Standardized indices of abundance for Atlantic sharpnose sharks from the University of North Carolina bottom longline survey

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SEDAR34-WP-38

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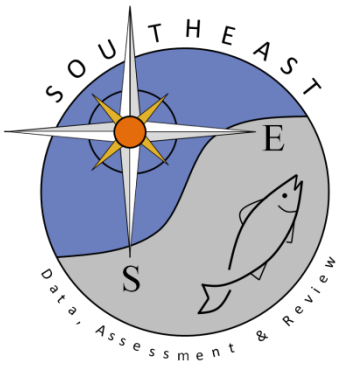

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SEDAR 34 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for Atlantic sharpnose sharks from the University of North Carolina bottom longline survey

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Summary

This document details the Atlantic sharpnose shark catch from April-November, 1972-2011, at two fixed stations in Onslow Bay south of Shackleford Banks, North Carolina. Catch per unit effort (CPUE) by set in number of sharks per number of set hooks were examined by year. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. No Atlantic sharpnose sharks were caught during the three longline sets conducted in 1972. The nominal and standardized relative abundance for Atlantic sharpnose sharks show an increasing trend throughout the majority of the time series that peaks in 2005 and then appears to decrease during the remaining years, ending in 2011.

Introduction

In North Carolina waters, information about sharks was limited prior to 1972. This led to the establishment of a bi-weekly longline survey (April-November, 1972-2011) conducted at two fixed stations south of Shackleford Banks in Onslow Bay, North Carolina by the University of North Carolina (UNC), Institute of Marine Sciences. The survey's objective was to define what sharks occurred in the area, their sizes, life stages, relative abundances and seasonal occurrences. Relative abundance indices from this survey have been previously generated for Atlantic sharpnose sharks covering the time period from 1972 to 2005 (Schwartz et al. 2007). In this document, these time series are updated with data through 2011, including recovered temperature data and data corrections detailing missing water hauls and missing or incorrect information pertaining to individual animal records.

Methods

Sampling gear

An unanchored longline, approximately 4.8 km long of braided nylon (about 7.6 mm diameter) was suspended by orange 1.3 m diameter polyfoam plastic floats spaced every 10 hooks, spacing between hooks was 4.5 m. Gangions were 1.8 m long of No. 2 (95 kg) porch swing chain terminating in a No. 9 Mustad tuna hook. This gear was not altered throughout the 30 + years of sampling. The number of hooks varied more during early sample years and less during later years, rarely less than 100 hooks per set. Bait was fresh fish trawled near Beaufort Inlet, North Carolina, usually consisting of spot *Leiostomus xanthus* and Atlantic croaker *Micropogonias undulatus*, occasionally pigfish *Orthopristis chrysptera* and pinfish *Lagodon rhombiodes*.

Survey design

A bi-weekly shark survey occurred between April and November at two fixed stations 1-3.4 km south of Shackleford Banks in Onslow Bay, NC. The daily sampling protocol generally included an early morning set at the east-west (E-W) station, followed by a later set in the day at the north-south (N-S) station. The shallow (13 m) E-W set was over sandy-silt and the deeper (22 m) N-S set was primarily over sandy areas. Weather occasionally prevented occupying both stations on a single day. Soak time was one hour, to avoid longer intervals that would often produce dead or dying sharks. Surface water temperatures were recorded at the beginning of the set. Fork length and sex were recorded for each shark species caught. Any specimen that was partially eaten, damaged or lost during line retrieval was counted but not measured.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per hook were used to examine the relative abundance of total and age 1+ Atlantic sharpnose sharks caught during the UNC longline survey conducted between 1972

and 2011 in Onslow Bay, NC. For the purposes of this SEDAR process, male Atlantic sharpnose sharks smaller than 38 cm fork length, and female Atlantic sharpnose sharks smaller than 43 cm fork length were considered to be young-of-the-year sharks and excluded from analyses of age 1+ sharks. 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 the CPUE for these analyses were: year (1972 – 2011), month (April – November), station (E-W, N-S), and temperature (<20 deg C, 20-24 deg C, 25-29 deg C, and 30+ deg C). The proportion of sets with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE 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. 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). The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and lognormal components.

Results

Total Atlantic sharpnose sharks

A total of 3111 Atlantic sharpnose sharks were caught during 951 longline sets from 1972 to 2011. The proportion of sets with positive catch (at least one A. sharpnose shark caught) was 58%. 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 1a and 1b). 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 2.

Age 1+ Atlantic sharpnose sharks

A total of 2907 age 1+ Atlantic sharpnose sharks were caught during 951 longline sets from 1972 to 2011. The size range of age 1+ Atlantic sharpnose sharks caught by year is displayed in Figure 3. The proportion of sets with positive catch (at least one A. sharpnose shark caught) was 55%. 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 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 4 and are plotted by year in Figure 5.

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.

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Table 1. Results of the stepwise procedure for development of the UNC longline survey catch rate model for total Atlantic sharpnose 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	623	909.8267	1.4604				
YEAR	584	699.3337	1.1975	18.0019	18.0019	100.46	<.0001
TEMP	620	859.2861	1.3859	5.1013		50.54	<.0001
MONTH	616	855.7359	1.3892	4.8754		54.09	<.0001
STATION	621	908.5026	1.4630	-0.1780		1.32	0.5158
YEAR +							
MONTH	577	652.3239	1.1305	22.5897	4.5878	37.03	<.0001
TEMP	581	669.3075	1.1520	21.1175	3.1156	21.47	<.0001
YEAR + MONTH							
TEMP	574	641.1690	1.1170	23.5141	0.9244	8.74	0.0329

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + MONTH	822.8	1057.5	811.0

Type 3 Test of Fixed Effects

Fixed effect	YEAR	MONTH
Significance (Pr>Chi)	<.0001	<.0001
DF	37	7
CHI SQUARE	109.85	37.03

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	493	466.8036	0.9469				
YEAR	455	343.7371	0.7555	20.2133	20.2133	151.18	<.0001
MONTH	486	440.6213	0.9066	4.2560		28.52	0.0002
TEMP	490	464.0656	0.9471	-0.0211		2.91	0.4063
STATION	491	465.5126	0.9481	-0.1267		1.37	0.5046
YEAR +							
MONTH	448	317.1248	0.7079	25.2403	5.0269	39.81	<.0001

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + MONTH	207.5	209.7	205.5

Type 3 Test of Fixed Effects

Fixed effect	YEAR	MONTH
Significance (Pr>Chi)	<.0001	<.0001
DF	38	7
CHI SQUARE	162.47	39.81

