SCDNR Charterboat Logbook Program Data, 1993 - 2011

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SEDAR32-DW-08

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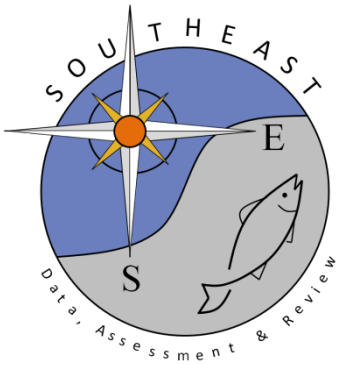
***Addendum added to reflect changes made during the data workshop.**
Final index is found in the addendum.



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SCDNR Charterboat Logbook Program Data, 1993 - 2011

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Abstract:
The South Carolina Department of Natural Resources (SCDNR) charterboat logbook program was used to develop indices of abundance for gray triggerfish from 1993 – 2012. No blueline tilefish were reported caught during the entire charterboat logbook program, so blueline tilefish indecies will not be created. The indices of abundance are standardized catch per unit effort (CPUE; catch per angler hour). For gray triggerfish, a delta-gamma 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), in 2008 additional fishing methods were added to the logbook forms, including 4) cast, 5) cast and bottom, and 6) gig, and in 2012 the location of the trip start was recorded.

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 gray triggerfish represent mostly bottom fishing trips in estuarine, nearshore (0-3 miles) or offshore (3+ miles) waters. All trips that either caught or targeted gray triggerfish are included. Also, all trips that targeted species that are considered by MARMAP to be associated with gray triggerfish in the MARMAP traps are also included. These fish include black seabass, red, gag, and unclassified groupers, grunts, pinfish, porgies, scamp, red, vermilion, and unclassified snappers.

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 gray triggerfish were built assuming a gamma 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. 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 autumn from Sept. to Nov.

Results:

The SCDNR charterboat logbook data represent 3,870 fishing trips in which anglers caught 21,623 gray triggerfish and harvested 19,375 gray triggerfish. 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 a higher AIC value for the binomial sub-model and a lower AIC value 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=0.456). Comparing the total SE to the total CPUE (% Total CPUE) again showed no significant difference between the two model runs (p=0.506). 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 only difference in the boxplots is that those for the monthly run have higher positive outliers than those for the seasonal model (note the scale on the y-axes).

The binomial model results paint the opposite picture for the two model runs, in terms of the fits and the residuals. The residual plots are identical except for the number of residuals. As was noted for the gamma model runs, the monthly model has more residuals than the seasonal model run due to the higher number of parameters. However, because the residuals don't lie on the zero line very well, the monthly model has more residuals further from zero and, therefore, the AIC is higher for this model. The Normal Q-Q plot shows the same information as the residual plot does in terms of fit. The boxplots are also very similar to one another. The appearance of the monthly boxplots fitting better is actually misleading due to the enormous difference in the scales of the axes between the two model runs. The reason for the difference in the scales between model runs is that there is one enormous outlier n the monthly model that is skewing the boxplots. This is the result of one trip in January of 2007 that caught 6 gray triggerfish within the Estuarine locale. The same outlier is present in the seasonal model, but is just not as severe because the monthly CPUEs are combined into seasons.

Literature Cited:

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

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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.

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Table 1. Annual gray triggerfish catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1993-2011.

Year	Vessel Trips	% Trips with Gray Triggerfish Catch	Gray Triggerfish Catch (# fish)	Gray Triggerfish Harvest (# fish)	Gray Triggerfish Released (# fish)	% Released
1993	4,798	2.40%	618	529	89	14.40%
1994	5,653	2.90%	1,048	943	105	10.02%
1995	5,645	2.18%	775	704	71	9.16%
1996	5,836	2.59%	847	806	41	4.84%
1997	6,204	4.00%	1,603	1,427	176	10.98%
1998	7,731	3.70%	1,783	1,718	65	3.65%
1999	7,900	2.27%	1,004	935	69	6.87%
2000	9,022	1.80%	1,436	1,303	133	9.26%
2001	8,795	2.07%	1,071	985	86	8.03%
2002	8,758	2.52%	1,180	1,017	163	13.81%
2003	8,541	2.24%	912	785	127	13.93%
2004	8,541	2.44%	982	876	106	10.79%
2005	9,058	1.89%	895	789	106	11.84%
2006	8,920	1.88%	693	616	77	11.11%
2007	9,462	2.18%	1,310	1,127	183	13.97%
2008	8,897	3.26%	1,493	1,301	192	12.86%
2009	9,190	2.05%	990	864	126	12.73%
2010	10,436	2.74%	1,330	1,179	151	11.35%
2011	11,055	2.99%	1,653	1,471	182	11.01%

Table 2. Gray triggerfish 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	0.11383	0.0490917	0.02951	0.07860	0.01958	0.0910428	0.03004	0.12109	0.06100
1994	0.13306	0.0934538	0.04465	0.13811	0.04880	0.0776739	0.02911	0.10679	0.04856
1995	0.12534	0.0741950	0.02382	0.09801	0.05038	0.0733081	0.01217	0.08548	0.06113
1996	0.10867	0.0241498	0.01649	0.04064	0.00766	0.0582902	0.03382	0.09211	0.02447
1997	0.17172	0.0961928	0.03099	0.12719	0.06520	0.0885272	0.05089	0.13942	0.03764
1998	0.17800	0.0625690	0.03601	0.09857	0.02656	0.0766482	0.04621	0.12286	0.03044
1999	0.12301	0.0721888	0.02331	0.09550	0.04888	0.0840579	0.01574	0.09980	0.06832
2000	0.18113	0.0314992	0.01880	0.05030	0.01270	0.0674776	0.04754	0.11501	0.01994
2001	0.12013	0.0359728	0.02746	0.06343	0.00851	0.0573494	0.00972	0.06707	0.04763
2002	0.12119	0.0760773	0.02068	0.09676	0.05540	0.0737970	0.03377	0.10757	0.04002
2003	0.09578	0.1041565	0.02365	0.12781	0.08051	0.1021737	0.03372	0.13589	0.06845
2004	0.10688	0.0677986	0.02297	0.09077	0.04483	0.0760573	0.05144	0.12749	0.02462
2005	0.10392	0.0661254	0.01765	0.08377	0.04848	0.0679581	0.01584	0.08379	0.05212
2006	0.06667	0.0166593	0.01117	0.02783	0.00549	0.0351592	0.02241	0.05757	0.01275
2007	0.11744	0.0907453	0.02227	0.11301	0.06848	0.0948592	0.01520	0.11006	0.07966
2008	0.08176	0.0523299	0.01767	0.07000	0.03466	0.0621261	0.01059	0.07272	0.05153
2009	0.08735	0.0532814	0.01183	0.06511	0.04145	0.0412753	0.00977	0.05105	0.03150
2010	0.08730	0.0599937	0.01586	0.07585	0.04413	0.0563033	0.01606	0.07236	0.04024
2011	0.09710	0.0640068	0.02458	0.08859	0.03943	0.0458569	0.01114	0.05700	0.03471

Table 3. Comparison of AIC values for the Monthly and Seasonal gray triggerfish standardized index model runs. SE is the standard error calculated from the model jack knife. % Total CPUE is sum(SE)/sum(CPUE). Combined is the combined AIC (Binomial AIC + Positive AIC).

AIC	**Standardized CPUE (Monthly)**	**Standardized CPUE (Seasonal)**
Binomial	337.3149	136.3277
Positive	-750.784	-402.439
Combined	-413.4691	-266.1113
Sum of SE	0.439362	0.4952051
% Total CPUE	36.91%	37.24%

Figure 1. Distribution of gray trigger catch from SCDNR 6-pack Charterboat Logbook data. Each square represents a 10 mile^2 area**.** Only data from 2008-2011 were used because prior to 2008 approximately 80% of the logbook trips included in the analysis did not include location information.

