Standardized indices of abundance for Atlantic sharpnose sharks from the Georgia Department of Natural Resources red drum longline survey

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SEDAR 34 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for Atlantic sharpnose sharks from the Georgia Department of Natural Resources red drum longline survey

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Summary

This document details the shark catches from the Georgia Department of Natural Resources (GADNR) adult red drum longline survey conducted in Georgia and northern Florida's nearshore and offshore waters from 2007-2011. Catch per unit effort (CPUE) in number of sharks per hook were used to examine 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. Nominal and standardized CPUE results from the GADNR red drum survey indicate an initial increase in Atlantic sharpnose shark relative abundance from 2007 to 2008 followed by a gradual decreasing trend in relative abundance during the remaining survey years.

Introduction

In 2006 a pilot study to work out the logistics of a Georgia Department of Natural Resources (GADNR) adult red drum longline survey was conducted. The objectives of this survey are to develop a state specific sampling protocol that provides a fisheries independent index of abundance for adult red drum, to sample adult red drum and develop information on catch per unit effort (CPUE) and size, to collect migratory and stock identification data on adult red drum *Sciaenops ocellatus* to evaluate age composition and reproductive status of red drum <90 cm total length, and to disseminate accomplishments and results to the Atlantic States Marine Fisheries Commission (ASMFC) and the National Marine Fisheries Service (NMFS) for inclusion in stock assessment efforts. The GADNR adult red drum survey gear also targets multiple coastal shark species. The survey design was finalized and sampling began in 2007.

Methods

Sampling Gear and Data Collection

A stratified random sampling approach was used to select sampling locations. General sampling sites were selected based on scientific expertise and known historical areas of high abundance for red drum. Strata are defined spatially and temporally. There are two spatial strata: nearshore waters and offshore artificial reefs. Temporal stratification proportionally allocates effort between the nearshore and offshore areas over the duration of the sampling season and mirrors the offshore migration of the adult red drum. Starting in September 75% of the effort is focused in the nearshore waters and 25% is focused in the offshore. In October the allocation shifts to 50% nearshore and 50% offshore. In November the shift becomes 25% / 75%, ending at 0% / 100% in December. Sampling units are defined as 0.5 by 0.5 nautical mile quadrats which overlay the sampling area described above. A total of 25 stations are sampled from April through August off coastal Georgia. Starting in September a total of 35 stations are selected each month; 25 stations in waters off Georgia, 10 stations off northeast Florida (Figure 2). The mainline for the GADNR red drum survey is approximately 926 m in length consisting of 3.0 mm (273 kg) monofilament, containing 60 gangions. Gangions are 0.7 m of 1.6 mm (91 kg) monofilament terminating in either a 12/0 or 15/0 circle hook with the barb depressed. Hook type is equally represented during a set. Each set contained a combination of hooks baited with squid and hooks baited with fish. Soak times were 30 minutes in duration, measured from second anchor deployed to first anchor retrieved.

The station location, water and air temperatures, depth, salinity, and time of day were recorded for each set. The sex, weight, fork length, total length, and umbilical scar condition of all sharks were recorded. Umbilical scar condition was recorded in six categories: "umbilical remains," "fresh open," "partially healed," "mostly healed," "well healed," and none. Sharks were then tagged with a NMFS blue rototag in the first dorsal fin or a steel tipped dart tag (M-tag) and released.

Data Analysis

CPUE in number of sharks per number of hooks for the GADNR red drum sets was used to examine the relative abundance of age 1+ Atlantic sharpnose sharks in Georgia's coastal waters. 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 GADNR red drum sets were year (2007 – 2011), month (April-December) and depth (0-19 m, 20+ m). 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

A total of 1592 Atlantic sharpnose sharks were caught during 1215 longline sets from 2007 to 2011. The size range of Atlantic sharpnose sharks caught by year is displayed in Figure 2. The proportion of sets with positive catch (at least one A. sharpnose shark caught) was 31%. 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 may be acceptable, but the histogram for the lognormal model residuals on positive catch rates 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.

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 red drum survey catch rate model for 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.

