SEDAR 21 DATA WORKSHOP DOCUMENT

Standardized catch rates for juvenile sandbar sharks caught during NMFS COASTSPAN longline survey in Delaware Bay

Camilla T. McCandless
NOAA/NMFS
Northeast Fisheries Science Center
Apex Predators Investigation
28 Tarzwell Drive
Narragansett, RI 02882

July 2010

Summary

This document details the young of the year, age 1+ juvenile and the total juvenile sandbar shark catch from the Northeast Fisheries Science Center (NEFSC), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Delaware Bay. Catch per unit effort (CPUE) in number of sharks per 50-hook set per hour was used to examine the relative abundance of juvenile sandbar sharks between the summer nursery seasons from 2001 to 2009. 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. All three juvenile sandbar shark time series showed a fairly stable trend in relative abundance from 2001 to 2005 with only a brief decrease in abundance in 2002, which may be attributed to a large storm (associated with a hurricane offshore) that passed through the Bay that year. This stable trend was followed by a decreasing trend from 2005 to 2008 and ends with an increase in relative abundance in 2009.

Introduction

Delaware Bay is one of the principal pupping and nursery grounds for sandbar sharks, *Carcharhinus plumbeus*, in the east coast waters of the United States. Researchers from the NEFSC Apex Predators Program (APP) have been conducting gillnet and/or longline surveys for juvenile sandbar sharks in Delaware Bay since 1995. In 2001, a juvenile shark bottom longline survey using a random stratified sampling plan based on depth and geographic location was initiated to assess and monitor the juvenile sandbar shark population. Relative abundance indices from this survey have been previously generated for juvenile sandbar sharks covering the time period from 2001 to 2005 (McCandless 2005). In this document, these time series are updated with data through 2009.

Methods

Sampling Gear and Data Collection

A 50-hook bottom longline was used at random stratified sampling stations based on depth and geographic location during the summer months from 2001 to 2009. 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. The 50 gangions were placed along the mainline in 6 m (20 ft) intervals. Longline soak time was approximately 30 minutes. Hooks were baited with thawed Atlantic mackerel, *Scomber scombrus*. The gear was set with weights and/or anchors to maintain position and enough line to account for the depth at the sampling location for attachment to a fluorescent ball buoy and a staff buoy with a fluorescent flag to mark each end of the gear.

Station location, water and air temperatures, depth, salinity, and time of day were recorded for each set. When possible, bottom type was determined by observing bottom sediment on the anchor. The sex, weight, fork length, total length, and umbilical scar condition of all sandbar sharks were recorded. Umbilical scar condition was recorded in six categories: “umbilical remains,” “fresh open,” “partially healed,” “mostly healed,” “well healed,” and none. Sandbar sharks were then tagged with a NMFS blue rototag or a steel tipped dart tag (M-tag) and released.

Sampling Design

A random stratified sampling plan based on depth and geographic location was initiated in July 2001 to assess and monitor the juvenile sandbar shark population in Delaware Bay. The

Bay was split into nine different geographic regions, three across the northern section of the Bay (NW, NC, NE), three across the middle section of the Bay (CW, CC, CE) and three across the southern section of the Bay (SW, SC, SE) (Figure 1). Within each of these regions, different sampling areas were determined based on the mean low water depth strata (0-2 m, 2-5 m, 5-10 m, and 10+ m) located within that region (Figure 1). The geographic regions and depth strata ranges were chosen based on differences seen during sampling for juvenile sandbar sharks in Delaware Bay by the National Marine Fisheries Service from 1995 to 2000. In some locations throughout the Bay where small areas of one depth stratum occur within another, and there is no significant difference between catch rates during historical sampling in these areas, the two areas are combined into one sample area under the larger of the two depth strata. When a depth stratum from one geographic region crosses into another geographic region, but only a very small portion, then that small portion will remain attached to the larger portion in the original geographic region.

Depth data used in this study were derived from a bathymetric digital elevation model (30 m resolution) based on 17 surveys containing 321,774 soundings in Delaware Bay conducted by the National Ocean Service (NOS). The surveys dated from 1945 to 1993. This data was verified and corrected using field observations and a geographically referenced, digital version of the 2000 NOS nautical chart of Delaware Bay (# 12304).

Stations in each depth stratum within the nine geographic regions of the Bay were chosen randomly from a list of every point (latitude, longitude) within that depth stratum in decimal degrees out to four decimal places. A macro was created in Excel that randomly chose a station from these lists of possible station locations for each month sampled. Sampling occurred during a one-week time frame in mid July and early August from 2001 to 2009.

Data Analysis

Log-normal error models have been used to standardize fishery-independent catch rates from shark surveys (Carlson 2001, Simpfendorfer et al. 2002). Currently, there is another approach to modeling catch data that takes into account highly skewed data with many zeros which is commonly seen in marine data (Pennington 1983, 1996). This approach is based on a delta-lognormal model and is a two-step approach that models the zero catch separately from the positive catch, which was originally proposed by Lo et al. (1992) for use in analyzing fish spotter data for northern anchovy, *Engraulis mordax*, from the southern California purse-seine fishery. Carlson (2002) also used this method to conduct a fishery independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. The Lo et al. method for standardizing data can correct the bias that may be introduced into log-normal error models when a significant number of zero catches in the data may cause zero catches with low effort to appear higher

Catch per unit effort (CPUE) in number of sharks per 50-hook set per hour was used to examine the relative abundance of juvenile sandbar sharks in Delaware Bay between the summer nursery seasons from 2001 to 2009 for three dependent variables: total juvenile sandbar shark CPUE, young of the year (YOY) sandbar shark CPUE, and juvenile (age 1+) sandbar shark CPUE. The CPUE was standardized using the Lo et al. (2002) method, which models the proportion of positive sets separately from the positive catch. Factors considered as potential influences on CPUE were: year (2001-2009), month (July and August), depth (0-2, 2-5, 5-10 and 10+ m) and region (NW, NC, NE, CW, CC, CE, SW, SC, SE). 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

Total juvenile sandbar sharks

A total of 1117 juvenile sandbar sharks (including YOY) were caught during 503 longline sets from 2001 to 2009. The size range of juvenile sandbar sharks caught by year is displayed in Figure 2. The proportion of sets with positive catch (at least one sandbar shark caught) was 53%. 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 3a and 3b). 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 4.

Young of the year sandbar sharks

A total of 455 YOY sandbar sharks were caught during 503 longline sets from 2001 to 2009. The size range of YOY sandbar sharks caught by year is displayed in Figure 5. The proportion of sets with positive catch (at least one sandbar shark caught) was 24%. 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 is acceptable (Figures 6a and 6b). 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 7.

Age 1+ sandbar sharks

A total of 661 juvenile sandbar sharks (age 1+) were caught during 503 longline sets from 2001 to 2009. The size range of age 1+ sandbar sharks caught by year is displayed in Figure 8. The proportion of sets with positive catch (at least one sandbar shark caught) was 48%. 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 9a and 9b). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Table 6 and are plotted by year in Figure 10.

References

Carlson, J.K. 2001. A fishery-independent assessment of stock abundance for small coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 01-06. 8pp.

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.

McCandless, C.T. 2005. Relative abundance trends for juvenile sandbar sharks in Delaware Bay from 2001 to 2005. LCS05/06-DW-30-V2. 23 pp.

Pennington, M. 1983. Efficient estimators of abundance for fish and plankton surveys. Biometrics 39:281-286.

Pennington, M. 1996. Estimating the mean and variance from highly skewed marine data. Fish. Bull. 94:498-505.

Simpfendorfer, C.A., R.E. Hueter, U. Bergman, and S.M.H. Connett. 2002. Standardization of catch and effort data in a spatially-structured shark fishery. Fish. Res. 45:129-145.

Table 1. Results of the stepwise procedure for development of the catch rate model for total juvenile sandbar sharks caught during the NMFS 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	502	694.8687	1.3842				
REGION	494	621.3387	1.2578	9.1316	9.1316	73.53	<.0001
YEAR	494	640.4581	1.2965	6.3358		54.41	<.0001
DEPTH	499	686.0867	1.3749	0.6719		8.78	0.0323
MONTH	501	690.4359	1.3781	0.4407		4.43	0.0353
REGION +							
YEAR	486	558.1565	1.1485	17.0279	7.8963	63.18	<.0001
REGION + YEAR							
REGION*YEAR	422	469.6722	1.1130	19.5925	2.5647	Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
REGION + YEAR	2252.6	2256.7	2250.6

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

Significance (Pr>Chi) of Type 3	REGION	YEAR
test of fixed effects for each factor	<.0001	<.0001
DF	8	8
CHI SQUARE	66.61	51.43

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	268	231.8147	0.8650				
YEAR	260	216.0137	0.8308	3.9538	9.5286	18.99	0.0149
REGION	260	219.2055	0.8431	2.5318		15.04	0.0583
DEPTH	265	228.2378	0.8613	0.4277		4.18	0.2424
MONTH	267	231.4727	0.8669	-0.2197		0.40	0.5286

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR	721.7	725.2	719.7

Type 3 Test of Fixed Effects for Final Model = YEAR

Significance (Pr>Chi) of Type 3	YEAR
test of fixed effects for each factor	0.0826
DF	24
CHI SQUARE	34.12

Table 2. Total juvenile 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
2001	56	36	0.6429	4.4286	5.7278	3.6063	9.0972	0.2345
2002	56	21	0.3750	2.3571	2.4572	1.2289	4.9133	0.3571
2003	56	36	0.6429	6.3571	6.1907	3.8978	9.8325	0.2345
2004	56	32	0.5714	5.2507	5.1643	3.0862	8.6418	0.2617
2005	56	31	0.5536	5.7394	5.9995	3.5361	10.1790	0.2690
2006	55	27	0.4909	3.3488	2.9235	1.6101	5.3082	0.3050
2007	56	31	0.5536	2.4211	2.8790	1.6971	4.8842	0.2690
2008	56	11	0.1964	1.0111	0.9009	0.3411	2.3795	0.5157
2009	56	44	0.7857	7.8322	8.2684	5.6866	12.0222	0.1888

