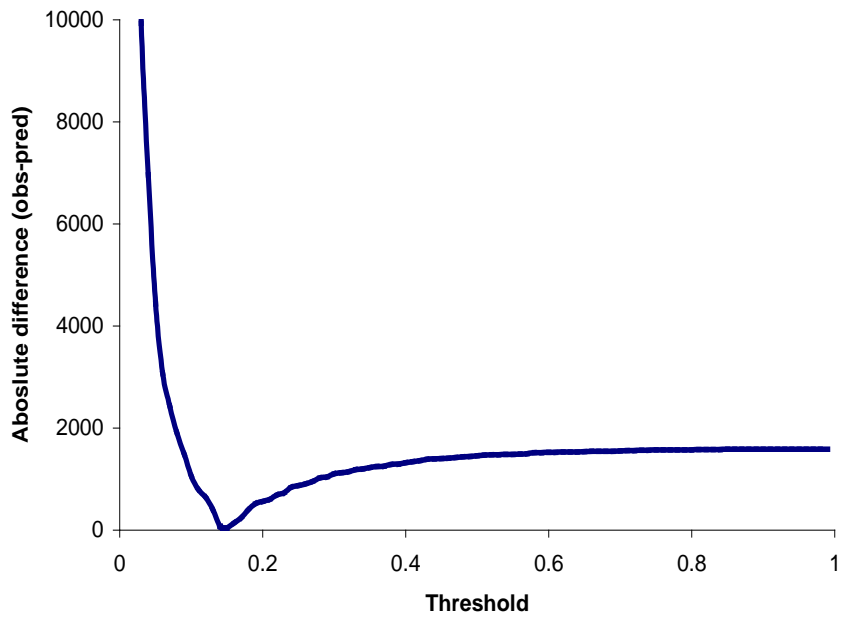
Figure 4. Absolute difference between the number of observed and predicted intercepts with black grouper from the logistic regression over a range of threshold values.

a.

b.

c.

d.

e.
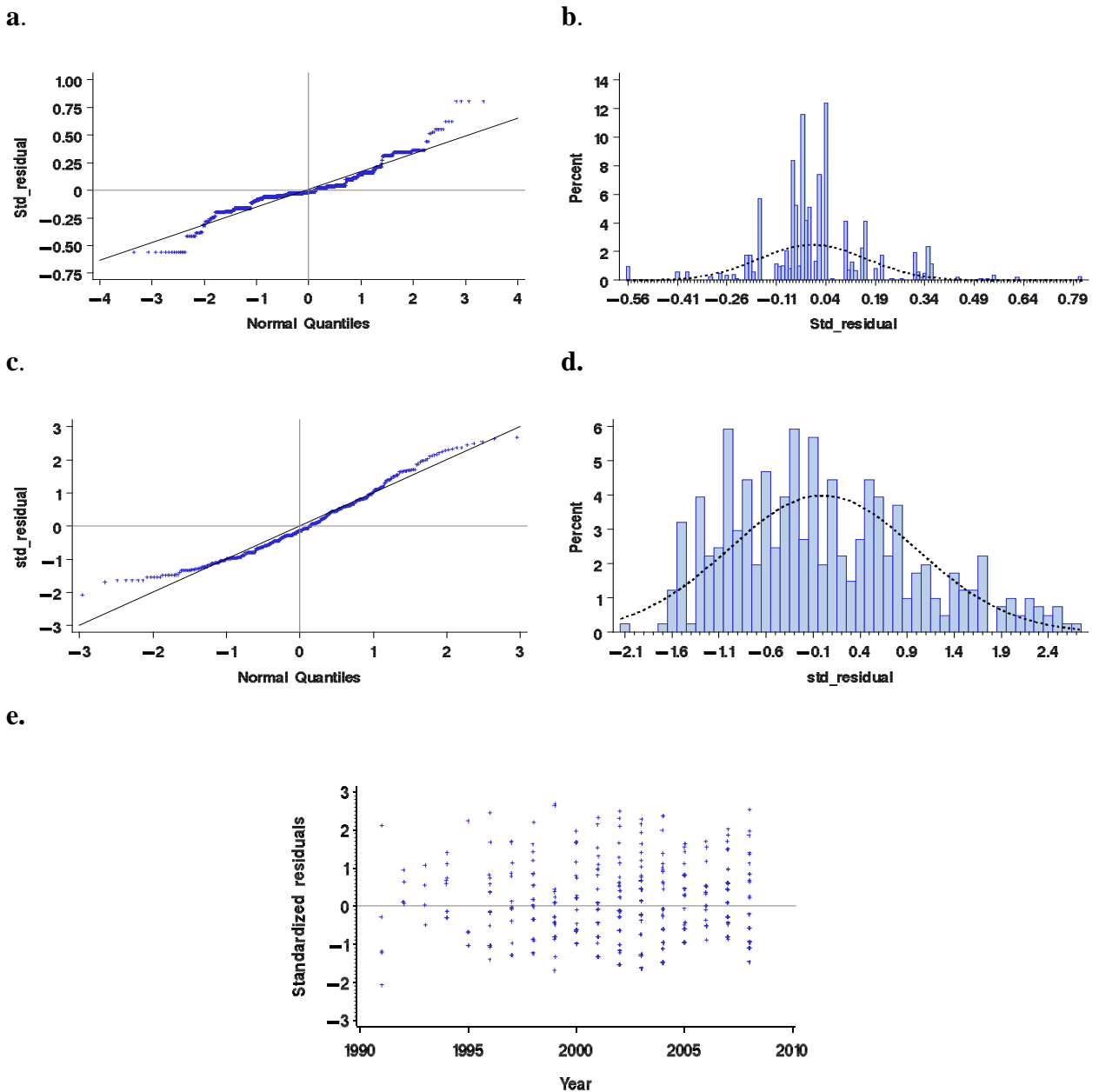
Figure 5. Quantiles plot (a) and distribution (b) of standardized residuals for the proportion of positive catches of black grouper from the generalized linear model (GLM) with a binomial distribution and a logit link and quantiles plot (c), distribution (d), and