SCDNR Charterboat Logbook Program Data, 1993-2017

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SEDAR58-DW07

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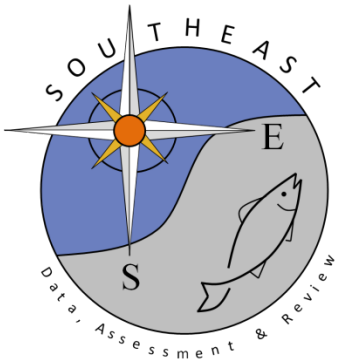

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SCDNR Charterboat Logbook Program Data, 1993 - 2017

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Abstract:
The South Carolina Department of Natural Resources (SCDNR) charterboat logbook program was used to develop indices of abundance for cobia from 1998 - 2017. The indices of abundance are standardized catch per unit effort (CPUE; catch per angler hour). A delta-lognormal GLM was used to produce annual abundance estimates for cobia. The index is meant to describe the population trends of fish caught by charter vessels (6-pack) operating in or off of South Carolina.

Background:
The South Carolina Department of Natural Resources (SCDNR) issues licenses to charter vessels on a fiscal year (July 1 – June 30). In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory trip-level 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 and carrying fishermen on a for-hire basis, are required to submit trip level reports of their fishing activity. Logbook reports are submitted to the SCDNR Fisheries Statistics section monthly either in person, by mail, fax, or scan and beginning in 2016, electronically through a web-based application. To date, ~68% of license holders are currently reporting online. 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, >3 miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, depth range (minimum/maximum), catch (number of landed vs. released fish by species), and estimated landed pounds 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 cast, cast and bottom, and gig. Furthermore, the fishing method dive was added in 2012.

After being tracked for compliance, each charterboat logbook report is coded and entered, or uploaded into an existing database. Since the inception of the logbook 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 present, staff have tried to fill in these data gaps through outreach 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 present, however, details on these procedures are not available since staff members working on this project prior to 1998 are no longer with SCDNR. Data are not validated in the field and currently no correction factors are used to account for reporting errors via paper submission; however, the online system is built with error messages and constraints to prevent common reporting mistakes and overlaps in the data. 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. The electronic reporting application has already shown a decrease in this recall bias.

Data:

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 2017, 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, with the exception of 2015-2017, presumably due to regulation changes.

For all model runs, 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 cobia throughout most of the dataset's time series (see Management Histories on cobia provided for SEDAR 58). 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 using the rstan package (version 2.18.1, Stan Development Team 2018). A delta GLM model was chosen due to the significant number 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 pers. comm., 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 cobia were built assuming a lognormal distribution. A Gamma distribution was explored, but the fit using the lognormal distribution was much better (*Figure 3*) and the form of the positive data was more closely fit by a lognormal than a Gamma distribution (*Figure 4*). 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.

The rstan package allowed the fitting of all models within a Bayesian framework, using Monte Carlo sampling as the fitting algorithm. A normal prior was used for all regression coefficients and the intercept. An exponential prior was used for the Gaussian sigma parameter. The Bayesian framework allowed the use of the posterior distribution to estimate the uncertainty in the index directly, rather than the use of a Jackknife approach. The original Frequentist method of Dick 2004 was also attempted, but it had issues converging. Convergence could only be achieved by excluding many of the strata with too few observations to inform the model. Once convergence was achieved, the result was an index with the uncertainty greatly underestimated (Figure 5).

Two model runs, using different subsets of the data, were conducted. The first modeling approach used all the data provided, from 1998 to 2017, with the same explanatory variables used in SEDAR 28 (Year, Month, and Locale, referred to as the "all months" model). The model had some trouble fitting this initial model. It was forced to drop certain strata that did not have enough positive trips to inform the lognormal portion of the model. Therefore, the second modeling approach only used data from the peak fishing months, which were determined to be April-August (referred to as the "peak" model).

For locale (for all model runs for both species), inshore 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:

The SCDNR charterboat logbook data represent 149,023 fishing trips in which anglers caught 16,057 cobia and harvested 7,211 cobia. Summarized catch and effort data are presented in Table 1. The indices are presented in Table 2Table 3, and Figure 6. AIC values for the monthly model run are: 229.310 (binomial) and -1884.522 (lognormal). Diagnostics for both model runs are found in Table 4and Figure 7Figure 10. The Peak Months model outperforms the All Months model in several areas. Since there are less parameters in the Peak Months model, the BIC is significantly lower for both the Lognormal and the Binomial components (Table 4). Also, due to the higher proportion of positive trips, the effective sample sizes for all the parameters are higher than for the All Months model (Table 4). The diagnostic plots also favor the Peak Months model. Both the Normal QQ plot and the monthly residuals show more of the residuals on or tending around the zero line for both the Lognormal (Figure 7Figure 8) and the Binomial components (Figure 9Figure 10). In the Binomial component, the Peak Months model also has tighter residuals around the zero line for year and locale (Figure 9Figure 10). 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 – 2017, an average of 7.0% of all trips that either targeted or caught cobia reached or exceeded the bag limit (Table 5).

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 cobia catch, harvest, release and trip effort from SCDNR Charterboat Logbook Program, 1998-2017.

Year	Vessel Trips	% Trips with Cobia Catch	Cobia Total Catch (# fish)	Cobia Harvest (# fish)	Cobia Released (#fish)	% Released
1998	5,050	5.1%	779	178	601	77%
1999	5,294	6.9%	1046	509	537	51%
2000	6,222	6.0%	720	311	409	57%
2001	6,357	6.0%	967	433	534	55%
2002	6,515	5.3%	698	347	351	50%
2003	6,539	4.8%	605	374	231	38%
2004	6,570	5.4%	731	436	295	40%
2005	6,910	4.9%	676	403	273	40%
2006	7,002	5.3%	881	212	669	76%
2007	7,629	6.2%	1281	481	800	62%
2008	7,237	5.0%	901	433	468	52%
2009	6,976	4.9%	858	390	468	55%
2010	6,891	4.5%	799	385	414	52%
2011	7,305	3.9%	587	251	336	57%
2012	8,398	4.7%	872	447	425	49%
2013	9,044	4.5%	946	486	460	49%
2014	9,286	3.8%	735	379	356	48%
2015	10,733	3.3%	970	458	512	53%
2016	9,251	2.9%	550	228	322	59%
2017	9,530	2.4%	449	0	449	100%

Table 2. Cobia catch per unit effort (catch per angler hour) for the All Months model run.