Table 3. Results of the stepwise procedure for development of the catch rate model for young of the year sandbar sharks caught during the NMFS 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	502	559.5862	1.1147				
REGION	494	489.1254	0.9901	11.1779	11.1779	70.46	<.0001
DEPTH	499	528.4931	1.0591	4.9879		31.09	<.0001
YEAR	494	537.3809	1.0878	2.4132		22.21	0.0045
MONTH	501	559.2901	1.1163	-0.1435		0.30	0.5864
REGION +							
DEPTH	491	461.3810	0.9397	15.6993	4.5214	27.74	<.0001
YEAR	486	464.8390	0.9565	14.1922		24.29	0.0021
REGION + DEPTH							
YEAR	483	434.8187	0.9002	19.2428	3.5436	26.56	0.0008
REGION + DEPTH + YEAR +							
REGION*YEAR	419	350.4950	0.8365	24.9574	5.7145	Negative of Hessian not positive definite	
REGION*DEPTH	467	398.8012	0.8540	23.3875		Negative of Hessian not positive definite	
DEPTH*YEAR	459	411.9007	0.8974	19.4940		Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
REGION + DEPTH + YEAR	2303.5	2307.6	2301.5

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

Significance (Pr>Chi) of Type 3	REGION	DEPTH	YEAR
test of fixed effects for each factor	<.0001	<.0001	0.0253
DF	7	3	8
CHI SQUARE	33.60	24.84	17.50

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	122	126.8550	1.0398				
YEAR	114	110.8375	0.9723	6.4916	3.9538	16.60	0.0345
REGION	115	112.0488	0.9743	6.2993		15.27	0.0327
DEPTH	119	123.1011	1.0345	0.5097		3.69	0.2964
MONTH	121	126.6134	1.0464	-0.6347		0.23	0.6282
YEAR +							
REGION	107	95.9016	0.8963	13.8007	7.3091	17.80	0.0129
YEAR + REGION +							
YEAR*REGION	73	52.5032	0.7192	30.8329	17.0321	74.10	<.0001

MIXED MODELS	AIC	BIC	(-2) Res Log Likelihood
YEAR + REGION	330.9	333.6	328.9
*YEAR + REGION + YEAR*REGION*	*222.0*	*224.3*	*220.0*

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

Significance (Pr>Chi) of Type 3	YEAR	REGION	YEAR*REGION
test of fixed effects for each factor	0.0002	0.0010	0.0036
DF	8	7	34
CHI SQUARE	30.23	24.31	60.34

Table 4. Young of the year 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
2001	56	17	0.3036	1.3214	3.2400	1.7900	5.8649	0.3034
2002	56	12	0.2143	1.1786	0.9271	0.4645	1.8504	0.3561
2003	56	19	0.3393	3.2500	2.9196	1.7556	4.8553	0.2585
2004	56	15	0.2679	1.7822	2.8208	1.3779	5.7747	0.3700
2005	56	17	0.3036	2.4217	3.0284	1.7428	5.2624	0.2816
2006	55	13	0.2364	1.2298	0.9556	0.4969	1.8378	0.3359
2007	56	10	0.1786	0.7161	0.5964	0.2825	1.2588	0.3869
2008	56	3	0.0536	0.4863	0.5618	0.1444	2.1860	0.7658
2009	56	17	0.3036	3.4340	4.5242	2.3721	8.6286	0.3314

Table 5. Results of the stepwise procedure for development of the catch rate model for juvenile sandbar sharks (age 1+) caught during the NMFS 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	502	696.4291	1.3873				
REGION	494	633.4754	1.2823	7.5687	7.5687	62.95	<.0001
YEAR	494	644.8611	1.3054	5.9036		51.57	<.0001
MONTH	501	689.4903	1.3762	0.8001		6.94	0.0084
DEPTH	499	691.9207	1.3866	0.0505		4.51	0.2115
REGION + YEAR	486	574.6436	1.1824	14.7697	7.2010	58.83	<.0001
REGION + YEAR REGION*YEAR	422	493.8113	1.1702	15.6491	0.8794	Negative of Hessian not positive definite	

FINAL MODEL	**AIC**	**BIC**	**(-2) Res Log Likelihood**
REGION + YEAR	2236.9	2241.0	2234.9

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

Significance (Pr>Chi) of Type 3	REGION	YEAR
test of fixed effects for each factor	<.0001	<.0001
DF	8	8
CHI SQUARE	57.76	48.85

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQ**	**PR>CHI**
NULL	240	154.5920	0.6441				
YEAR	232	146.1700	0.6300	2.1891	9.5286	13.50	0.0958
REGION	232	150.2762	0.6477	-0.5589		6.82	0.5558
DEPTH	237	154.4875	0.6518	-1.1955		0.16	0.9833
MONTH	239	154.2421	0.6454	-0.2018		0.55	0.4600

FINAL MODEL	**AIC**	**BIC**	**(-2) Res Log Likelihood**
YEAR	582.2	585.6	580.2

Type 3 Test of Fixed Effects for Final Model = YEAR

Significance (Pr>Chi) of Type 3	YEAR
test of fixed effects for each factor	0.0998
DF	8
CHI SQUARE	13.37

Table 6. Juvenile sandbar shark (age 1+) 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
2001	56	34	0.6071	3.1071	3.6544	2.3319	5.7268	0.2275
2002	56	15	0.2679	1.1786	1.2643	0.5739	2.7850	0.4108
2003	56	32	0.5714	3.0714	3.4478	2.1442	5.5438	0.2409
2004	56	28	0.5000	3.5042	3.4316	2.0180	5.8352	0.2702
2005	56	30	0.5357	3.2819	3.5605	2.1550	5.8826	0.2551
2006	55	24	0.4364	2.1191	1.8436	1.0092	3.3678	0.3082
2007	56	26	0.4643	1.7051	1.9247	1.0976	3.3748	0.2864
2008	56	11	0.1964	0.5248	0.5959	0.2363	1.5025	0.4883
2009	56	41	0.7321	4.3982	4.7730	3.2936	6.9168	0.1871

Figure 1: Bathymetric map of Delaware Bay showing the nine geographic regions and the four depth strata used during this study

