SEDAR 21 DATA WORKSHOP DOCUMENT

Standardized catch rates sandbar and blacknose sharks from the GADNR COASTSPAN and red drum longline surveys

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Summary

This document details the shark catches from the Georgia Department of Natural Resources (GADNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Georgia's estuarine waters from 2000-2009 and the GADNR adult red drum survey conducted in Georgia's estuarine and nearshore waters from 2007-2009. Catch per unit effort (CPUE) in number of sharks per hook hour for GA COASTSPAN longline sets and in number of sharks per number of hooks for the GADNR red drum sets were used to examine blacknose and/or sandbar shark relative abundance in Georgia's coastal waters. The CPUE was standardized using a two-step delta-lognormal approach originally proposed by Lo et al (1992) that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. Sandbar sharks from the GADNR COASTSPAN survey showed a fairly stable trend in relative abundance throughout the time series. Blacknose and sandbar sharks from the GADNR red drum survey also showed a relatively stable trend during the three year time frame this survey has been in existence.

Introduction

Prior to 1998, Georgia's only sources of data relative to shark species were anecdotal accounts from fishermen, the State's recreation fishing records, and any incidental bycatch reports that identified sharks captured during various projects conducted by Georgia's Department of Natural Resources. In 1998 the Northeast Fisheries Science Center, Apex Predators Program began the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program funded through the Highly Migratory Species Management Division's Office of Sustainable Fisheries. This program funded a pilot study through Savannah State University to determine the presence/absence of juvenile sharks in Georgia's estuarine waters. In 2000, the University of Georgia in cooperation with the Georgia Department of Natural Resources (GADNR) developed a coastal shark survey in Georgia's estuarine waters as part of the COASTSPAN program. In addition to the estuarine COASTSPAN survey, the GADNR red drum survey provides information on shark catches in Georgia's nearshore waters. In 2006 a pilot study to work out the logistics of the GADNR adult red drum longline survey was conducted. The survey design was finalized and sampling began in 2007.

Methods

Sampling Gear and Data Collection

<u>GA COASTSPAN survey</u>

The Georgia Cooperative Atlantic States Shark Pupping and Nursery (GA COASTSPAN) survey was conducted in St Andrews and St Simons Sounds from 2000 to 2009 and was restricted to inshore areas. Each of these sound systems were sampled during two days of each month from mid April through the end of September and five random bottom longline sets were conducted during each of the days sampling occurred. The mainline consisted of 305 m (1000 ft) of 0.64 cm (1/4 in) braided nylon mainline, and 50 gangions comprised of 12/0 Mustad circle hooks with barbs depressed, 50 cm of 1/16 stainless cable, and 100 cm (39 in) of 0.64 cm (1/4 inch) braided nylon line with 4/0 longline snaps. In 2008 and 2009 gangions were modified to consist of a 200lb monofilament leader attached to a 12/0 Mustad circle hook, with barbs depressed. This transition occurred in stages throughout the sampling seasons and gear comparisons were conducted to determine if this change affected catch rates. Based on a Wilcoxon Signed-rank test at an alpha = 0.5, there were no significant differences in catch rates between the mono and wire leaders for sandbar sharks (n=19, p=0.1098). Each set contained hooks baited with either squid or a combination of hooks baited with squid and hooks baited with fish. The 50 gangions were placed along the mainline in 4.5 - 6.1 m intervals. Longline soak time varied between 30 and 60 minutes.

GADNR red drum survey

A stratified random sampling approach was used to select sampling locations. General sampling sites were selected based on scientific expertise and known historical areas of high abundance. Strata are defined spatially and temporally. There are two spatial strata: nearshore waters and offshore artificial reefs. Temporal stratification proportionally allocates effort between the nearshore and offshore areas over the duration of the sampling season and mirrors the offshore migration of the adult red drum. Starting in September 75% of the effort is focused in the nearshore waters and 25% is focused in the offshore. In October the allocation shifts to 50% nearshore and 50% offshore. In November the shift becomes 25% / 75%, ending at 0% / 100% in December. Sampling units are defined as 0.5 by 0.5 nautical mile quadrats which overlay the sampling area described above. A total of 35 stations are selected each month; 25 stations in waters off Georgia, 10 stations off northeast Florida (Figure 2). The mainline for the GADNR red drum survey is approximately 926 m in length consisting of 3.0 mm (273 kg) monofilament, containing 60 gangions. Gangions are 0.7 m of 1.6 mm (91 kg) monofilament terminating in either a 12/0 or 15/0 circle hook with the barb depressed. Hook type is equally represented during a set. Each set contained a combination of hooks baited with squid and hooks baited with fish. Soak times were 30 minutes in duration, measured from second anchor deployed to first anchor retrieved.

For both gear types the station location, water and air temperatures, depth, salinity, and time of day were recorded for each set. The sex, weight, fork length, total length, and umbilical scar condition of all sharks were recorded. Umbilical scar condition was recorded in six categories: “umbilical remains,” “fresh open,” “partially healed,” “mostly healed,” “well healed,” and none. Sharks were then tagged with a NMFS blue rototag in the first dorsal fin or a steel tipped dart tag (M-tag) and released.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per hook hour for GA COASTSPAN longline sets and in number of sharks per number of hooks for the GADNR red drum sets was used to examine the relative abundance of blacknose and/or sandbar sharks in Georgia’s coastal waters. The CPUEs were standardized using the Lo et al. (2002) method which models the proportion of positive sets separately from the positive catch. This analysis was done for the following dependent variables: GA COASTSPAN sandbar shark CPUE, GADNR red drum sandbar shark CPUE and GADNR red drum blacknose shark CPUE. After initial exploratory analysis, factors considered as potential influences on the GA COASTSPAN sets were: year (2000 – 2009), month (April – September), temperature (<20 deg C, 20-24 deg C, 25-29 deg C, 30+ deg C), salinity (<20 ppt, 20-24 ppt, 25-29 ppt, 30+ ppt), depth (<5 m, >5 m) , sound system (St Simons, St Andrew) and bait type (squid, squid and fish) and for GADNR red drum sets were year (2007 – 2009), month (September-November) and depth (0-5 m, 6+ m). The proportion of sets with positive catch values was modeled assuming a binomial distribution with a logit link function and the positive catch sets were modeled assuming a lognormal distribution.

Models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model provided the effect was significant at $\alpha = 0.05$ based on a Chi-Square test, and the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. The factor "year" was kept in all final models, regardless of its significance, to allow for calculation of indices. Single factors were incorporated first, followed by fixed first-level interactions. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were then run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS MIXED procedure (Wolfinger, SAS Institute, Inc), in which all interactions including the "year" factor were treated as a random effect. The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and lognormal components.

Results

GA COASTSPAN survey - sandbar sharks

A total of 276 sandbar sharks were caught during 410 longline sets from 2000 to 2009. The size range of juvenile sandbar sharks caught by year is displayed in Figure 3. The proportion of sets with positive catch (at least one sandbar shark caught) was 40%. The stepwise construction of each model and the resulting statistics for the mixed models are detailed in Table

1. Model diagnostic plots reveal that the model fit is acceptable (Figures 4a and 4b). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Table 2 and are plotted by year in Figure 5.

GADNR red drum survey - sandbar sharks

A total of 41 sandbar sharks were caught during 48 longline sets from 2007 to 2009. The size range of juvenile sandbar sharks caught by year is displayed in Figure 6. The proportion of sets with positive catch (at least one sandbar shark caught) was 25%. The stepwise construction of each model and the resulting statistics for the mixed models are detailed in Table 3. Model diagnostic plots reveal that the model fit may be acceptable, but the histogram for the lognormal model residuals on positive catch rates are not normally distributed (Figures 7a and 7b). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Table 4 and are plotted by year in Figure 8.

GADNR red drum survey - blacknose sharks

A total of 425 blacknose sharks were caught during 48 longline sets from 2007 to 2009. The size range of juvenile sandbar sharks caught by year is displayed in Figure 9. The proportion of sets with positive catch (at least one sandbar shark caught) was 67%. The stepwise construction of each model and the resulting statistics for the mixed models are detailed in Table 5. Model diagnostic plots reveal that the model fit is acceptable (Figures 10a and 10b). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Table 4 and are plotted by year in Figure 11.

References

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (*Thunnus albacares*) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Table 1. Results of the stepwise procedure for development of the catch rate model for sandbar sharks caught during the Georgia COASTSPAN survey. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	406	456.0855	1.1234				
MONTH	401	420.3857	1.0483	6.6851	6.6851	35.70	<.0001
TEMP	403	427.3406	1.0604	5.6080		28.74	<.0001
YEAR	399	440.2658	1.1034	1.7803		15.82	0.0268
DEPTH	404	448.9741	1.1113	1.0771		7.11	0.0286
SALI NITY	403	452.0765	1.1218	0.1424		4.01	0.2605
SYSTEM	405	455.8406	1.1255	-0.1869		0.24	0.6207
BAIT	404	455.9728	1.1286	-0.4629		0.11	0.9452
MONTH +							
YEAR	394	401.7455	1.0294	8.3675	1.6824	18.64	0.0094
DEPTH	399	411.2512	1.0307	8.2517		9.13	0.0104
TEMP	398	414.0236	1.0403	7.3972		6.36	0.0953
MONTH + YEAR							
DEPTH	392	392.0527	1.0001	10.9756	2.6082	9.69	0.0079
TEMP	391	395.0576	1.0104	10.0588		6.69	0.0825
MONTH + YEAR + DEPTH							
YEAR*DEPTH	383	386.4451	1.009	10.1834		5.61	0.7785
YEAR*MONTH	359	347.4286	0.9678	13.8508		Negative of Hessian not positive definite	
MONTH*DEPTH	384	380.5083	0.9909	11.7946		Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR + DEPTH	1722.7	1726.6	1720.7

Type 3 Test of Fixed Effects for Final Model = MONTH + YEAR + DEPTH

Significance (Pr>Chi) of Type 3	MONTH	YEAR	DEPTH
test of fixed effects for each factor	<.0001	0.0265	0.0098
DF	5	7	2
CHI SQUARE	30.69	15.85	9.25