Year	Nominal CPUE	Standardized CPUE	SE	95% Unc. Int.	Upper 95%	Lower 95%
1998	0.0017412	7.48E-05	0.001407	3.88E-05	1.14E-04	3.60E-05
1999	0.0024993	9.84E-05	0.002031	5.47E-05	1.53E-04	4.37E-05
2000	0.001108	6.67E-05	0.001256	3.12E-05	9.79E-05	3.55E-05
2001	0.0018797	6.79E-05	0.001331	3.27E-05	1.01E-04	3.52E-05
2002	0.0012002	5.68E-05	0.001111	2.70E-05	8.38E-05	2.99E-05
2003	0.00119	4.79E-05	0.000805	1.95E-05	6.74E-05	2.83E-05
2004	0.0010114	6.24E-05	0.001278	3.09E-05	9.33E-05	3.15E-05
2005	0.0005894	4.00E-05	0.00093	2.19E-05	6.19E-05	1.81E-05
2006	0.0008022	5.18E-05	0.000988	2.32E-05	7.50E-05	2.87E-05
2007	0.0011307	6.48E-05	0.001139	2.55E-05	9.04E-05	3.93E-05
2008	0.0007728	4.59E-05	0.000918	2.11E-05	6.71E-05	2.48E-05
2009	0.0012849	6.53E-05	0.001072	2.52E-05	9.04E-05	4.01E-05
2010	0.0009691	3.93E-05	0.000767	1.81E-05	5.74E-05	2.12E-05
2011	0.0007736	3.95E-05	0.000699	1.60E-05	5.55E-05	2.35E-05
2012	0.0011507	4.58E-05	0.000759	1.62E-05	6.20E-05	2.96E-05
2013	0.0005354	2.83E-05	0.000513	1.06E-05	3.89E-05	1.78E-05
2014	0.0006169	2.16E-05	0.00041	8.34E-06	3.00E-05	1.33E-05
2015	0.0004677	1.59E-05	0.000263	4.97E-06	2.09E-05	1.09E-05
2016	0.0004894	2.20E-05	0.000414	8.43E-06	3.04E-05	1.35E-05
2017	0.0005166	2.23E-05	0.000346	6.95E-06	2.92E-05	1.53E-05

Table 3. Cobia catch per unit effort (catch per angler hour) for the Peak Months model run.

Year	Nominal CPUE	Standardized CPUE	SE	95% Unc. Int.	Upper 95%	Lower 95%
1998	0.0017412	1.05E-04	2.10E-03	5.79E-05	1.63E-04	4.70E-05
1999	0.0024993	9.63E-05	1.76E-03	4.74E-05	1.44E-04	4.89E-05
2000	0.001108	6.96E-05	1.34E-03	3.33E-05	1.03E-04	3.63E-05
2001	0.0018797	8.79E-05	1.74E-03	4.29E-05	1.31E-04	4.50E-05
2002	0.0012002	5.37E-05	1.05E-03	2.56E-05	7.92E-05	2.81E-05
2003	0.00119	4.36E-05	8.07E-04	1.96E-05	6.31E-05	2.40E-05
2004	0.0010114	7.17E-05	1.37E-03	3.30E-05	1.05E-04	3.86E-05
2005	0.0005894	4.26E-05	8.48E-04	2.00E-05	6.26E-05	2.26E-05
2006	0.0008022	5.49E-05	1.03E-03	2.41E-05	7.90E-05	3.08E-05
2007	0.0011307	6.17E-05	1.19E-03	2.67E-05	8.85E-05	3.50E-05
2008	0.0007728	4.36E-05	8.05E-04	1.85E-05	6.22E-05	2.51E-05
2009	0.0012849	6.11E-05	1.17E-03	2.74E-05	8.85E-05	3.36E-05
2010	0.0009691	3.39E-05	6.56E-04	1.55E-05	4.94E-05	1.84E-05
2011	0.0007736	3.65E-05	6.67E-04	1.53E-05	5.18E-05	2.12E-05
2012	0.0011507	4.06E-05	7.57E-04	1.62E-05	5.68E-05	2.44E-05
2013	0.0005354	2.80E-05	5.12E-04	1.05E-05	3.86E-05	1.75E-05
2014	0.0006169	2.08E-05	4.40E-04	8.94E-06	2.98E-05	1.19E-05
2015	0.0004677	1.20E-05	2.21E-04	4.19E-06	1.62E-05	7.80E-06
2016	0.0004894	1.86E-05	3.58E-04	7.31E-06	2.59E-05	1.13E-05
2017	0.0005166	1.53E-05	2.85E-04	5.73E-06	2.10E-05	9.57E-06

Table 4. Index model diagnostics for the Lognormal and Binomial components of the All Months and Peak Months standardization models. BIC is the Bayesian Information Criterion and is the Bayesian equivalent to the AIC, PPD is the sample average posterior predictive distribution of the outcome, Log-Post is the Log-Posterior of the MCMC runs, Sigma is the standard deviation for the Lognormal distribution, Mean is the mean value from the posterior MCMC distribution, MCSE is the standard error from the MCMC posterior distribution, and Eff. N is the effective sample size.

Parameter		Lognormal		Binomial	
		All Months	Peak Months	All Months	Peak Months
BIC		1,344.58	1,017.34	537.25	225.07
PPD	Mean	-11.155	-11.104	0.628	0.957
	MCSE	0.00128	0.00146	0.00029	0.00022
	Eff. N	3,913	3,965	3,464	4,153
Log-Post	Mean	-613.949	-464.081	-217.228	-75.195
	MCSE	0.11302	0.09402	0.10708	0.08894
	Eff. N	1,343	1,607	1,492	1,762
Sigma	Mean	1.129	1.104		
	MCSE	0.00081	0.00081		
	Eff. N	2,975	3,528		

Table 5. Percentage of 6-pack charterboat bottom fishing trips that reported catching or exceeding the cobia 2 fish per person daily bag limit. No trips in 2017 met or exceeded the bag limit.

