SCDNR Charterboat Logbook Program Data, 1993-2010

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Abstract:
The South Carolina Department of Natural Resources (SCDNR) charterboat logbook program was used to develop indices of abundance for Spanish mackerel and cobia for 1993 - 2010. The indices of abundance are standardized catch per unit effort (CPUE; catch per angler hour). For Spanish mackerel, a delta-gamma GLM was used to produce annual abundance estimates and for cobia a delta-lognormal GLM was used to produce annual abundance estimates. The indices are meant to describe the population trends of fish caught by V1 (6-pack) charter vessels operating in or off of South Carolina.

Background:
The South Carolina Department of Natural Resources (SCDNR) issues three types of charter vessel licenses: V1 (vessels carrying six or fewer passengers), V2 (vessels carrying 7 to 49 passengers), and V3 (vessels carrying 50 or more passengers). In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory logbook reporting system for all charter vessels to collect basic catch and effort data. Under state law, vessel owners/operators purchasing South Carolina Charter Vessel Licenses (V1, V2, or V3) and carrying fishermen on a for-hire basis are required to submit trip level reports of their fishing activity in waters off of SC. Logbook reports are submitted by mail or fax to the SCDNR Fisheries Statistics section monthly. Reporting compliance is tracked by staff, and charter vessel owners/operators failing to submit reports can be charged with a misdemeanor. The charterboat logbook program is a complete census and should theoretically represent the total catch and effort of the charterboat trips in waters off of SC.

Logbook Data:
The charterboat logbook reports include: date, number of fishermen, fishing locale (inshore, 0-3 miles, >3miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, and catch (number of landed and released fish by species) per vessel per trip. The logbook forms have remained similar throughout the program's existence with a few exceptions: in 1999 the logbook forms were altered to begin collecting the number of fish released alive and the number of fish released dead (prior to 1999 only the total numbers of fish released were recorded) and in 2008 additional fishing methods were added to the logbook forms, including 4) cast, 5) cast and bottom, and 6) gig.

After being tracked for compliance each V1 charterboat logbook report is coded and entered into an existing Access database. (V2 and V3 charterboat logbook reports are tracked for compliance but are currently not coded and entered electronically. Most of these vessels participate in the NMFS Beaufort Headboat Logbook Survey.) Since the inception of the program, a variety of staff have coded the charterboat logbook data. From ~1999 to 2006, only information that was explicitly filled out by the charterboat owners/operators on the logbook forms was coded and entered into the database. No efforts were made to fill in incomplete reports. From 2007 to the present, staff have tried to fill in incomplete trip reports through conversations with charterboat owners/operators and by making assumptions based on the submitted data (i.e. if a location description was given instead of a grid location – a grid location was determined, if fishing method was left blank – it was determined based on catch, etc.). From 1999 to 2006 each individual trip record was reviewed to look for anomalies in the data. Starting in 2007 queries were used to look for and correct anomalous data and staff began checking a component of the database records against the raw logbook reports. Coding and QA/QC measures prior to 1999 were likely similar to those used from 1999 to the present. However, details on these procedures were not available since staff members working on this project prior to 1998 are no longer with the SCDNR. Data are not validated in the field and currently no correction factors are used to account for reporting errors. Recall periods for logbook records are typically one month or less. However, in the case of delinquent reports recall periods could be up to several months.

Methods:

SCDNR charterboat logbook vessel trips included in the analysis for Spanish mackerel represent trolling fishing trips in nearshore (0-3 miles) or offshore (3+ miles) waters. SCDNR charterboat logbook vessel trips included in the analysis for cobia represent bottom fishing trips in estuarine, nearshore (0-3 miles) and offshore (3+ miles) waters.

The indices were standardized using a delta generalized linear model (GLM) approach. All analyses were conducted in R, based primarily on code adapted from Dick (2004). A delta GLM model was chosen due to the significant amount of zeros in the CPUE data. A delta model has 2 components to it. First, the probability of a positive catch is modeled. Then the positive catch rates are modeled separately. Finally, the two are multiplied together to get the predicted CPUE (Dick 2004, Li et al. 2011, Siquan et al. 2009, and Yu et al. 2011)

$$\widehat{CPUE} = \hat{d}\ x\ \hat{q}$$

Where $\widehat{CPUE}$ is the standardized CPUE, $\hat{d}$ is the predicted catch rate of the positive catches, and $\hat{q}$ is the probability of a positive catch. The models for Spanish mackerel were built assuming a gamma distribution. The models for cobia were built assuming a lognormal distribution. The model of the positive catch rates used was:

$$ln(\hat{d}) = \beta_0 + \sum_{i=1} \beta_i X_i$$

Where β_0 is the intercept and β_i is the coefficient for the i^{th} explanatory variable X_i. The probability of a positive catch was modeled as:

$$ln\left(\frac{\hat{q}}{1-\hat{q}}\right) = \alpha_0 + \sum_{i=1} \alpha_i X_i$$

Where α_0 is the intercept and α_i is the coefficient for the i^{th} explanatory variable X_i.

Two model runs, using slightly different explanatory variables, are included in this working paper for both species. The first modeling approach used the year, the locale of the catch, and the month as explanatory variables (referred to as the "monthly" standardization). The second modeling approach used the year, the locale of the catch, and the season as explanatory variables (referred to as the "seasonal" standardization). For locale (for both model runs for both species), estuarine was considered for all trips that occurred in waters inside the col regs line, nearshore was considered for all trips that occurred in waters from 0-3 miles, and offshore for waters >3 miles. For the seasonal model runs for both species, winter was considered for all trips occurring from Dec. to Feb., spring from Mar. to May, summer from June to Aug. and fall from Sept. to Nov.

Results:

<u>Spanish Mackerel</u>

The SCDNR charterboat logbook data represent 49,132 fishing trips in which anglers caught 186,444 Spanish mackerel and harvested 147,141 Spanish mackerel. Summarized catch and effort data are presented in Table 1. The indices are presented in Table 2 and Figure 2. Comparisons between the AIC values of the two model runs are presented in Table 3. The monthly model run had higher AIC values for the binomial sub-model and lower AIC values for the gamma sub-model when compared to the seasonal model run. When looking at the variation in each of the model runs (standard error, SE), there was no significant difference between the monthly and seasonal runs (p=0.742). Comparing the total SE to the total CPUE (% Total CPUE) again showed no significant difference between the two model runs (p=0.416). Diagnostics for the monthly model run are found in Figures 3 and 4. Diagnostics for the seasonal model run are found in Figures 5 and 6.

The biggest difference between these two model runs is related to the number of parameters present. There are three times more time parameters in the monthly model than the seasonal model. When looking at the plot of the residuals to the fitted

values for the gamma model, the spread of the data is not much different. However, the monthly run has more residuals clustered around zero because there are simply more residuals, which causes the run to have a lower AIC for the gamma model. The same trend is apparent in the Normal Q-Q plot for the gamma model. The plots look the same for each run, but the monthly run has more points on it and they are clustered on the 1:1 line, therefore increasing the fit and decreasing the AIC. The boxplots show no significant difference between the two runs.

The binomial model results in a difference between the two runs. The residual plot for the monthly data is on a whole different scale than the seasonal plot, by several orders of magnitude. The residuals for the seasonal run are much lower than the monthly run. Also, the Normal Q-Q plot shows a much better fit for the seasonal run than the monthly run. The boxplots also show significant differences between the two runs. The monthly boxplots are all centered around zero, but the seasonal boxplots are all at either +1 or -1. However, the monthly boxplots show outliers that are an order of magnitude larger than the seasonal boxplots.

Cobia

The SCDNR charterboat logbook data represent 107,199 fishing trips in which anglers caught 11,582 cobia and harvested 5,253 cobia. Summarized catch and effort data are presented in Table 4. The indices are presented in Table 5 and Figure 7. Comparisons between the AIC values of the two model runs are presented in Table 6. The monthly model run had higher AIC values for the binomial sub-model and lower AIC values for the lognormal sub-model when compared to the seasonal model run. When looking at the variation in each of the model runs (standard error, SE), the monthly model run had significantly higher SE than the seasonal run ($p=0.0062$). Comparing the total SE to the total CPUE (% Total CPUE) again showed a significant difference between the two model runs ($p=0.000006$). The monthly run's total SE was much higher when compared to the total CPUE than for the seasonal run. Diagnostics for the monthly model run are found in Figures 8 and 9. Diagnostics for the seasonal model run are found in Figures 10 and 11.

Again, the biggest difference between these two model runs is related to the number of parameters present. There are three times more time parameters in the monthly model than the seasonal model. The same trends are present here as for Spanish mackerel. When looking at the plot of the residuals to the fitted values for the lognormal model, the spread of the data is not much different. However, the monthly run has more residuals clustered around zero because there are simply more residuals, which causes the run to have a lower AIC when compared to the seasonal run for the lognormal model. The same thing is apparent in the Normal Q-Q plot for the lognormal model. The plots look the same for each run, but the monthly run has more points on it and they are clustered on the 1:1 line, therefore increasing the fit and decreasing the AIC. The boxplots show no significant difference between the two runs for the lognormal model.

The binomial model also shows a difference between the two runs. The residual plots show a similar pattern seen in the lognormal model. The trend of the residuals is the same, but there are more points on the monthly graph that are away from the zero line, therefore making the fit poorer and the AIC higher. The Normal Q-Q plot actually shows a much better fit for the seasonal run than the monthly run. The boxplots also show differences between the two runs. The boxplots from both runs are all centered on zero, but the magnitude and spread of the outliers is different. The seasonal boxplots have outliers in each that are more extreme than in any of the monthly boxplots. However, there is only one large outlier in each boxplot or only one factor. There are more outliers in the monthly and more of a spread of the outliers in the monthly than the seasonal boxplots.

Literature Cited:

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Li, Y., Jiao, Y., He, Q. 2011. Decreasing uncertainty in catch rate analyses using Delta-AdaBoost: An alternative approach in catch and bycatch analyses with high percentage of zeros. Fisheries Research 107: 261-271.

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Yu, Hao, Jiao, Y., and Winter, A. 2011. Catch rate standardization of yellow perch in Lake Erie: a comparison of the spatial generalized linear model and generalized additive model. Transactions of the American Fisheries Society 140 (4): 905-918.

Table 1. Annual Spanish mackerel catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1993-2010.

Year	Vessel Trips	% Trips with Spanish Mackerel Catch	Spanish Mackerel Catch (# fish)	Spanish Mackerel Harvest (# fish)	Spanish Mackerel Released (# fish)	% Release
1993	3142	36.86	10163	9119	1044	10.27
1994	3100	36.68	9984	8352	1632	16.35
1995	2614	24.52	6029	5191	838	13.90
1996	2730	32.42	10037	8090	1947	19.40
1997	2914	33.91	11063	8643	2420	21.87
1998	3207	36.86	10404	8815	1589	15.27
1999	3121	41.56	20626	15031	5595	27.13
2000	3511	40.42	14296	10968	3328	23.28
2001	2959	29.23	8493	5908	2585	30.44
2002	2758	33.36	12486	8884	3602	28.85
2003	2449	31.60	8525	6481	2044	23.98
2004	2460	36.83	10766	8736	2030	18.86
2005	2749	37.98	12316	9815	2501	20.31
2006	2400	37.63	9298	7178	2120	22.80
2007	2458	30.63	6164	4664	1500	24.33
2008	2310	36.23	8923	7323	1600	17.93
2009	2060	39.08	8808	7548	1260	14.31
2010	2190	41.14	8063	6395	1668	20.69

Table 2. Spanish mackerel catch per unit effort (catch per angler hour) for the Monthly and Seasonal standardized index model runs.

Year	Nominal CPUE	Model Run 1				Model Run 2			
		Standardized CPUE (Monthly)	SE (Monthly)	Upper (Monthly)	Lower (Monthly)	Standardized CPUE (Seasonal)	SE (Seasonal)	Upper (Seasonal)	Lower (Seasonal)
1993	0.1617	0.1286	0.0251	0.1538	0.1035	0.1345	0.0223	0.1568	0.1122
1994	0.1513	0.1277	0.0230	0.1507	0.1047	0.1191	0.0250	0.1441	0.0941
1995	0.1060	0.0863	0.0187	0.1050	0.0676	0.0769	0.0131	0.0900	0.0637
1996	0.1686	0.1097	0.0203	0.1300	0.0894	0.0902	0.0179	0.1081	0.0724
1997	0.1734	0.1231	0.0231	0.1462	0.0999	0.1135	0.0150	0.1286	0.0985
1998	0.1460	0.1395	0.0310	0.1705	0.1085	0.1104	0.0180	0.1285	0.0924
1999	0.2878	0.1689	0.0314	0.2003	0.1376	0.1637	0.0286	0.1923	0.1351
2000	0.1870	0.1565	0.0373	0.1937	0.1192	0.1272	0.0274	0.1546	0.0999
2001	0.1177	0.1539	0.0477	0.2015	0.1062	0.1260	0.0378	0.1637	0.0882
2002	0.1857	0.1679	0.0403	0.2082	0.1276	0.1569	0.0523	0.2092	0.1046
2003	0.1312	0.0982	0.0198	0.1179	0.0784	0.0976	0.0231	0.1208	0.0745
2004	0.1735	0.1170	0.0277	0.1448	0.0893	0.1089	0.0349	0.1438	0.0741
2005	0.1757	0.1146	0.0277	0.1424	0.0869	0.1252	0.0317	0.1570	0.0935
2006	0.1465	0.1046	0.0205	0.1251	0.0841	0.0887	0.0200	0.1086	0.0687
2007	0.0981	0.0825	0.0135	0.0960	0.0690	0.0737	0.0133	0.0871	0.0604
2008	0.1491	0.1105	0.0316	0.1421	0.0789	0.0901	0.0262	0.1163	0.0639
2009	0.1716	0.1235	0.0241	0.1476	0.0994	0.1095	0.0344	0.1439	0.0751
2010	0.1493	0.0681	0.0198	0.0879	0.0483	0.0618	0.0231	0.0850	0.0387

Table 3. Comparison of AIC values for the Monthly and Seasonal Spanish mackerel standardized index model runs. SE is the standard error calculated from the model jack knife. % Total CPUE is sum(SE)/sum(CPUE).

AIC	Standardized CPUE (Monthly)	Standardized CPUE (Seasonal)
Binomial	106.9724023	44
Positive	-416.5194936	-181.8648745
Sum of SE	0.482642994	0.464215698
% Total CPUE	22.13%	23.52%

Table 4. Annual cobia catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1993-2010.

Year	Vessel Trips	% Trips with Cobia Catch	Cobia Total Catch (# fish)	Cobia Harvest (# fish)	Cobia Released (# fish)	% Release
1993	1968	5.18	191	109	82	42.93
1994	2926	3.11	141	100	41	29.08
1995	3242	1.57	67	50	17	25.37
1996	3378	1.39	67	43	24	35.82
1997	3622	2.71	167	55	112	67.07
1998	5050	5.17	780	178	602	77.18
1999	5294	7.10	1046	509	537	51.34
2000	6222	5.98	720	311	409	56.81
2001	6357	6.09	967	433	534	55.22
2002	6515	5.39	698	347	351	50.29
2003	6560	4.83	605	374	231	38.18
2004	6588	5.46	734	439	295	40.19
2005	6927	4.89	676	403	273	40.38
2006	7064	5.22	881	212	669	75.94
2007	7662	6.17	1284	482	802	62.46
2008	7242	4.98	901	433	468	51.94
2009	6976	4.97	858	390	468	54.55
2010	6900	4.52	799	385	414	51.81

Table 5. Cobia catch per unit effort (catch per angler hour) for the monthly and seasonal model runs.

Year	Nominal CPUE	Standardized CPUE (Seasonal)	SE (Seasonal)	Upper (Seasonal)	Lower (Seasonal)	Standardized CPUE (Monthly)	SE (Monthly)	Upper (Monthly)	Lower (Monthly)
1993	0.0066	0.0043	0.0012	0.0055	0.0031	0.0047	0.0020	0.0068	0.0027
1994	0.0033	0.0030	0.0008	0.0038	0.0022	0.0028	0.0008	0.0036	0.0020
1995	0.0015	0.0018	0.0004	0.0022	0.0014	0.0015	0.0005	0.0020	0.0010
1996	0.0015	0.0018	0.0006	0.0023	0.0012	0.0017	0.0006	0.0023	0.0011
1997	0.0035	0.0040	0.0014	0.0053	0.0026	0.0028	0.0014	0.0042	0.0014
1998	0.0122	0.0057	0.0018	0.0075	0.0040	0.0062	0.0028	0.0090	0.0035
1999	0.0159	0.0074	0.0023	0.0097	0.0051	0.0107	0.0049	0.0156	0.0058
2000	0.0094	0.0055	0.0013	0.0068	0.0041	0.0048	0.0021	0.0069	0.0027
2001	0.0123	0.0065	0.0017	0.0082	0.0048	0.0065	0.0027	0.0091	0.0038
2002	0.0085	0.0051	0.0016	0.0067	0.0034	0.0056	0.0029	0.0084	0.0027
2003	0.0072	0.0038	0.0008	0.0046	0.0029	0.0041	0.0012	0.0053	0.0028
2004	0.0088	0.0063	0.0016	0.0080	0.0047	0.0056	0.0025	0.0081	0.0032
2005	0.0072	0.0049	0.0012	0.0061	0.0038	0.0063	0.0020	0.0083	0.0044
2006	0.0092	0.0049	0.0011	0.0059	0.0038	0.0047	0.0017	0.0063	0.0030
2007	0.0122	0.0059	0.0014	0.0073	0.0045	0.0084	0.0033	0.0117	0.0051
2008	0.0086	0.0042	0.0010	0.0052	0.0033	0.0055	0.0017	0.0072	0.0038
2009	0.0089	0.0053	0.0013	0.0066	0.0040	0.0068	0.0023	0.0091	0.0045
2010	0.0082	0.0038	0.0011	0.0048	0.0027	0.0050	0.0020	0.0071	0.0030

Table 6. Comparison of AIC values for the Monthly and Seasonal cobia Standardized index model runs. SE is the standard error calculated from the model jack knife. % Total CPUE is sum(SE)/sum(CPUE).

