Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks from the Georgia Department of Natural Resources ecological monitoring trawl surveys

Camilla T. McCandless, Jim Page, and Carolyn N. Belcher

SEDAR34-WP-35

16 July 2013

Please cite this document as:

McCandless, C.T., J. Page, and C.N. Belcher. 2013. Standardized indices of abundance for bonnethead and Atlantic sharpnose sharks from the Georgia Department of Natural Resources ecological monitoring trawl surveys. SEDAR34-WP-35. SEDAR, North Charleston, SC. 19 pp.

SEDAR 34 DATA WORKSHOP DOCUMENT

Standardized catch rates for bonnetheads and Atlantic sharpnose sharks from the Georgia Department of Natural Resources Ecological Monitoring Trawl Survey

Camilla T. McCandless
NOAA/NMFS/NEFSC
Apex Predators Investigation
28 Tarzwell Drive
Narragansett, RI 02882

Jim Page
Carolyn N. Belcher
Georgia Department of Natural Resources
Coastal Resources Division
One Conservation Way, Suite 300
Brunswick, GA 31520

cami.mccandless@noaa.gov
jim.page@dnr.state.ga.us
carolyn.belcher@dnr.state.ga.us

June 2013

Summary
This document details the shark catches from the Georgia Department of Natural Resources (GADNR) Ecological Monitoring Trawl Survey conducted from 2003-2011. Catch per unit effort (CPUE) in number of sharks per tow hour were used to examine age 1+ bonnethead and Atlantic sharpnose shark relative abundance in Georgia's coastal waters. 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 GADNR trawl survey show no apparent overall trends in age 1+ bonnethead and Atlantic sharpnose shark relative abundance across survey years.

Introduction

The GADNR Ecological Monitoring Trawl Survey, formerly known as the Shrimp Assessment Survey, is conducted year round in six of GA's commercially important estuarine systems. Small coastal sharks are caught during the warmer months of the survey. This paper analyzes a subset of the GADNR trawl survey database excluding the time of year (December-March) in which the capture of small coastal sharks is not likely.

Methods

Sampling Gear and Data Collection

The GADNR trawl survey is conducted monthly at 42 fixed sites in six of Georgia's estuarine systems (Wassaw, Ossabaw, Sapelo, St. Simons, St. Andrew, Cumberland). This bottom trawl survey is conducted with a 60ft shrimp trawler (R/V *Anna*) pulling a single 40' Flat trawl net (1 $^{7}/_{8}$" mesh), equipped with tickler chain and 5 ft wooden doors. Within each sampled estuary, three sectors are sampled (beaches, sounds, rivers/creeks), all of which are in state waters (0 – 3 miles). In each sector, at least two stations are sampled, resulting in a minimum of six stations per estuary.

Upon arriving at a designated fixed sample site, the crew uses a double-drum winch to deploy the net from a single outrigger on the starboard side of the vessel. Ample scope is provided for the net based on the depth at the sampled station. Once the net has been let out with ample scope, the winch is stopped or "dogged off". It is at this point when the winch is dogged off that the tow time officially begins. After the winch is dogged off the net will be towed for a standardized 15 minutes. After 15 minutes of towing, the winch is be re-engaged, at which point the tow time officially ends. After the net is retrieved via the winch, the cod end of the net is brought onboard the vessel. Only the biota in the cod end of the net is sampled and data recorded. After the bag is untied and the contents of the cod end are dumped onto the back deck, all biota are separated to the species level. Data, including lengths and weights, are recorded for each species.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per tow hour was used to examine the relative abundance of age 1+ bonnethead and Atlantic sharpnose sharks in Georgia's coastal waters. 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 from GADNR trawl tows were year (2003 – 2011), month (April-November), depth (<20 m, 20+ m),

salinity (<30 ppt, 30+ ppt), temperature (<25 degC, 24+ degC), and area (Wassaw, Ossabaw, Sapelo, St. Simons, St. Andrew, and Cumberland 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

GADNR trawl survey – age 1+ bonnetheads

A total of 856 age 1+ bonnetheads were caught during 2964 trawl tows from 2003 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 14%. The stepwise construction of each model and the resulting statistics for the mixed models are detailed in Table 1. Some model diagnostic plots reveal that the model fit may be acceptable, but the histogram for the lognormal model residuals on positive catch rates and the Q-Q plot indicates that the positive catch data are not normally distributed (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.

GADNR trawl survey – age 1+ Atlantic sharpnose sharks

A total of 1715 age 1+ Atlantic sharpnose sharks were caught during 2964 trawl tows from 2003 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 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

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 GADNR trawl 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	1165	1299.4202	1.1154				
month	1157	1125.2282	0.9725	12.8115	12.8115	174.19	<.0001
temp	1164	1221.4906	1.0494	5.9172		77.93	<.0001
year	1157	1244.4807	1.0756	3.5682		54.94	<.0001
area	1160	1253.8747	1.0809	3.0931		45.55	<.0001
sal	1164	1281.2095	1.1007	1.3179		18.21	<.0001
depth	1164	1297.4279	1.1146	0.0717		1.99	0.1581
month +							
area	1152	1077.9177	0.9357	16.1108	3.2993	47.31	<.0001
year	1149	1075.6228	0.9361	16.0750	3.2634	49.61	<.0001
sal	1156	1119.6218	0.9685	13.1702	0.3586	5.61	0.0179
temp	1156	1122.0904	0.9707	12.9729	0.1614	3.14	0.0765
month +area+							
year	1144	1026.7400	0.8975	19.5356	6.5627	51.18	<.0001

FINAL MODEL: month + area + year

AIC 1336.8 **BIC** 1337.3 **(-2) Res LL** 1292.8

Type 3 Test of Fixed Effects

Fixed effect	month	area	year
Significance (Pr>Chi)	<.0001	<.0001	<.0001
DF	8	5	8
CHI SQUARE	171.13	48.88	51.18

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	363	171.2962	0.4719				
year	355	163.2398	0.4598	2.5641	2.5641	17.54	0.0250
month	356	166.1798	0.4668	1.0807		11.04	0.1370
depth	362	169.2934	0.4677	0.8900		4.28	0.0385
area	358	167.9102	0.4690	0.6145		7.27	0.2015
temp	362	170.4189	0.4708	0.2331		1.87	0.1716
sal	362	171.2248	0.4730	-0.2331		0.15	0.6969

FINAL MODEL: year

AIC 761.1 **BIC** 800.1 **(-2) Res LL** 741.1

Type 3 Test of Fixed Effects

Fixed effect	year
Significance (Pr>Chi)	0.0250
DF	8
CHI SQUARE	114.38

Table 2. GADNR trawl 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 tow 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
2003	136	41	0.3015	2.7941	3.1847	2.3087	4.3931	0.1619
2004	126	21	0.1667	2.1270	2.3650	1.4937	3.7448	0.2329
2005	171	10	0.0585	0.7251	0.9221	0.4679	1.8172	0.3492
2006	315	55	0.1746	1.2305	1.5913	1.1958	2.1177	0.1436
2007	292	40	0.1370	2.0040	1.7236	1.2291	2.4171	0.1703
2008	334	32	0.0958	0.6225	0.8106	0.5513	1.1917	0.1945
2009	256	59	0.2305	2.0814	2.7136	2.0784	3.5429	0.1339
2010	275	53	0.1920	1.3966	1.4885	1.1020	2.0105	0.1512
2011	321	60	0.1869	1.6616	1.8546	1.4130	2.4343	0.1366

Table 3. Results of the stepwise procedure for development of the GADNR trawl 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	1165	1756.6761	1.5079				
month	1157	1009.1709	0.8722	42.1580	42.1580	747.51	<.0001
temp	1164	1388.7391	1.1931	20.8767		367.94	<.0001
sal	1164	1701.1651	1.4615	3.0771		55.51	<.0001
year	1157	1717.2028	1.4842	1.5717		39.47	<.0001
area	1160	1730.4216	1.4917	1.0743		26.25	<.0001
depth	1164	1756.6485	1.5091	-0.0796		0.03	0.8681
month +							
year	1149	963.8226	0.8388	44.3730	2.2150	45.35	<.0001
area	1152	968.5211	0.8407	44.2470	2.0890	40.65	<.0001
sal	1156	1000.9273	0.8659	42.5758	0.4178	8.24	0.0041
temp	1156	1004.3444	0.8688	42.3834	0.2255	4.83	0.0280
month +year +							
area	1144	921.2945	0.8053	46.5946	4.2112	42.53	<.0001