Table 2. UNC longline survey total Atlantic sharpnose shark analysis number of model observations per year (obs n), number of positive model observations per year (obs pos), proportion of positive model observations 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 (LCI), the upper 95% confidence limit for the est cpue (UCI), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
1972	3	0	0.0000	0.0000	.	.	.	.
1973	9	4	0.4444	0.0102	0.0100	0.0026	0.0390	0.7688
1974	15	2	0.1333	0.0037	0.0039	0.0006	0.0246	1.1661
1975	19	6	0.3158	0.0087	0.0087	0.0026	0.0285	0.6522
1976	25	4	0.1600	0.0032	0.0043	0.0010	0.0184	0.8303
1977	29	6	0.2069	0.0071	0.0071	0.0021	0.0240	0.6692
1978	23	10	0.4348	0.0161	0.0159	0.0065	0.0388	0.4699
1979	26	11	0.4231	0.0103	0.0119	0.0049	0.0286	0.4610
1980	25	12	0.4800	0.0123	0.0102	0.0045	0.0231	0.4266
1981	26	10	0.3846	0.0072	0.0072	0.0028	0.0188	0.5036
1982	31	10	0.3226	0.0028	0.0038	0.0015	0.0099	0.5023
1983	29	16	0.5517	0.0131	0.0155	0.0078	0.0310	0.3565
1984	29	16	0.5517	0.0099	0.0101	0.0050	0.0204	0.3624
1985	27	15	0.5556	0.0162	0.0125	0.0058	0.0266	0.3937
1986	22	7	0.3182	0.0149	0.0136	0.0045	0.0414	0.6005
1987	21	12	0.5714	0.0205	0.0179	0.0081	0.0395	0.4112
1988	24	15	0.6400	0.0361	0.0334	0.0171	0.0656	0.3465
1989	25	10	0.3846	0.0144	0.0124	0.0048	0.0319	0.5008
1990	19	13	0.6842	0.0217	0.0169	0.0085	0.0337	0.3551
1991	19	13	0.7000	0.0350	0.0274	0.0137	0.0548	0.3578
1992	14	12	0.8667	0.0676	0.0538	0.0289	0.1002	0.3187
1993	14	7	0.5000	0.0540	0.0312	0.0105	0.0926	0.5875
1994	19	11	0.6000	0.0325	0.0273	0.0125	0.0596	0.4058
1995	19	12	0.6316	0.0575	0.0492	0.0232	0.1041	0.3888
1996	20	15	0.7727	0.0292	0.0218	0.0121	0.0395	0.3030
1997	24	15	0.6250	0.0314	0.0313	0.0157	0.0626	0.3563
1998	23	19	0.8261	0.0367	0.0366	0.0219	0.0612	0.2612
1999	21	16	0.7619	0.0322	0.0328	0.0181	0.0594	0.3041
2000	21	18	0.8571	0.0428	0.0442	0.0259	0.0756	0.2730
2001	13	13	1.0000	0.0654	.	.	.	.
2002	21	17	0.8095	0.0494	0.0423	0.0237	0.0752	0.2946
2003	19	16	0.8421	0.0726	0.0871	0.0500	0.1519	0.2831
2004	16	13	0.8235	0.0686	0.0684	0.0378	0.1240	0.3039
2005	18	17	0.9444	0.0932	0.1059	0.0663	0.1690	0.2370
2006	25	24	0.9600	0.0473	0.0593	0.0401	0.0877	0.1972
2007	21	18	0.8571	0.0600	0.0647	0.0386	0.1084	0.2623
2008	20	16	0.8000	0.0573	0.0669	0.0373	0.1200	0.2982
2009	15	12	0.8000	0.0414	0.0404	0.0205	0.0798	0.3498
2010	15	13	0.8667	0.0605	0.0655	0.0349	0.1232	0.3236
2011	24	21	0.8750	0.0321	0.0349	0.0218	0.0557	0.2373

Table 3. Results of the stepwise procedure for development of the UNC longline survey catch rate model for age 1+ Atlantic sharpnose 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	623	905.4292	1.4533				
YEAR	584	705.7455	1.2085	16.8444	16.8444	100.46	<.0001
MONTH	616	847.8909	1.3764	5.2914		57.54	<.0001
TEMP	620	859.5158	1.3863	4.6102		45.91	<.0001
STATION	621	904.3207	1.4562	-0.1995		1.11	0.5745
YEAR +							
MONTH	577	652.1758	1.1303	22.2253	5.3809	37.03	<.0001
TEMP	581	677.5535	1.1662	19.7550	2.9106	Negative of Hessian not positive definite	

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + MONTH	837.7	843.6	842.5

Type 3 Test of Fixed Effects

Fixed effect	YEAR	MONTH
Significance (Pr>Chi)	<.0001	<.0001
DF	37	7
CHI SQUARE	109.85	37.03

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	473	439.7513	0.9297				
YEAR	435	328.2013	0.7545	18.8448	18.8448	138.68	<.0001
MONTH	466	411.0048	0.8820	5.1307		32.04	<.0001
TEMP	470	435.8849	0.9274	0.2474		4.19	0.2421
STATION	471	438.4904	0.9310	-0.1398		1.36	0.5064
YEAR +							
MONTH	428	299.3489	0.6994	24.7714	5.9266	43.62	<.0001

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + MONTH	1221.3	1416.9	1127.3

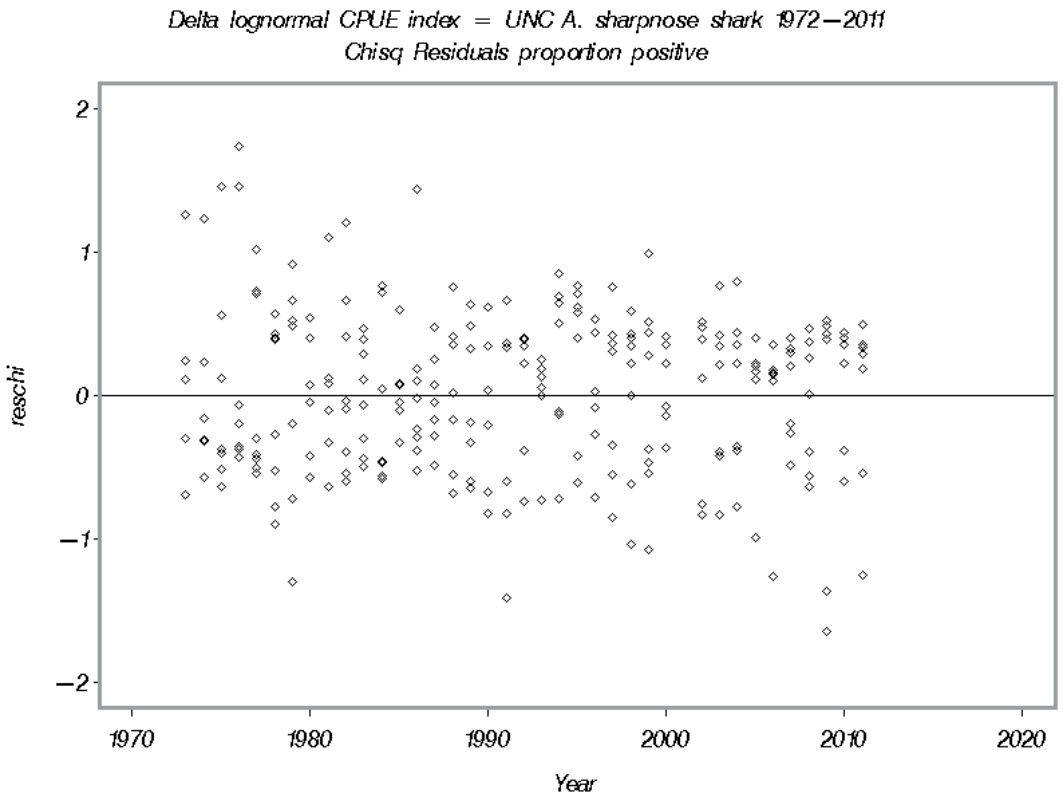
Type 3 Test of Fixed Effects

Fixed effect	YEAR	MONTH
Significance (Pr>Chi)	<.0001	<.0001
DF	38	7
CHI SQUARE	150.26	43.62

