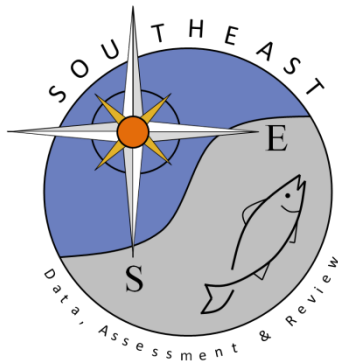Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the Cooperative Atlantic States Shark Pupping and Nursery longline surveys from South Carolina to northern Florida

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SEDAR34-WP-37

16 July 2013

Please cite this document as:

McCandless, C.T., C.N. Belcher, B.S. Frazier, M. McCallister, R. Ford, and J. Gelsleichter. 2013. Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the Cooperative Atlantic States Shark Pupping and Nursery longline surveys from South Carolina to northern Florida. SEDAR34-WP-37. SEDAR, North Charleston, SC. 18 pp.

SEDAR 34 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks caught during the Cooperative Atlantic States Shark Pupping and Nursery longline surveys from South Carolina to northern Florida

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Summary

This document details the shark catches from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline surveys conducted in estuarine and nearshore waters from South Carolina to northern Florida. Catch per unit effort (CPUE) in number of sharks per hook hour were used to examine age 1+ bonnethead and Atlantic sharpnose shark relative abundance from 2000-2011. 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. The standardized indices of abundance from the COASTSPAN longline surveys show a peak in abundance in 2001 for bonnethead and Atlantic sharpnose sharks. Relative abundance, for both species, then drops closer to previous levels in 2002 and appears to stabilize before starting an increasing trend in recent years.

Introduction

In an effort to examine the use of South Carolina's, Georgia's and northern Florida's estuarine and nearshore waters as nursery areas for coastal shark species, personnel from the South Carolina Department of Natural Resources (SCDNR), Georgia Department of Natural Resources (GADNR), and the University of North Florida (UNF) in collaboration with the National Marine Fisheries Service's (NMFS) Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey began sampling for sharks using longline and/or gillnet methods in several of their state's estuaries and nearshore waters. Sampling by SCDNR and GADNR began in 1998 and in 2008 by UNF. The first year of the UNF survey and the first two years of the SCDNR and GADNR surveys were exploratory in nature and were not included in the analyses discussed in this working paper.

Methods

Sampling Gear and Data Collection

The COASTSPAN longline gear consists of 305 m of 0.64 cm braided nylon mainline and 50 gangions comprised of a 0.5 m, 91 kg test monofilament leader, size 120 stainless steel longline snap, 4/0 swivel and a 12/0 circle hook. Hooks are baited with Atlantic mackerel (*Scomber scombrus*) during SCDNR and UNF surveys and with squid (*Loligo sp.*) during GADNR surveys. Soak times varied, but averaged 30 minutes. At a minimum the set number, date, set and haul times, number of hooks, station location, depth, water temperature, and salinity were recorded for each set; and the species, sex, and fork length were recorded for each shark caught. Sharks were then tagged with either a NMFS rototag, jumbo rototag, or steel tipped dart tag (M-tag) and released.

Data Analysis

CPUE in number of sharks per tow hour was used to examine the relative abundance of age 1+ bonnethead and Atlantic sharpnose sharks. For the purposes of this SEDAR process, male bonnetheads smaller than 37 cm fork length (FL), female bonnetheads smaller than 36 cm FL, male Atlantic sharpnose smaller than 38 cm fork length, and female Atlantic sharpnose smaller than 43 cm fork length were considered to be young-of the-year sharks and excluded from analyses. The CPUEs were standardized using the Lo et al. (2002) method which models the proportion of positive sets separately from the positive catch. After initial exploratory analysis, factors considered as potential influences on the catch were year (2000 – 2011), month (April-November), depth (<5 m, 5+ m), salinity (0-15.4 ppt, 15.5-30.4 ppt, 30.5+ ppt), temperature (<20.5 degC, 20.5-26.4 degC, 26.5+ degC), and area (Bulls Bay, Charleston Harbor, North Edisto, St Helena, St. Simons, St. Andrew, Cumberland, and Nassau sound systems). 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. 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

Age 1+ bonnetheads

A total of 930 age 1+ bonnetheads were caught during 2296 longline sets from 2000 to 2011. The size range of bonnetheads caught by year is displayed in Figure 2. The proportion of sets with positive catch (at least one age 1+ bonnethead caught) was 23%. 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.

Age 1+ Atlantic sharpnose sharks

A total of 1790 age 1+ Atlantic sharpnose sharks were caught during 2296 longline sets from 2000 to 2011. The size range of Atlantic sharpnose sharks caught by year is displayed in Figure 5. The proportion of sets with positive catch (at least one age 1+ A. sharpnose shark caught) was 27%. 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

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 COASTSPAN longline survey catch rate model for age 1+ bonnetheads. %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	1123	1393.2046	1.2406				
area	1682	1713.6155	1.0188	17.8784	17.8784	316.21	<.0001
temp	1688	1970.0917	1.1671	5.9246		59.74	<.0001
year	1679	1969.3241	1.1729	5.4570		60.50	<.0001
month	1683	1990.7252	1.1828	4.6590		39.10	<.0001
depth	1689	2015.1753	1.1931	3.8288		14.65	0.0001
set	1680	2008.7425	1.1957	3.6192		21.08	0.0205
sal	1688	2029.1272	1.2021	3.1033		0.70	0.7047
area +							
temp	1680	1629.3442	0.9698	21.8281	3.9497	84.27	<.0001
month	1675	1639.1224	0.9786	21.1188	3.2404	74.49	<.0001
year	1671	1670.4482	0.9997	19.4180	1.5396	43.17	<.0001
sal	1680	1692.5571	1.0076	18.7845	0.9060	21.06	<.0001
depth	1681	1705.6889	1.0147	18.2089	0.3305	7.93	0.0049
set	1672	1708.2841	1.0217	17.6447	-0.2338	5.33	0.8680
area + temp +							
year	1669	1582.3794	0.9481	23.5773	1.7492	46.96	<.0001
month	1673	1615.1434	0.9654	22.1828	0.3547	14.20	0.0477

FINAL MODEL: area + temp + year

AIC 1697.1   BIC 1819.7   (-2) Res LL 1727.3

Type 3 Test of Fixed Effects

Fixed effect	area	temp	year
Significance (Pr>Chi)	<.0001	<.0001	<.0001
DF	8	2	11
CHI SQUARE	323.18	88.07	46.96

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	480	192.3697	0.4008				
area	473	166.0794	0.3511	12.4002	12.4002	70.68	<.0001
year	469	178.2824	0.3891	2.9192		36.58	0.0001
month	474	188.8270	0.3984	0.5988		8.94	0.1769
set	471	187.6806	0.3985	0.5739		11.87	0.2207
depth	479	191.4601	0.3997	0.2745		2.28	0.1311
temp	478	191.2699	0.4001	0.1747		2.77	0.2509
sal	478	192.3592	0.4024	-0.3992		0.03	0.9869
area +							
year	462	154.0691	0.3335	16.7914	4.3912	36.11	0.0002

FINAL MODEL: area + year

AIC 857.4   BIC 940.9   (-2) Res LL 817.4

Type 3 Test of Fixed Effects

Fixed effect	area	year
Significance (Pr>Chi)	<.0001	<.0001
DF	7	11
CHI SQUARE	70.21	36.11

5

Table 2. COASTSPAN longline survey age 1+ bonnethead 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 hour (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
2000	121	17	0.1405	14.0856	15.5909	8.0146	30.3295	0.3421
2001	71	6	0.0845	18.1930	63.4174	24.6606	163.0846	0.4999
2002	47	4	0.0851	13.4429	40.0829	12.6517	126.9904	0.6280
2003	125	32	0.2560	46.0973	39.2522	23.8899	64.4932	0.2522
2004	129	51	0.3953	100.2171	60.7645	40.1337	92.0007	0.2096
2005	204	38	0.1863	35.8743	39.1143	25.1336	60.8717	0.2239
2006	190	56	0.2947	46.6831	51.3089	36.4143	72.2960	0.1727
2007	151	37	0.2450	39.4855	32.8825	20.9807	51.5359	0.2275
2008	157	53	0.3376	50.6698	45.8413	31.6252	66.4479	0.1872
2009	242	53	0.2190	30.0043	44.4845	30.8575	64.1294	0.1844
2010	303	91	0.3003	55.9702	89.2012	69.8428	113.9254	0.1228
2011	310	63	0.2032	41.7065	71.7390	52.6230	97.7993	0.1559

Table 3. Results of the stepwise procedure for development of the COASTSPAN 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	1690	2062.3595	1.2203				
month	1683	1978.1853	1.1754	3.6794	3.6794	84.17	<.0001
area	1682	1986.7763	1.1812	3.2041		75.58	<.0001
temp	1688	2014.0740	1.1932	2.2208		48.29	<.0001
year	1679	2014.1093	1.1996	1.6963		48.25	<.0001
depth	1689	2039.1339	1.2073	1.0653		23.23	<.0001
set	1680	2045.0823	1.2173	0.2458		17.28	0.0685
sal	1688	2053.2829	1.2164	0.3196		9.08	0.0107
month +							
area	1675	1891.1989	1.1291	7.4736	3.7941	86.99	<.0001
year	1672	1924.5469	1.1516	5.6298	1.9503	52.64	<.0001
depth	1682	1957.0936	1.1636	4.6464	0.9670	21.09	<.0001
temp	1681	1966.1099	1.1696	4.1547	0.4753	12.08	0.0024
month + area +							
year	1664	1821.3407	1.0946	10.3007	2.8272	69.86	<.0001