AIC	Stand CPUE (Monthly)	Stand CPUE (Seasonal)
Binomial	320.7548191	93.77095859
Positive	-2574.575251	-1227.143977
Sum of SE	0.037283909	0.037283909
% Total CPUE	39.75%	26.73%

Figure 1. Distribution of Spanish mackerel catch from SCDNR 6-pack Charterboat Logbook data. Each square represents a 10 mile^2 area. Only charterboat logbook data from 2008 to 2010 was used to create these maps because prior to 2008 an average of 80% of logbooks did not include location information. Similarly to all the data presented above only charterboat trips that indicated they were trolling fishing and fishing nearshore (0-3 miles) and offshore (3+ miles) waters were used to create the map.

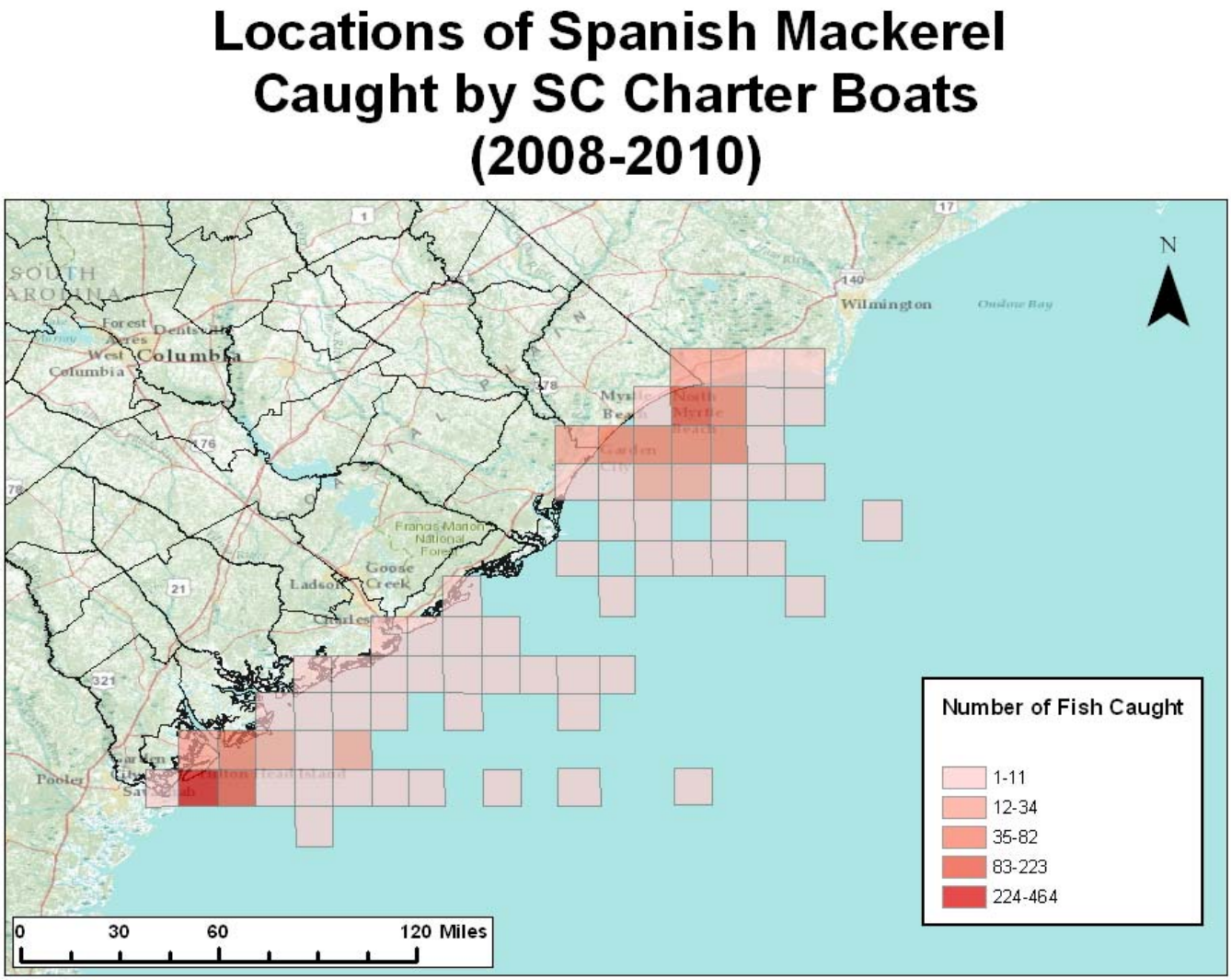


Figure 2. Spanish mackerel CPUE from SCDNR 6-pack Charterboat Logbook data from 1993-2010. Nominal (blue), Monthly standardized (green), and Seasonal standardized (red) catch per angler-hour are shown. The dotted lines show 1 standard error from the Standardized CPUE.

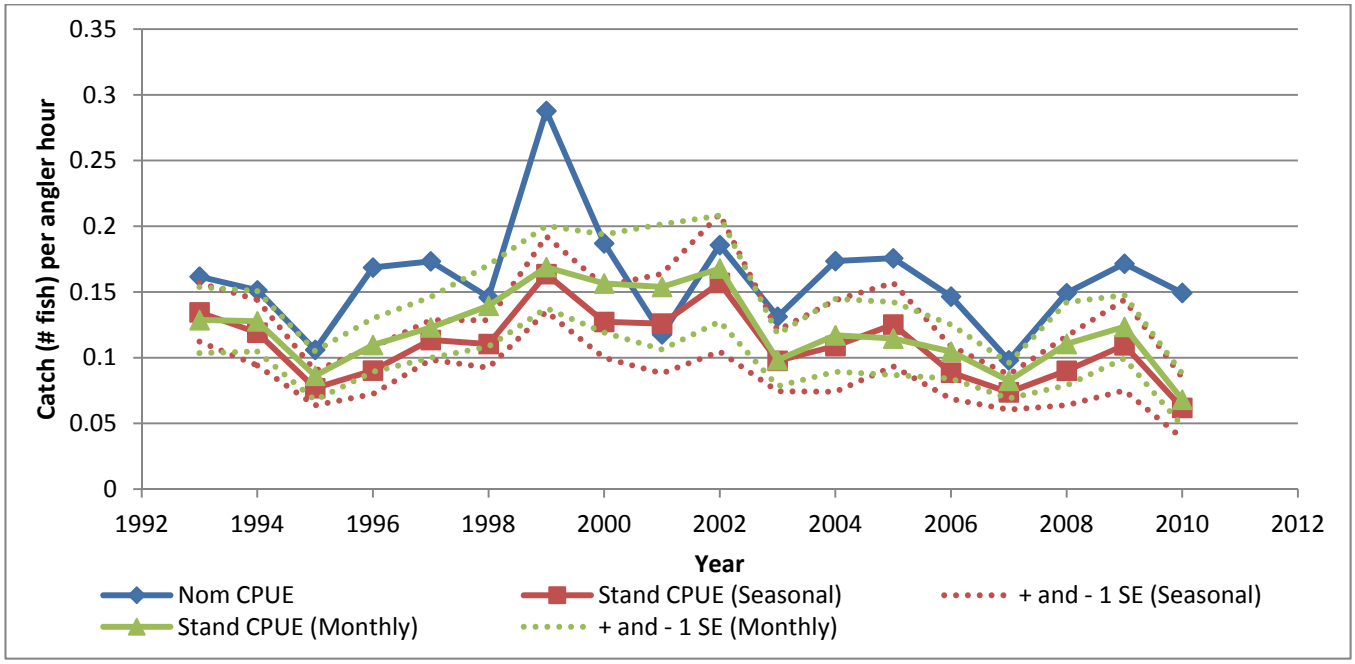
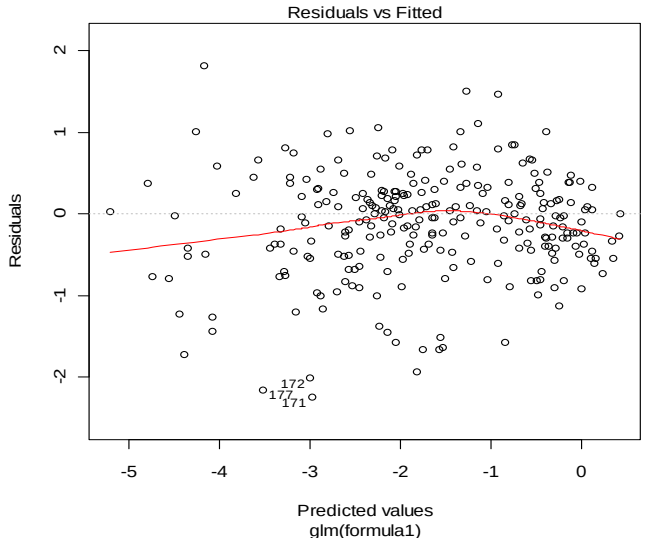


Figure 3. Diagnostic plots for gamma component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year; **D.** the residuals by locale; **E.** the residuals by season

A



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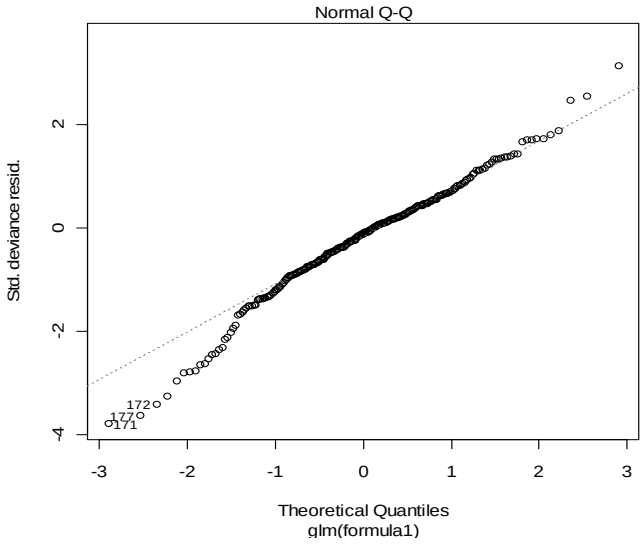

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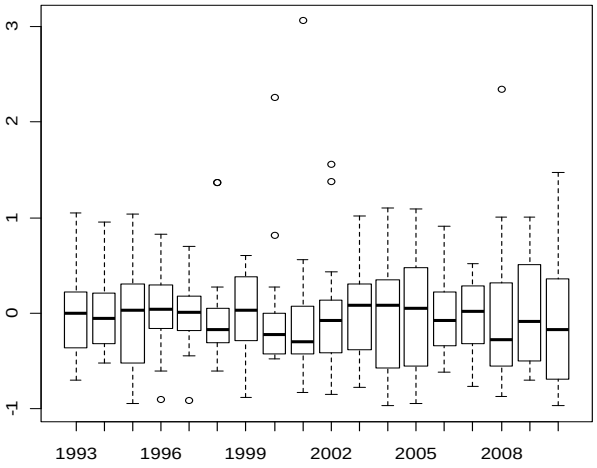

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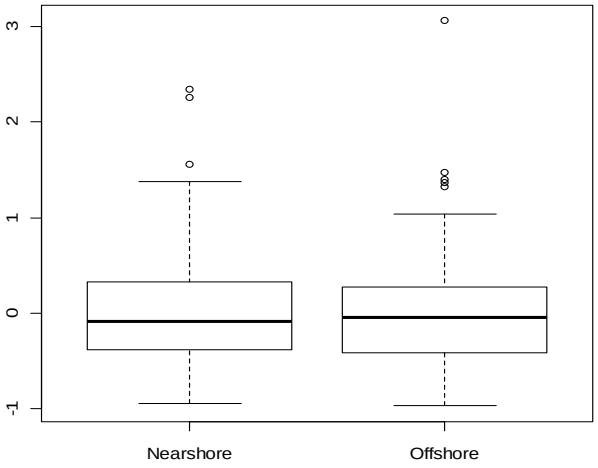

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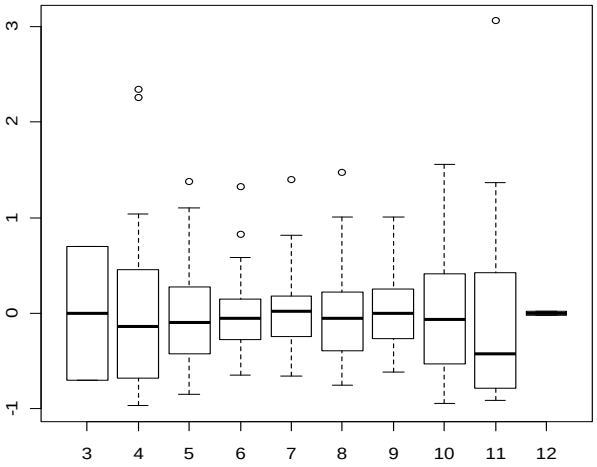
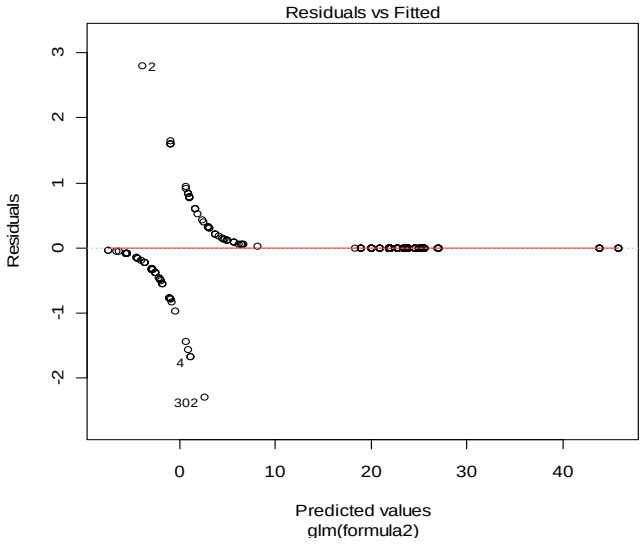


Figure 4. Diagnostic plots for binomial component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



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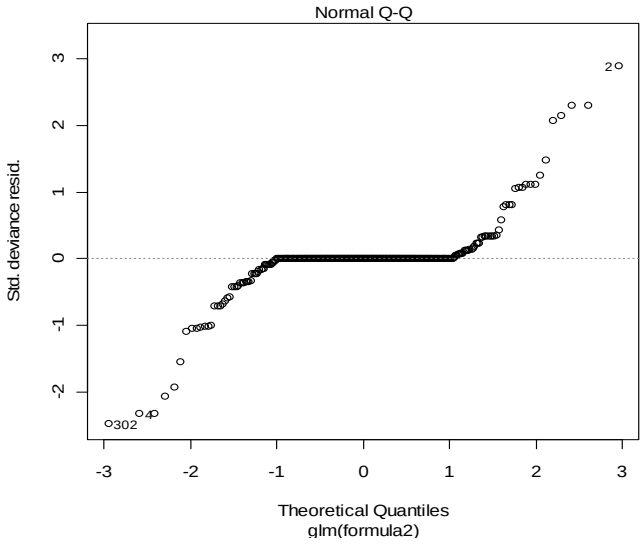

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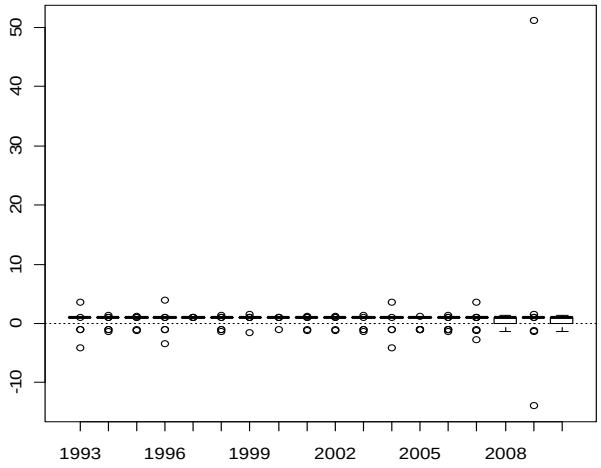