Year	Number of trips targeting or catching cobia	Number of trips reaching or exceeding bag limit	% trips keeping >= 2 fish
1998	279	38	13.62
1999	429	124	28.90
2000	466	69	14.81
2001	461	107	23.21
2002	517	77	14.89
2003	419	92	21.96
2004	500	86	17.20
2005	500	88	17.60
2006	489	40	8.18
2007	611	100	16.37
2008	473	87	18.39
2009	428	87	20.33
2010	414	83	20.05
2011	389	46	11.83
2012	561	98	17.47
2013	620	104	16.77
2014	542	75	13.84
2015	464	97	20.91
2016	310	56	18.06

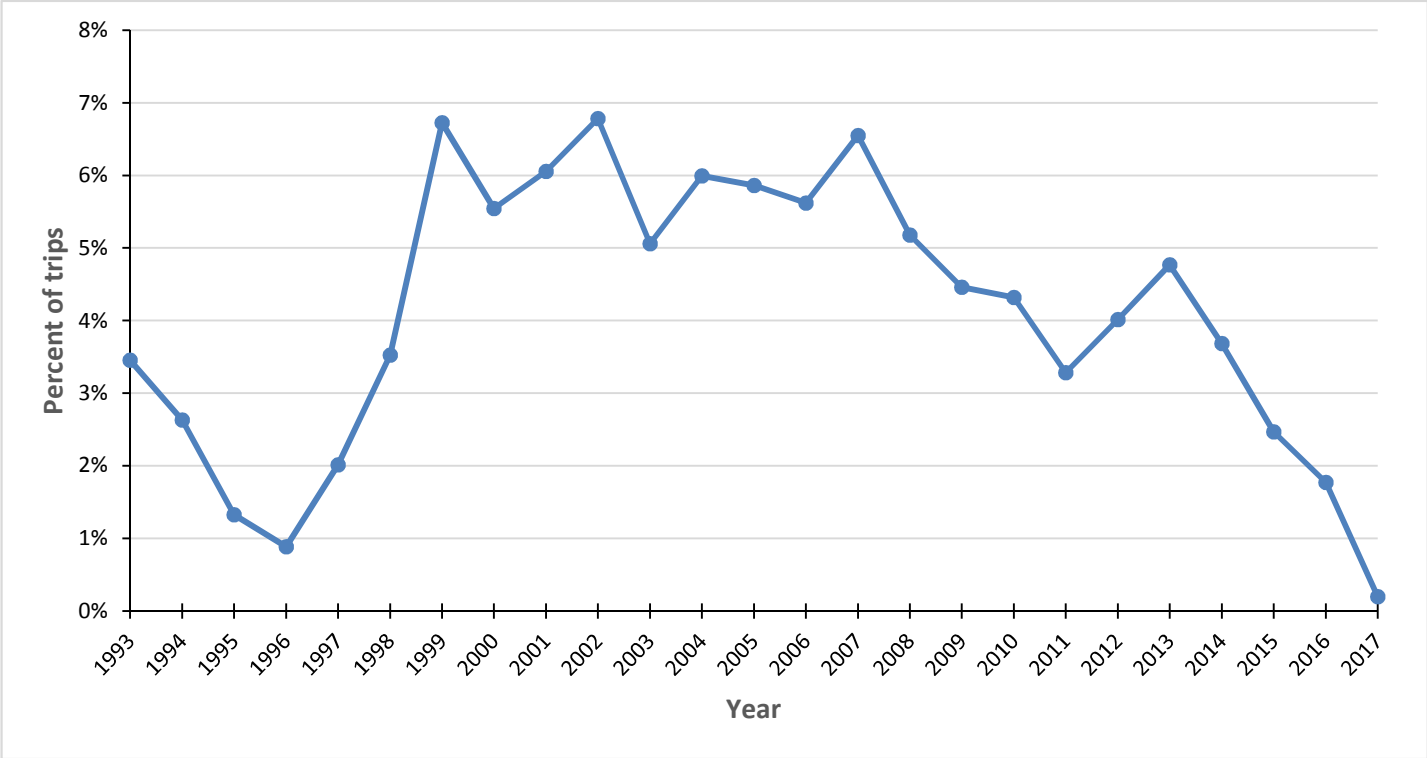

Figure 1. Percentage of SCDNR Charterboat Logbook bottom fishing trips that reported targeting cobia from 1993-2017.