Table 4. UNC longline survey age 1+ Atlantic sharpnose shark analysis number of model observations per year (obs n), number of positive model observations per year (obs pos), proportion of positive model observations 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 (LCI), the upper 95% confidence limit for the est cpue (UCI), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
1972	3	0	0	0	.	.	.	.
1973	9	4	0.4444	0.0102	0.0100	0.0026	0.0390	0.7688
1974	15	2	0.1333	0.0037	0.0039	0.0006	0.0246	1.1661
1975	19	6	0.3158	0.0087	0.0087	0.0026	0.0285	0.6522
1976	25	4	0.1600	0.0032	0.0043	0.0010	0.0184	0.8303
1977	29	6	0.2069	0.0071	0.0071	0.0021	0.0240	0.6692
1978	23	10	0.4348	0.0161	0.0159	0.0065	0.0388	0.4699
1979	26	11	0.4231	0.0103	0.0119	0.0049	0.0286	0.4610
1980	25	12	0.4800	0.0123	0.0102	0.0045	0.0231	0.4266
1981	26	10	0.3846	0.0072	0.0072	0.0028	0.0188	0.5036
1982	31	10	0.3226	0.0028	0.0038	0.0015	0.0099	0.5023
1983	29	16	0.5517	0.0131	0.0155	0.0078	0.0310	0.3565
1984	29	16	0.5517	0.0099	0.0101	0.0050	0.0204	0.3624
1985	27	15	0.5556	0.0162	0.0125	0.0058	0.0266	0.3937
1986	22	7	0.3182	0.0149	0.0136	0.0045	0.0414	0.6005
1987	21	12	0.5714	0.0205	0.0179	0.0081	0.0395	0.4112
1988	24	15	0.6400	0.0361	0.0334	0.0171	0.0656	0.3465
1989	25	10	0.3846	0.0144	0.0124	0.0048	0.0319	0.5008
1990	19	13	0.6842	0.0217	0.0169	0.0085	0.0337	0.3551
1991	19	13	0.7000	0.0350	0.0274	0.0137	0.0548	0.3578
1992	14	12	0.8667	0.0676	0.0538	0.0289	0.1002	0.3187
1993	14	7	0.5000	0.0540	0.0312	0.0105	0.0926	0.5875
1994	19	11	0.6000	0.0325	0.0273	0.0125	0.0596	0.4058
1995	19	12	0.6316	0.0575	0.0492	0.0232	0.1041	0.3888
1996	20	15	0.7727	0.0292	0.0218	0.0121	0.0395	0.3030
1997	24	15	0.6250	0.0314	0.0313	0.0157	0.0626	0.3563
1998	23	19	0.8261	0.0367	0.0366	0.0219	0.0612	0.2612
1999	21	16	0.7619	0.0322	0.0328	0.0181	0.0594	0.3041
2000	21	18	0.8571	0.0428	0.0442	0.0259	0.0756	0.2730
2001	13	13	1.0000	0.0654	.	.	.	.
2002	21	17	0.8095	0.0494	0.0423	0.0237	0.0752	0.2946
2003	19	16	0.8421	0.0726	0.0871	0.0500	0.1519	0.2831
2004	16	13	0.8235	0.0686	0.0684	0.0378	0.1240	0.3039
2005	18	17	0.9444	0.0932	0.1059	0.0663	0.1690	0.2370
2006	25	24	0.9600	0.0473	0.0593	0.0401	0.0877	0.1972
2007	21	18	0.8571	0.0600	0.0647	0.0386	0.1084	0.2623
2008	20	16	0.8000	0.0573	0.0669	0.0373	0.1200	0.2982
2009	15	12	0.8000	0.0414	0.0404	0.0205	0.0798	0.3498
2010	15	13	0.8667	0.0605	0.0655	0.0349	0.1232	0.3236
2011	24	21	0.8750	0.0321	0.0349	0.0218	0.0557	0.2373

Figure 1a. Total Atlantic sharpnose shark model diagnostic plots for the binomial component.



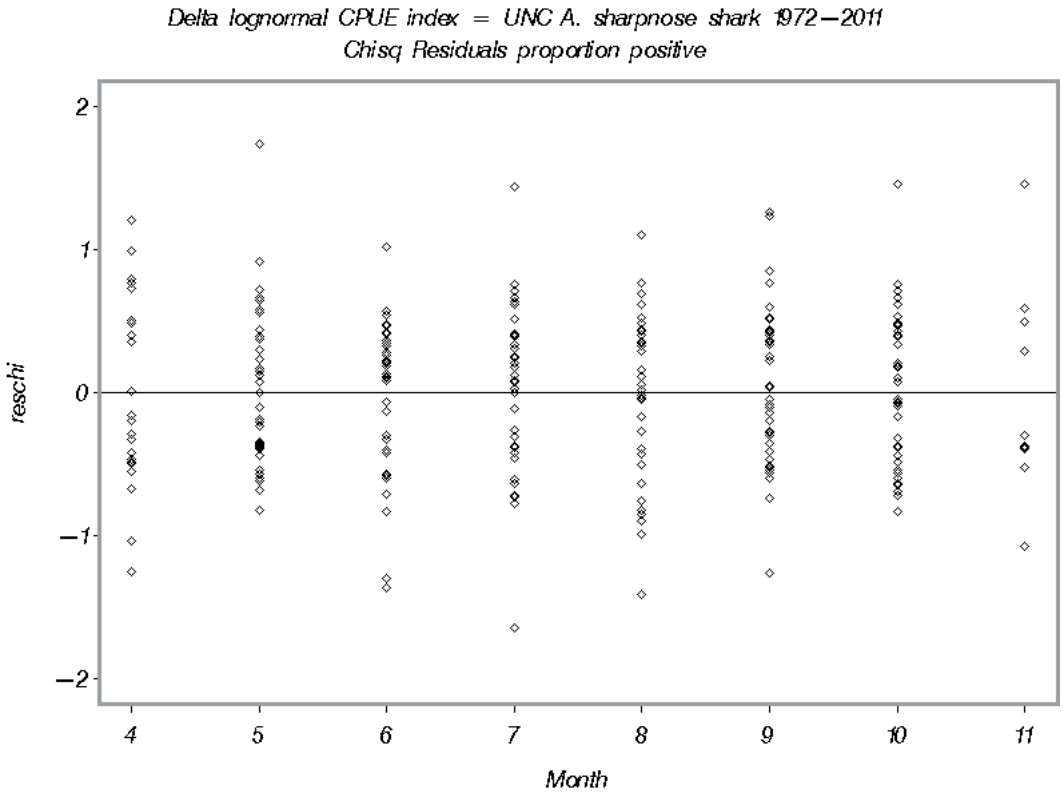


Figure 1a continued. Total Atlantic sharpnose shark model diagnostic plots for the binomial component.

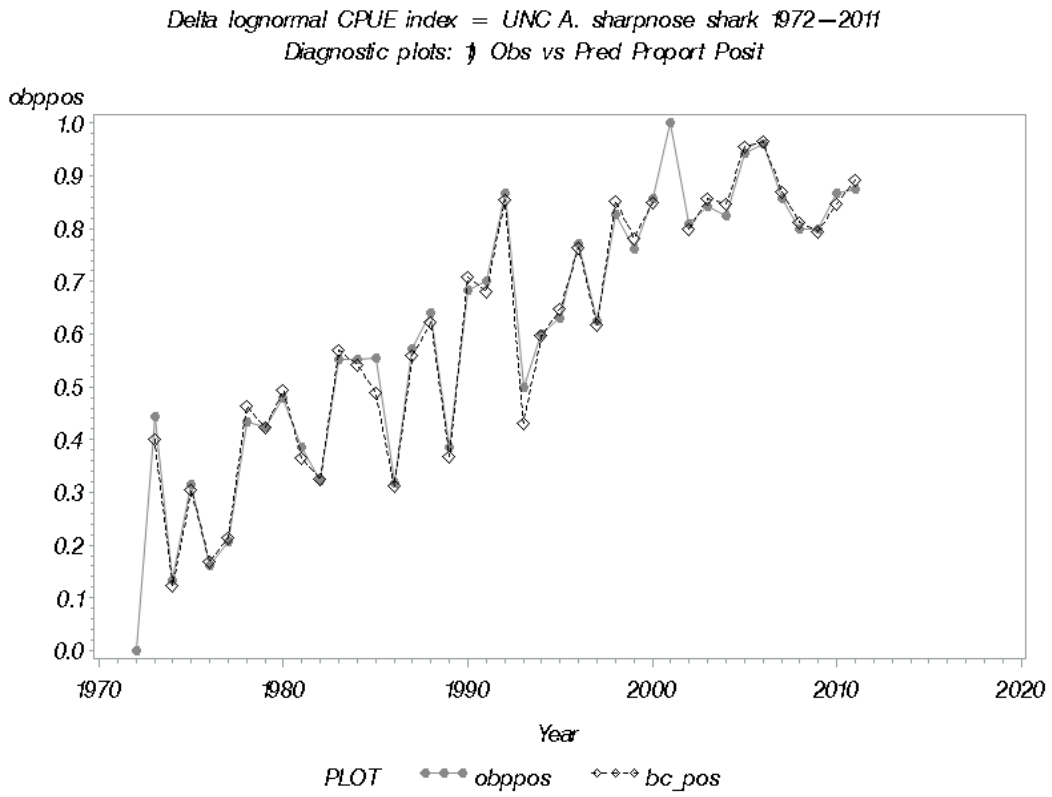


Figure 1b. Total Atlantic sharpnose shark model diagnostic plots for lognormal component.