FINAL MODEL: month + area + year

AIC 1989.2   BIC 2139.8   (-2) Res LL 2057.4

Type 3 Test of Fixed Effects

Fixed effect	month	area	year
Significance (Pr>Chi)	<.0001	0.0027	0.0391
DF	7	8	11
CHI SQUARE	99.42	104.21	69.86

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	540	395.8063	0.7330				
area	532	349.0911	0.6562	10.4775	10.4775	67.95	<.0001
year	529	366.8918	0.6936	5.3752		41.04	<.0001
month	533	385.7524	0.7237	1.2688		13.92	0.0526
temp	538	393.781	0.7319	0.1501		2.78	0.2497
depth	539	395.5824	0.7339	-0.1228		0.31	0.5801
sal	538	395.3666	0.7349	-0.2592		0.60	0.7404
set	531	391.8797	0.7380	-0.6821		5.39	0.7987
area +							
year	521	319.9071	0.6140	16.2347	5.7572	47.23	<.0001

FINAL MODEL: area + year

AIC 1293.1   BIC 1383.1   (-2) Res LL 1251.1

Type 3 Test of Fixed Effects

Fixed effect	area	year
Significance (Pr>Chi)	<.0001	<.0001
DF	8	11
CHI SQUARE	74.14	47.23

Table 4. COASTSPAN 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 hour (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).

n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
121	27	0.2231	54.9171	30.0374	15.4504	58.3961	0.3418
71	25	0.3521	241.2269	158.5449	82.5800	304.3897	0.3350
47	7	0.1489	32.3404	33.9021	11.7229	98.0436	0.5707
125	30	0.2400	48.1842	46.3254	27.3286	78.5274	0.2685
129	33	0.2558	37.8868	38.6373	22.8954	65.2026	0.2662
204	30	0.1471	67.9129	48.2762	28.1776	82.7109	0.2742
190	55	0.2895	62.0980	63.6434	43.6178	92.8630	0.1906
151	28	0.1854	27.1340	28.7236	16.6553	49.5366	0.2776
157	53	0.3376	66.9373	71.6558	49.1228	104.5248	0.1905
242	68	0.2810	76.1370	82.6795	58.4307	116.9917	0.1749
303	115	0.3795	115.5232	119.0110	91.3148	155.1074	0.1330
310	97	0.3129	91.0784	89.7414	67.5272	119.2633	0.1429

Figure 1. Fork lengths (cm) of bonnetheads caught during the COASTSPAN longline survey from 2000-2011.
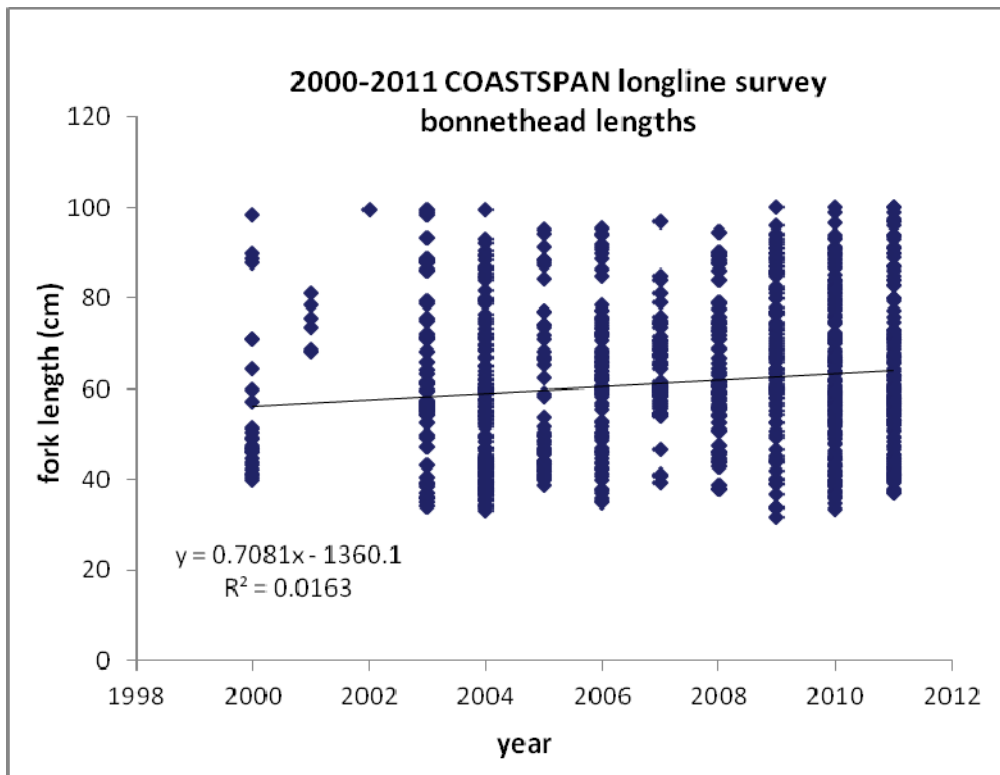

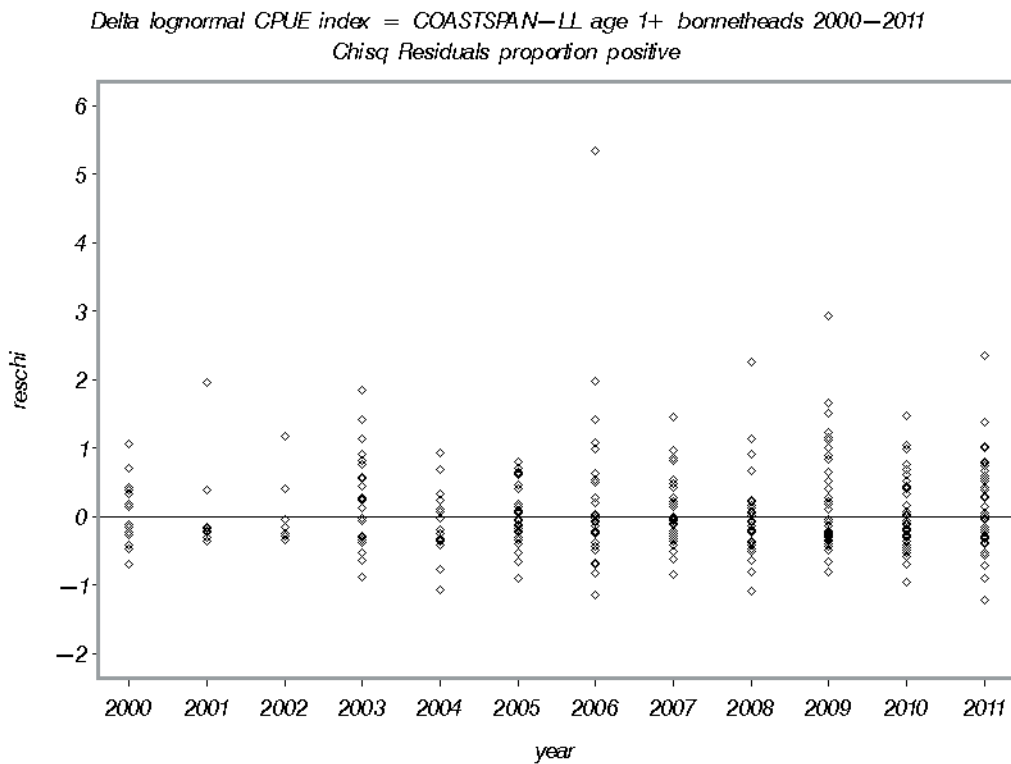Figure 3a. Age 1+ bonnethead model diagnostic plots for the binomial component.