FINAL MODEL: month + year + area

AIC 98.4 **BIC** 132.6 **(-2) Res LL** 88.5

Type 3 Test of Fixed Effects

Fixed effect	month	year
Significance (Pr>Chi)	<.0001	0.0360
DF	8	4
CHI SQUARE	38.43	10.28

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	490	364.2118	0.7433				
month	483	330.9504	0.6852	7.8165	7.8165	47.02	<.0001
year	482	340.1013	0.7056	5.0720		33.63	<.0001
temp	489	356.0585	0.7281	2.0449		11.12	0.0009
sal	489	361.6411	0.7396	0.4978		3.48	0.0622
depth	489	363.8630	0.7441	-0.1076		0.47	0.4928
area	485	337.6607	0.7990	-7.4936		37.31	<.0001
month +							
year	475	300.3882	0.6324	14.9200	7.1035	47.57	<.0001
temp	482	330.0166	0.6847	7.8838	0.0673	1.39	0.2389

FINAL MODEL: month + year

AIC 239.0 **BIC** 254.4 **(-2) Res LL** 225.0

Type 3 Test of Fixed Effects

Fixed effect	month	area	year
Significance (Pr>Chi)	<.0001	<.0001	0.2250
DF	8	5	4
CHI SQUARE	114.38	78.52	5.67

Table 4. GADNR trawl 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 observatoins per year (obs ppos), nominal cpue as sharks per tow 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).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
2003	136	37	0.2721	3.9412	6.1762	3.9784	9.5882	0.2226
2004	126	37	0.2937	5.4286	7.7411	5.1358	11.6680	0.2073
2005	171	12	0.0702	1.0994	2.0943	0.9497	4.6181	0.4114
2006	315	81	0.2571	2.8558	4.1455	3.0910	5.5598	0.1476
2007	292	60	0.2055	2.0285	3.2053	2.2582	4.5496	0.1765
2008	334	84	0.2515	2.7660	4.5139	3.3823	6.0242	0.1451
2009	256	62	0.2422	6.6580	10.2605	7.5258	13.9890	0.1559
2010	276	57	0.2065	2.5094	2.6676	1.8152	3.9202	0.1943
2011	321	68	0.2118	1.8656	3.2621	2.3426	4.5425	0.1667

Figure 1. Georgia's coastline with the labeled sound systems. Sampling areas for the GADNR trawl surveys are located in the Wassaw, Ossabaw, Sapelo, St. Simons, St. Andrew, and Cumberland sound systems

Figure 2. Fork lengths (cm) of bonnethead caught during the GADNR trawl survey from 2003-2011.

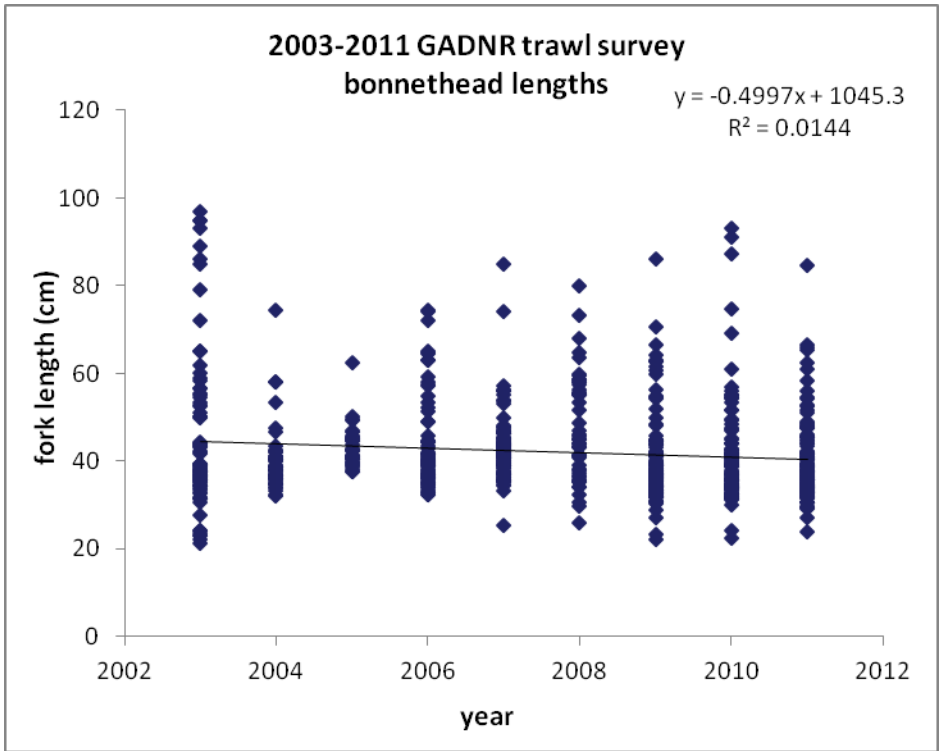


Figure 3a. Age 1+ bonnethead model diagnostic plots for the binomial component.

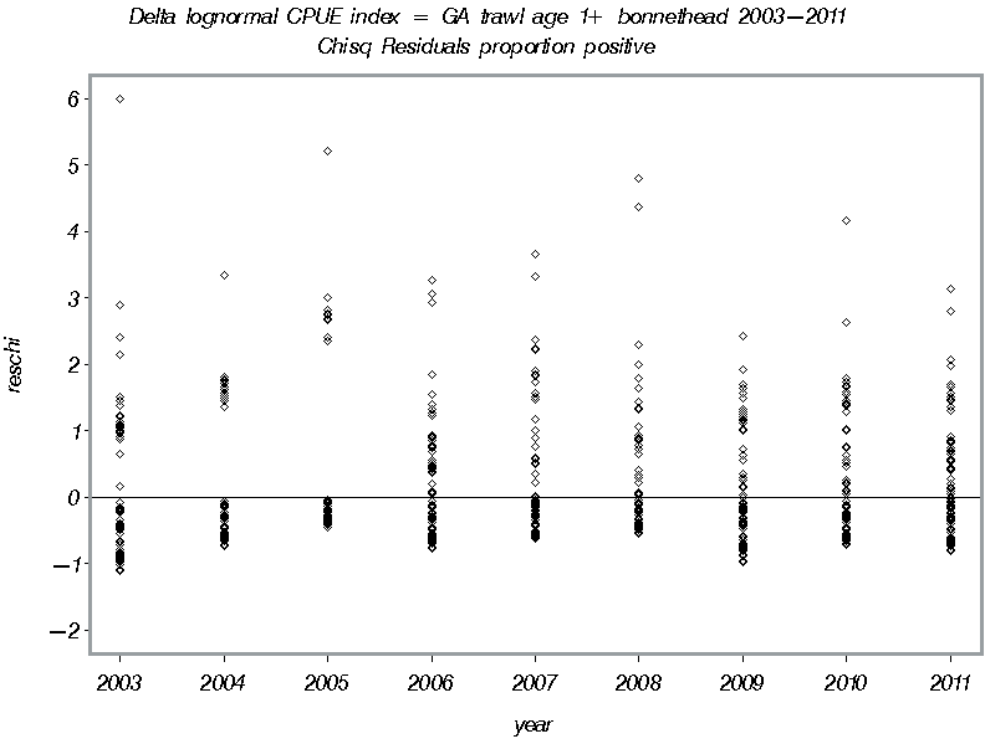
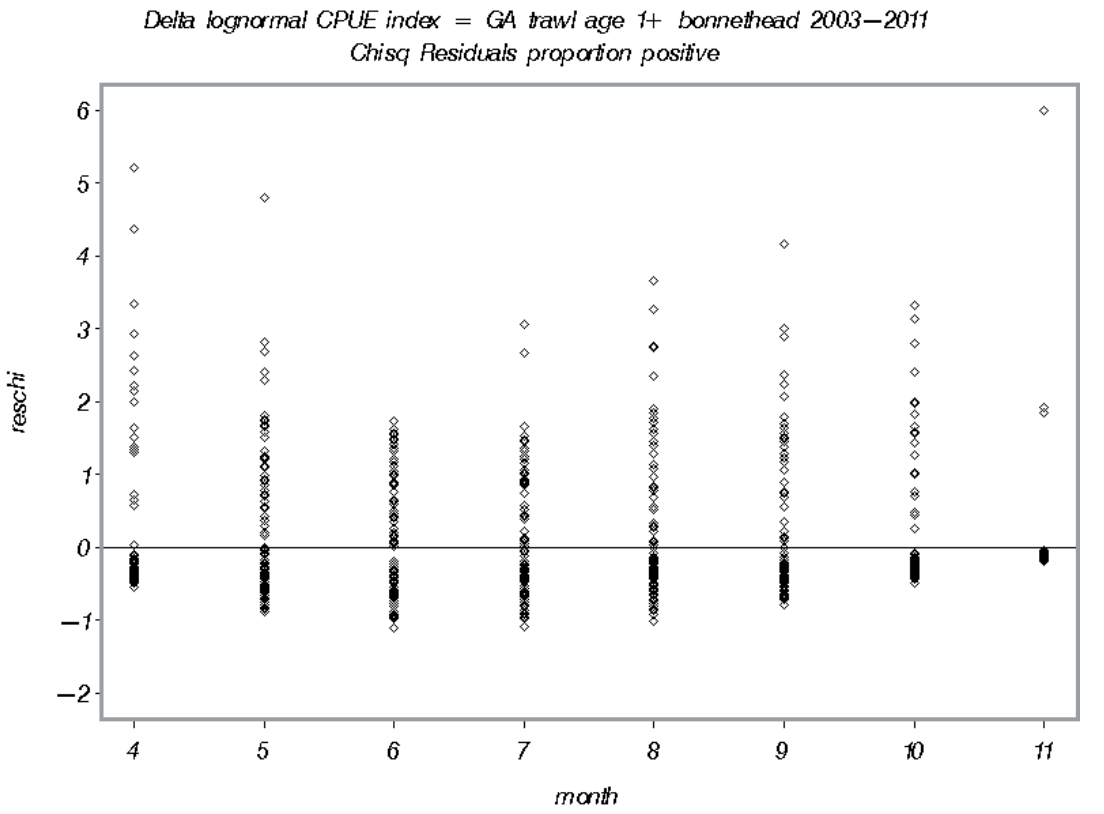