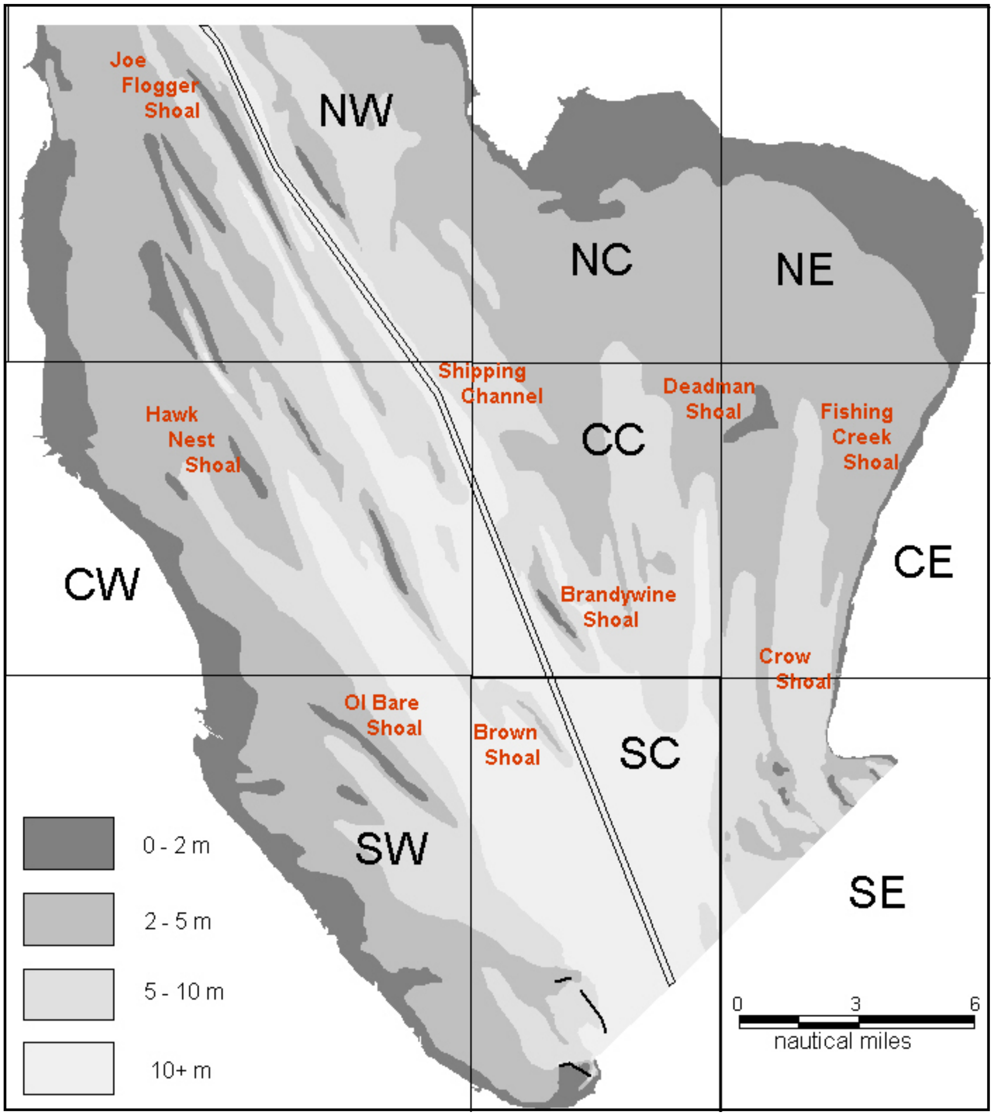


Figure 2. Fork lengths (cm) of total juvenile sandbar sharks caught by year

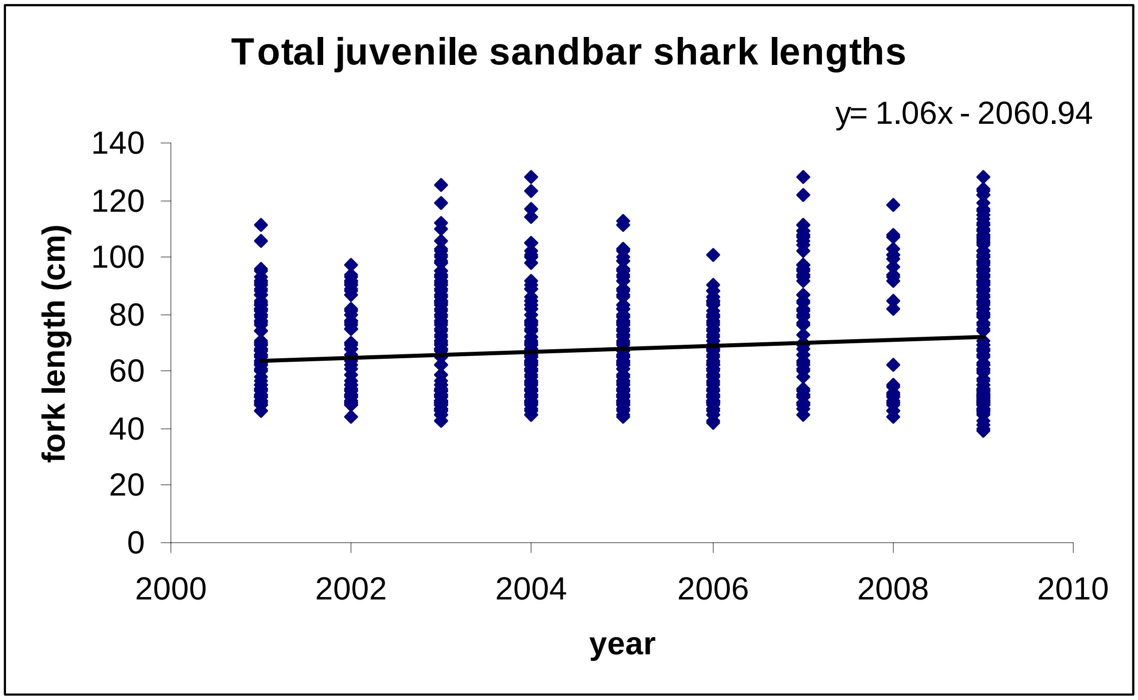


Figure 3a. Total juvenile sandbar shark model diagnostic plots for the binomial component.

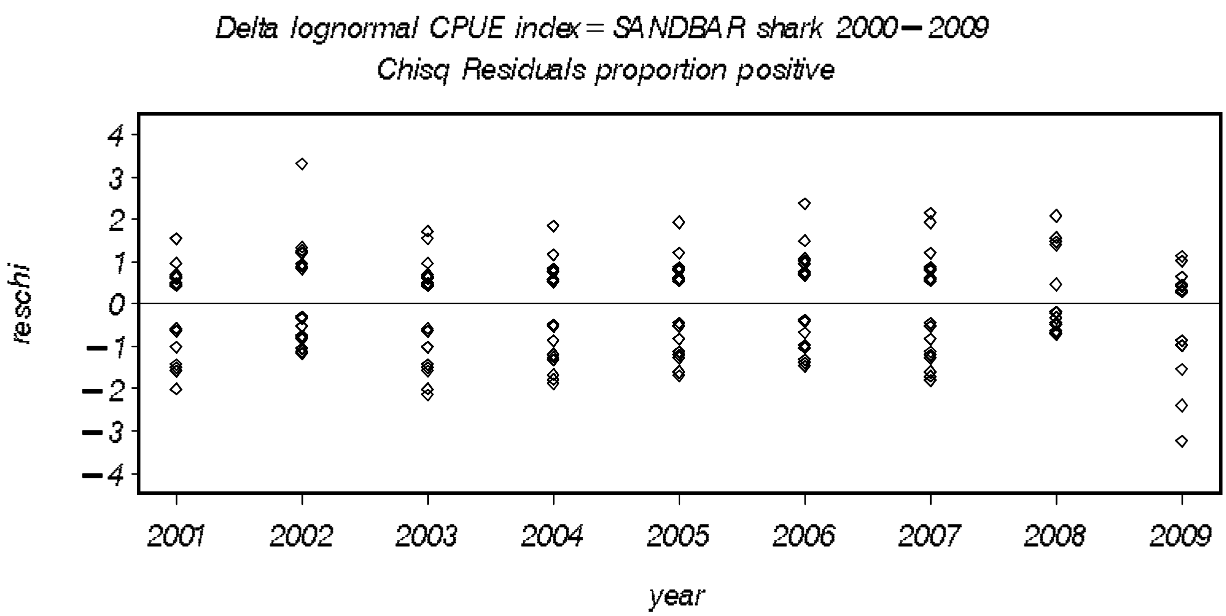
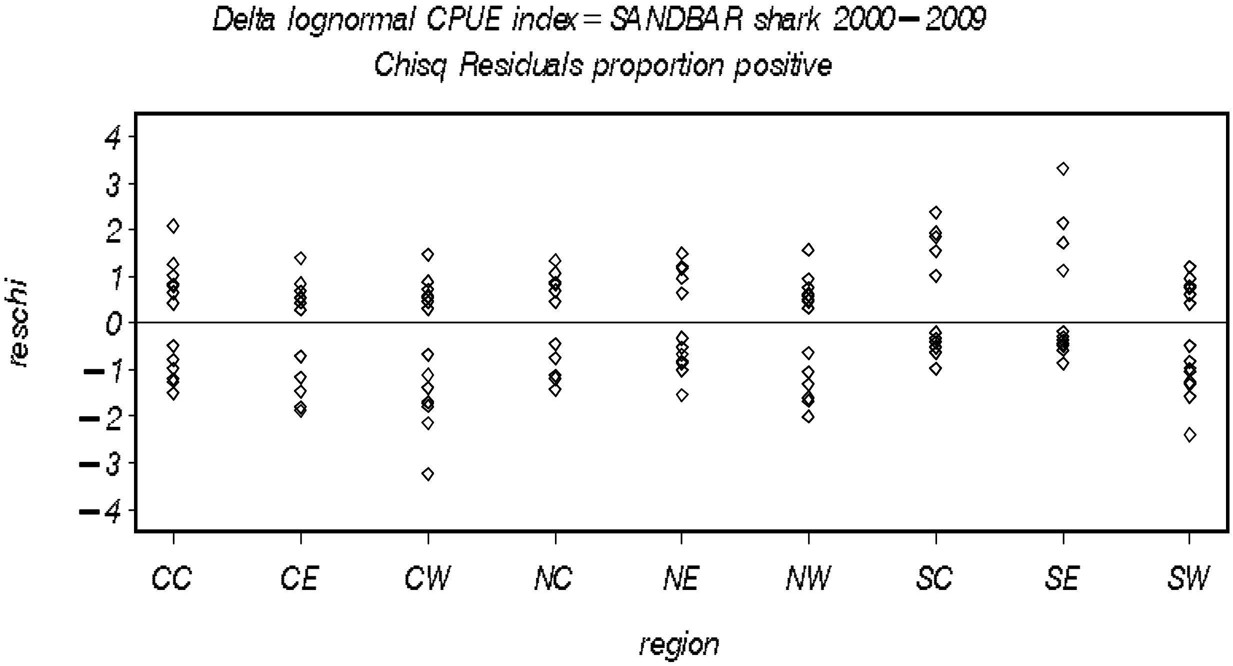


Figure 3a continued. Total juvenile sandbar shark model diagnostic plots for the binomial component.