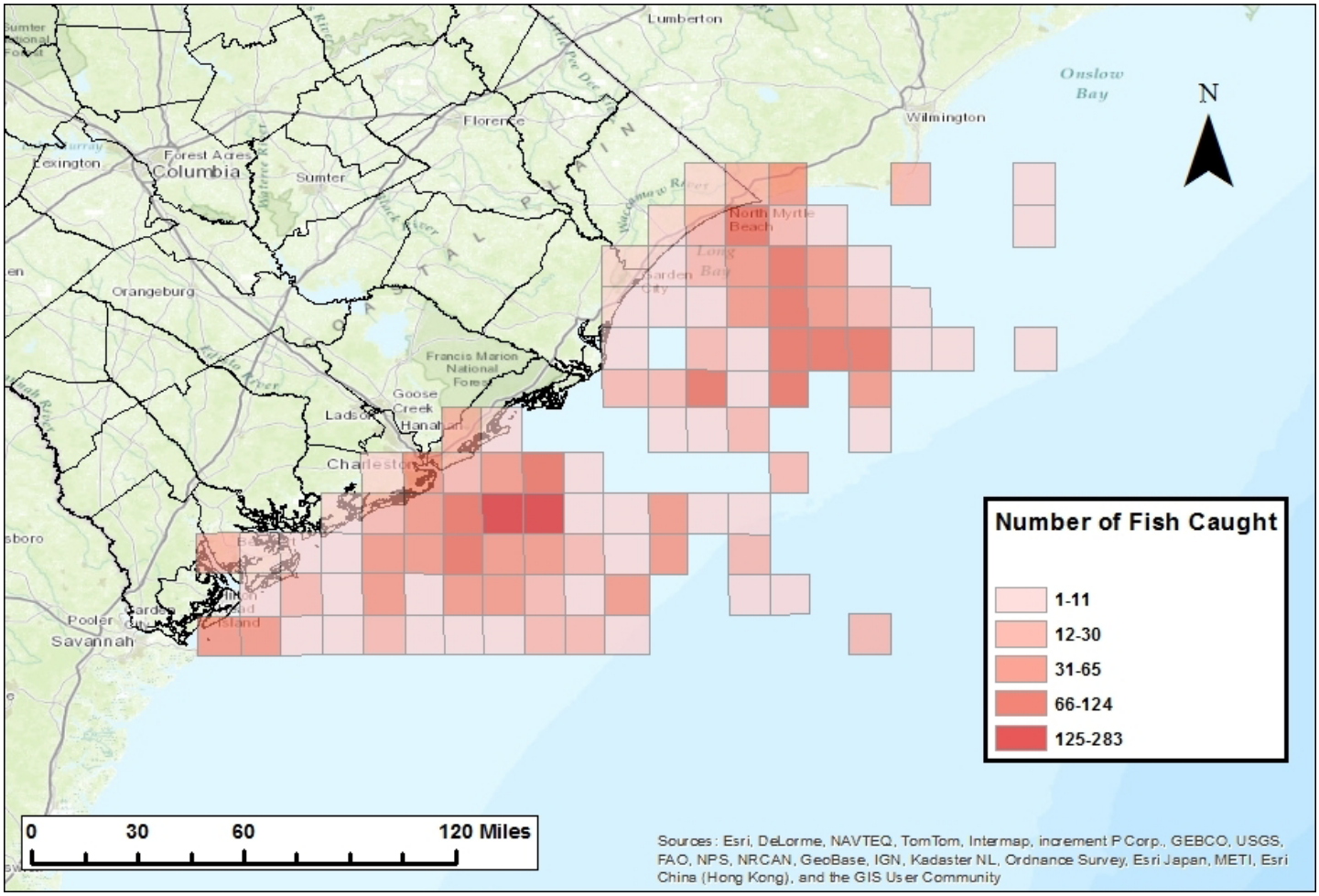


Figure 2. Gray triggerfish CPUE from SCDNR 6-pack Charterboat Logbook data from 1993-2011. Nominal (blue), Monthly standardized (red), and Seasonal standardized (green) catch per angler-hour are shown. The dotted lines show 1 standard error from the Standardized CPUE.

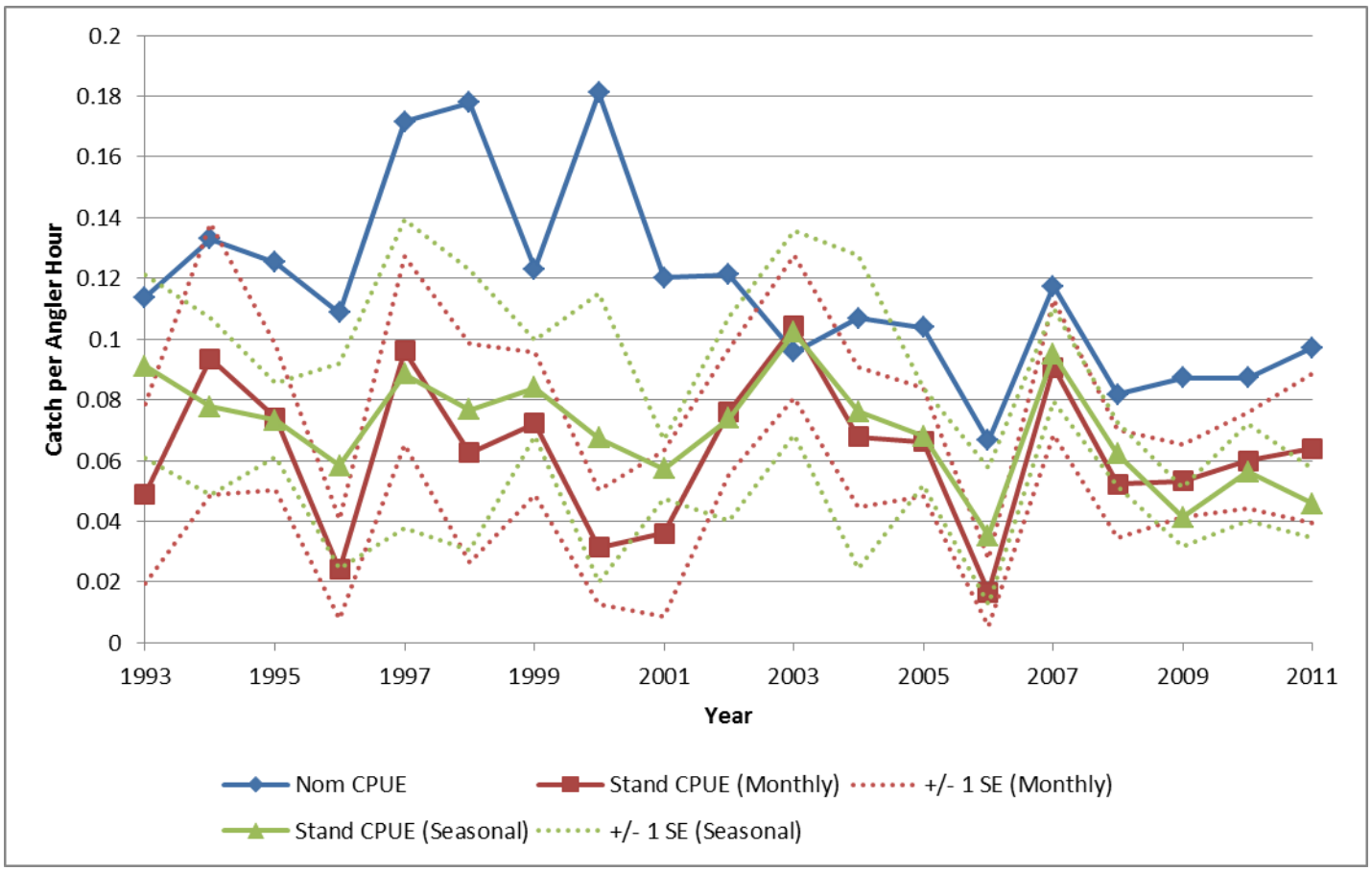
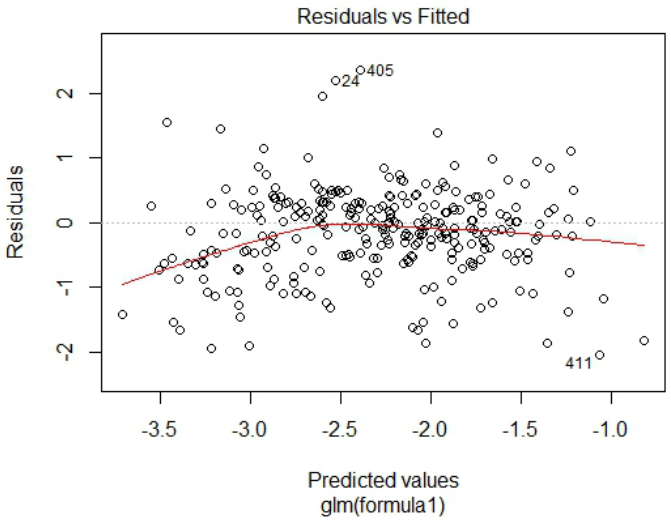


Figure 3. Diagnostic plots for gamma component of the gray triggerfish SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year; **D.** the residuals by locale; **E.** the residuals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

A



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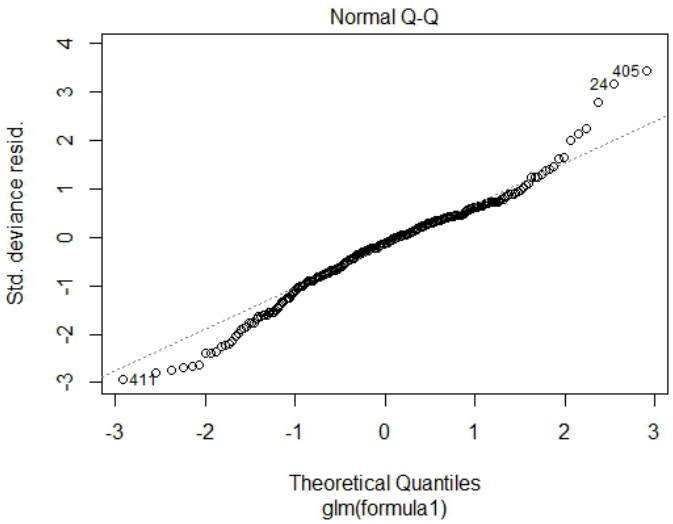