Figure 3a continued. Age 1+ bonnethead model diagnostic plots for the binomial component.



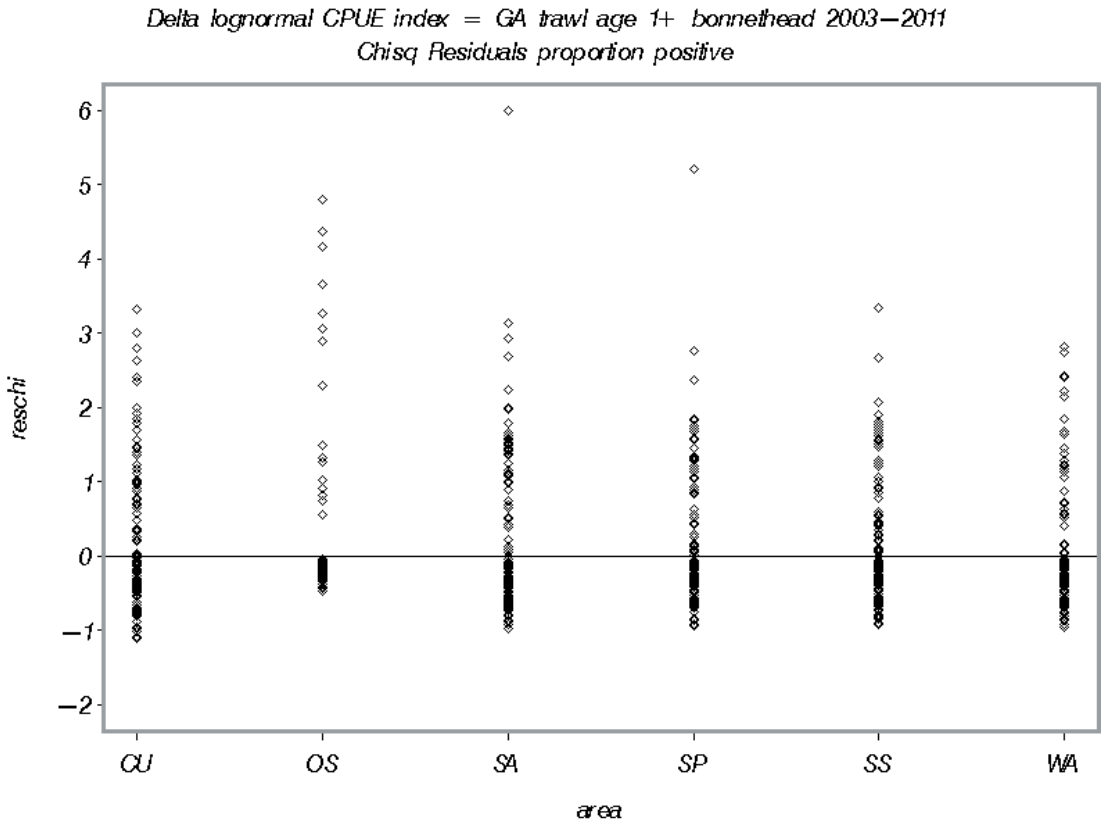


Figure 3a continued. Age 1+ bonnethead model diagnostic plots for the binomial component.

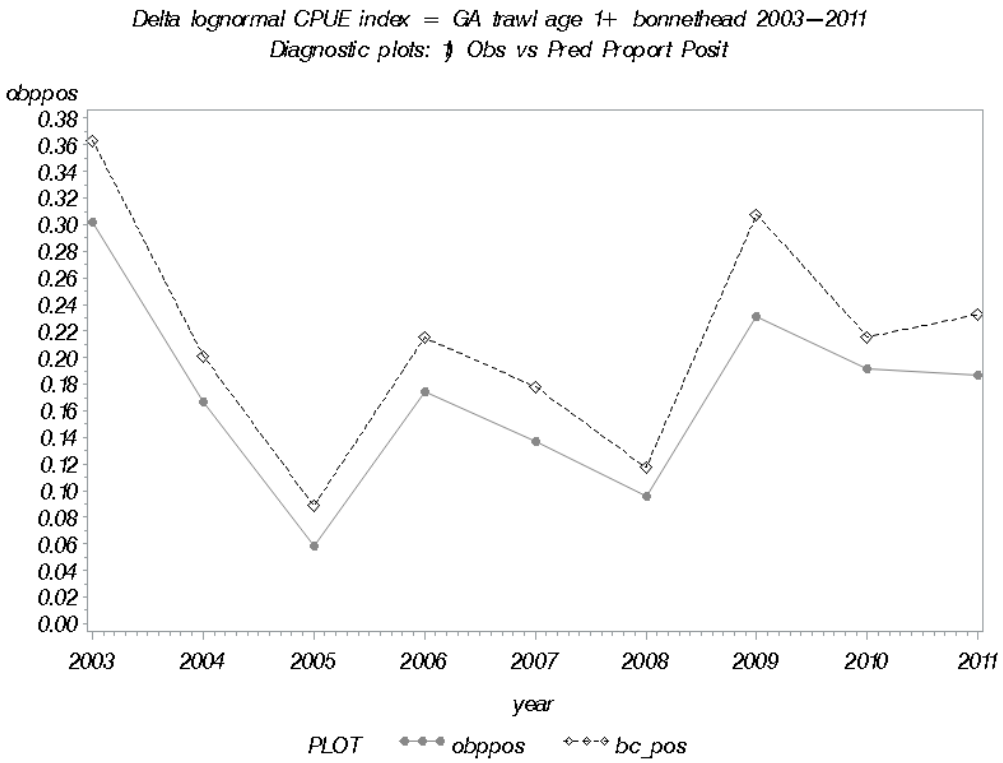


Figure 3b. Age 1+ bonnethead model diagnostic plots for lognormal component.