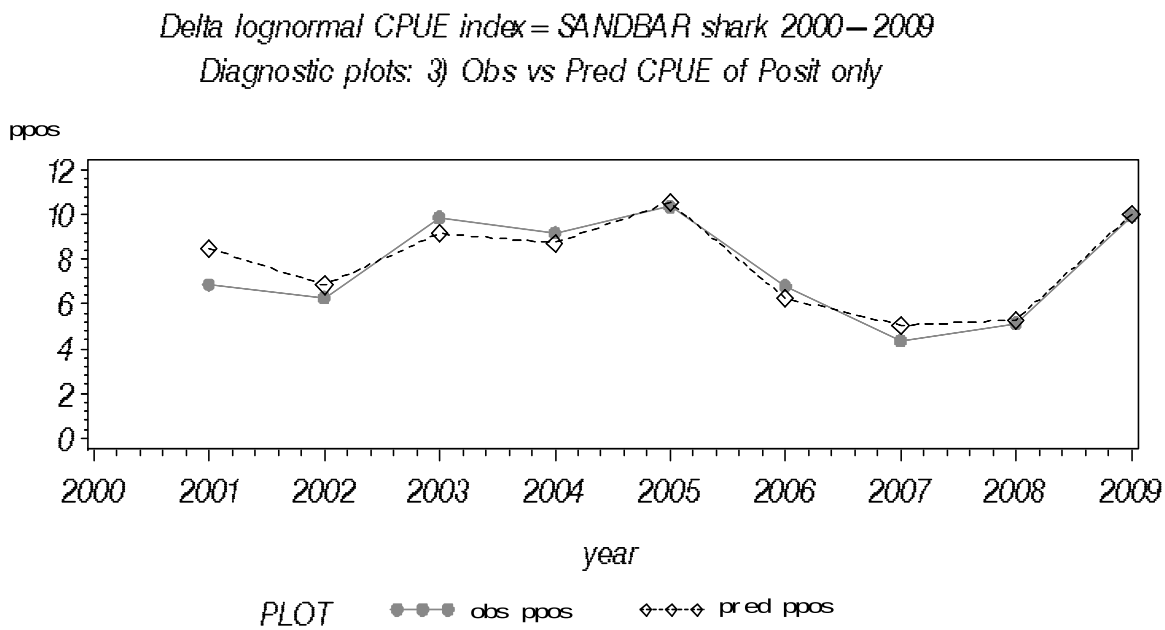
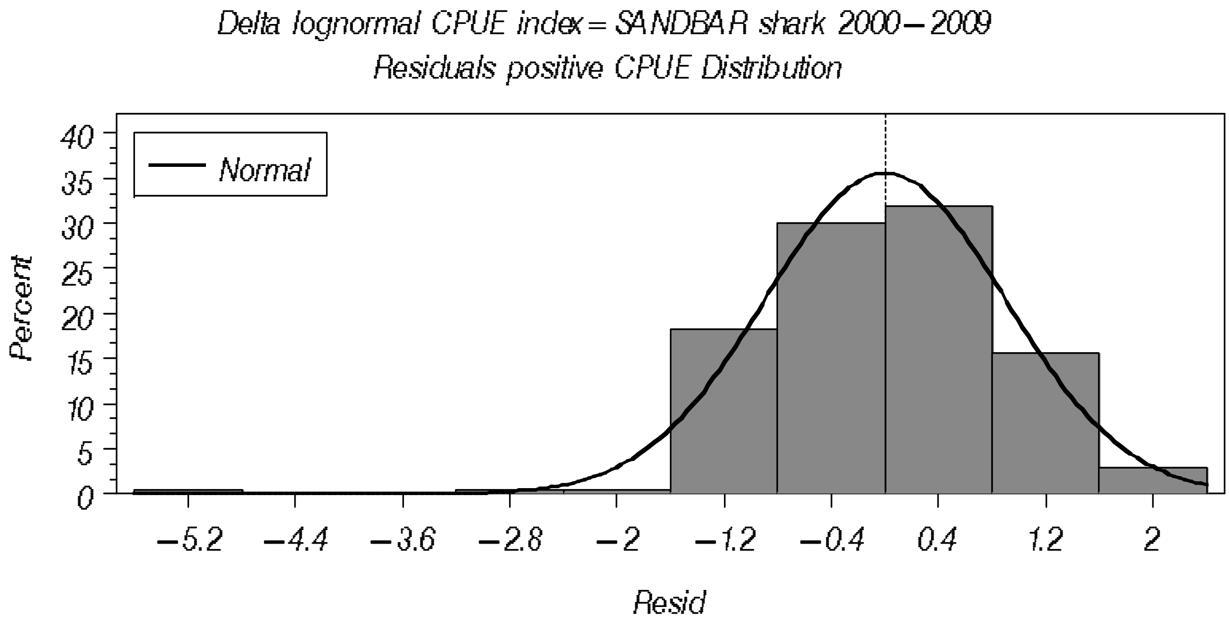


Figure 3b. Total juvenile sandbar shark model diagnostic plots for lognormal component.



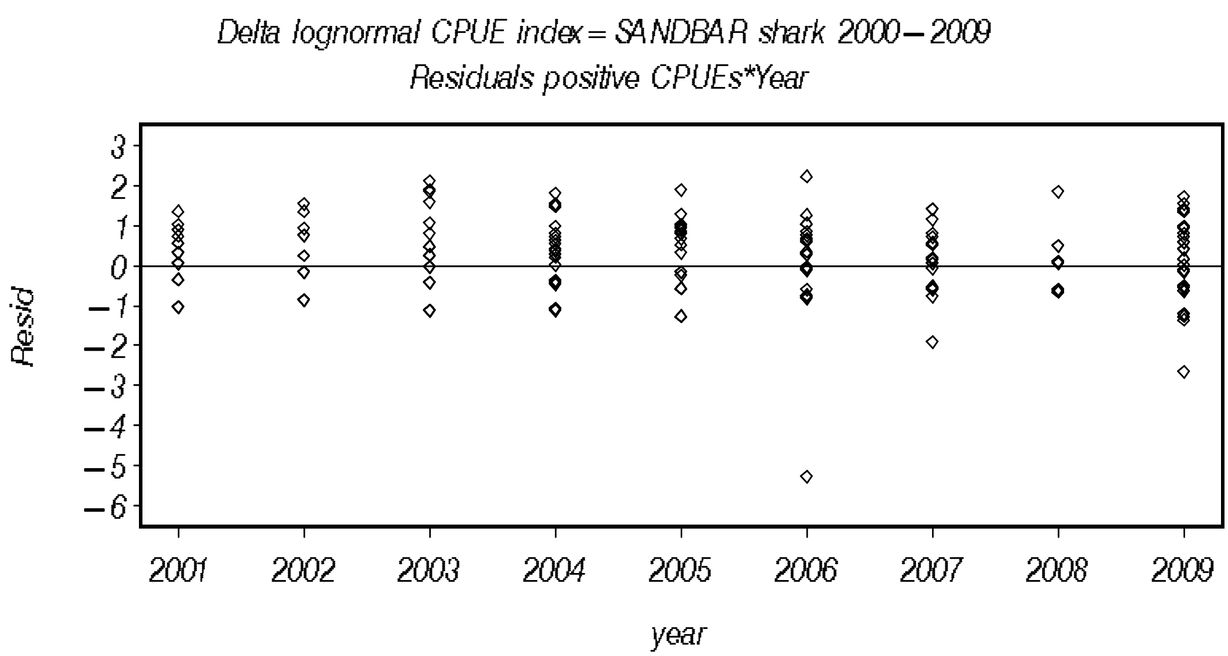


Figure 3b continued. Total juvenile sandbar shark model diagnostic plots for lognormal component.

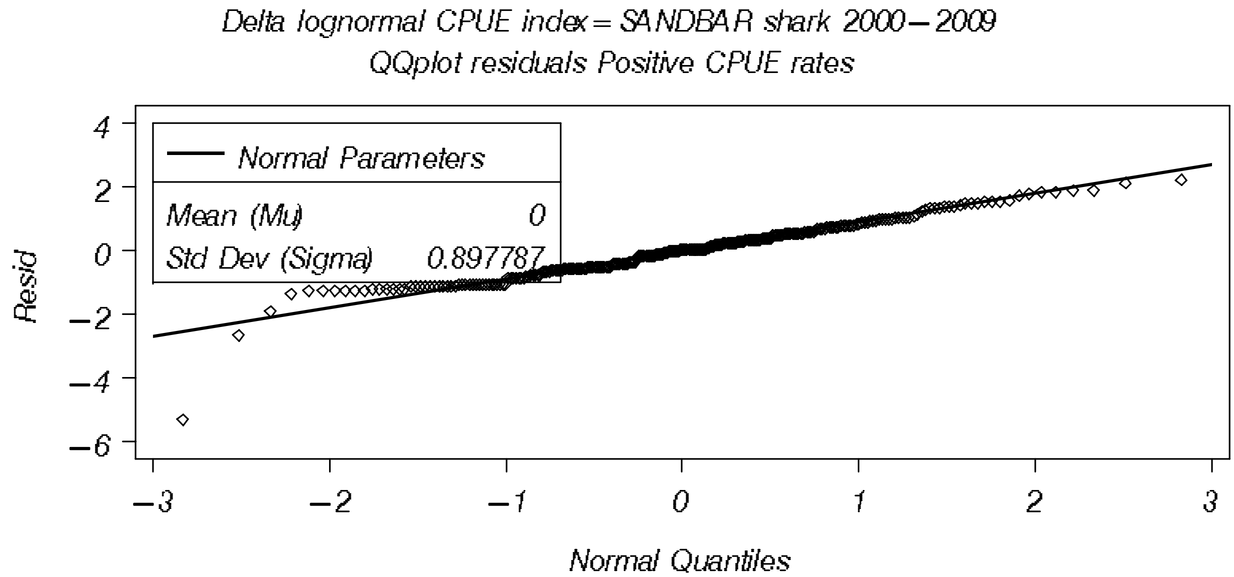


Figure 4. Total juvenile sandbar shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).

