Relative abundance of gag grouper and greater amberjack based on observer data collected in the reeffish bottom longline fishery

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SEDAR33-DW26

20 May 2013

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Please cite as:

Carlson, J., S. Gulak, E. Scott-Denton, and J. Pulver. 2013. Relative abundance of gag grouper and greater amberjack based on observer data collected in the reeffish bottom longline fishery. SEDAR33-DW26. SEDAR, North Charleston, SC. 16 pp.

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Introduction

This reeffish fishery in the Gulf of Mexico consists of approximately 890 federally permitted vessels. Primary gears used in this fishery include bottom longline, vertical line (bandit or handline) and more recently buoy gear. Although all reef fish species are retained, the predominant target species are groupers, *Epinephelus* spp., and snappers, *Lutjanus* spp. Details of the fishery and its operations can be found in Scott-Denton et al. (2011). Of the approximately 890 permitted vessels about 130 report fishing with bottom longline gear opposed to bandit or handline for the majority of their trips.

Data collected by at-sea observers of this fishery began in 2005 by the NMFS-Panama City Laboratory. While the focus of the Panama City Laboratory observer program was on shark directed bottom longline trips, observers also boarded bottom longline fishing trips that targeted grouper, snapper, and tilefish because of the overlap in vessels carrying dual permits (shark and reeffish). The NMFS-Galveston Laboratory also began observer coverage of this fishery in 2006 as part of the observer program to monitor the reeffish fishery in the Gulf of Mexico. Both programs have continued observations of this fishery since 2006. Herein we determine a relative abundance index for gag grouper and greater amberjack for the bottom longline portion of the reeffish fishery in the Gulf of Mexico using combined data from both the Panama City and Galveston Laboratory observer programs.

Methods

Vessel selection

NMFS observers were placed on bottom longline vessel targeting reeffish throughout the Gulf of Mexico based season, gear, and region. Observer coverage is based on proportional sampling effort, based on coastal logbook data, among seasons and gears in the eastern and western Gulf of Mexico. Further details are available in Scott-Denton et al. (2011) and Hale et al. (2012).

Selection letters requiring observer coverage were issued to permit holders via U.S. certified mail approximately one month prior to the upcoming fishing season. Once the permit holder received the selection letter, he or she was required to contact the observer coordinator and indicate intent to fish during the upcoming fishing season. If the permit holder intended to fish, the observer coordinator deployed an observer to the port of departure (Hale et al. 2007; Scott-Denton et al. 2011).

Observer Protocol

For consistency among longline observer programs throughout the Southeast Fisheries Science Center, observers complete three data forms: Longline Gear Characteristic Log, Longline Haul Log, and Individual Animal Log. The Longline Gear Characteristic Log is used to record the type and length of the mainline used, number and length of gangions, and make and model of hooks used. The Longline Haul Log is used to record the length, location, and time duration for each set and haulback, as well as environmental information and the type(s) of bait used. The Individual Animal Log records all species caught, condition on capture (e.g. alive, dead, damaged, or unknown) when brought to the vessel, and the final condition on release (e.g. kept, released, finned, etc.). When an animal is brought aboard the vessel, the observer records species, condition on capture, sex (when possible), and length.

Catch rate analysis

A combined data set was developed based on observer programs from Hale et al. (2012) and Scott-Denton et al. (2011). Only sets that reported targeting reeffish with bottom longline gear were included in the analysis. Catch rates were standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). For the purposes of analysis, several categorical variables were constructed assumed to influence the probability and rate of capture:

● "Year" (7 Levels)
-2006-2012

● "Time of Day"(4 Levels): the time of day the set started defined from the time the first hook was set in the water
-22.1 to 4.0 hrs =Night
-4.1 to 10.0=Dawn
-10.1 to 16.0=Day
-16.1 to 22.0 hrs=Dusk

●"Season" (4 Levels)
-Winter = January-March
-Spring = April-June
-Summer = July-September
-Fall = October-December

●"Depth" (4 levels): defined as the mean depth (m) when the first hook was set and the last hook was retrieved
-0-100 m
-100-200 m
-200-300 m

->300 m

●"Hook type" (Levels): the hook that was used by the majority of the set
-Circle hook types 10-15, 6, 9
-Not defined or multiple hook types

We attempted to classify bait into a categorical variable however the extreme variability in the types of bait used for a particular set precluded adding this variable to the analysis.