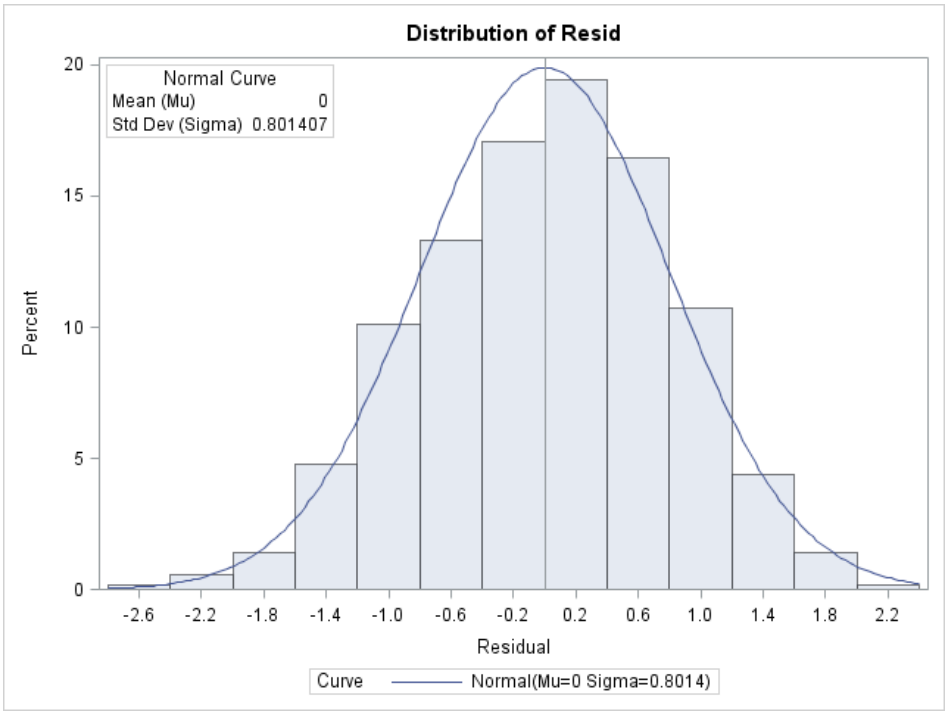
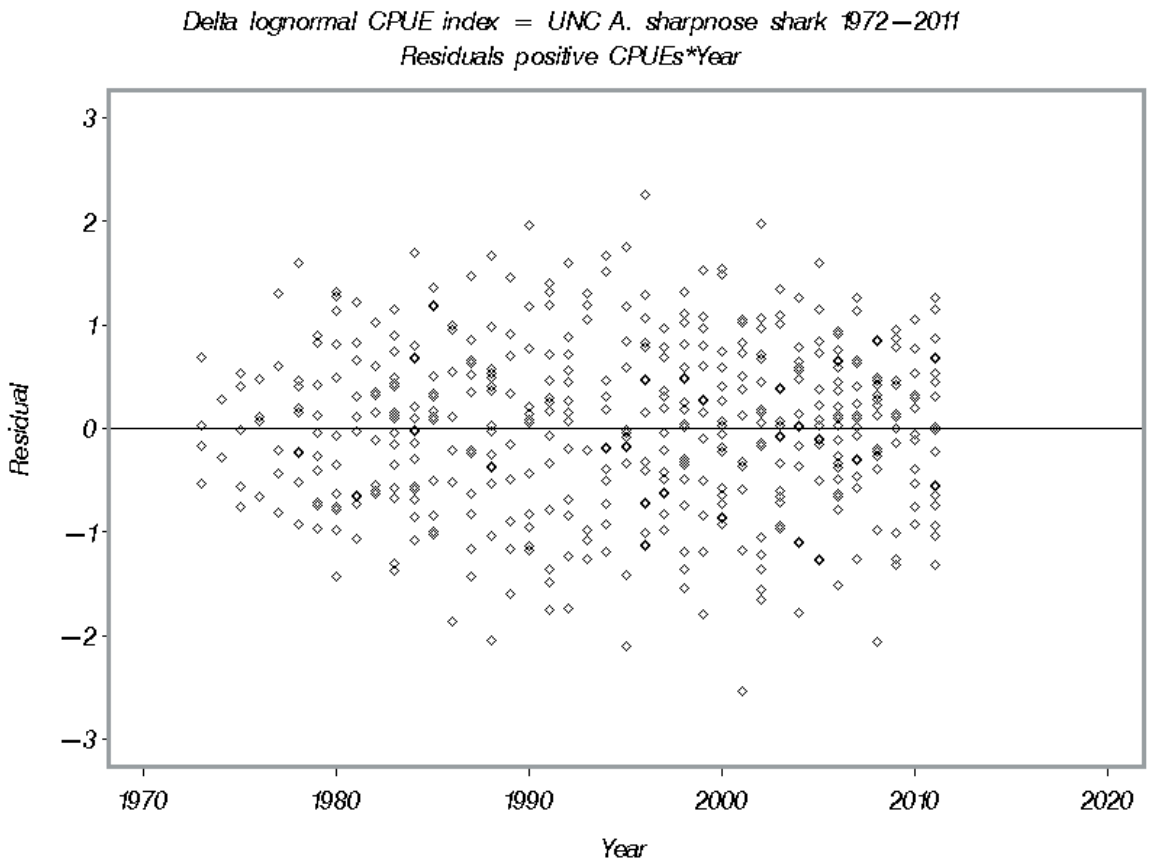


Figure 1b continued. Total Atlantic sharpnose shark model diagnostic plots for lognormal component.



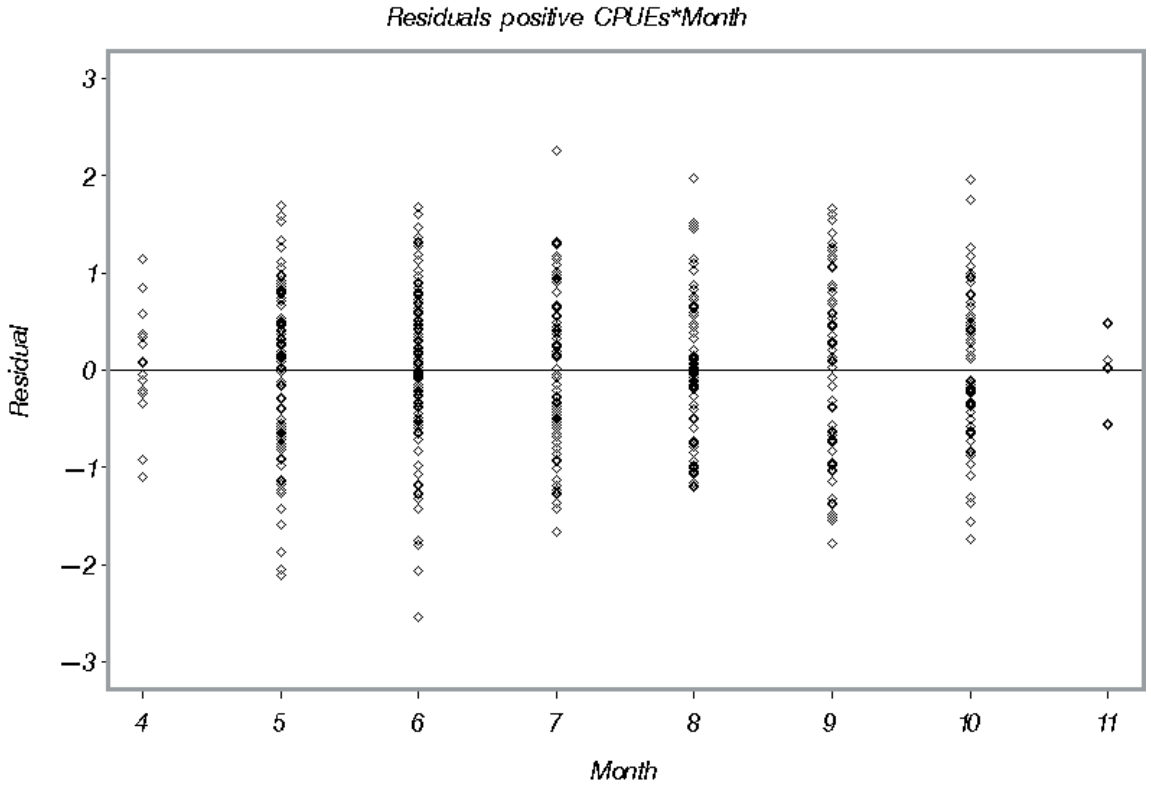


Figure 1b continued. Total Atlantic sharpnose shark model diagnostic plots for lognormal component.