Table 1. Results of the stepwise procedure for development of the SC-COASTSPAN-LL catch rate model for sharpnose. %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. L is the log likelihood.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	77	101.9484	1.3240				
month	69	68.2728	0.9895	25.2644	25.2644	33.68	<.0001
year	73	96.4229	1.3209	0.2341		5.53	0.2375
depth	76	101.4092	1.3343	-0.7779		0.54	0.4628
month +							
year	65	57.9938	0.8922	32.6133	7.3489	10.28	0.0360

FINAL MODEL: month + year

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	65	165.2284	2.5420				
depth	64	128.4300	2.0067	21.0582	21.0582	16.63	<.0001
month	57	134.4996	2.3596	7.1755		13.58	0.0934
year	61	159.1377	2.6088	-2.6279		2.48	0.6484
depth +							
year	60	116.9007	1.9483	23.3556	2.2974	6.21	0.1842

FINAL MODEL: depth + year

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

Type 3 Test of Fixed Effects

Fixed effect	depth	year
Significance (Pr>Chi)	<.0001	0.1842
DF	1	4
CHI SQUARE	20.36	6.21

Table 2. GADNR red drum survey 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
2007	31	19	0.6129	0.1509	0.1000	0.0437	0.2290	0.4327
2008	20	13	0.6500	0.4078	0.4526	0.1866	1.0976	0.4657
2009	13	11	0.8462	0.2782	0.2642	0.1145	0.6096	0.4370
2010	23	13	0.5652	0.1950	0.1566	0.0562	0.4367	0.5483
2011	19	10	0.5263	0.2956	0.1474	0.0485	0.4476	0.6011

Figure 1. Sampling areas for the GADNR red drum survey located in southern Georgia and northern Florida.

