SEDAR 21 DATA WORKSHOP DOCUMENT

Standardized catch rates for sandbar and dusky sharks from the NMFS Northeast Longline Survey

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Summary

This document details sandbar and dusky shark catch from the Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey, conducted by the Apex Predators Program, Narragansett Laboratory, Narragansett, RI from 1996-2009. Data from this survey were used to look at the trends in relative abundance of sandbar and dusky sharks in the waters off the east coast of the United States. Catch per unit effort (CPUE) by set in number of sharks/(hooks*soak time) were examined for each year of the bottom longline survey, 1996, 1998, 2001, 2004, 2007, and 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. Sandbar sharks show a declining trend from 1998 to 2004 followed by an increase in relative abundance through 2009. Dusky sharks show an increasing trend in relative abundance across the time series.

Introduction

The Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey is conducted by the Apex Predators Program, Narragansett Laboratory, Narragansett, RI. The primary objective of this survey is to conduct a standardized, systematic survey of the shark populations off the US Atlantic coast to provide unbiased indices of the relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. It also provides an opportunity to tag sharks as part of the NEFSC Cooperative Shark Tagging Program and to collect biological samples and data used in analyses of life history characteristics (age, growth, reproductive biology, trophic ecology, etc.) and other research of sharks in US coastal waters. Relative abundance indices from this survey have been previously generated for dusky and sandbar sharks covering the time period from 1996 to 2004 (Natanson and McCandless 2005). In this document, these time series are updated with data through 2009, including recovered surface water temperature and depth data.

Methods

Sampling Gear and Data Collection

The NEFSC Coastal Shark Survey (1996-2009) covers the US continental shelf waters from Key West, FL to Delaware in depths of 9-80 m. The survey utilizes a fixed station design with stations generally located approximately 30 nm apart except where the continental shelf narrows off Cape Hatteras, NC (Fig. 1). Standard sampling gear consists of a 300 hook 'Florida' commercial style bottom longline. This gear consists of a 940 lb test monofilament mainline with 12 foot (3.6 m) gangions composed of 730 lb test monofilament with a longline clip at one end and a 3/0 shark hook at the other. Gangions (referred to hereafter simply as 'hooks') baited with chunks of spiny dogfish are attached to the mainline at 60-70 ft (21 m) intervals; 5 lb (2.3 kg) weights are attached every 15 hooks and a bullet float and 15 lb (6.8 kg) weights are placed at 50 hook intervals. A 20 ft (6 m) staff buoy ('high flyer') equipped with radar reflectors and flashers (at night) is attached to a poly ('tag') buoy by a 12 ft (3.6 m) line. The poly buoy is then attached to the mainline and there is a set of these to mark each end of the mainline. To ensure that the gear fishes on the bottom, 20 lb (9.1 kg) weights are placed at the beginning and end of the mainline after a length of line 2-3 times the water depth is deployed.

Once set, the gear is fished for three hours with approximately six hours from start of setting to completion of haulback. The mainline covers from 2.0 to 5.5 nm with an average of 3.7 nm. Fishing takes place at all times of the day. Number of sets completed per day varies from one to three with an average of 2.5 sets per day. The number of sets is dependent on distance between stations, weather conditions, and the length of time to complete previous sets during the day.

Data is recorded at the beginning and end of each set and haul, when available these data consist of: number of hooks, time, location, surface temperature, depth, air temperature, wind direction and strength, and sea state. During all surveys catch data recorded at each station include, at a minimum: species, sex and length (estimated or measured).

Data Analysis

Catch per unit effort (CPUE) for each set is defined as the number of sharks/(hooks*soak time). 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 (1996, 1998, 2001, 2004, 2007, 2009), month (April, May), area (1 = <33.8 ^{o} latitude, 2 = 33.8 to 35.7 ^{o} latitude, 3 = > 35.7 ^{o} latitude), depth (<20, 20-29, 30-39, 40-49, 50+ m), and surface water temperature (<21, 21+ deg C). 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 providing 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

Sandbar shark

A total of 2606 sandbar sharks were caught during 404 longline sets from 1996 to 2009. The size range of sandbar sharks caught by year is displayed in Figure 2. The proportion of sets with positive catch (at least one sandbar shark caught) was 54%. 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.

Dusky shark

A total of 529 dusky sharks were caught during 404 longline sets from 1996 to 2009. The size range of dusky sharks caught by year is displayed in Figure 5. The proportion of sets with positive catch (at least one sandbar shark caught) was 20%. 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.

References Cited

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.

Natanson, L.J. and C.T. McCandless. 2005. Catch Rate Information Obtained from the NMFS Northeast Longline Survey. LCS05/06-DW-33-V2. 43 pp.

Table 1. Results of the stepwise procedure for development of the catch rate model for sandbar sharks. %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	398	550.0573	1.3821				
AREA	396	479.5843	1.2111	12.3725	12.3725	70.47	<.0001
YEAR	393	499.7927	1.2717	7.9878		50.26	<.0001
MONTH	397	538.3306	1.3560	1.8884		11.73	0.0006
DEPTH	394	537.4919	1.3642	1.2951		12.57	0.0136
TEMP	397	548.9263	1.3827	-0.0434		1.13	0.2876
AREA +							
YEAR	391	438.1966	1.1207	18.9132	6.5408	41.39	<.0001
MONTH	395	468.4433	1.1859	14.1958		11.14	0.0008
DEPTH	392	472.5463	1.2055	12.7777		7.04	0.1339
AREA + YEAR +							
MONTH	390	415.31	1.0649	22.9506	4.0373	22.89	<.0001
AREA + YEAR + MONTH							
AREA*MONTH	389	413.9252	1.0641	23.0085	0.0579	1.3800	0.2393
AREA*YEAR	382	391.8451	1.0258	25.7796		Negative of Hessian not positive definite	
YEAR*MONTH	385	409.6752	1.0641	23.0085		Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
AREA + YEAR + MONTH	463.0	465.7	461.0

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

Significance (Pr>Chi) of Type 3	AREA	YEAR	MONTH
test of fixed effects for each factor	<.0001	<.0001	<.0001
DF	2	5	1
CHI SQUARE	37.80	35.47	18.79

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	215	338.6133	1.5749				
YEAR	210	248.2141	1.1820	24.9476	24.9476	67.08	<.0001
AREA	213	300.8068	1.4122	10.3308		25.57	<.0001
DEPTH	211	327.5476	1.5524	1.4287		7.18	0.1268
MONTH	214	336.5791	1.5728	0.1333		1.30	0.2539
TEMP	214	338.6033	1.5823	-0.4699		0.01	0.9365
YEAR +							
AREA	208	215.3349	1.0353	34.2625	9.3149	30.69	<.0001
YEAR + AREA +							
YEAR*AREA	200	207.3003	1.0365	34.1863	-0.0762	8.21	0.4129

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + AREA	627.1	630.5	625.1

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

Significance (Pr>Chi) of Type 3	YEAR	AREA
test of fixed effects for each factor	<.0001	<.0001
DF	5	2
CHI SQUARE	82.56	31.76

Table 2. 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
1996	91	34	0.3696	0.0006	0.0005	0.0002	0.0010	0.3664
1997								
1998	88	47	0.5341	0.0039	0.0031	0.0018	0.0052	0.2669
1999								
2000								
2001	84	45	0.5357	0.0018	0.0015	0.0009	0.0026	0.2716
2002								
2003								
2004	69	32	0.4638	0.0014	0.0012	0.0006	0.0023	0.3450
2005								
2006								
2007	22	19	0.8636	0.0056	0.0052	0.0029	0.0094	0.3039
2008								
2009	50	43	0.8600	0.0105	0.0106	0.0071	0.0160	0.2068

