Standardized catch rates of black grouper. *Mycteroperca bonaci*, and red grouper, *Epinephelus morio*, from Florida's commercial trip tickets, 1991-2008

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Introduction

Groupers are southern U.S. species. Although red grouper are targeted by commercial reef fish fishers along the southern Gulf coast of Florida including the Florida Keys, fishers along Florida's Atlantic coast catch red grouper incidentally. The trip ticket index for red grouper only includes commercial trips from the Atlantic coast. Fishers primarily catch black grouper in southern Florida from Tampa Bay on the Gulf coast of Florida to Cape Canaveral on the Atlantic coast. Because genetic studies have shown that black grouper in the southeast U.S. is a single stock (Zatcoff 2001), the black grouper index will use trips from both coasts.

The reported landings for these grouper species is short. Prior to the implementation of the Florida Fish and Wildlife Conservation Commission's (FWC) Marine Resources Information System (trip ticket program) in 1984, both of these species were landed as 'Unclassified Groupers'. With the trip ticket program, landings of the different grouper began to be tracked because the trip ticket system has separate codes for the each species of grouper as well as for other fish. A complication for the accuracy of black grouper landings is that gag grouper, *Mycteroperca microlepis*, are commonly called 'black grouper' along the Gulf coast of Florida. For the SEDAR assessment, landings were adjusted for the misidentification based on commercial biosampling in the fish houses that compared the market category for the species to the actual identification of the species; however, adjusting for misidentification was not possible on per trip basis because of relatively small number of samples per month per county. This mislabeling was more prevalent in the 1980s but still continues in some areas.

Florida's commercial fishers have been required to sell their catch to licensed wholesale dealers and each sale is recorded on a trip ticket, a copy of which goes to the FWC. Information collected on trip tickets include the fisher's Saltwater Products License number, wholesale dealer's license number, date landed, time fished, area fished, county landed, depth, gear fished, number of sets, number of traps pulled, soak time, species codes, size or market categories, amount of catch, and unit price, with these last fields completed for everything landed. Beginning in 1991, each trip ticket included a series of boxes so that the fishers could indicate the gear used on the trip.

The most common commercial gear used to catch black and red groupers is hook-and-line (HL) which includes bandit boats. The other gears included long lines (LL), spears, and traps. However for comparability, the analyses will only consider HL and LL trips

for black grouper and only (HL) trips for red grouper for the period 1991 through 2008. There are insufficient data to generate a South Atlantic LL index because of regulatory changes. In 1992, the South Atlantic Council restricted LL fishers to depths of least 50 fathoms and in 1999, the Council prohibited fishers from using LL to catch bottom species such as groupers.

To account for spatial differences, trip tickets were assigned to regions based on area fished, when available, or county landed. For consistency, I used the same regions that the Marine Recreational Fisheries Statistics Survey uses for the For Hire Sector (Northeast -- Nassau-Brevard, 2) Southeast -- Indian River - Miami Dade, 3) Florida Keys -- Monroe county, 4) West coast -- Collier - Citrus counties, and 5) Panhandle -- Dixie - Escambia counties) (Figure 1). The 'area fished' field was used to distinguish Atlantic trips from Gulf of Mexico trips in the Florida Keys for the red grouper index.

In addition to spatial restrictions, there are also season closures for grouper fishing. In 1999, the Gulf of Mexico Fishery Management Council implemented a closure for groupers from February 15 through March 15 and the South Atlantic Fishery Management Council, in the same year, implemented a closure during March and April. Therefore in all years, trip tickets from those regions and days were excluded from the subsequent analyses and because fishers in the Florida Keys fish in both jurisdictions, trip tickets from the Florida Keys that fished from February 15 through April 30 were excluded.

The purpose of this exercise was to compare the standardized catch rates derived from FWC's trip ticket program to those derived from NMFS Coastal Fisheries Logbook Program (logbook) (McCarthy and Baertlein 2009, SEDAR19-DW-13,and SEDAR19-DW-14). Are the catch rate patterns similar in the data from the two programs? The underlying assumption is that both programs are reporting fishing activity but the logbooks record more detailed effort information. The use of trip tickets to confirm logbook data was raised during the SEDAR19 DW planning conference call in April 2009.

Methods

The initial step in the standardization process was to extract all trip tickets with finfish landings from 1991 through 2008 from the FWC Marine Resources Information System (trip tickets). Landings of invertebrate or marine life species, e.g. shrimp, crabs hard clams, oysters, or butterflyfish, were omitted from further consideration. Depending on the species and gear to be analyzed, these trips tickets were subset by geographic area and time. To simplify the analyses, any species caught on less than 1% of the trips by gear also was excluded from further consideration.

Since trip tickets only report trips with landings, there were other trips that could have caught the target species but did not and that additional effort goes unreported. To account for that extra effort, I used the Stephens and MacCall (2004) logistic regression approach. Species landed on more than 1% of the trips by gear, had their landings

converted to presence (at least one pound landed) or absence (zero landed) on each trip. A logistic regression used the presence or absence of the target species (black or red grouper) as the response variable and the other species as independent variables. The full model included all the species and the reduced model only included species with regression coefficients that were significant at the $\alpha = 0.05$ level. The reduced model regression was used to calculate the probability of the target species on each trip. Those trips with a probability above the threshold value (the threshold value between 0.01 and 0.99 with the least absolute difference between the observed number of trips that landed the target species and the predicted number of trips) were selected for calculating the standardized catch rates.

After the trips to be included in the standardization were selected, the catch rates for the target species were calculated with generalized linear models (GLM). There were two GLM models per species per gear: the first model estimated the proportion of trips that caught the target species by gear and by year and used a binomial distribution with a logit link and the second model estimated the landings of the target species in pounds on positive trips, i.e. those trips that caught the target species, and used a gamma distribution with a log link (Lo *et al.* 1992).The gamma distribution was chosen because it reduced the mean deviance more than the log-normal distribution for the same variables and the gamma estimated annual mean landings at levels that fishers relate to instead of the smaller values from the back-transformed log normal distributions. Potential explanatory variables in the GLMs were year, month, region, depth , and days fished. The categories of values for region, days fished and for depth differed with species and gear. The variables included in the GLMs were chosen in a stepwise manner using the smallest Akaike Information Criterion (AIC) at each level of the number of predictor variables, provided that the variable was significant at the $\alpha = 0.05$ level in the regression with the significance based on two times the change in log-likelihood (Chi-square distribution).

Annual variability was estimated with a Monte Carlo approach that used the least squares means and their standard errors from the GLMs for the significant variables identified by AIC. 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. The process was repeated each year the same number of times as the number of trips that landed the target species in that year.

Plots and correlations were used to compare the trip ticket catch rates to the logbook catch rates.

Results

Black grouper

Hook-and-line

There were 595,674 hook-and-line trip tickets recorded from the three regions for black grouper: West coast of Florida, the Florida Keys, and Southeast Florida (regions: 2-4) from 1991 through 2008. For black grouper, these three regions accounted for 97% of the trips and 95% of landings. There were 217 species recorded on those tickets. However, there were only 38 species that occurred on at least 1% (5,957 trips) and of those trips, black grouper was reported on 46,135 trips. The nominal catch rates (landings per trip) for black grouper for HL trips in the West coast through Southeast regions are included in Table 1.

The full model for black grouper with all 38 species revealed that three species were not significant in the regression at the $\alpha = 0.05$ level and these three species were removed in the reduced model. The 35 species in the final, reduced black grouper model are shown in Figure 2. Note that the regression coefficient for gag grouper was negative which is consistent with black grouper rarely being caught on the same trip as gag grouper. The smallest difference between the observed number of black grouper trips and the predicted number was with a threshold of 0.232 (Figure 3). With that threshold value, the number of trips selected was 45,985 trips; however, some of those trips were missing days fished or depth and the final number of selected HL trips for black grouper was 36,028 trips.

The depth categories (lower limit) for black grouper HL trips were 1, 5, 10, 15, 20, 25, 50, 75, …, 200+ m. Similarly, the categories for days fished were 1, 2, 3, 4, 5, 6, 7,9, 12+ days .

The fit of the model looked reasonable (Figure 4). All of the variables were significant in the GLM predicting the annual proportion of positive trips with the binomial distribution and the model reduced the mean deviance (deviance/degrees of freedom) by 6.1% with days fished accounting for 3.3%, region (1.3%), month (0.5%), year (0.5%), and depth (0.4%) (Table 2a). The fit of the model for the landings of black grouper on positive trips was better than the binomial model (Figure 4) and all of the variables were significant as well. The model reduced the deviance by 35.4% with region accounting for 19.2%, days fished (9.9%), depth (3.6%), %), year (2.4%), and month (0.2%) (Table 2b).

Black grouper's standardized catch rates on HL trips increased from 1991 to 2005 and then declined afterwards (Figure 5). As mentioned above, the objective of determining the trip ticket catch rates was to provide a check on the catch rates calculated from the NMFS Reef Fish Logbook program (McCarthy and Baertlein 2009, SEDAR19-DW-13) . Ideally, the catch rates from the two programs would have similar patterns. A comparison of the FWC trip ticket HL index to the NMFS Logbook vertical line index showed that, indeed, the patterns were similar (correlation coefficient, $r = 0.86$, $df = 14$, $P < 0.05$; Figure 6).

Longline

The analytical process was repeated for trip tickets specifying longline (LL) gear; however, when run with the same geographical restraints as were used with black grouper HL trips, i.e., the West coast of Florida through the Keys and the Southeast (Figure 1),

there were only 18 trip tickets from the Southeast region so the LL analysis only was redone using only trip tickets from the West coast of Florida and the Florida Keys (regions: 3-4). After removing the trip tickets from February 15 through March 15 on the West coast of Florida and removing the trip tickets from February 15 through April 30 in the Keys (depending on where they fish, fishers there are subject to both the South Atlantic and the Gulf of Mexico regulations), there were 28,759 LL trips and those trips landed 167 species. Black grouper were landed on 6,321 LL trips.