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	100	50.729	0.5957				
YEAR	93	48.4231	0.5207	12.5902	12.5902	20.93	0.0039
MONTH	95	54.4577	0.5732	3.7771		9.07	0.1063
TEMP	97	56.5315	0.5828	2.1655		5.30	0.1514
SYSTEM	99	58.7411	0.5933	0.4029		1.42	0.2328
SALINITY	97	58.6349	0.6045	-1.4773		1.61	0.6580
BAIT	98	59.3316	0.6054	-1.6283		0.41	0.8133
DEPTH	98	59.5378	0.6075	-1.9809		0.06	0.9691

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR	225.1	227.6	223.1

Type 3 Test of Fixed Effects for Final Model = MONTH + YEAR

Significance (Pr>Chi) of Type 3	YEAR
test of fixed effects for each factor	0.7614
DF	7
CHI SQUARE	4.16

Table 2. GA COASTSPAN survey sandbar shark analysis number of sets per year (obs n), number of positive sets per year (obs pos), proportion of positive sets per year (obs ppos), nominal cpue as sharks per hook (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
2000	31	7	0.2258	0.0074	0.0043	0.0002	0.0819	2.7688
2001								
2002								
2003	55	11	0.2000	0.0225	0.0238	0.0051	0.1119	0.9060
2004	38	10	0.2632	0.0255	0.0268	0.0058	0.1232	0.8896
2005	64	6	0.0938	0.0088	0.0083	0.0006	0.1090	2.0618
2006	48	14	0.2917	0.0242	0.0307	0.0086	0.1098	0.7073
2007	56	17	0.3036	0.0487	0.0496	0.0188	0.1312	0.5166
2008	60	16	0.2667	0.0340	0.0432	0.0149	0.1252	0.5722
2009	58	81	0.3621	0.0338	0.0357	0.0129	0.0989	0.5449

Table 3. Results of the stepwise procedure for development of the catch rate model for sandbar sharks caught during the GADNR red drum survey. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	46	53.4018	1.1609				
MONTH	41	38.2973	0.9341	19.5366	19.5366	15.10	0.0099
DEPTH	45	53.2179	1.1826	-1.8692		0.18	0.6681
YEAR	44	53.3233	1.2119	-4.3931		0.08	0.9615
MONTH + YEAR	39	38.2241	0.9801	15.5741	-3.9624	0.07	0.9641

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR	91.1	92.0	89.1

Type 3 Test of Fixed Effects for Final Model = MONTH + YEAR

Significance (Pr>Chi) of Type 3	MONTH	YEAR
test of fixed effects for each factor	0.2124	0.9665
DF	3	2
CHI SQUARE	4.50	0.07

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	11	5.0589	0.4599				
DEPTH	10	4.7866	0.4787	-4.0878		0.66	0.4152
YEAR	9	4.6832	0.5204	-13.1550		0.93	0.6294
MONTH	8	4.1423	0.5178	-12.5897		2.40	0.4938

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR	25.7	25.8	23.7

Type 3 Test of Fixed Effects for Final Model = YEAR

Significance (Pr>Chi) of Type 3	YEAR
test of fixed effects for each factor	0.6970
DF	2
CHI SQUARE	0.72

Table 4. GADNR red drum survey sandbar shark analysis number of sets per year (obs n), number of positive sets per year (obs pos), proportion of positive sets per year (obs ppos), nominal cpue as sharks per hook (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
2007	23	6	0.2609	0.0133	0.0204	0.0074	0.0558	0.5382
2008	12	3	0.2500	0.0181	0.0272	0.0076	0.0980	0.7124
2009	13	3	0.2308	0.0090	0.0159	0.0044	0.0576	0.7153

Table 5. Results of the stepwise procedure for development of the catch rate model for blacknose sharks caught during the GADNR red drum survey. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	46	60.2838	1.3105				
MONTH	41	33.2353	0.8106	38.1457	38.1457	27.05	<.0001
YEAR	44	59.3115	1.3480	-2.8615		0.97	0.6150
DEPTH	45	60.2753	1.3395	-2.2129		0.01	0.9265
MONTH + YEAR	39	29.0002	0.7436	43.2583	5.1126	4.24	0.1203

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR	91.5	92.4	89.5

Type 3 Test of Fixed Effects for Final Model = MONTH + YEAR

Significance (Pr>Chi) of Type 3	MONTH	YEAR
test of fixed effects for each factor	0.0028	0.0365
DF	3	2
CHI SQUARE	14.04	6.62

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	30	34.8072	1.1602				
MONTH	26	26.0903	1.0035	13.5063		8.94	0.0627
DEPTH	29	32.9363	1.1357	2.1117		1.71	0.1906
YEAR	28	34.1637	1.2201	-5.1629		0.58	0.7488

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR	94.0	95.3	92.0

Type 3 Test of Fixed Effects for Final Model = YEAR

Significance (Pr>Chi) of Type 3	YEAR
test of fixed effects for each factor	0.7682
DF	2
CHI SQUARE	0.53

Table 6. GADNR red drum survey blacknose shark analysis number of sets per year (obs n), number of positive sets per year (obs pos), proportion of positive sets per year (obs ppos), nominal cpue as sharks per hook (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
2007	23	14	0.6087	0.0770	0.0644	0.0234	0.1773	0.5410
2008	12	9	0.7500	0.1250	0.1611	0.0688	0.3773	0.4456
2009	13	9	0.6923	0.0936	0.1448	0.0587	0.3573	0.4754

Figure 1. Georgia's coastline with the labeled sound systems. Sampling areas for the 2000-2009 GA COASTSPAN survey were in the St Simons and St. Andrew sound systems.

Figure 2. Sampling areas for the GADNR red drum survey located in southern Georgia and northern Florida.

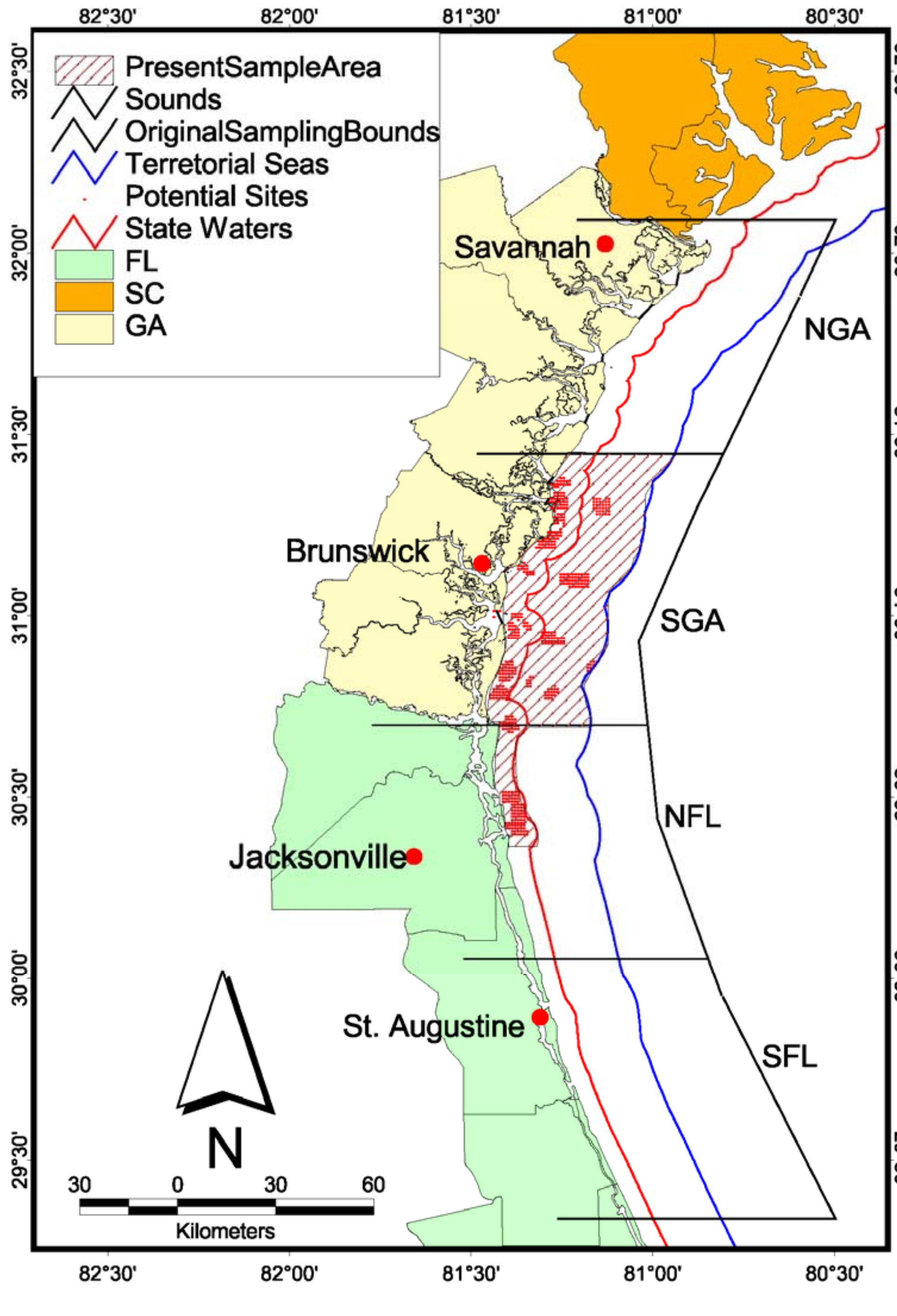


Figure 3. Fork lengths (cm) of sandbar sharks caught during the GA COASTSPAN longline survey from 2000-2009.