Table 3. Results of the stepwise procedure for development of the catch rate model for dusky sharks. %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	398	405.3455	1.0185				
AREA	396	357.0467	0.9016	11.4777	11.4777	48.30	<.0001
YEAR	393	355.6303	0.9049	11.1537		49.72	<.0001
DEPTH	394	379.9215	0.9643	5.3216		25.42	<.0001
MONTH	397	393.3748	0.9909	2.7099		11.97	0.0005
TEMP	397	401.3468	1.0109	0.7462		4.00	0.0455
AREA +							
YEAR	391	308.9659	0.7902	22.4153	10.9377	48.08	<.0001
DEPTH	392	338.8521	0.8644	15.1301		18.19	0.0011
MONTH	395	353.4368	0.8948	12.1453		3.61	0.0574
TEMP	395	356.1792	0.9017	11.4678		0.87	0.3517
AREA + YEAR +							
DEPTH	387	295.0549	0.7624	25.1448	2.7295	13.91	0.0076
AREA + YEAR + DEPTH							
AREA*DEPTH	380	284.8344	0.7496	26.4016	1.2568	10.22	0.1764
AREA*YEAR	379	289.0448	0.7627	25.1154		6.010	0.6461
YEAR*DEPTH	367	274.3711	0.7476	26.5979		Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
AREA + YEAR + DEPTH	492.9	495.5	490.9

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

	AREA	YEAR	DEPTH
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	<.0001	0.0092
DF	2	5	1
CHI SQUARE	38.45	37.21	13.48

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	81	91.7484	1.1327				
AREA	79	72.182	0.9137	19.3343	19.3343	19.67	<.0001
DEPTH	77	79.0853	1.0271	9.3229		12.18	0.0161
YEAR	76	78.9631	1.0390	8.2723		12.31	0.0308
MONTH	80	88.2754	1.1034	2.5867		3.16	0.0753
TEMP	80	89.6809	1.1210	1.0329		1.87	0.1716
AREA +							
YEAR	74	56.2239	0.7598	32.9213	13.5870	20.49	0.0010
DEPTH	75	64.4846	0.8598	24.0929		9.25	0.0552
AREA + YEAR							
AREA*YEAR	68	51.5658	0.7583	33.0538	8.9609	7.09	0.3124

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
AREA + YEAR	211.1	213.4	209.1

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

	AREA	YEAR
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	0.0008
DF	2	5
CHI SQUARE	29.93	21.00

Table 4. Dusky 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
1996	91	5	0.05435	0.00005	0.00006	0.00002	0.00022	0.74921
1997								
1998	88	10	0.11364	0.00026	0.00024	0.00009	0.00066	0.52833
1999								
2000								
2001	84	12	0.14286	0.00040	0.00026	0.00010	0.00066	0.48418
2002								
2003								
2004	69	25	0.36232	0.00073	0.00076	0.00042	0.00138	0.30684
2005								
2006								
2007	22	10	0.45455	0.00103	0.00071	0.00027	0.00187	0.51659
2008								
2009	50	20	0.40000	0.00235	0.00218	0.00112	0.00423	0.34033