For the Stephens and MacCall logistic regression method described above, there were 50 species that were landed on at least 1% of the LL trips in these two regions. For each trip, the landings of the 50 species, including black grouper, were converted to presence or absence and the full model regression showed that there were 32 species with significant coefficients (Figure 7). There were 6,317 LL trips selected with the threshold of 0.345 (Figure 8). As with the other analyses, not all of the trip tickets included days fished and depth, so the analyses used 5,397 LL trips and the nominal LL catch rates for black grouper are included in Table 3.

The depth categories for black grouper LL trips were 25, 50, 75, …, 225+ m and the categories for days fished were 1, 2, 4, 6, 8, 10, 12, 14, 16+ days. As expected for the LL fishery, the fishers fished deeper and made longer trips.

The catch rates were standardized using two GLM models. The fit of the GLM model looked reasonable (Figure 9). All of the variables were significant in the GLM predicting the annual proportion of positive trips with the binomial distribution and the model reduced the mean deviance (deviance/degrees of freedom) by 8.0% with depth accounting for 3.4%, year (2.1%), region (1.1%), days fished (1.0%), and month (0.3%) (Table 4a). The fit of the model for the quantity of landings of black grouper on positive LL trips was better than the binomial model (Figure 9) and all of the variables were significant as well. The model reduced the deviance by 15.3% with year accounting for 9.7%, depth (3.2%), days fished (1.7%), month (0.7%), and region (0.1%) (Table 4b).

Black grouper's standardized catch rates on longline trips increased from a low in 1997 to 2003 and then declined to about 230 lb per trip of black grouper during 2005-2007, and followed by another drop in 2008 (Figure 10). A comparison of the Florida trip ticket LL index to the NMFS logbook LL index (McCarthy and Baertlein 2009, SEDAR19-DW-13) for black grouper showed that the two patterns also were similar (correlation coefficient, $r = 0.71$, $df = 14$, $P < 0.05$; Figure 11).

Red grouper

Hook-and-line

There were 605,293 hook-and-line trips from the Atlantic coast of Florida (Northeast region through the Florida Keys, region 1-3) and these trips reported 219 species. Red grouper were landed on 30,788 of those trips.

For the Stephens and MacCall logistic regression method described above, there were 36 species that were landed on at least 1% of the HL trips in these three regions. For each trip, the landings of the 36 species, including red grouper, were converted to presence (1) or absence (0) and the full model regression showed that there were 30 species with significant coefficients (Figure 12). There were 30,978 HL trips selected with the threshold of 0.229 (Figure 13). As with the other analyses, not all of the trip tickets included days fished and depth, so the analyses used 24,844 HL trips and the nominal catch rates for red grouper from Atlantic coast are included in Table 5.

The depth categories for red grouper HL trips were 1, 5, 10, 15, 20, 25, 50, 75,100+ m and the categories for days fished were 1, 2, 3, 4, 5, 6, 7,9, 12+ days.

The catch rates were standardized using two GLM models. The fit of the GLM model looked very good (Figure 14). All of the variables were significant in the GLM predicting the annual proportion of positive trips with the binomial distribution and the model reduced the mean deviance (deviance/degrees of freedom) by 37.6% with region accounting almost all of the reduction at 35.9%, depth (1.1%), year (0.3%), month (0.2%), and days fished (0.1%) (Table 6a). The fit of the model for the quantity of landings of black grouper on positive trips (14,064 trips) was not as good as the binomial model (Figure 14) but all of the variables were significant as well. The model reduced the deviance by 19.8% with days fished accounting for 10.9%, depth (4.3%), year (3.8%), month (0.6%), and region (0.3%) (Table 6b).

Red grouper's standardized catch rates on HL trips increased from a low in 1991 to 2004 and then declined afterwards (Figure 15). A comparison of the Florida trip ticket index to the NMFS logbook vertical line index for red grouper HL trips (McCarthy and Baertlein 2009, SEDAR19-DW-14) showed that these patterns were not similar (correlation coefficient, $r = 0.17$, $df = 14$, $P = 0.53$; Figure 16).

Discussion

There was good agreement between the two indices with black grouper because the center of that fishery is southern Florida such that both data sources captured the same signal from the fishery because both systems were tracking the same stock. However, red grouper have a disjunct distribution on the Atlantic coast with red grouper landings in the Southeast and in the Florida Keys and then not many landed until South Carolina and North Carolina. Logbooks included data from throughout the species' range and the spatial differences were accounted for by the 'Area fished' term while the FWC trip tickets only tracked the southern portion of the fishery. This indicates that the northern portion of the stock may have a different dynamic than the southern portion. This exercise supports using the logbook catch rates in the stock assessment because the index is based on observations from throughout red grouper's range along the Atlantic coast.

The indices by gear were similar for the two data sources for black grouper but do the HL indices and the LL indices have a similar pattern? When the four indices were plotted

together (Figure 17), there was consistency among the indices with low levels in the early to mid-1990s followed by an increase that peaked in the mid-2000s and then declined afterward to about the same level as before. At first glance, it looks like some good years of recruitment working through the population but a recruitment index would be necessary to confirm this speculation.

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Table 1. Nominal and standardized catch rates of black grouper using hook and line trips from the West coast, Florida Keys, and Southeast regions. The standardized catch rates were calculated with trips selected with the Stephens and MacCall logistic regression. The column labeled 'Number of trips' were the HL trips that landed black grouper. The logbook index is also included to facilitate comparisons.

| Year | Nominal | | | | Stephens and MacCall | | | | Logbook |
	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Index (scaled to mean)
1991	1233	66.09	0.066	0.90	303	24.77	0.100	0.43	
1992	3040	105.06	0.052	1.42	615	42.13	0.073	0.73	
1993	4288	71.99	0.031	0.97	844	47.49	0.071	0.83	0.76
1994	4497	67.81	0.030	0.92	858	39.75	0.069	0.69	0.75
1995	4624	60.47	0.030	0.82	1305	54.50	0.063	0.95	0.81
1996	4192	66.08	0.031	0.89	1445	55.78	0.060	0.97	0.83
1997	3184	59.05	0.047	0.80	1156	43.99	0.066	0.77	0.75
1998	2876	69.41	0.045	0.94	1010	54.40	0.070	0.95	0.97
1999	2159	67.66	0.049	0.92	731	47.43	0.071	0.83	0.76
2000	2109	88.79	0.057	1.20	789	64.74	0.070	1.13	0.82
2001	2214	91.07	0.048	1.23	882	84.01	0.070	1.46	1.25
2002	2165	85.21	0.064	1.15	946	69.21	0.064	1.21	1.15
2003	2034	84.57	0.051	1.15	782	71.46	0.071	1.25	1.28
2004	2210	75.96	0.045	1.03	856	75.11	0.070	1.31	1.35
2005	1829	74.74	0.048	1.01	592	74.54	0.072	1.30	1.32
2006	1281	84.09	0.080	1.14	445	67.59	0.081	1.18	1.38
2007	1202	71.93	0.046	0.97	321	54.51	0.097	0.95	1.02
2008	998	58.04	0.061	0.79	303	37.39	0.096	0.65	0.80
Total	46135				14183				

Table 2a. Stepwise selection of variables to include in estimating the proportion of hook-and-line trips that landed black grouper (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	% Δ mean dev	Cum %	log like	Δ log like	2*Δ log like	df	Prob Ho	AIC
Null	36027	48303.44	1.3408				-24151.721			1		48305.44
Year	36010	48034.29	1.3339	0.0069	0.51%		-24017.144	-134.576	269.152	17	2.50676E-47	48070.29
Month	36016	48016.76	1.3332	0.0076	0.57%		-24008.379	-143.342	286.683	11	5.57267E-55	48040.76
Region	36025	47552.47	1.3200	0.0208	1.55%		-23776.235	-375.486	750.972	2	8.4821E-164	47558.47
Depth	36015	47847.02	1.3285	0.0123	0.92%		-23923.511	-228.209	456.418	12	4.09323E-90	47873.02
Days	36019	46676.23	1.2959	0.0449	3.35%	3.3%	-23338.114	-813.607	1627.213	8	0	46694.23
With days												
Year	36002	46400.53	1.2888	0.0071	0.53%		-23200.263	-137.851	275.702	17	1.13364E-48	46452.53
Month	36008	46354.07	1.2873	0.0086	0.64%		-23177.036	-161.078	322.156	11	1.861E-62	46394.07
Region	36017	46062.28	1.2789	0.0170	1.27%	4.6%	-23031.139	-306.975	613.949	2	4.8148E-134	46084.28
Depth	36007	46501.61	1.2915	0.0044	0.33%		-23250.804	-87.310	174.619	12	5.4114E-31	46543.61
With days and region												
Year	36000	45793.61	1.2720	0.0069	0.51%		-22896.805	-134.335	268.669	17	3.14943E-47	45849.61
Month	36006	45790.96	1.2718	0.0071	0.53%	5.1%	-22895.481	-135.658	271.316	11	9.46689E-52	45834.96
Depth	36005	45825.94	1.2728	0.0061	0.45%		-22912.969	-118.170	236.341	12	9.57677E-44	45871.94
With days, region, and month												
Year	35989	45538.82	1.2654	0.0064	0.48%	5.6%	-22769.409	-126.072	252.144	17	7.61168E-44	45616.82
Depth	35994	45568.17	1.2660	0.0058	0.43%		-22784.087	-111.394	222.788	12	6.26676E-41	45636.17
With days, region, month, and year												
Depth	35977	45313.90	1.2595	0.0059	0.44%	6.1%	-22656.949	-112.461	224.921	12	2.26114E-41	45415.90