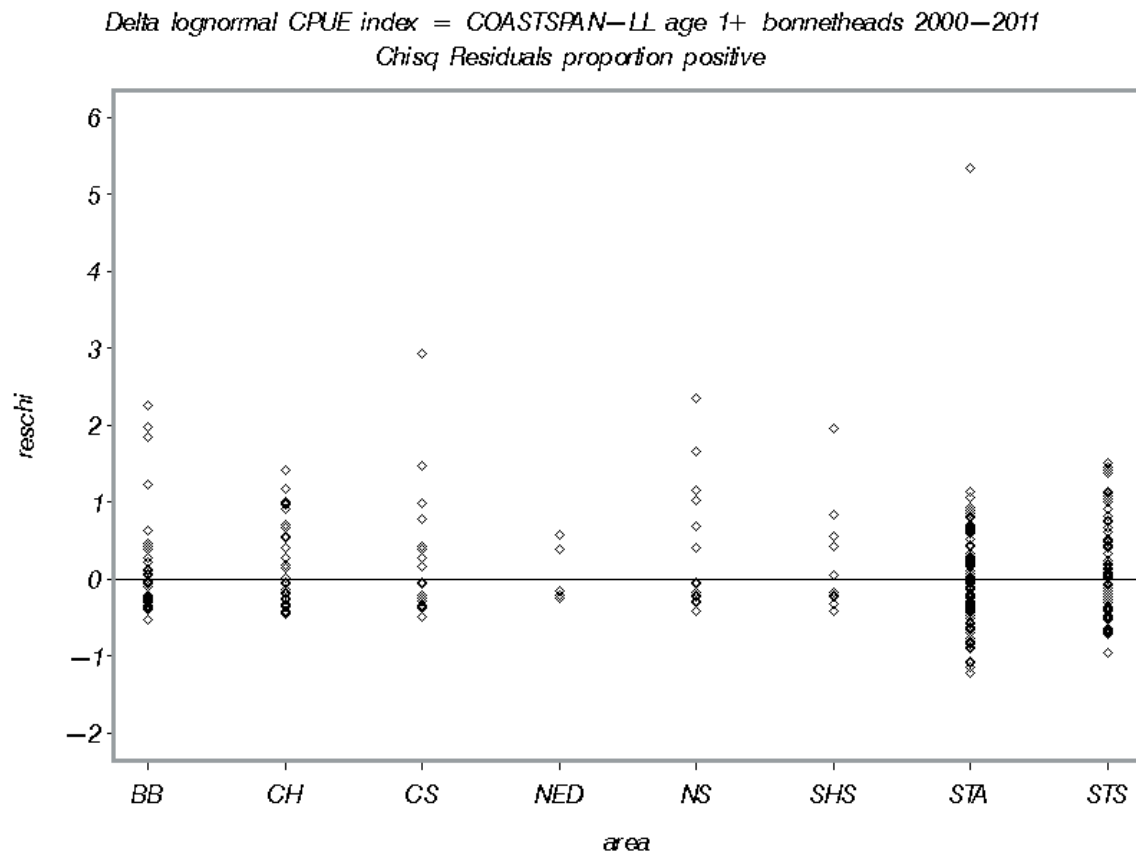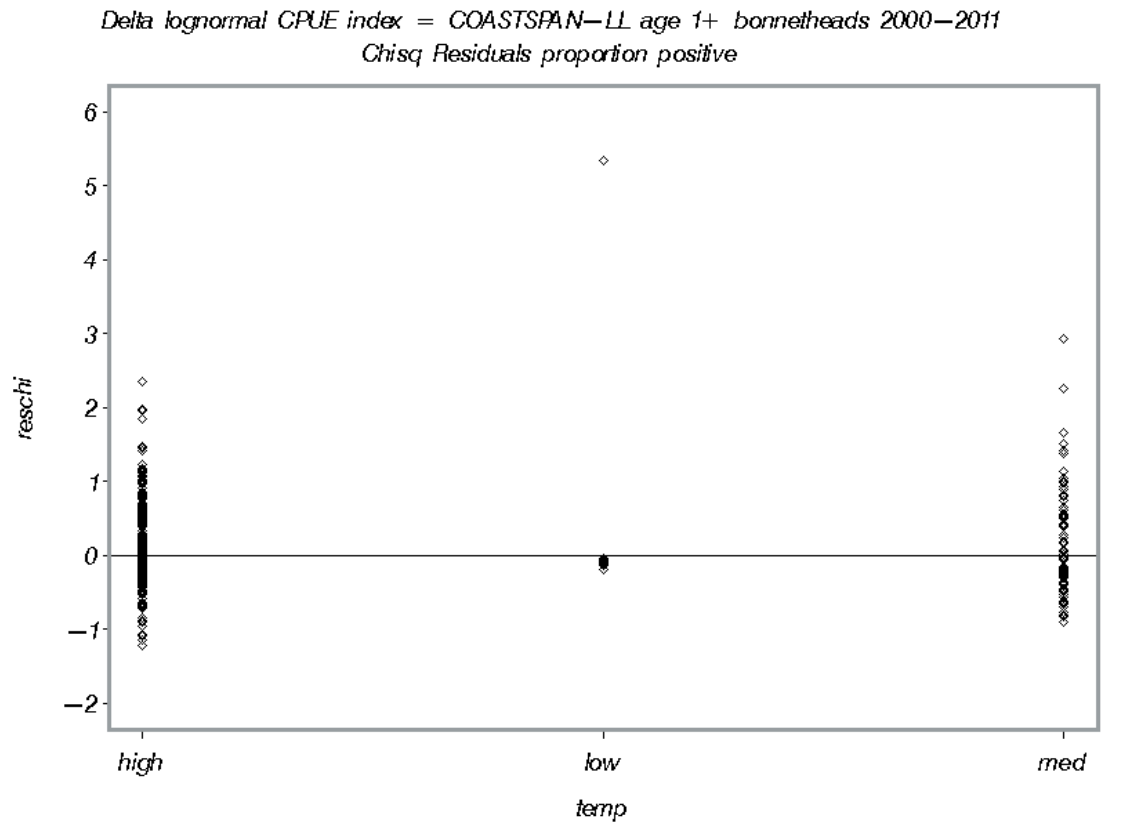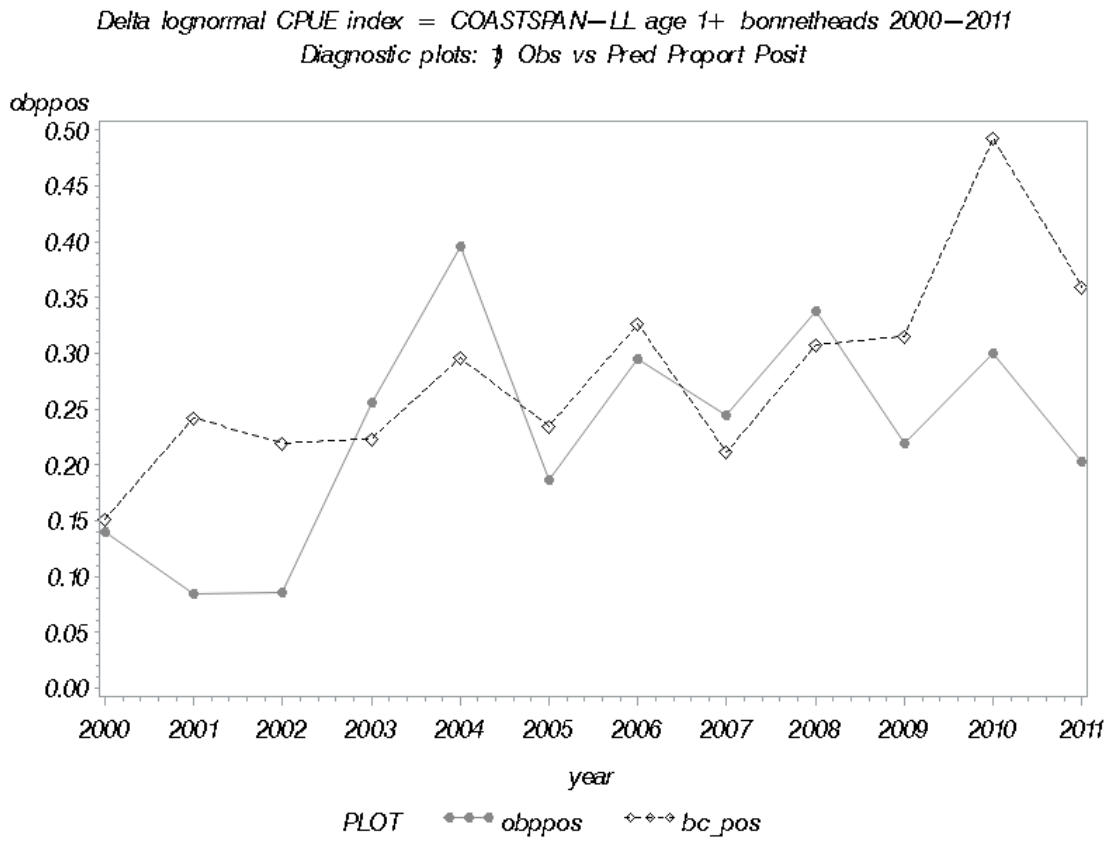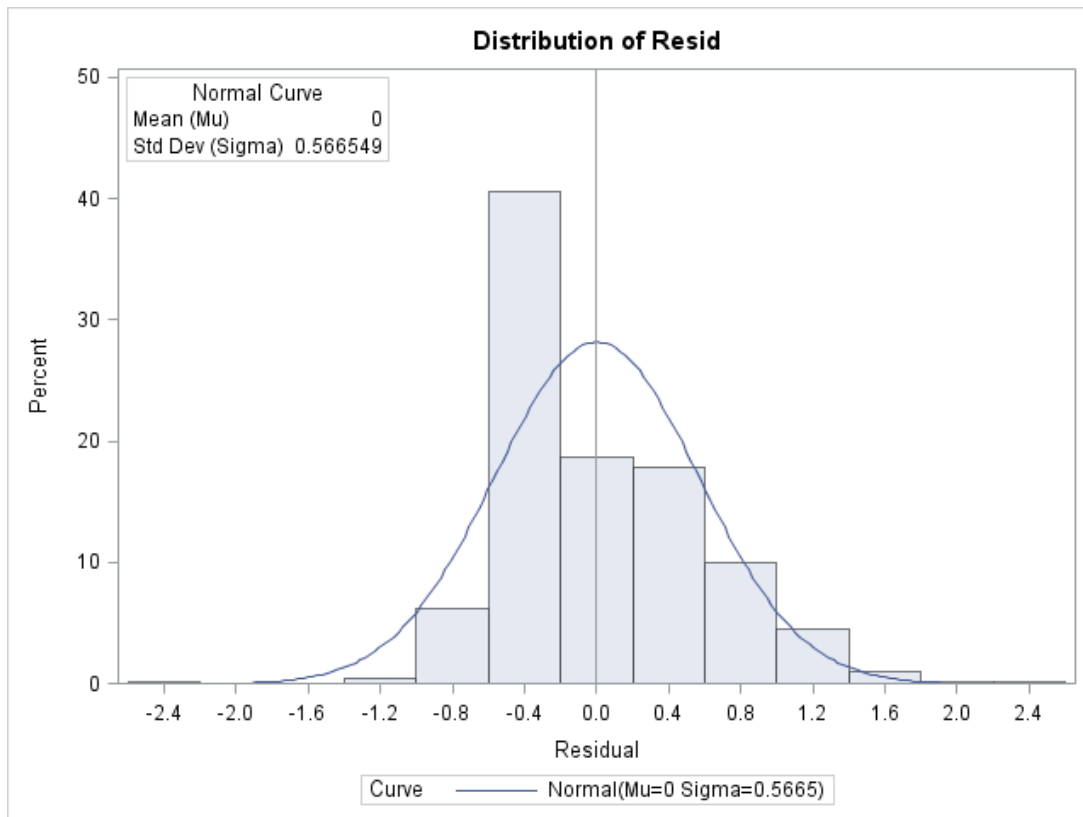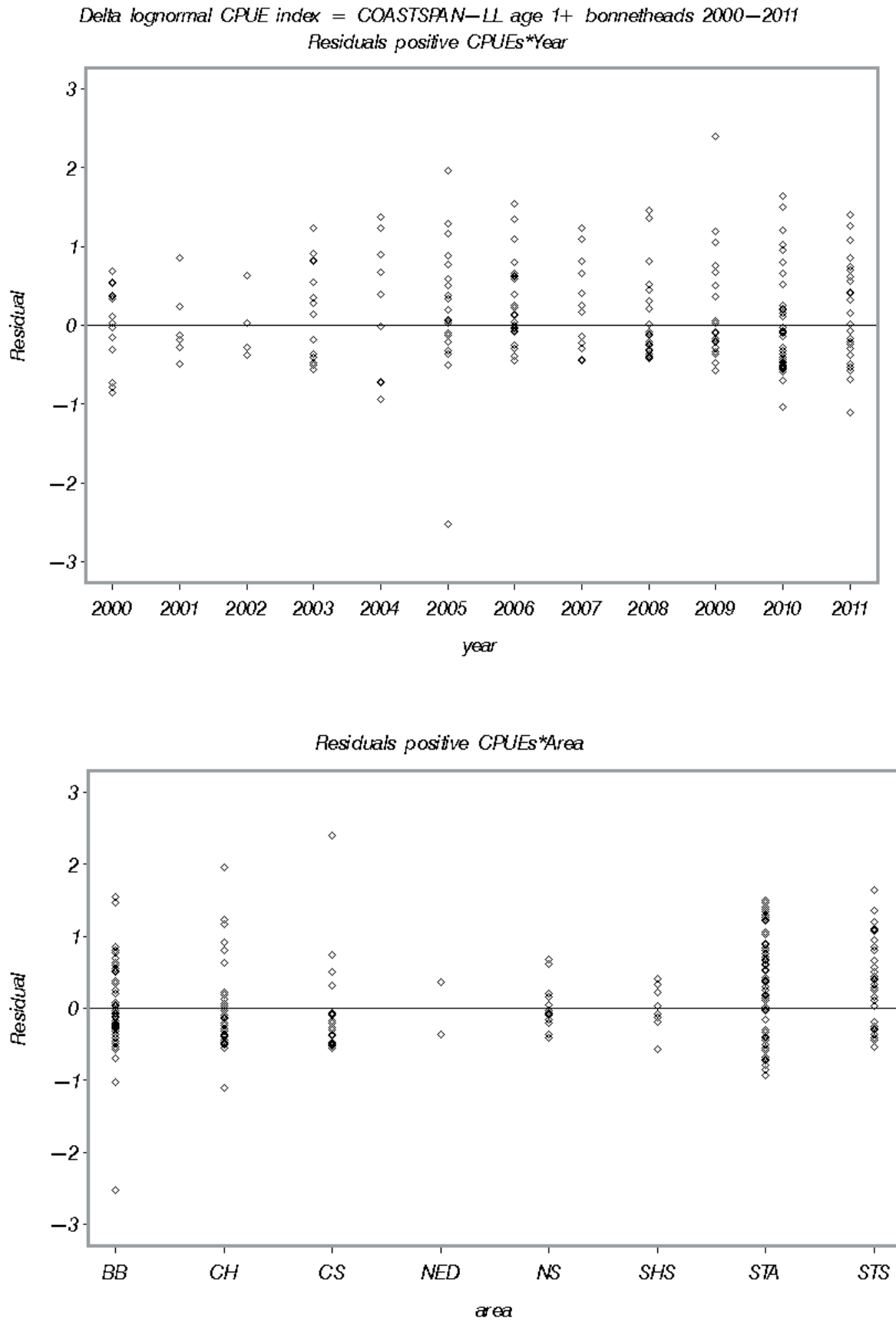