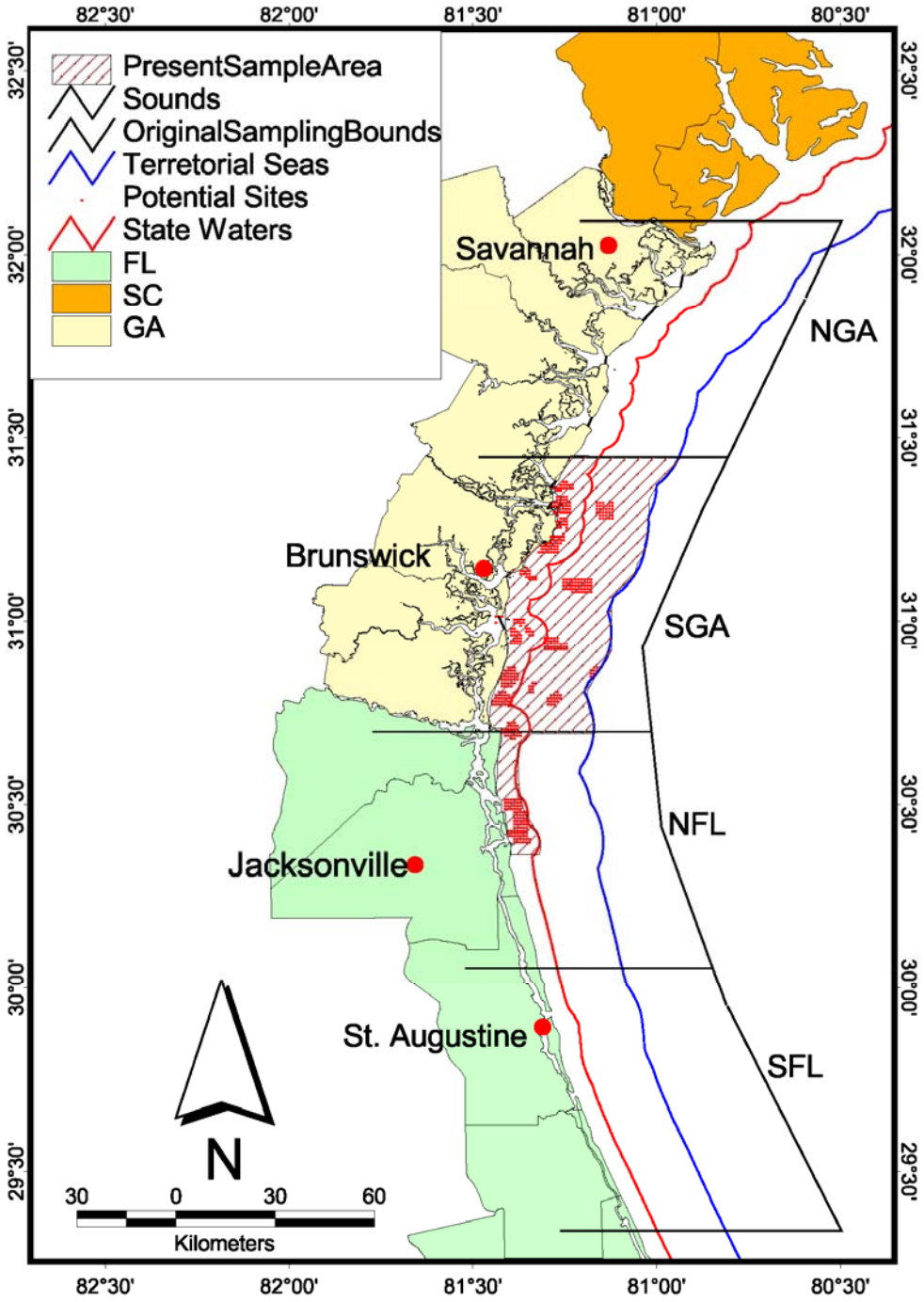


Figure 2. Fork lengths (cm) of Atlantic sharpnose sharks caught during the GADNR red drum longline survey from 2007-2011.

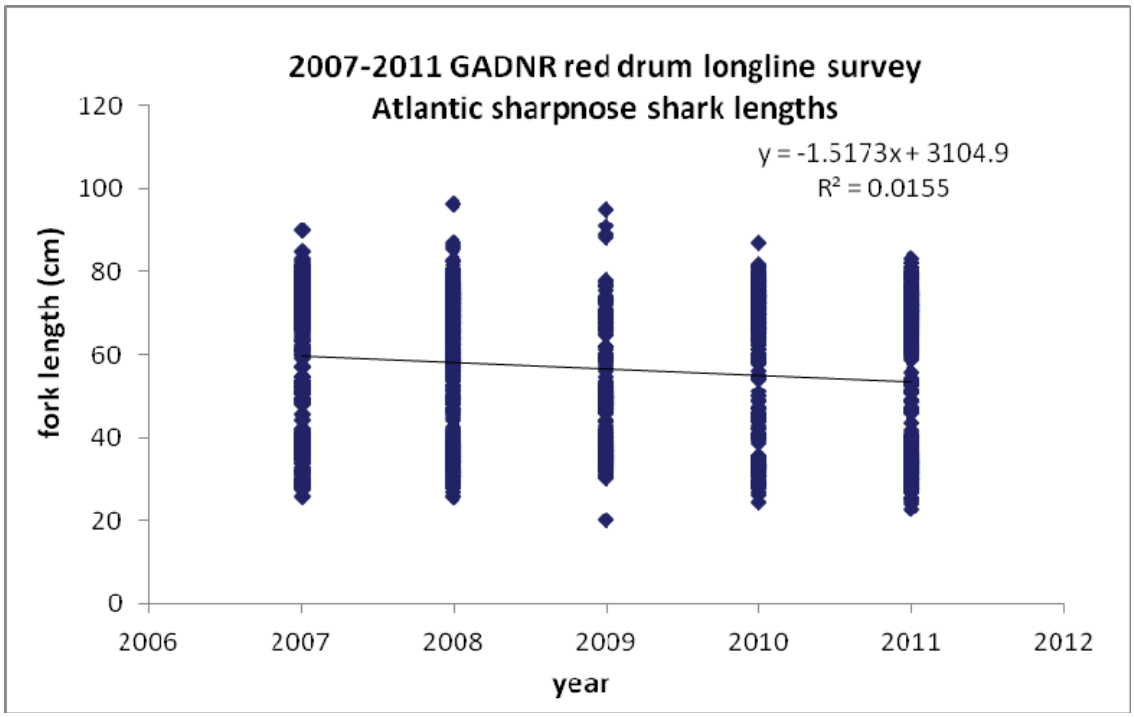


Figure 3a. Model diagnostic plots for the binomial component.