The proportion of sets that caught gag or greater amberjack (when at least one fish was caught) was modeled assuming a binomial distribution with a logit link function. Positive catches were modeled using a dependent variable of the natural logarithm of CPUE expressed as the number of fish caught per 100 hook hrs

CPUE = log{(fish kept+fish released)/ ((number of hooks/100)*soak)}

A null model was run with no factors entered into the model. Models were then fit in a stepwise-forward manner adding one independent variable. Each factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model provided the effect was significant at $p<0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all final models. After selecting the set of fixed factors and interactions for each error distribution, all interactions that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final model determination was evaluated using the Akaike Information Criteria (AIC). These models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models.

Results and Discussion

Gag grouper

The final bottom longline dataset analyzed contained 2917 sets. Of those sets, gag grouper were reported caught on 30.6% of sets. The stepwise construction of the model is summarized in Table 1 and the index statistics can be found in Table 2. Table 3 provides a table of the frequency of observations by factor and level. The standardized abundance index is shown in Figure 1 and the diagnostic plots assessing the fit of the models are in Figure 2.

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for gag grouper. Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	3.636				
YEAR	3.1437	13.540	13.540	164.11	<.0001
YEAR+					
SETDEPTH	1.718	52.759	39.219	417.26	<.0001
SEASON	3.0833	15.201		26.68	<.0001
HOOKTYPE	3.1116	14.422		34.17	<.0001
SETBEGIN	3.1519	13.314		7.06	0.0699
YEAR+SETDEPTH+					
SEASON	1.721	52.668	-0.091	4.20	0.240
HOOKTYPE	1.6237	55.344		The negative of the Hessian is not positive definite.	
MIXED MODEL	**AIC**				
YEAR+SETDEPTH	**52.6**				
YEAR+SETDEPTH YEAR*SETDEPTH	89.2				
Proportion positive-Lognormal error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	2.2162				
YEAR	0.9818	55.699	55.699	732.27	<.0001
YEAR+					
HOOKTYPE	0.9102	58.930	3.231	74.56	<.0001
SETBEGIN	0.9726	56.114		11.43	0.0096
SETDEPTH	0.9736	56.069		9.46	0.0088
SEASON	0.976	55.961		8.26	0.041
YEAR+HOOKTYPE+					
SEASON	0.8861	60.017	1.087	27.02	<.0001
SETDEPTH	0.8959	59.575		16.17	0.0003
SETBEGIN	0.9016	59.318		11.54	0.0091
MIXED MODEL	**AIC**				
YEAR+HOOKTYPE+ SEASON	2447.7				
YEAR+HOOKTYPE+ SEASON YEAR*HOOKTYPE	**2393.8**				
YEAR+HOOKTYPE+ SEASON YEAR*SEASON	2417.7				

Table 2. The standardized and nominal index of absolute abundance, and coefficients of variation (CV) for gag grouper. N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
2006	228	0.012	1.55	0.014	1.38
2007	363	0.033	0.52	0.035	0.49
2008	273	0.046	0.90	0.059	0.71
2009	737	0.024	0.57	0.010	1.35
2010	531	0.231	0.19	0.204	0.22
2011	225	0.150	0.34	0.152	0.33
2012	560	0.374	0.14	0.392	0.13

Table 3. Frequency of observations by factor and level used in the development of the standardized catch rate series.