Figure 1. Current Survey Stations

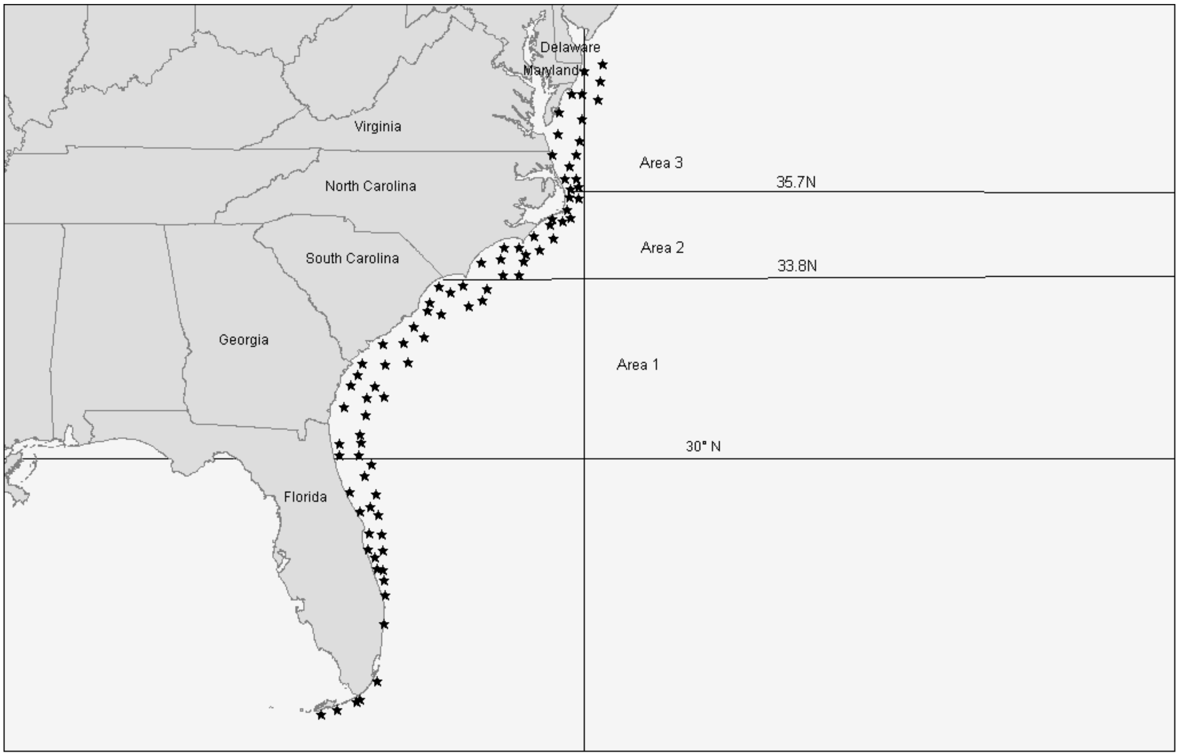


Figure 2. Fork lengths (cm) of sandbar sharks caught by year

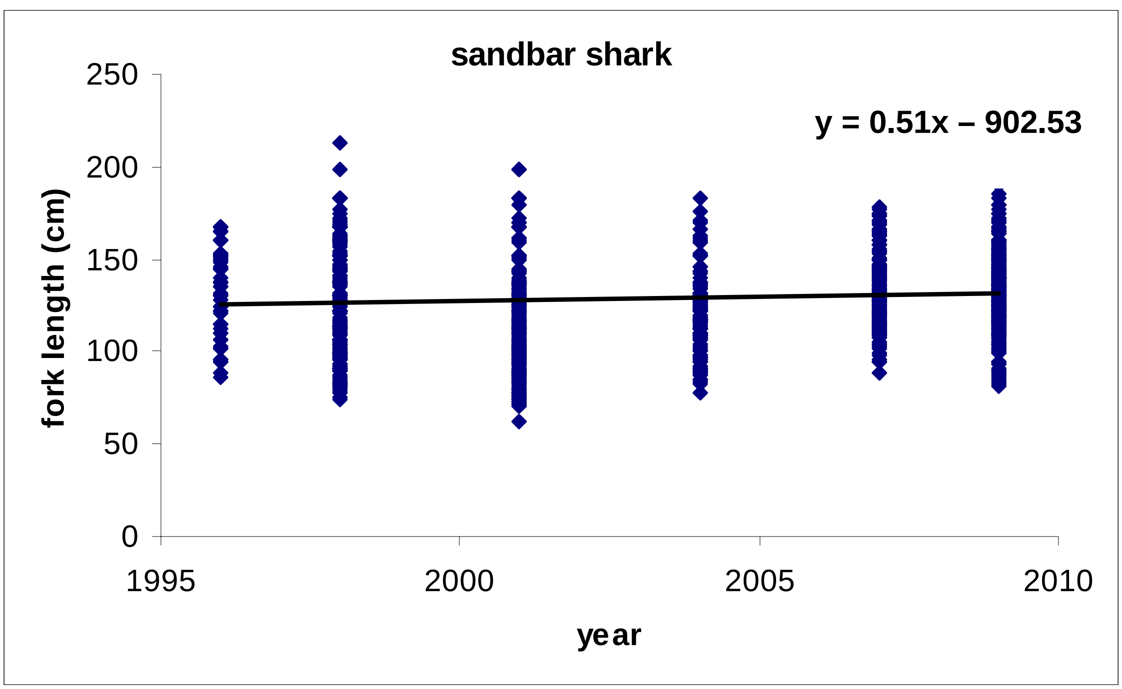
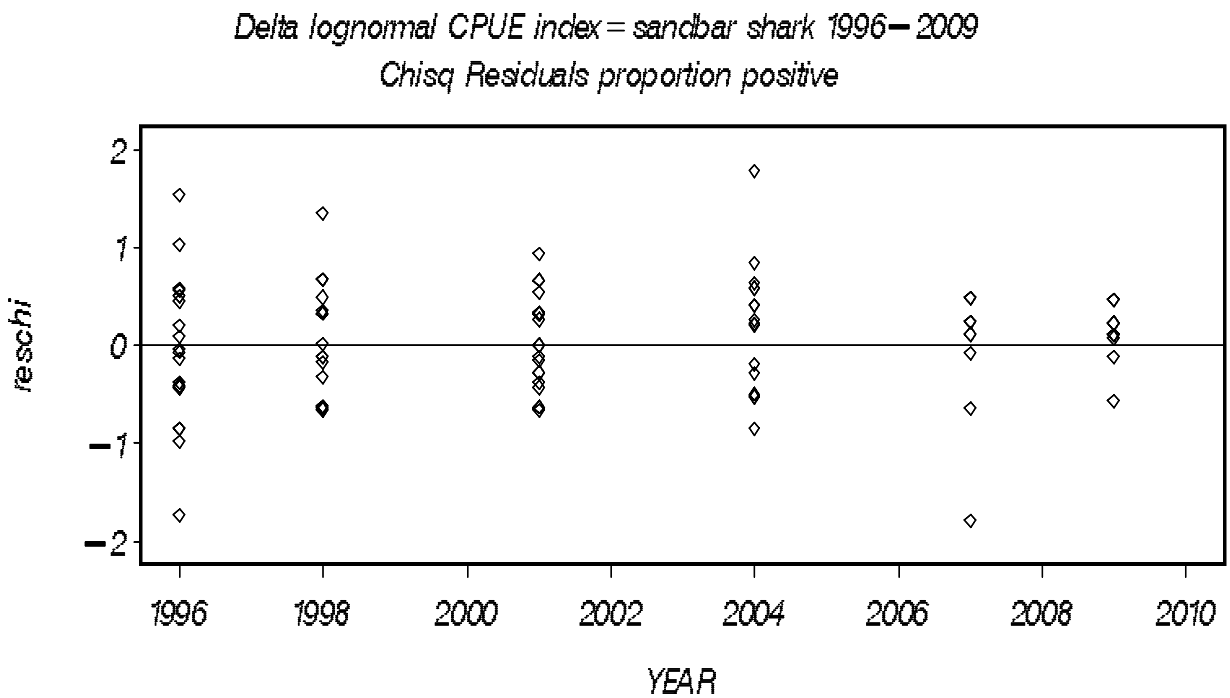


Figure 3a. Sandbar shark model diagnostic plots for the binomial component.



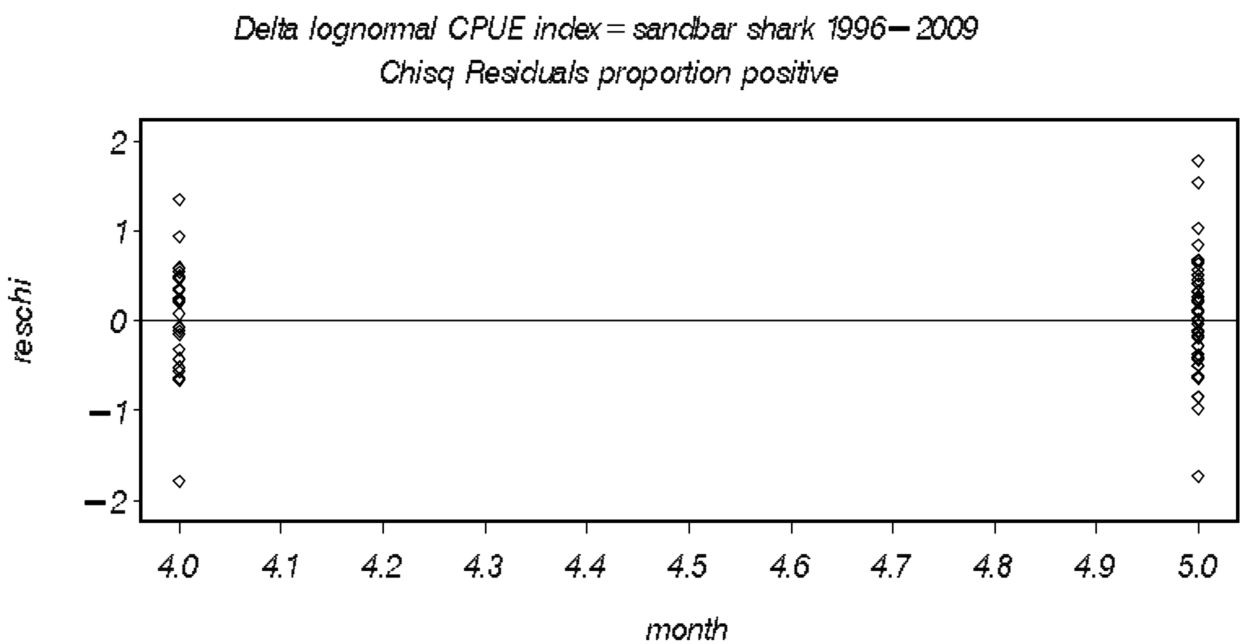
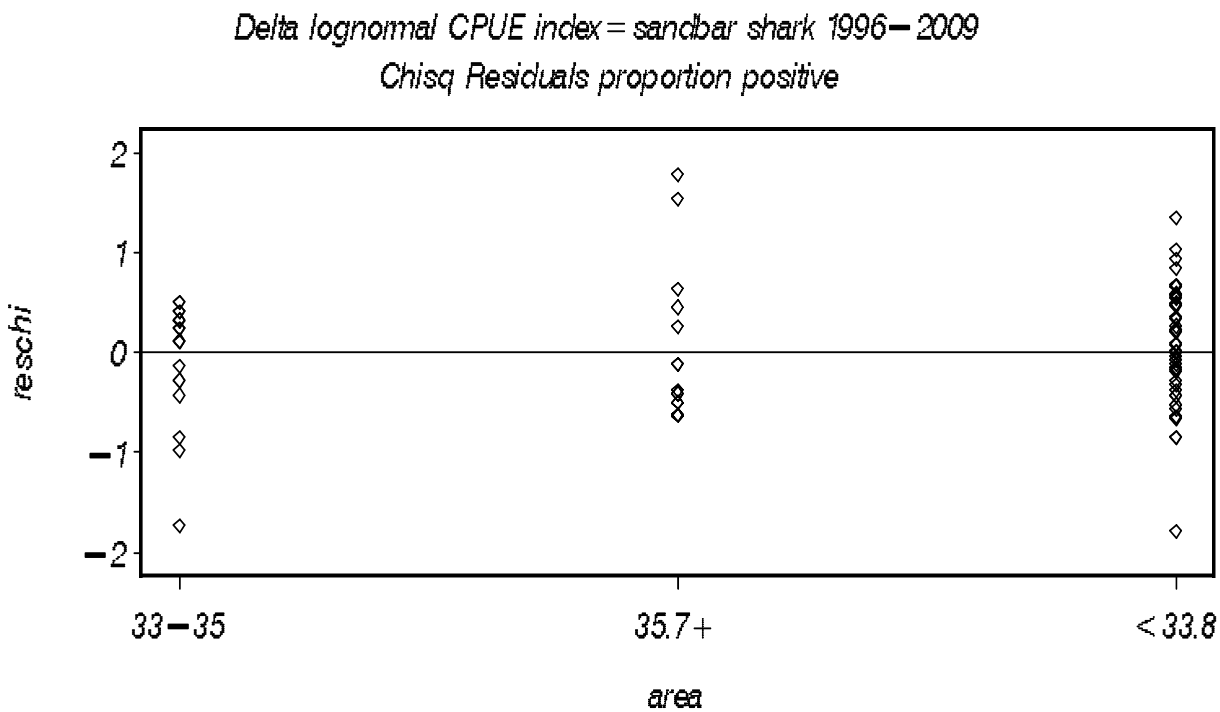