plot of standardized residuals by year (e) for the number of black grouper positive intercepts from the GLM with a gamma distribution and a log link for the intercepts identified with the Stephens and MacCall regression.
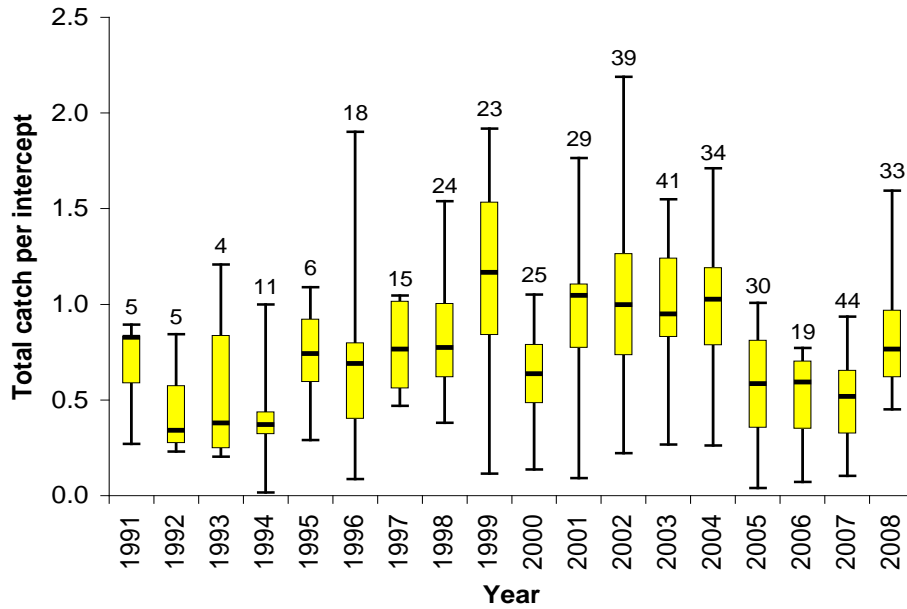
Figure 6. Standardized annual total catch of black grouper per angler hour per intercept with intercepts selected by Stephens and MacCall's logistic regression. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of intercepts that caught black grouper for each year.