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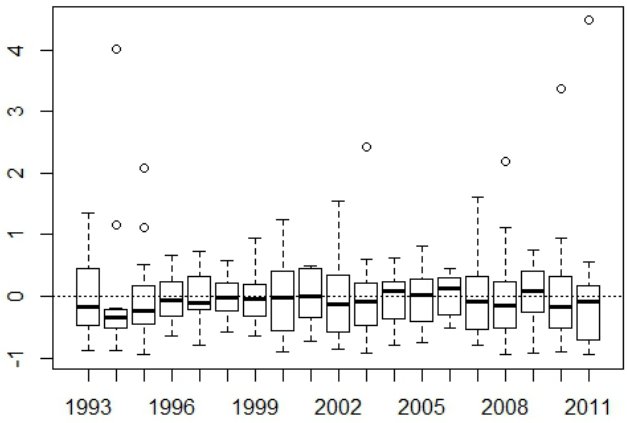

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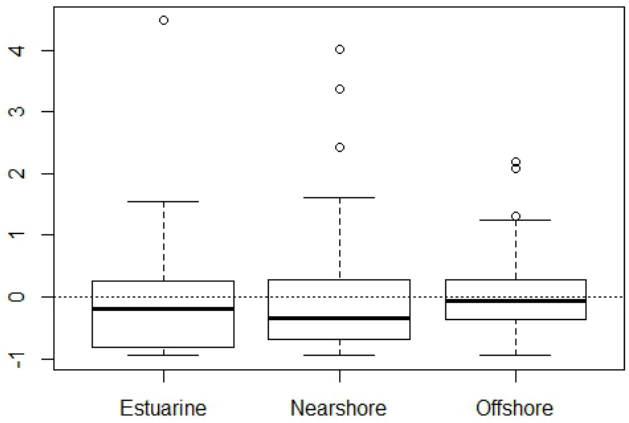

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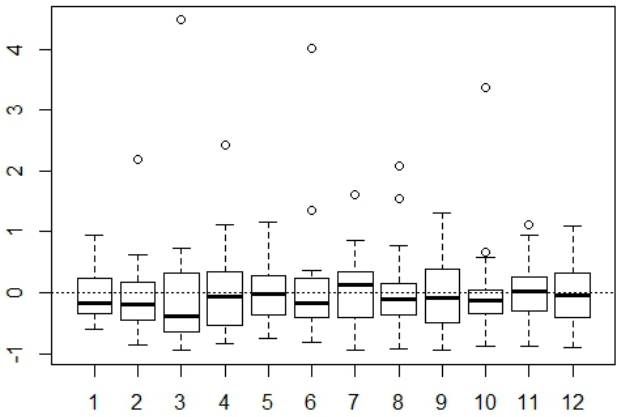
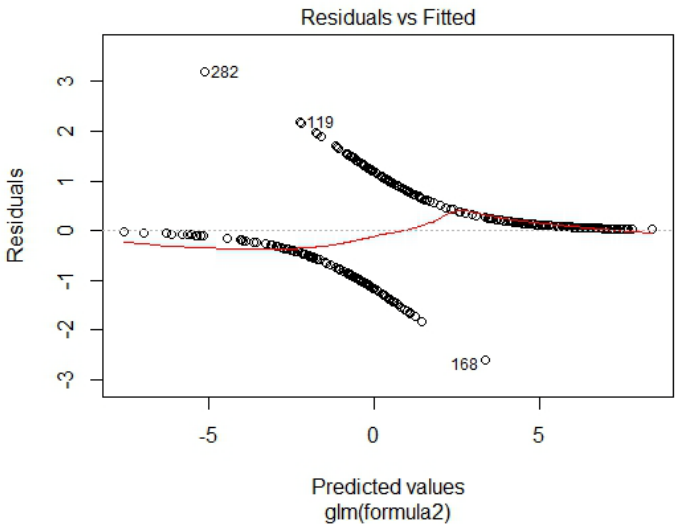


Figure 4. Diagnostic plots for binomial component of the gray triggerfish SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals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

A



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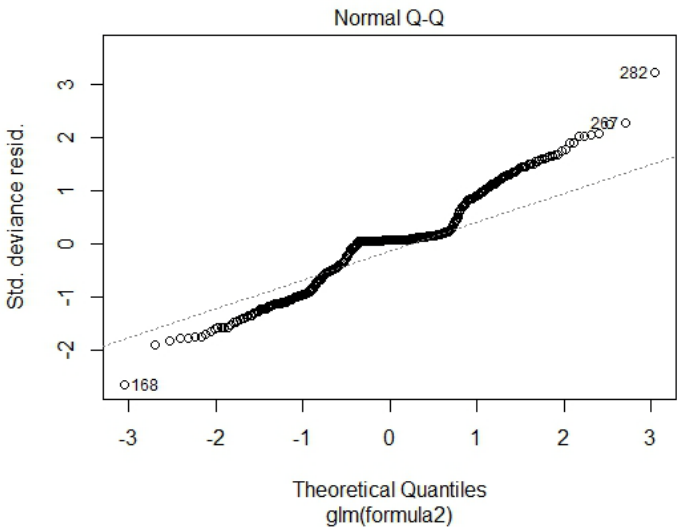

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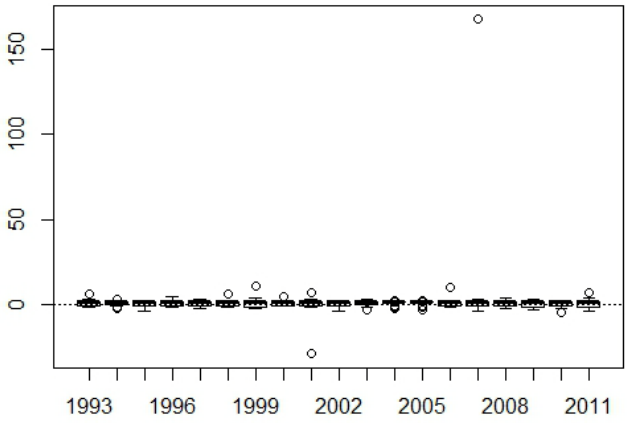

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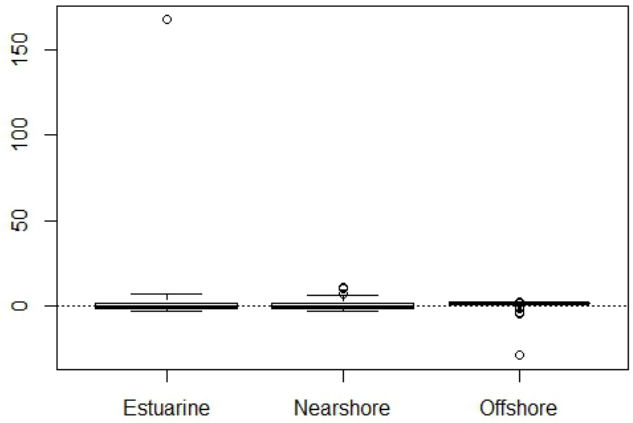

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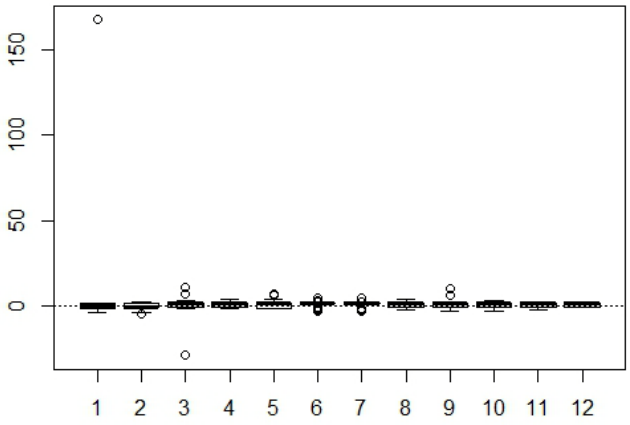
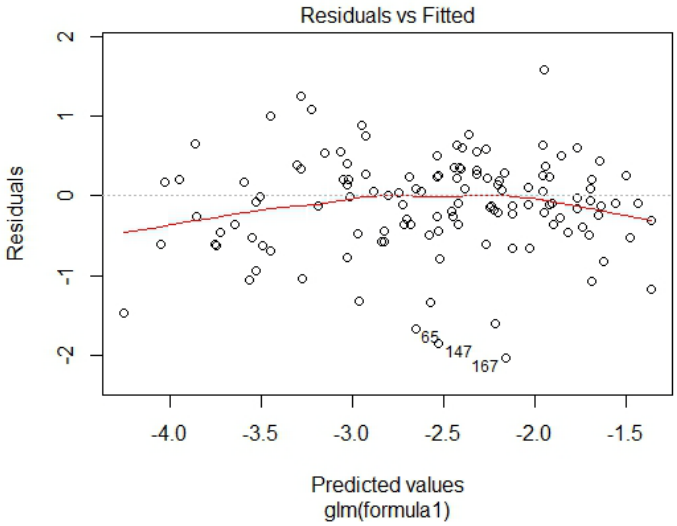


Figure 5. Diagnostic plots for gamma component of the gray triggerfish SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals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