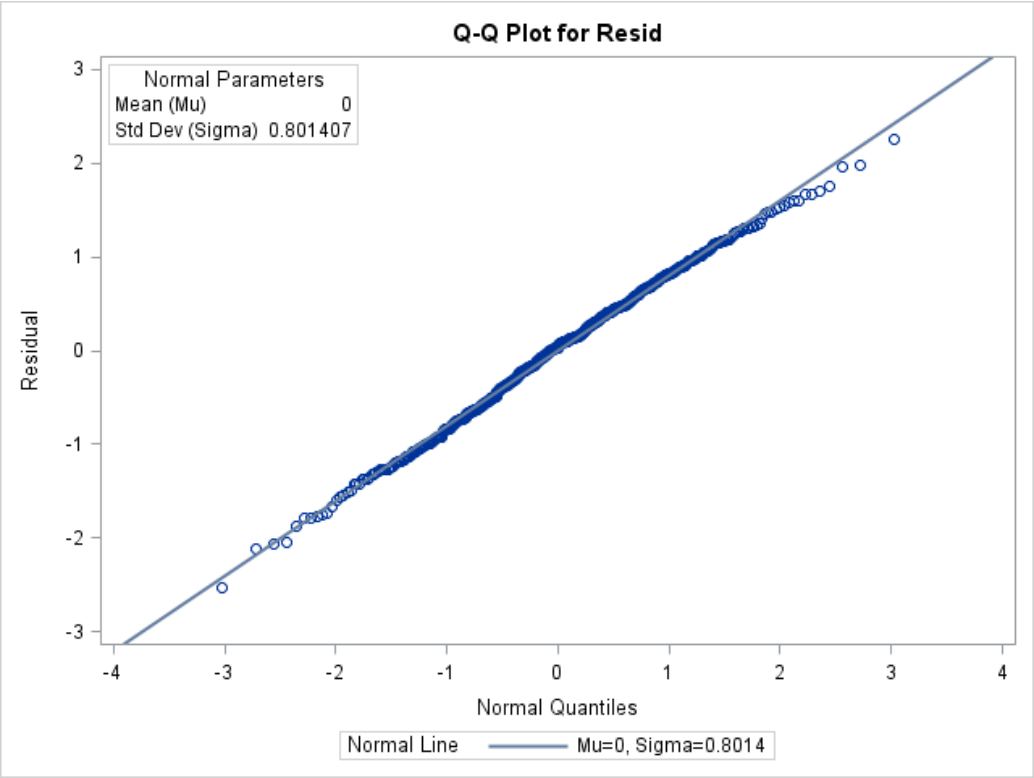


Figure 2. UNC longline survey total Atlantic sharpnose shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCL0, UCL0).

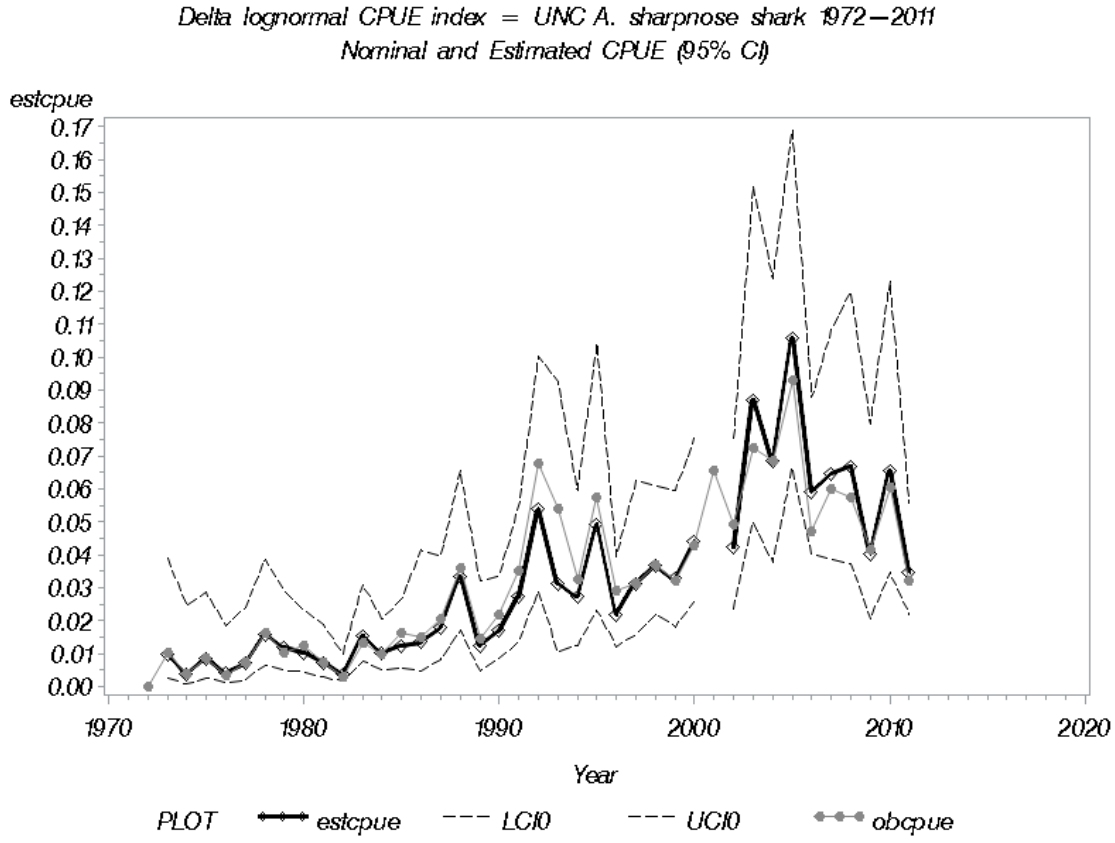


Figure 3. Fork lengths (cm) of age 1+ Atlantic sharpnose sharks caught during the UNC longline survey from 1973-2011.