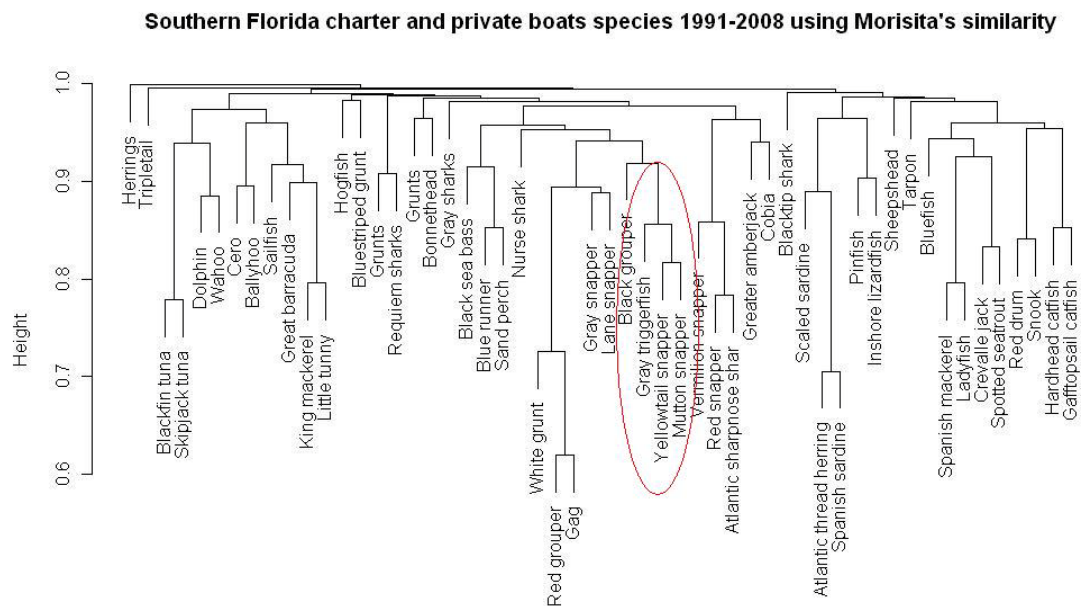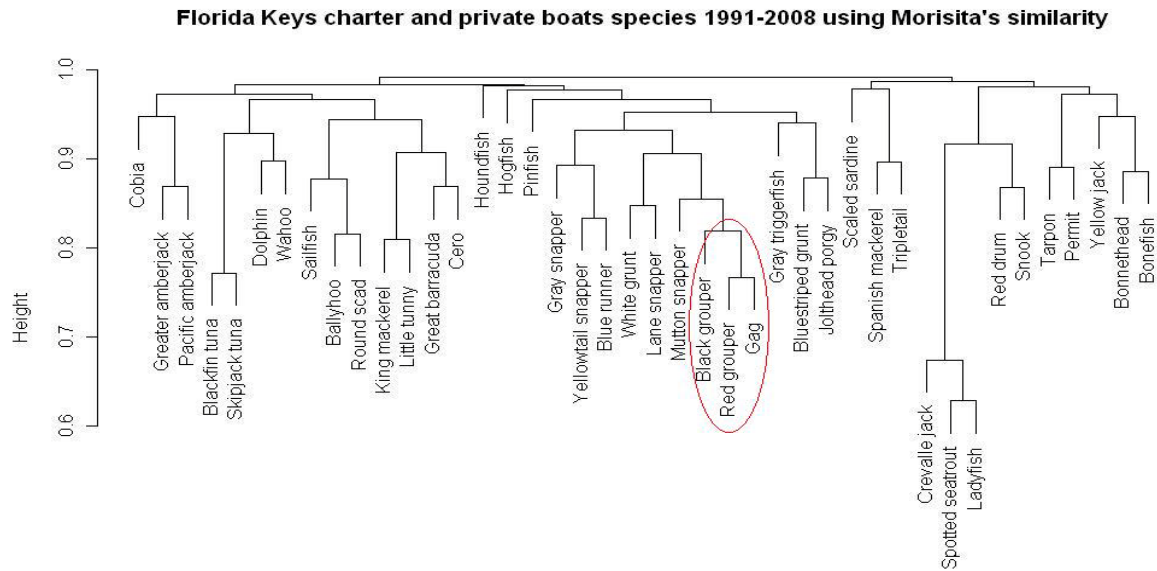
Figure 7. Species clusters identified with hierarchical cluster analysis of pair-wise similarity of species by trip for MRFSS charterboat and private/rental intercepts from nearshore and offshore waters for the southern portion of Florida (Pinellas through Volusia counties) for 1991-2008. The cluster containing black grouper is in the ellipse.