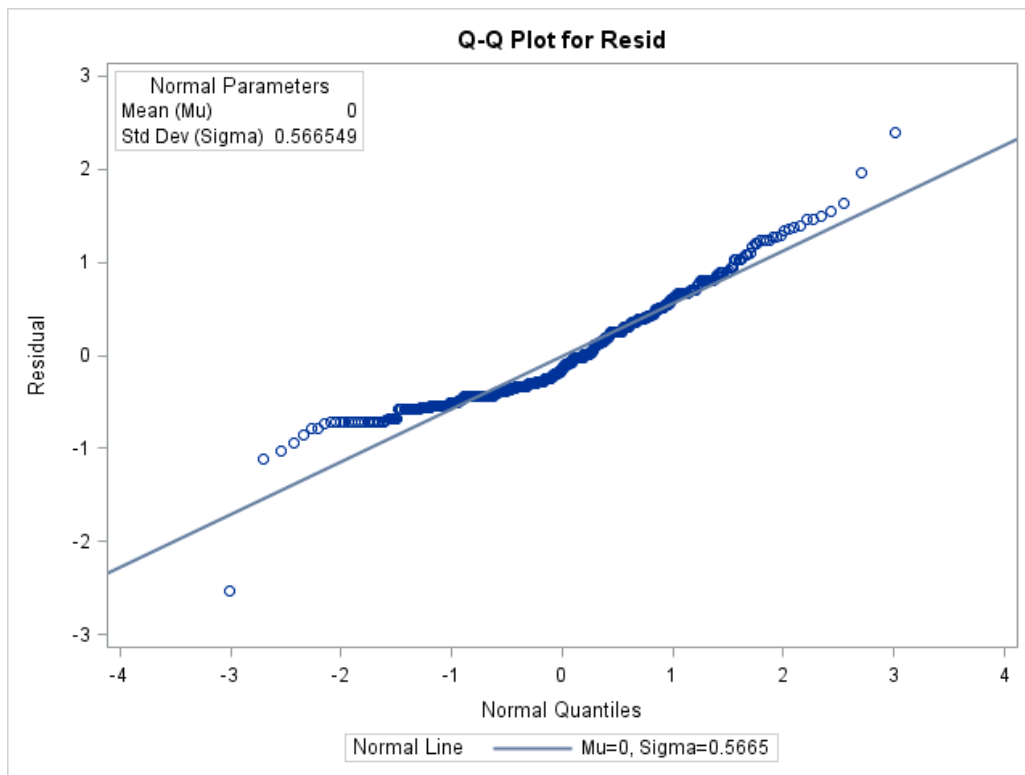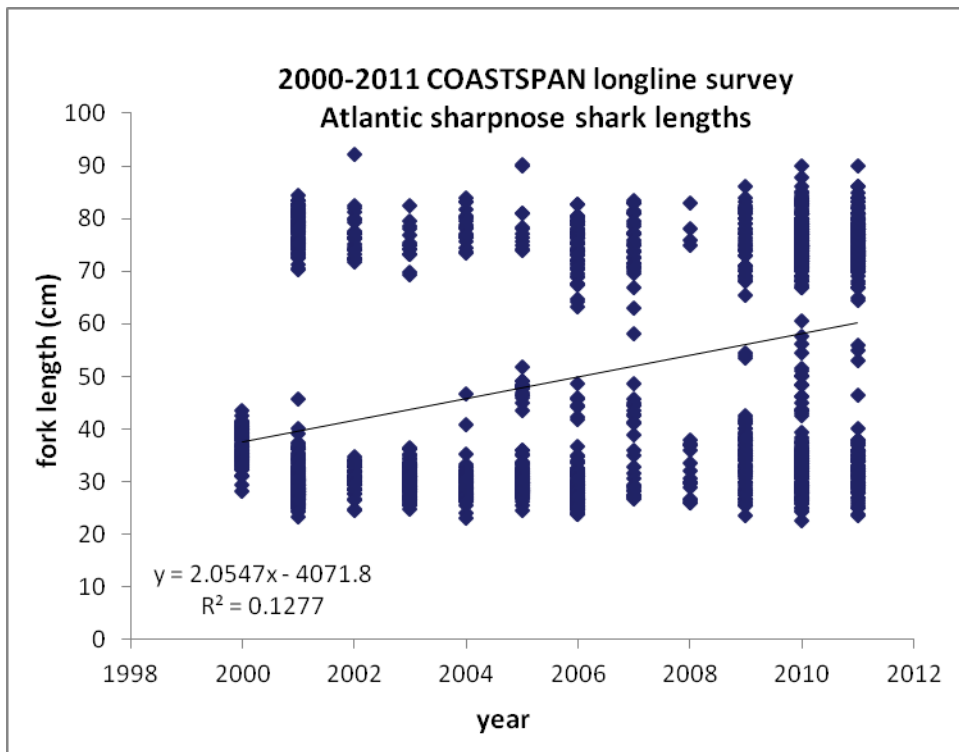Figure 3a continued. Age 1+ bonnethead model diagnostic plots for the binomial component.