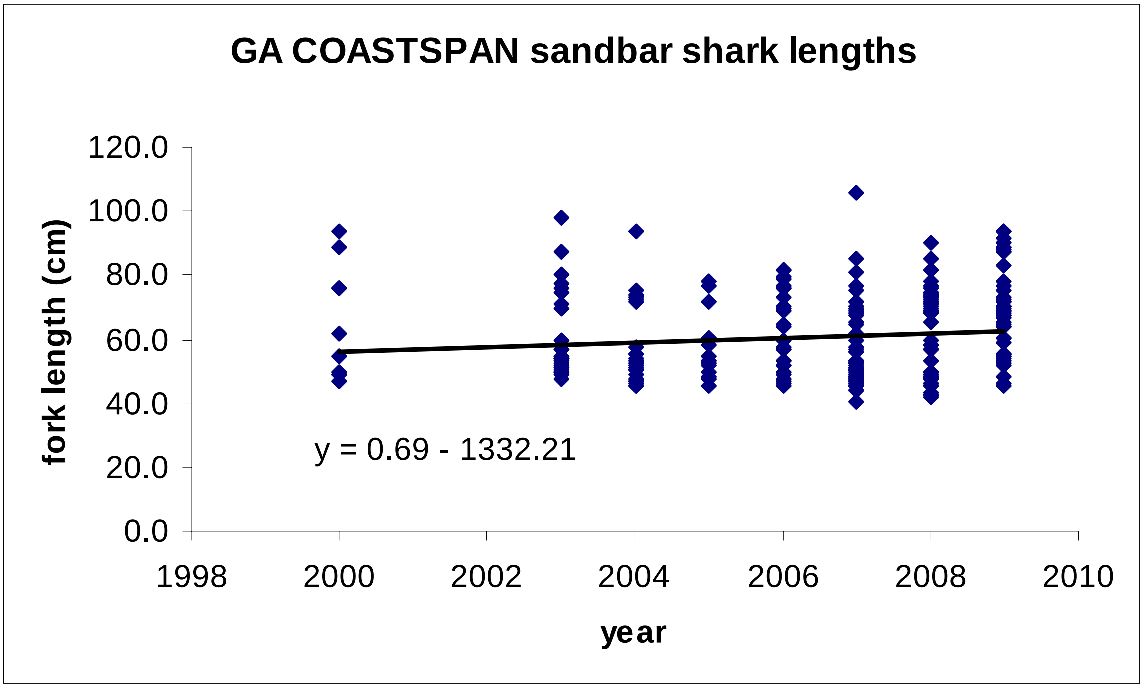


Figure 4a. GA COASTSPAN sandbar shark model diagnostic plots for the binomial component.

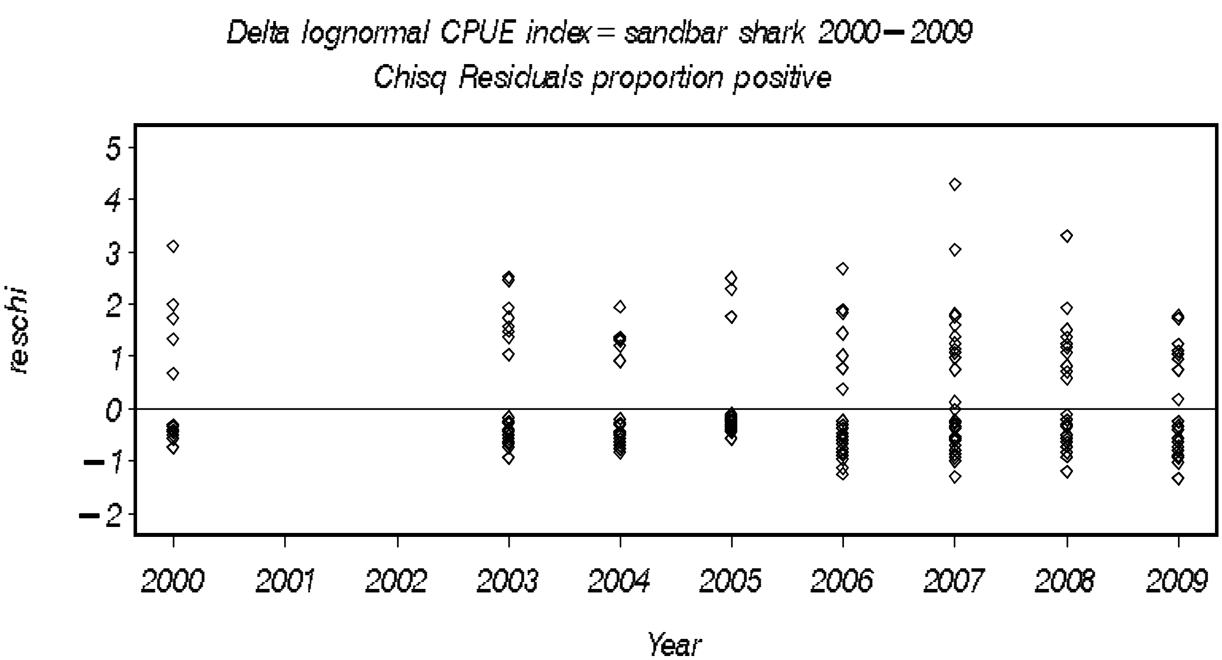
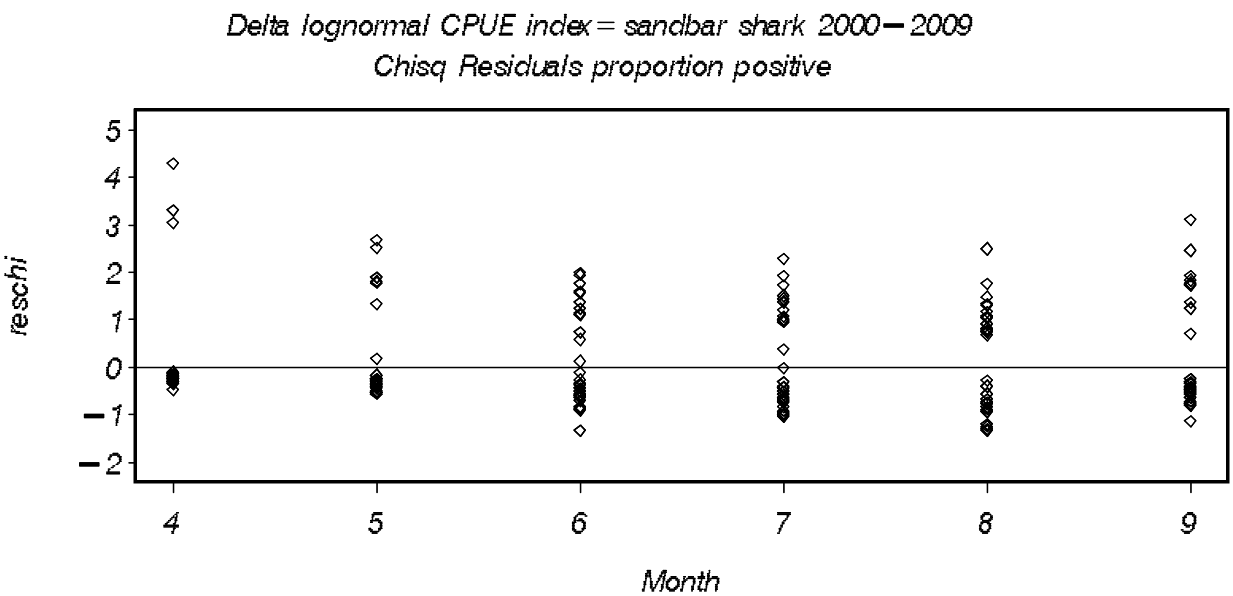


Figure 4a continued. GA COASTSPAN sandbar shark model diagnostic plots for the binomial component.



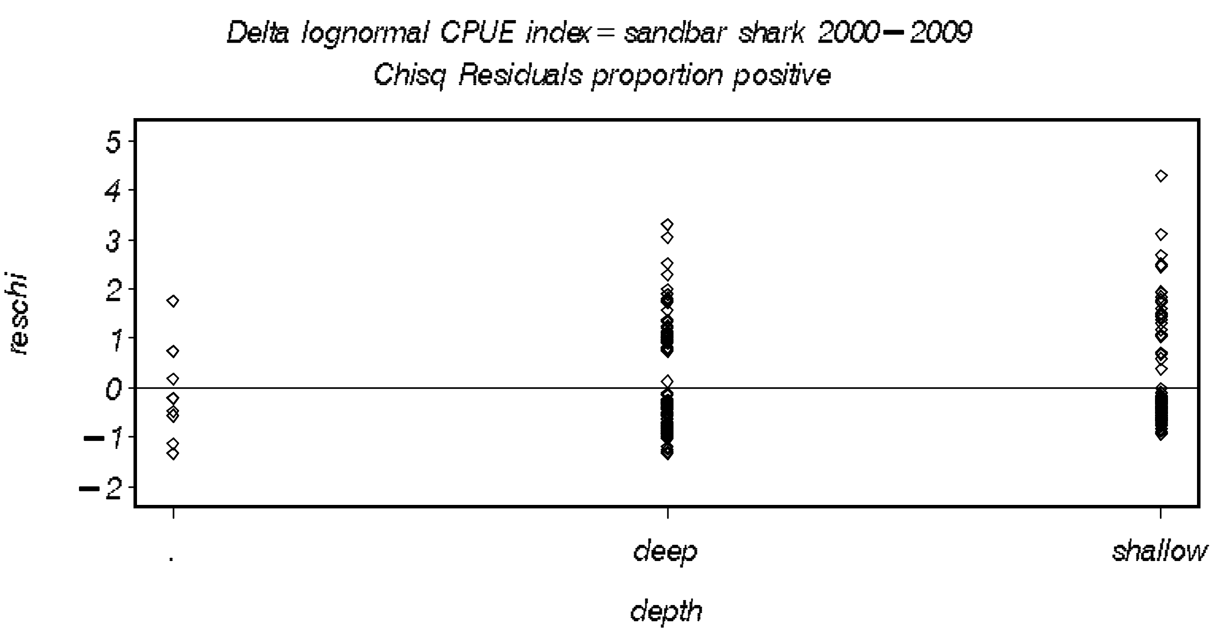


Figure 4a continued. GA COASTSPAN sandbar shark model diagnostic plots for the binomial component.