Figure 3a continued. Sandbar shark model diagnostic plots for binomial component.



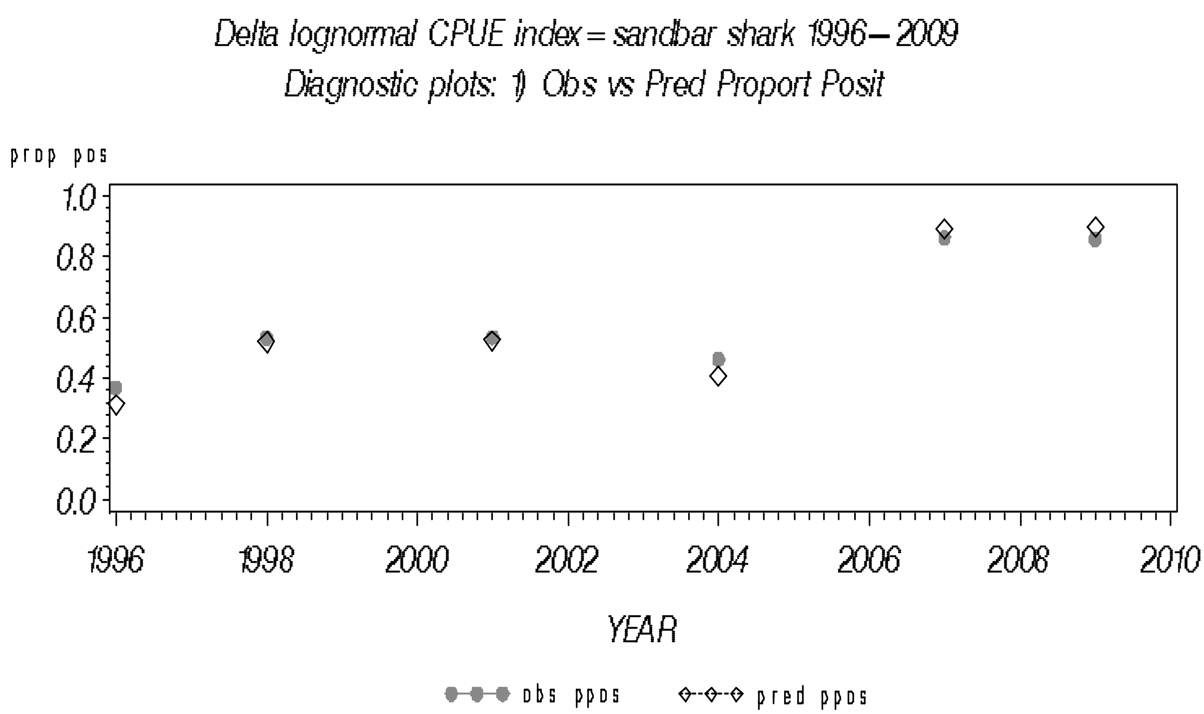
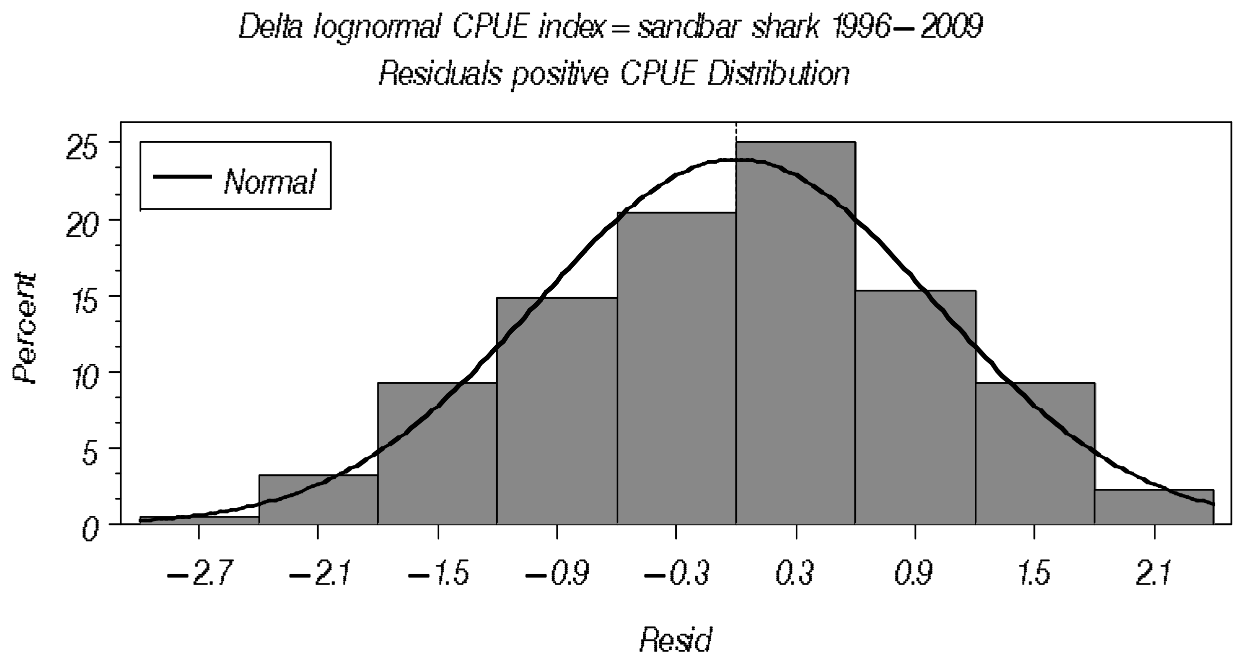


Figure 3b. Sandbar shark model diagnostic plots for lognormal component.