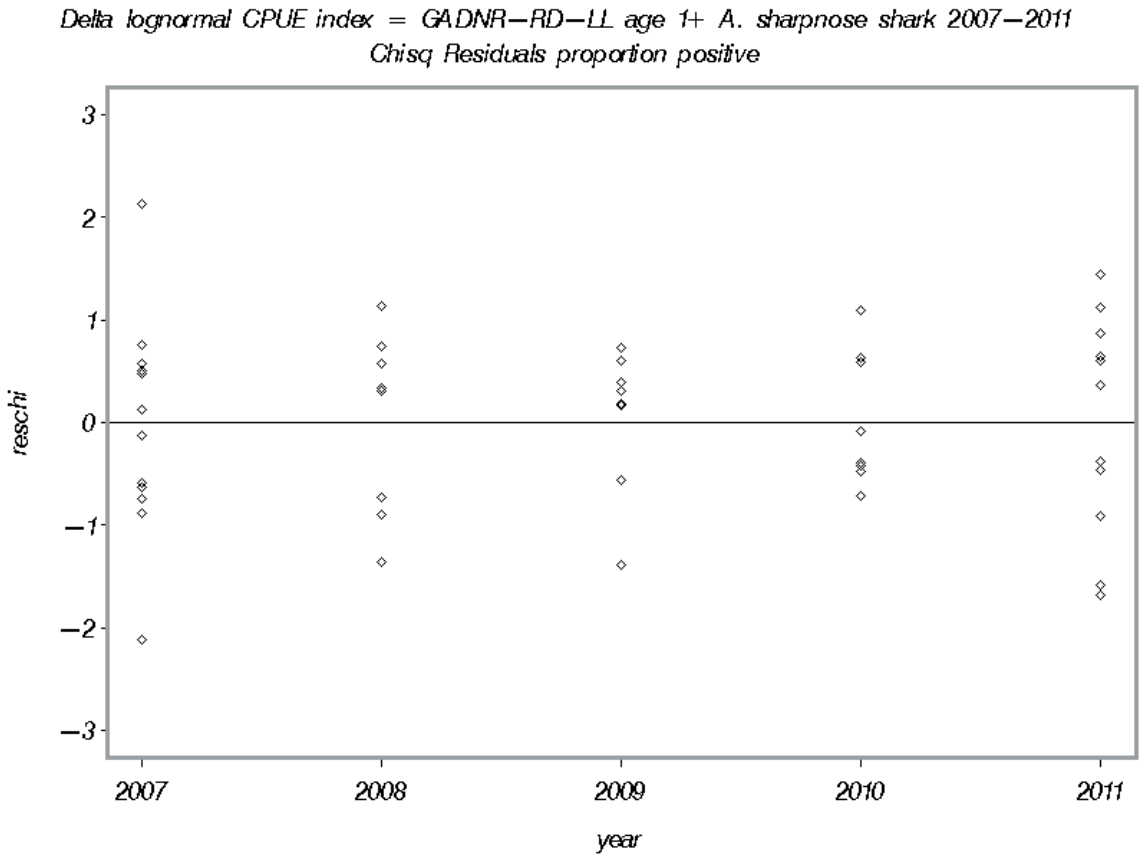
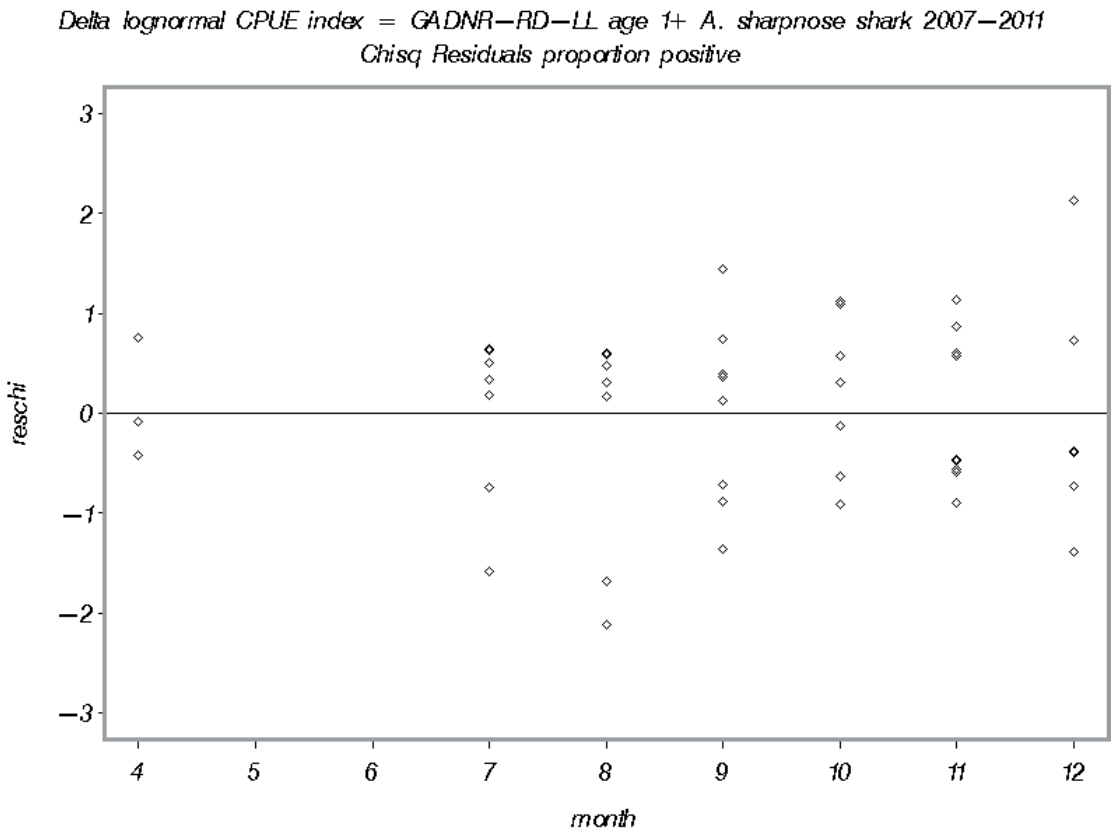