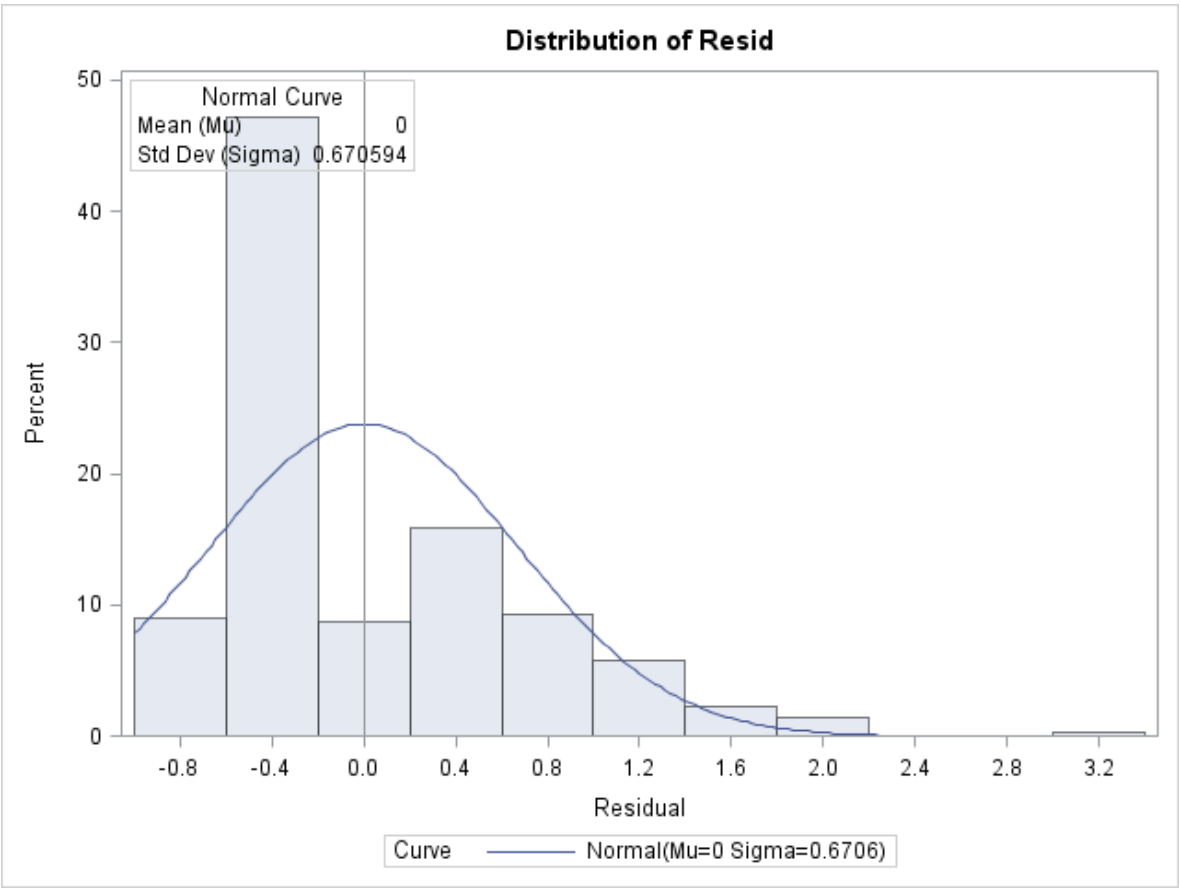
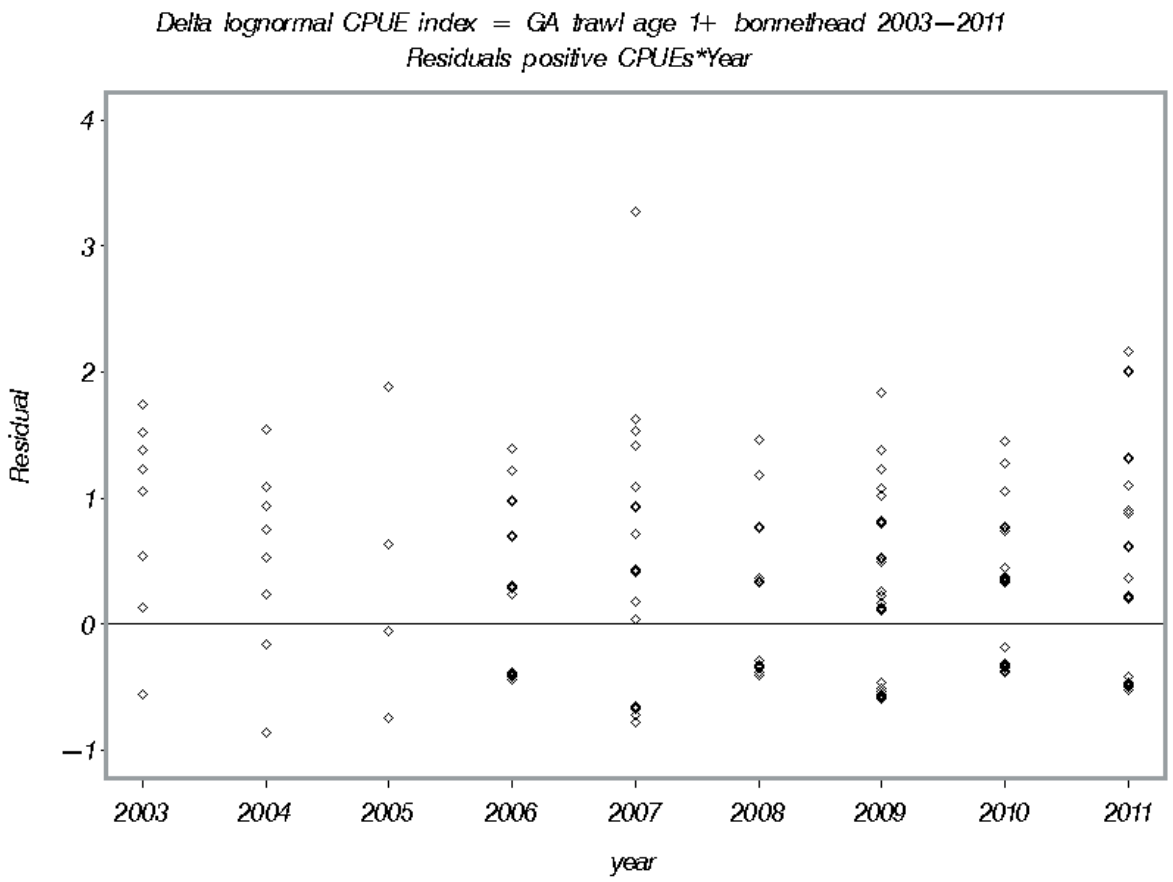


Figure 3b continued. Age 1+ bonnethead model diagnostic plots for lognormal component.



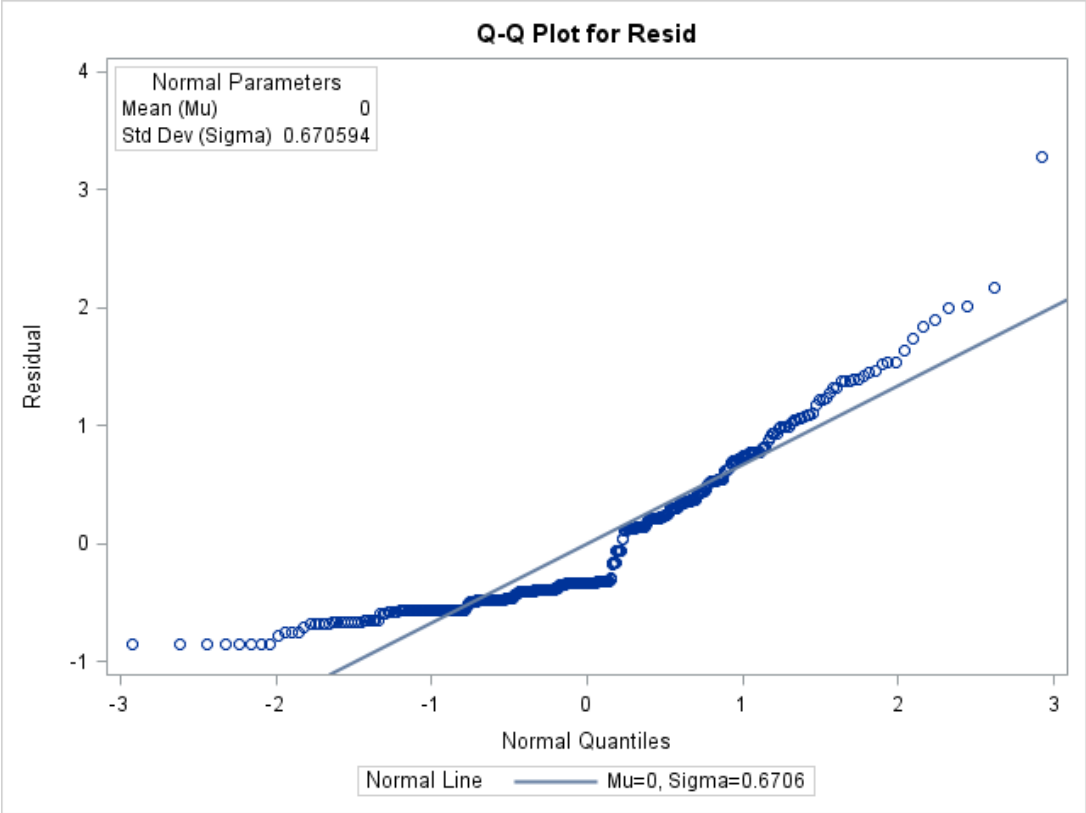


Figure 4. GADNR trawl survey age 1+ bonnethead nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0), UCI0).