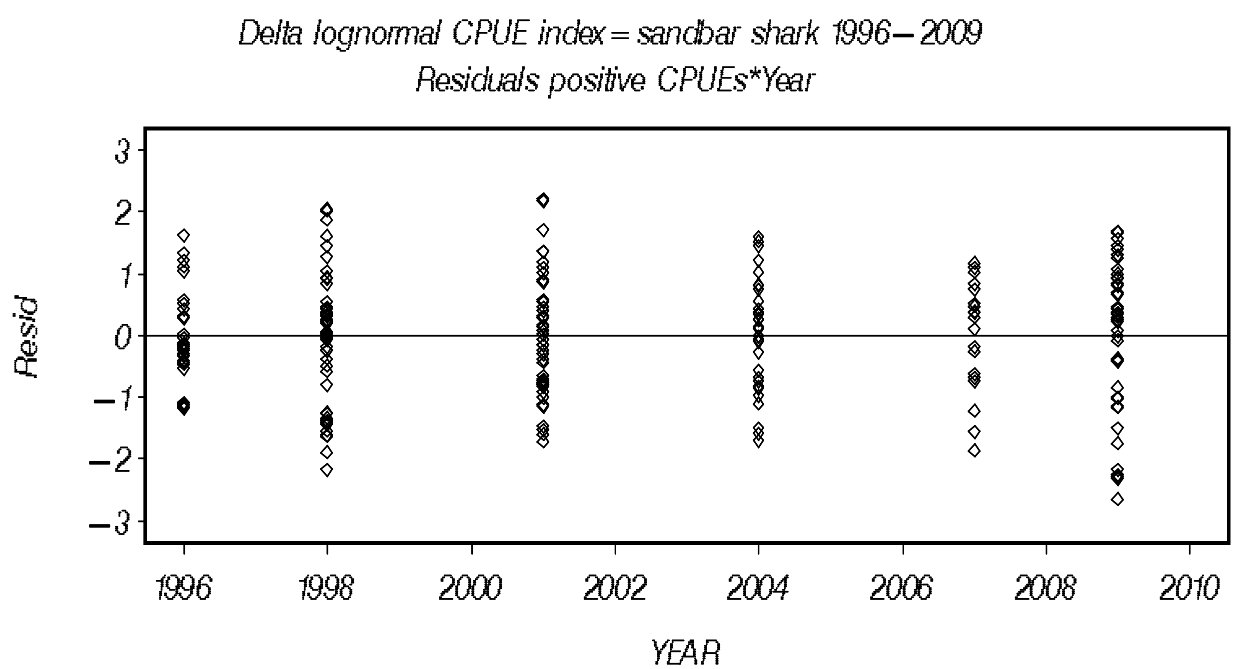


Figure 3b continued. Sandbar shark model diagnostic plots for lognormal component.

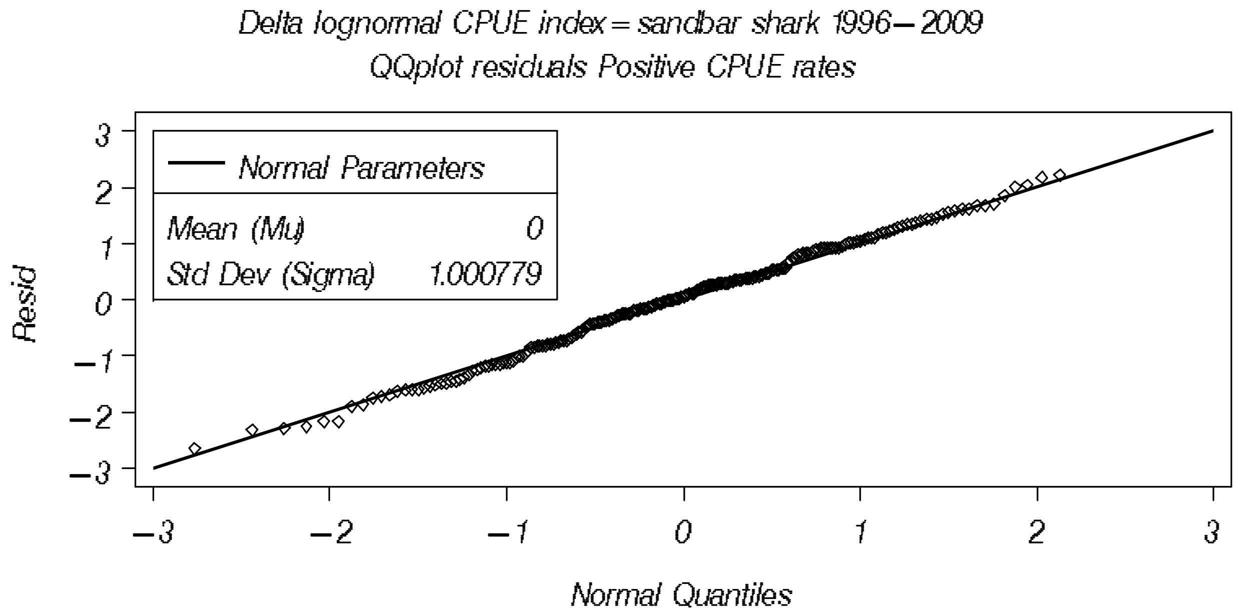


Figure 4. Sandbar shark nominal (obscpue1) and estimated (STDCPUE1) indices divided by the mean values with 95% confidence limits (LCL1, UCL1).