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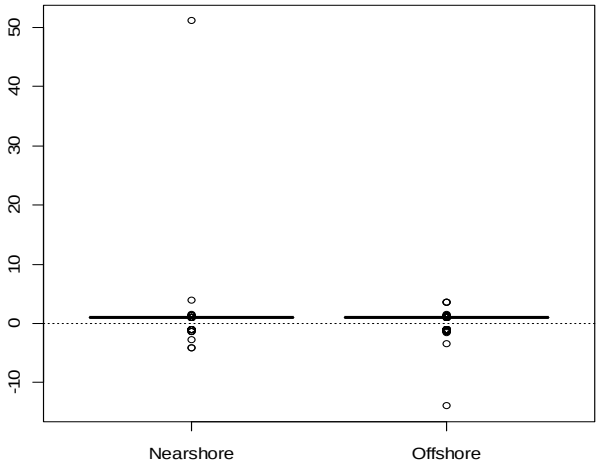

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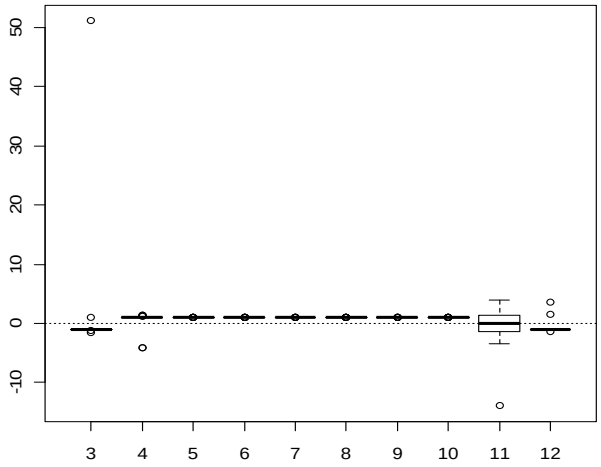
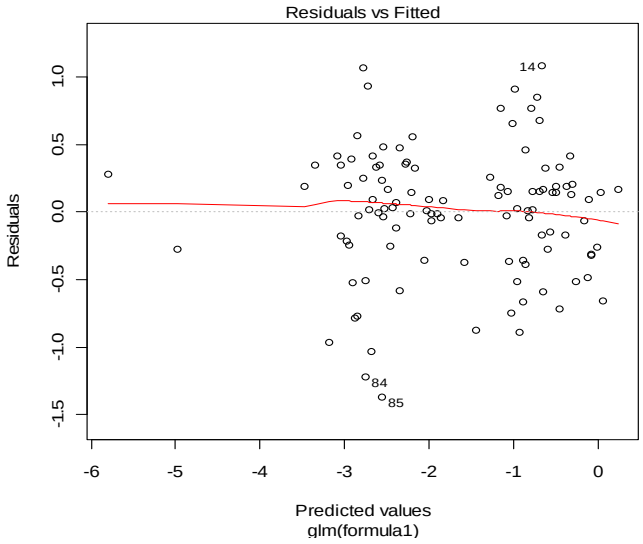
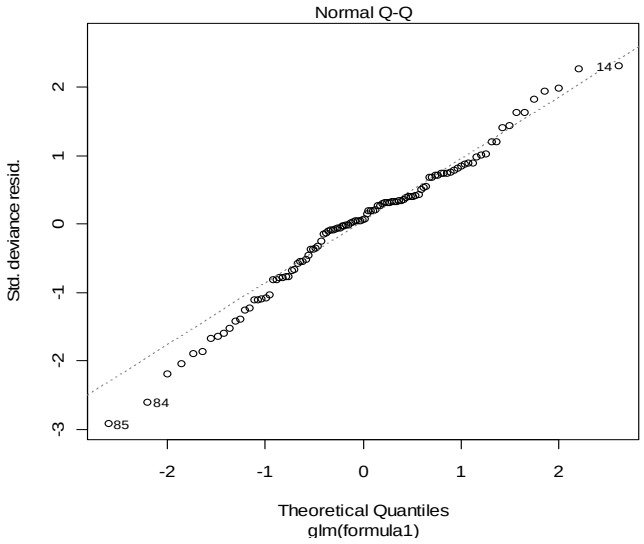


Figure 5. Diagnostic plots for gamma component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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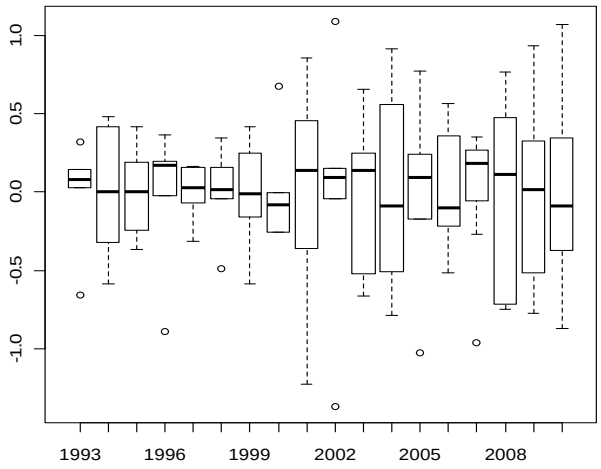

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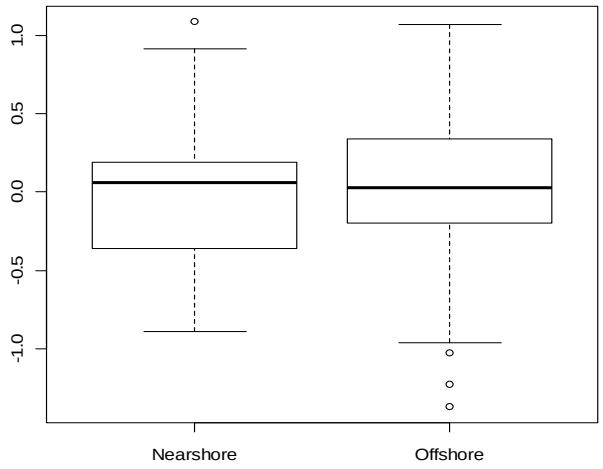

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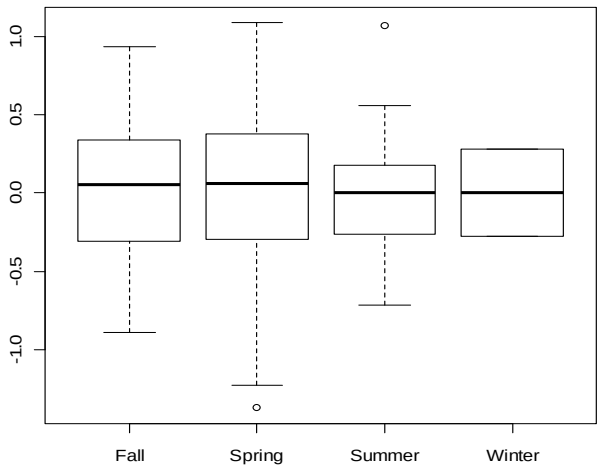
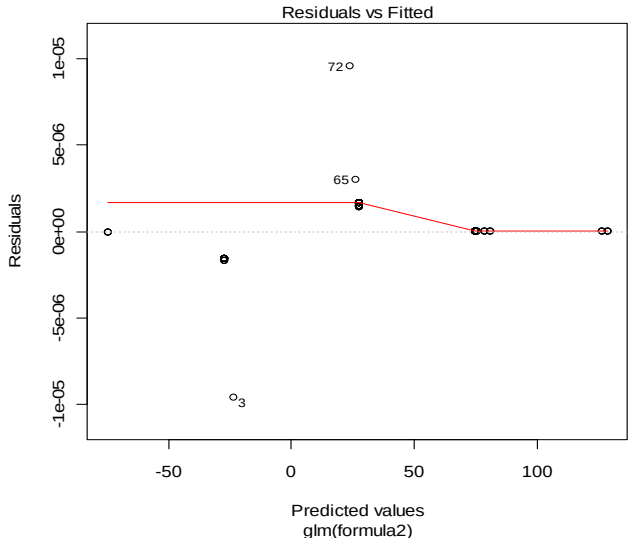


Figure 6. Diagnostic plots for binomial component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



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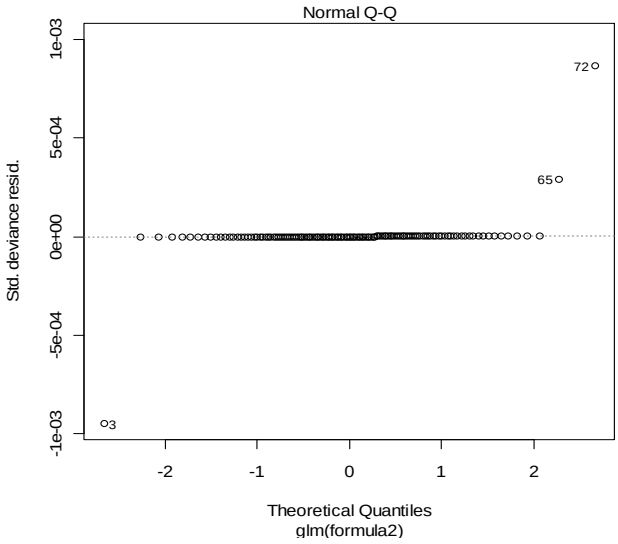

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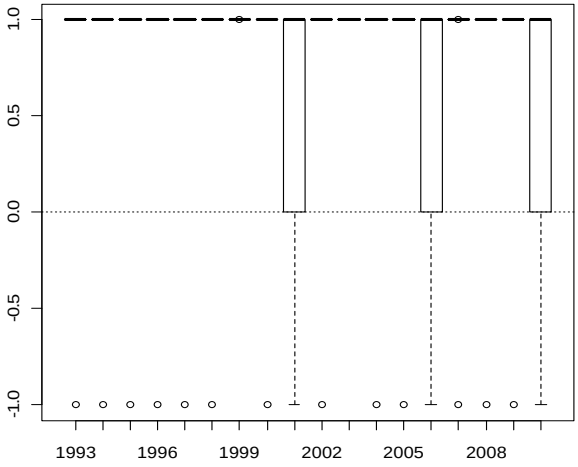

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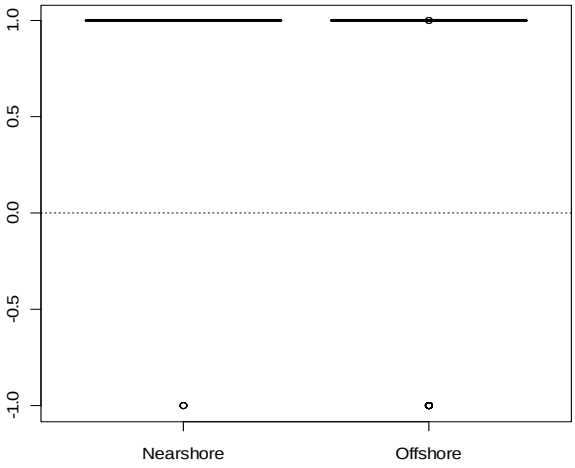

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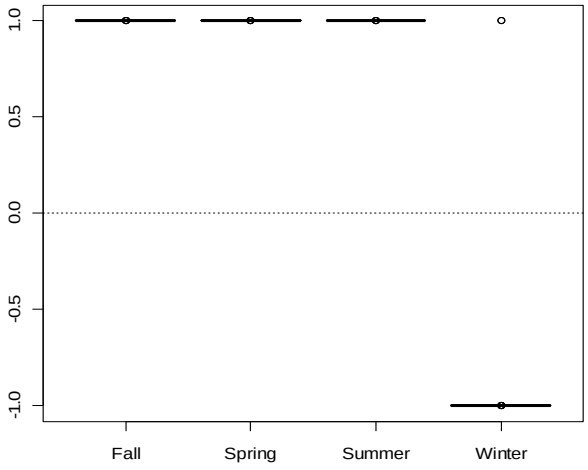


Figure 7. Distribution of cobia catch from SCDNR 6-pack Charterboat logbook data. Each square represents a 10 mile^2 area. Only charterboat logbook data from 2008 to 2010 was used to create these maps because prior to 2008 an average of 80% of logbooks did not include location information. Similarly to all the data presented above only charterboat trips that indicated they were bottom fishing were used to create the map.

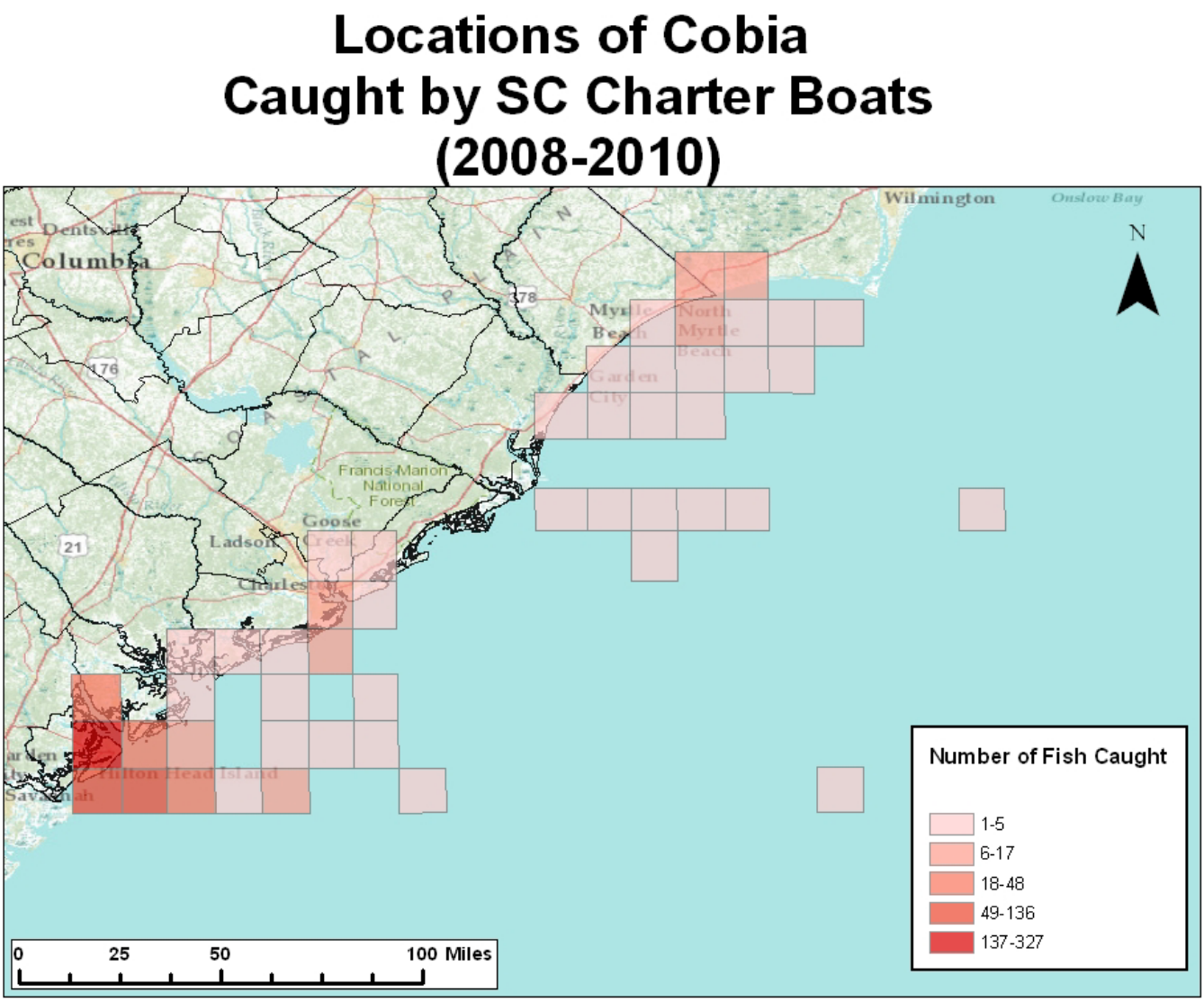


Figure 8. Cobia CPUE from SCDNR 6-pack Charterboat Logbook data from 1993-2010. Nominal (blue), Monthly standardized (green), and Seasonal standardized (red) catch per angler-hour are shown. The dotted lines show 1 standard error from the Standardized CPUE.