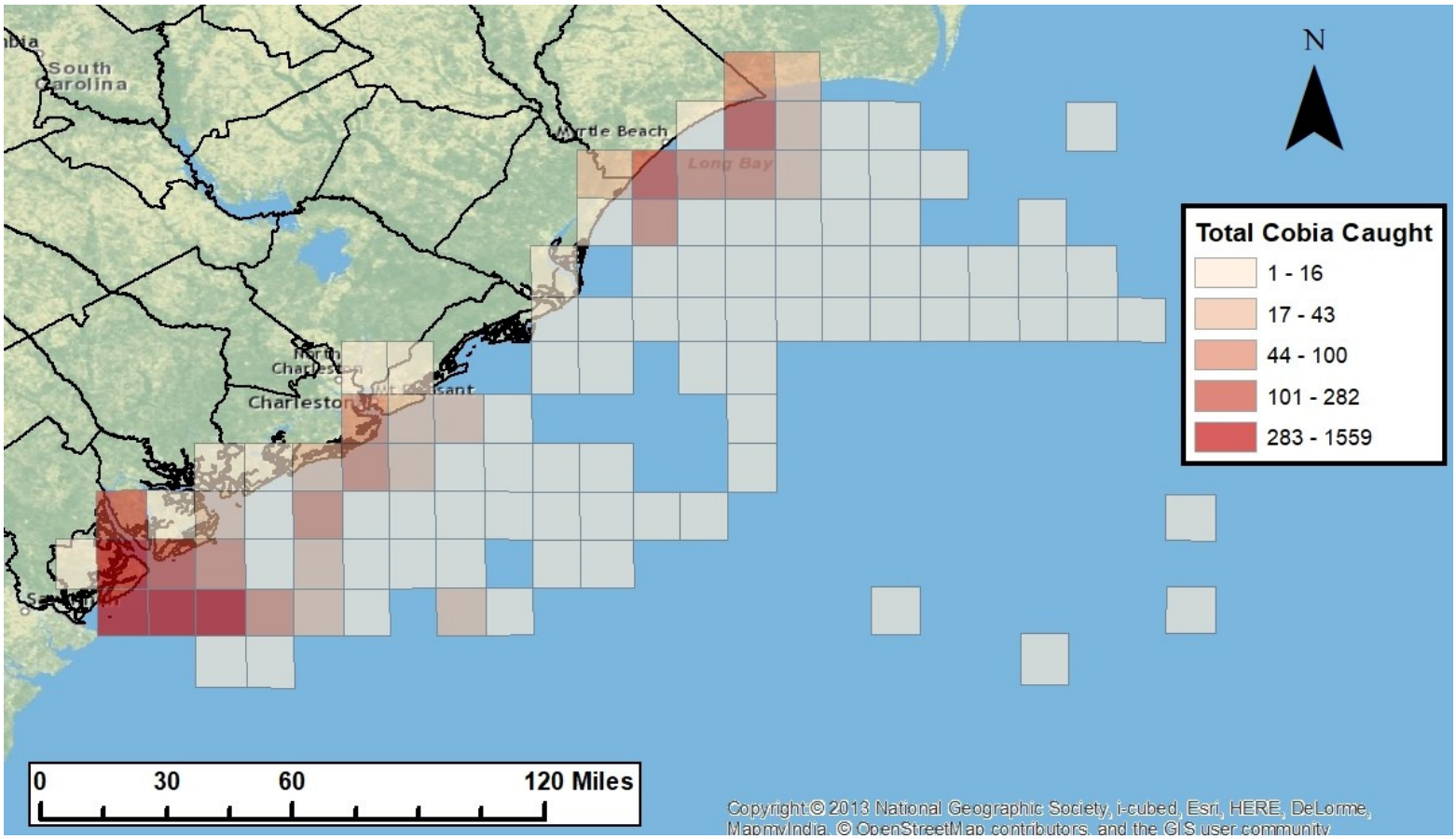

Figure 2. Distribution of cobia catch from SCDNR Charterboat Logbook data. Each square represents a 10 mile^2 area. ***Only charterboat logbook data that reported bottom fishing from 2008 to 2017 were used to create this map*** *because prior to 2008, approximately 90% of logbook trips included in the analysis did not include location information.*

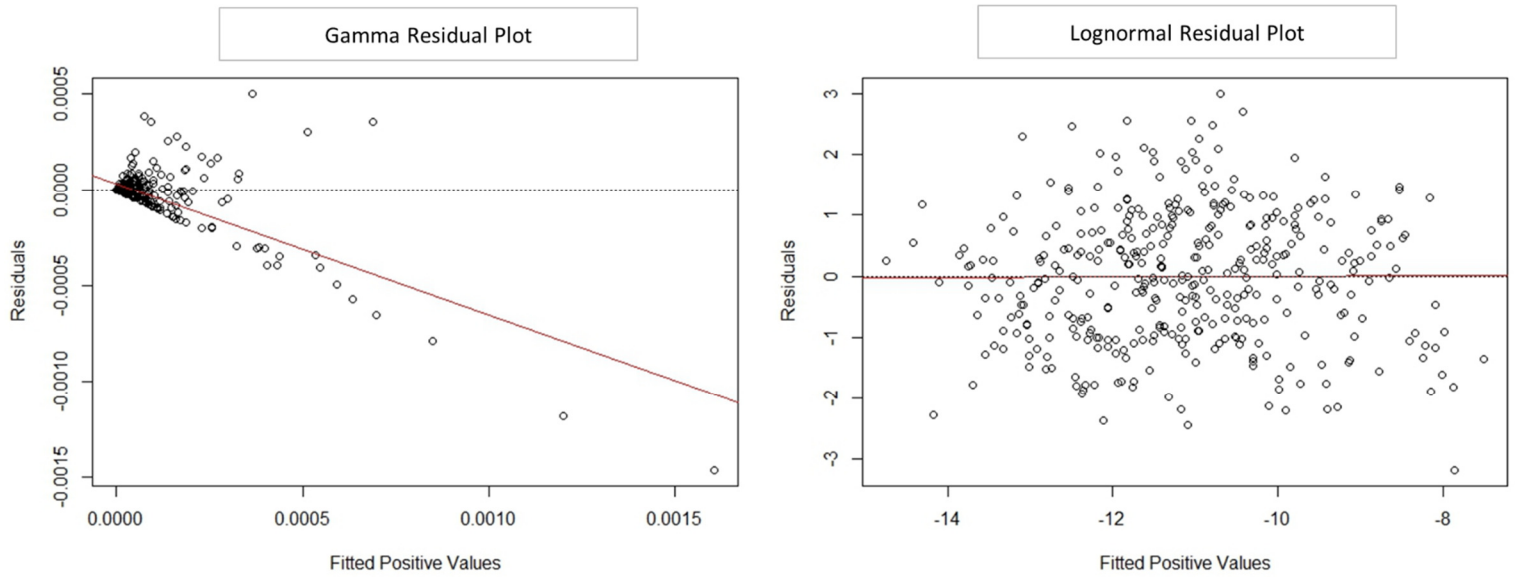

Figure 3. Residual plots for the Gamma run and the lognormal run. The Gamma plot has all the residuals clumped together, with extreme outliers falling well off of the zero line, biasing the trend. The lognormal plot has the residuals nice and scattered with the trend line running right along the zero line.