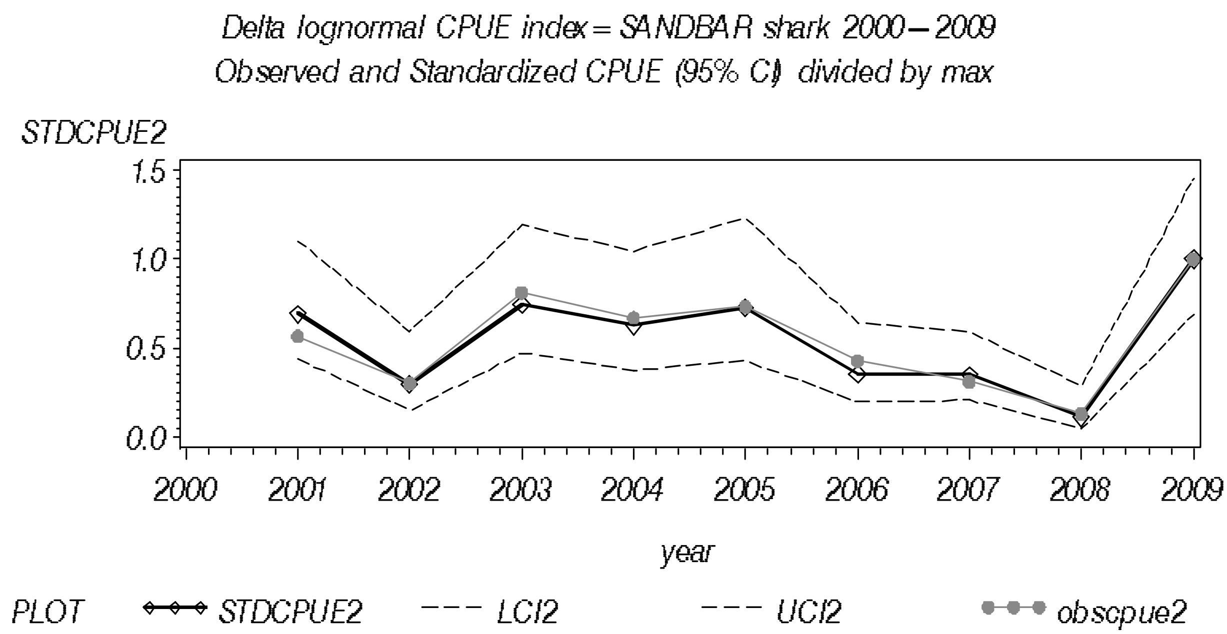


Figure 5. Fork lengths (cm) of young of the year sandbar sharks caught by year

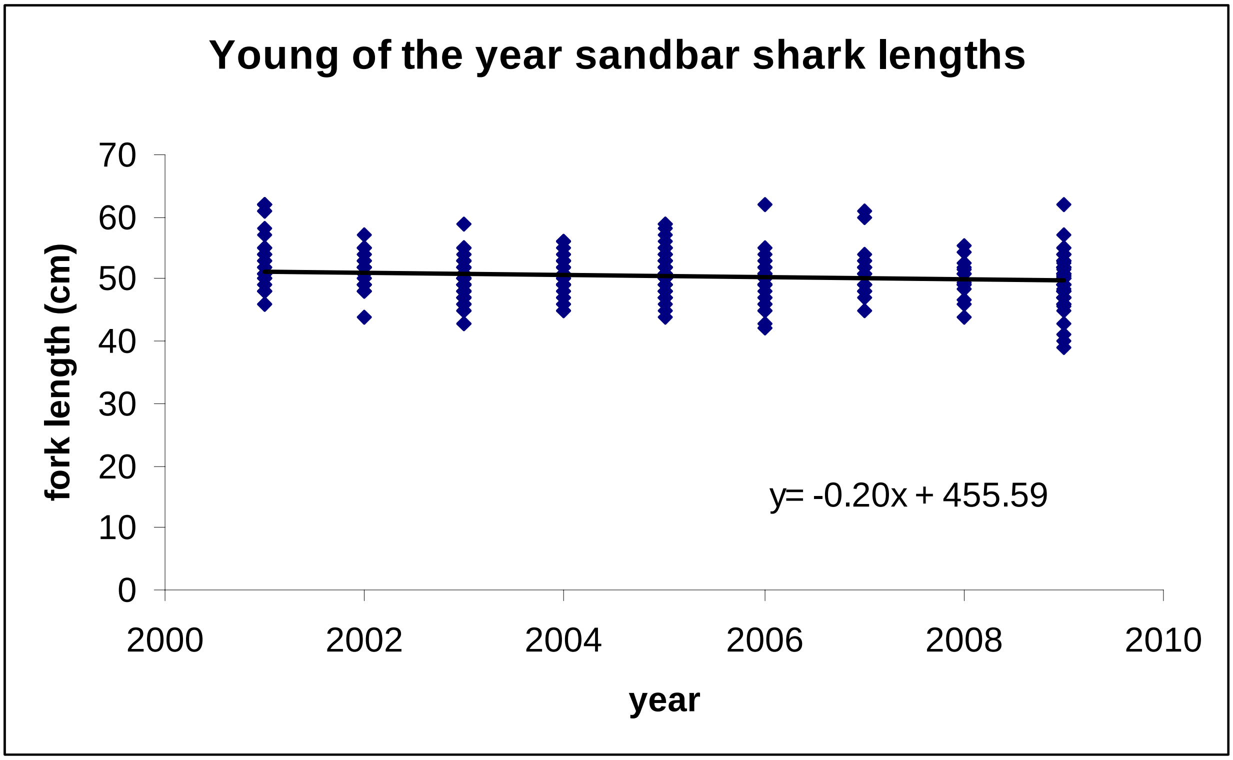


Figure 6a. Young of the year sandbar shark model diagnostic plots for the binomial component.

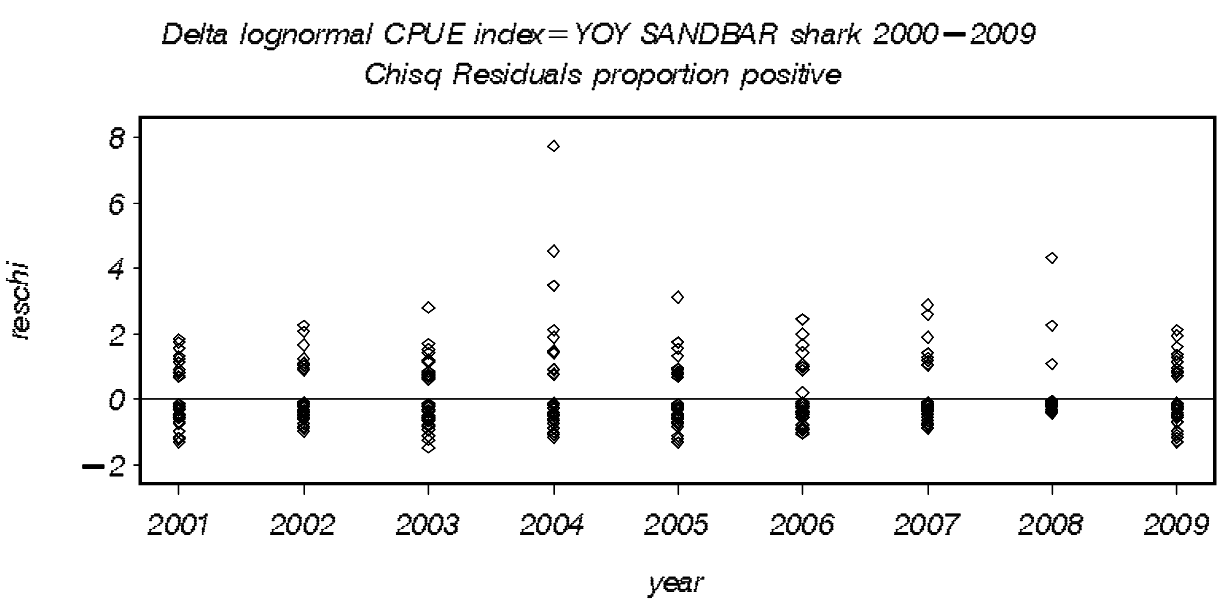
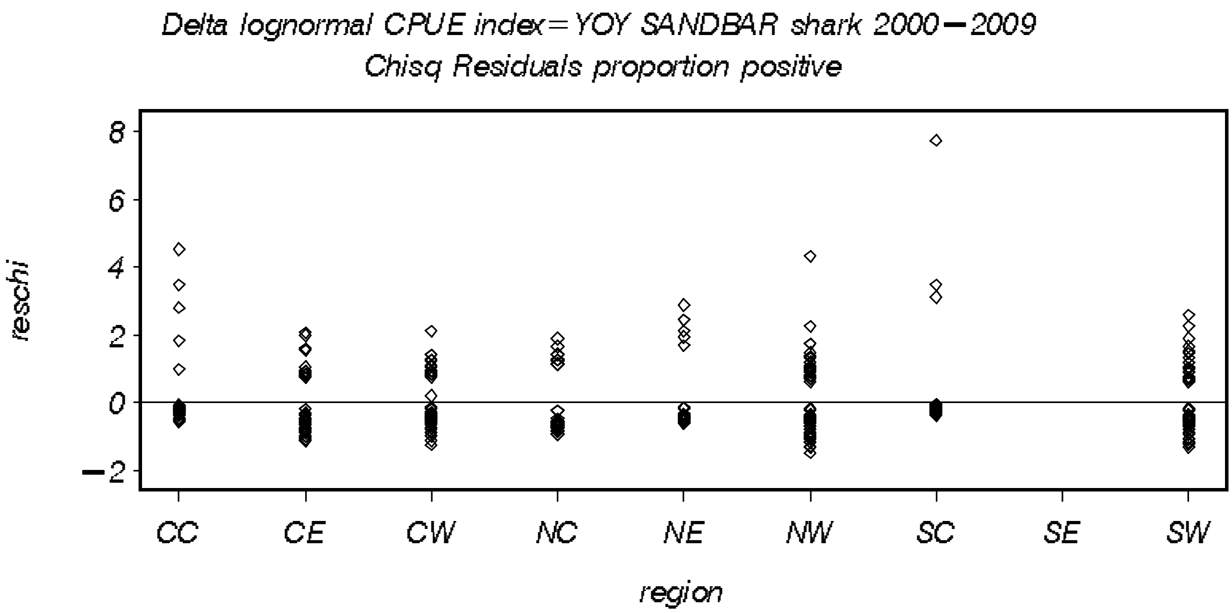


Figure 6a continued. Young of the year sandbar shark model diagnostic plots for the binomial component.