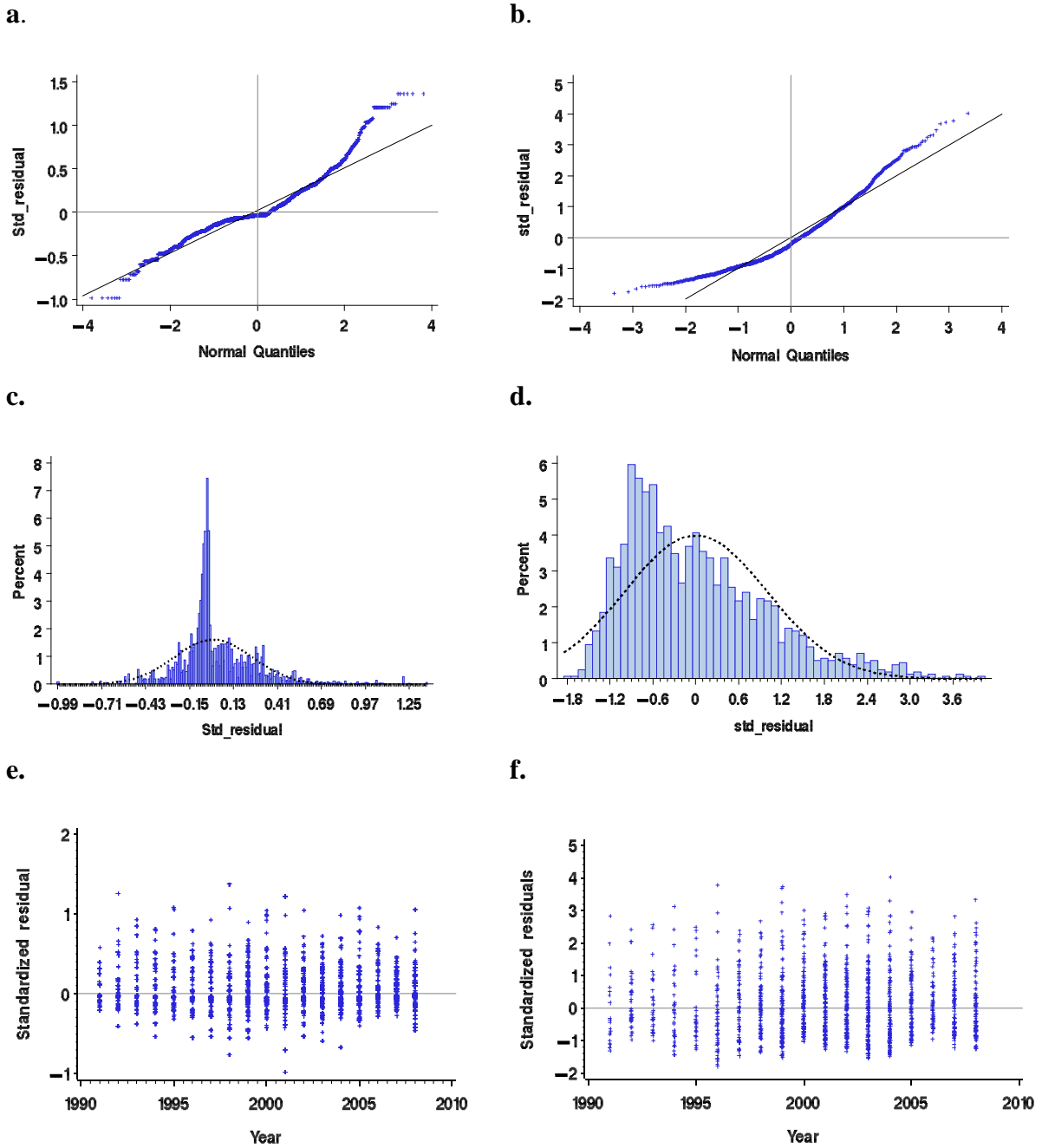
Figure 8. Quantiles plot (a), distribution (c), and plot of standardized residuals by year (e) for the proportion of positive catches of black grouper from the generalized linear model with a binomial distribution and a logit link for the intercepts identified with cluster analysis and quantiles plot (b) and distribution (d) and plot of standardized residuals by year (e) for the