Table 2b. Stepwise selection of variables to include in estimating the black grouper landings on positive hook-and-line trips (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	% Δ mean	Cum %	log like	Δ log like	-2*Δ log like	df	Prob Ho	AIC
Null	14181	28932.81	2.0401				-79144.588			2		158293.18
Year	14164	28320.16	1.9993	0.0408	2.00%		-78957.519	-187.069	374.138	17	4.65E-69	157953.04
Month	14170	28059.12	1.9800	0.0601	2.95%		-78876.738	-267.851	535.701	11	7.7E-108	157779.48
Region	14179	23368.41	1.6480	0.3921	19.22%	19.2%	-77300.022	-1844.567	3689.133	2	0	154608.04
Depth	14169	24276.65	1.7132	0.3269	16.02%		-77625.746	-1518.842	3037.685	12	0	155279.49
Days	14173	23598.41	1.6649	0.3752	18.39%		-77383.546	-1761.043	3522.085	8	0	154787.09
With region												
Year	14162	22313.89	1.5755	0.0725	3.55%		-76907.567	-392.455	784.910	17	7.5E-156	153857.13
Month	14168	23270.94	1.6424	0.0056	0.27%		-77264.410	-35.611	71.223	11	7.15E-11	154558.82
Depth	14167	21292.71	1.5029	0.1451	7.11%		-76511.626	-788.396	1576.792	12	0	153055.25
Days	14171	20484.51	1.4454	0.2026	9.93%	29.2%	-76186.187	-1113.835	2227.670	8	0	152396.37
With region and days fished												
Year	14154	19668.64	1.3895	0.0559	2.74%		-75845.931	-340.255	680.511	17	1.2E-133	151749.86
Month	14160	20384.87	1.4395	0.0059	0.29%		-76145.285	-40.902	81.804	11	6.6E-13	152336.57
Depth	14159	19431.22	1.3723	0.0731	3.58%	32.7%	-75744.565	-441.622	883.244	12	2.3E-181	151537.13
With region, days fished, and depth												
Year	14142	18704.70	1.3225	0.0498	2.44%	35.2%	-75427.404	-317.161	634.321	17	7.6E-124	150936.81
Month	14148	19344.10	1.3672	0.0051	0.25%		-75707.096	-37.469	74.938	11	1.39E-11	151484.19
With region, days fished, depth, and year												
Month	14131	18628.21	1.3182	0.0043	0.21%	35.4%	-75393.378	-34.026	68.052	11	2.86E-10	150890.76

Table 3. Nominal and standardized catch rates of black grouper using longline trips along Florida's West coast and Florida Keys regions. The standardized catch rates were calculated with trips selected with the Stephens and MacCall logistic regression. The number of trips were the number of longline trips that landed black grouper. The logbook index is also included to facilitate comparisons.

| Year | Nominal | | | | Stephens and MacCall | | | | Logbook |
	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Index (scaled to mean)
1991	212	307.9	0.128	0.79	84	243.2	0.157	0.77	
1992	303	235.1	0.081	0.61	121	200.1	0.137	0.63	
1993	507	249.6	0.081	0.64	243	211.4	0.108	0.67	0.39
1994	328	247.1	0.089	0.64	94	154.3	0.151	0.49	0.30
1995	293	243.4	0.098	0.63	114	160.4	0.146	0.51	0.40
1996	332	224.0	0.073	0.58	148	176.3	0.138	0.56	0.45
1997	310	204.3	0.108	0.53	169	136.5	0.118	0.43	0.46
1998	344	389.6	0.106	1.01	239	340.8	0.104	1.08	0.75
1999	485	431.6	0.084	1.11	342	357.9	0.090	1.13	0.83
2000	436	487.6	0.077	1.26	296	470.9	0.096	1.49	1.06
2001	412	546.7	0.094	1.41	251	403.1	0.108	1.27	1.41
2002	360	582.7	0.090	1.50	220	419.9	0.118	1.33	1.58
2003	413	665.2	0.111	1.72	246	551.7	0.105	1.74	1.84
2004	434	573.1	0.091	1.48	295	440.8	0.099	1.39	1.87
2005	317	344.3	0.098	0.89	199	225.5	0.108	0.71	1.80
2006	359	371.2	0.085	0.96	214	228.0	0.123	0.72	1.11
2007	259	384.7	0.085	0.99	148	231.1	0.154	0.73	1.05
2008	217	182.3	0.094	0.47	106	91.8	0.142	0.29	0.69
Total	6321				3529				

Table 4a. Stepwise selection of variables to include in estimating the proportion of longline trips that landed black grouper (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	% Δ mean dev	Cum %	log like	Δ log like	-2*Δ log like	df	Prob Ho	AIC
Null	5396	6962.24	1.2903				-3481.122			1		6964.24
Year	5379	6798.08	1.2638	0.0265	2.05%		-3399.041	-82.080	164.160	17	4.01E-26	6834.08
Month	5385	6923.06	1.2856	0.0047	0.36%		-3461.530	-19.591	39.182	11	4.93E-05	6947.06
Region	5395	6855.32	1.2707	0.0196	1.52%		-3427.658	-53.463	106.926	1	4.62E-25	6859.32
Depth	5388	6714.34	1.2462	0.0441	3.42%	3.4%	-3357.172	-123.950	247.900	8	4.8E-49	6732.34
Days	5388	6877.10	1.2764	0.0139	1.08%		-3438.550	-42.572	85.143	8	4.48E-15	6895.10
With depth												
Year	5371	6547.64	1.2191	0.0271	2.10%	5.5%	-3273.818	-83.3540	166.708	17	1.26E-26	6599.64
Month	5377	6677.53	1.2419	0.0043	0.33%		-3338.767	-18.4052	36.810	11	0.000124	6717.53
Region	5387	6653.94	1.2352	0.0110	0.85%		-3326.968	-30.2038	60.408	1	7.71E-15	6673.94
Days	5380	6656.35	1.2372	0.0090	0.70%		-3328.177	-28.9947	57.989	8	1.15E-09	6690.35
With depth and year												
Month	5360	6513.91	1.2153	0.0038	0.29%		-3256.958	-16.8603	33.721	11	0.000402	6587.92
Region	5370	6469.34	1.2047	0.0144	1.12%	6.6%	-3234.669	-39.1484	78.297	1	8.87E-19	6523.34
Days	5363	6487.04	1.2096	0.0095	0.74%		-3243.518	-30.3002	60.600	8	3.55E-10	6555.04
With days, region, and month												
Month	5359	6432.65	1.2003	0.0044	0.34%		-3216.327	-18.3427	36.685	11	0.00013	6508.65
Days	5362	6388.29	1.1914	0.0133	1.03%	7.7%	-3194.147	-40.5222	81.044	8	3.01E-14	6458.29
With days, region, month, and days fished												
Month	5351	6354.76	1.1876	0.0038	0.29%	8.0%	-3177.379	-16.7682	33.536	11	0.000431	6446.76

Table 4b. Stepwise selection of variables to include in estimating the black grouper landings on positive longline trips (shaded lines) with a GLM (gamma distribution and log link) selected with Stephens and MacCall 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	% Δ mean	Cum %	log like	Δ log like	-2*Δ log like	df	Prob Ho	AIC
Null	3528	5981.43	1.6954				-25386.381			2		50776.76
Year	3511	5376.18	1.5312	0.1642	9.69%	9.7%	-25160.824	-225.5571	451.114	17	3.62E-85	50359.65
Month	3517	5894.03	1.6759	0.0195	1.15%		-25355.088	-31.2935	62.587	11	3.05E-09	50736.18
Region	3527	5956.06	1.6887	0.0067	0.40%		-25377.338	-9.0431	18.086	1	2.11E-05	50760.68
Depth	3520	5665.38	1.6095	0.0859	5.07%		-25271.244	-115.1370	230.274	8	2.59E-45	50562.49
Days	3520	5733.45	1.6288	0.0666	3.93%		-25296.513	-89.8684	179.737	8	1.17E-34	50613.03
With year												
Month	3500	5304.74	1.5156	0.0156	0.92%		-25132.743	-28.0805	56.161	11	4.75E-08	50325.49
Region	3510	5362.93	1.5279	0.0033	0.19%		-25155.640	-5.1844	10.369	1	0.001282	50351.28
Depth	3503	5173.59	1.4769	0.0543	3.20%	12.9%	-25080.307	-80.5168	161.034	8	9.72E-31	50214.61
Days	3503	5210.48	1.4874	0.0438	2.58%		-25095.172	-65.6521	131.304	8	1.52E-24	50244.34
With year and depth												
Month	3492	5108.26	1.4628	0.0141	0.83%		-25053.749	-26.5586	53.117	11	1.71E-07	50183.50
Region	3502	5171.86	1.4768	0.0001	0.01%		-25079.607	-0.7003	1.401	1	0.236623	50215.21
Days	3495	5063.35	1.4487	0.0282	1.66%	14.6%	-25035.316	-44.9916	89.983	8	4.69E-16	50140.63
With year, depth, and days fished												
Month	3484	5009.11	1.4377	0.0110	0.65%	15.2%	-25012.859	-22.4568	44.914	11	5.02E-06	50117.72
Region	3494	5058.48	1.4478	0.0009	0.05%		-25033.309	-2.0064	4.013	1	0.045156	50138.62
With region, days fished, depth, and year												
Region	3483	5001.49	1.4360	0.0017	0.10%	15.3%	-25009.687	-3.172	6.343	1	0.011783	50081.37

Table 5. Nominal and standardized catch rates of red grouper using hook and line trip tickets from Florida's Atlantic coast. The standardized catch rates were calculated with trips selected with the Stephens and MacCall logistic regression. The number of trips were the trips that landed red grouper. The logbook index is also included to facilitate comparisons.