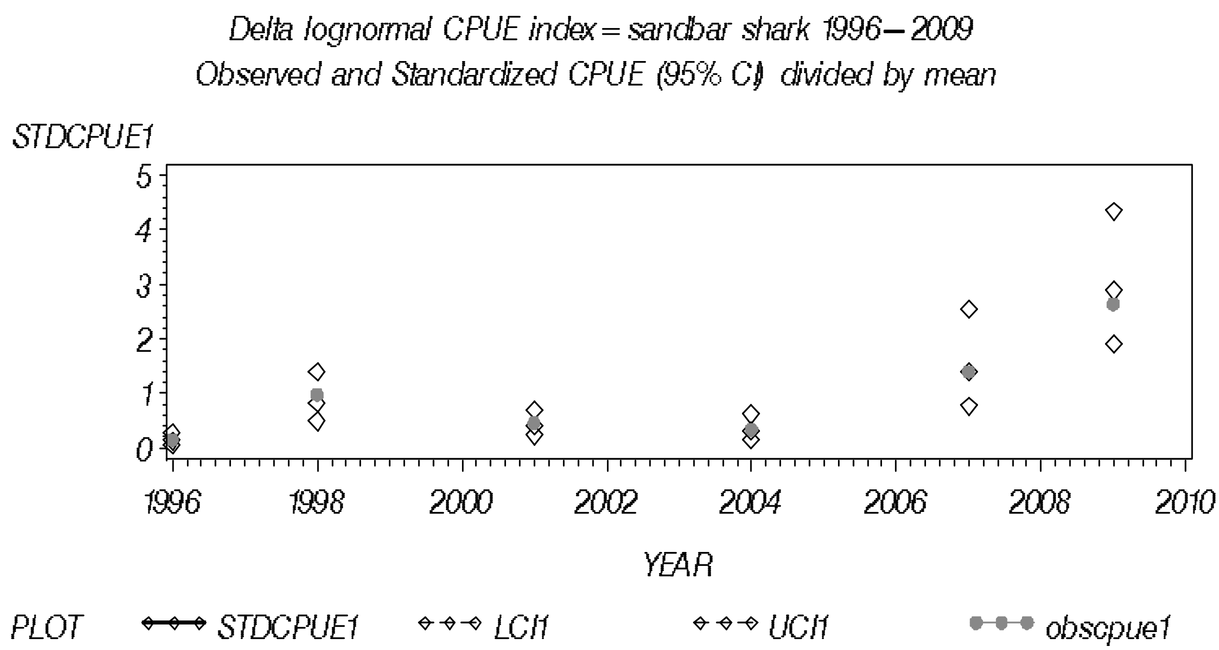
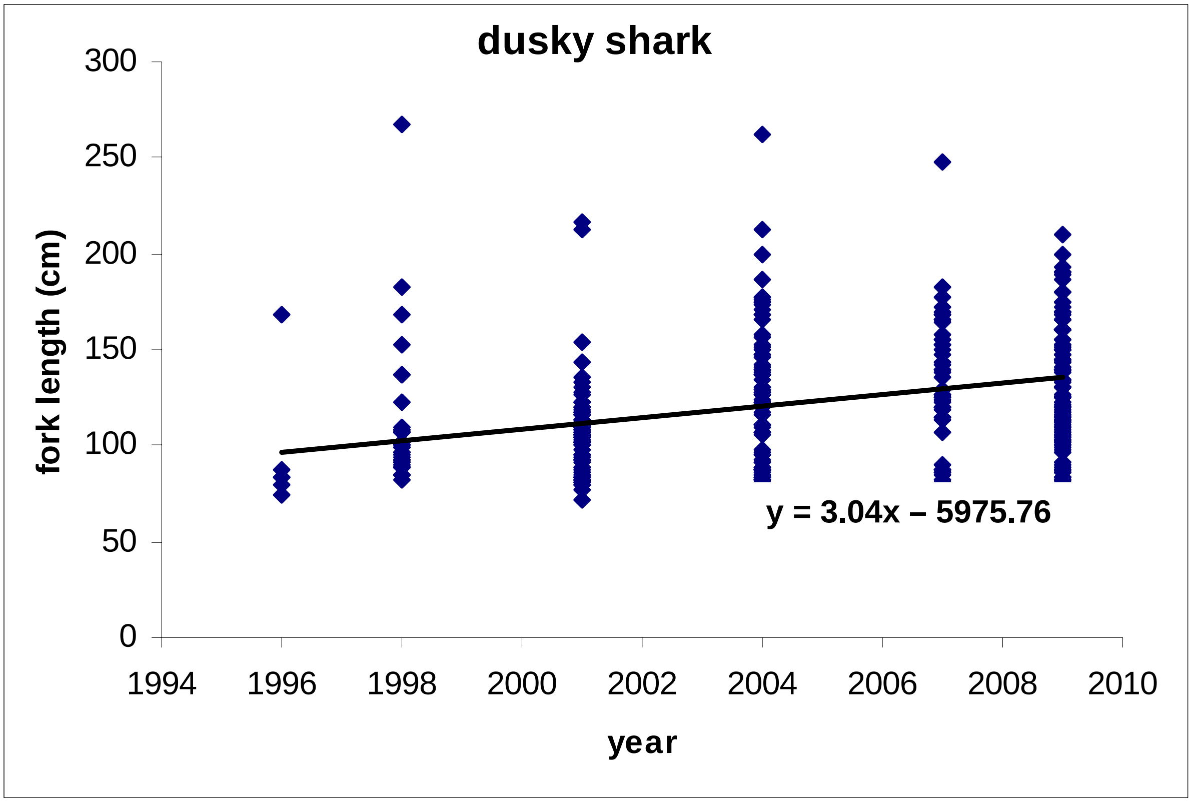


Figure 5. Fork lengths (cm) of dusky sharks caught by year



6a. Dusky shark model diagnostic plots for the binomial component.

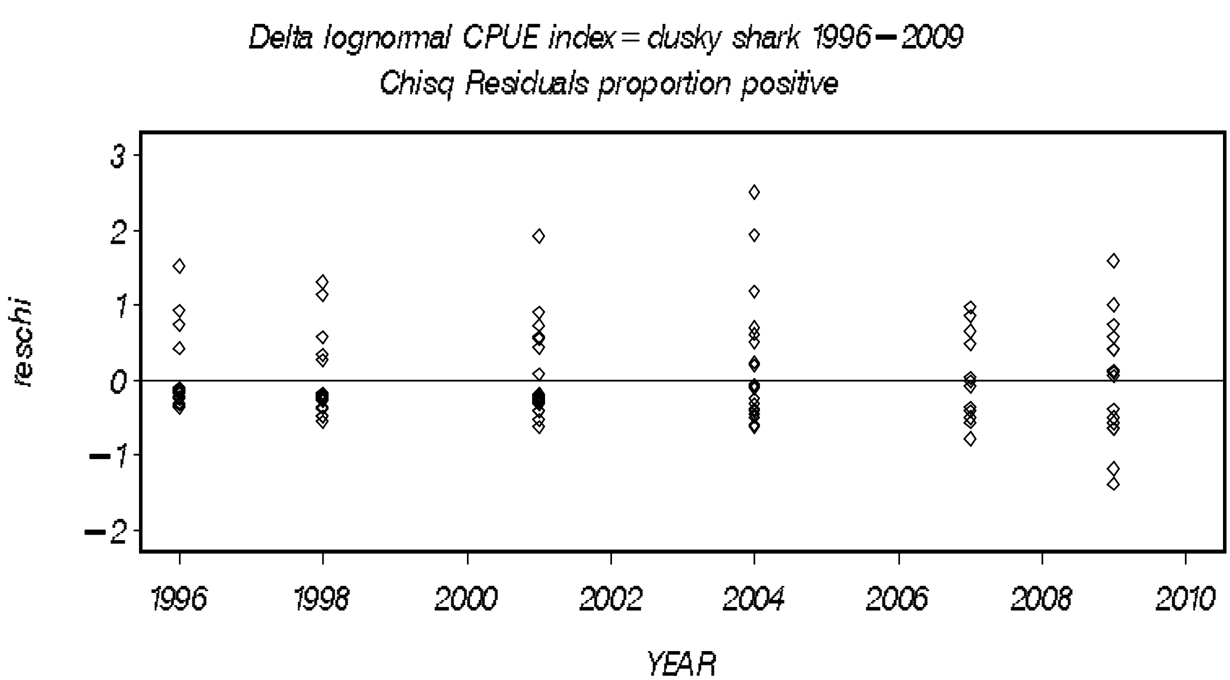
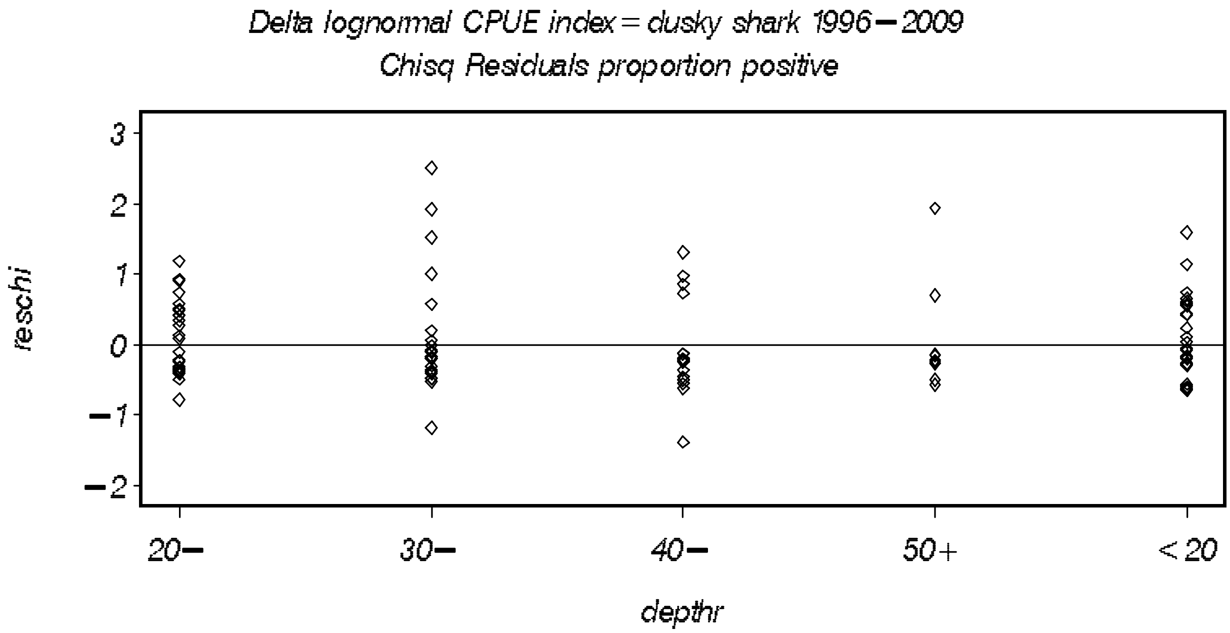