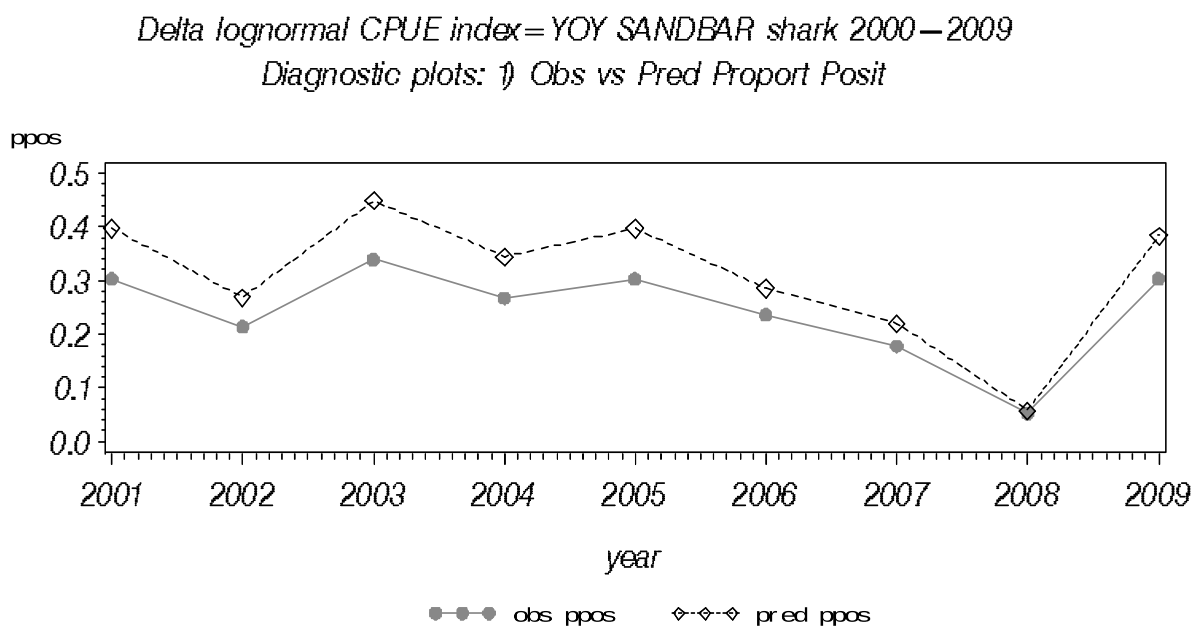
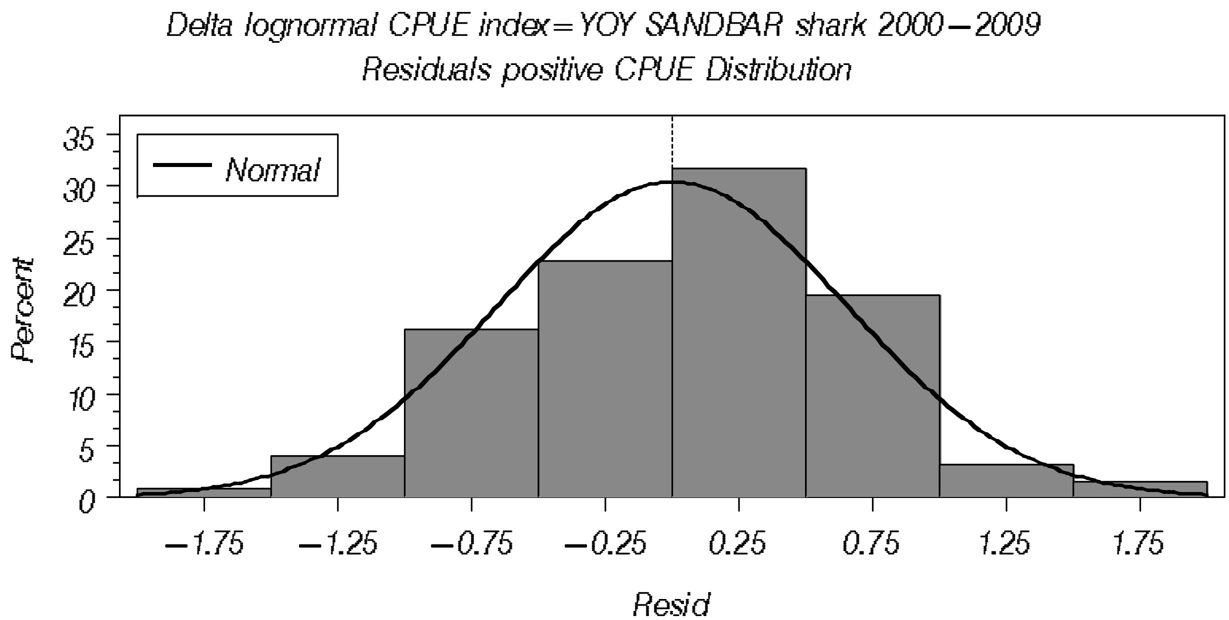


Figure 6b. Young of the year sandbar shark model diagnostic plots for the lognormal component.



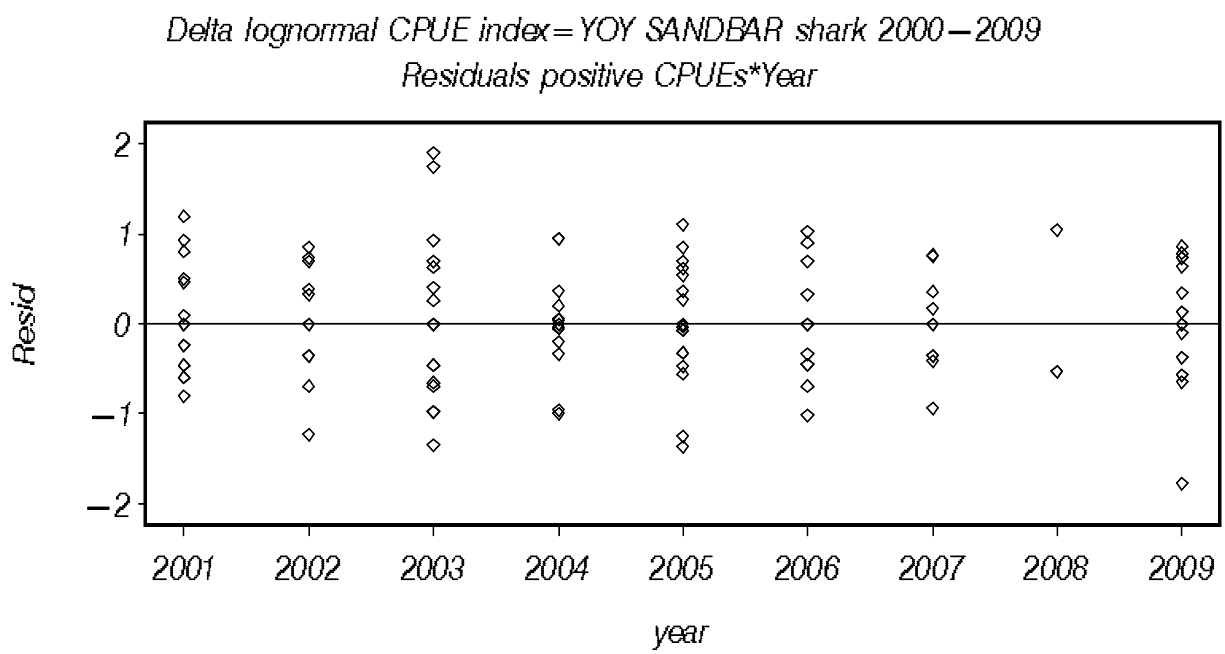


Figure 6b continued. Young of the year sandbar shark model diagnostic plots for the lognormal component.

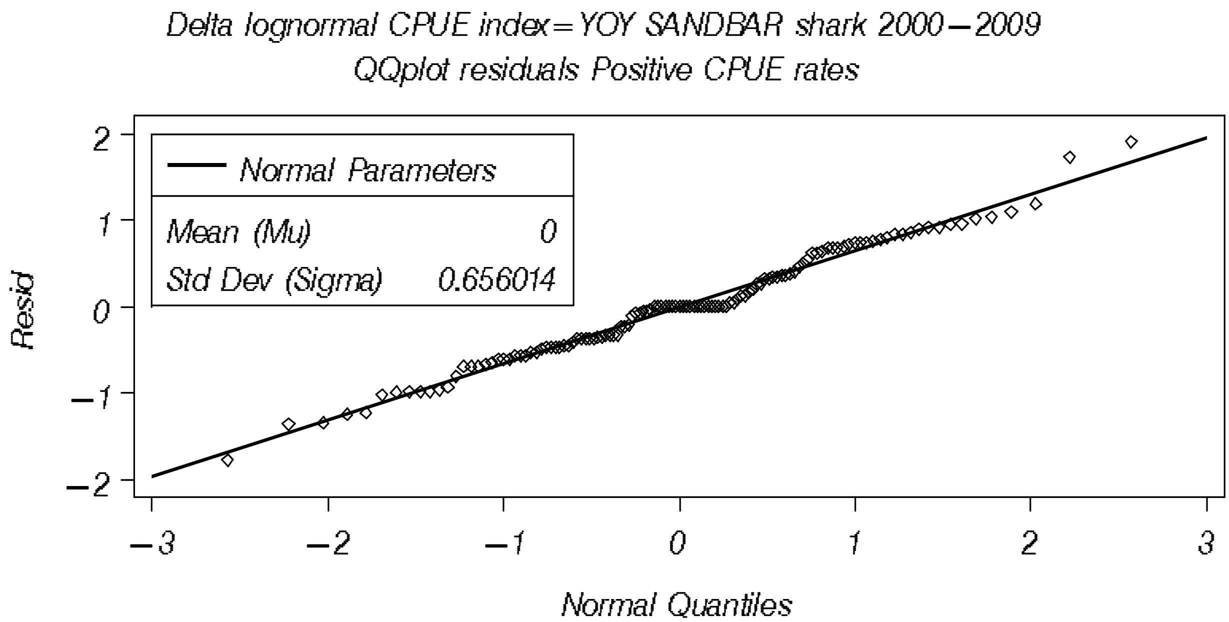


Figure 7. Young of the year sandbar shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).