A



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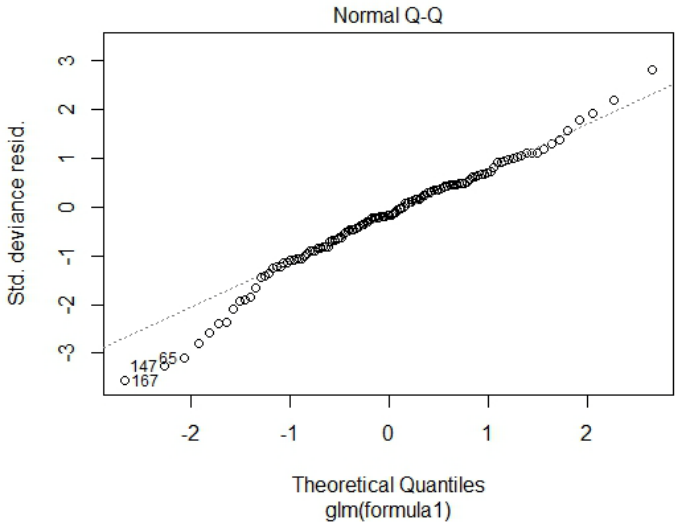

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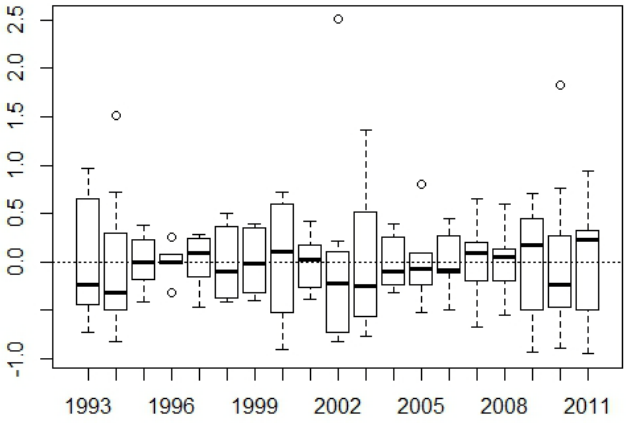

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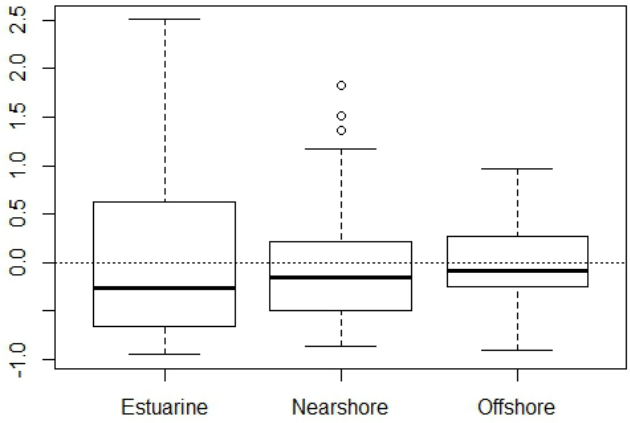

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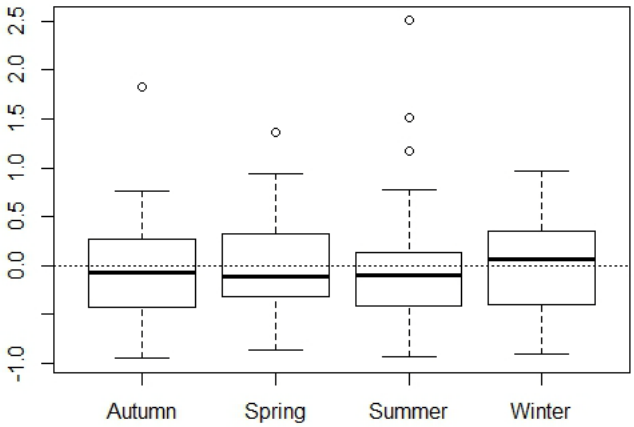
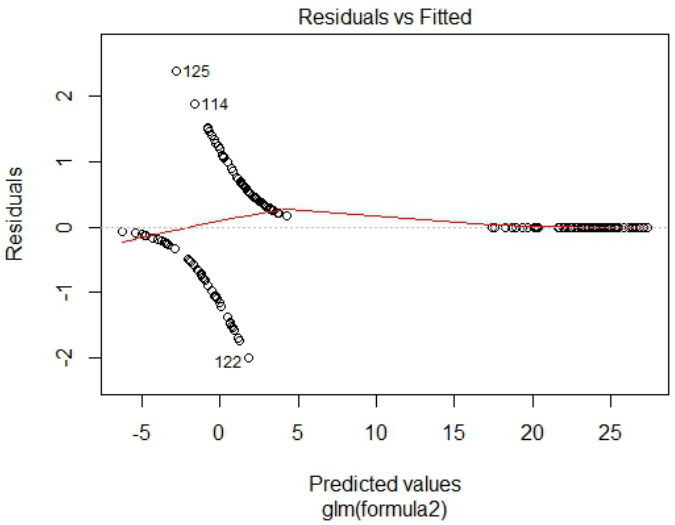


Figure 6. Diagnostic plots for binomial component of the gray triggerfish SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the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

A



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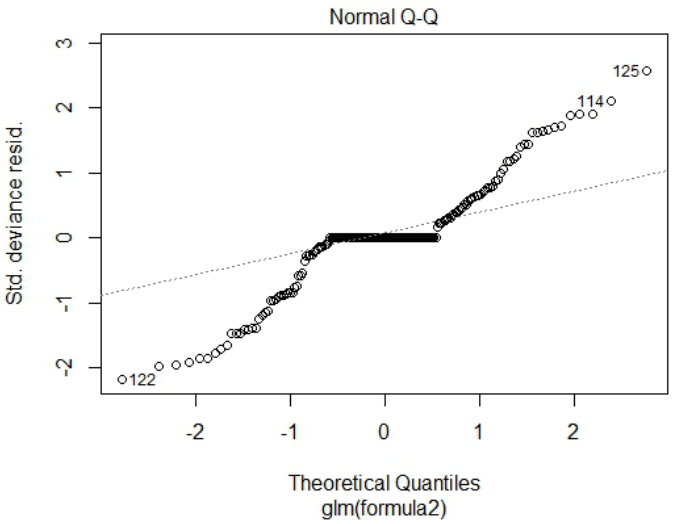

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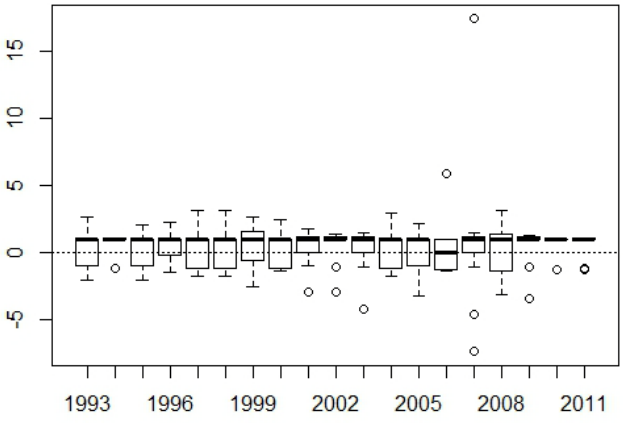

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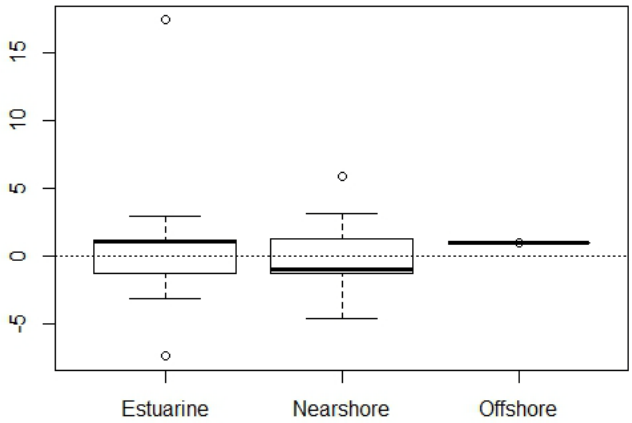

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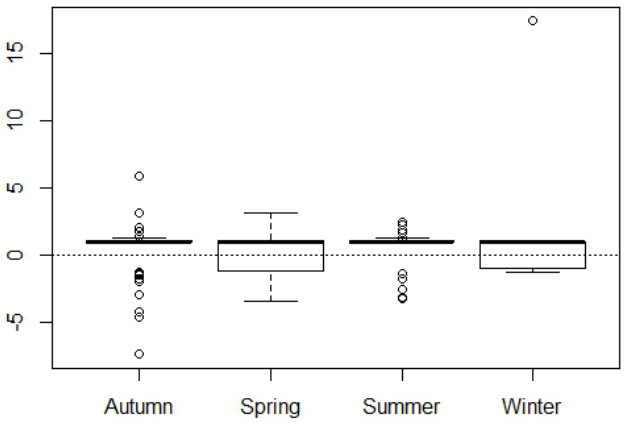

ADDENDUM

SCDNR Charterboat Logbook Program Data, 1993 - 2011

Date: **3/04/2013 - ADDENDUM**

Prepared by: **Mike Errigo, South Atlantic Fishery Management Council**
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For: **SEDAR 32 Data Workshop, February 2013**

Abstract:
The South Carolina Department of Natural Resources (SCDNR) charterboat logbook program was used to develop indices of abundance for gray triggerfish from 1993 – 2012. No blueline tilefish were reported caught during the entire charterboat logbook program, so blueline tilefish indecies will not be created. The indices of abundance are standardized catch per unit effort (CPUE; catch per angler hour). For gray triggerfish, a delta-gamma 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), in 2008 additional fishing methods were added to the logbook forms, including 4) cast, 5) cast and bottom, and 6) gig, and in 2012 the location of the trip start was recorded.