number of black grouper per intercept from the generalized linear model with a gamma distribution and a log link for the intercepts identified with cluster analysis.
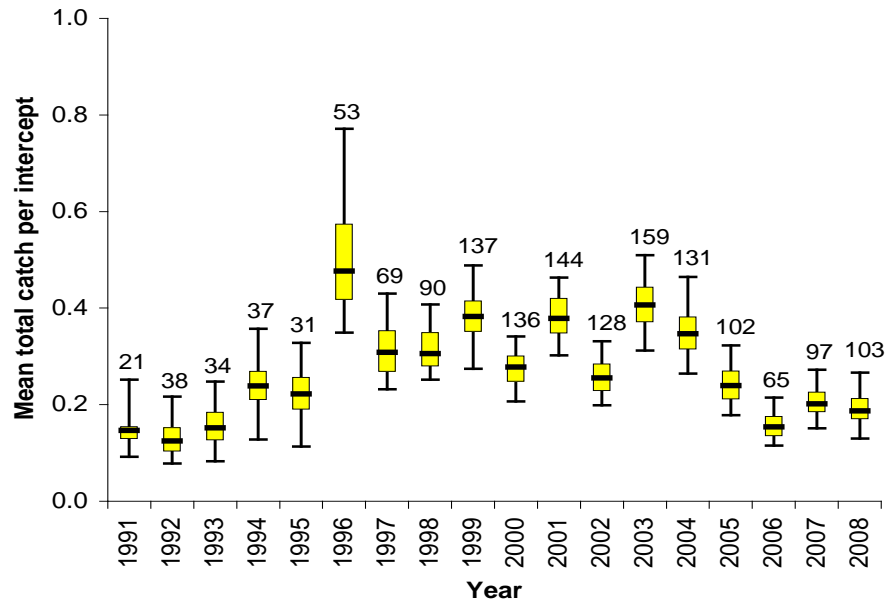
Figure 9. Standardized total catch of black grouper per intercept with intercepts selected by cluster analysis. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of intercepts that caught black grouper for the year.