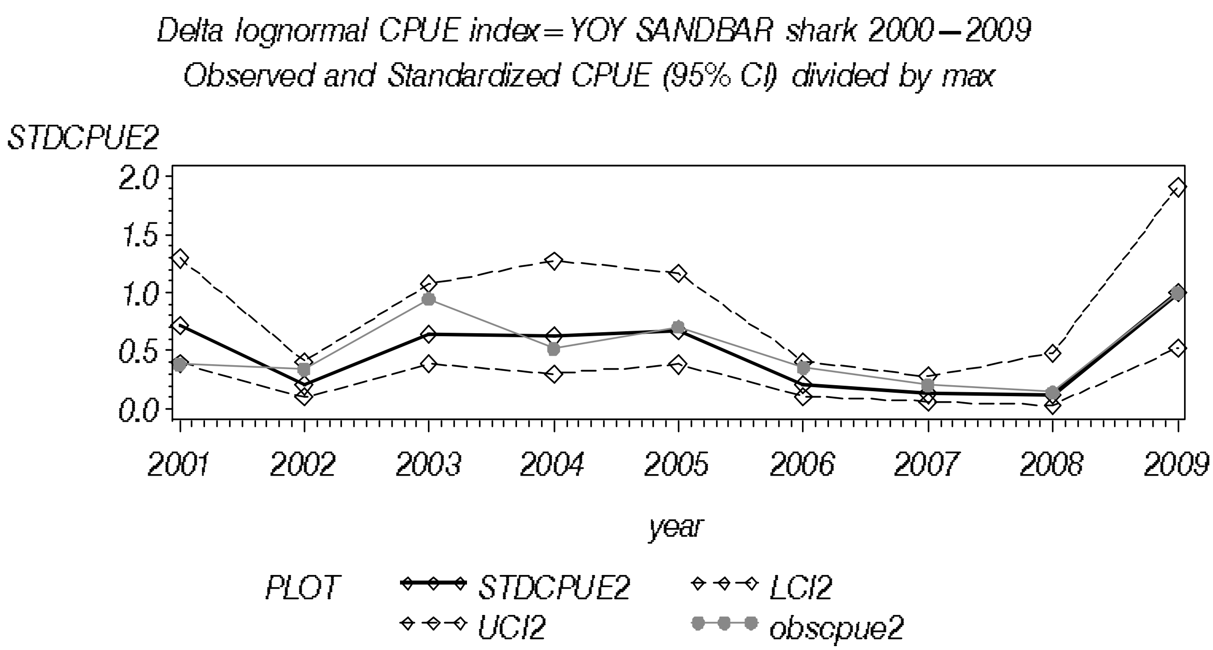


Figure 8. Fork lengths (cm) of age 1+ sandbar sharks caught by year

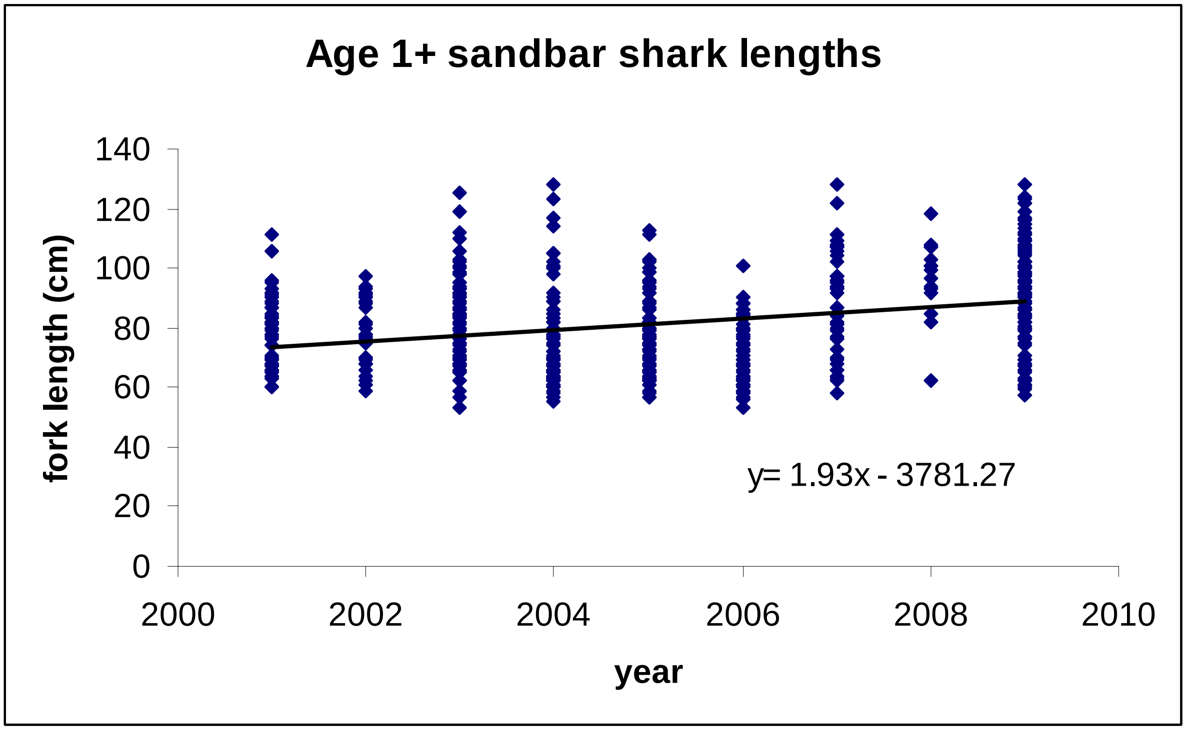


Figure 9a. Age 1+ sandbar shark model diagnostic plots for the binomial component.

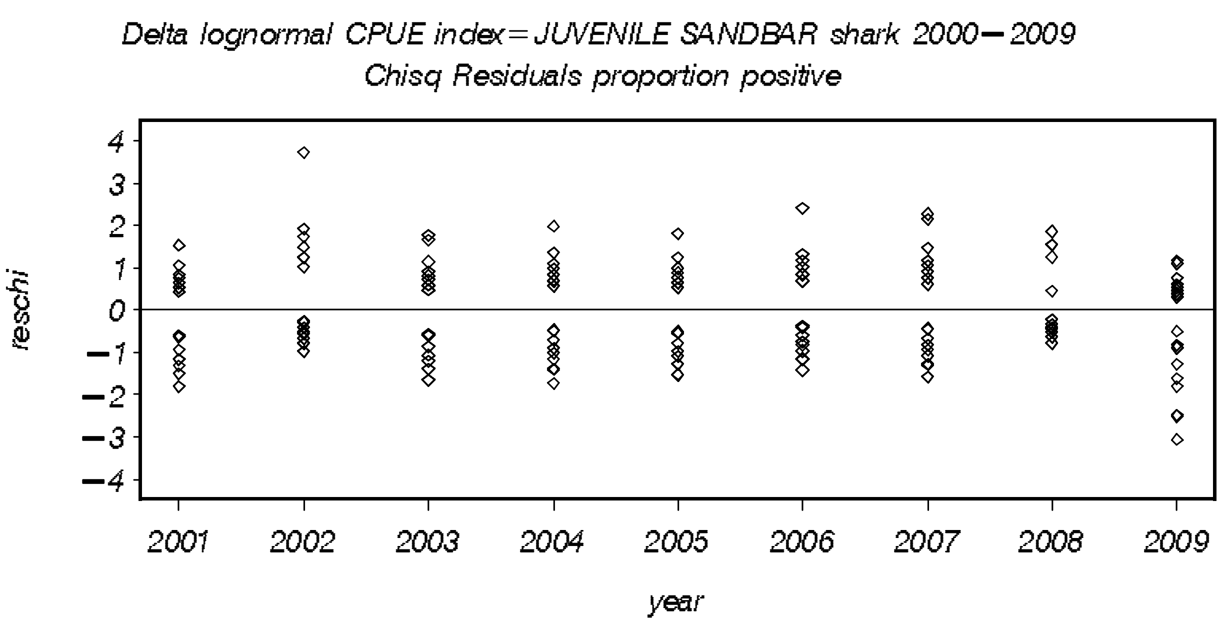
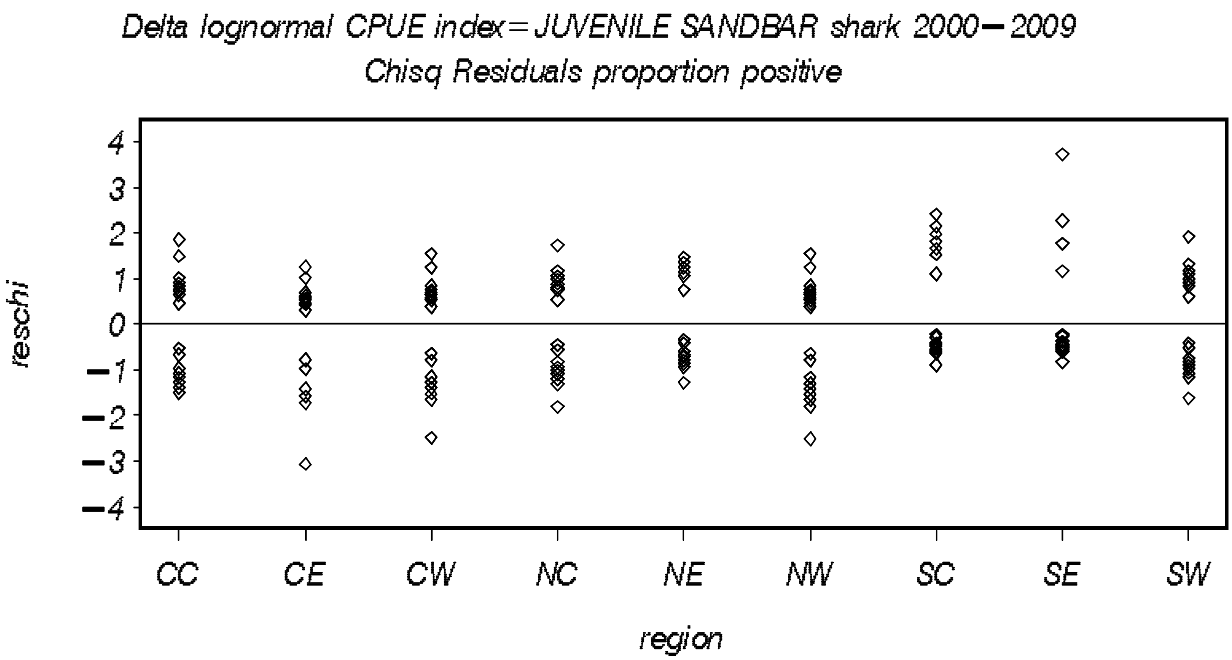


Figure 9a continued. Age 1+ sandbar shark model diagnostic plots for the binomial component.