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 gray triggerfish represent mostly bottom fishing trips in estuarine, nearshore (0-3 miles) or offshore (3+ miles) waters. All trips that either caught or targeted gray triggerfish are included. Also, all trips that targeted species that are considered by MARMAP to be associated with gray triggerfish in the MARMAP traps are also included. These fish include black seabass, red, gag, and unclassified groupers, grunts, pinfish, porgies, scamp, red, vermilion, and unclassified snappers.

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 gray triggerfish 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. 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, the month, and the trip length as explanatory variables (referred to as the "trip length" 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 trip length model runs, those trips labeled as half were all trips up to 4 hours in length and those labeled full were all trips greater than 4 hours in length.

Results:

The SCDNR charterboat logbook data represent 3,870 fishing trips in which anglers caught 21,623 gray triggerfish and harvested 19,375 gray triggerfish. 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 a higher AIC value for the binomial sub-model and a lower AIC value 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=0.456). Comparing the total SE to the total CPUE (% Total CPUE) again showed no

significant difference between the two model runs (p=0.506). 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. The monthly model uses year, month, and locale to predict the CPUE. The trip length run used all those same variables with the addition of the trip length variable. 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 trip length run has more residuals clustered around zero because there are simply more residuals, which causes the run to have a lower AIC for the lognormal model. The same trend is apparent in the Normal Q-Q plot for the lognormal model. The plots look the same for each run, but the trip length run has more points on it and they are clustered on the 1:1 line, therefore increasing the fit and decreasing the AIC. The only difference in the boxplots is that those for the trip length run have more spread around the zero line than the monthly model (note the scale on the y-axes).

The binomial model results paint the opposite picture for the two model runs, in terms of the fits and the residuals. The residual plots are identical except for the number of residuals. As was noted for the lognormal model runs, the trip length model has more residuals than the monthly model run due to the higher number of parameters. However, because the residuals don't lie on the zero line very well, the trip length model has more residuals further from zero and, therefore, the AIC is higher for this model. The Normal Q-Q plot shows the same information as the residual plot does in terms of fit. The boxplots are also very similar to one another. The appearance of the monthly boxplots fitting better is actually misleading due to the enormous difference in the scales of the axes between the two model runs. The reason for the difference in the scales between model runs is that there is one enormous outlier in the monthly model that is skewing the boxplots. This is the result of one trip in January of 2007 that caught 6 gray triggerfish within the Estuarine locale.

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.

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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 gray triggerfish catch, harvest, and effort from SCDNR Charterboat Logbook Program, 1993-2011.

Year	Vessel Trips	% Trips with Gray Triggerfish Catch	Gray Triggerfish Catch (# fish)	Gray Triggerfish Harvest (# fish)	Gray Triggerfish Released (# fish)	% Released
1993	4,798	2.40%	618	529	89	14.40%
1994	5,653	2.90%	1,048	943	105	10.02%
1995	5,645	2.18%	775	704	71	9.16%
1996	5,836	2.59%	847	806	41	4.84%
1997	6,204	4.00%	1,603	1,427	176	10.98%
1998	7,731	3.70%	1,783	1,718	65	3.65%
1999	7,900	2.27%	1,004	935	69	6.87%
2000	9,022	1.80%	1,436	1,303	133	9.26%
2001	8,795	2.07%	1,071	985	86	8.03%
2002	8,758	2.52%	1,180	1,017	163	13.81%
2003	8,541	2.24%	912	785	127	13.93%
2004	8,541	2.44%	982	876	106	10.79%
2005	9,058	1.89%	895	789	106	11.84%
2006	8,920	1.88%	693	616	77	11.11%
2007	9,462	2.18%	1,310	1,127	183	13.97%
2008	8,897	3.26%	1,493	1,301	192	12.86%
2009	9,190	2.05%	990	864	126	12.73%
2010	10,436	2.74%	1,330	1,179	151	11.35%
2011	11,055	2.99%	1,653	1,471	182	11.01%

Table 2. Gray triggerfish 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 (Trip Length)	SE (Trip Length)	Upper (Trip Length)	Lower (Trip Length)
1993	0.11383	0.0177475	0.01081	0.02856	0.00694	0.0260805	0.01393	0.04001	0.01215
1994	0.13306	0.0273265	0.01243	0.03975	0.01490	0.0804425	0.05696	0.13740	0.02349
1995	0.12534	0.0329192	0.01403	0.04695	0.01889	0.0613105	0.03532	0.09663	0.02599
1996	0.10867	0.0092127	0.00639	0.01560	0.00282	0.0213584	0.01133	0.03268	0.01003
1997	0.17172	0.0355870	0.01414	0.04973	0.02145	0.0832785	0.03803	0.12131	0.04525
1998	0.17800	0.0239760	0.01742	0.04139	0.00656	0.0549237	0.02494	0.07987	0.02998
1999	0.12301	0.0264327	0.00897	0.03540	0.01746	0.0506434	0.02913	0.07978	0.02151
2000	0.18113	0.0096859	0.00628	0.01597	0.00340	0.0364166	0.01847	0.05489	0.01795
2001	0.12013	0.0136333	0.01209	0.02573	0.00154	0.0428775	0.03164	0.07451	0.01124
2002	0.12119	0.0238596	0.00866	0.03252	0.01520	0.0563506	0.02244	0.07879	0.03391
2003	0.09578	0.0337029	0.01212	0.04582	0.02158	0.0603595	0.01932	0.07968	0.04104
2004	0.10688	0.0201725	0.00915	0.02932	0.01102	0.0715384	0.03488	0.10642	0.03666
2005	0.10392	0.0186330	0.00591	0.02455	0.01272	0.0535585	0.01468	0.06824	0.03888
2006	0.06667	0.0045519	0.00336	0.00791	0.00119	0.0127368	0.00621	0.01894	0.00653
2007	0.11744	0.0228002	0.00756	0.03036	0.01524	0.0546014	0.02031	0.07491	0.03429
2008	0.08176	0.0060263	0.00218	0.00821	0.00384	0.0152610	0.00459	0.01986	0.01067
2009	0.08735	0.0112587	0.00409	0.01535	0.00717	0.0310527	0.01020	0.04125	0.02085
2010	0.08730	0.0098039	0.00288	0.01269	0.00692	0.0223384	0.00788	0.03022	0.01446
2011	0.09710	0.0077880	0.00314	0.01092	0.00465	0.0289542	0.01059	0.03955	0.01836

Table 3. Comparison of AIC values for the Monthly and Seasonal gray triggerfish standardized index model runs. SE is the standard error calculated from the model jack knife. % Total CPUE is sum(SE)/sum(CPUE). Combined is the combined AIC (Binomial AIC + Positive AIC).

AIC	Standardized CPUE (Monthly)	Standardized CPUE (Trip Length)
Binomial	337.3	497.2
Positive	-2144.5	-2845.0
Combined	-1807.2	-2347.8
Sum of SE	0.161607	0.410859
% Total CPUE	45.51%	47.55%

Figure 1. Distribution of gray trigger catch from SCDNR 6-pack Charterboat Logbook data. Each square represents a 10 mile^2 area**.** Only data from 2008-2011 were used because prior to 2008 approximately 80% of the logbook trips included in the analysis did not include location information.