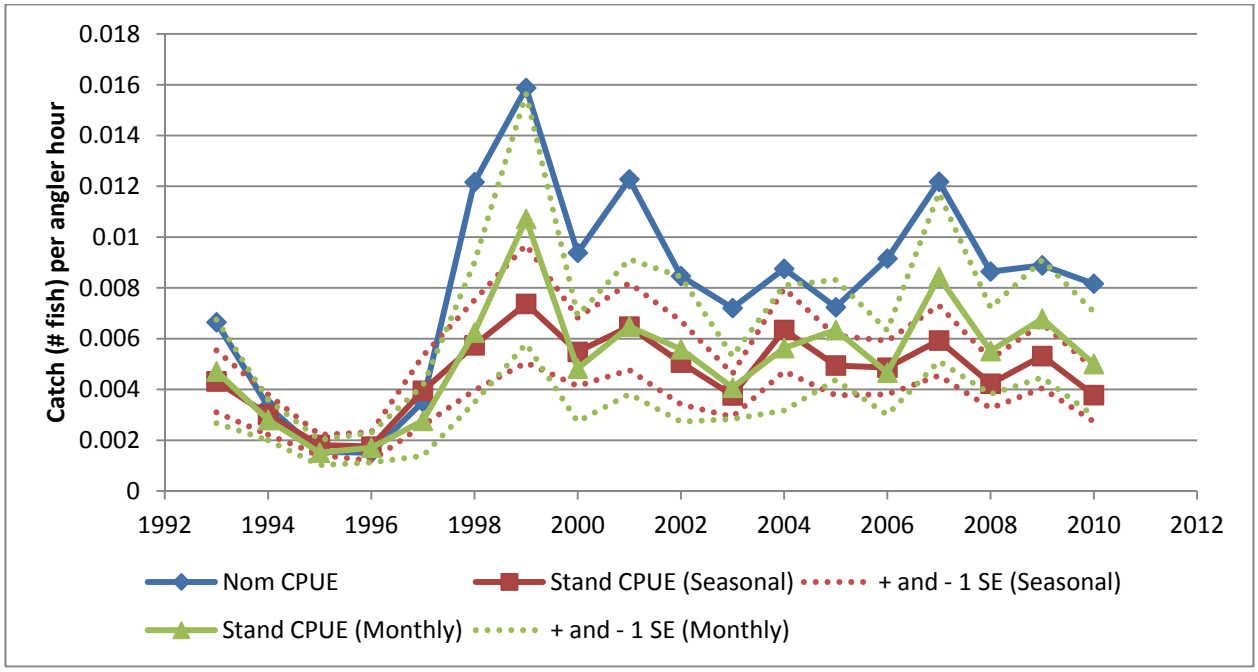
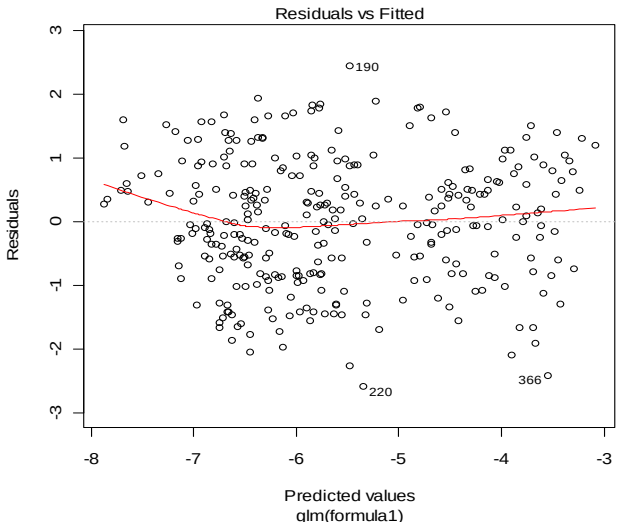


Figure 9. Diagnostic plots for lognormal component of the Cobia SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



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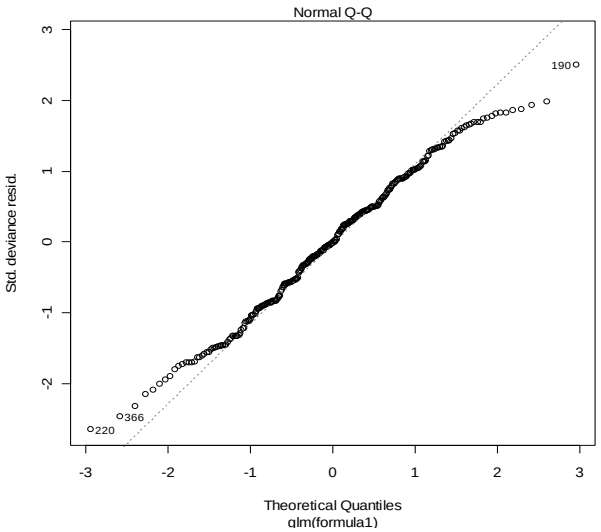

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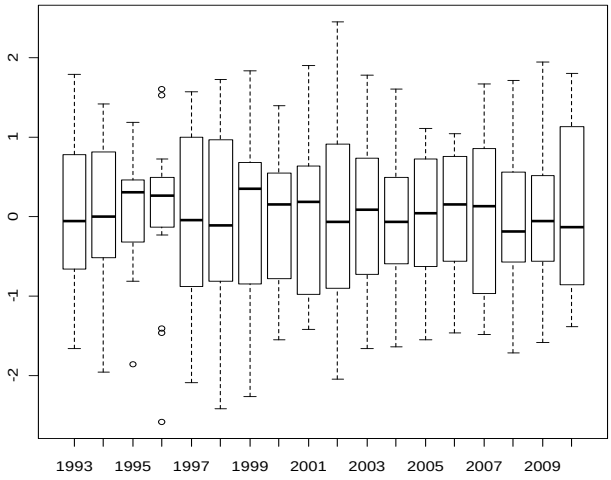

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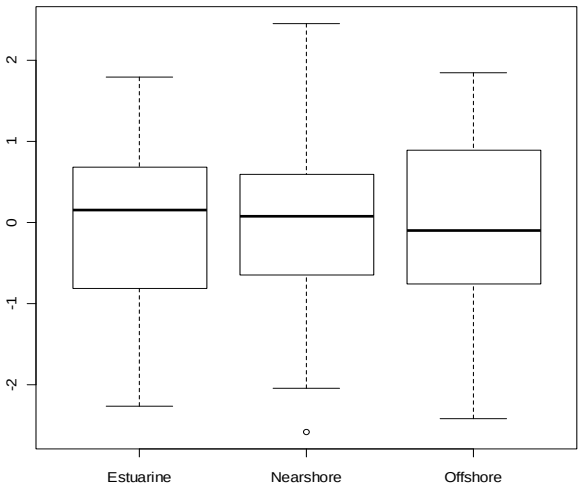

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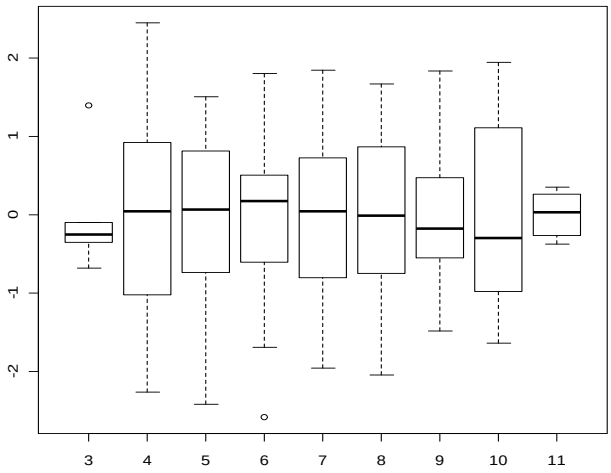
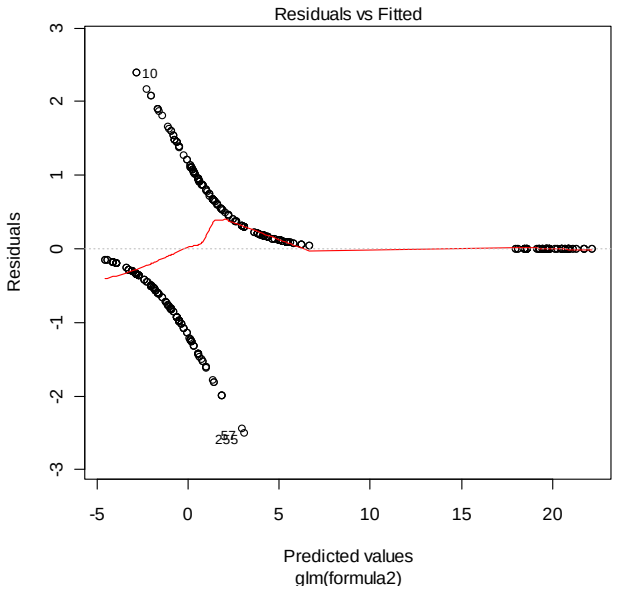
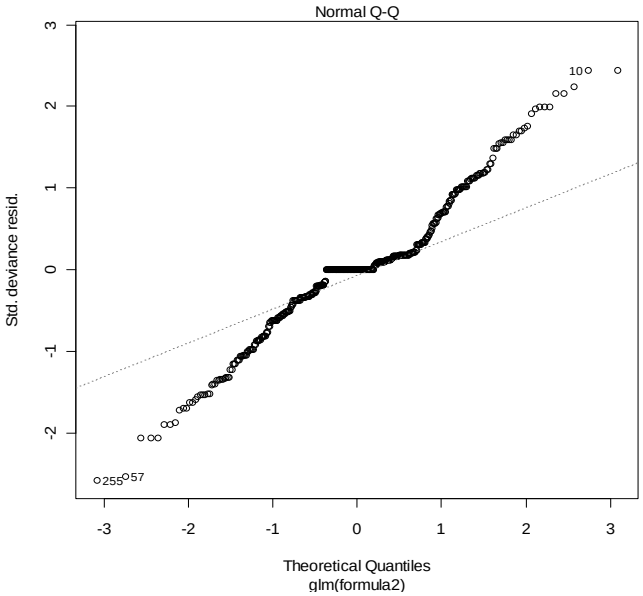


Figure 10. Diagnostic plots for binomial component of the Cobia SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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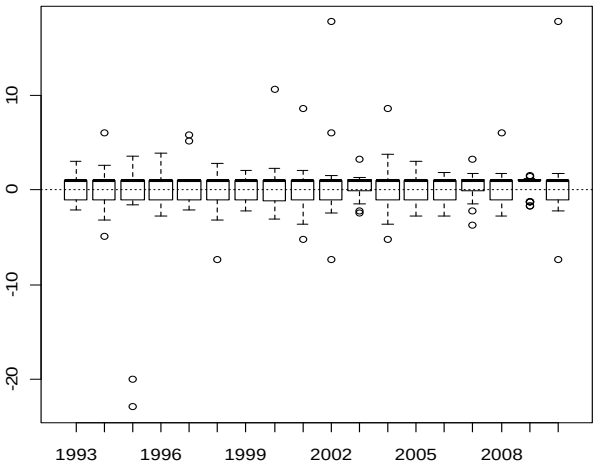

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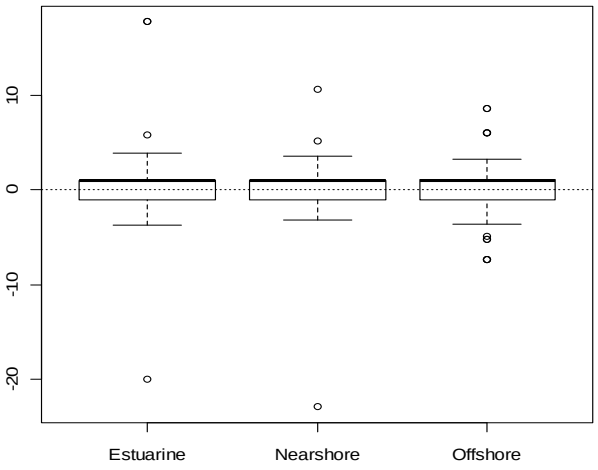


E

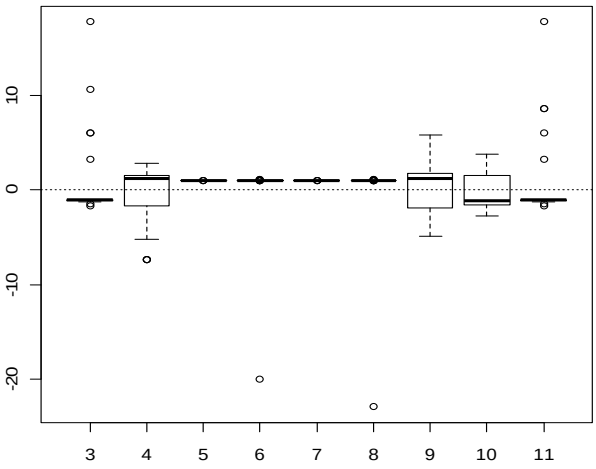
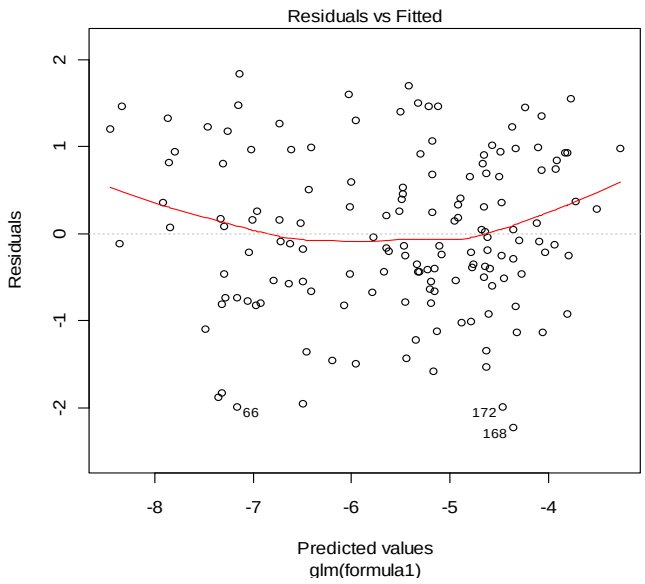
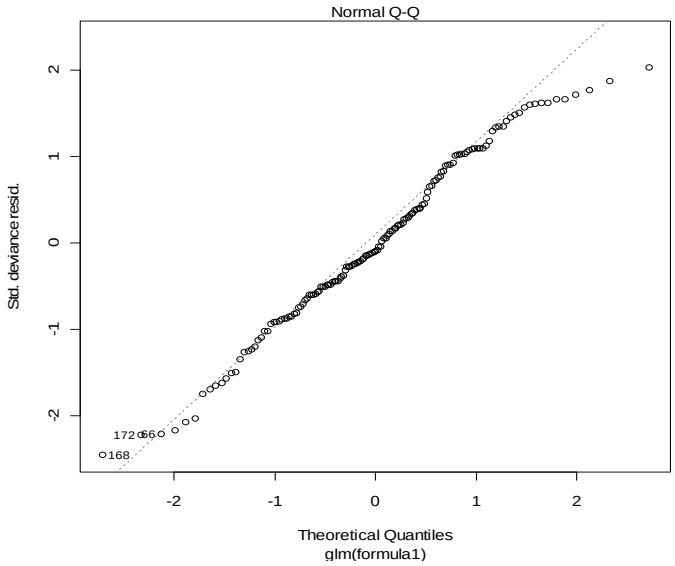


Figure 11. Diagnostic plots for lognormal component of the Cobia SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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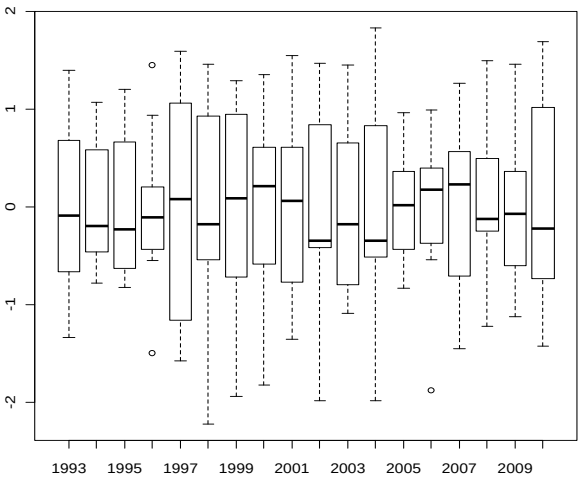

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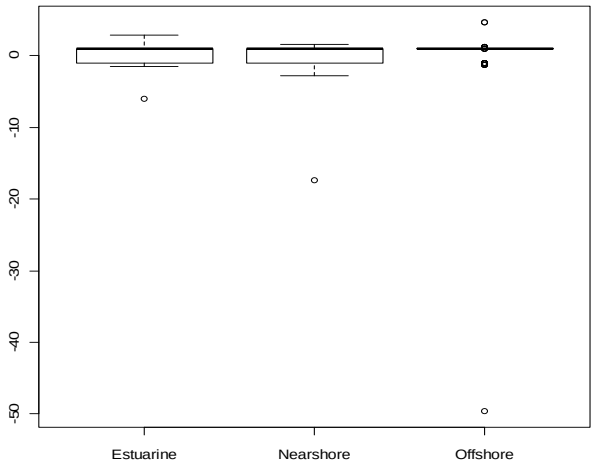