Figure 3a continued. Model diagnostic plots for the binomial component.



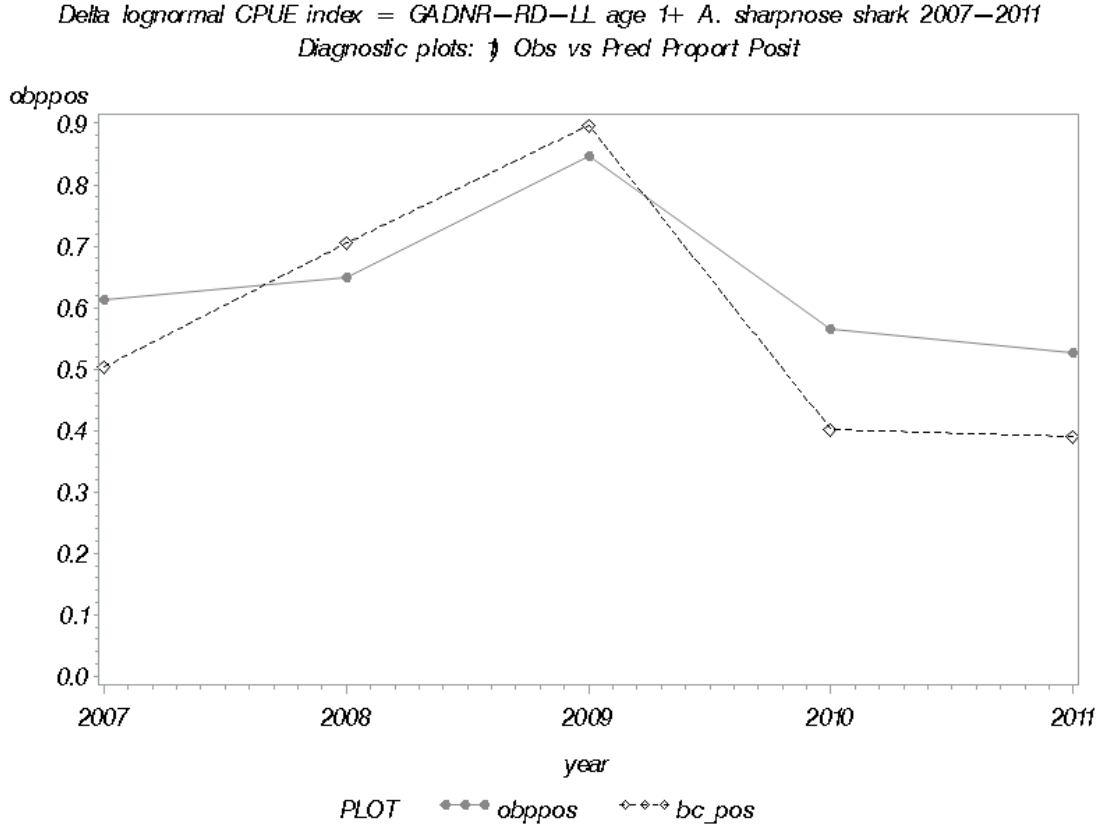
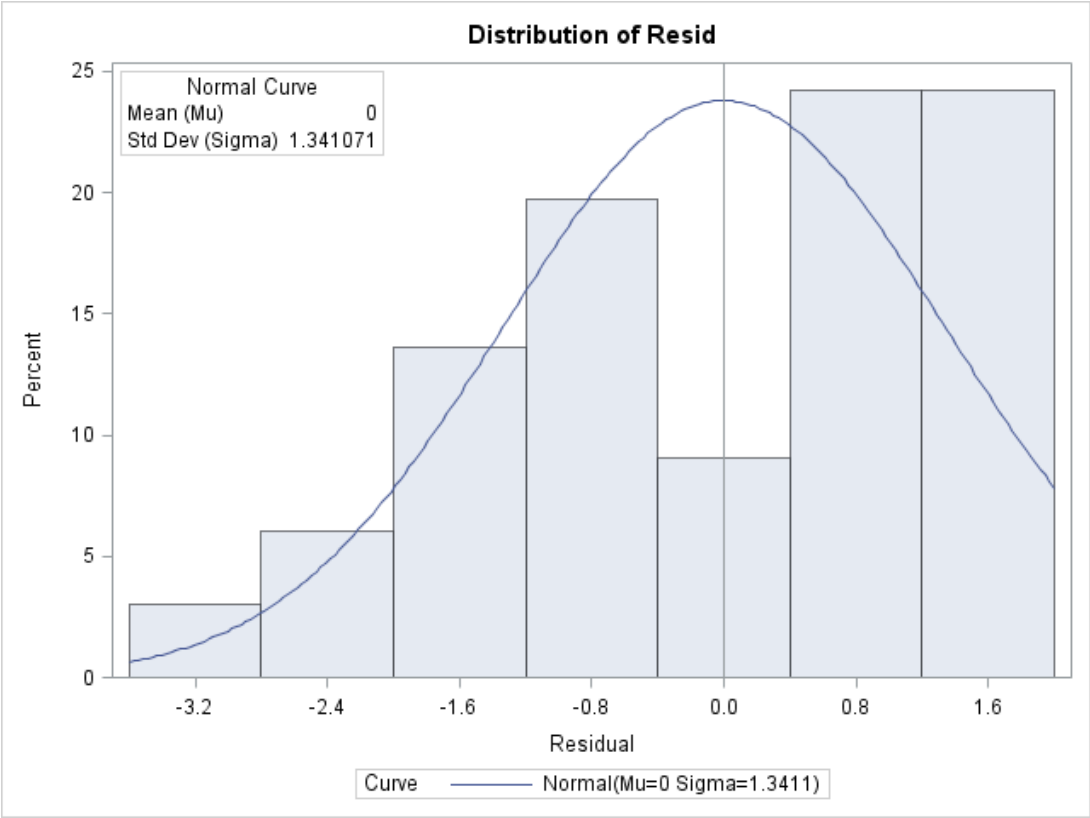