Year	Nominal				Stephens and MacCall				Logbook
	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Number of Trips	Landings/trip (lb)	Coefficient of Variation	Index (scaled to mean)	Index (scaled to mean)
1991	1005	46.11	0.092	0.95	285	6.27	0.139	0.29	
1992	1624	44.45	0.078	0.92	430	13.85	0.118	0.63	
1993	2577	33.50	0.086	0.69	771	21.18	0.098	0.96	0.31
1994	2319	41.79	0.063	0.86	789	21.61	0.098	0.98	0.30
1995	2455	42.42	0.078	0.88	1250	19.98	0.090	0.91	0.49
1996	2523	42.98	0.111	0.89	1388	17.62	0.091	0.80	0.49
1997	2508	51.67	0.064	1.07	1289	14.38	0.091	0.65	0.63
1998	2422	48.61	0.073	1.01	1084	19.79	0.091	0.90	0.95
1999	1493	57.62	0.088	1.19	679	23.65	0.105	1.08	1.40
2000	1431	73.47	0.091	1.52	663	25.93	0.102	1.18	1.07
2001	1653	54.81	0.074	1.13	803	28.26	0.098	1.28	0.84
2002	1925	61.74	0.059	1.28	897	29.21	0.098	1.33	0.85
2003	1512	49.38	0.087	1.02	831	24.72	0.101	1.12	1.04
2004	1582	54.58	0.101	1.13	932	28.88	0.100	1.31	0.99
2005	1211	40.69	0.064	0.84	672	27.54	0.101	1.25	0.90
2006	867	50.79	0.088	1.05	489	25.73	0.109	1.17	1.40
2007	903	51.07	0.104	1.06	428	24.61	0.116	1.12	2.03
2008	778	32.37	0.064	0.67	386	19.60	0.127	0.89	2.34
Total	30788				14066				

Table 6a. Stepwise selection of variables to include in estimating the proportion of hook-and-line trips along Florida's Atlantic coast that landed red grouper (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	% Δ mean dev	Cum %	log like	Δ log like	-2*Δ log like	df	Prob Ho	AIC
Null	24843	34004.66	1.3688				-17002.332			1		34006.66
Year	24826	33844.45	1.3633	0.0055	0.40%		-16922.224	-80.109	160.218	17	2.41E-25	33880.45
Month	24832	32655.67	1.3151	0.0537	3.92%		-16327.833	-674.499	1348.999	11	1.2E-282	32679.67
Region	24841	21809.20	0.8780	0.4908	35.86%	35.9%	-10904.599	-6097.733	12195.466	2	0	21815.20
Depth	24835	31968.92	1.2873	0.0815	5.95%		-15984.458	-1017.875	2035.749	8	0	31986.92
Days	24835	32830.49	1.3219	0.0469	3.43%		-16415.244	-587.089	1174.177	8	3.6E-248	32848.49
With region												
Year	24824	21710.09	0.8746	0.0034	0.25%		-10855.046	-49.553	99.106	17	1.3E-13	21750.09
Month	24830	21710.76	0.8744	0.0036	0.26%		-10855.378	-49.221	98.443	11	3.63E-16	21738.76
Depth	24833	21418.45	0.8625	0.0155	1.13%	37.0%	-10709.225	-195.375	390.749	8	1.78E-79	21440.45
Days	24833	21729.35	0.8750	0.0030	0.22%		-10864.676	-39.924	79.847	8	5.25E-14	21751.35
With region and depth												
Year	24816	21308.59	0.8587	0.0038	0.28%	37.3%	-10654.294	-54.931	109.862	17	1.28E-15	21364.59
Month	24822	21328.71	0.8593	0.0032	0.23%		-10664.355	-44.870	89.739	11	1.88E-14	21372.71
Days	24825	21377.85	0.8611	0.0014	0.10%		-10688.926	-20.299	40.598	8	2.48E-06	21415.85
With region, depth, and year												
Month	24805	21227.37	0.8558	0.0029	0.21%	37.5%	-10613.686	-40.608	81.216	11	8.58E-13	21305.37
Days	24808	21269.66	0.8574	0.0013	0.09%		-10634.829	-19.465	38.930	8	5.07E-06	21341.66
With days, region, year, and month												
Days	24797	21193.19	0.8547	0.0011	0.08%	37.6%	-10596.595	-17.091	34.182	8	3.77E-05	21287.19