E

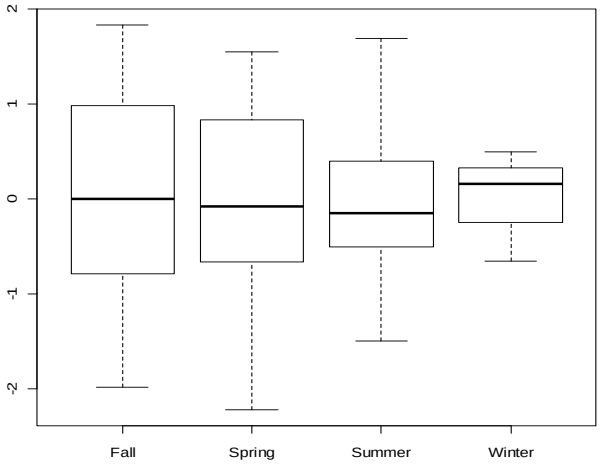
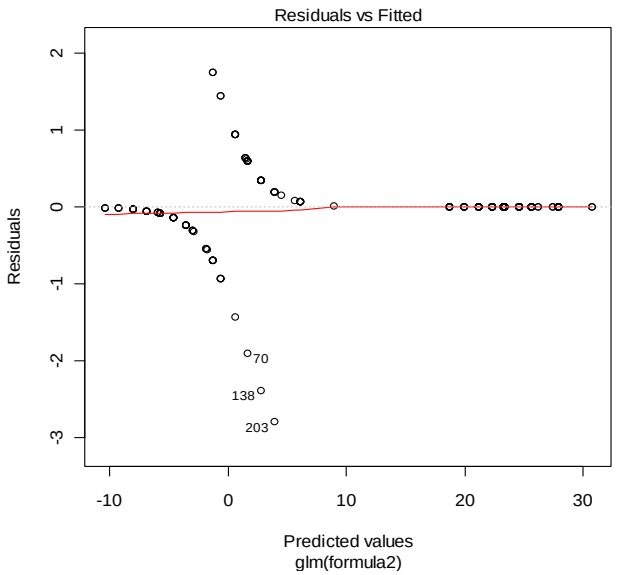
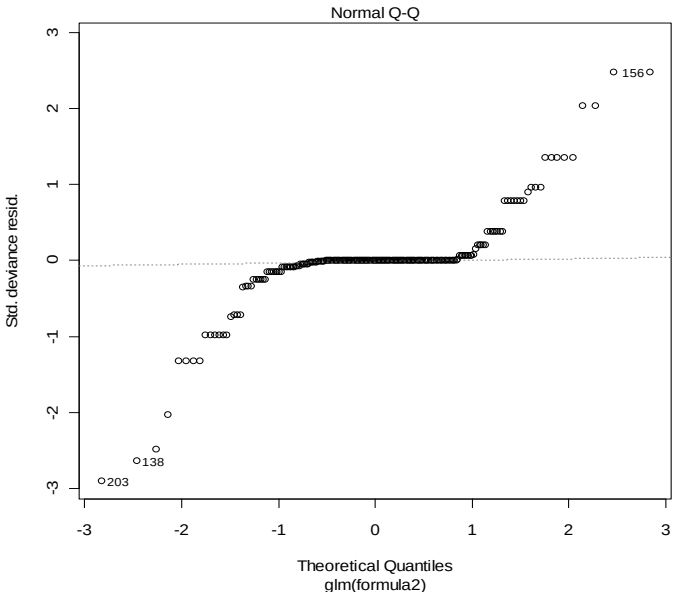


Figure 12. Diagnostic plots for binomial component of the Cobia SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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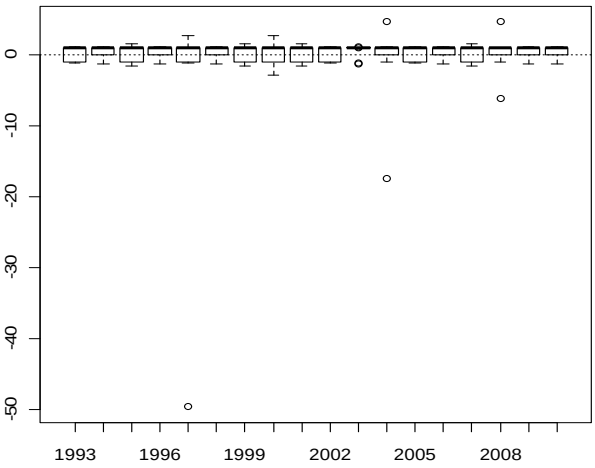

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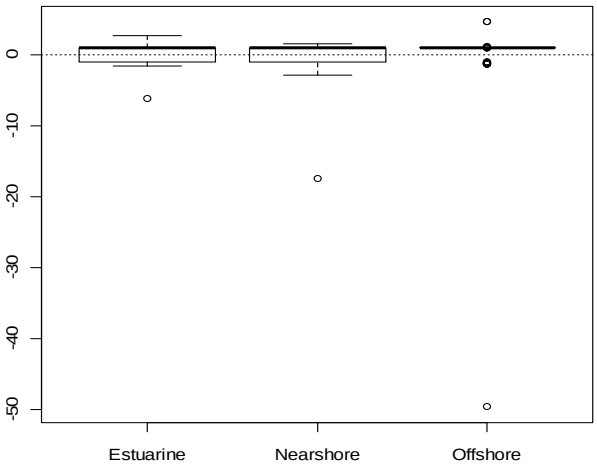
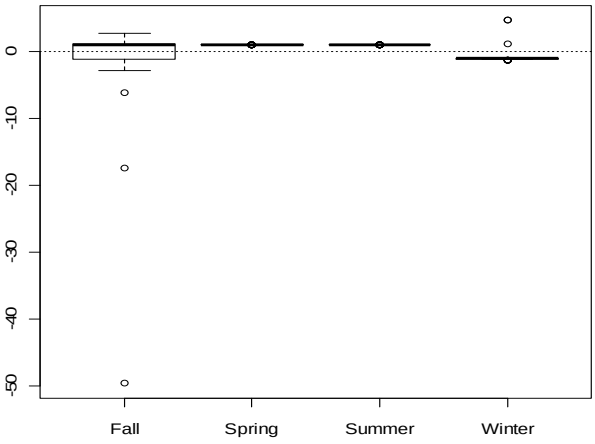


E



SCDNR Charterboat Logbook Program Data, 1993 - 2010

Date: **2/22/2012 – ADDENDUM**

Prepared by: **Mike Errigo, South Atlantic Fishery Management Council**

Eric Hiltz and Julia Byrd, South Carolina Department of Natural Resources

For: **SEDAR 28 Data Workshop, February 2012**

Abstract:

The South Carolina Department of Natural Resources (SCDNR) charterboat logbook program was used to develop indices of abundance for Spanish mackerel from 1993 – 2010 and for cobia from 1998 - 2010. The indices of abundance are standardized catch per unit effort (CPUE; catch per angler hour). For Spanish mackerel, a delta-gamma GLM was used to produce annual abundance estimates and for cobia a delta-lognormal GLM was used to produce annual abundance estimates. The indices are meant to describe the population trends of fish caught by V1 (6-pack) charter vessels operating in or off of South Carolina.

Background:

The South Carolina Department of Natural Resources (SCDNR) issues three types of charter vessel licenses: V1 (vessels carrying six or fewer passengers), V2 (vessels carrying 7 to 49 passengers), and V3 (vessels carrying 50 or more passengers). In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory logbook reporting system for all charter vessels to collect basic catch and effort data. Under state law, vessel owners/operators purchasing South Carolina Charter Vessel Licenses (V1, V2, or V3) and carrying fishermen on a for-hire basis are required to submit trip level reports of their fishing activity in waters off of SC. Logbook reports are submitted by mail or fax to the SCDNR Fisheries Statistics section monthly. Reporting compliance is tracked by staff, and charter vessel owners/operators failing to submit reports can be charged with a misdemeanor. The charterboat logbook program is a complete census and should theoretically represent the total catch and effort of the charterboat trips in waters off of SC.

Logbook Data:

The charterboat logbook reports include: date, number of fishermen, fishing locale (inshore, 0-3 miles, >3miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, and catch (number of landed and released fish by species) per vessel per trip. The logbook forms have remained similar throughout the program's existence with a few exceptions: in 1999 the logbook forms were altered to begin collecting the number of fish released alive and the number of fish released dead (prior to 1999 only the total numbers of fish released were recorded) and in 2008 additional fishing methods were added to the logbook forms, including 4) cast, 5) cast and bottom, and 6) gig.

After being tracked for compliance each V1 charterboat logbook report is coded and entered into an existing Access database. (V2 and V3 charterboat logbook reports are tracked for compliance but are currently not coded and entered electronically. Most of these vessels participate in the NMFS Beaufort Headboat Logbook Survey.) Since the inception of the program, a variety of staff have coded the charterboat logbook data. From ~1999 to 2006, only information that was explicitly filled out by the charterboat owners/operators on the logbook forms was coded and entered into the database. No efforts were made to fill in incomplete reports. From 2007 to the present, staff have tried to fill in incomplete trip reports through conversations with charterboat owners/operators and by making assumptions based on the submitted data (i.e. if a location description was given instead of a grid location – a grid location was determined, if fishing method was left blank – it was determined based on catch, etc.). From 1999 to 2006 each individual trip record was reviewed to look for anomalies in the data. Starting in 2007 queries were used to look for and correct anomalous data and staff began checking a component of the database records against the raw logbook reports. Coding and QA/QC measures prior to 1999 were likely similar to those used from 1999 to the present. However, details on these procedures were not available since staff members working on this project prior to 1998 are no longer with the SCDNR. Data are not validated in the field and currently no correction factors are used to account for reporting errors. Recall periods for logbook records are typically one month or less. However, in the case of delinquent reports recall periods could be up to several months.

Data:

SCDNR charterboat logbook vessel trips included in the analysis for Spanish mackerel represent reported trolling fishing trips in nearshore (0-3 miles) or offshore (3+ miles) waters.

SCDNR charterboat logbook vessel trips included in the analysis for cobia represent reported bottom fishing trips in estuarine, nearshore (0-3 miles) and offshore (3+ miles) waters. Data were available from 1993 to 2010, however it was determined by the Indices Working Group that the dataset would be truncated to only include data from 1998 onwards. This is due to a change in effort within the fishery. The percentage of trips reporting targeting cobia increased from an average of 2% from 1993-1997 to an average of 6% from 1998-2010 (Figure 1). Since 1998 the percentage of trips targeting cobia has remained relatively stable.

For all model runs for both species, catch per unit effort was calculated as the total number of fish caught per angler-hour. Management measures (bag and size limits) have been in place for both Spanish mackerel and cobia throughout most of the dataset's time series (see Management Histories on Spanish mackerel and cobia provided for SEDAR 28 data workshop). To limit the possible influence of bag limits, total catch (includes harvest and discards) was used to calculate the CPUE instead of harvest.

Methods:

The indices were standardized using a delta generalized linear model (GLM) approach. All analyses were conducted in R, based primarily on code adapted from Dick (2004). A delta GLM model was chosen due to the significant amount of zeros in the CPUE data. A delta model has 2 components to it. First, the probability of a positive catch is modeled. Then the positive catch rates are modeled separately. Finally, the two are multiplied together to get the predicted CPUE (Dick 2004, Li et al. 2011, Siquan et al. 2009, and Yu et al. 2011).

$$\widehat{CPUE} = \hat{d}\ x\ \hat{q}$$

Where $\widehat{CPUE}$ is the standardized CPUE, $\hat{d}$ is the predicted catch rate of the positive catches, and $\hat{q}$ is the probability of a positive catch. The models for Spanish mackerel were built assuming a gamma distribution. The models for cobia were built assuming a lognormal distribution. The model of the positive catch rates used was:

$$ln(\hat{d}) = \beta_0 + \sum_{i=1} \beta_i X_i$$

Where β_0 is the intercept and β_i is the coefficient for the i^{th} explanatory variable X_i. The probability of a positive catch was modeled as:

$$ln\left(\frac{\hat{q}}{1-\hat{q}}\right) = \alpha_0 + \sum_{i=1} \alpha_i X_i$$

Where α_0 is the intercept and α_i is the coefficient for the i^{th} explanatory variable X_i.

Two model runs, using slightly different explanatory variables, are included in this version of the working paper for Spanish mackerel. The first modeling approach used the year, the locale of the catch, and the month as explanatory variables (referred to as the "monthly" standardization). The second modeling approach used the year, the locale of the catch, and the season as explanatory variables (referred to as the "seasonal" standardization). For cobia monthly and seasonal model runs were also conducted. However, the Indices Working Group decided to use month as a factor over season due to the lower CVs and better fit when month was used in the model. A Jackknife approach was used to estimate the amount of variation in the model runs as per Dick (2004).

For locale (for all model runs for both species), estuarine was considered for all trips that occurred in waters inside the col regs line, nearshore was considered for all trips that occurred in waters from 0-3 miles, and offshore for waters >3 miles. For the seasonal model runs, winter was considered for all trips occurring from Dec. to Feb., spring from Mar. to May, summer from June to Aug. and fall from Sept. to Nov.

Results:

Spanish Mackerel

The SCDNR charterboat logbook data represent 49,132 fishing trips in which anglers caught 186,444 Spanish mackerel and harvested 147,141 Spanish mackerel. Summarized catch and effort data are presented in Table 1. The indices are presented in Table 2 and Figure 3. Comparisons between the AIC values of the two model runs are presented in Table 3. The monthly model run had higher AIC values for the binomial sub-model and lower AIC values for the gamma sub-model when compared to the seasonal model run. When looking at the variation in each of the model runs (standard error, SE), there was no significant difference between the monthly and seasonal runs ($p=0.742$). Comparing the total SE to the total CPUE (% Total CPUE) again showed no significant difference between the two model runs ($p=0.416$). Diagnostics for the monthly model run are found in Figures 4 and 5. Diagnostics for the seasonal model run are found in Figures 6 and 7.

The biggest difference between these two model runs is related to the number of parameters present. There are three times more time parameters in the monthly model than the seasonal model. When looking at the plot of the residuals to the fitted values for the gamma model, the spread of the data is not much different. However, the monthly run has more residuals clustered around zero because there are simply more residuals, which causes the run to have a lower AIC for the gamma model. The same trend is apparent in the Normal Q-Q plot for the gamma model. The plots look the same for each run, but the monthly run has more points on it and they are clustered on the 1:1 line, therefore increasing the fit and decreasing the AIC. The boxplots show no significant difference between the two runs.

The binomial model results in a difference between the two runs. The residual plot for the monthly data is on a whole different scale than the seasonal plot, by several orders of magnitude. The residuals for the seasonal run are much lower than the monthly run. Also, the Normal Q-Q plot shows a much better fit for the seasonal run than the monthly run. The boxplots also show significant differences between the two runs. The monthly boxplots are all centered around zero, but the seasonal boxplots are all at either +1 or -1. However, the monthly boxplots show outliers that are an order of magnitude larger than the seasonal boxplots.

Cobia

The SCDNR charterboat logbook data represent 85,357 fishing trips in which anglers caught 10,949 cobia and harvested 4,896 cobia. Summarized catch and effort data are presented in Table 4. The indices are presented in Table 5 and Figure 9. AIC values for the monthly model run are: 229.310 (binomial) and -1884.522 (lognormal). Diagnostics for the monthly model run are found in Table 6 and Figures 10-12. Additionally an analysis was run to examine the occurrence of charterboat trips reaching or exceeding the cobia 2 fish per person daily bag limit. From 1998 – 2010, an average of 6.3% of all trips that either targeted or caught cobia caught or exceeded the bag limit (Table 7).

Literature Cited:

Dick, E.J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70:351-366.

Li, Y., Jiao, Y., He, Q. 2011. Decreasing uncertainty in catch rate analyses using Delta-AdaBoost: An alternative approach in catch and bycatch analyses with high percentage of zeros. Fisheries Research 107: 261-271.

Siquan, T., Xinjun, C.,Yong, C., Liuxiong, X., Xiaojie, D. 2009. Standardizing CPUE of *Ommastrephes bartramii* for Chinese squid-jigging fishery in Northwest Pacific Ocean. Chinese Journal of Oceanology and Limnology 27 (4): 729-739.

Yu, Hao, Jiao, Y., and Winter, A. 2011. Catch rate standardization of yellow perch in Lake Erie: a comparison of the spatial generalized linear model and generalized additive model. Transactions of the American Fisheries Society 140 (4): 905-918.

Table 1. Annual Spanish mackerel catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1993-2010.

Year	Vessel Trips	% Trips with Spanish Mackerel Catch	Spanish Mackerel Catch (# fish)	Spanish Mackerel Harvest (# fish)	Spanish Mackerel Released (# fish)	% Release
1993	3142	36.86	10163	9119	1044	10.27
1994	3100	36.68	9984	8352	1632	16.35
1995	2614	24.52	6029	5191	838	13.90
1996	2730	32.42	10037	8090	1947	19.40
1997	2914	33.91	11063	8643	2420	21.87
1998	3207	36.86	10404	8815	1589	15.27
1999	3121	41.56	20626	15031	5595	27.13
2000	3511	40.42	14296	10968	3328	23.28
2001	2959	29.23	8493	5908	2585	30.44
2002	2758	33.36	12486	8884	3602	28.85
2003	2449	31.60	8525	6481	2044	23.98
2004	2460	36.83	10766	8736	2030	18.86
2005	2749	37.98	12316	9815	2501	20.31
2006	2400	37.63	9298	7178	2120	22.80
2007	2458	30.63	6164	4664	1500	24.33
2008	2310	36.23	8923	7323	1600	17.93
2009	2060	39.08	8808	7548	1260	14.31
2010	2190	41.14	8063	6395	1668	20.69

Table 2. Spanish mackerel catch per unit effort (catch per angler hour) for the Monthly and Seasonal standardized index model runs.