Figure 3b. Model diagnostic plots for lognormal component.



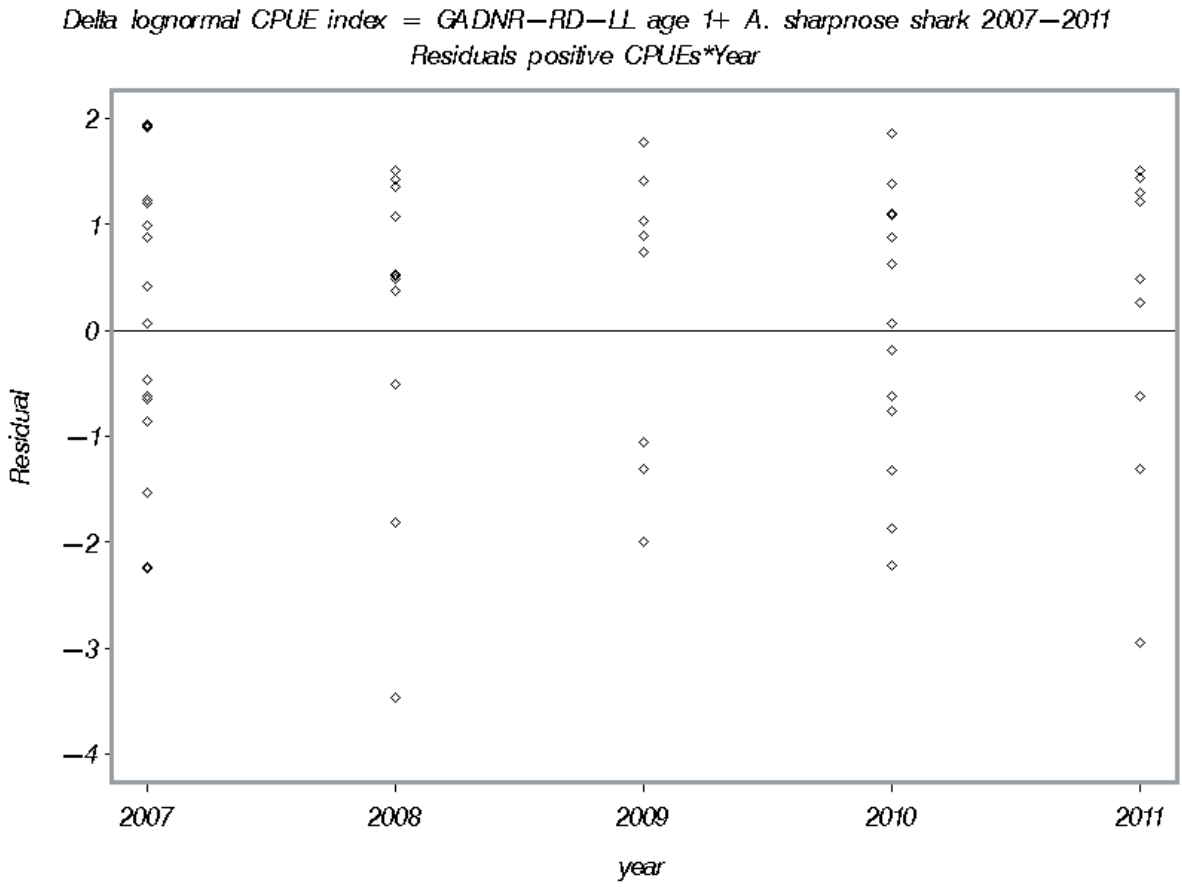
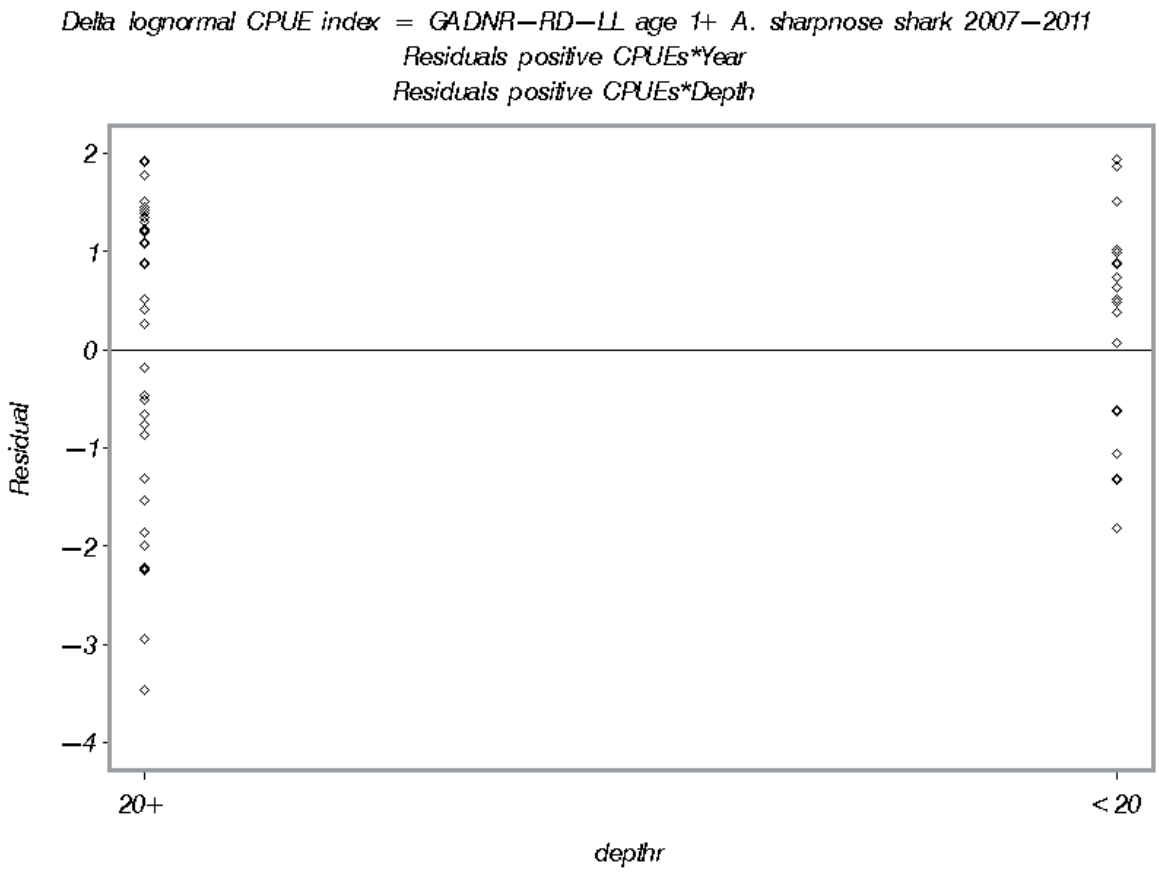