Figure 6a continued. Dusky shark model diagnostic plots for the binomial component.



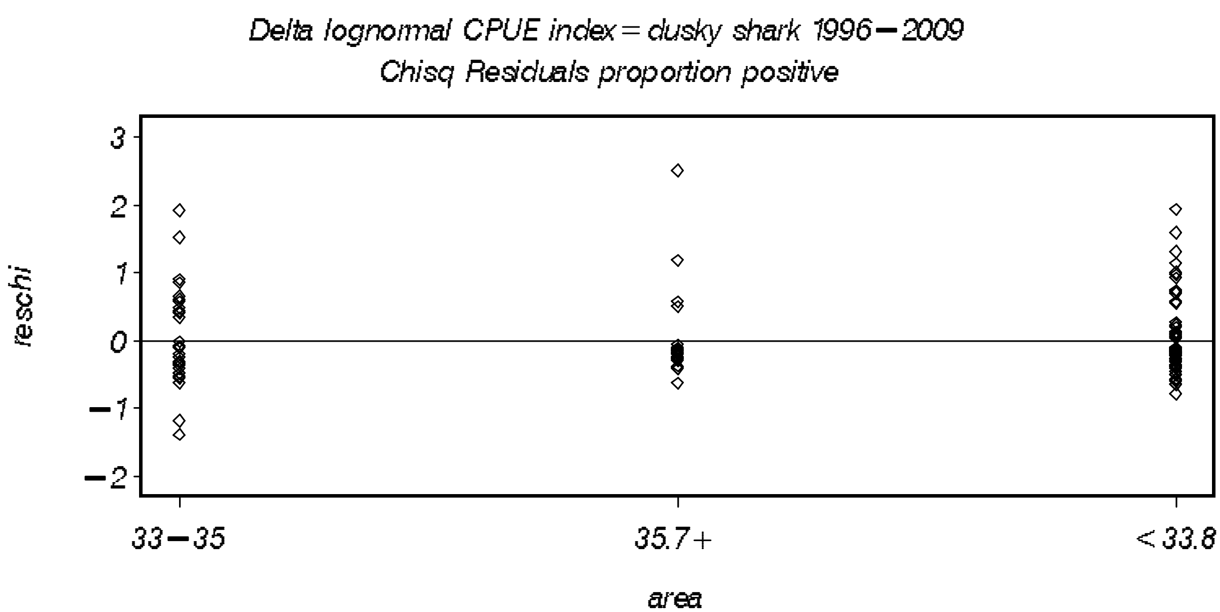


Figure 6a continued. Dusky shark model diagnostic plots for the binomial component.

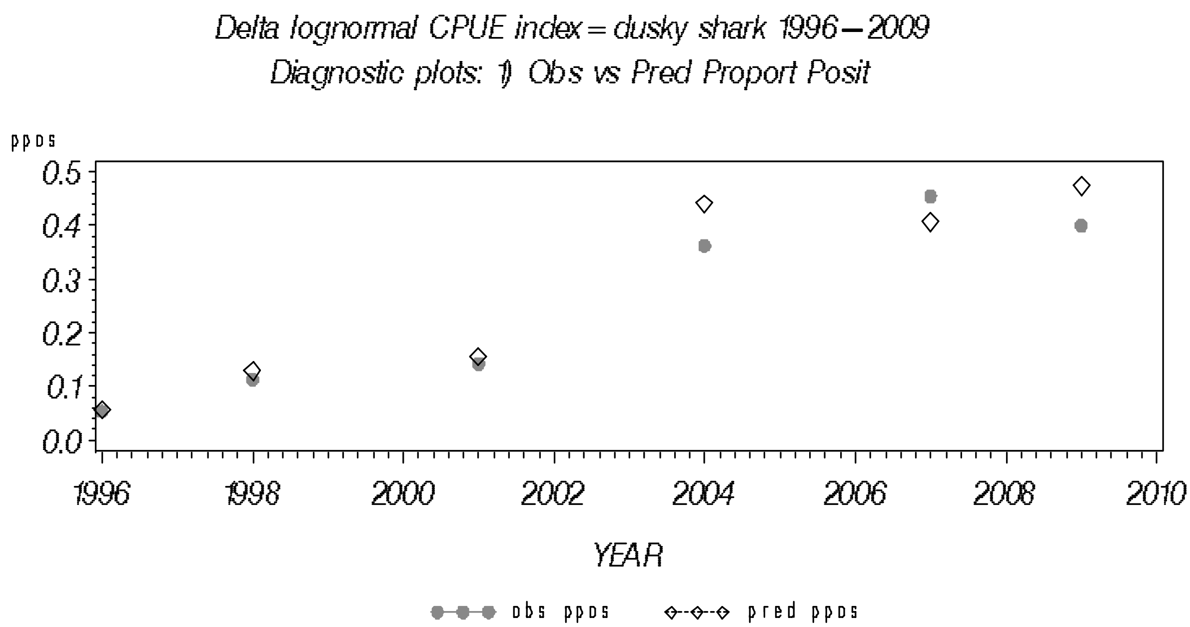


Figure 6b. Dusky shark model diagnostic plots for the lognormal component.