Year	Nominal CPUE	Model Run 1				Model Run 2			
		Standardized CPUE (Monthly)	SE (Monthly)	Upper (Monthly)	Lower (Monthly)	Standardized CPUE (Seasonal)	SE (Seasonal)	Upper (Seasonal)	Lower (Seasonal)
1993	0.1617	0.1286	0.0251	0.1538	0.1035	0.1345	0.0223	0.1568	0.1122
1994	0.1513	0.1277	0.0230	0.1507	0.1047	0.1191	0.0250	0.1441	0.0941
1995	0.1060	0.0863	0.0187	0.1050	0.0676	0.0769	0.0131	0.0900	0.0637
1996	0.1686	0.1097	0.0203	0.1300	0.0894	0.0902	0.0179	0.1081	0.0724
1997	0.1734	0.1231	0.0231	0.1462	0.0999	0.1135	0.0150	0.1286	0.0985
1998	0.1460	0.1395	0.0310	0.1705	0.1085	0.1104	0.0180	0.1285	0.0924
1999	0.2878	0.1689	0.0314	0.2003	0.1376	0.1637	0.0286	0.1923	0.1351
2000	0.1870	0.1565	0.0373	0.1937	0.1192	0.1272	0.0274	0.1546	0.0999
2001	0.1177	0.1539	0.0477	0.2015	0.1062	0.1260	0.0378	0.1637	0.0882
2002	0.1857	0.1679	0.0403	0.2082	0.1276	0.1569	0.0523	0.2092	0.1046
2003	0.1312	0.0982	0.0198	0.1179	0.0784	0.0976	0.0231	0.1208	0.0745
2004	0.1735	0.1170	0.0277	0.1448	0.0893	0.1089	0.0349	0.1438	0.0741
2005	0.1757	0.1146	0.0277	0.1424	0.0869	0.1252	0.0317	0.1570	0.0935
2006	0.1465	0.1046	0.0205	0.1251	0.0841	0.0887	0.0200	0.1086	0.0687
2007	0.0981	0.0825	0.0135	0.0960	0.0690	0.0737	0.0133	0.0871	0.0604
2008	0.1491	0.1105	0.0316	0.1421	0.0789	0.0901	0.0262	0.1163	0.0639
2009	0.1716	0.1235	0.0241	0.1476	0.0994	0.1095	0.0344	0.1439	0.0751
2010	0.1493	0.0681	0.0198	0.0879	0.0483	0.0618	0.0231	0.0850	0.0387

Table 3. Comparison of AIC values for the Monthly and Seasonal Spanish mackerel standardized index model runs. SE is the standard error calculated from the model jack knife. % Total CPUE is sum(SE)/sum(CPUE).

AIC	Standardized CPUE (Monthly)	Standardized CPUE (Seasonal)
Binomial	106.9724023	44
Positive	-416.5194936	-181.8648745
Sum of SE	0.482642994	0.464215698
% Total CPUE	22.13%	23.52%

Table 4. Annual cobia catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1998-2010.

Year	Vessel Trips	% Trips with Cobia Catch	Cobia Total Catch (# fish)	Cobia Harvest (# fish)	Cobia Released (# fish)	% Release
1998	5050	5.17	780	178	602	77.18
1999	5294	7.10	1046	509	537	51.34
2000	6222	5.98	720	311	409	56.81
2001	6357	6.09	967	433	534	55.22
2002	6515	5.39	698	347	351	50.29
2003	6560	4.83	605	374	231	38.18
2004	6588	5.46	734	439	295	40.19
2005	6927	4.89	676	403	273	40.38
2006	7064	5.22	881	212	669	75.94
2007	7662	6.17	1284	482	802	62.46
2008	7242	4.98	901	433	468	51.94
2009	6976	4.97	858	390	468	54.55
2010	6900	4.52	799	385	414	51.81

Table 5. Cobia catch per unit effort (catch per angler hour) for the monthly model run.

Year	Nominal CPUE	Standardized (Monthly) CPUE	SE (Monthly)	Upper (Monthly)	Lower (Monthly)
1998	0.012166	0.005838	0.001814	0.007652	0.004023
1999	0.015874	0.007121	0.002172	0.009294	0.004949
2000	0.009382	0.005318	0.001246	0.006563	0.004072
2001	0.012280	0.006175	0.001564	0.007739	0.004611
2002	0.008466	0.004925	0.001656	0.006580	0.003269
2003	0.007210	0.003714	0.000807	0.004520	0.002907
2004	0.008755	0.006102	0.001564	0.007666	0.004538
2005	0.007241	0.004861	0.001153	0.006014	0.003709
2006	0.009155	0.004808	0.001001	0.005809	0.003807
2007	0.012182	0.005736	0.001383	0.007120	0.004353
2008	0.008645	0.004071	0.000956	0.005028	0.003115
2009	0.008889	0.005337	0.001244	0.006581	0.004093
2010	0.008166	0.003695	0.001035	0.004730	0.002660

Table 6. Fit statistics for the binomial component of the monthly cobia index.

Binomial GLM

	Null	Residual
Degrees of Freedom	350	328

Null Deviance	444
Residual Deviance	183.3
AIC	229.3

Table 7. Percentage of 6-pack charterboat trips that reported catching or exceeding the cobia 2 fish per person daily bag limit.

Year	Number of trips targeting or catching cobia	Number of trips reaching or exceeding bag limit	% trips reaching or exceeding bag limit
1998	314	43	13.69%
1999	409	34	8.31%
2000	416	21	5.05%
2001	436	25	5.73%
2002	386	15	3.89%
2003	365	7	1.92%
2004	399	23	5.76%
2005	404	14	3.47%
2006	421	26	6.18%
2007	518	40	7.72%
2008	418	32	7.66%
2009	397	27	6.80%
2010	386	24	6.22%

Figure 1. Percentage of SCDNR Charterboat Logbook bottom fishing trips that reported targeting cobia from 1993 – 2010.

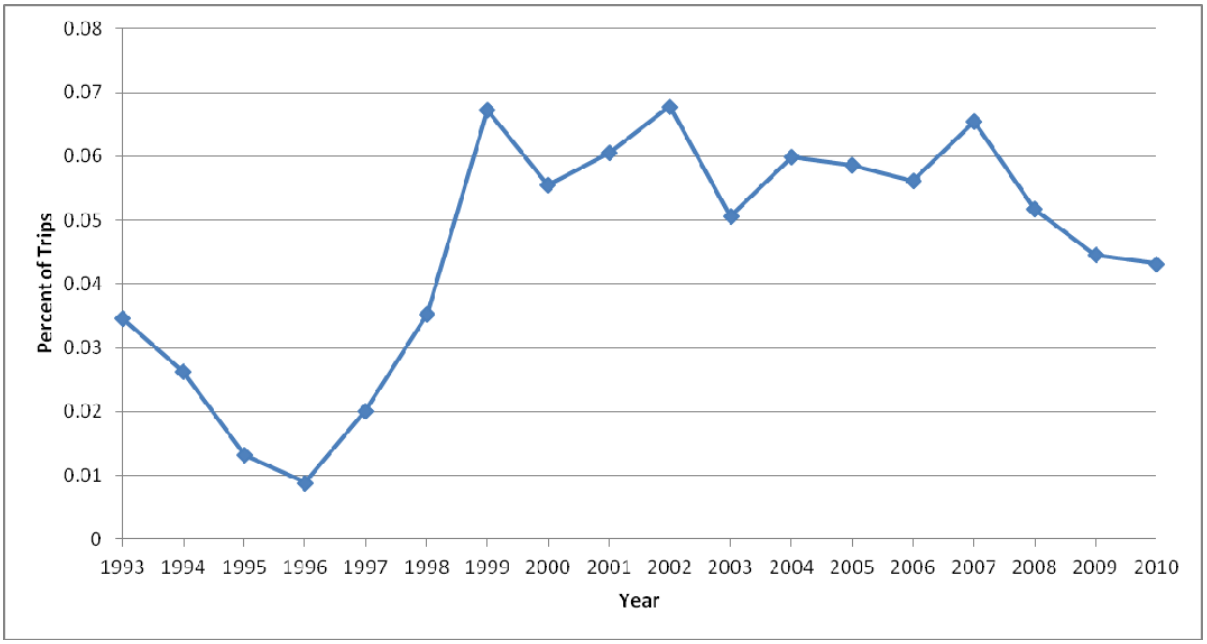


Figure 2. Distribution of Spanish mackerel catch from SCDNR 6-pack Charterboat Logbook data. Each square represents a 10 mile^2 area**. Only charterboat logbook data that reported trolling in nearshore and offshore waters from 2008 to 2010 were used to create this map.** Only data from 2008-2010 were used because prior to 2008 approximately 80% of the logbook trips included in the analysis did not include location information.

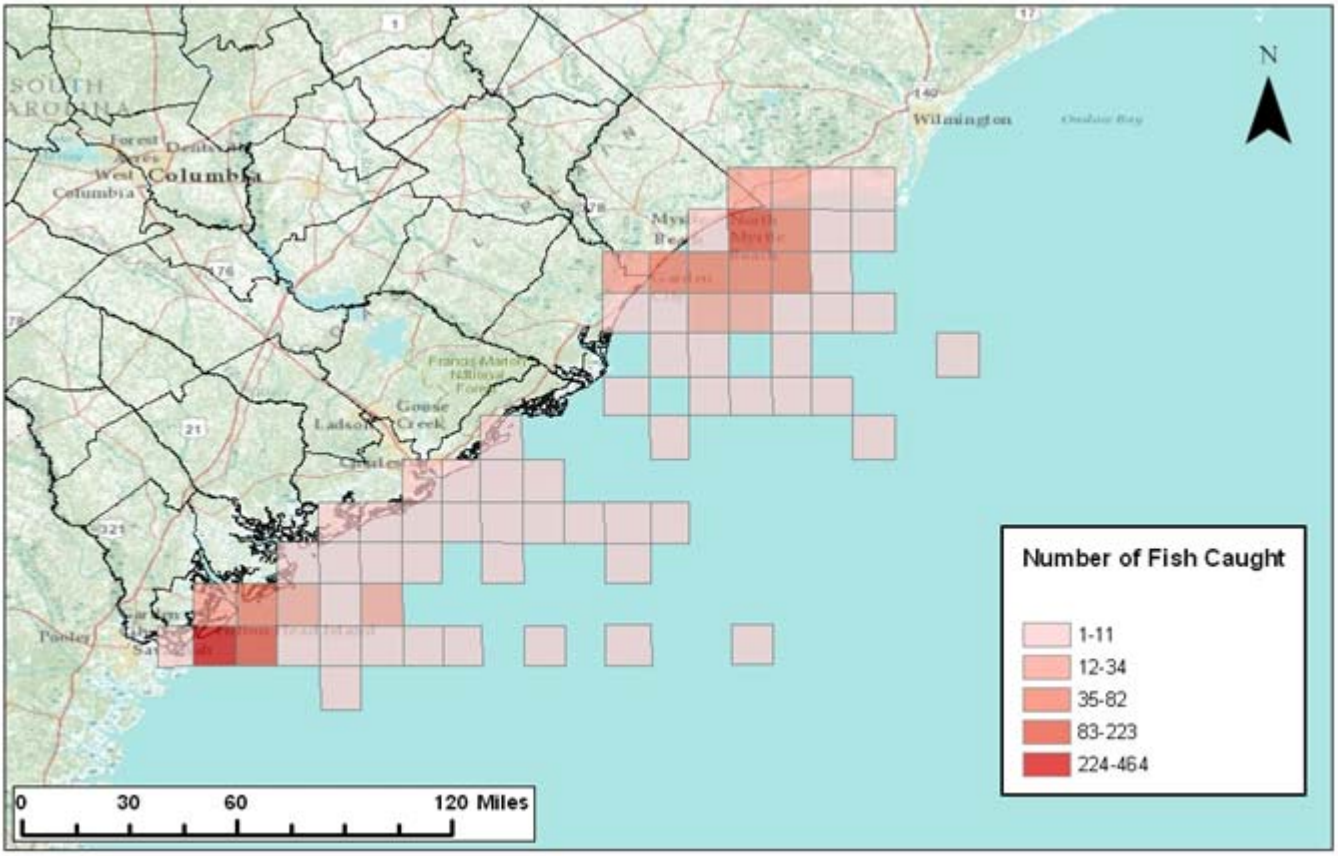


Figure 3. Spanish mackerel CPUE from SCDNR 6-pack Charterboat Logbook data from 1993-2010. Nominal (blue), Monthly standardized (green), and Seasonal standardized (red) catch per angler-hour are shown. The dotted lines show 1 standard error from the Standardized CPUE.

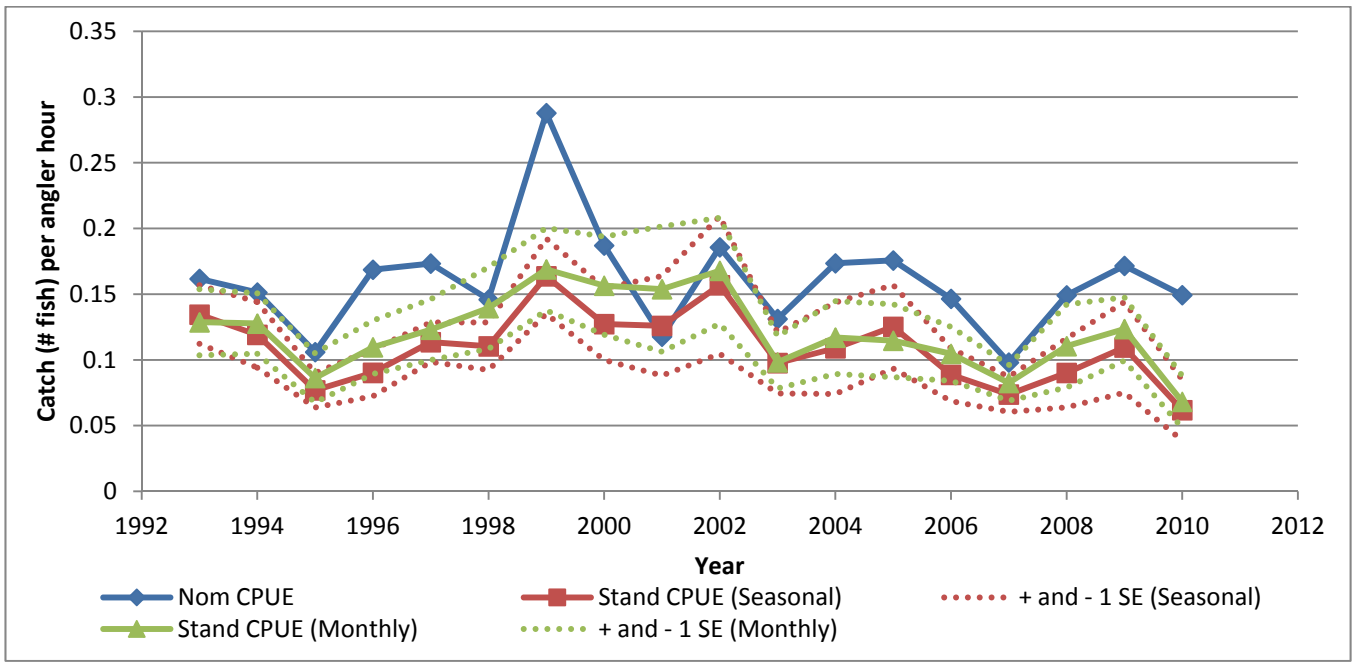
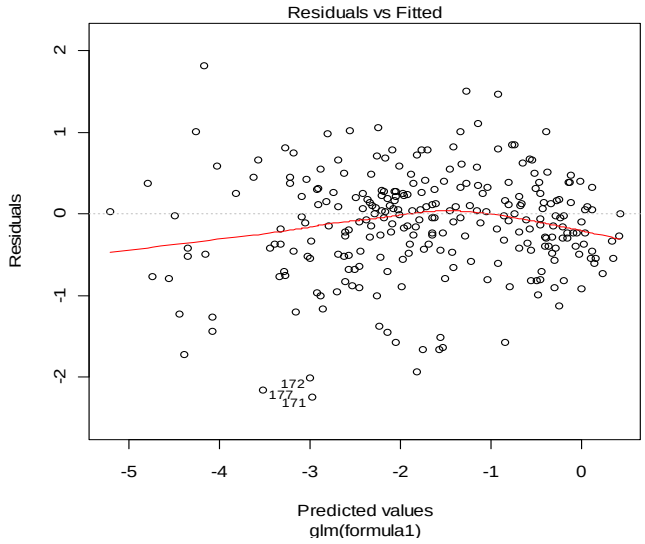
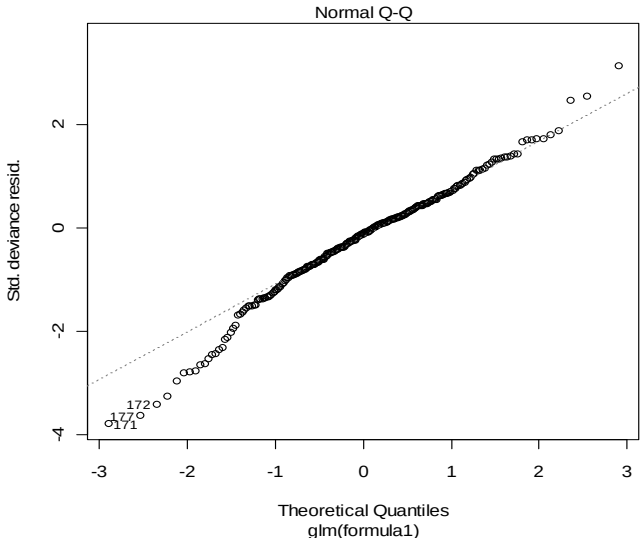


Figure 4. Diagnostic plots for gamma component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year; **D.** the residuals by locale; **E.** the residuals by season