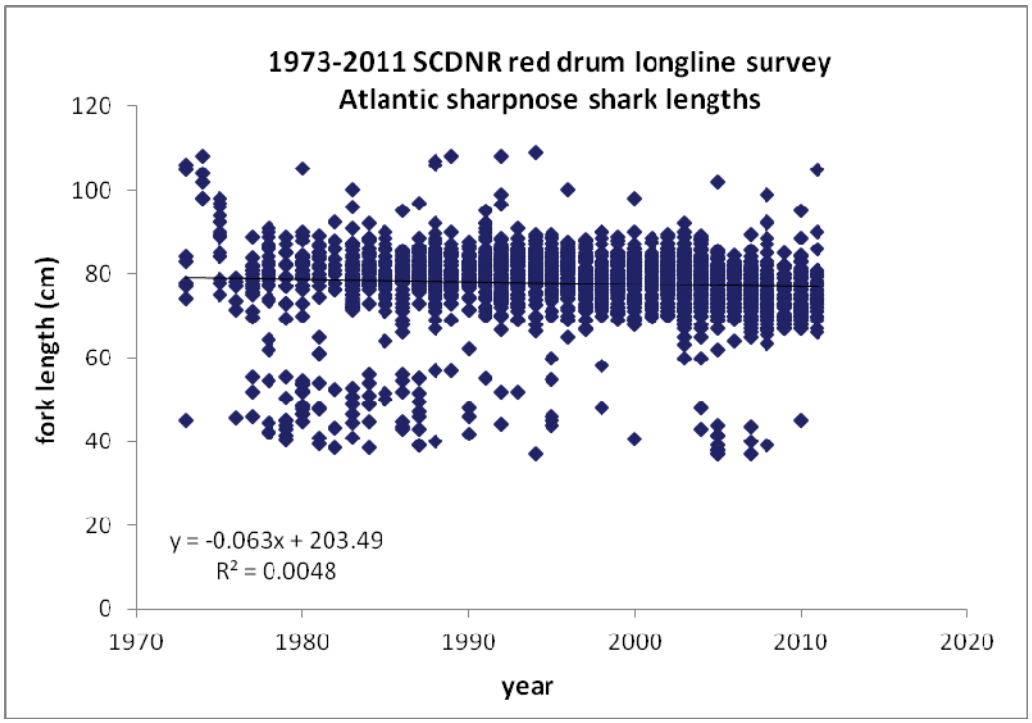


Figure 4a. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.

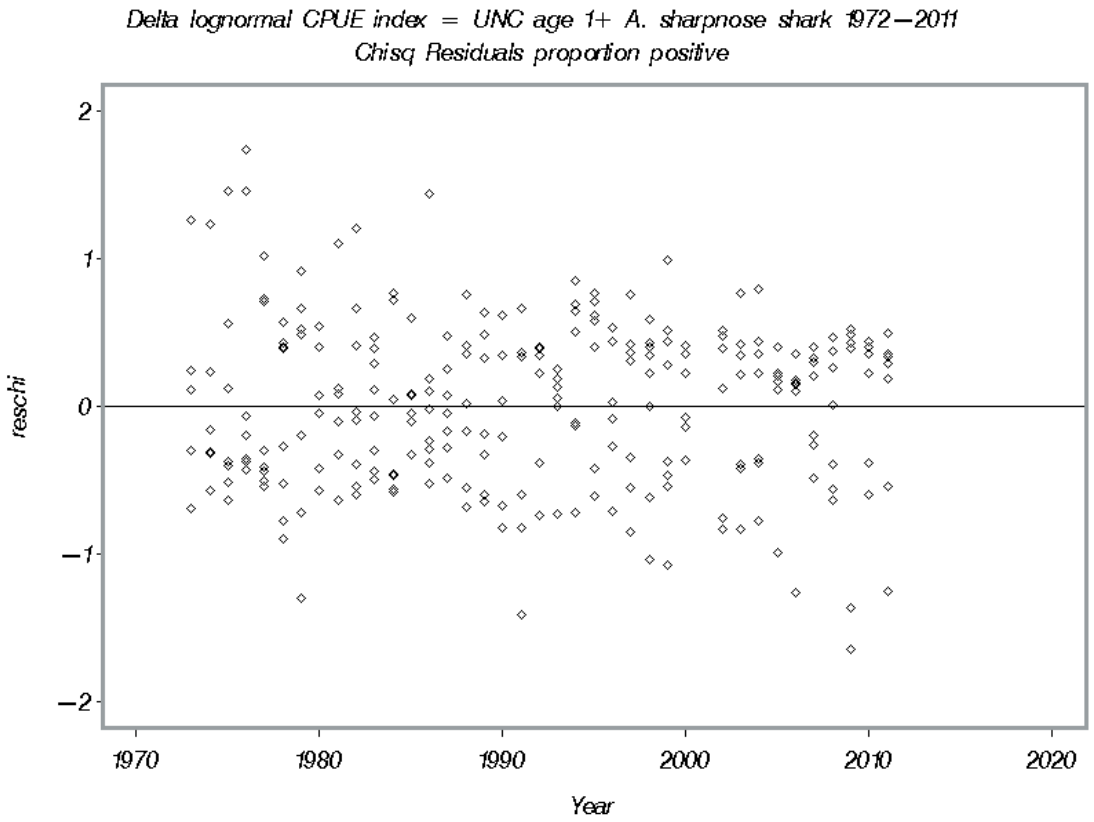
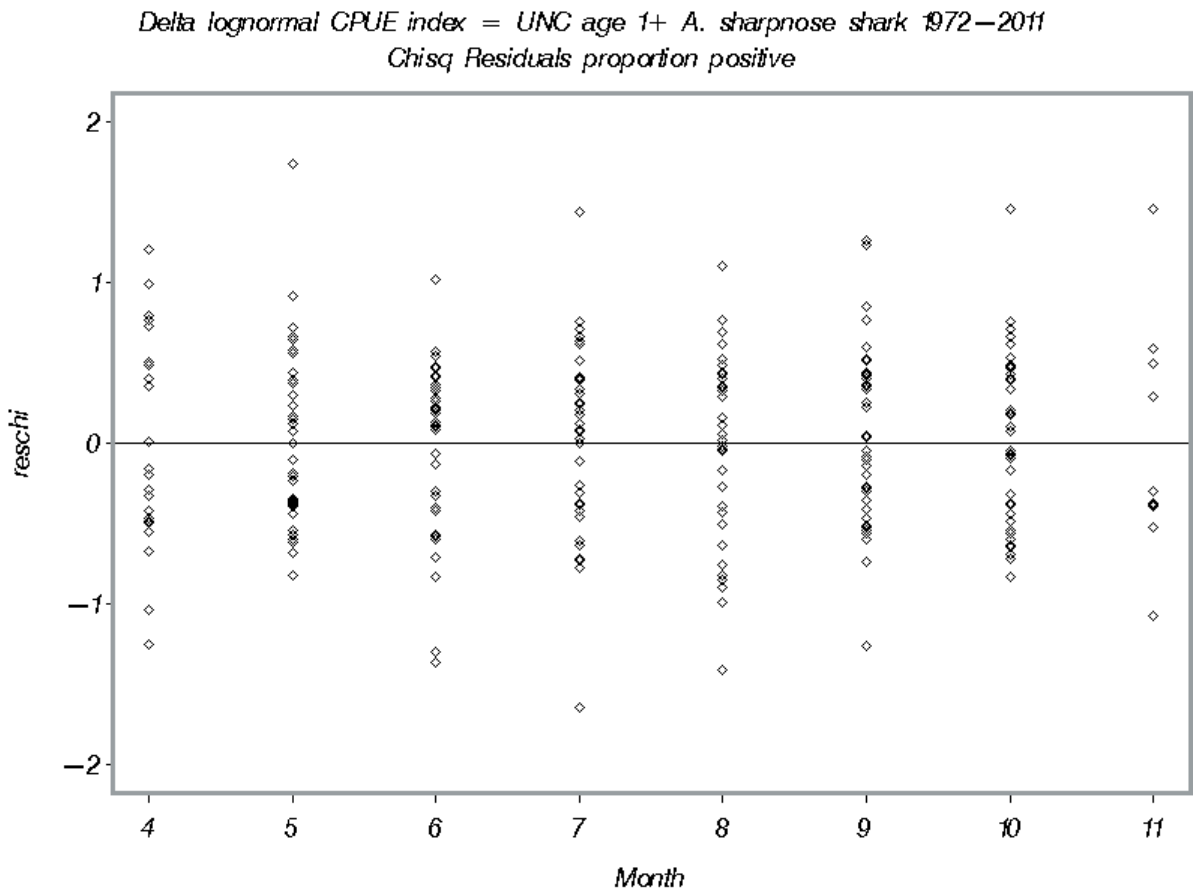


Figure 4a continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.