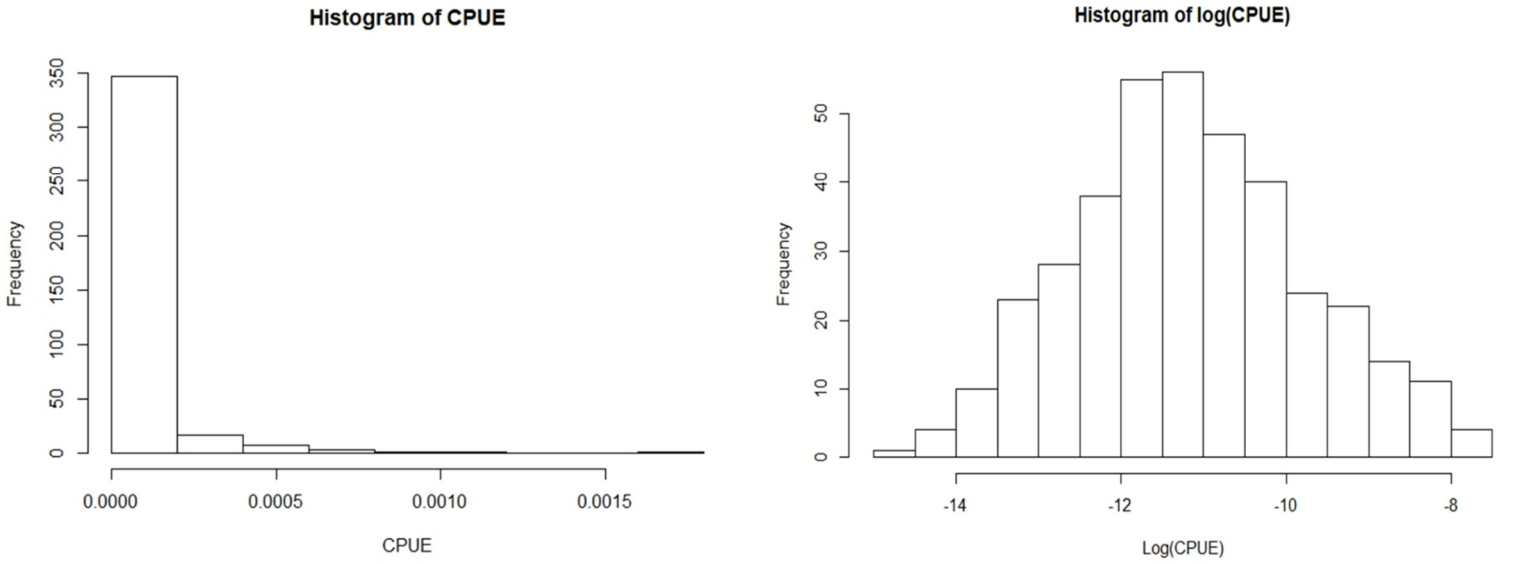

Figure 4. Histograms of the fitted values from the Gamma run (left) and the lognormal run (right). The Gamma histogram shows a heavy bar in the zero range, whereas the lognormal histogram is nicely normal shaped.

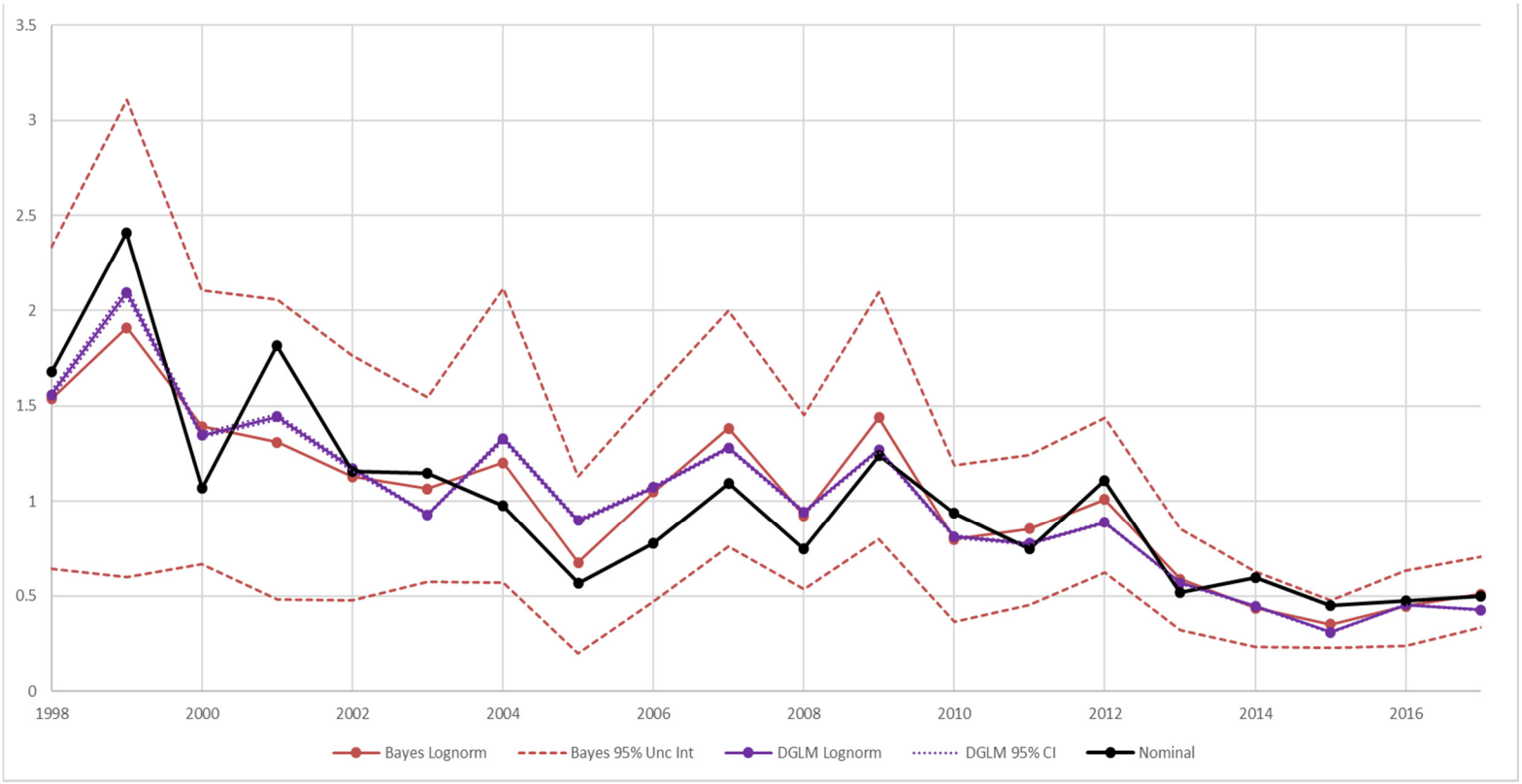

Figure 5. Bayesian (red) vs. Frequentist (DGLM, purple) runs of the All Months cobia CPUE standardization model with the Nominal (black) for reference, normalized to their long-term averages. Each model run has its respective uncertainty interval. The DGLM confidence interval is so small, it is barely visible. It appears as a ridge on the index line.