A



B



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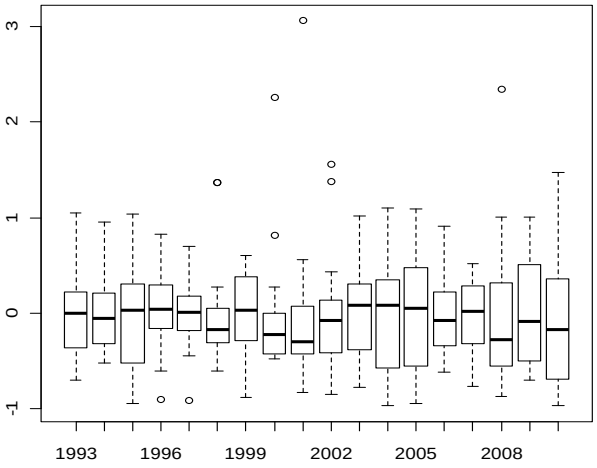

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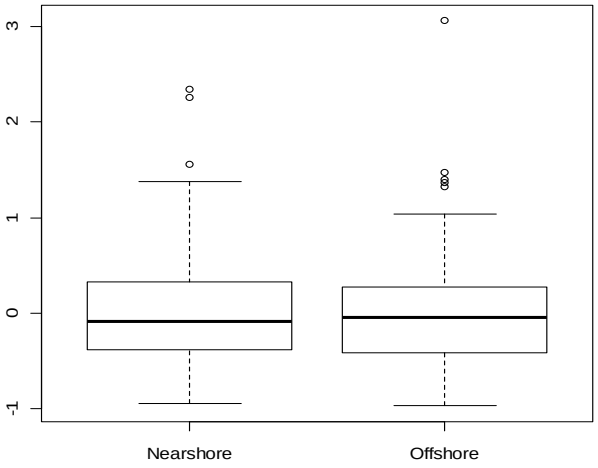


E

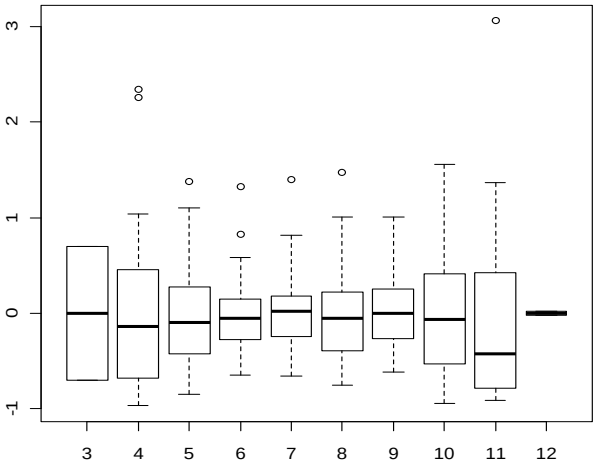
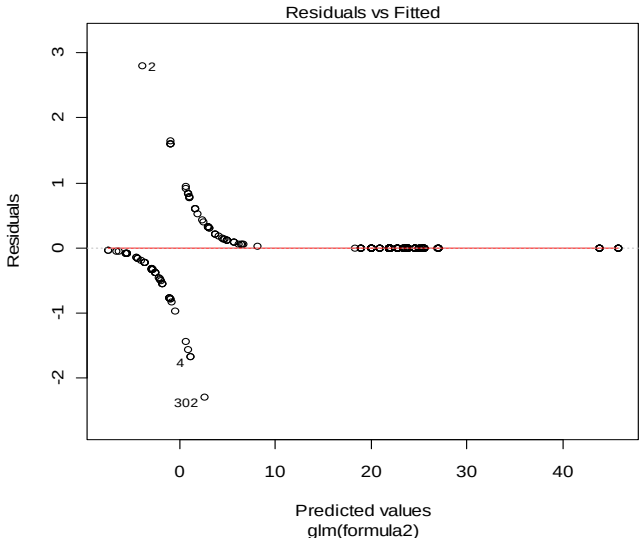
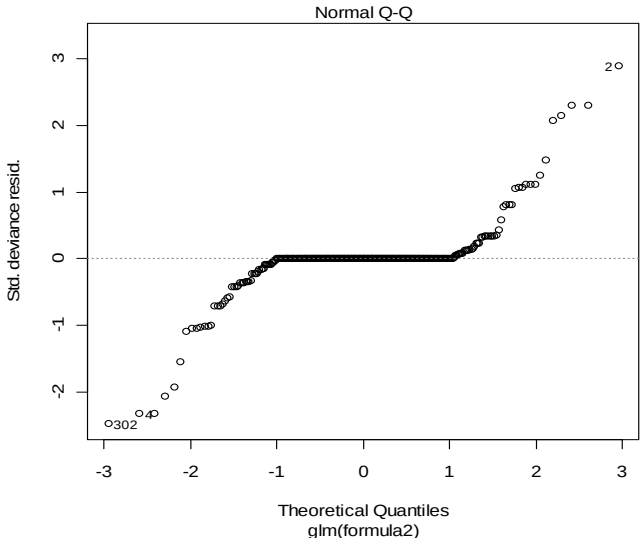


Figure 5. Diagnostic plots for binomial component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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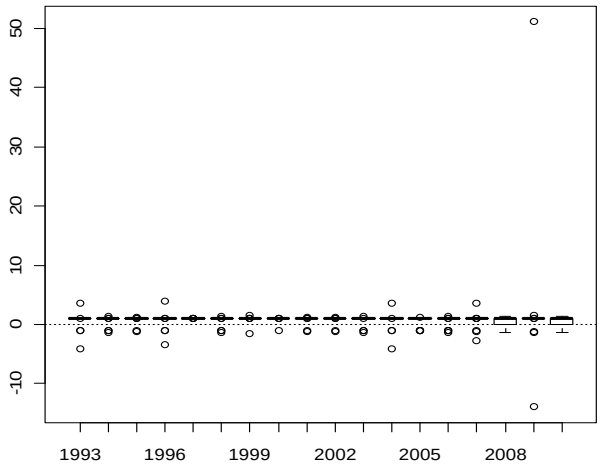

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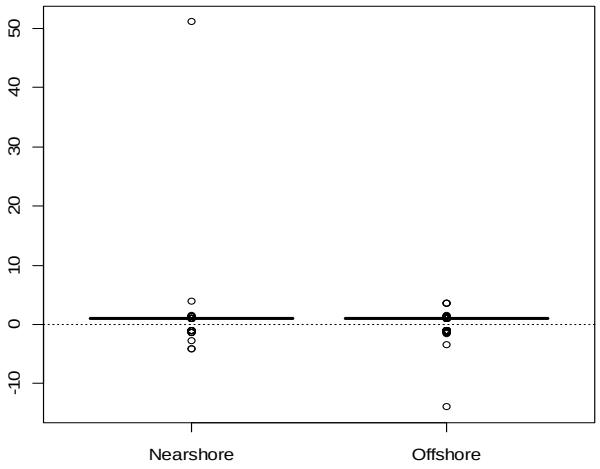

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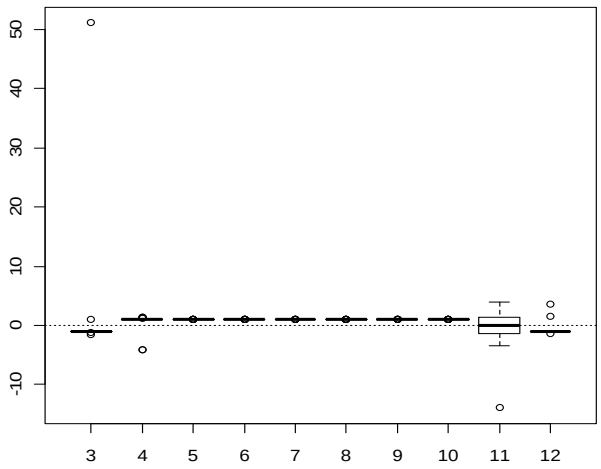
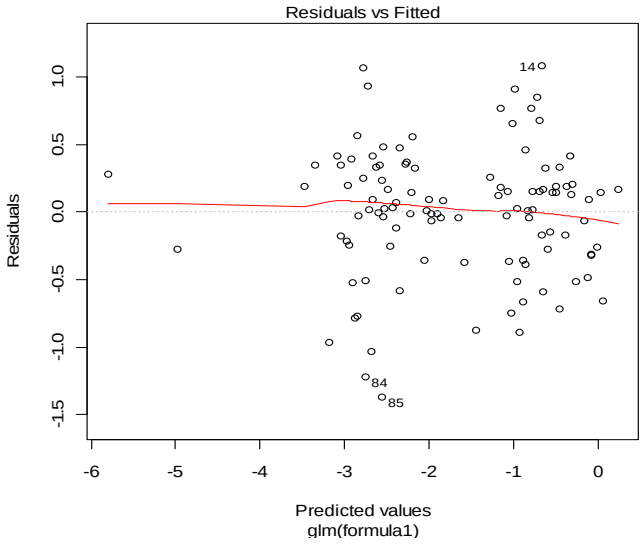
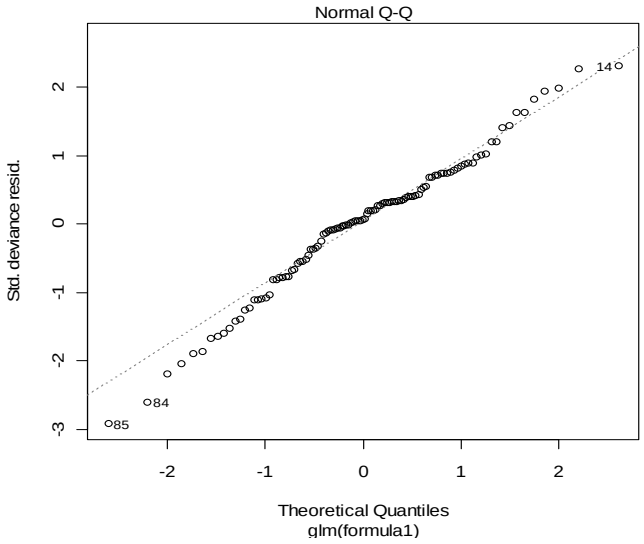


Figure 6. Diagnostic plots for gamma component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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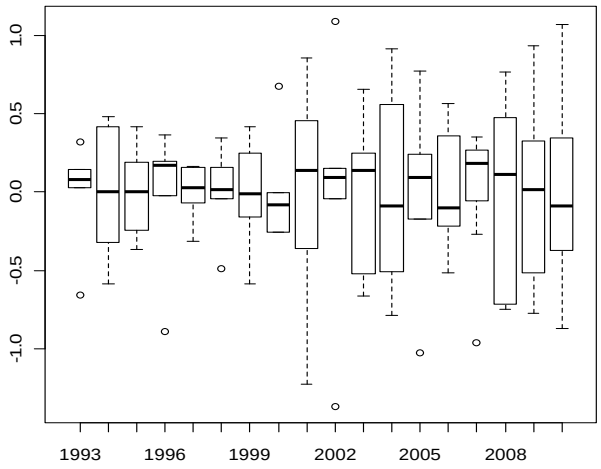

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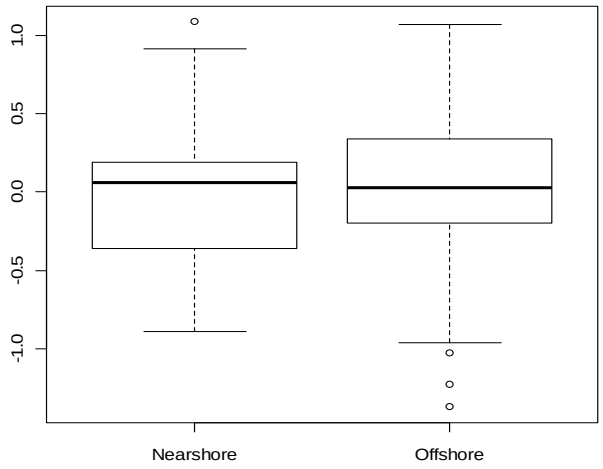

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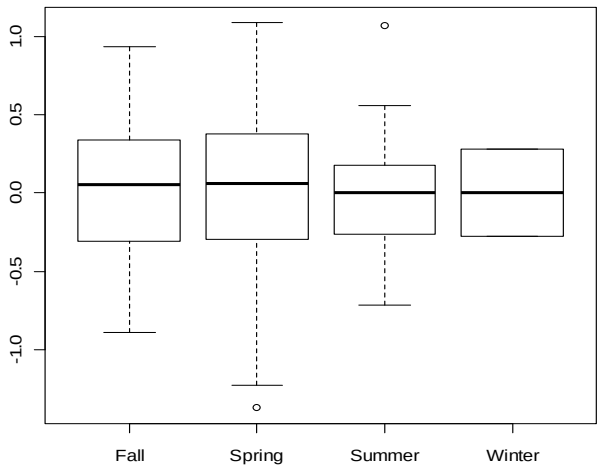
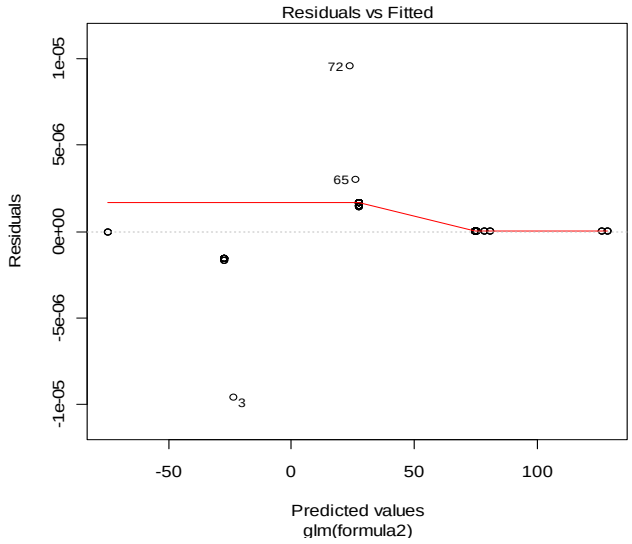


Figure 7. Diagnostic plots for binomial component of the Spanish mackerel SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



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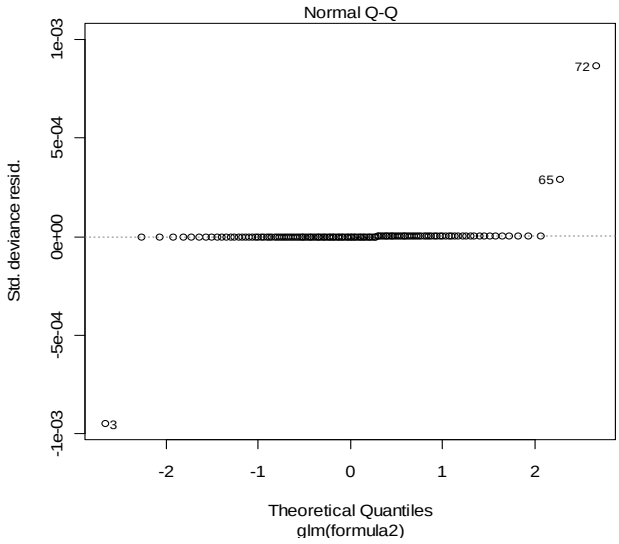

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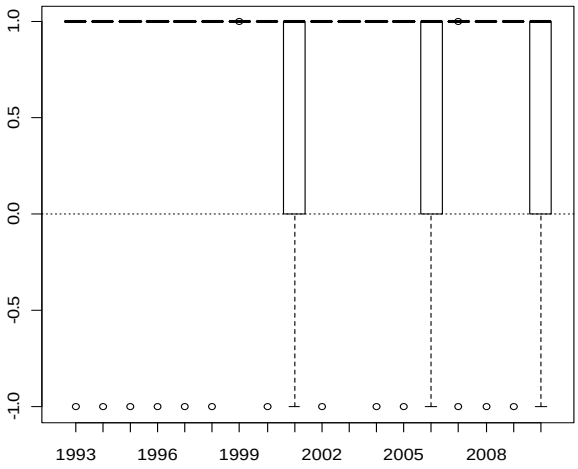

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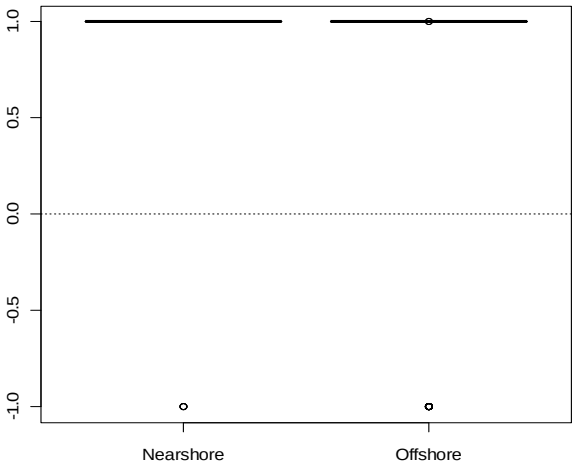

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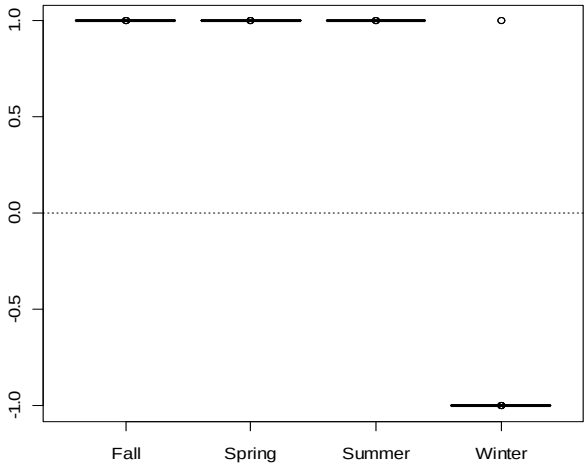


Figure 8. Distribution of cobia catch from SCDNR 6-pack Charterboat Logbook data. Each square represents a 10 mile^2 area**. Only charterboat logbook data that reported bottom fishing from 2008 to 2010 were used to create this map.** Only data from 2008-2010 were used because prior to 2008 approximately 90% of logbook trips included in the analysis did not include location information.