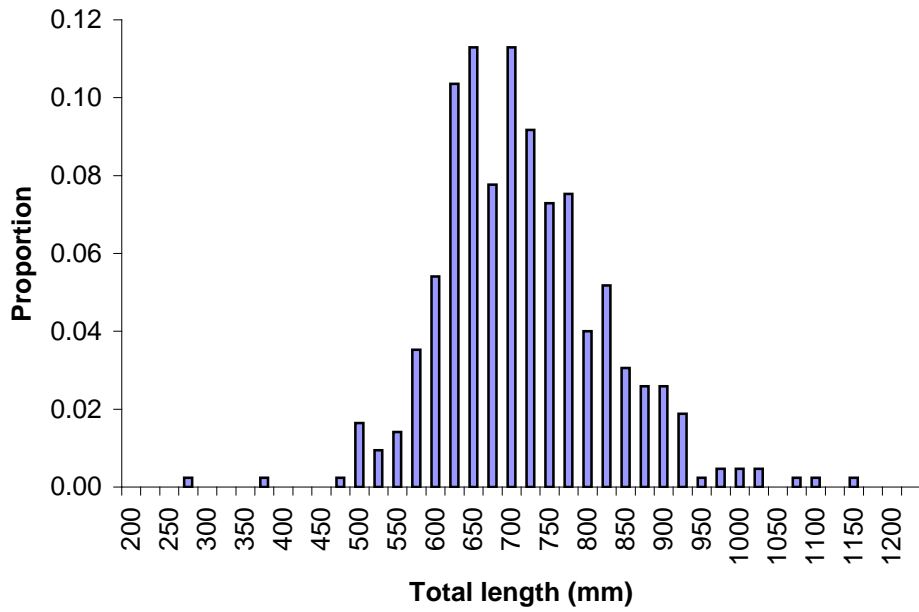
**Figure 10.** Total lengths of black grouper measured by MRFSS samplers from 2000-2008 in southern Florida.
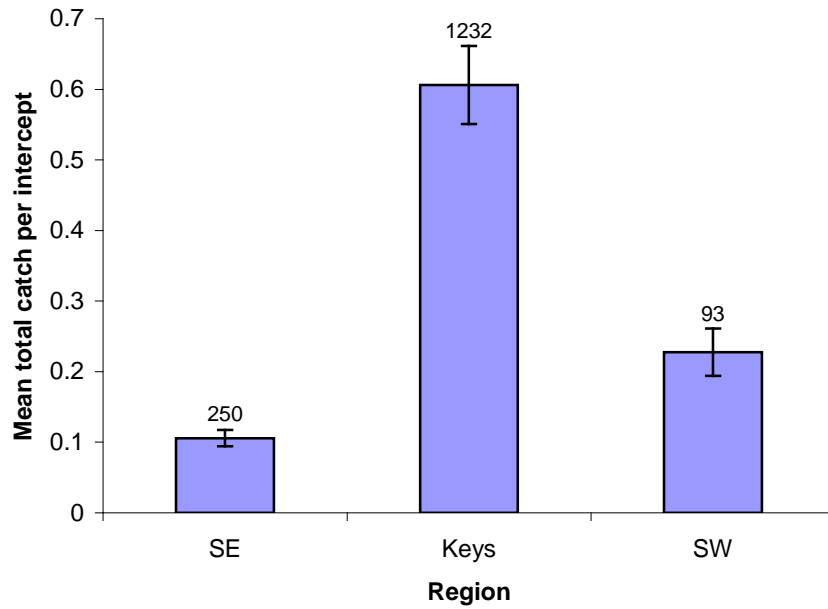
Figure 11. Standardized catch rate by region with intercepts selected by cluster analysis. The vertical lines are one standard deviation and the numbers above the bar are the number of intercepts per region.

Figure 12. Species clusters identified with hierarchical cluster analysis of pair-wise similarity of species by intercept for MRFSS charterboat and private/rental intercepts from nearshore and offshore waters for MRFSS intercepts only from the Florida Keys (Monroe county) for 1991-2008. The cluster containing black grouper is in the ellipse.