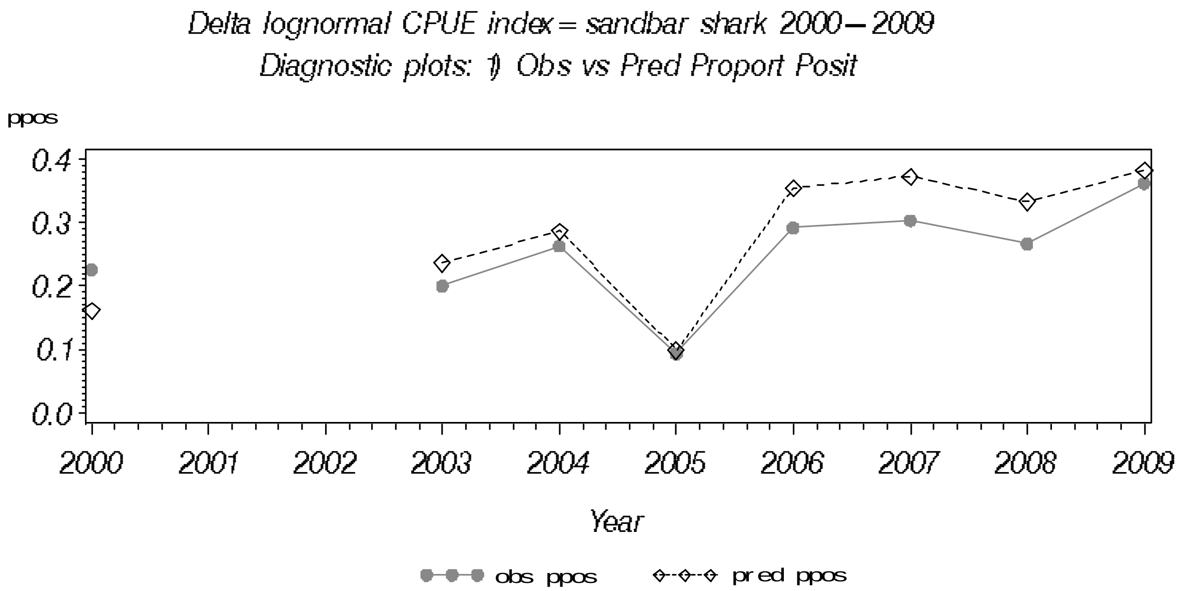


Figure 4b. GA COASTSPAN sandbar shark model diagnostic plots for lognormal component.

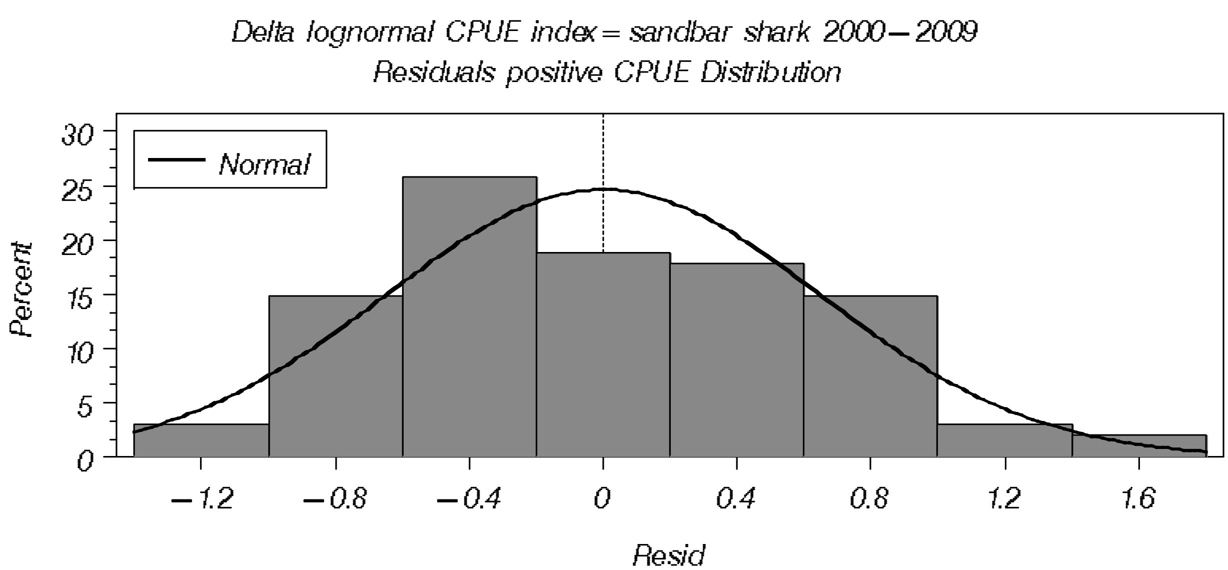
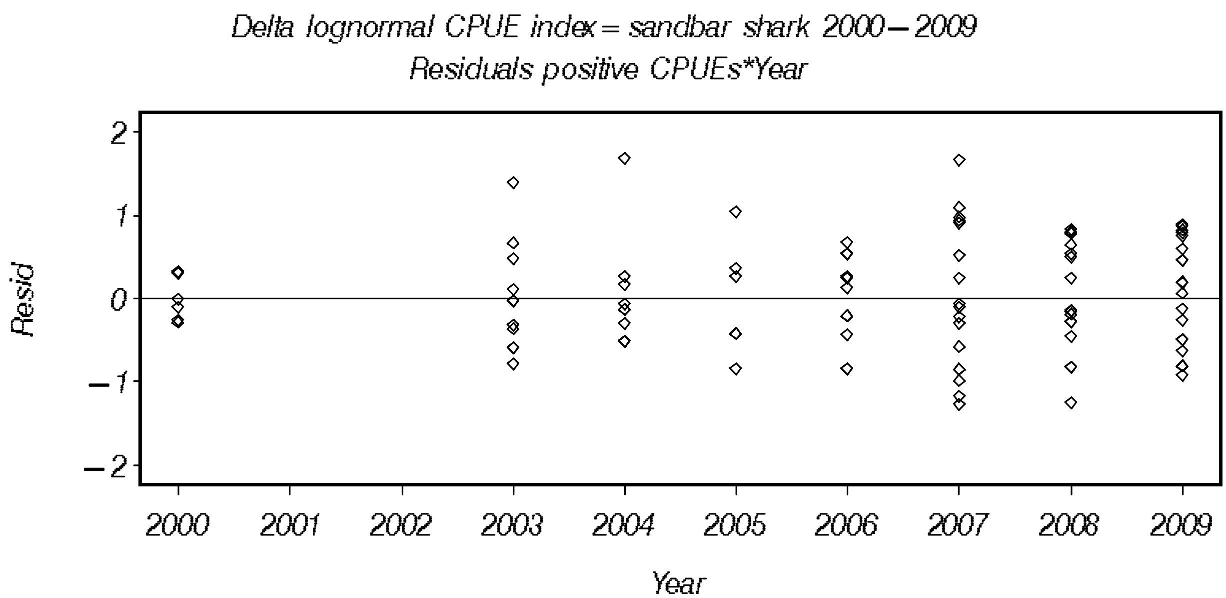


Figure 4b continued. GA COASTSPAN sandbar shark model diagnostic plots for lognormal component.



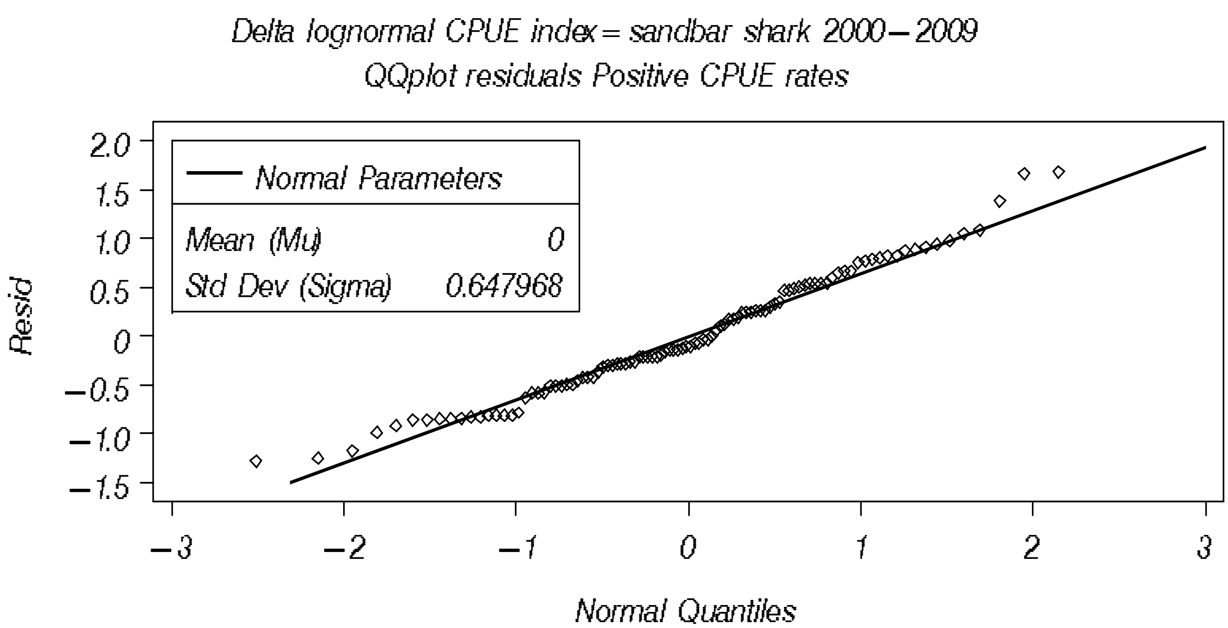


Figure 5. GA COASTSPAN sandbar shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).