FACTOR	LEVEL	FREQUENCY OF TOTAL
Year	2006	7.8
	2007	12.4
	2008	9.4
	2009	25.3
	2010	18.2
	2011	7.7
	2012	19.2
Time of Day	Dawn	41.8
	Day	44.0
	Dusk	12.5
	Night	1.7
Season	Fall	22.2
	Spring	34.4
	Summer	14.3
	Winter	29.1
Hook Type	C10	0.5
	C11	0.3
	C12	4.7
	C13	45.9
	C14	32.3
	C15	4.3
	C6	0.2
	C9	0.8
	OTHER	10.9
Set Depth	0-100	41.8
	100-200	44.0
	200-300	12.5
	300>	1.7

Figure 1. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for gag grouper. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index.

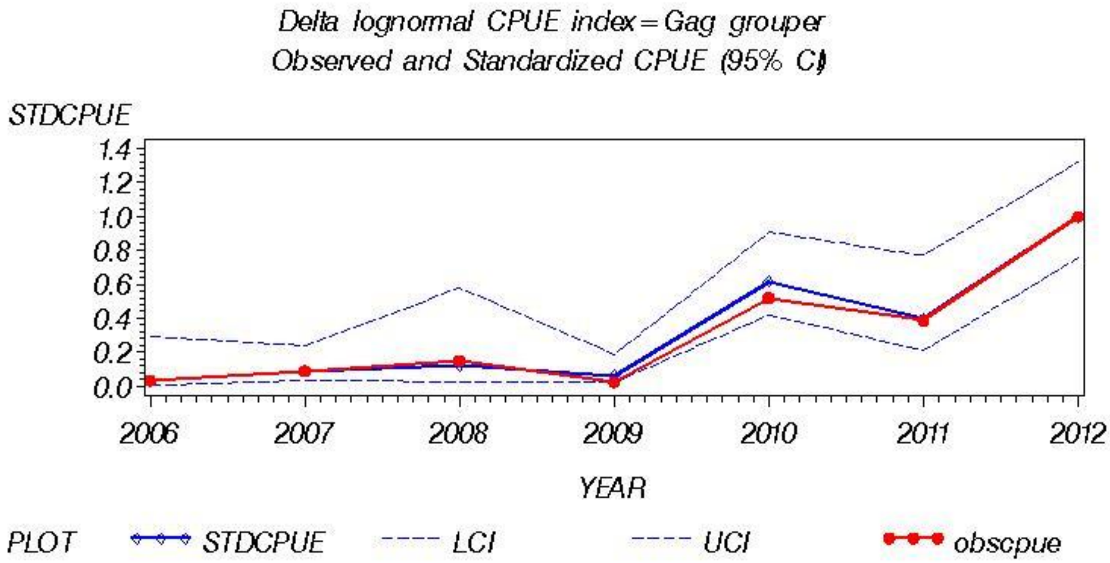
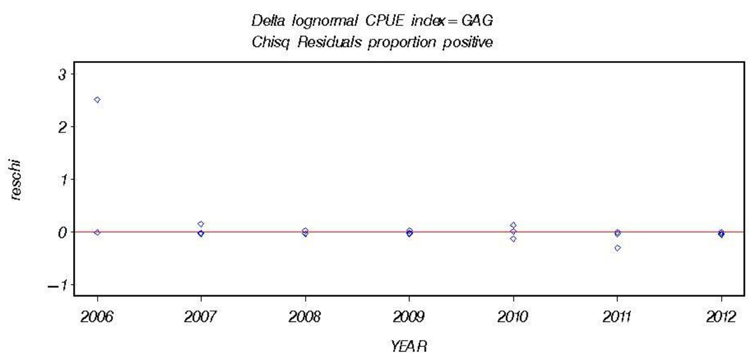
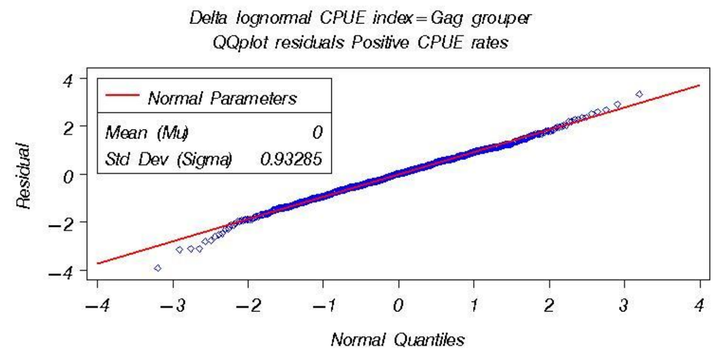
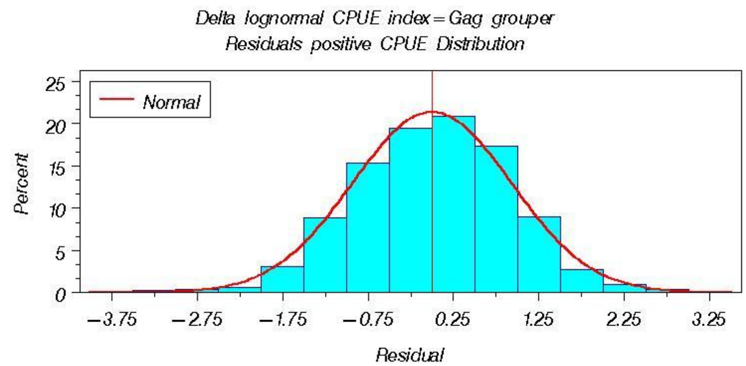
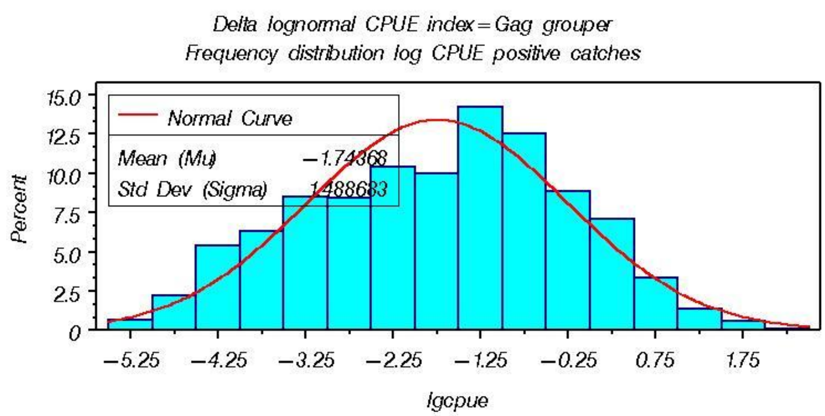