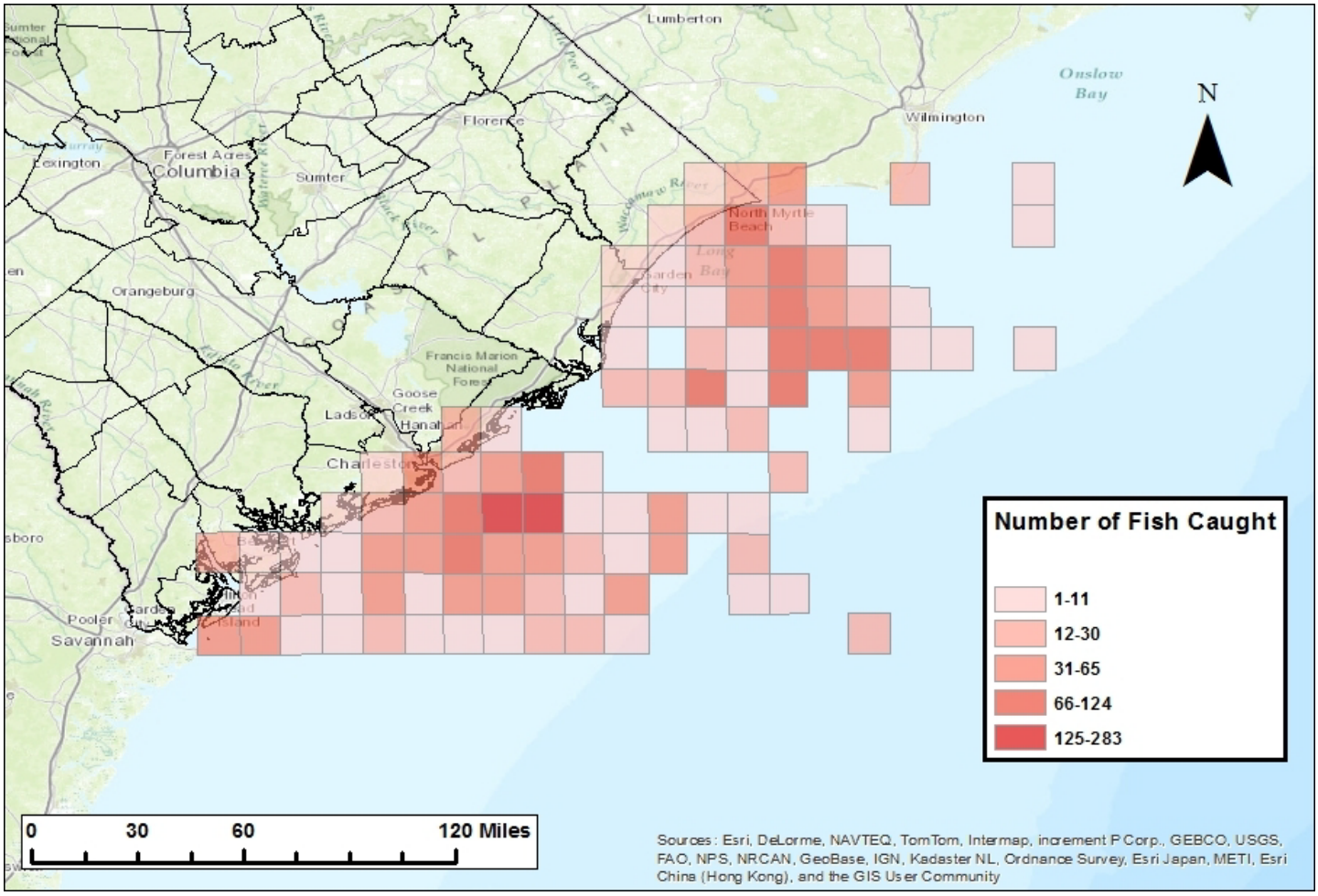


Figure 2. Gray triggerfish CPUE from SCDNR 6-pack Charterboat Logbook data from 1993-2011. Nominal (blue), Monthly standardized (red), and Trip Length standardized (green) catch per angler-hour are shown. The dotted lines show 1 standard error from the Standardized CPUE.

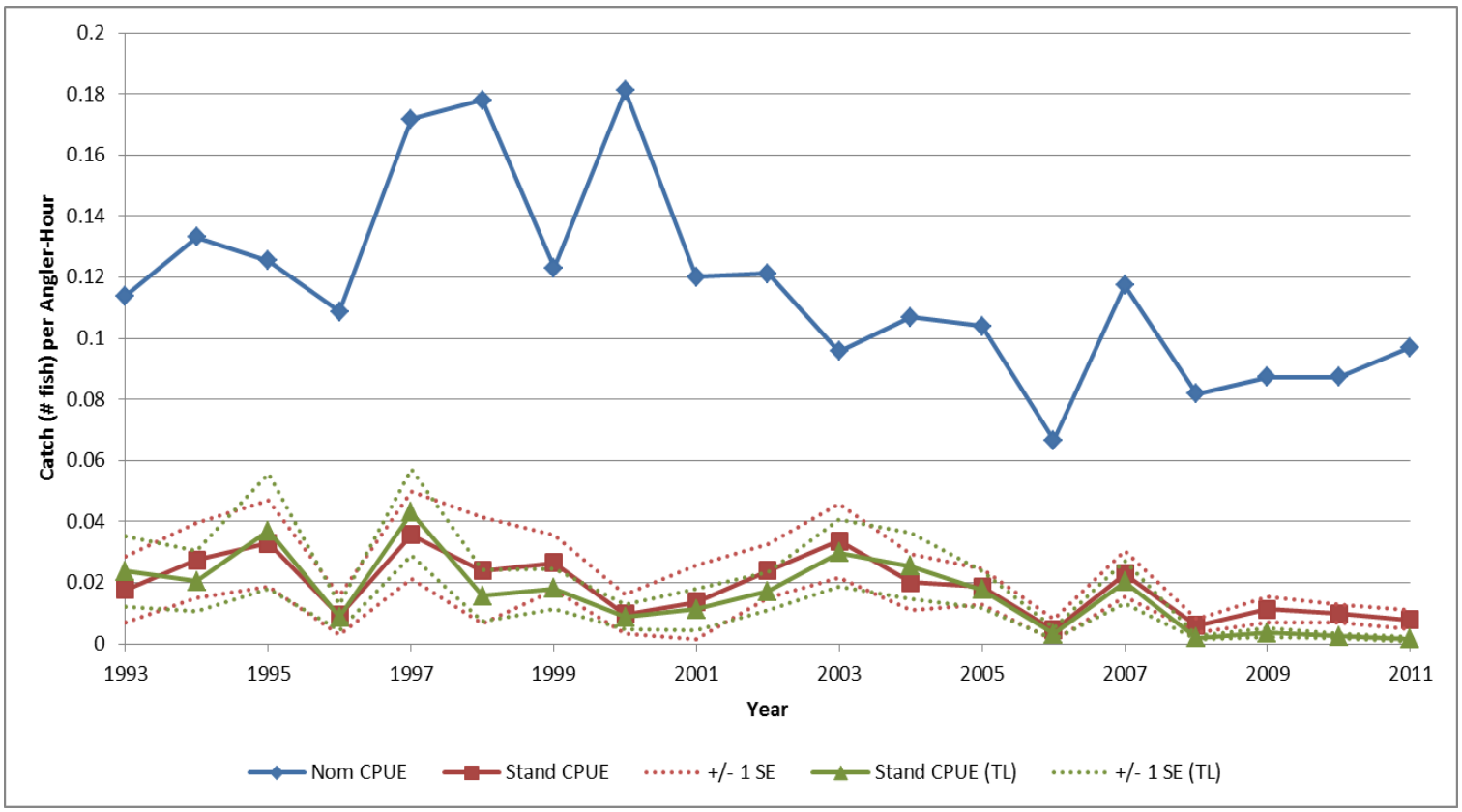
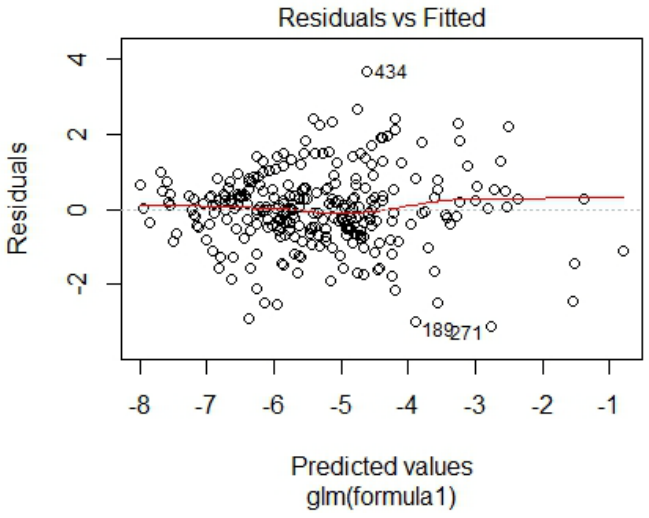


Figure 3. Diagnostic plots for the lognormal component of the gray triggerfish SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year; **D.** the residuals by locale; **E.**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

A



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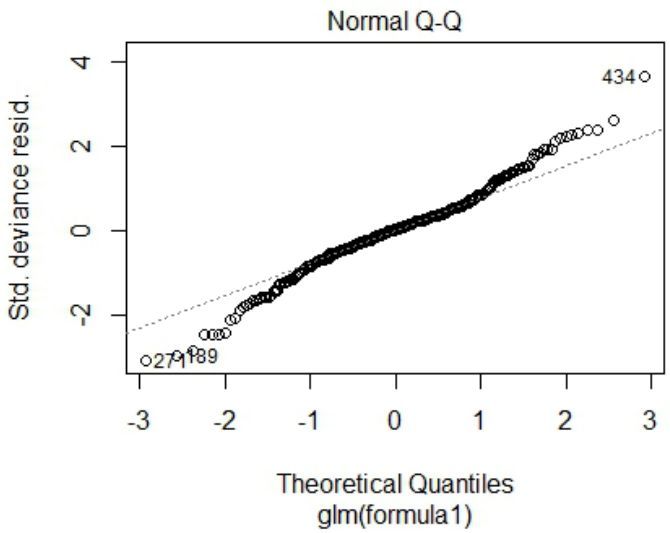

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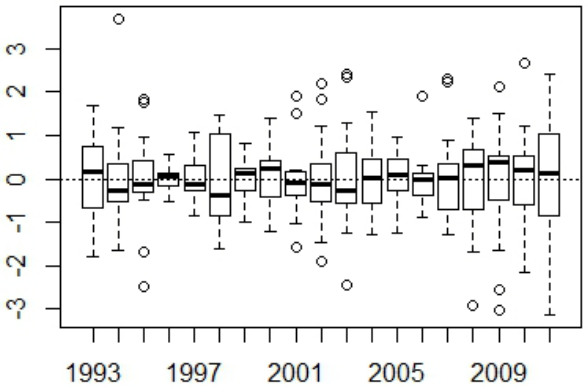