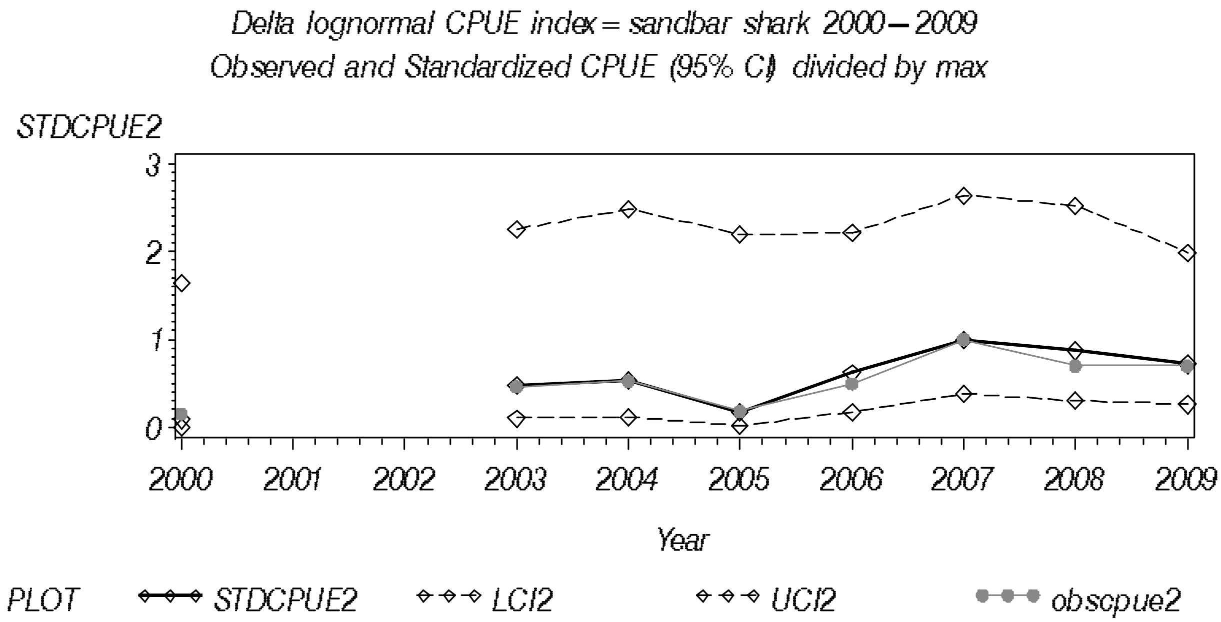


Figure 6. Fork lengths (mm) of sandbar sharks caught during the GADNR red drum survey by year.

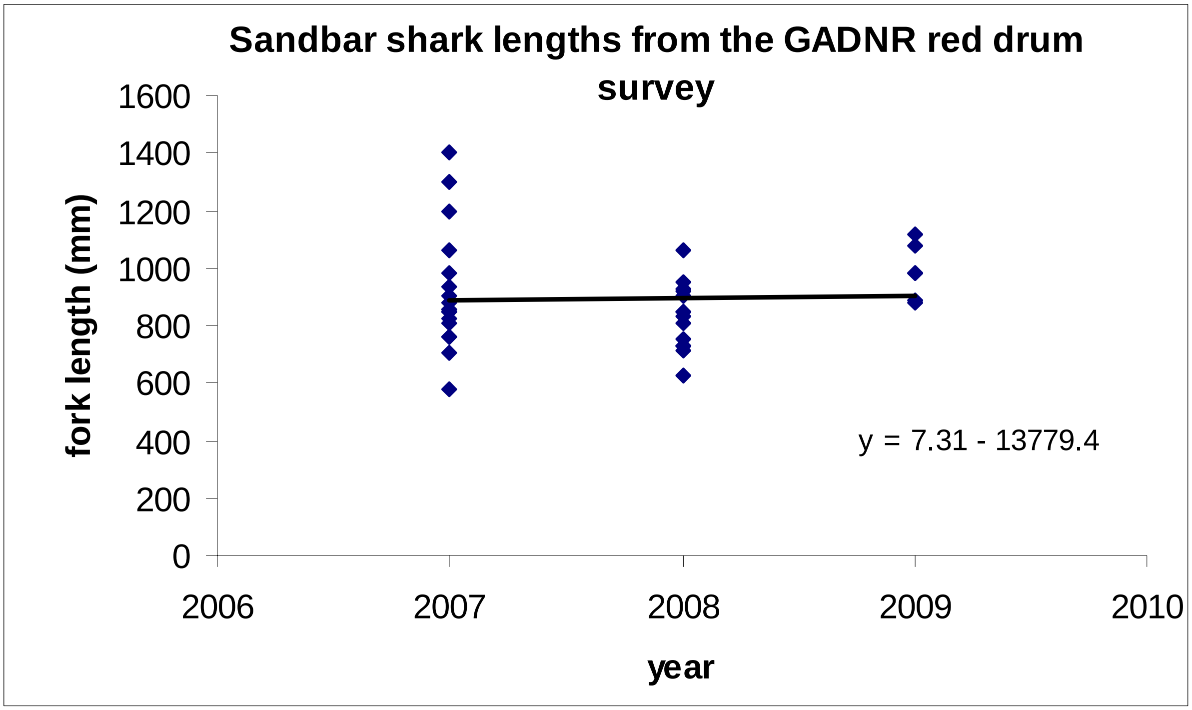
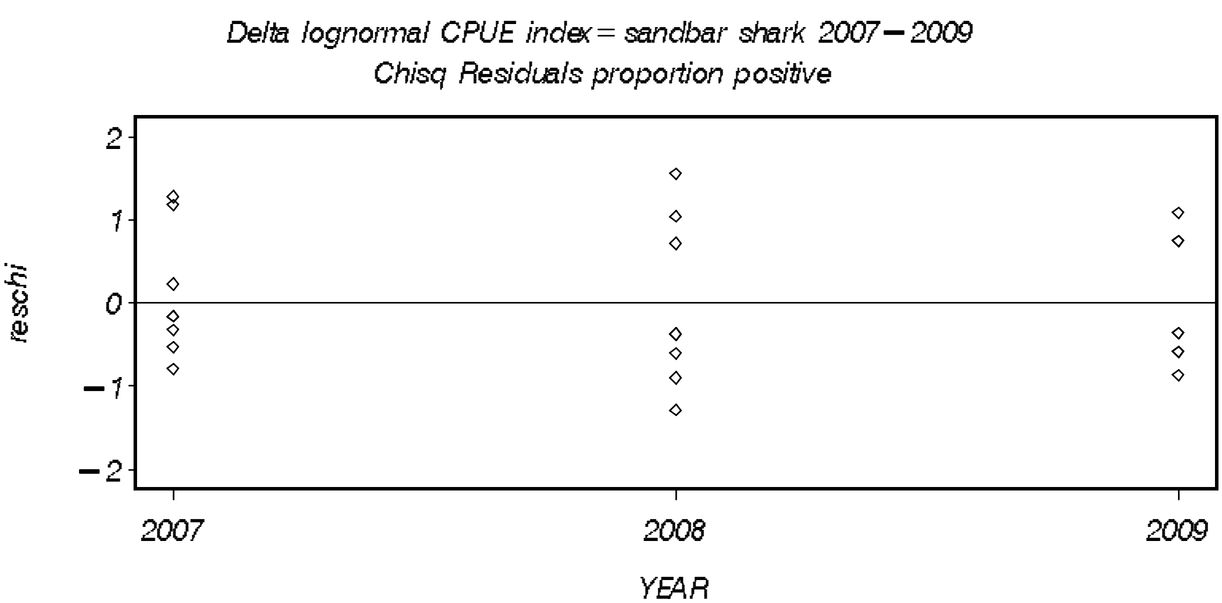


Figure 7a. GADNR red drum survey sandbar shark model diagnostic plots for the binomial component.



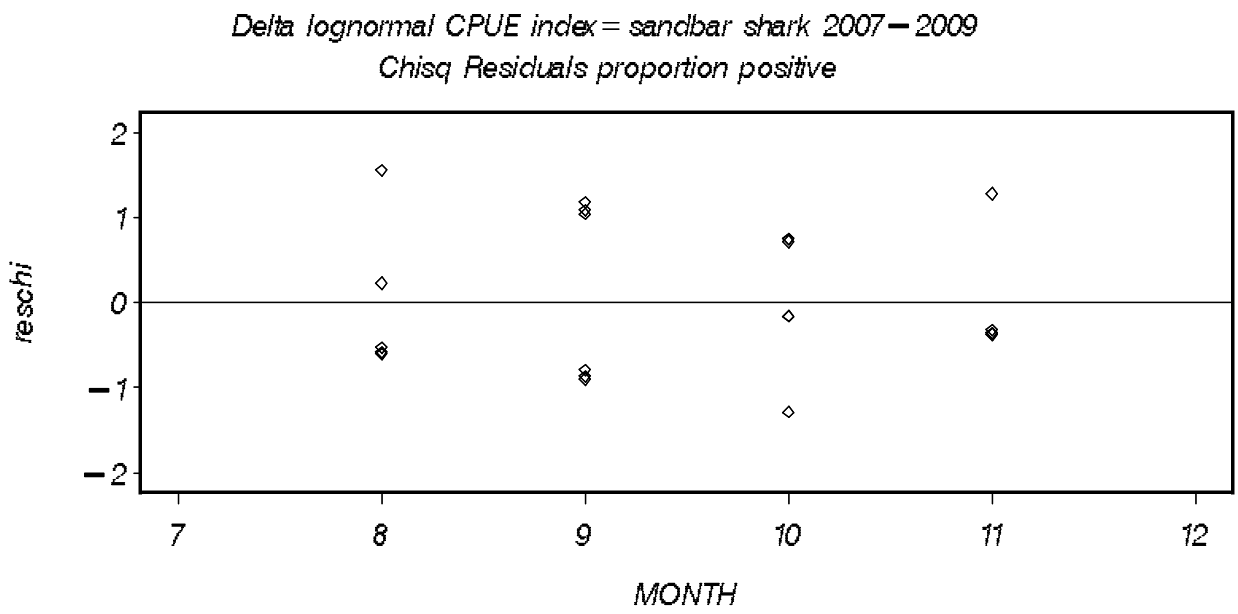


Figure 7a continued. GADNR red drum survey sandbar shark model diagnostic plots for the binomial component.