Table 6b. Stepwise selection of variables to include in estimating the red grouper landings on positive hook-and-line trips (shaded lines) with a GLM (gamma distribution and log link) selected with 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	% Δ mean dev	Cum %	log like	Δ log like	-2*Δ log like	df	Prob Ho	AIC
Null	14065	20445.27	1.4536				-68811.566			2		137627.13
Year	14048	19556.84	1.3921	0.0615	4.23%		-68442.515	-369.051	738.102	17	6.89E-146	136923.03
Month	14054	20305.75	1.4448	0.0088	0.61%		-68754.562	-57.004	114.009	11	2.891E-19	137535.12
Region	14063	20405.81	1.4510	0.0026	0.18%		-68795.478	-16.088	32.176	2	1.031E-07	137598.96
Depth	14057	19067.74	1.3565	0.0971	6.68%		-68232.959	-578.607	1157.214	8	1.68E-244	136485.92
Days	14057	18212.35	1.2956	0.1580	10.87%	10.9%	-67854.708	-956.858	1913.716	8	0	135729.42
With days fished												
Year	14040	17396.35	1.2391	0.0565	3.89%		-67478.849	-375.8592	751.718	17	8.72E-149	135011.70
Month	14046	18026.12	1.2834	0.0122	0.84%		-67770.269	-84.4386	168.877	11	2.008E-30	135582.54
Region	14055	18127.95	1.2898	0.0058	0.40%		-67816.538	-38.1696	76.339	2	2.649E-17	135657.08
Depth	14049	17321.04	1.2329	0.0627	4.31%	15.2%	-67443.376	-411.3323	822.665	8	2.68E-172	134922.75
With days fished and depth												
Year	14032	16531.30	1.1781	0.0548	3.77%	19.0%	-67062.823	-380.553	761.105	17	8.76E-151	134195.65
Month	14038	17140.46	1.2210	0.0119	0.82%		-67357.747	-85.629	171.258	11	6.5E-31	134773.49
Region	14047	17283.48	1.2304	0.0025	0.17%		-67425.629	-17.747	35.494	2	1.962E-08	134891.26
With days fished, depth, and year												
Month	14021	16397.08	1.1695	0.0086	0.59%	19.5%	-66996.537	-66.2860	132.572	11	5.247E-23	134085.07
Region	14030	16476.18	1.1744	0.0037	0.25%		-67035.663	-27.1603	54.321	2	1.601E-12	134145.33
With days fished, depth, year, and month												
Region	14019	16341.59	1.1657	0.0038	0.26%	19.8%	-66968.991	-27.5463	55.093	2	1.088E-12	134033.98
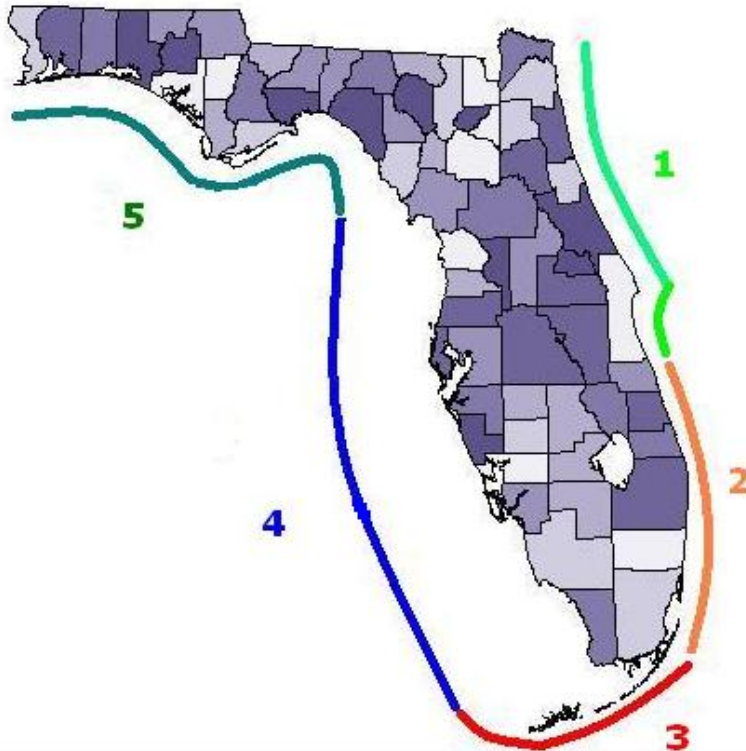
Figure 1. Florida's regions: 1) Northeast -- Nassau-Brevard, 2) Southeast -- Indian River - Miami Dade, 3) Florida Keys -- Monroe county, 4) West coast -- Collier - Citrus counties, and 5) Panhandle -- Dixie - Escambia counties based on the Marine Recreational Fisheries Statistics Survey's For Hire regions.
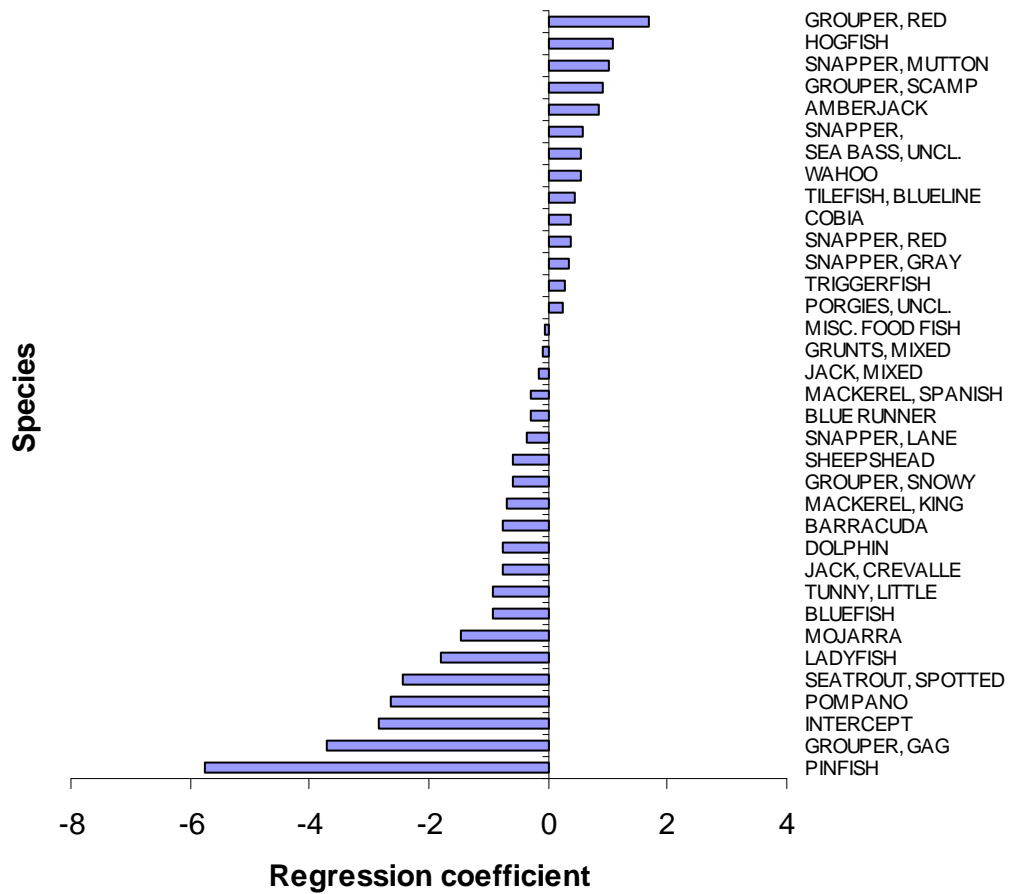
Figure 2. Species with significant regression coefficients for calculating the probability that black grouper were caught on a hook-and-line trip.
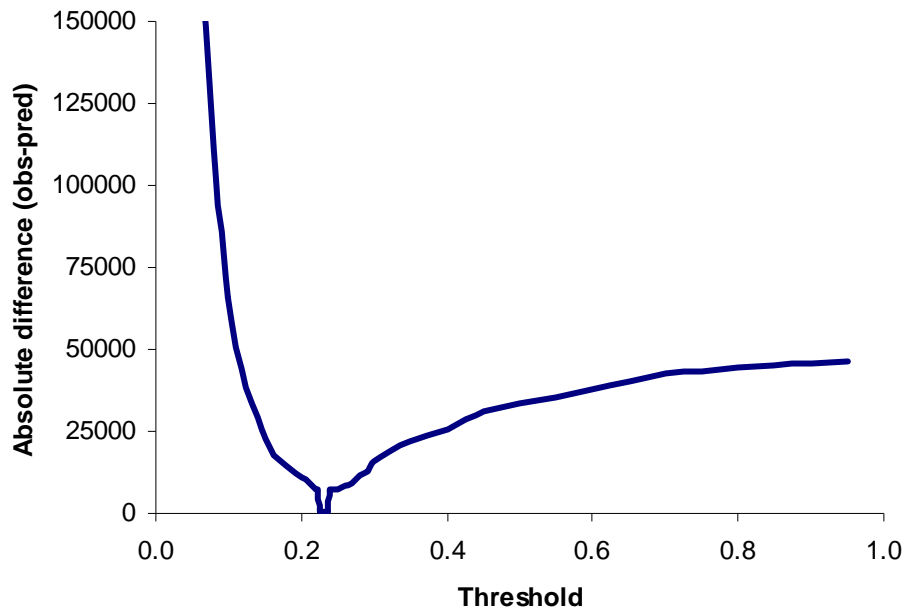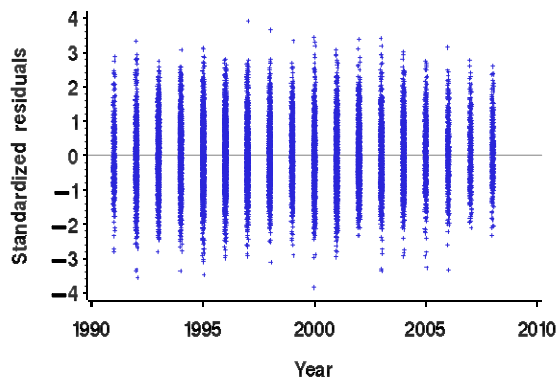
Figure 3. Absolute difference between the observed number of hook-and-line trips with black grouper and the predicted number of trips by threshold values.
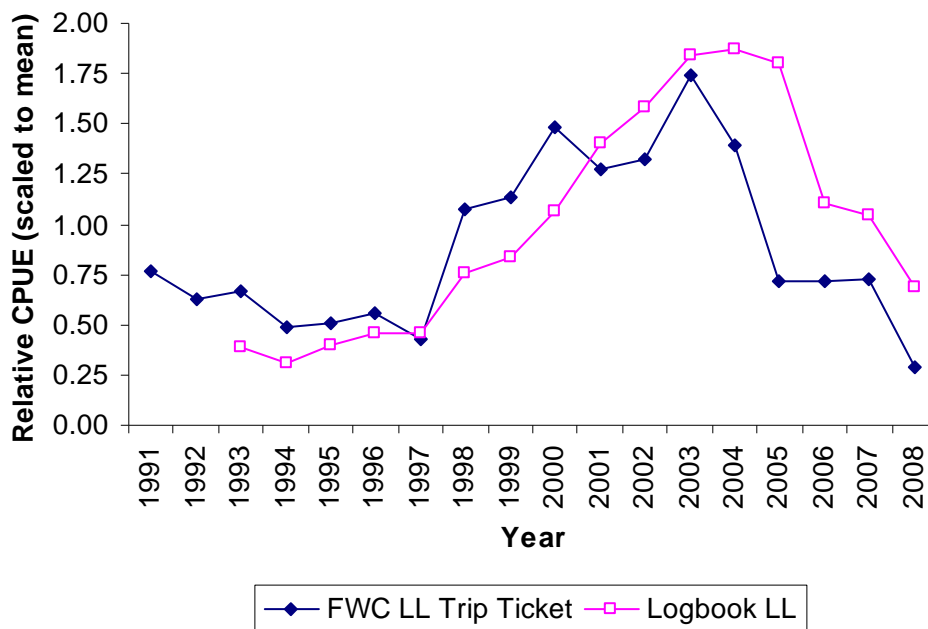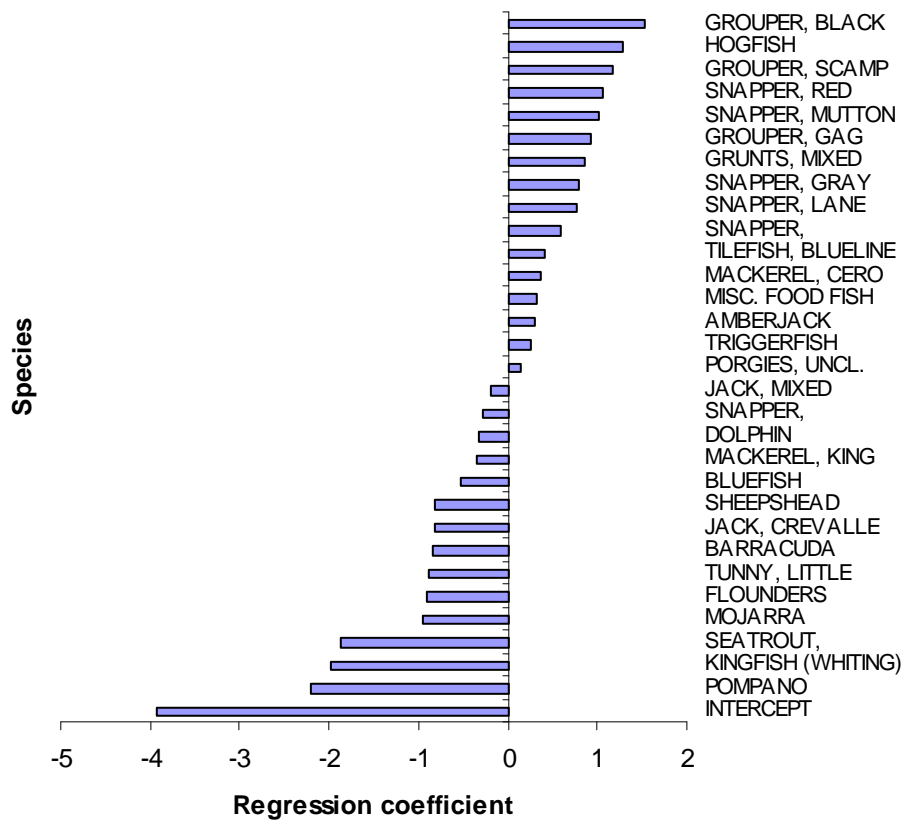
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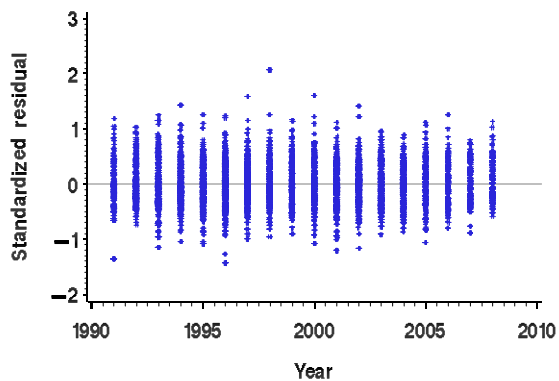
b.