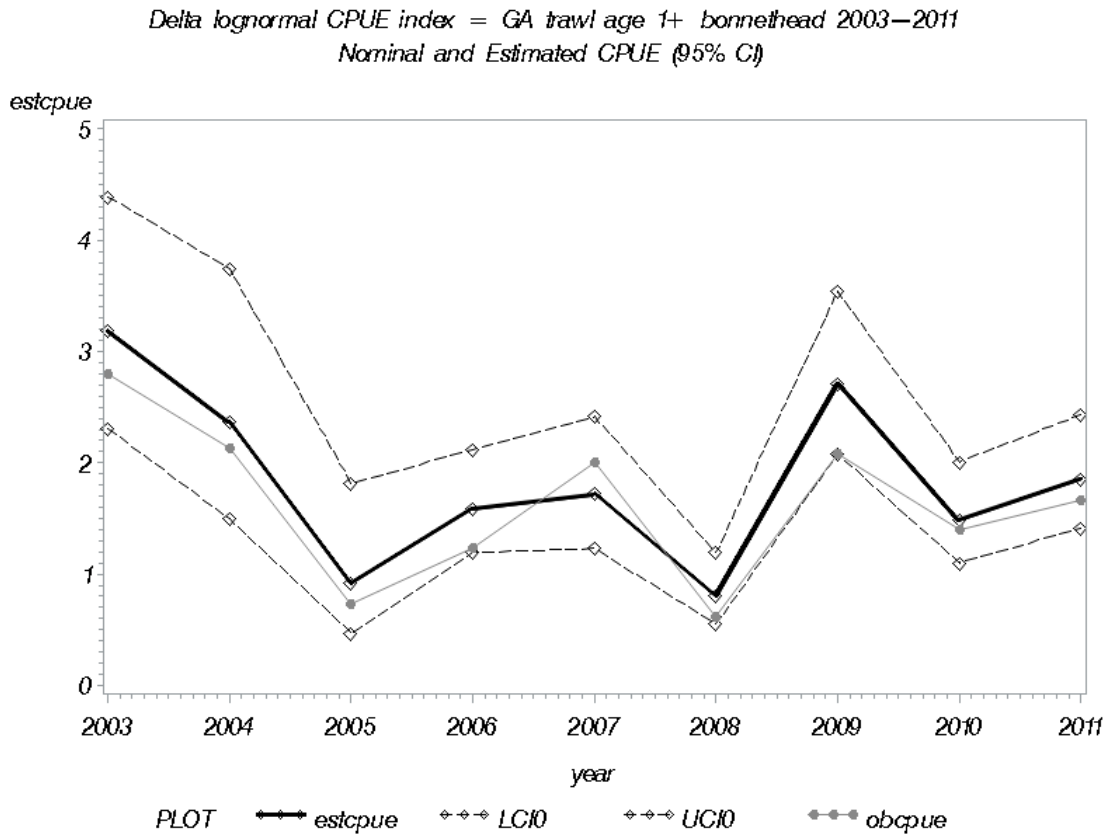


Figure 5. Fork lengths (cm) of Atlantic sharpnose sharks caught during the GADNR trawl survey from 2003-2011.

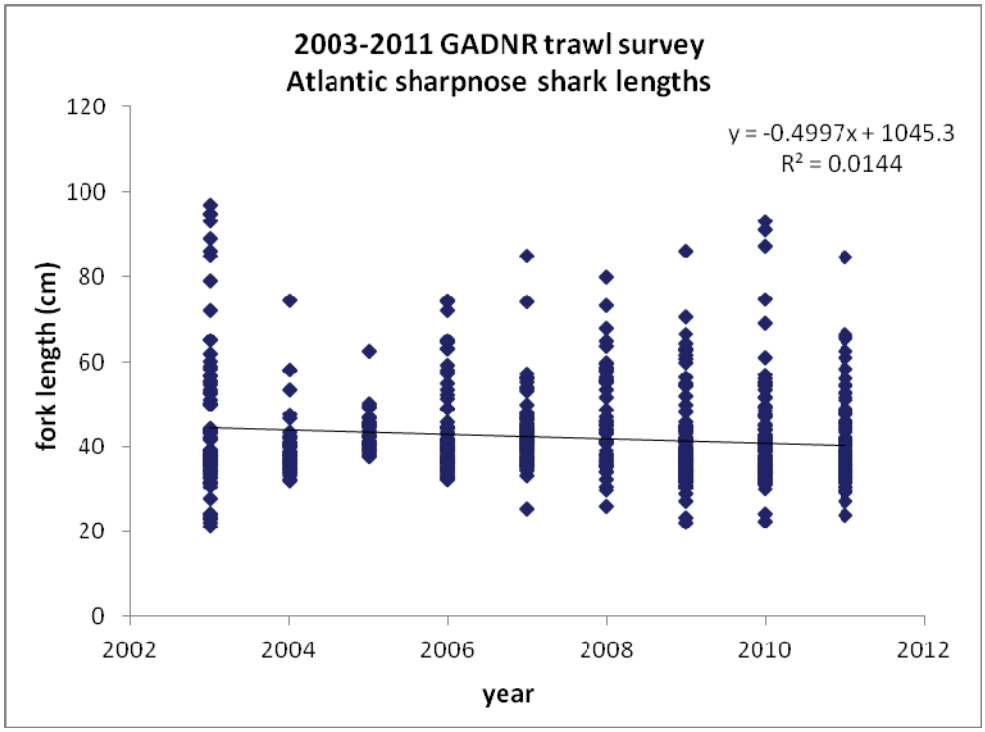
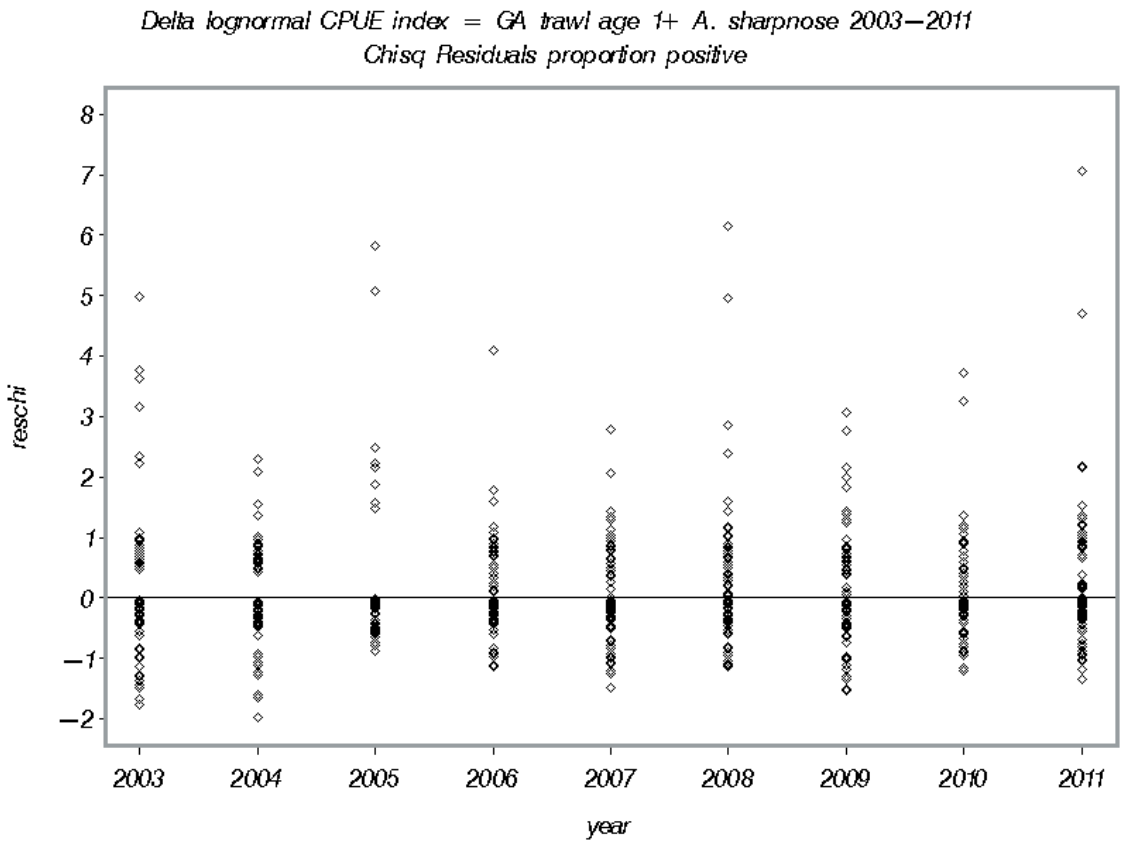


Figure 6a. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.