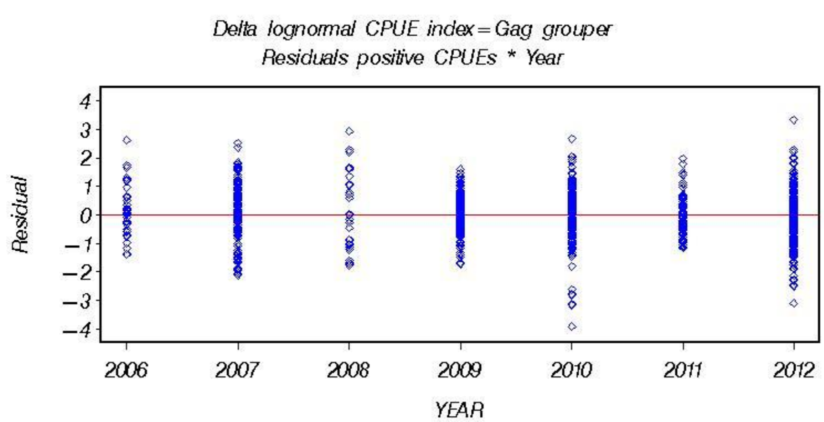
Figure 3. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year for gag grouper analysis.




Delta lognormal CPUE index=Gag grouper
QQplot residuals Positive CPUE rates
Normal Parameters
Mean (Mu) 0
Std Dev (Sigma) 0.93285
Residual
Normal Quantiles


Delta lognormal CPUE index=Gag grouper
Residuals positive CPUE Distribution
Normal
Percent
Residual


Delta lognormal CPUE index=Gag grouper
Frequency distribution log CPUE positive catches
Normal Curve
Mean (Mu) -1.74368
Std Dev (Sigma) 1.488683
Percent
lgcpue


Delta lognormal CPUE index=Gag grouper
Residuals positive CPUEs * Year
Residual
YEAR

Greater amberjack

The final bottom longline dataset analyzed contained 2917 sets. Of those sets, greater amberjack were reported caught on 11.5% of sets. The stepwise construction of the model is summarized in Table 3 and the index statistics can be found in Table 4. The standardized abundance index is shown in Figure 3 and the diagnostic plots assessing the fit of the models were deemed acceptable (Figure 4).

Table 3. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for greater amberjack. Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	2.263				
YEAR	1.835	18.920	18.920	137.32	<.0001
YEAR+					
SETDEPTH	1.648	27.187	8.267	59.03	<.0001
SETBEGIN	1.712	24.364		40.74	<.0001
SEASON	1.750	22.676		29.81	<.0001
HOOKTYPE	1.819	19.631		Negative of Hessian not positive definite	
YEAR+SETDEPTH+					
SETBEGIN	1.535	32.198	5.011	37.03	<.0001
SEASON	1.622	28.323		12.2	0.0067
YEAR+SETDEPTH+SETBEGIN					
SEASON	1.502	33.616	1.418	13.58	0.004
MIXED MODEL	**AIC**				
YEAR+SETDEPTH+SETBEGIN+SEASON	588.6				
YEAR+SETDEPTH+SETBEGIN+SEASON YEAR*SETDEPTH	600.3				
YEAR+SETDEPTH+SETBEGIN+SEASON YEAR*SETBEGIN	588.6				
YEAR+SETDEPTH+SETBEGIN+SEASON YEAR*SEASON	**584.5**				

Proportion positive-Lognormal error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	1.560				
YEAR	1.059	32.134	32.134	135.55	<.0001
YEAR+					
HOOKTYPE	0.802	48.567	16.433	96.71	<.0001
SETBEGIN	1.047	32.904		6.88	0.0757
SETDEPTH	1.049	32.763		6.18	0.103
SEASON	1.051	32.596		5.35	0.148
MIXED MODEL	**AIC**				
YEAR+HOOKTYPE	885.8				
YEAR+HOOKTYPE YEAR*HOOKTYPE	**882.7**				

Table 4. The standardized and nominal index of absolute abundance, and coefficients of variation (CV) for greater amberjack. N = number of sets.

YEAR	**N**	**ABSOLUTE STANDARDIZED INDEX**	**CV**	**ABSOLUTE NOMINAL INDEX**	**CV**
2006	228	0.005	1.48	0.002	3.40
2007	363	0.012	0.77	0.009	1.00
2008	273	0.025	0.51	0.084	0.15
2009	737	0.005	1.13	0.006	0.97
2010	531	0.009	1.03	0.012	0.78
2011	225	0.062	0.65	0.051	0.79
2012	560	0.026	0.64	0.015	1.07

Figure 3. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for greater amberjack. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index.