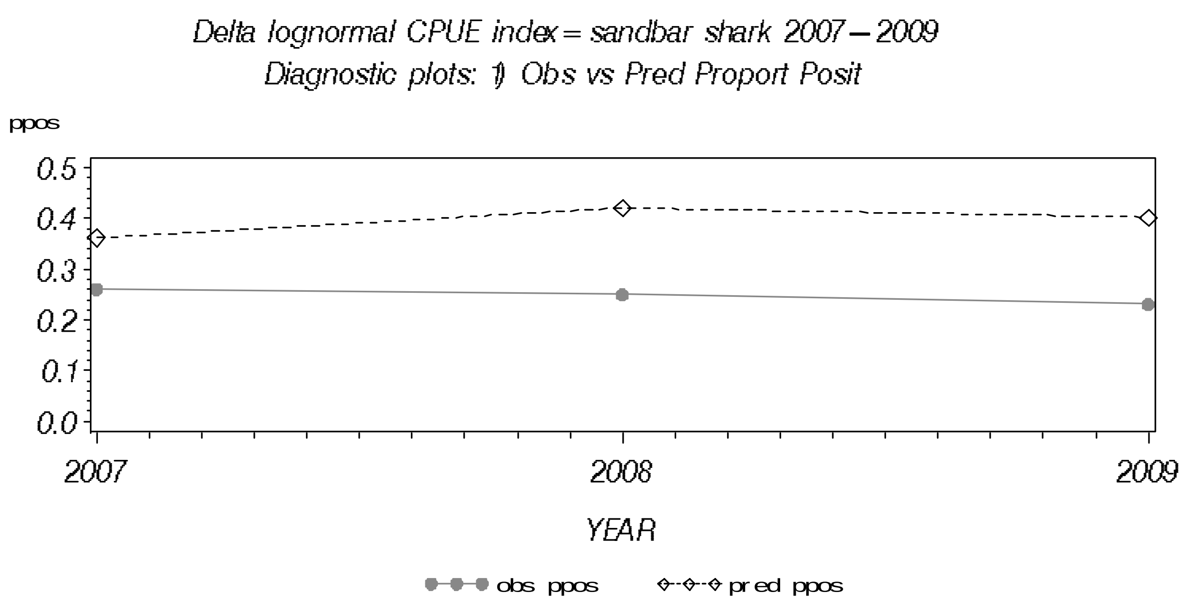


Figure 7b. GADNR red drum survey sandbar shark model diagnostic plots for the lognormal component.

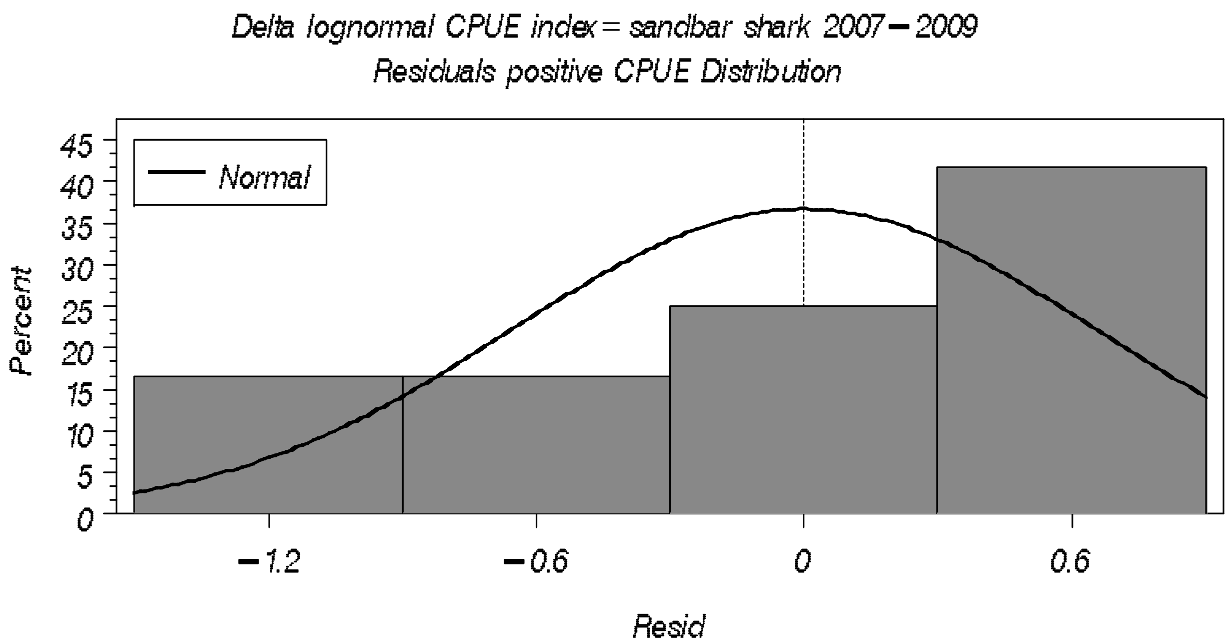
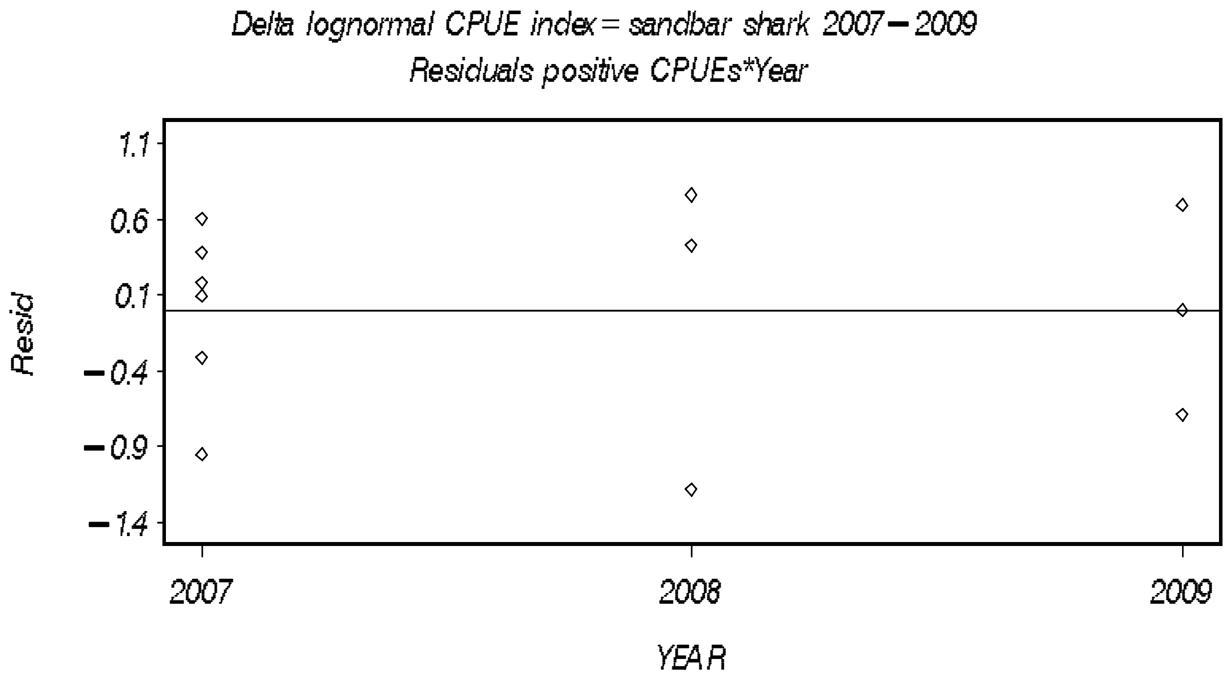


Figure 7b continued. GADNR red drum survey sandbar shark model diagnostic plots for the lognormal component.



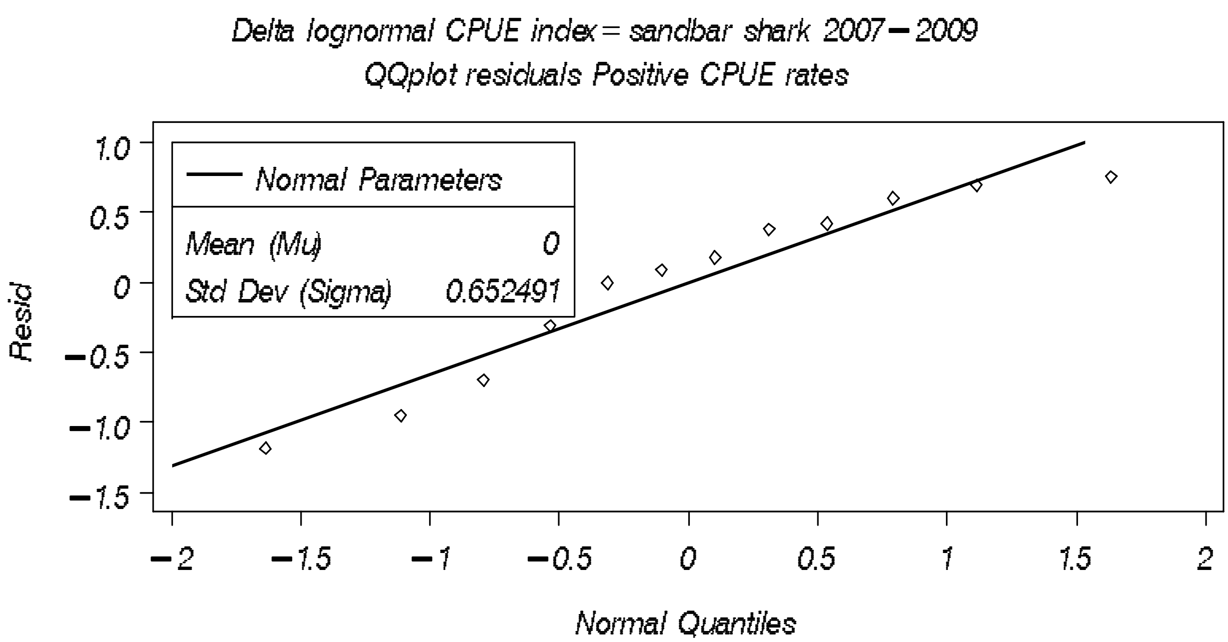


Figure 8. GADNR red drum survey sandbar shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).