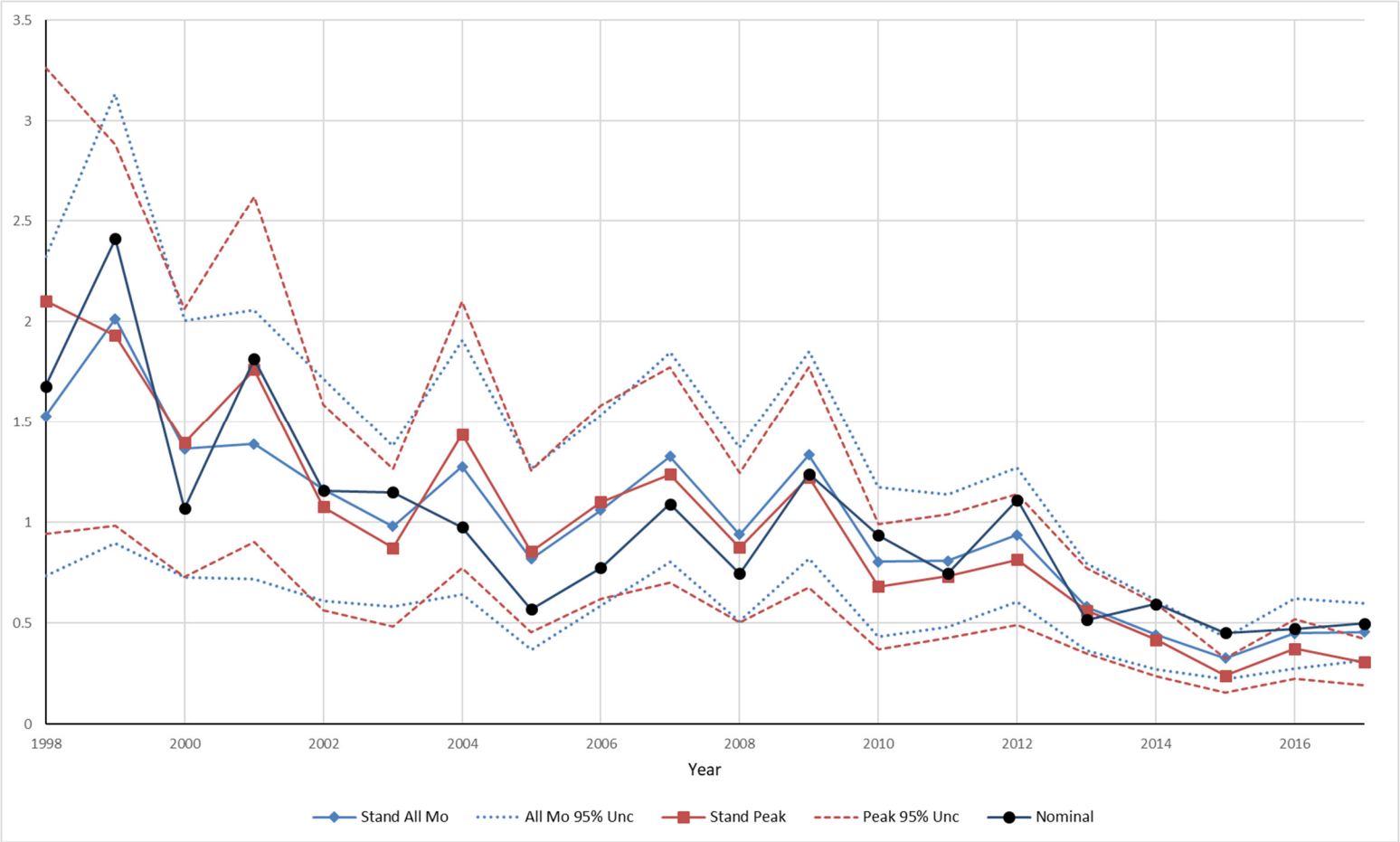

Figure 6. Standardized All Months (blue), Peak Months (red), and Nominal (black) CPUE indices for cobia normalized to their long-term averages with 95% uncertainty intervals.

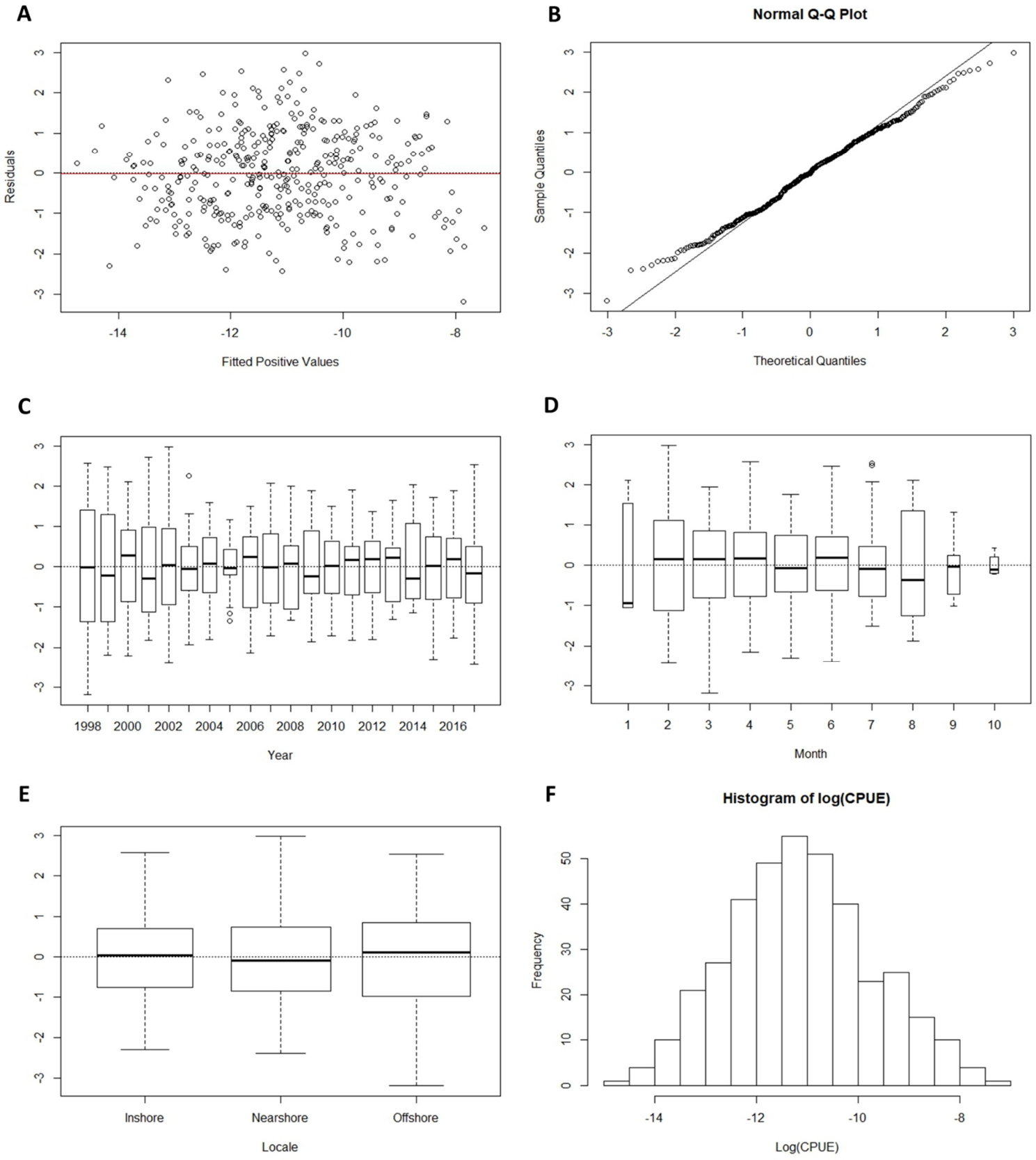

Figure 7. Diagnostic plots for lognormal component of the cobia SCDNR 6-pack Charterboat Logbook All Months model: ***A.*** *residuals plotted against predicted values;* ***B.*** *the cumulative normalized residuals (QQ plot);* ***C.*** *the residuals by year,* ***D.*** *the residuals by month;* ***E.*** *the residuals by locale;* ***F.*** *histogram of log (CPUE).*