c.
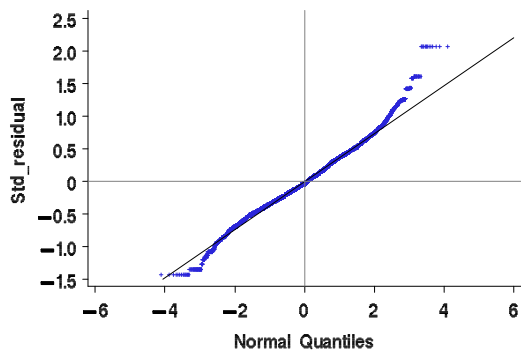
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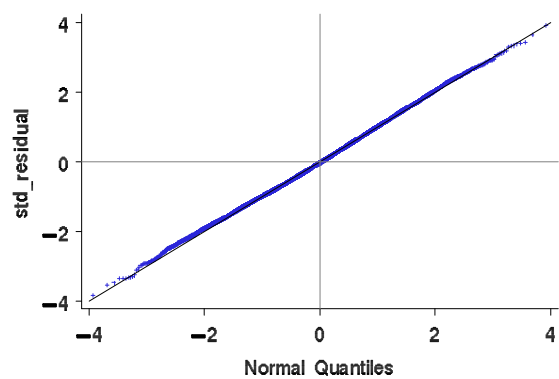
e.
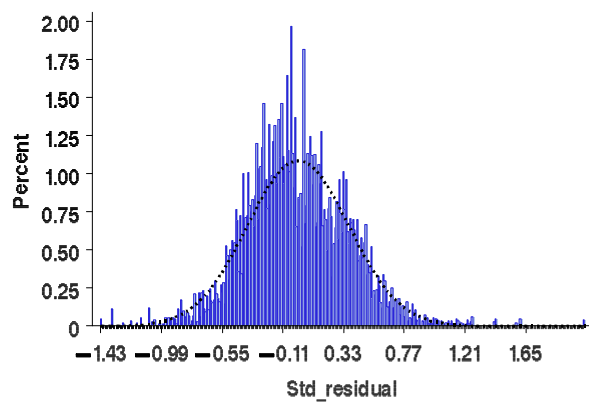
f.
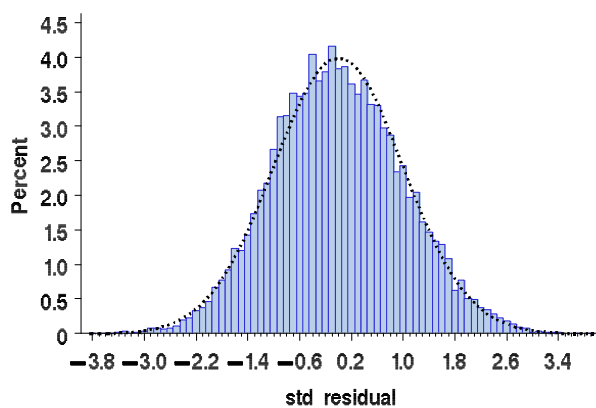
Figure 4. Residuals from the generalized linear models (GLM) for the proportion of positive trips (a) annual residual pattern, c) quantile plot, and e) residual distribution) and residuals from the GLM for the landings on positive trips (b) annual residual pattern, d) quantile plot, and f) residual distribution).
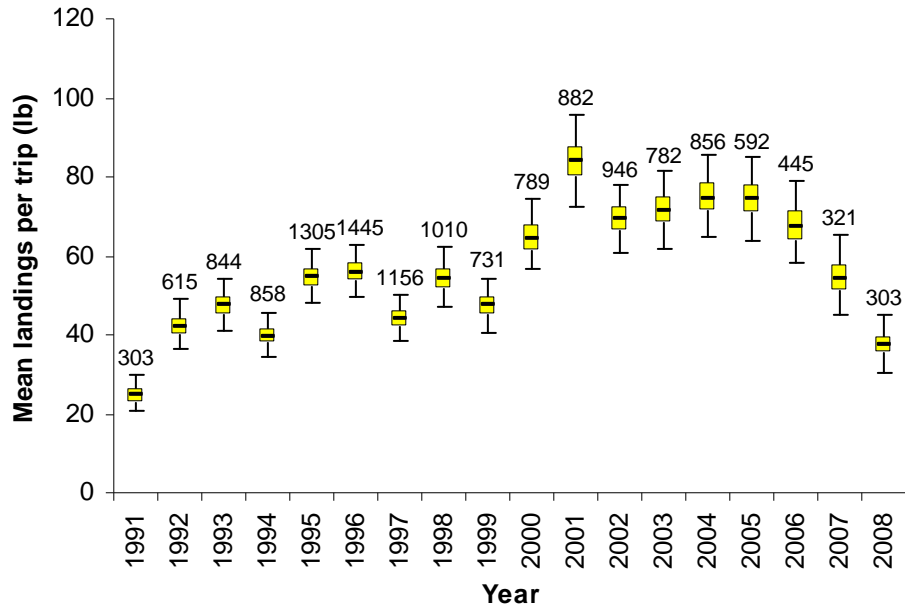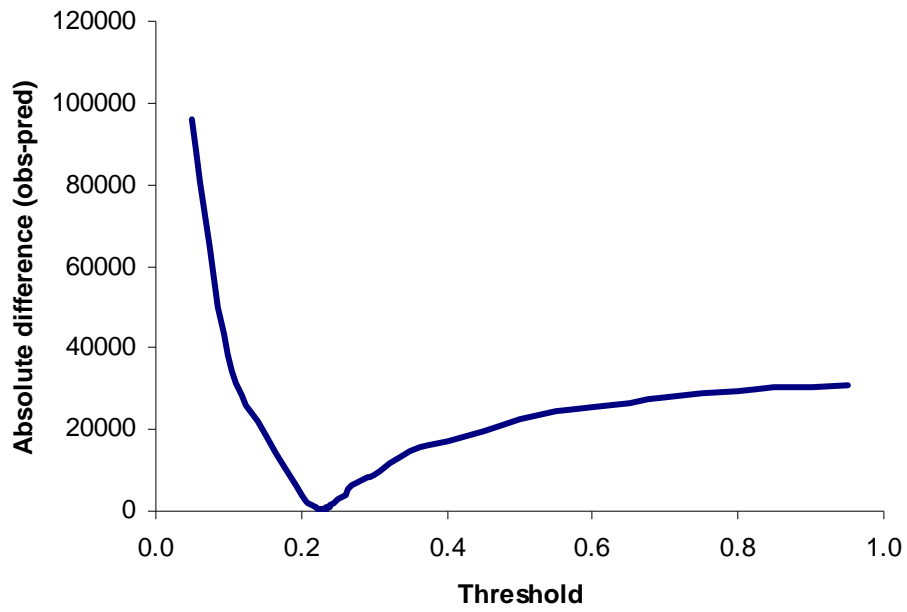
Figure 5. Standardized annual total catch of black grouper per hook-and-line trip with trips selected by Stephens and MacCall's logistic regression. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of hook-and-line trips that caught black grouper for each year.
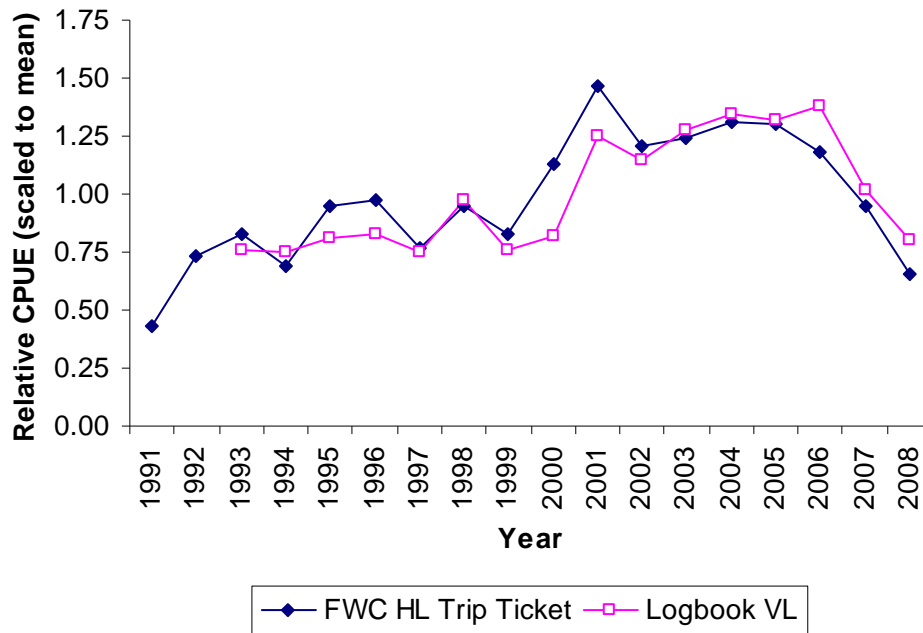
**Figure 6.** Comparison of standardized black grouper catch rates calculated from FWC's HL trip tickets and from NMFS's Logbook Program's vertical lines. The correlation between the two patterns is 0.86 which is significant at the $\alpha = 0.05$ level.
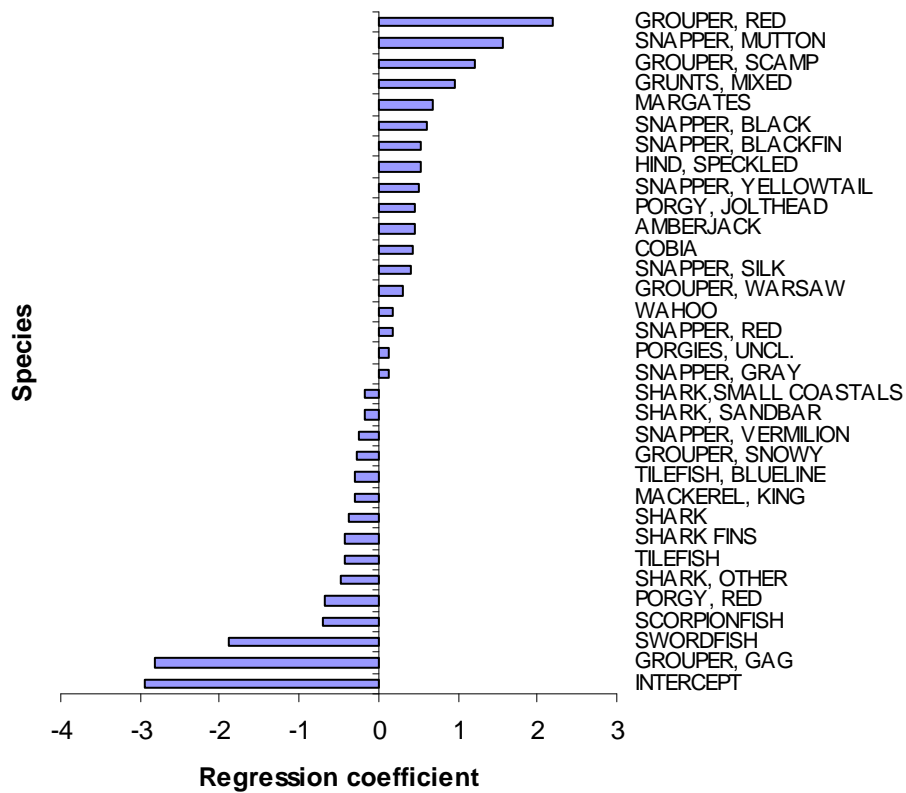
Figure 7. Species with significant regression coefficients for calculating the probability that black grouper were caught on a longline trip
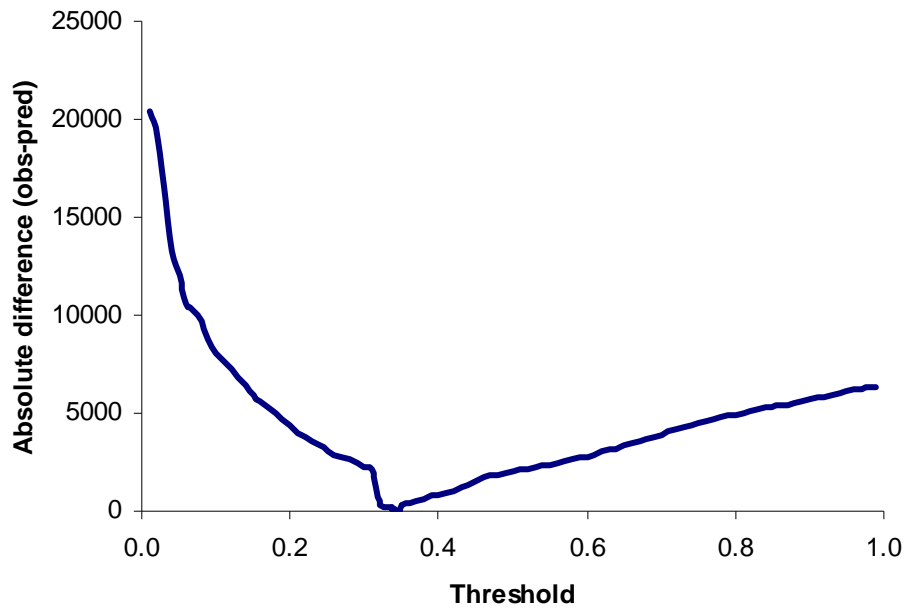
Figure 8. Absolute difference between the observed number of longline trips with black grouper and the predicted number of trips by threshold values.