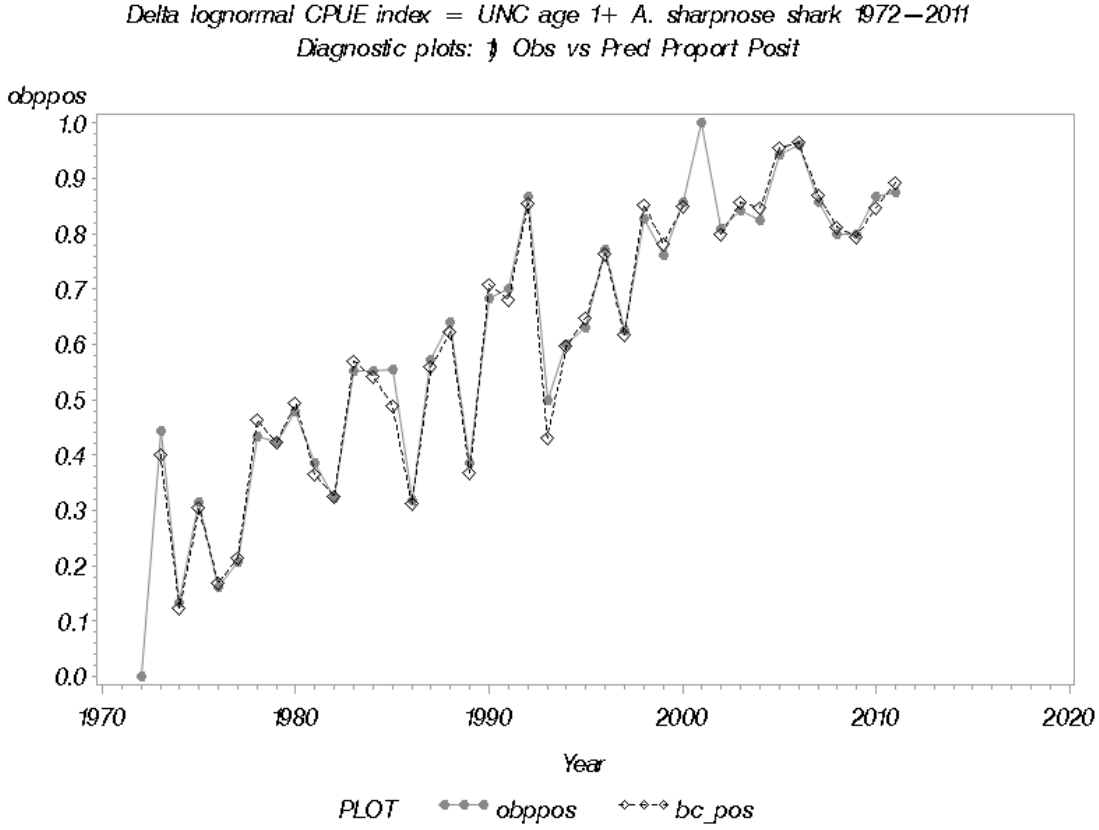
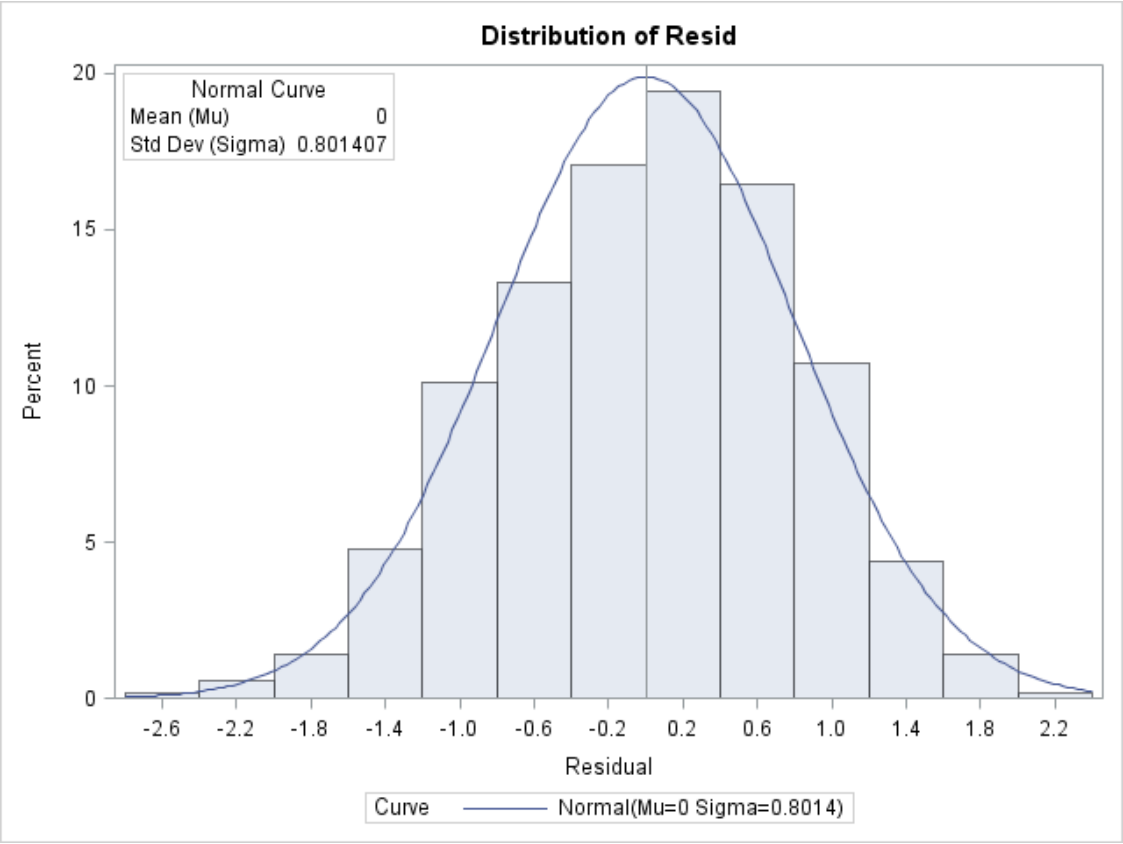


Figure 4b. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.