Delta lognormal CPUE index = COASTSPAN—LL age 1+ bonnetheads 2000—2011
Chisq Residuals proportion positive

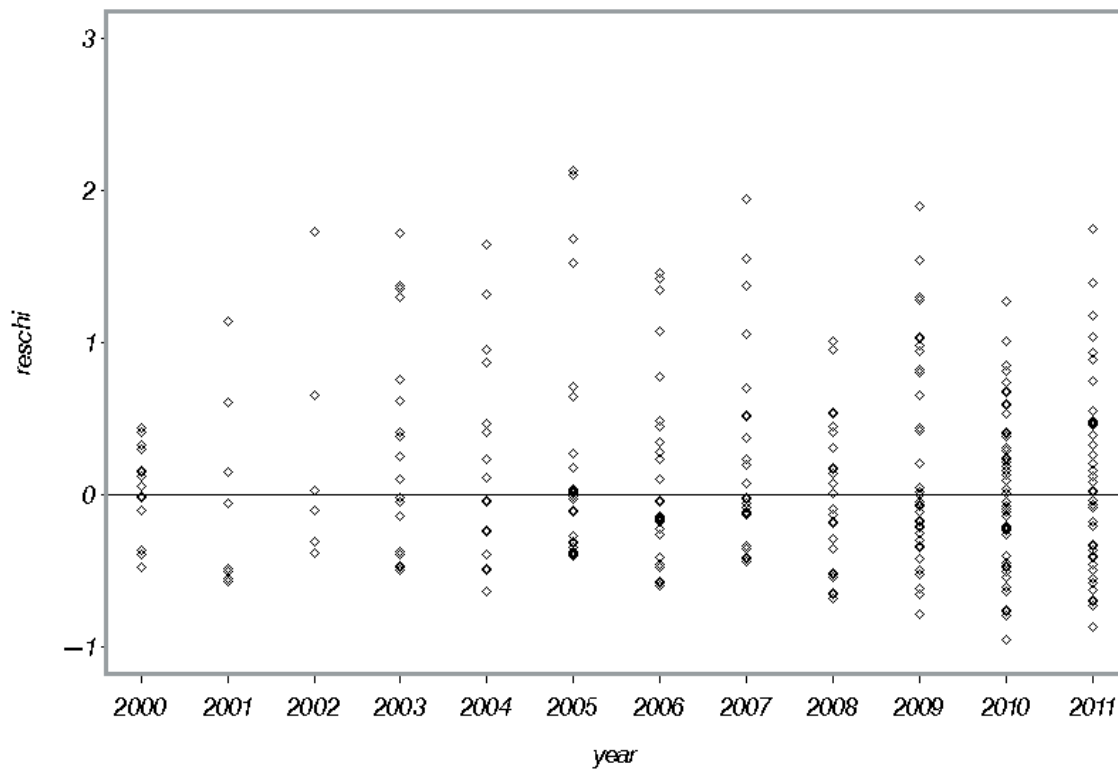Delta lognormal CPUE index = COASTSPAN—LL age 1+ bonnetheads 2000—2011
Chisq Residuals proportion positive

Figure 3a continued. Age 1+ bonnethead model diagnostic plots for the binomial component.

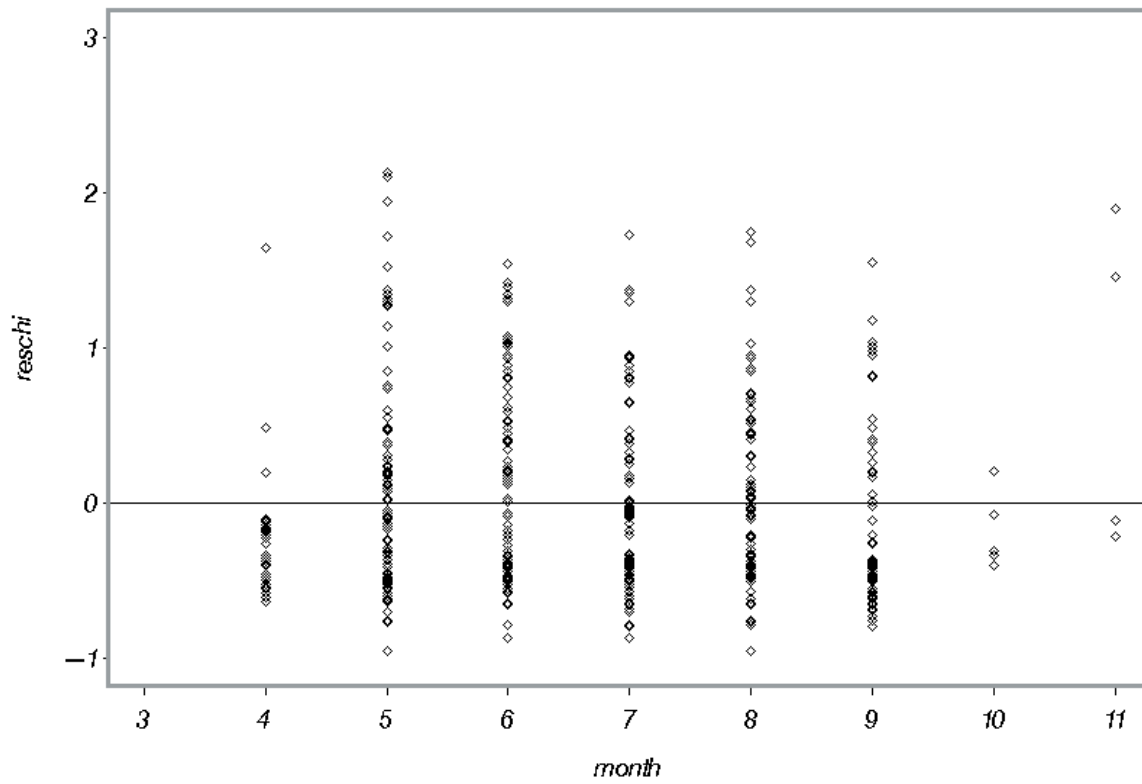Figure 3b. Age 1+ bonnethead model diagnostic plots for lognormal component.

Figure 3b continued. Age 1+ bonnethead model diagnostic plots for lognormal component.

Delta lognormal CPUE index = COASTSPAN−LL age 1+ bonnetheads 2000−2011
Residuals positive CPUEs*Year

Residuals positive CPUEs*Area

Figure 3b continued. Age 1+ bonnethead model diagnostic plots for lognormal component.