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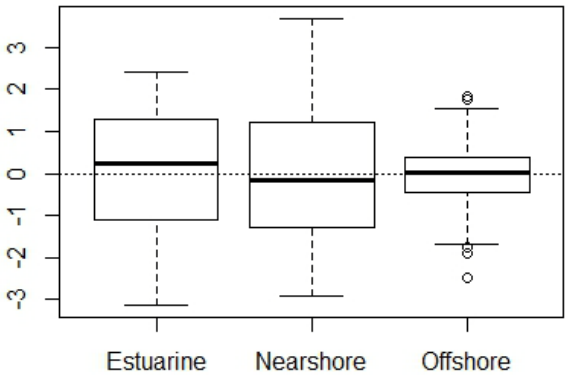

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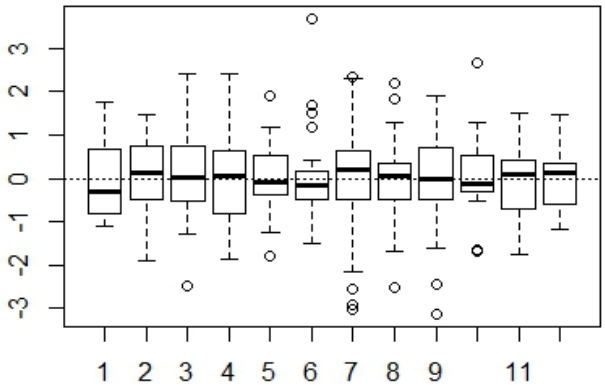
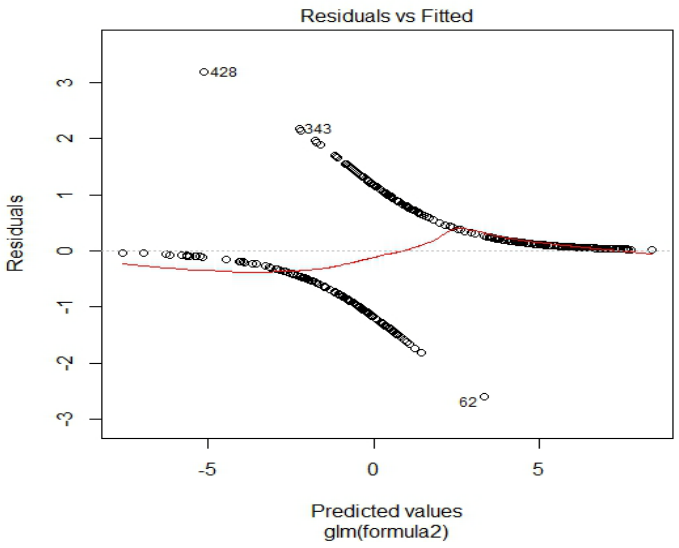


Figure 4. Diagnostic plots for binomial component of the gray triggerfish SCDNR 6-pack Charterboat Logbook MONTHLY model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals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

A



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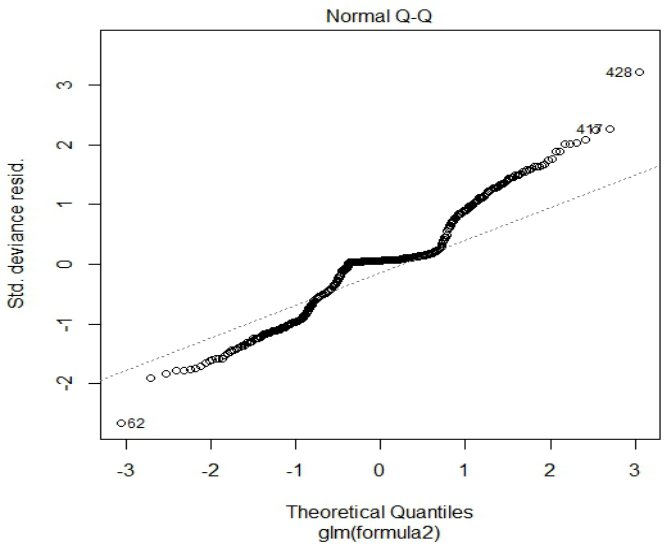

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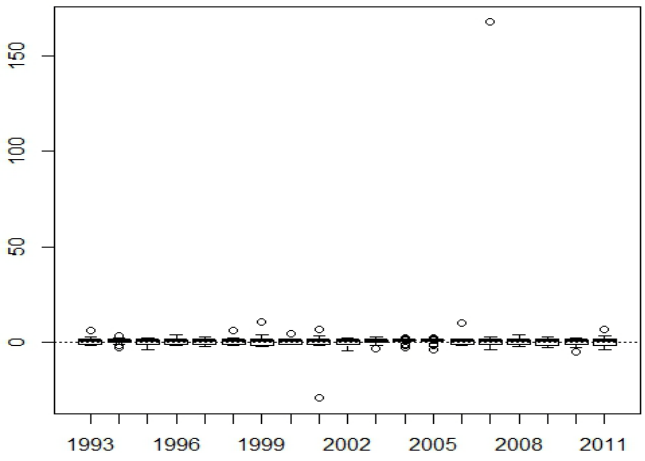

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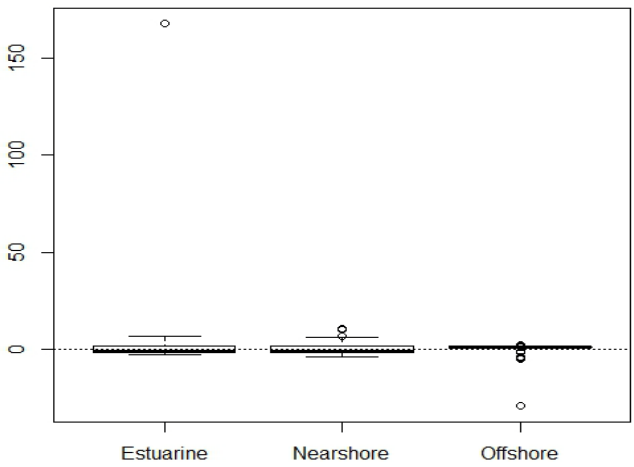

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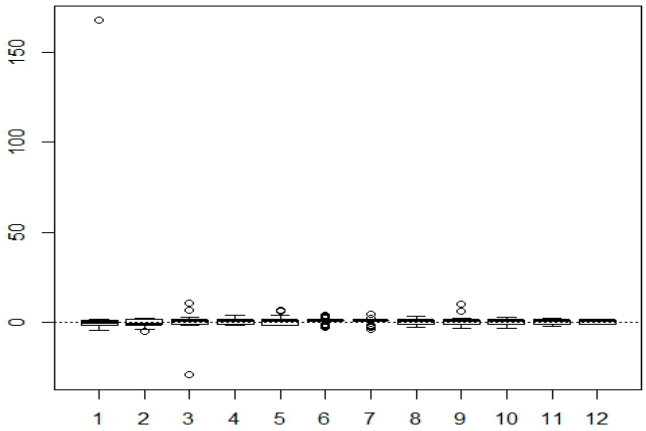
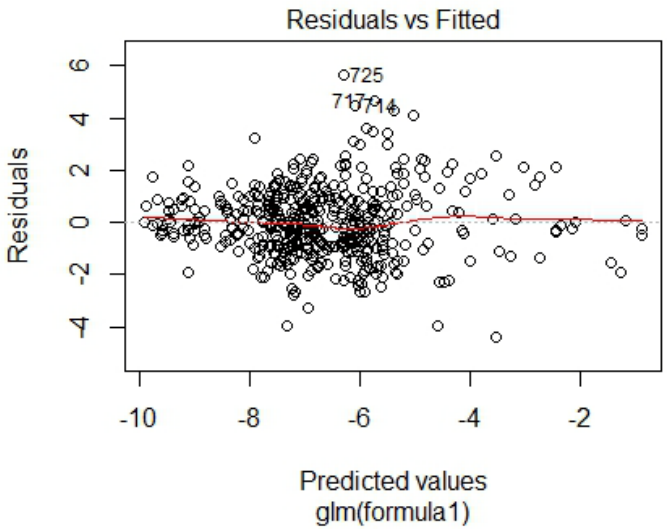


Figure 5. Diagnostic plots for the lognormal component of the gray triggerfish SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the residuals by month; **F.** the residuals by trip length

A



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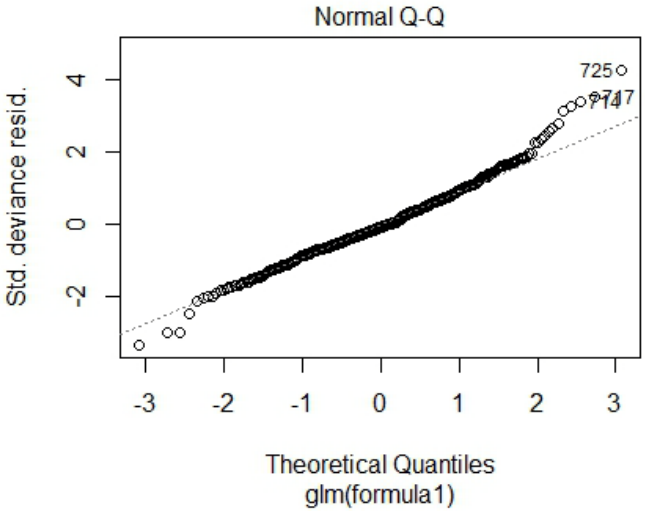