a.

b.

c.

d.

e.

f.
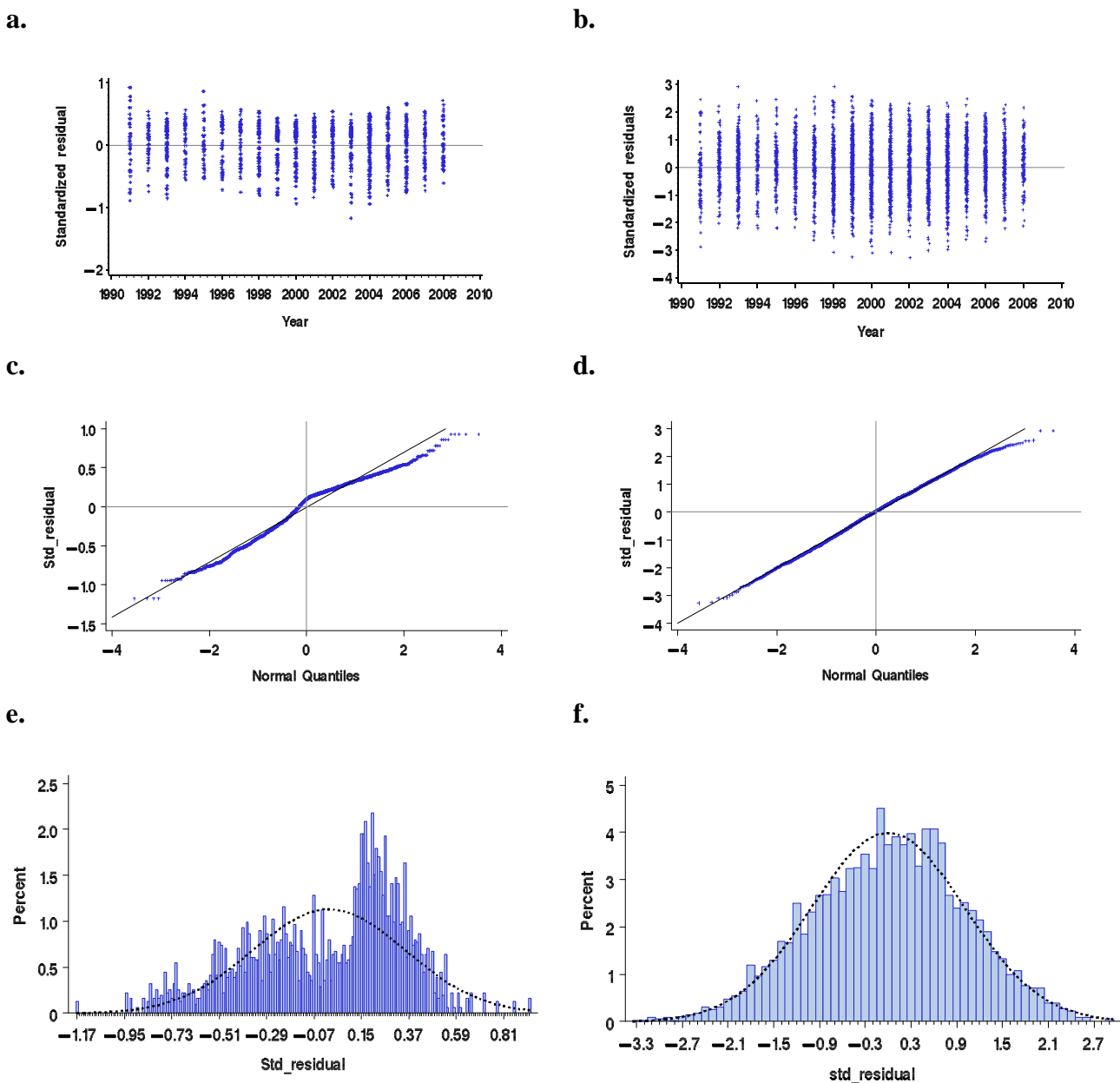
Figure 9. Residuals from the generalized linear models (GLM) for the proportion of positive black grouper, longline trips (a) annual residual pattern, c) quantile plot, and e) residual distribution) and residuals from the GLM for the landings on positive longline trips (b) annual residual pattern, d) quantile plot, and f) residual distribution).
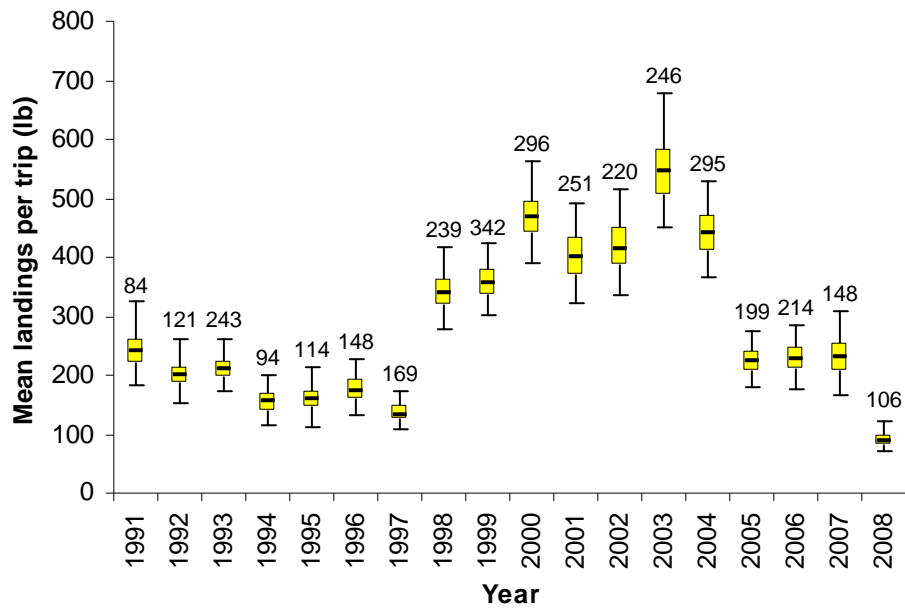
Figure 10. Standardized annual total catch of black grouper per longline trip with trips selected by Stephens and MacCall's logistic regression. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of longline trips that caught black grouper for each year.

Figure 11. Comparison of standardized black grouper catch rates calculated from FWC's longline trip tickets and from NMFS's Logbook Program's longline trips. The correlation between the two patterns is 0.71 which is significant at the $\alpha = 0.05$ level.

Figure 12. Species with significant regression coefficients for calculating the probability that red grouper were caught on a trip.