Figure 4. COASTSPAN longline survey age 1+ bonnethead nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0), UCI0).
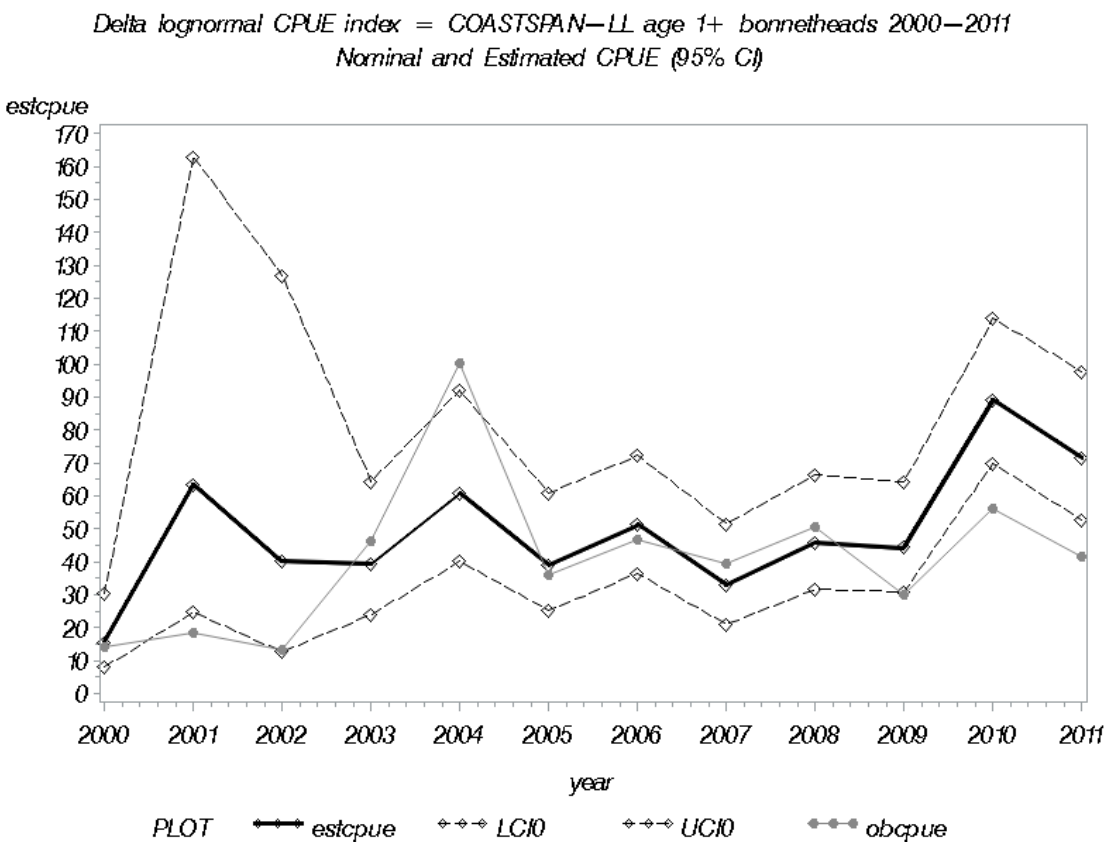
Figure 5. Fork lengths (cm) of age 1+ Atlantic sharpnose sharks caught during the COASTSPAN longline survey from 2000-2011.
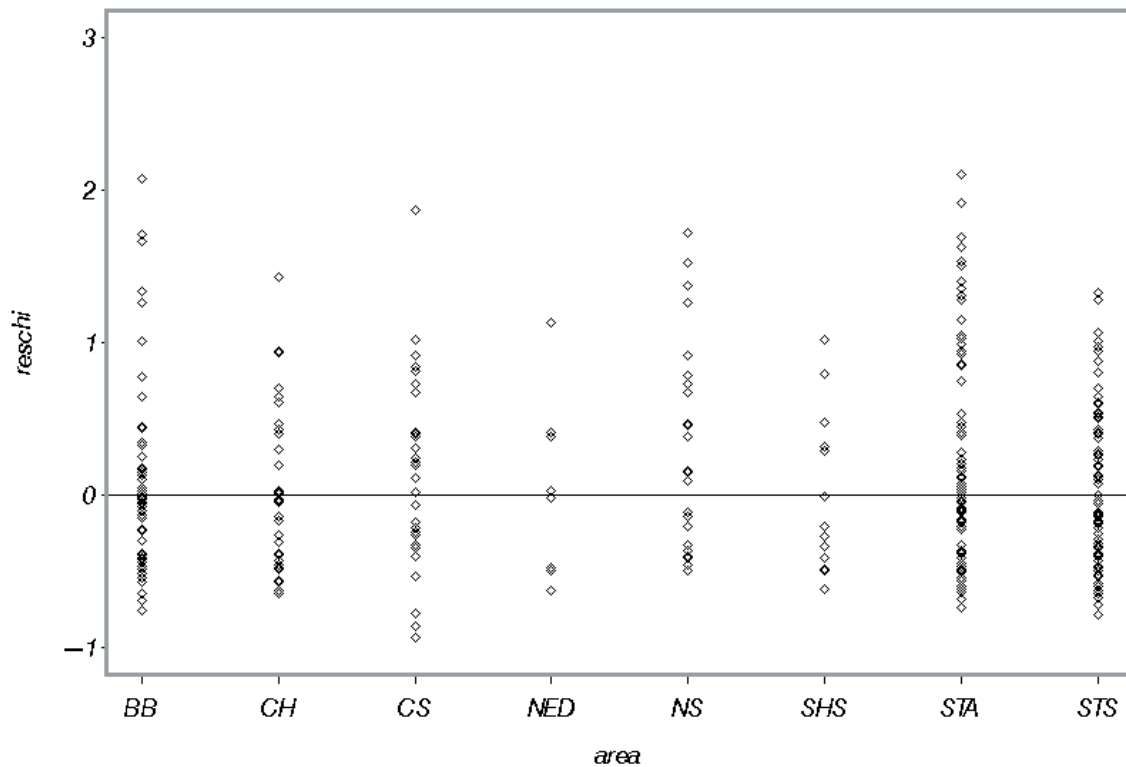

Figure 6a. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.

Figure 6a continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.

Delta lognormal CPUE index = COASTSPAN−LL age 1+ A. sharpnose sharks 2000−2011
Chisq Residuals proportion positive

Delta lognormal CPUE index = COASTSPAN−LL age 1+ A. sharpnose sharks 2000−2011
Chisq Residuals proportion positive