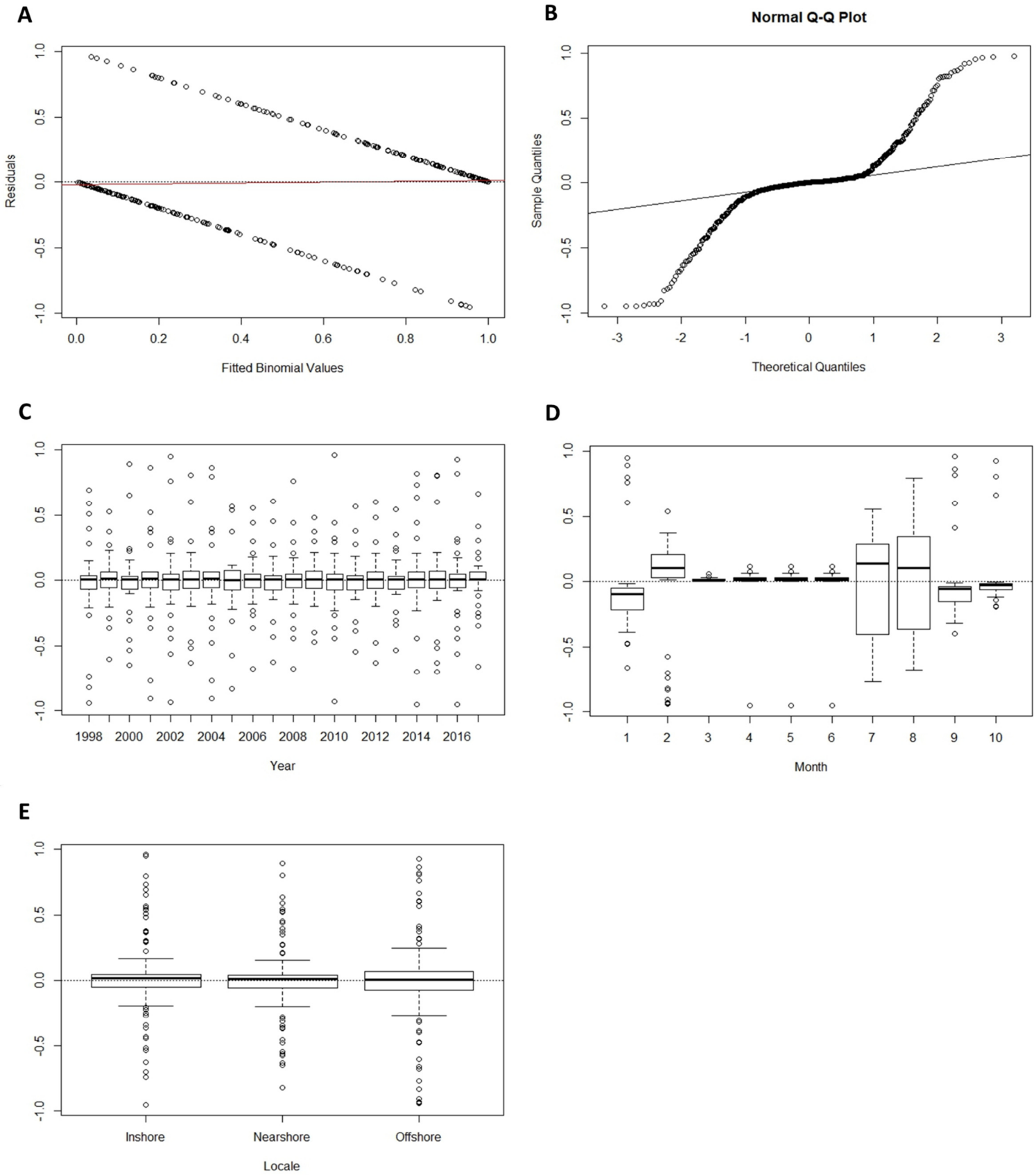

Figure 8. Diagnostic plots for binomial component of the cobia SCDNR 6-pack Charterboat Logbook All Months model: ***A.*** *residuals plotted against predicted values;* ***B.*** *the cumulative normalized residuals (QQ plot);* ***C.*** *the residuals by year,* ***D.*** *the residuals by month;* ***E.*** *the residuals by locale.*