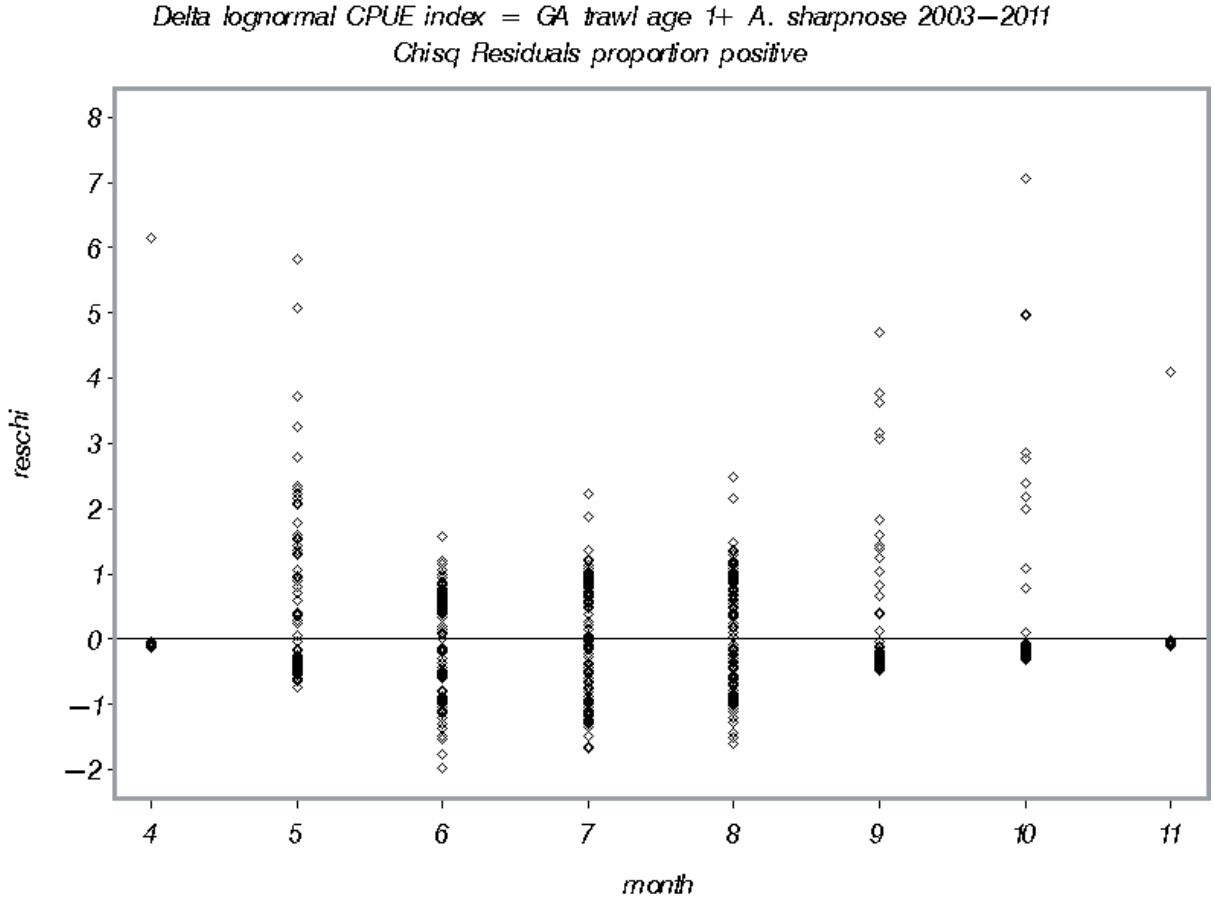
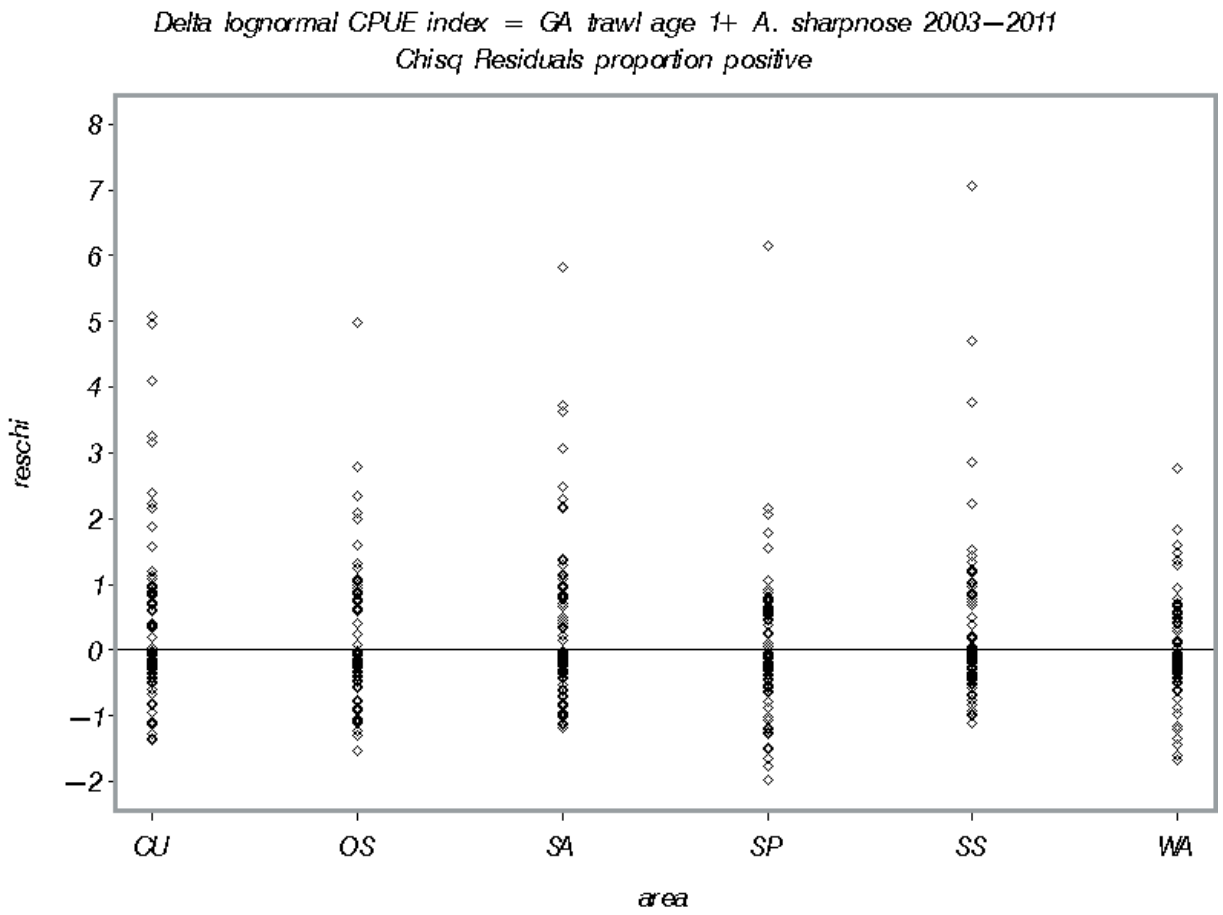


Figure 6a continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the binomial component.