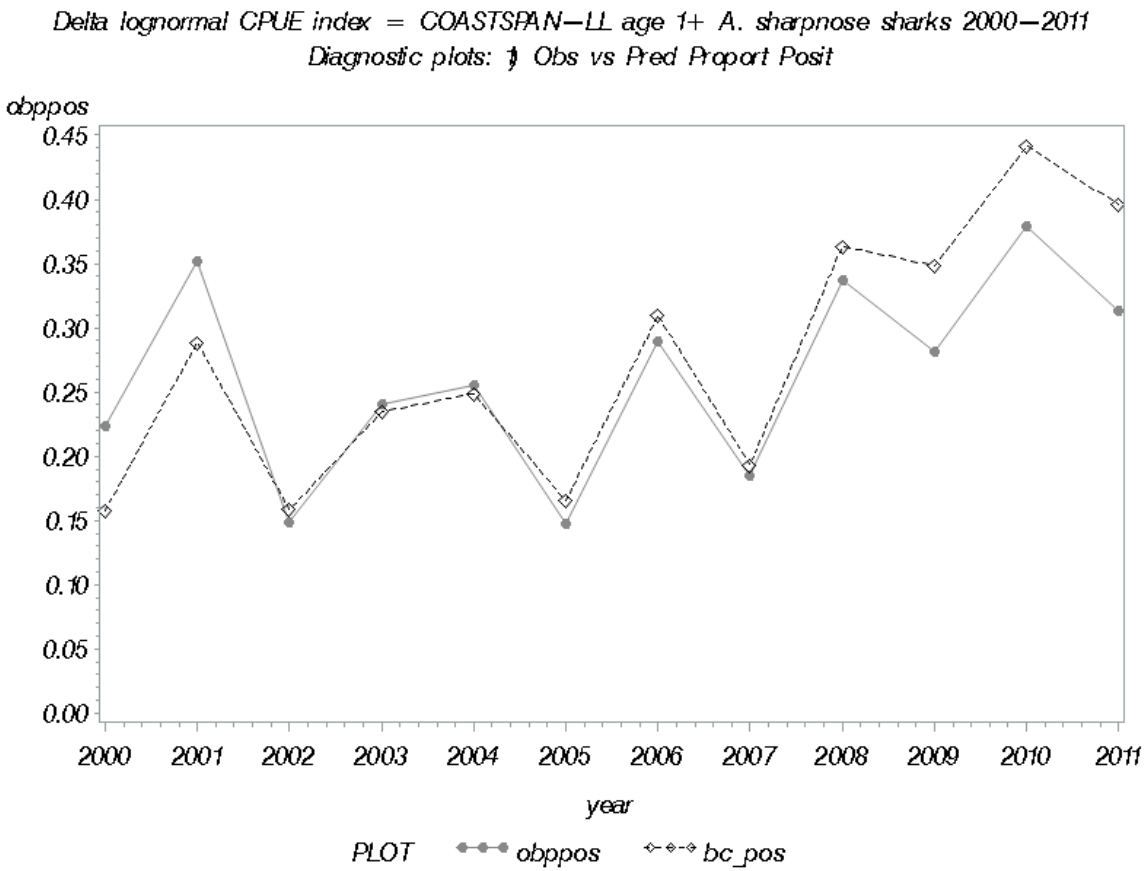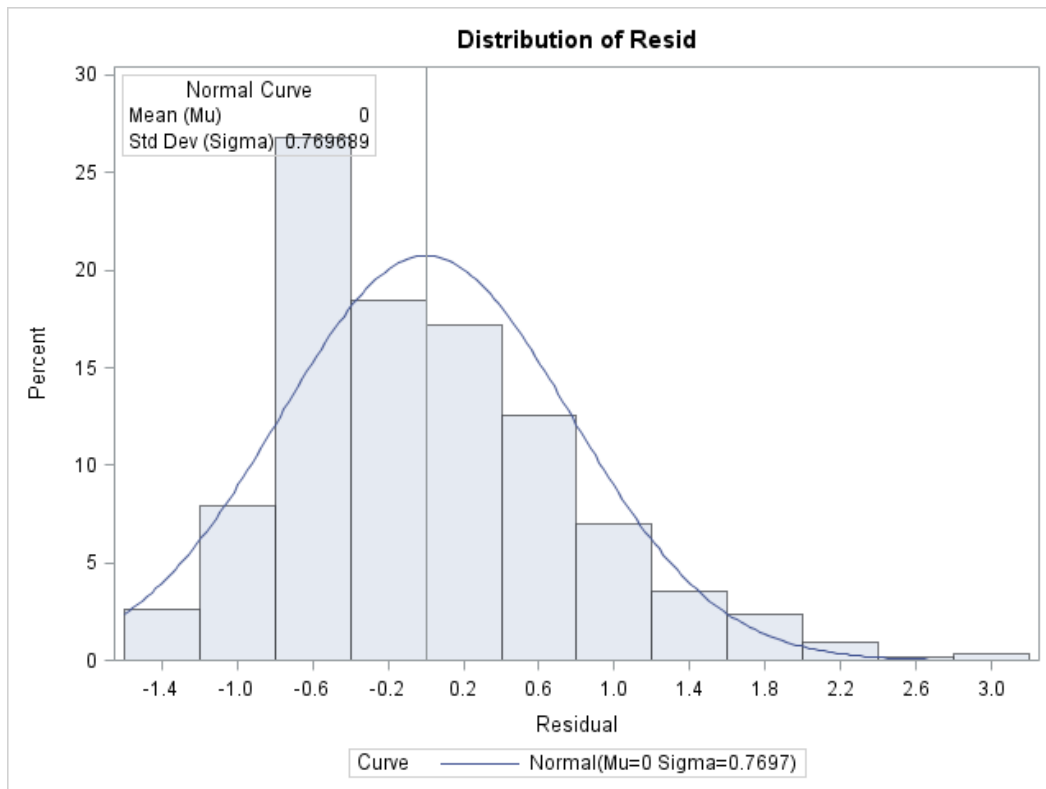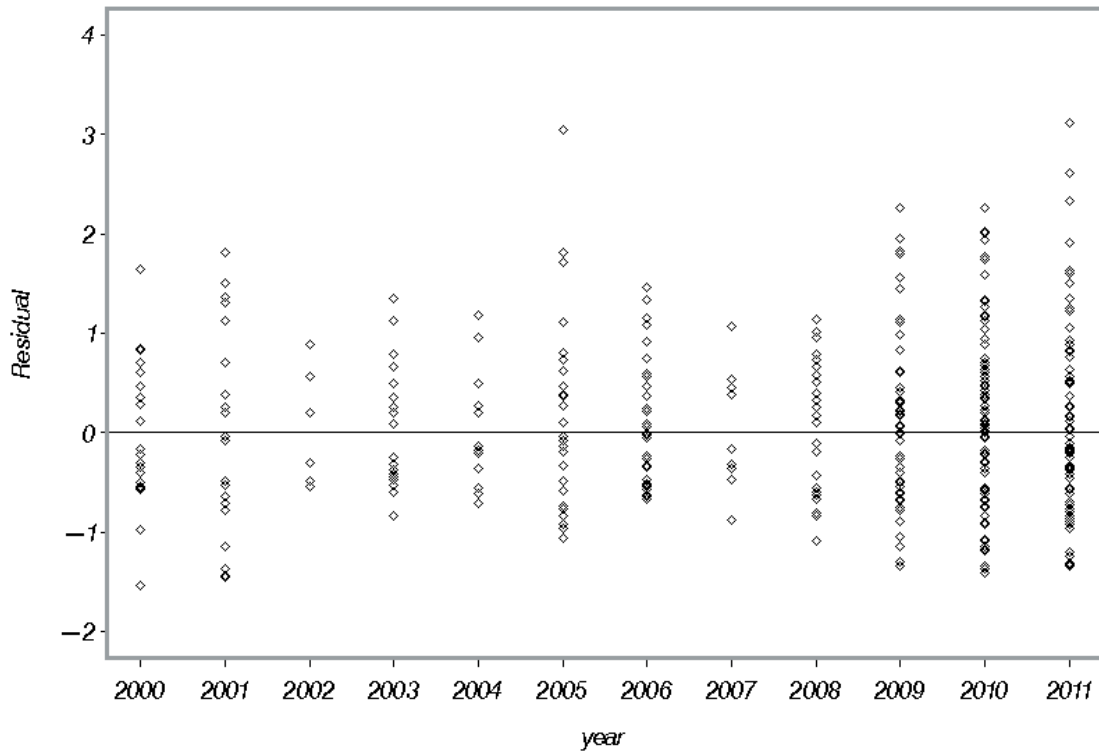Figure 6a continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.

Delta lognormal CPUE index = COASTSPAN−LL age 1+ A. sharpnose sharks 2000−2011
Diagnostic plots: 1) Obs vs Pred Proport Posit

Figure 6b. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.

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Figure 6b continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.

Delta lognormal CPUE index = COASTSPAN–LL age 1+ A. sharpnose sharks 2000–2011
Residuals positive CPUEs*Year