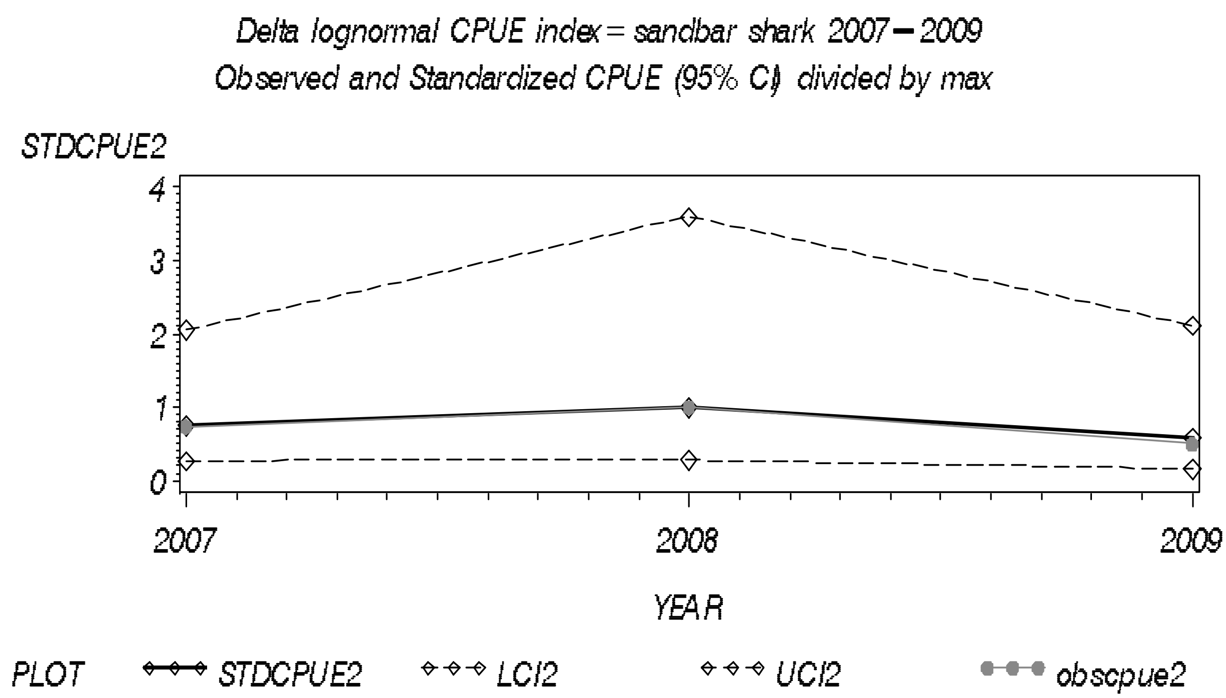


Figure 9. Fork lengths (mm) of blacknose sharks caught during the GADNR red drum survey by year.

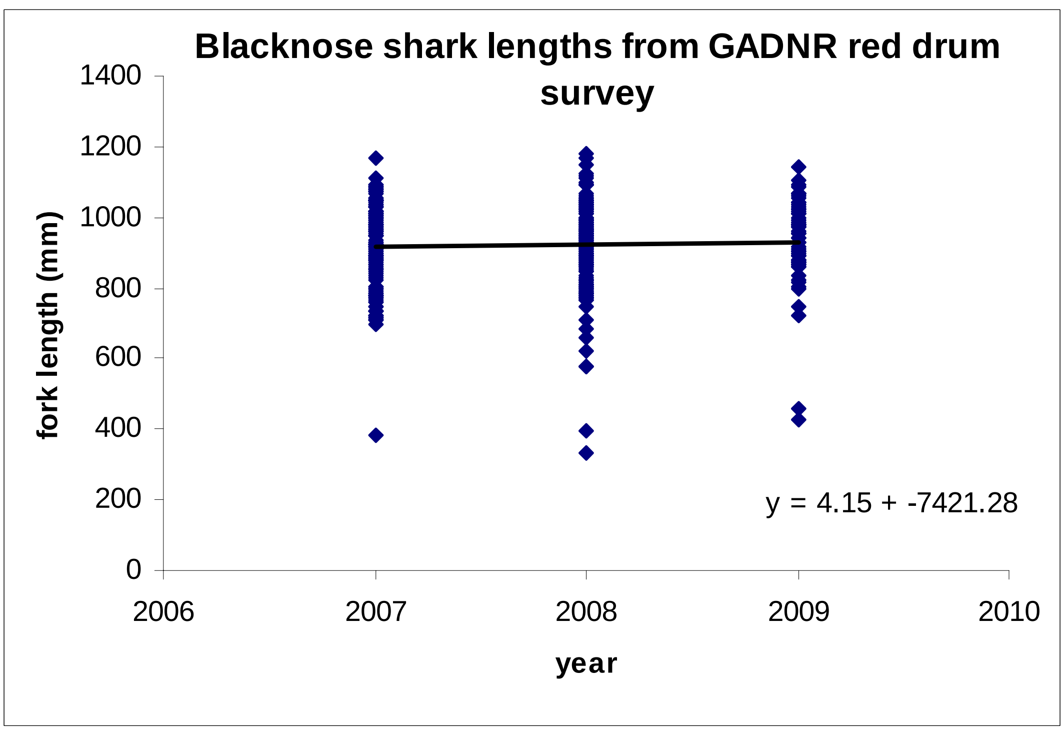
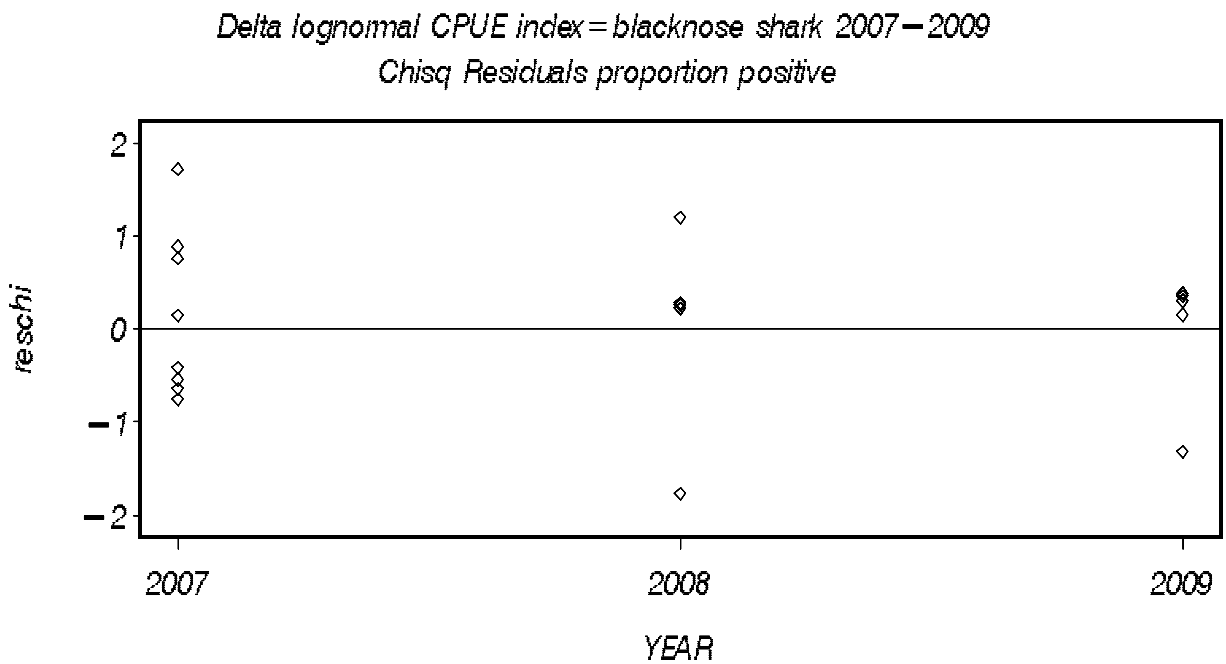


Figure 10a. GADNR red drum survey blacknose shark model diagnostic plots for the binomial component.


Delta lognormal CPUE index=blacknose shark 2007−2009
Chisq Residuals proportion positive
reschi
2
1
0
−1
−2
2007
2008
2009
YEAR

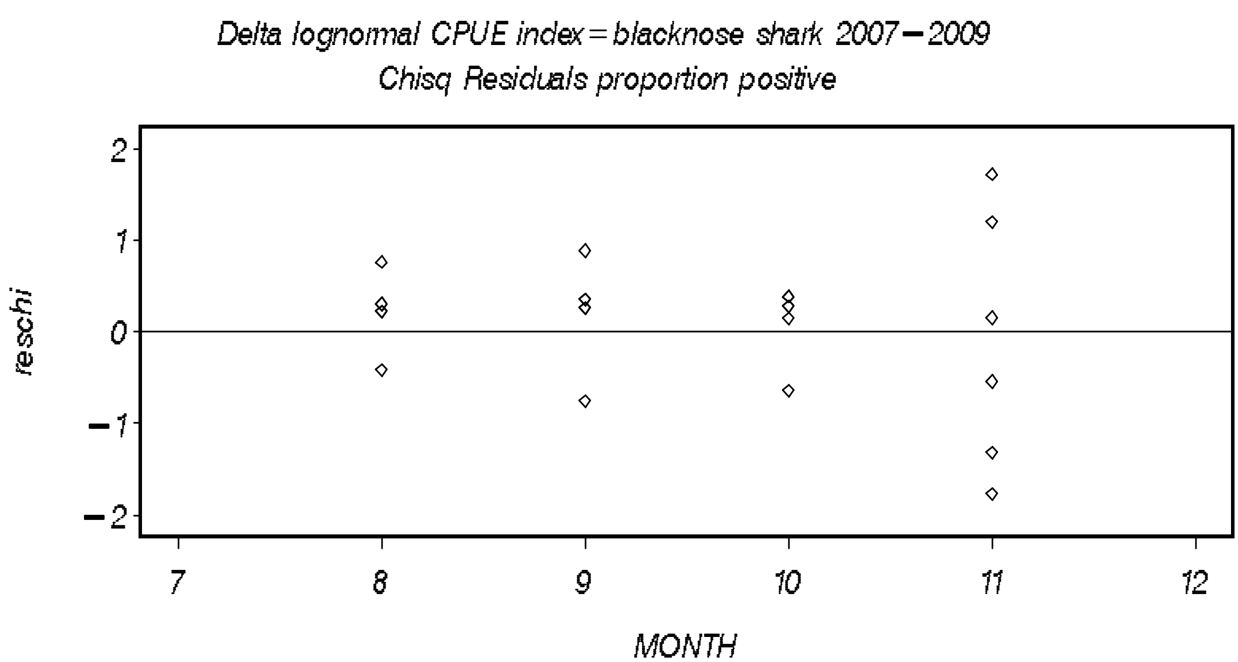

Delta lognormal CPUE index=blacknose shark 2007−2009
Chisq Residuals proportion positive
reschi
2
1
0
−1
−2
7
8
9
10
11
12
MONTH

Figure 10a continued. GADNR red drum survey blacknose shark model diagnostic plots for the binomial component.