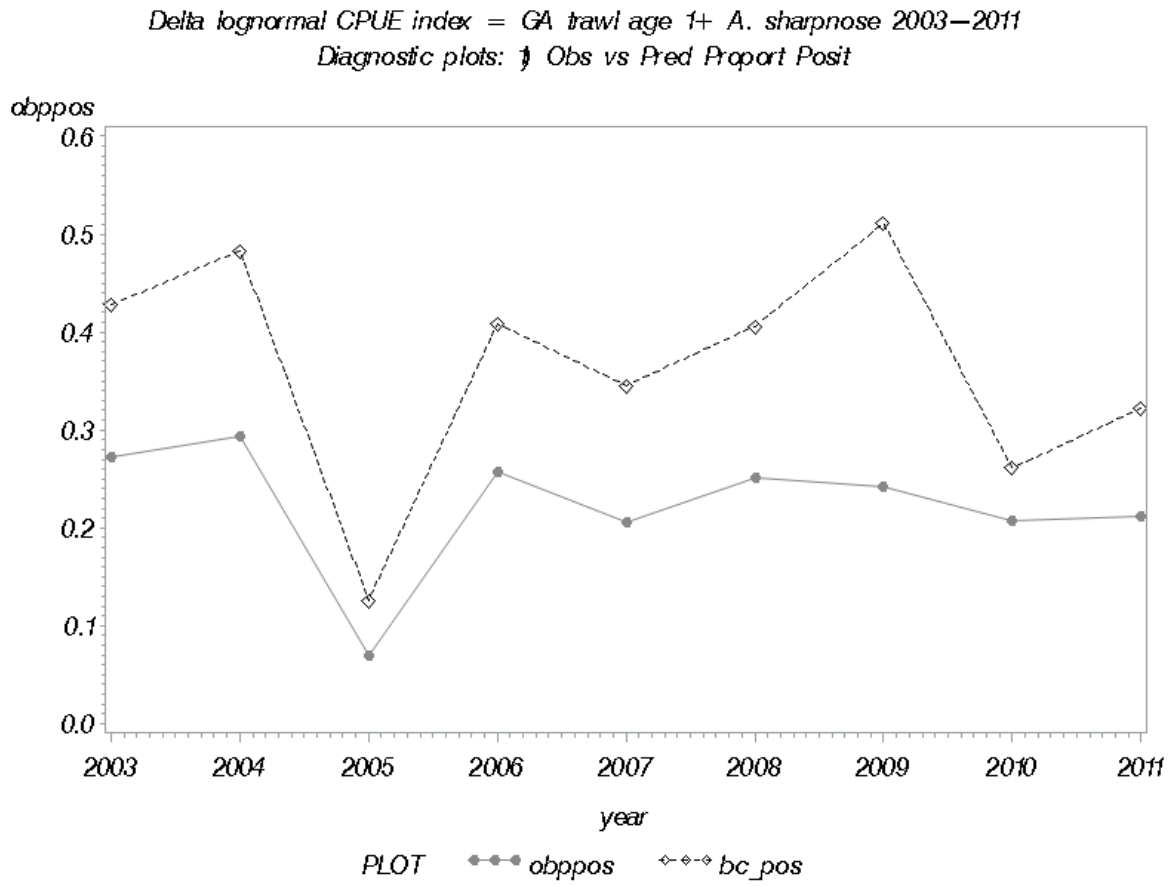
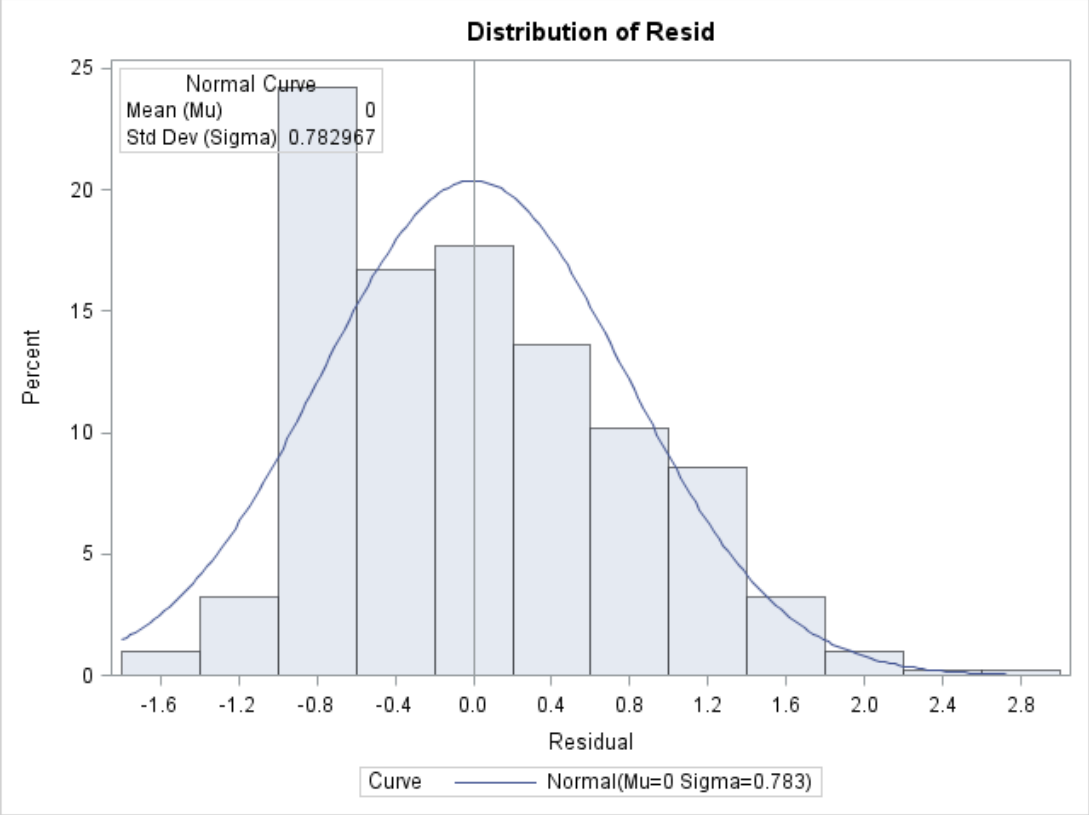


Figure 6b. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.



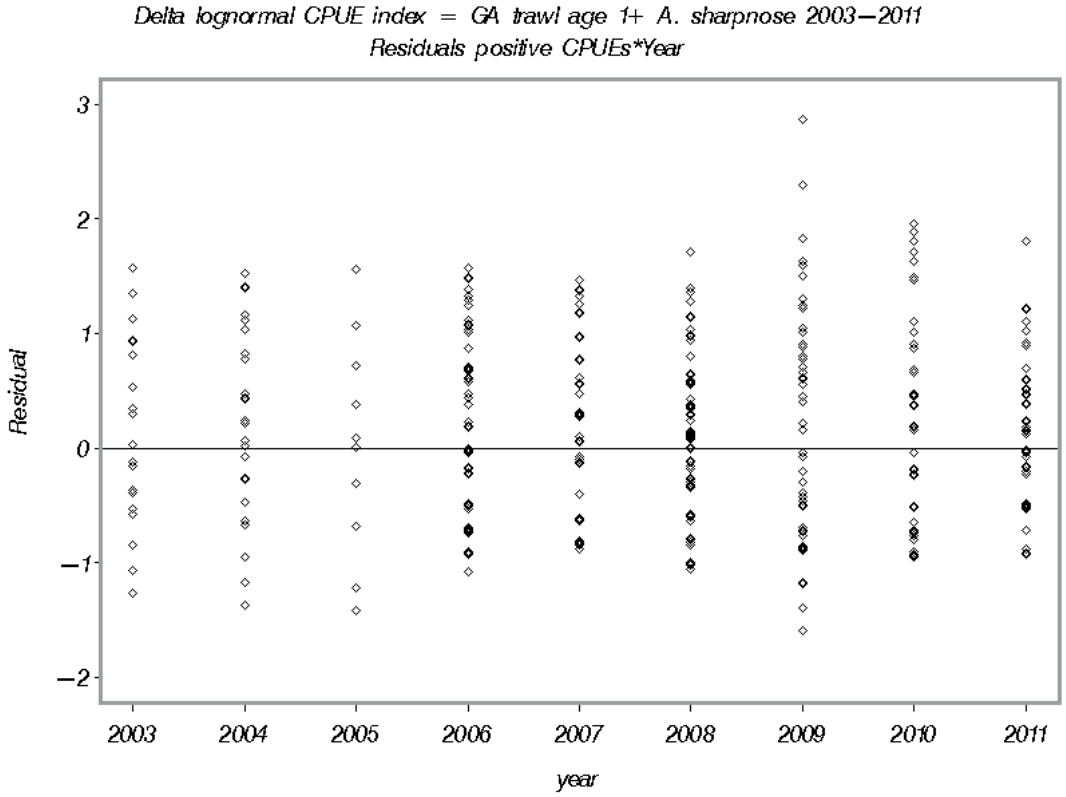
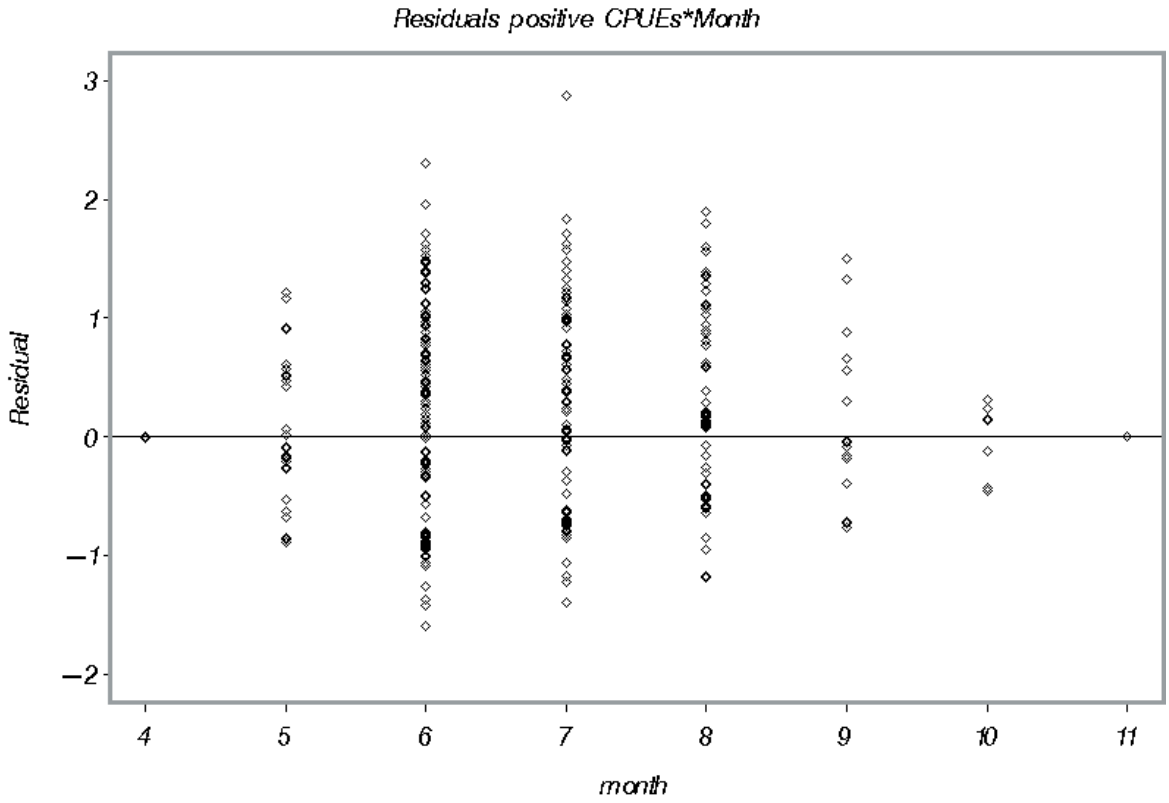