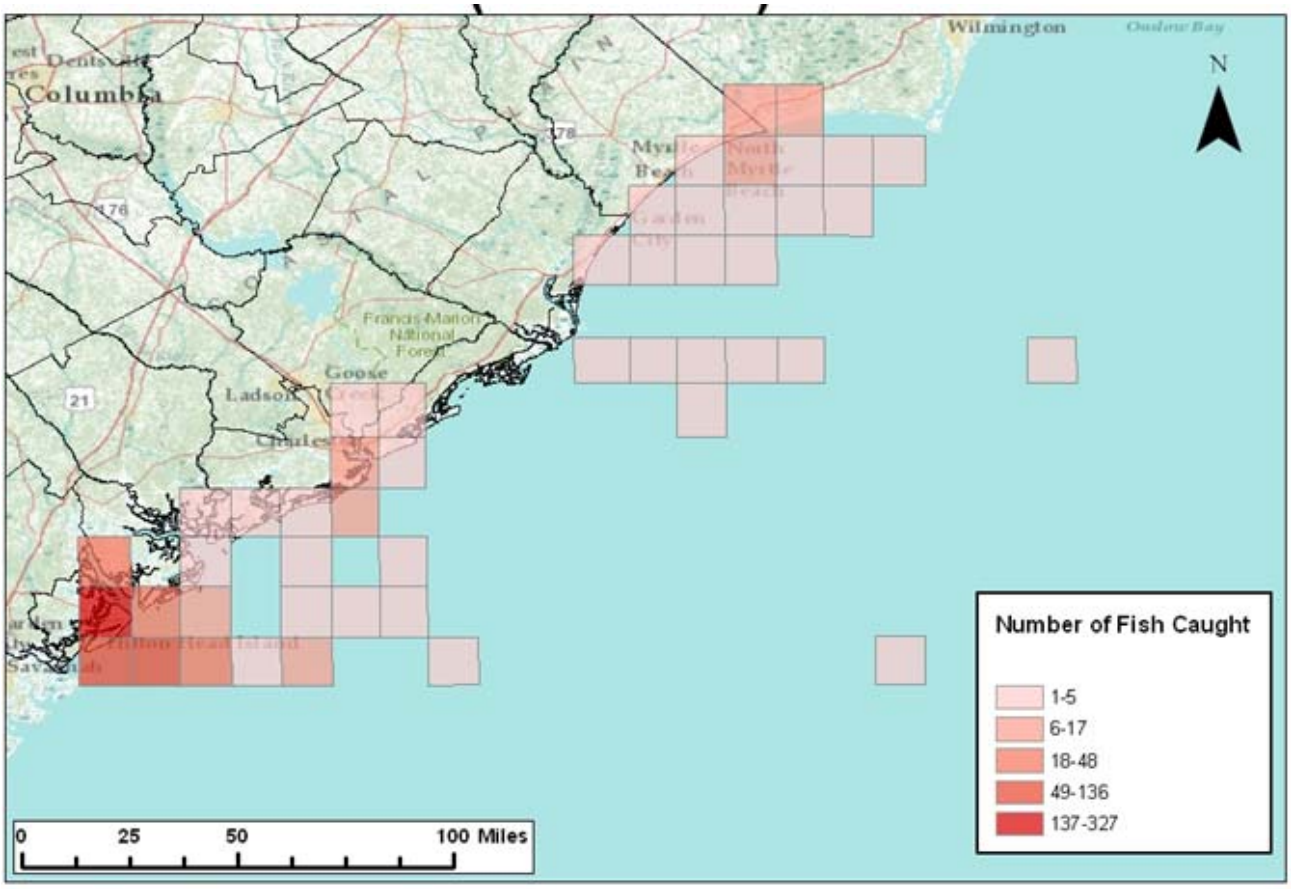


Figure 9. Cobia CPUE from SCDNR 6-pack Charterboat Logbook data from 1998-2010. Nominal (blue) and monthly standardized (red) catch per angler-hour are shown. The dotted lines show 1 standard error from the standardized CPUE.

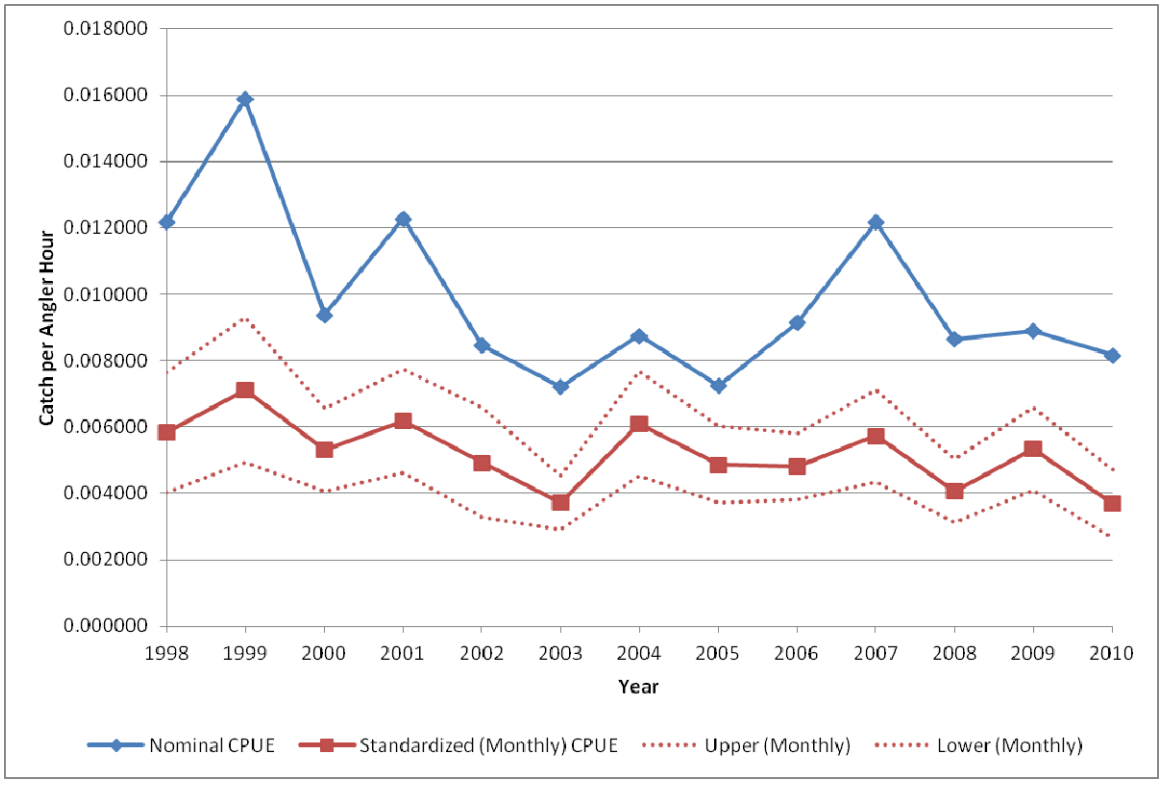
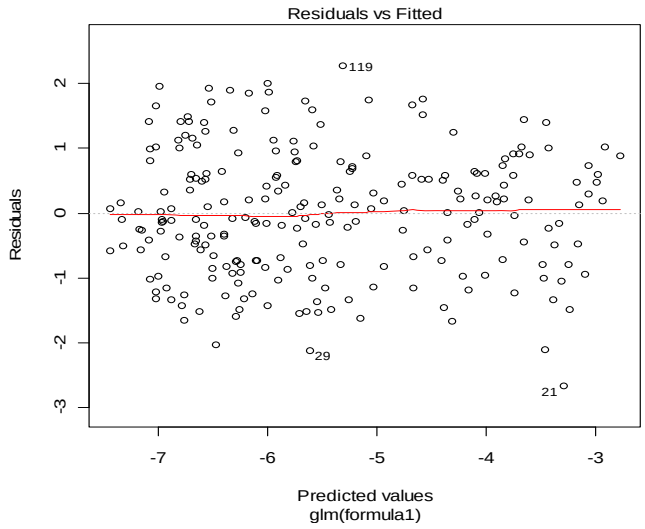
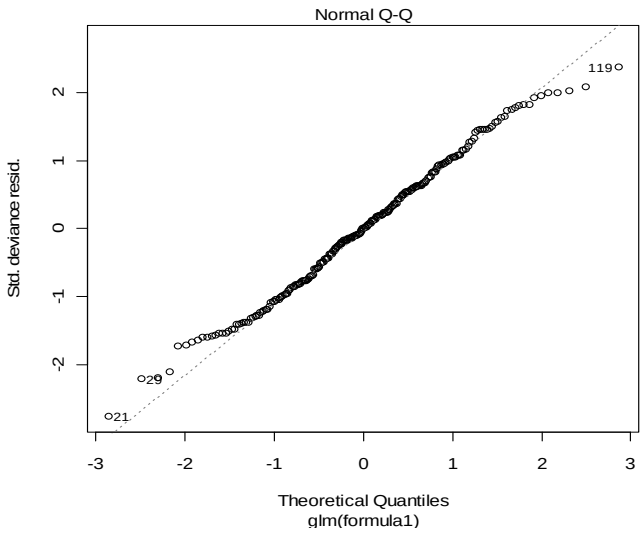


Figure 10. Diagnostic plots for lognormal component of the Cobia SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by season

A



B



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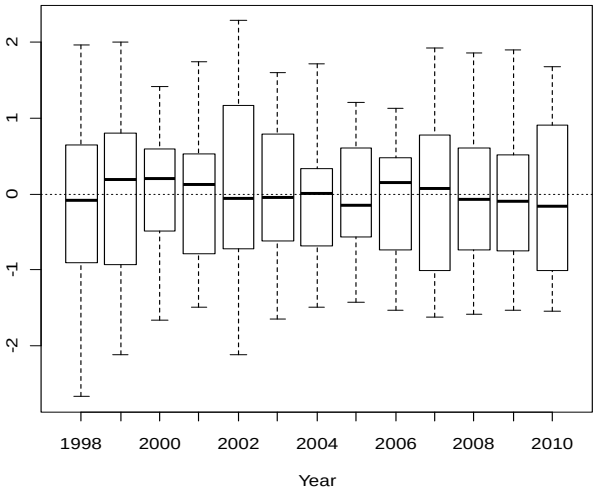

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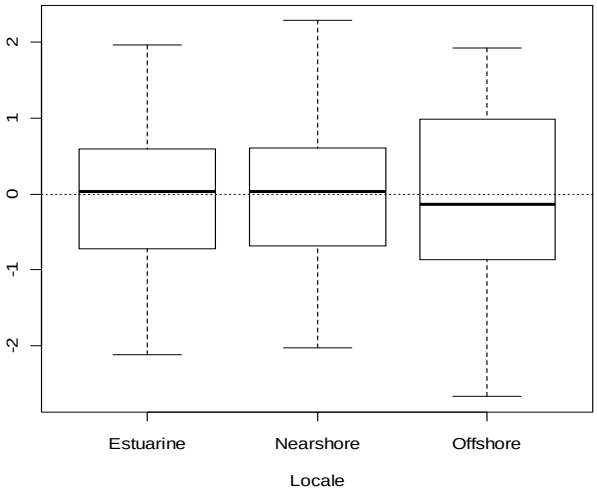

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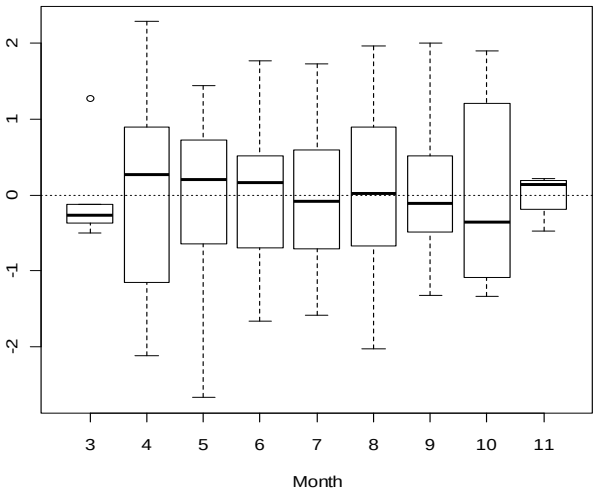
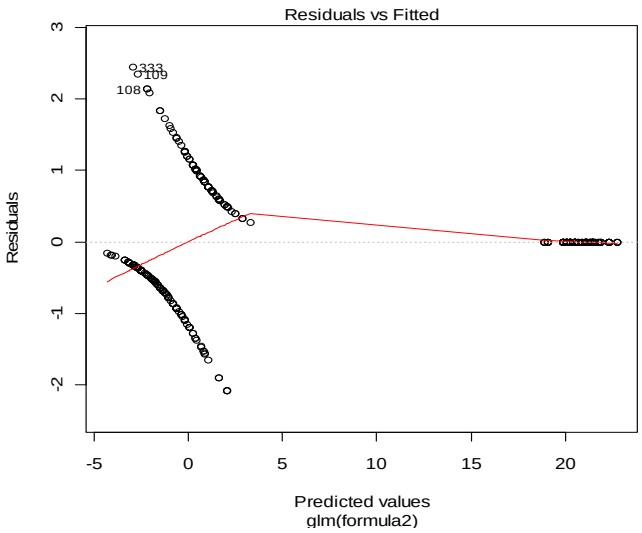


Figure 11. Diagnostic plots for binomial component of the Cobia SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the residuals by year, **C.** the residuals by locale; **D.** the residuals by season

A



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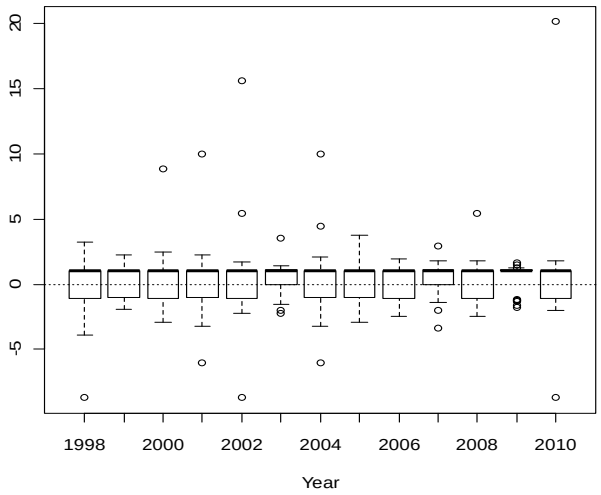

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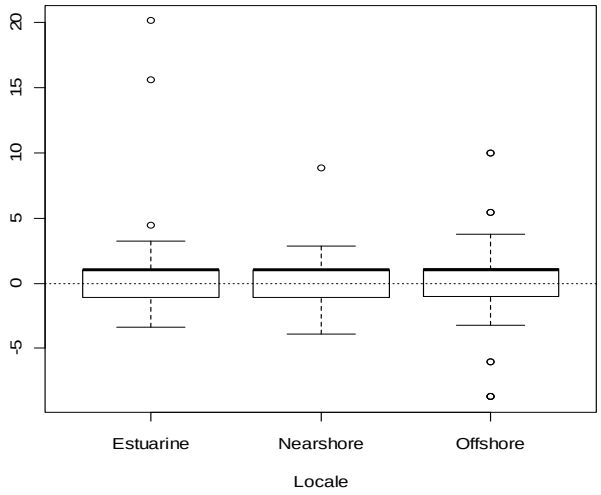

D

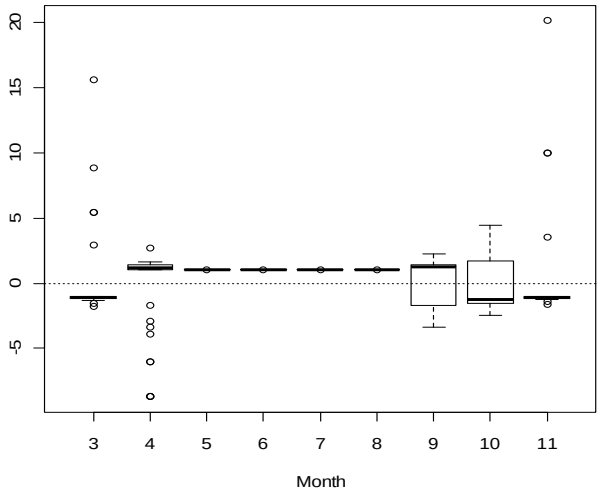

Figure 12. Histogram of log(CPUE) for the monthly cobia index.