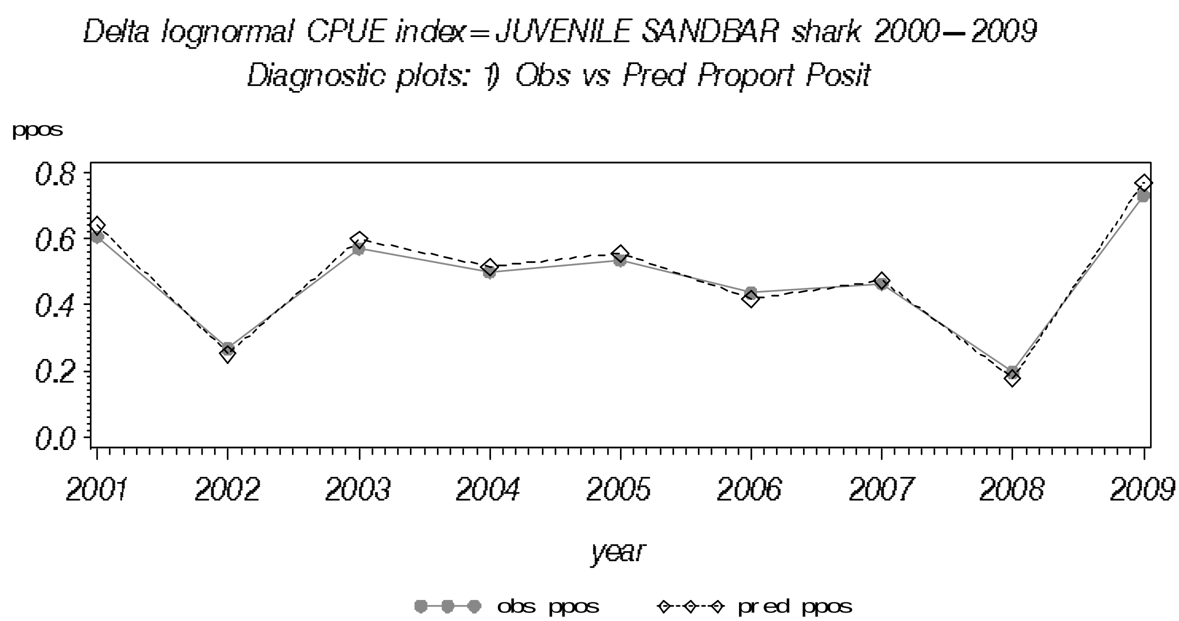
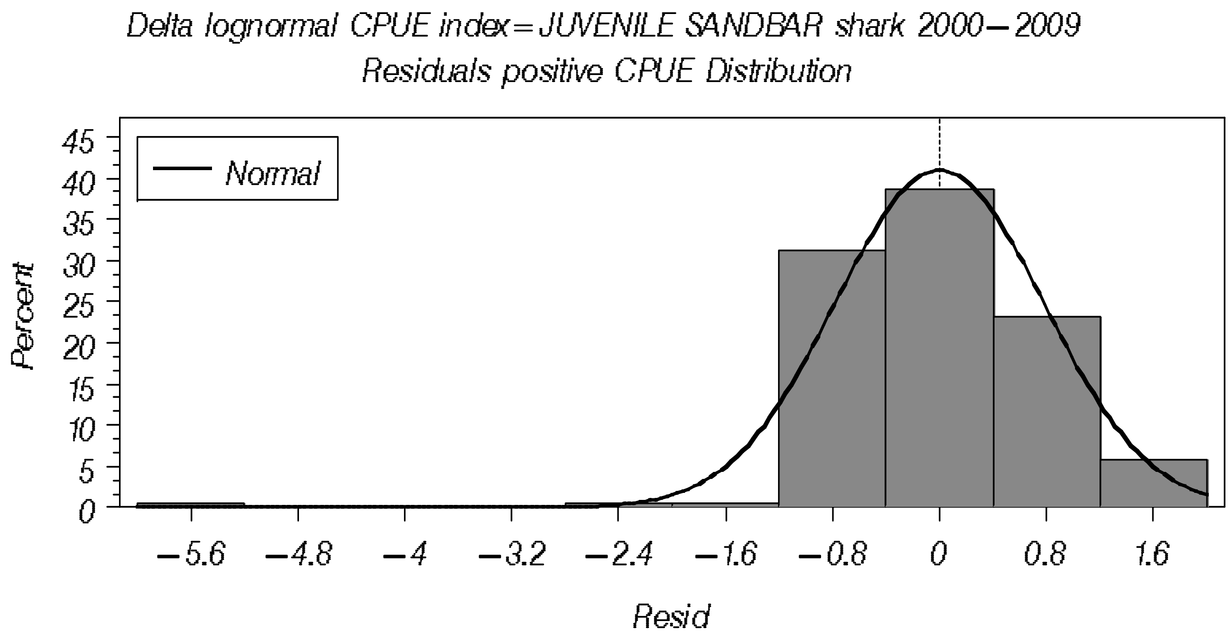


Figure 9b. Age 1+ sandbar shark model diagnostic plots for the lognormal component.



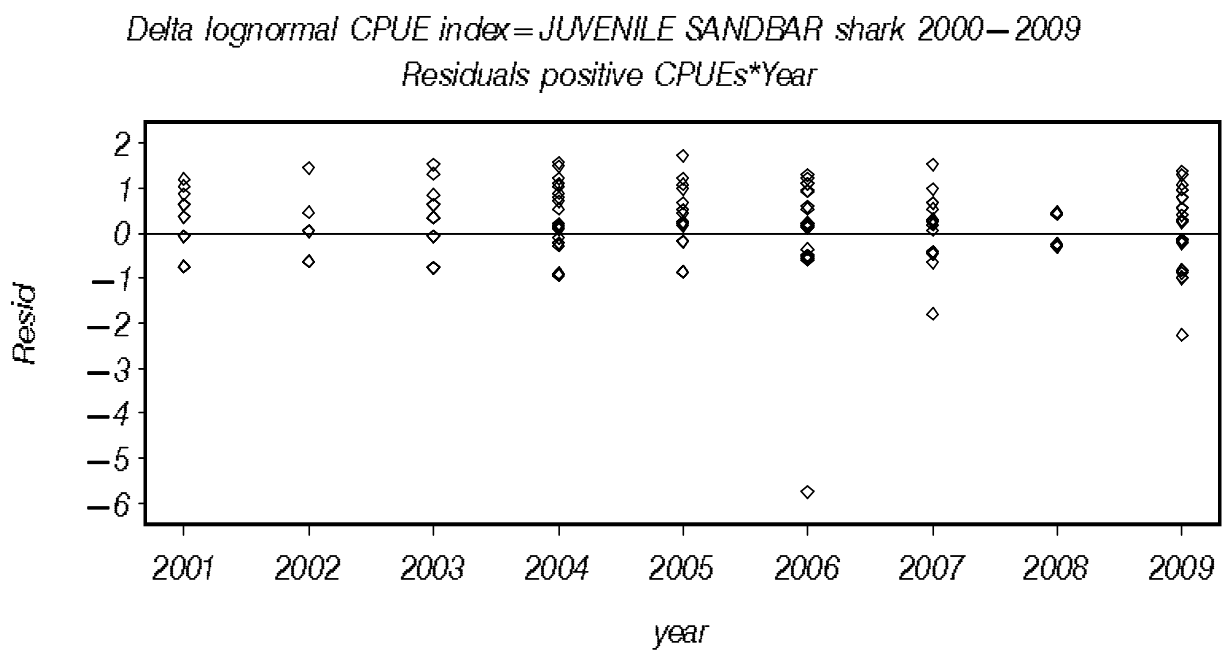


Figure 9b continued. Age 1+ sandbar shark model diagnostic plots for the lognormal component.

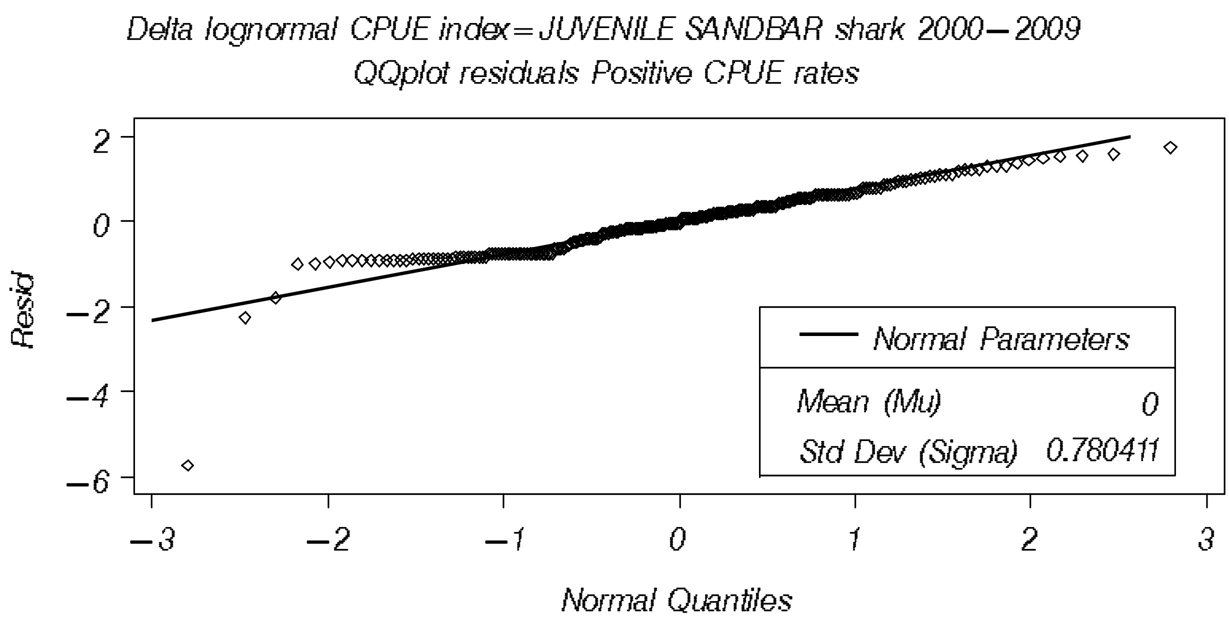


Figure 10. Age 1+ sandbar shark nominal (obscpue2) and estimated (STDCPUE2) indices divided by the maximum values with 95% confidence limits (LCL2, UCL2).