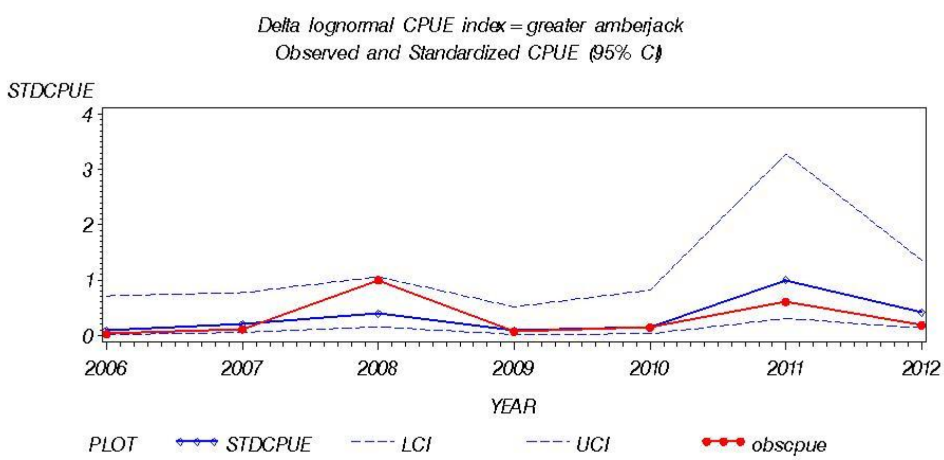
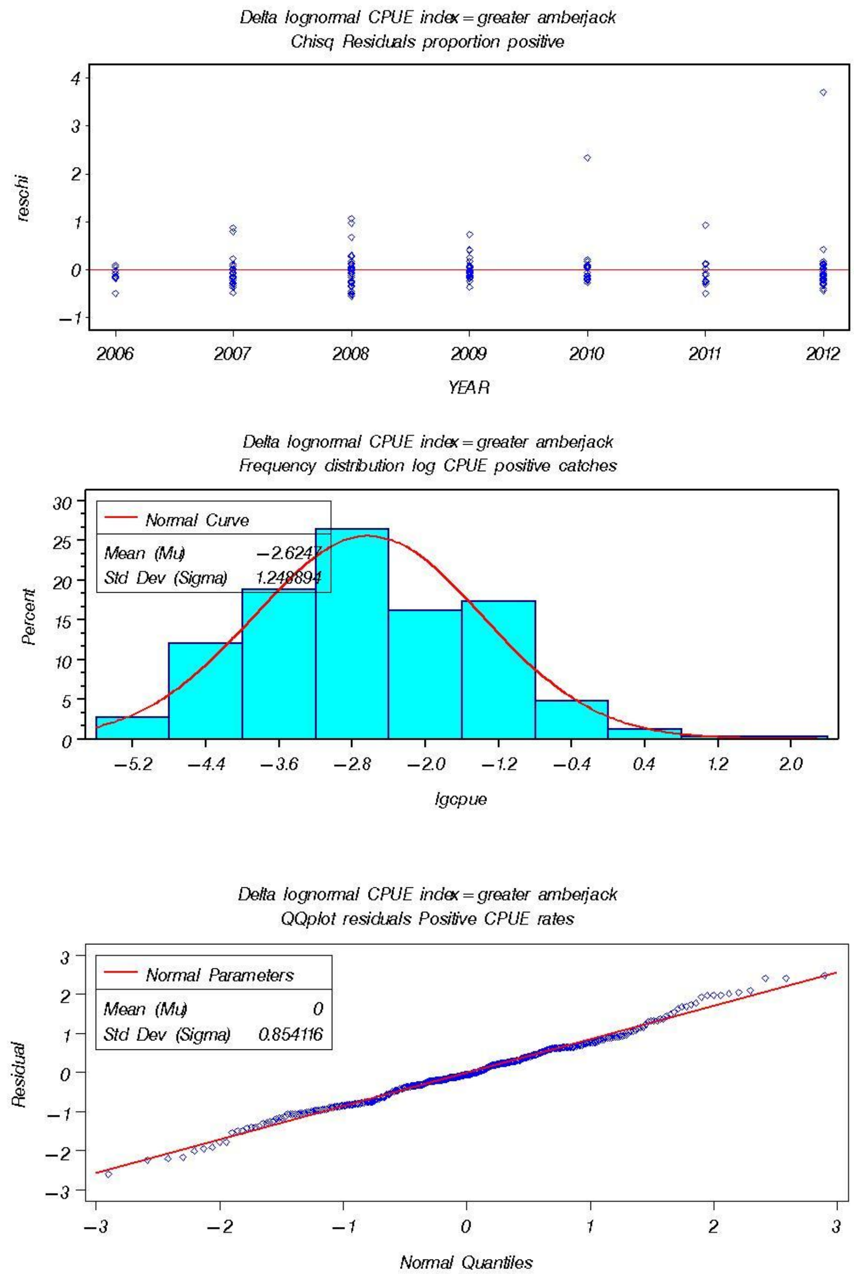
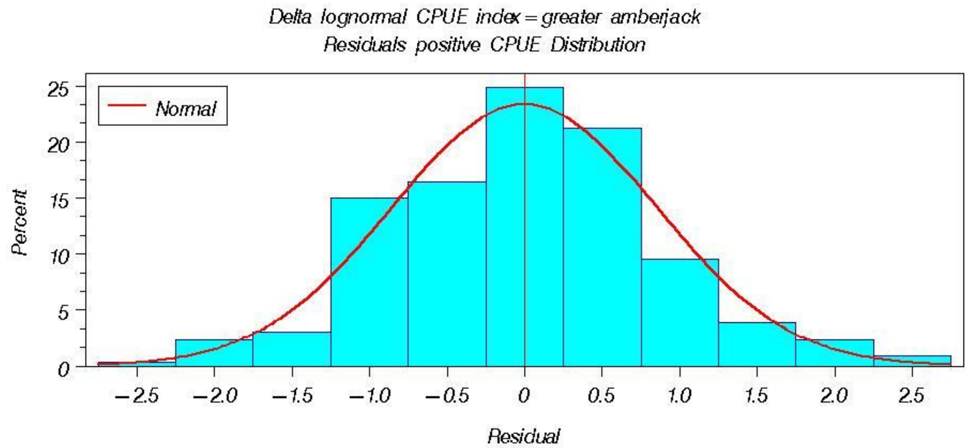
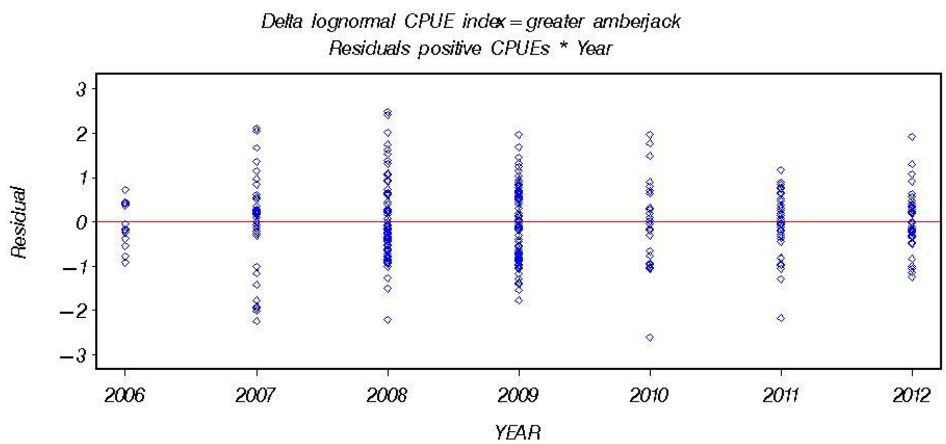


Figure 4. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year for greater amberjack analysis.





Delta lognormal CPUE index = greater amberjack
Residuals positive CPUE Distribution
Normal
Percent
0
5
10
15
20
25
−2.5
−2.0
−1.5
−1.0
−0.5
0
0.5
1.0
1.5
2.0
2.5
Residual



Delta lognormal CPUE index = greater amberjack
Residuals positive CPUEs * Year
Residual
3
2
1
0
−1
−2
−3
2006
2007
2008
2009
2010
2011
2012
YEAR