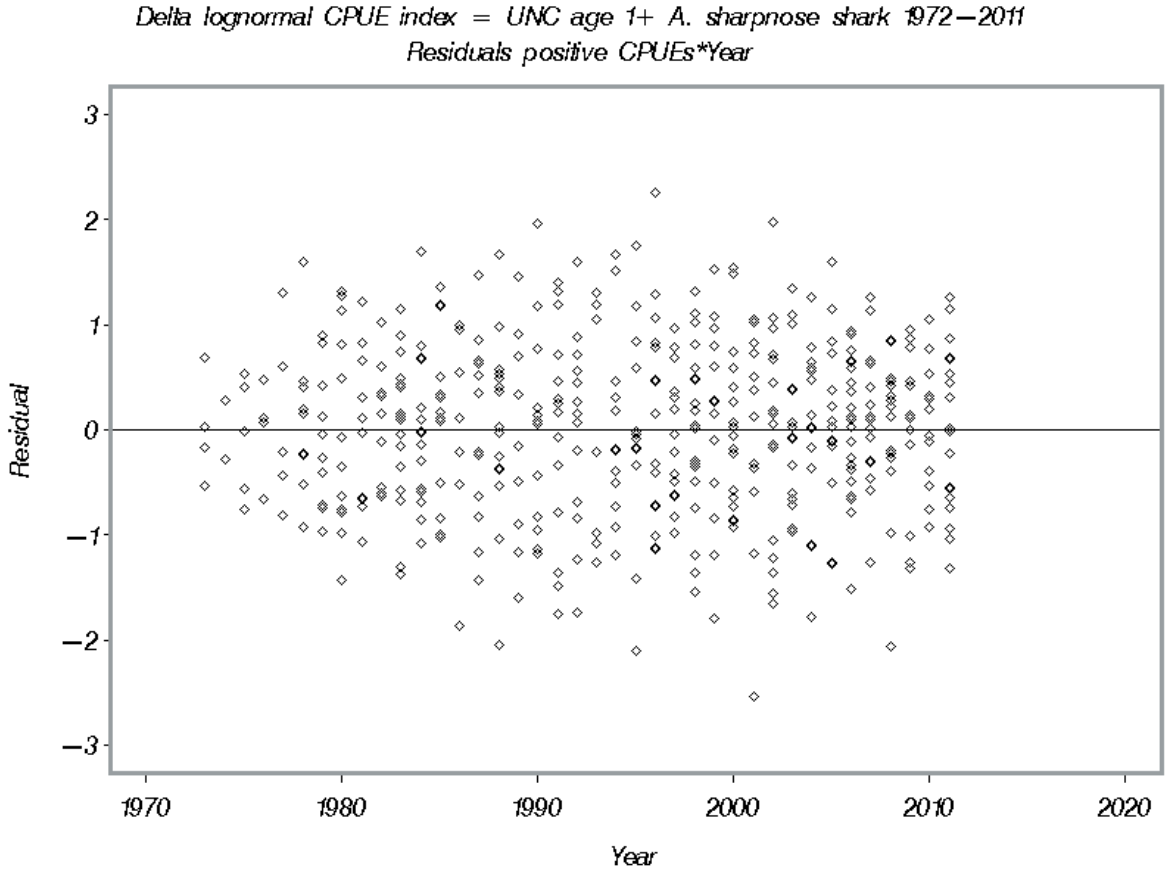
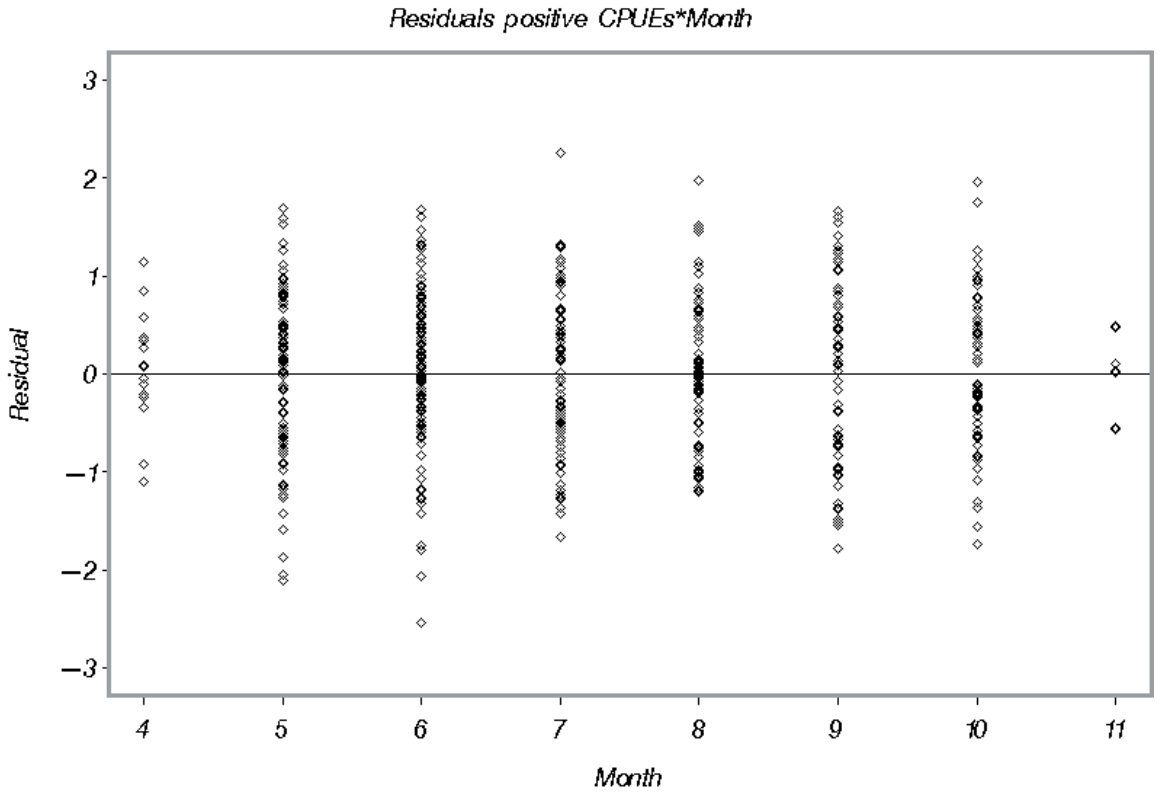


Figure 4b. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.



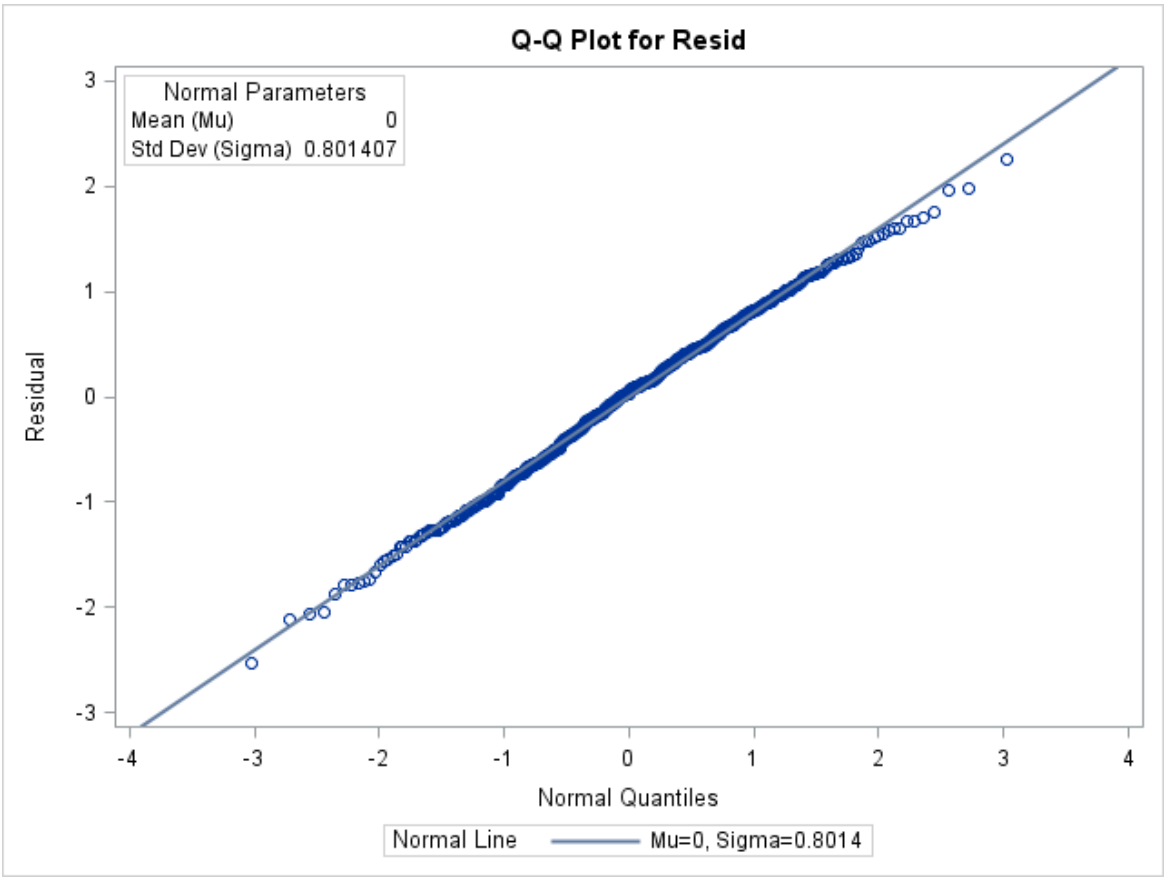


Figure 5. UNC longline survey age 1+ Atlantic sharpnose shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCL0, UCL0).