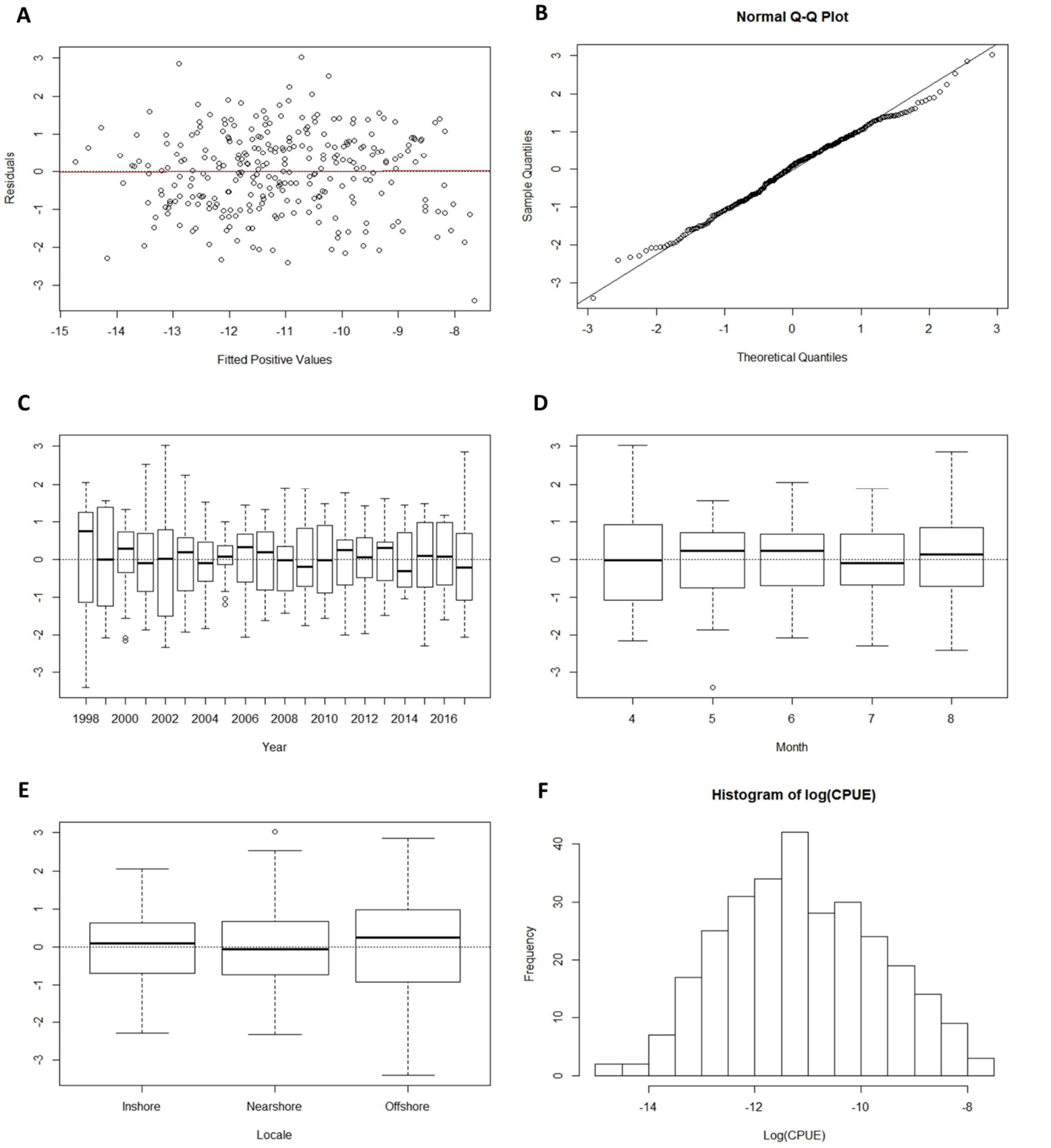

Figure 9. Diagnostic plots for lognormal component of the cobia SCDNR 6-pack Charterboat Logbook Peak Months model: ***A.*** *residuals plotted against predicted values;* ***B.*** *the cumulative normalized residuals (QQ plot);* ***C.*** *the residuals by year,* ***D.*** *the residuals by month;* ***E.*** *the residuals by locale;* ***F.*** *histogram of log (CPUE).*

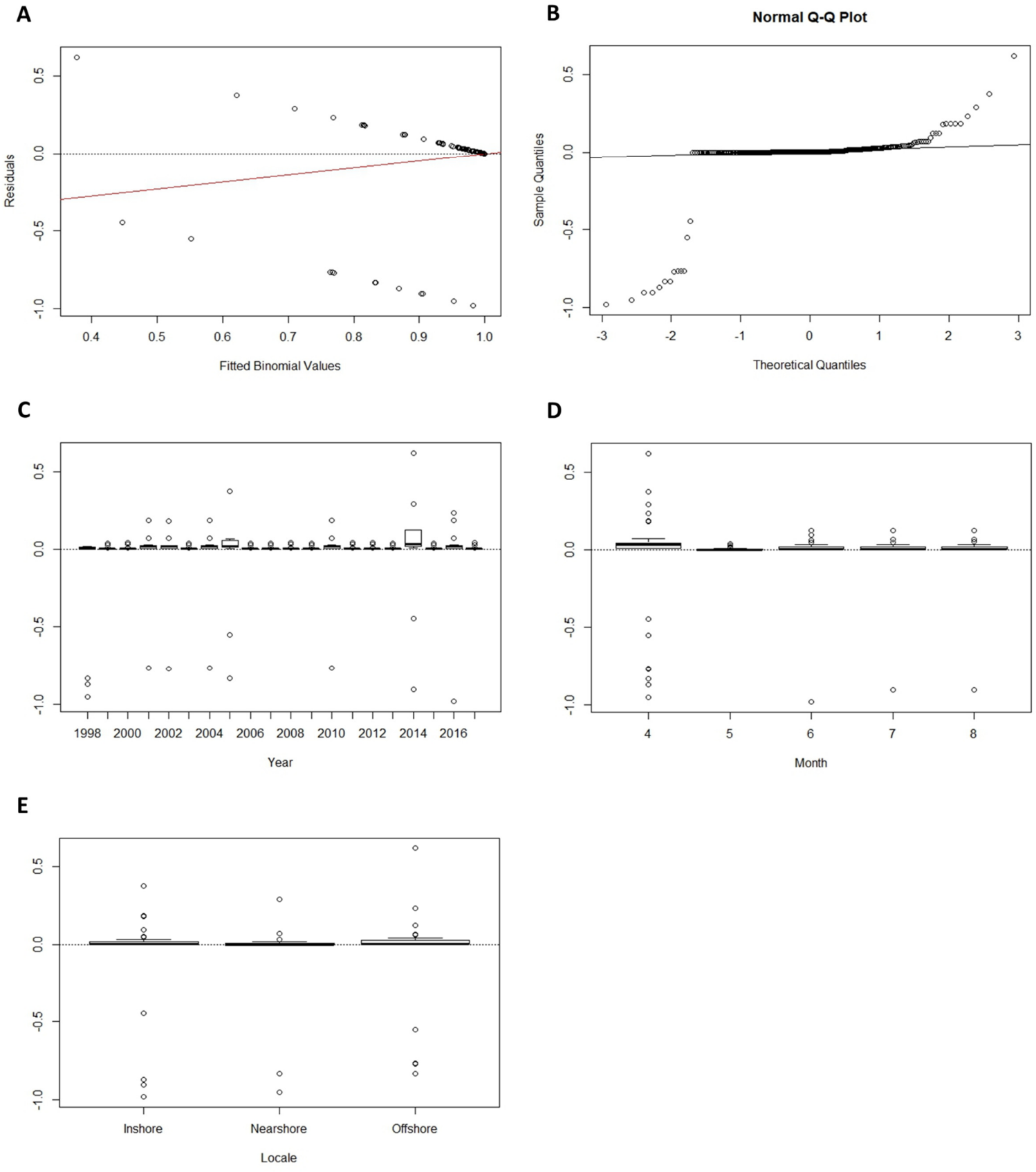

Figure 10. Diagnostic plots for binomial component of the cobia SCDNR 6-pack Charterboat Logbook Peak Months model: ***A.*** *residuals plotted against predicted values;* ***B.*** *the cumulative normalized residuals (QQ plot);* ***C.*** *the residuals by year,* ***D.*** *the residuals by month;* ***E.***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