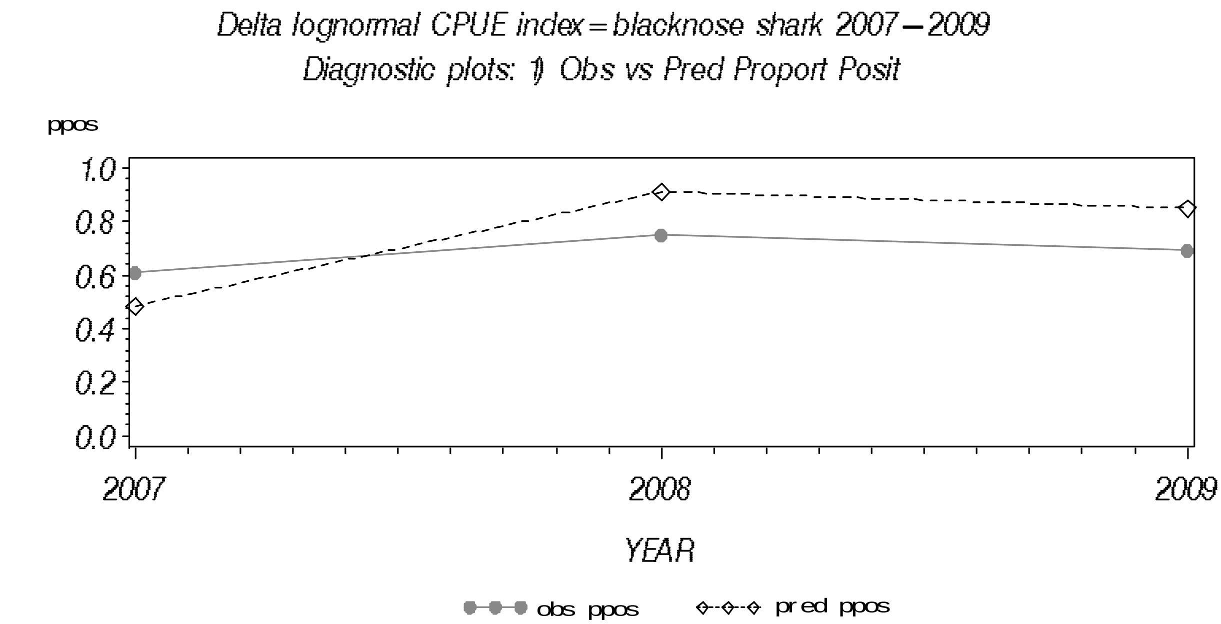


Figure 10b. GADNR red drum survey blacknose shark model diagnostic plots for the lognormal component.

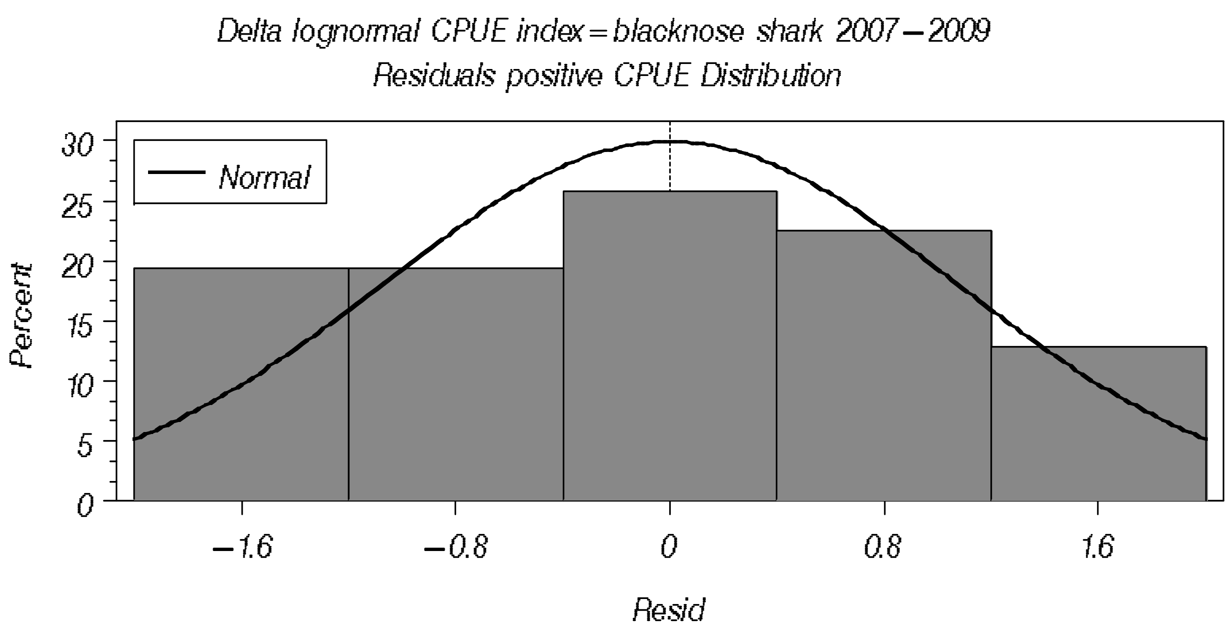
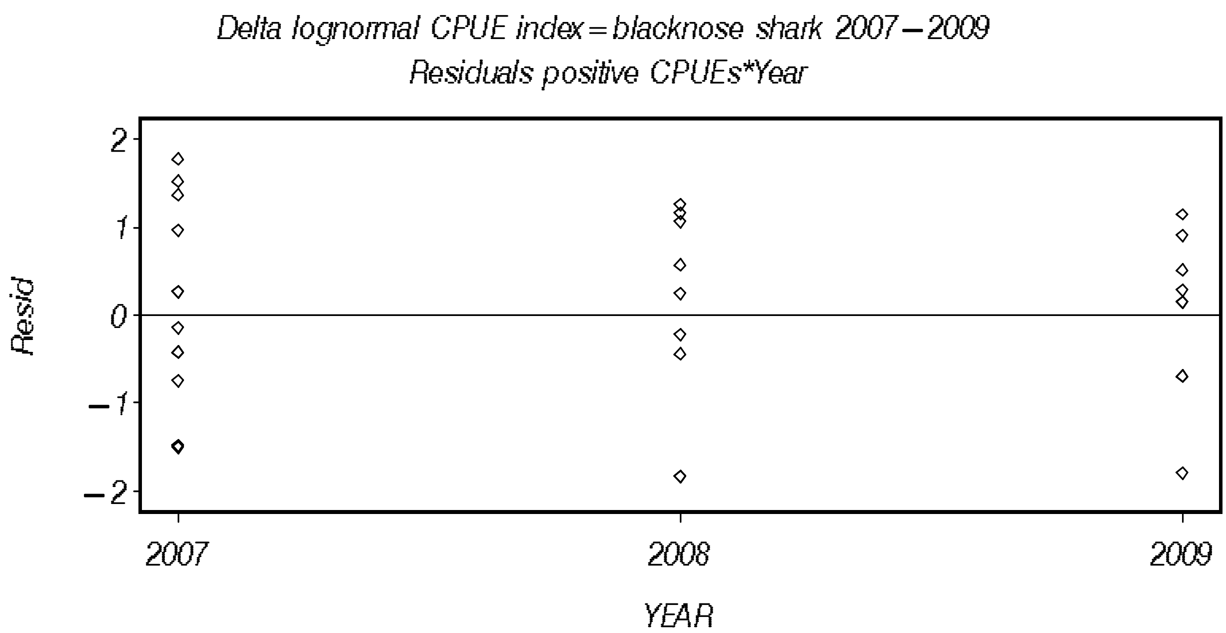


Figure 10b continued. GADNR red drum survey blacknose shark model diagnostic plots for the lognormal component.



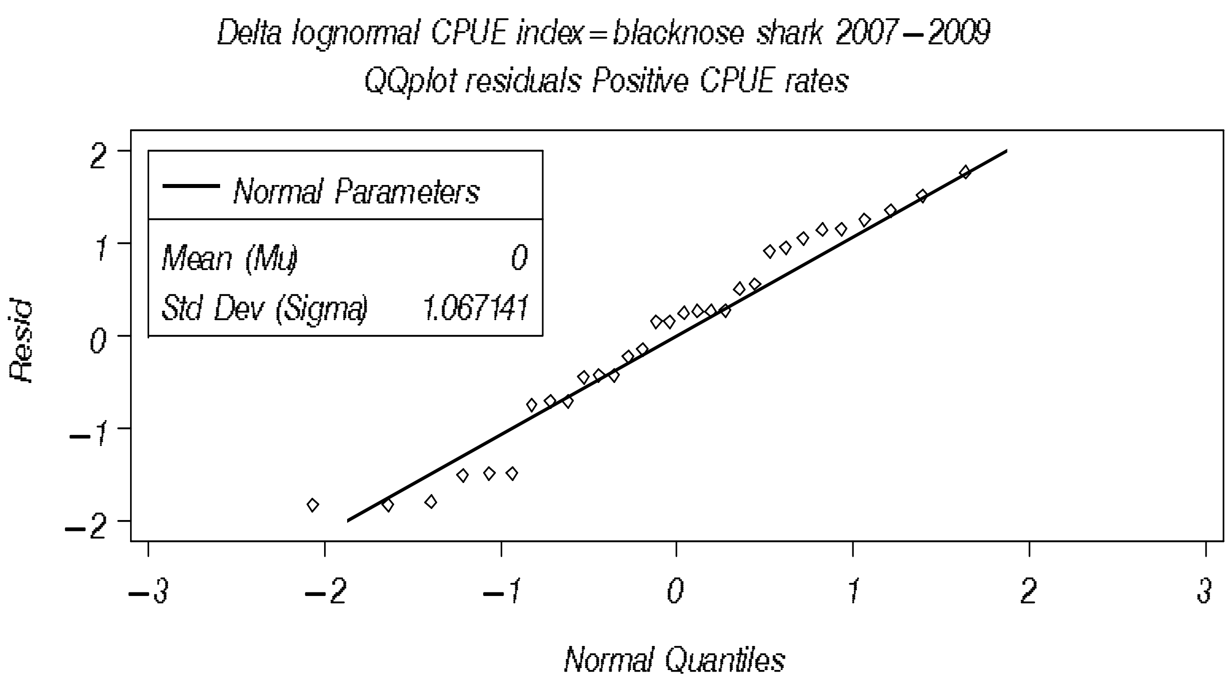


Figure 11. GADNR red drum survey blacknose shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).