Figure 6b continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.



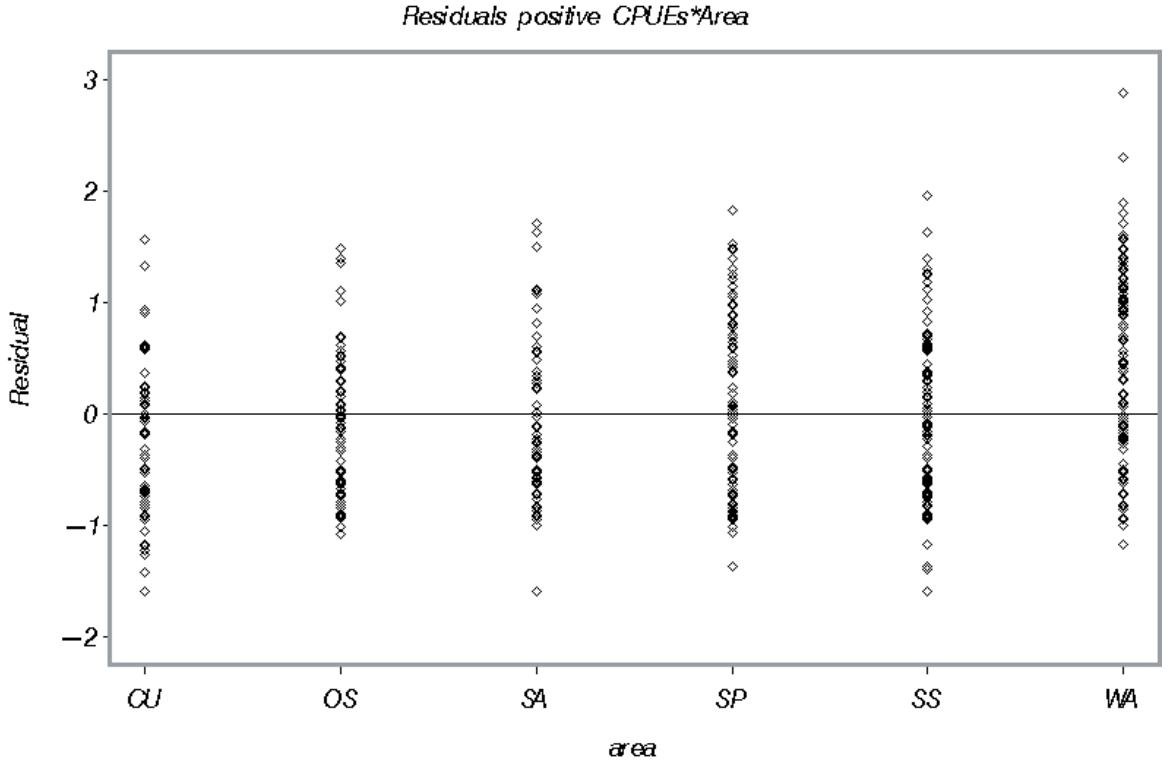


Figure 6b continued. Age 1+ Atlantic sharpnose shark model diagnostic plots for the lognormal component.

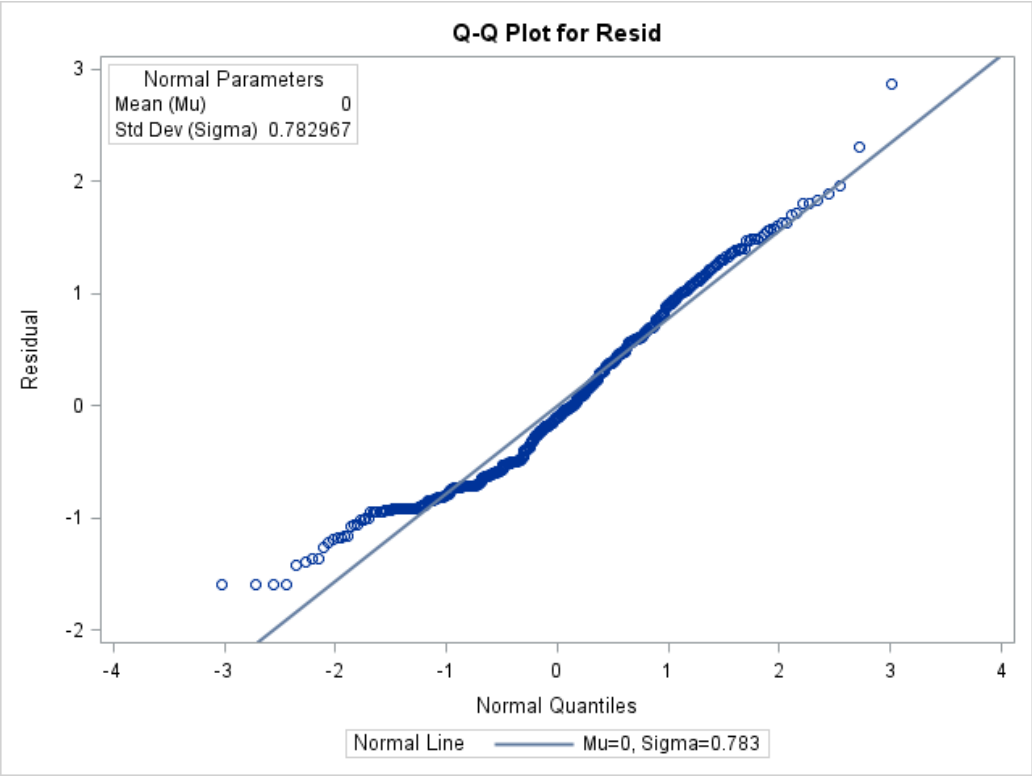


Figure 7. GADNR trawl survey age 1+ Atlantic sharpnose shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0), UCI0).