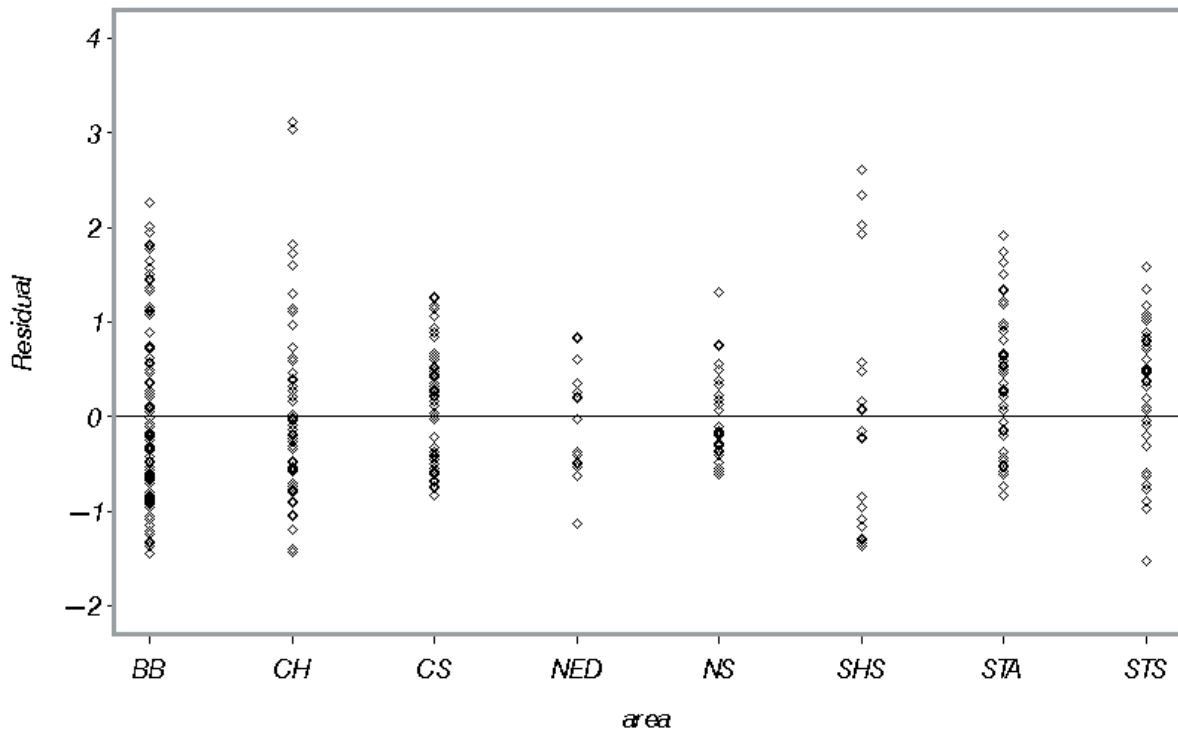Residuals positive CPUEs*Area

Figure 6b continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.
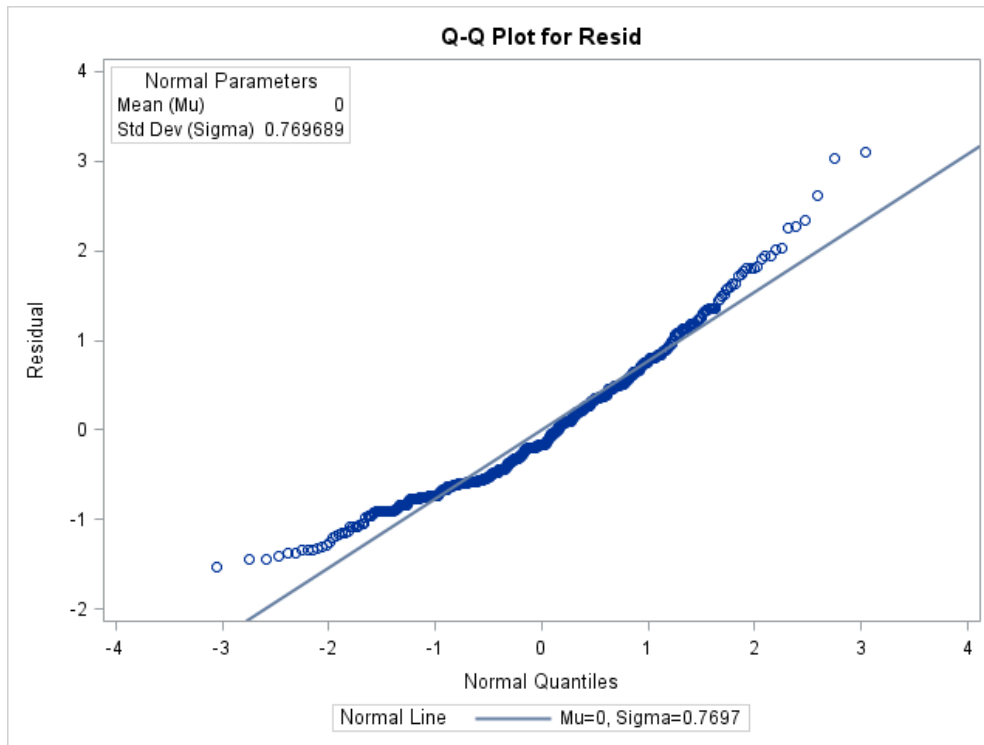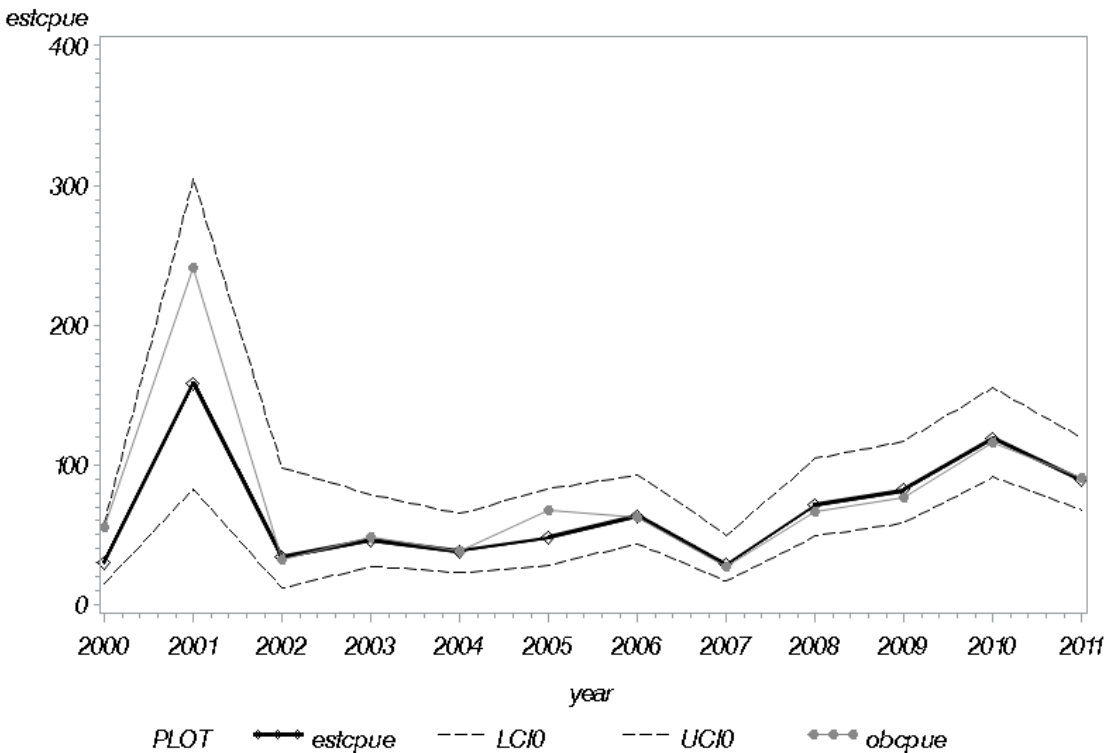

Figure 7. COASTSPAN longline survey age 1+ Atlantic sharpnose shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0), UCI0).

Addendum to SEDAR34-WP-37
by C.T. McCandless, C.B Belcher, and B.S. Frazier

After initial review it was requested to run the analyses on bonnetheads separately for the GA and SC COASTSPAN longline surveys to compare results to the combined index. The results are presented here:

Table 1. SC COASTSPAN longline survey bonnethead 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 hour (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
2000	72	5	0.0694	8.8104	10.1243	3.7434	27.3817	0.5299
2001	71	6	0.0845	18.1930	21.0844	8.3175	53.4480	0.4914
2002	47	4	0.0851	13.4429	12.6839	4.3194	37.2465	0.5801
2003	48	11	0.2292	34.6283	30.1550	14.6056	62.2583	0.3747
2004	51	1	0.0196	2.9412	.	.	.	.
2005	110	14	0.1273	26.5306	21.2454	11.9400	37.8029	0.2942
2006	88	15	0.1705	26.1568	26.6994	15.1609	47.0195	0.2887
2007	44	4	0.0909	15.4161	13.3763	4.7359	37.7804	0.5562
2008	37	14	0.3784	50.5719	51.0869	30.1238	86.6382	0.2688
2009	30	8	0.2667	20.4012	23.6688	11.7421	47.7098	0.3615
2010	76	10	0.1316	11.7995	13.2621	6.7436	26.0813	0.3481
2011	79	4	0.0506	5.6329	5.6577	1.9635	16.3021	0.5684

Table 2. GA COASTSPAN longline survey bonnethead 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 hour (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
2000	50	12	0.2400	21.4000	18.6666	8.1019	43.0076	0.4362
2001	.	.	.	.	.	.	.	.
2002	.	.	.	.	.	.	.	.
2003	75	21	0.2800	54.6667	58.7411	31.9570	107.9734	0.3116
2004	78	50	0.6410	163.8205	119.1282	80.0698	177.2395	0.2006
2005	95	24	0.2526	46.3158	53.0784	28.9051	97.4678	0.3110
2006	102	41	0.4020	64.3922	77.6798	51.9895	116.0648	0.2028
2007	107	33	0.3084	49.3832	58.9506	36.3643	95.5657	0.2451
2008	120	39	0.3250	50.7000	60.0990	38.6428	93.4687	0.2235
2009	106	39	0.3679	53.7547	68.6762	43.9135	107.4025	0.2264
2010	95	62	0.6526	155.7895	169.4012	128.1567	223.9194	0.1402
2011	85	49	0.5765	136.4706	146.5143	105.5245	203.4261	0.1652

Figure 1. SC COASTSPAN longline survey bonnethead nominal (obscpue1) and estimated (stdcpue1) indices divided by the mean with 95% confidence limits (LCI1), UCI1).
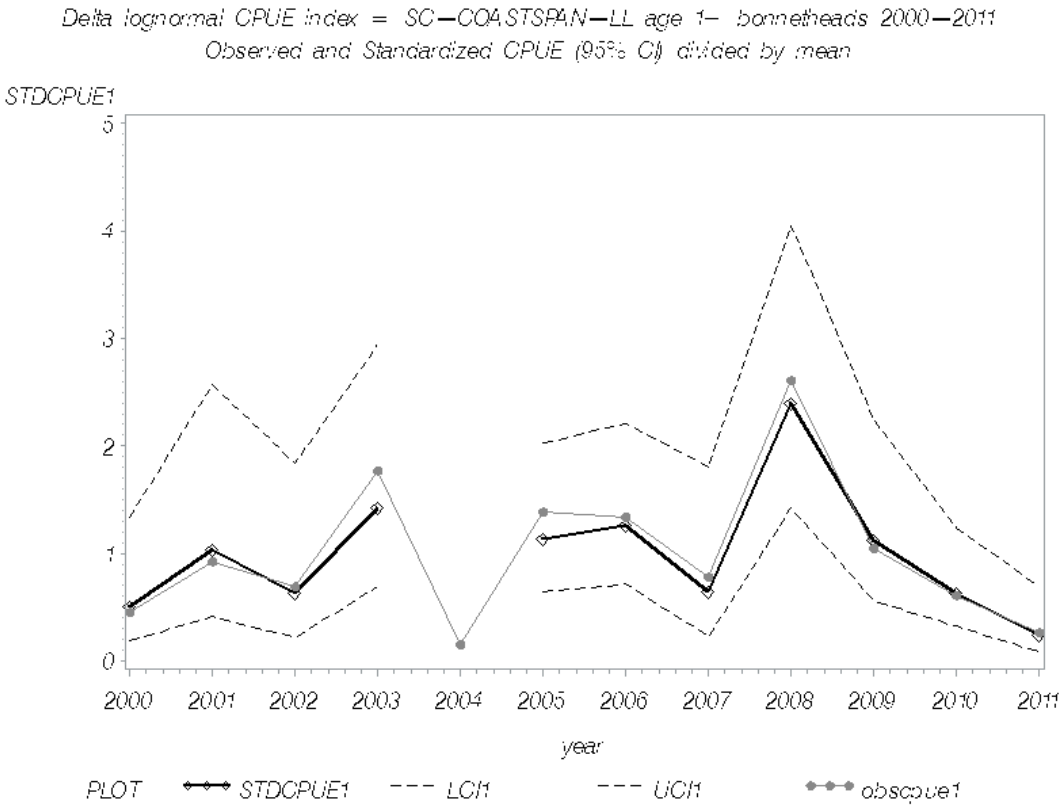

Figure 2. GA COASTSPAN longline survey bonnethead nominal (obscpue1) and estimated (stdcpue1) indices divided by the mean with 95% confidence limits (LCI1), UCI1).