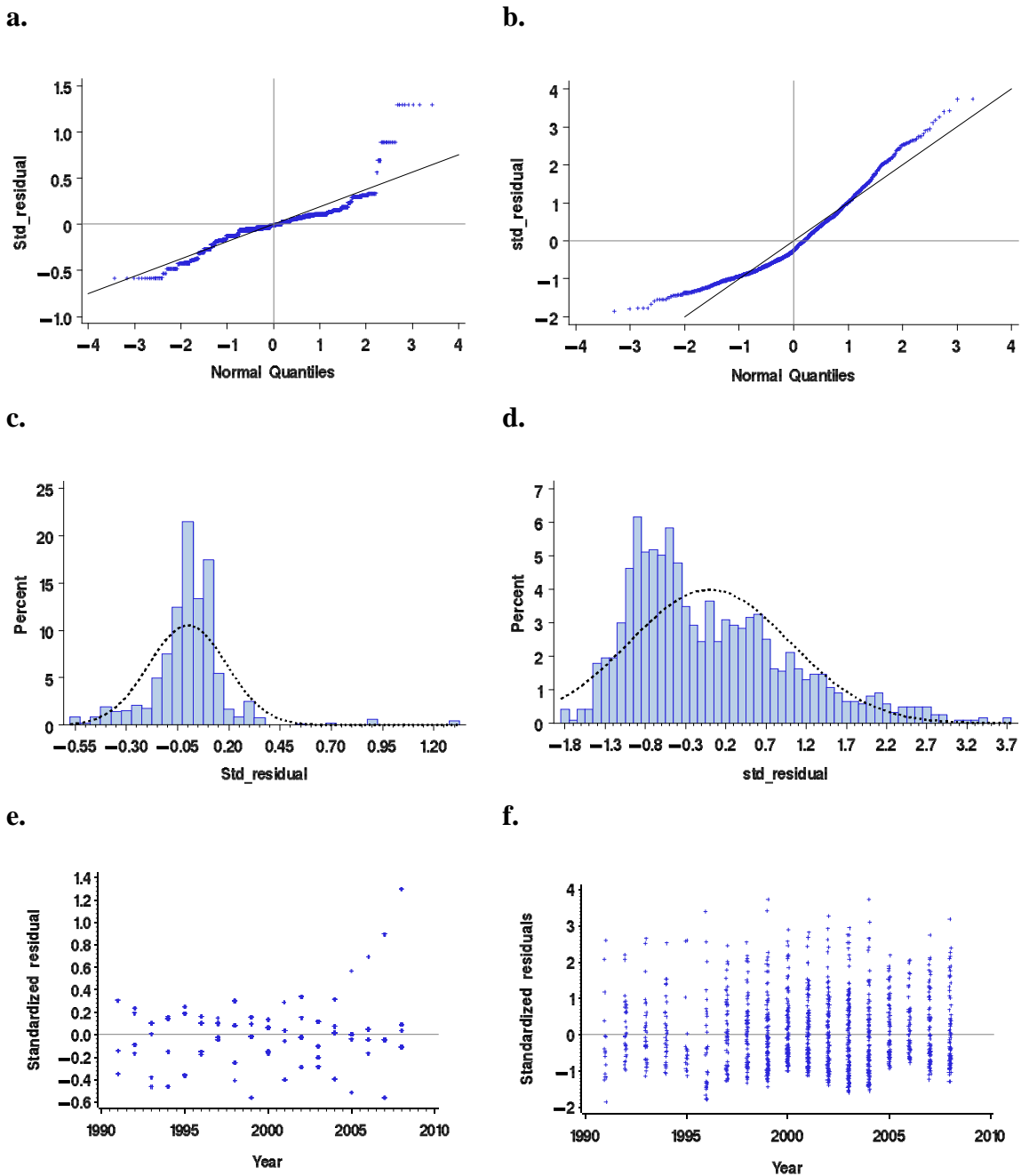
Figure 13 Quantiles plot (a), distribution (c), and plot of standardized residuals by year (e) for the proportion of positive catches of black grouper from the generalized linear model with a binomial distribution and a logit link for the intercepts identified with cluster analysis and quantiles plot (b) and distribution (d) and plot of standardized residuals by year (e) for the number of black grouper per intercept from the GLM with a gamma distribution and a log link for the intercepts identified with cluster analysis of MRFSS intercepts from the Florida Keys.