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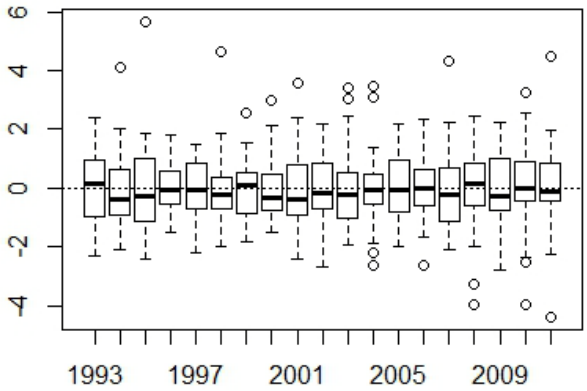

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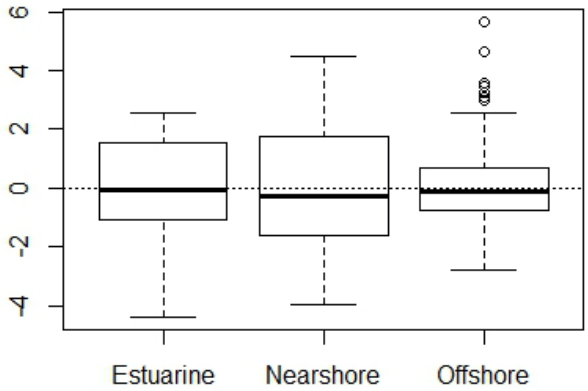

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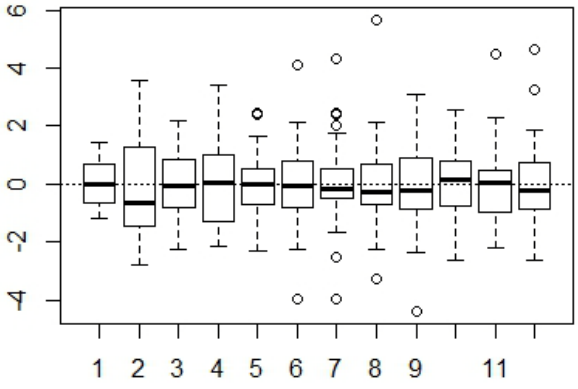

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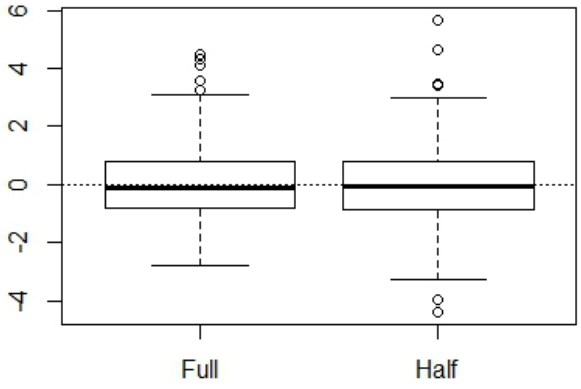
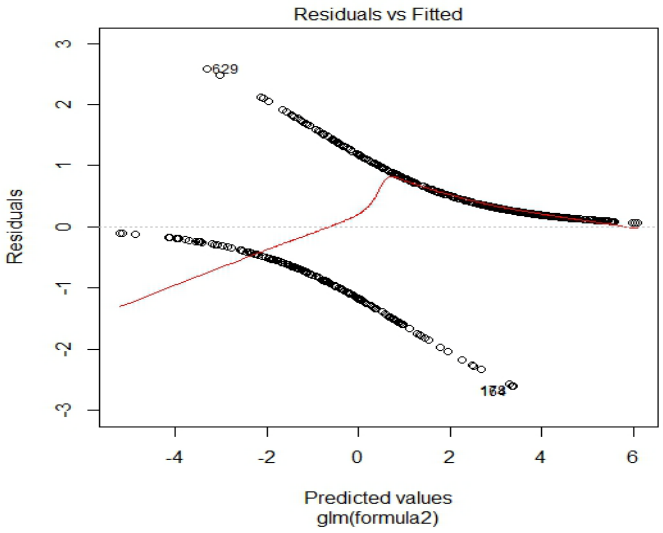


Figure 6. Diagnostic plots for binomial component of the gray triggerfish SCDNR 6-pack Charterboat Logbook SEASONAL model: **A.** residuals plotted against predicted values; **B.** the cumulative normalized residuals (QQ plot); **C.** the residuals by year, **D.** the residuals by locale; **E.** the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

A



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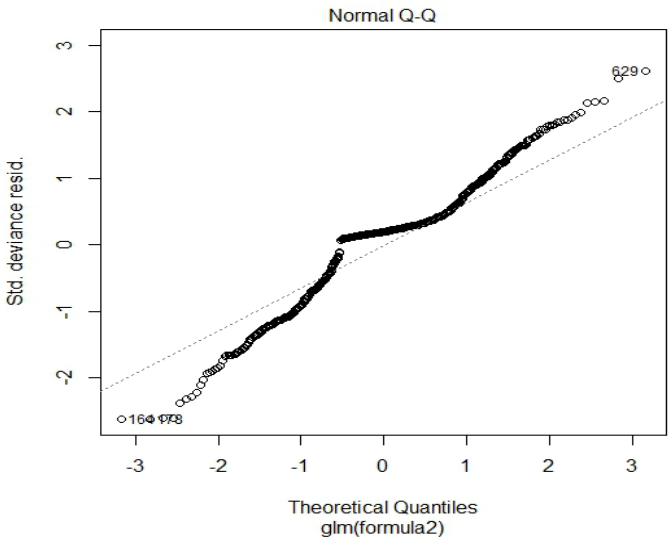

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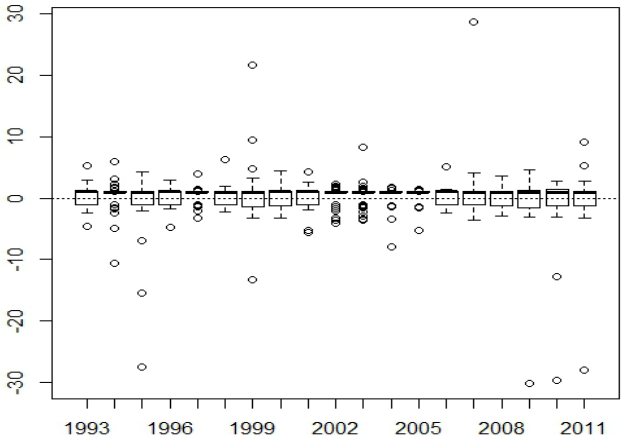

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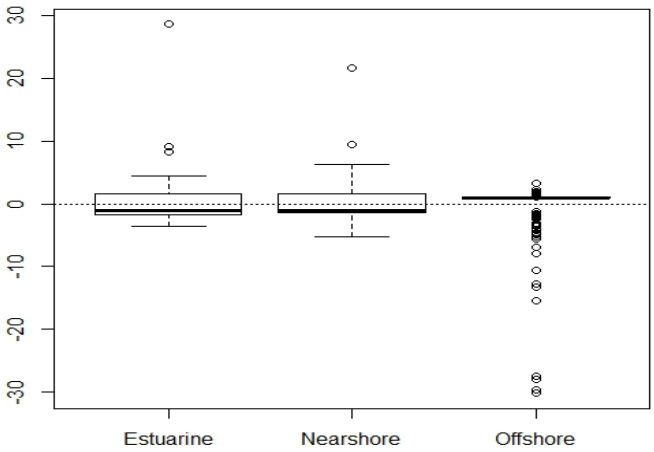

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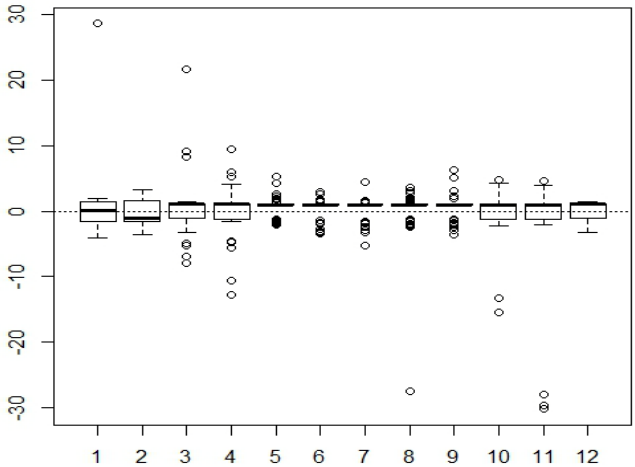
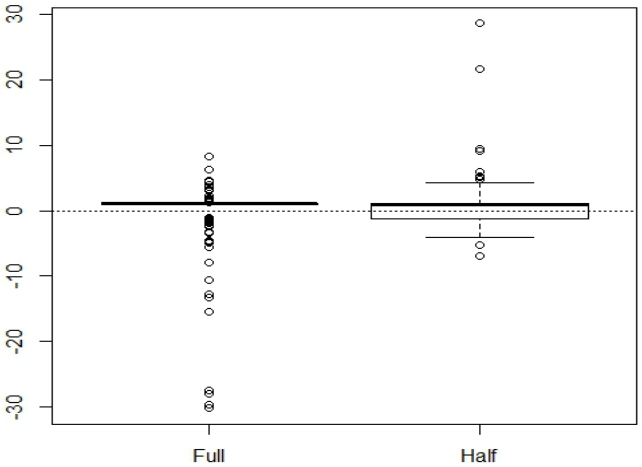
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