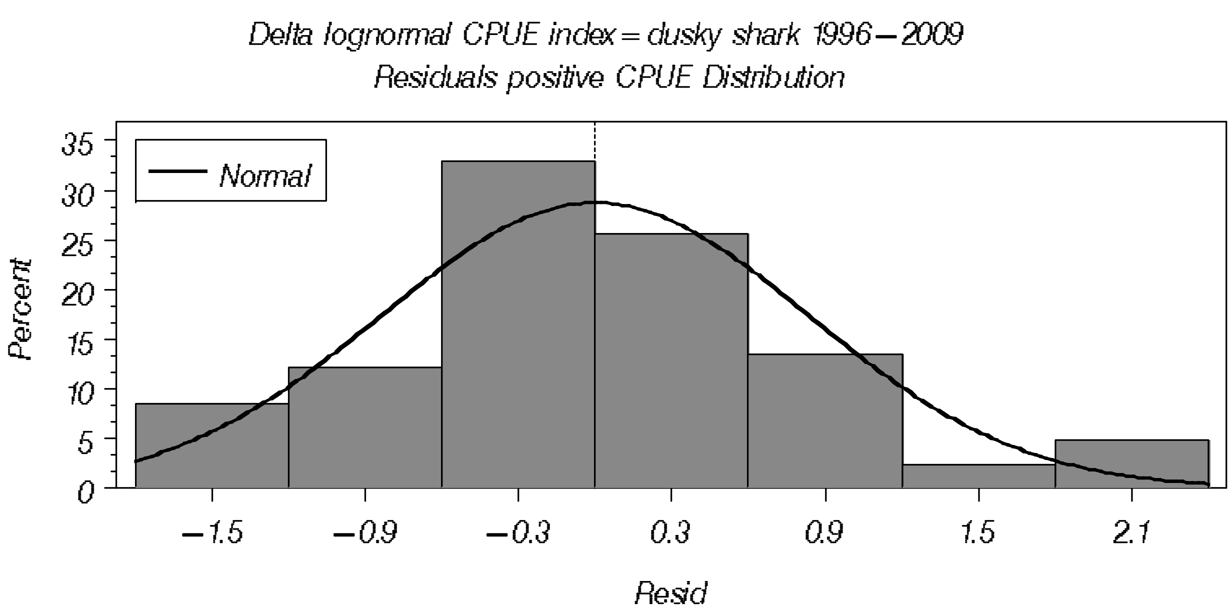
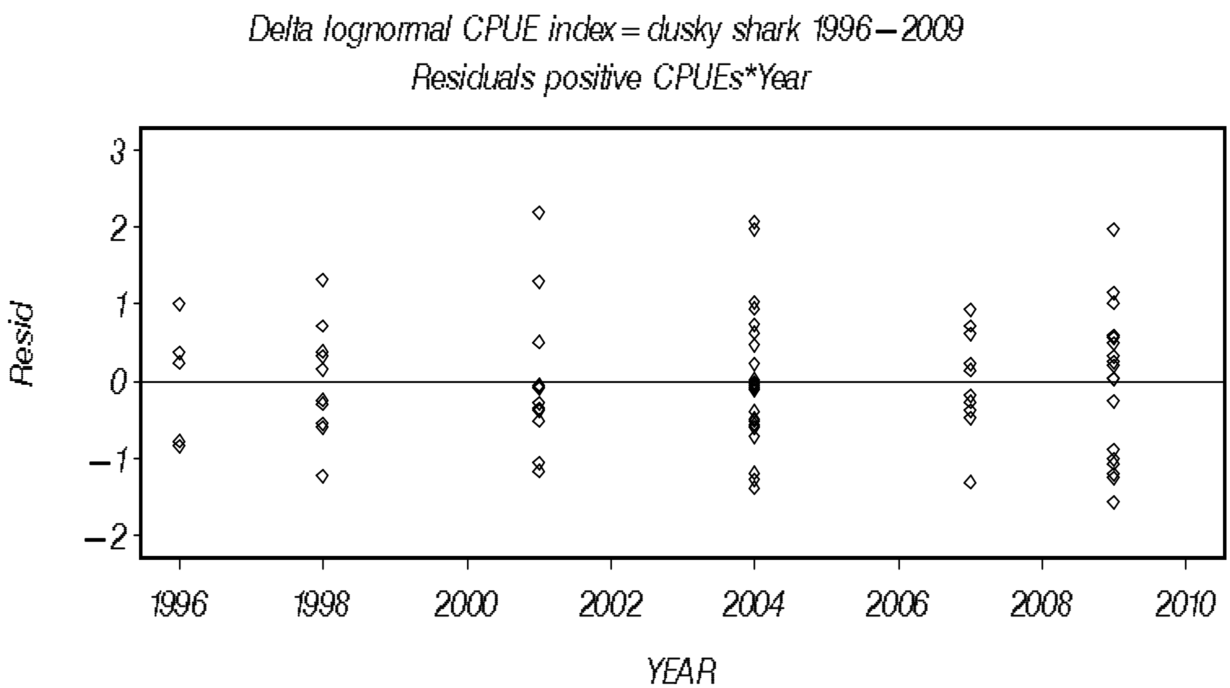


Figure 6b continued. Dusky shark model diagnostic plots for the lognormal component.



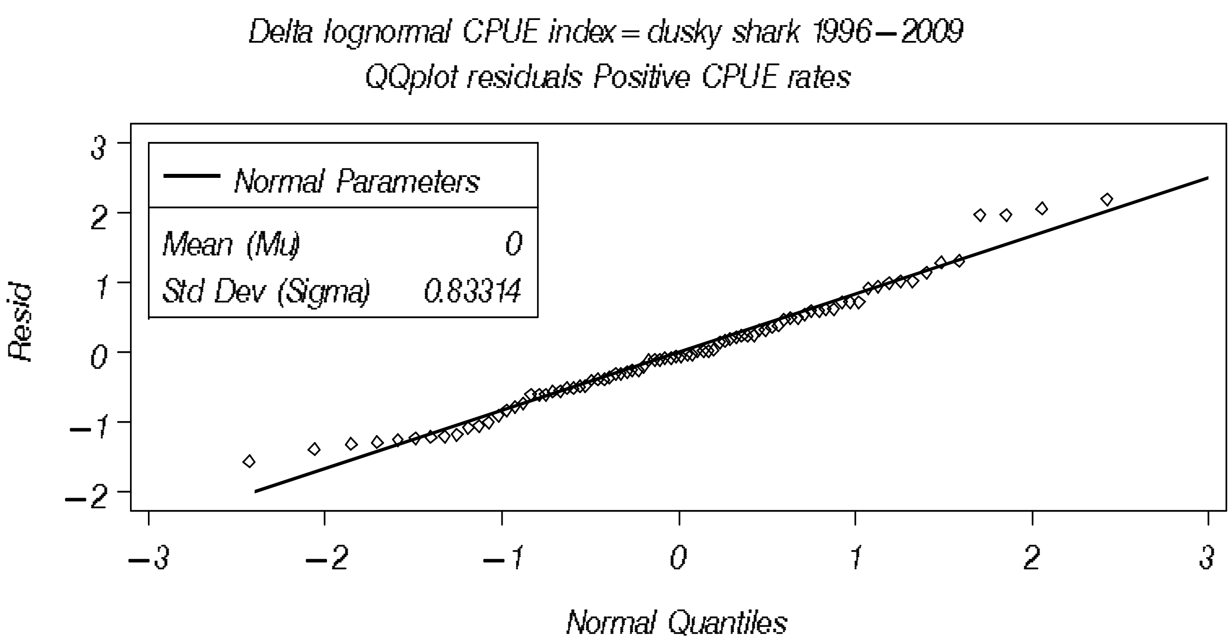


Figure 7. Dusky shark nominal (obscpue1) and estimated (STDCPUE1) indices divided by the mean values with 95% confidence limits (LCL1, UCL1).