Figure 13. Absolute difference between the observed number of hook-and-line trips with red grouper and the predicted number of trips by threshold values.
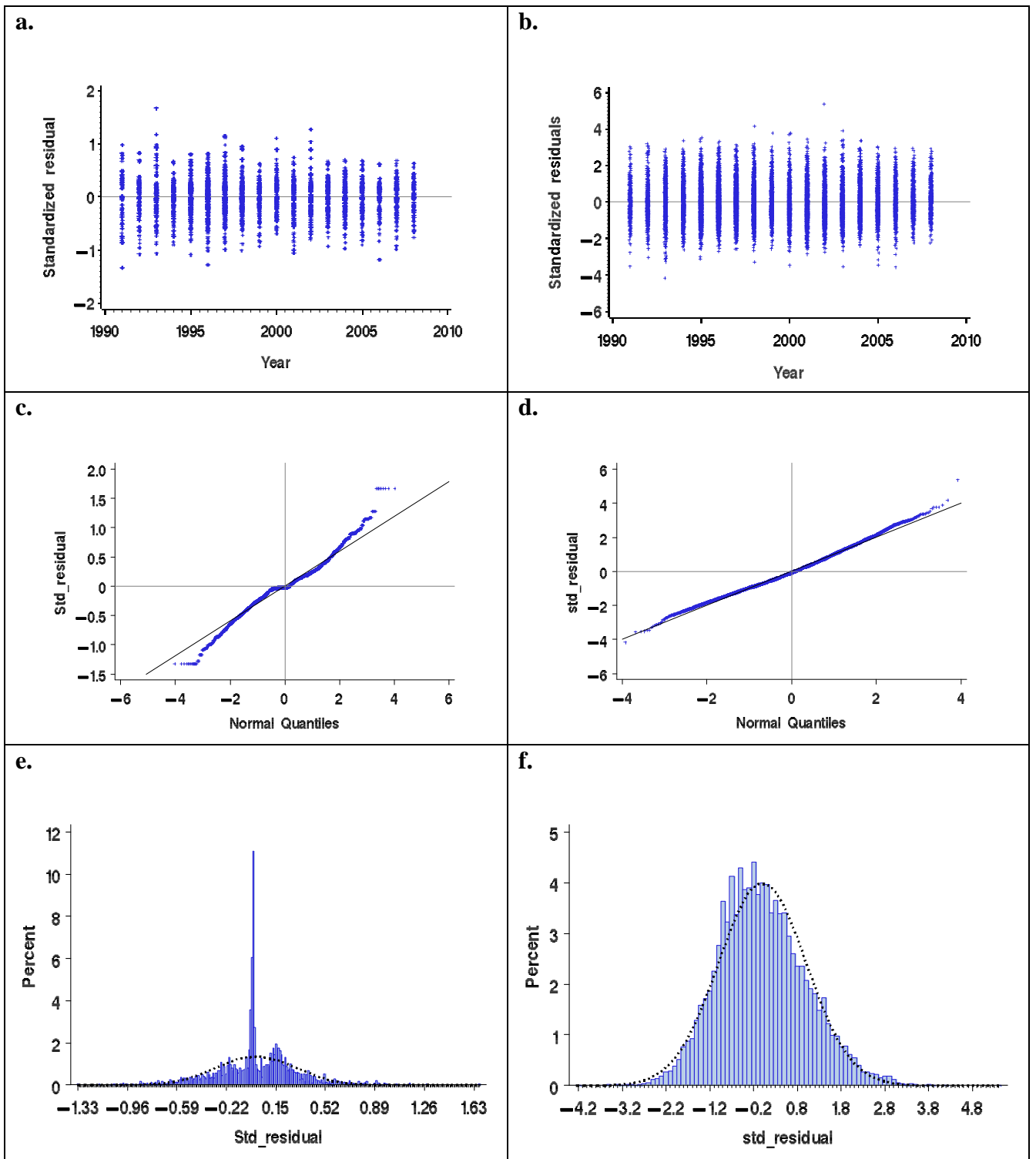
Figure 14. Residuals from the generalized linear models (GLM) for the proportion of positive trips landing red grouper selected by Stephens and MacCall (a) annual residual pattern, c) quantile plot, and e) residual distribution) and residuals from the GLM for the landings on positive trips (b) annual residual pattern, d) quantile plot, and f) residual distribution).
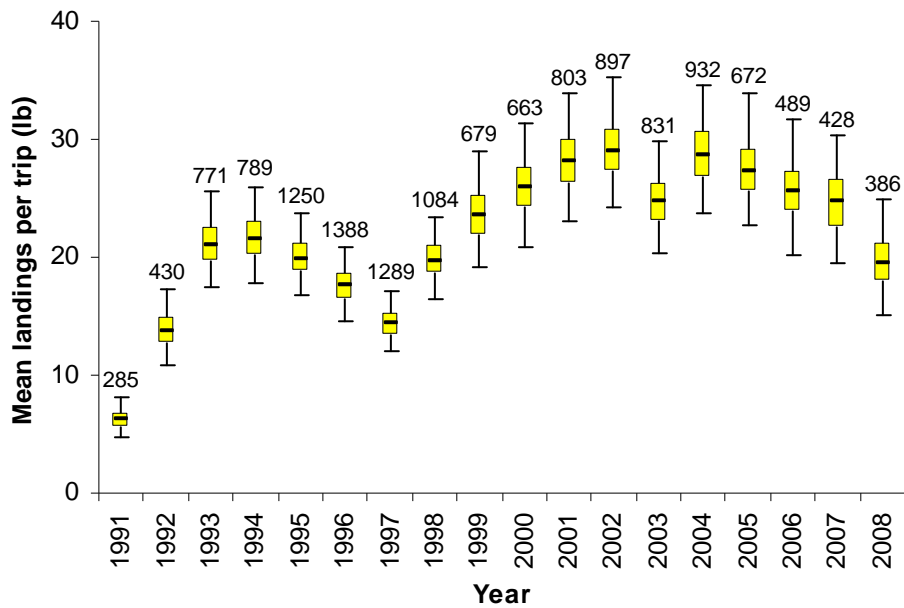
Figure 15. Standardized annual total catch of red grouper per HL trip with trips selected by Stephens and MacCall logistic regression. The vertical lines are the 95% confidence interval, the box is the inter-quartile range, the horizontal line is the median of the outcomes and the number above the lines are the number of HL trips that caught red grouper for each year.
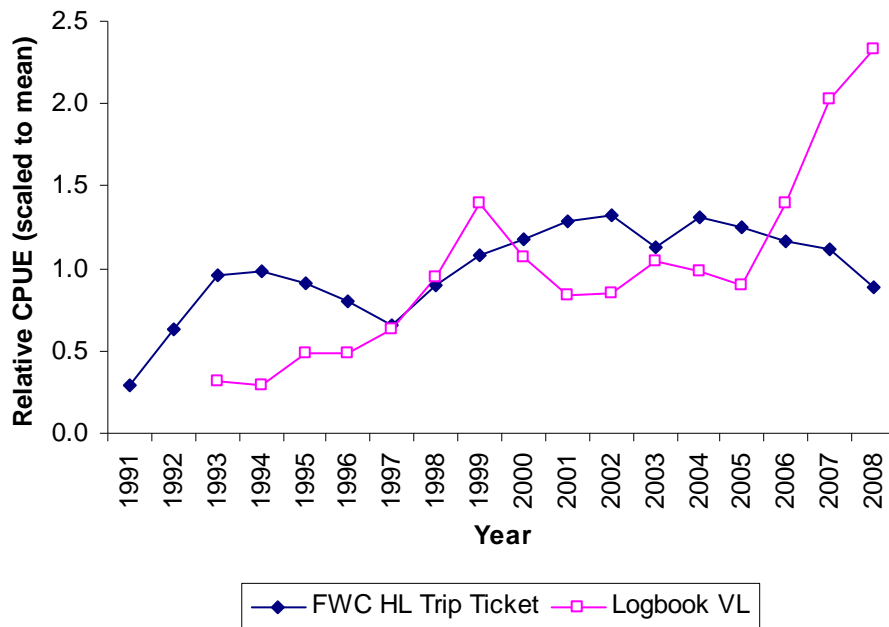
Figure 16. Comparison of standardized catch rates for red grouper HL trips from the FWC trip ticket program with the standardized catch rates from NMFS Logbook Program's vertical lines. Both methods used Stephens and MacCall logistic regressions to select trips. The correlation was 0.17 and was not significant at the $\alpha = 0.05$ level.
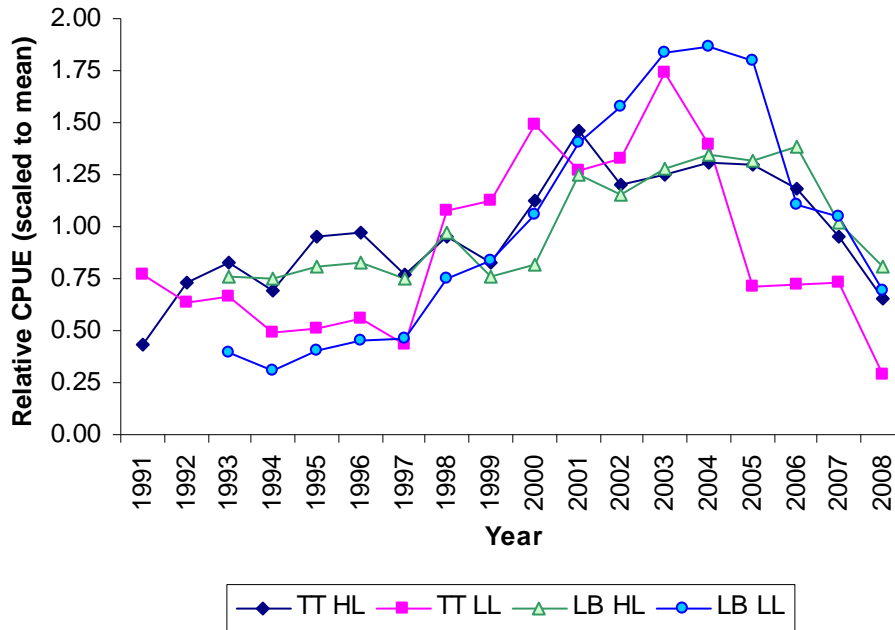
Figure 17. Comparison of the FWC trip ticket (TT, solid symbols) and NMFS logbook (LB, open symbols) black grouper indices for hook-and-line (HL) and longline (LL).