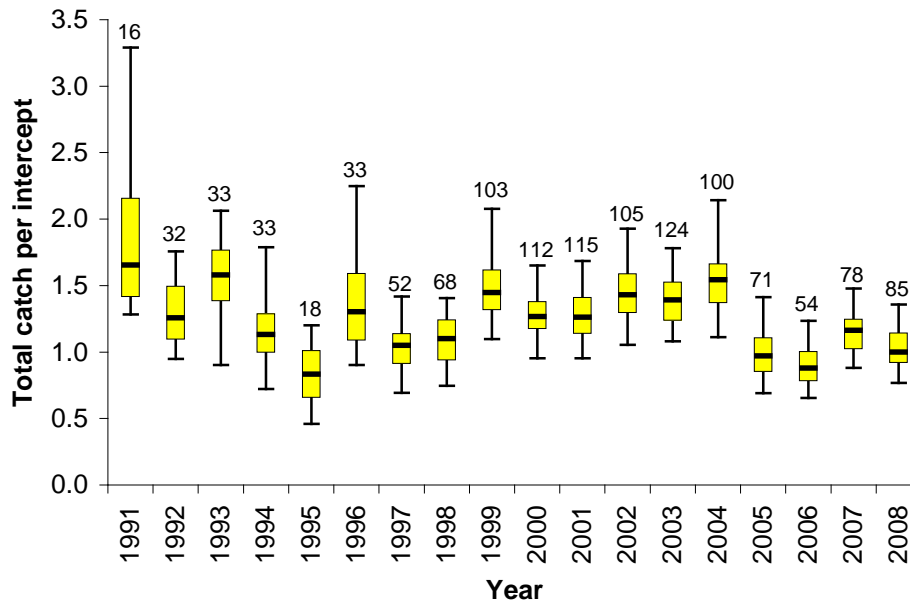
Figure 14. Standardized total catch rate of black grouper per intercept with intercepts from the Florida Keys identified by cluster analysis. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of intercepts for the year.
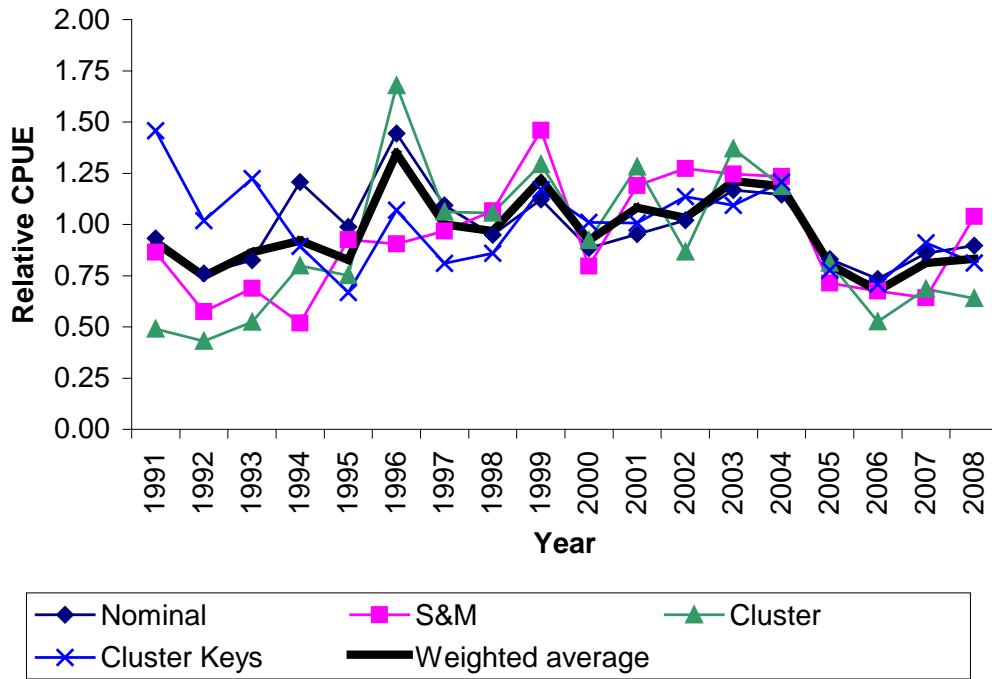
Figure 15. Comparison of the nominal catch rates to the standardized catch rates calculated with intercepts selected by the Stephens and MacCall regression, cluster analysis, cluster analysis of intercepts from the Florida Keys and a weighted average line weighted by the inverse coefficients of variation.