Figure 3b continued. Model diagnostic plots for lognormal component.



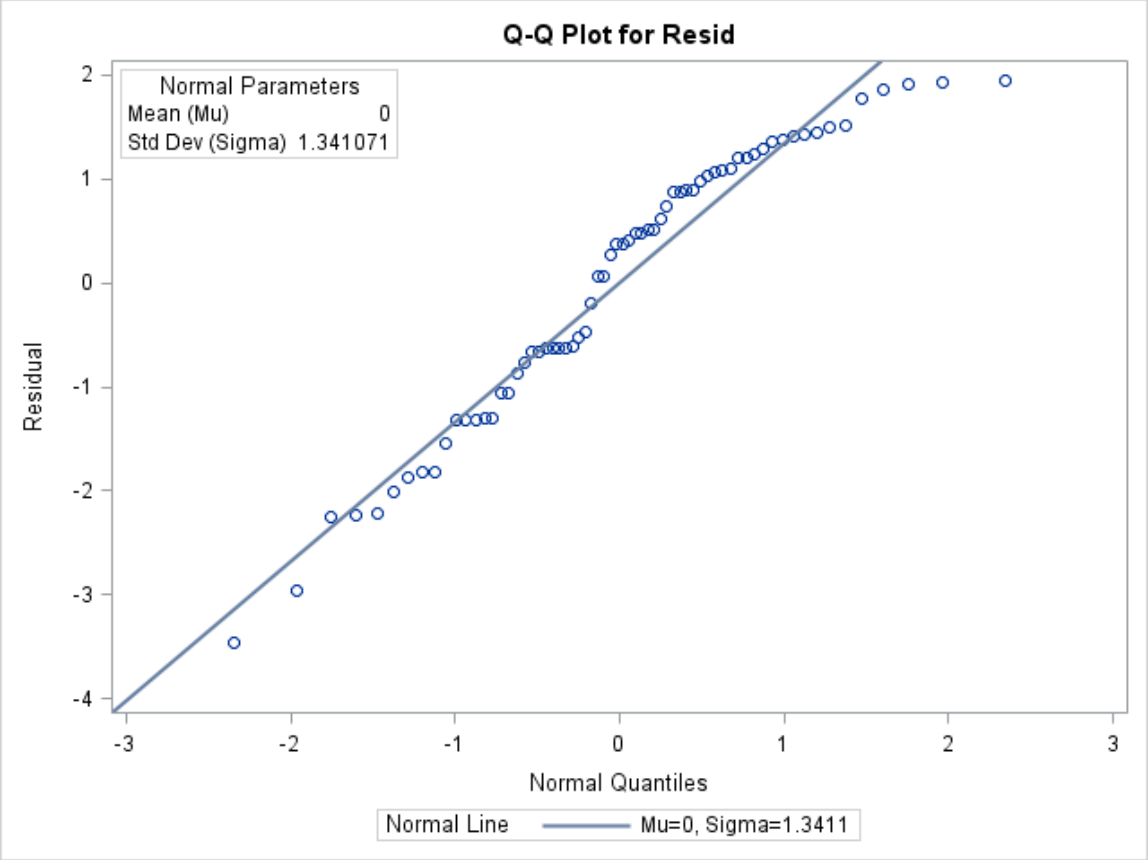
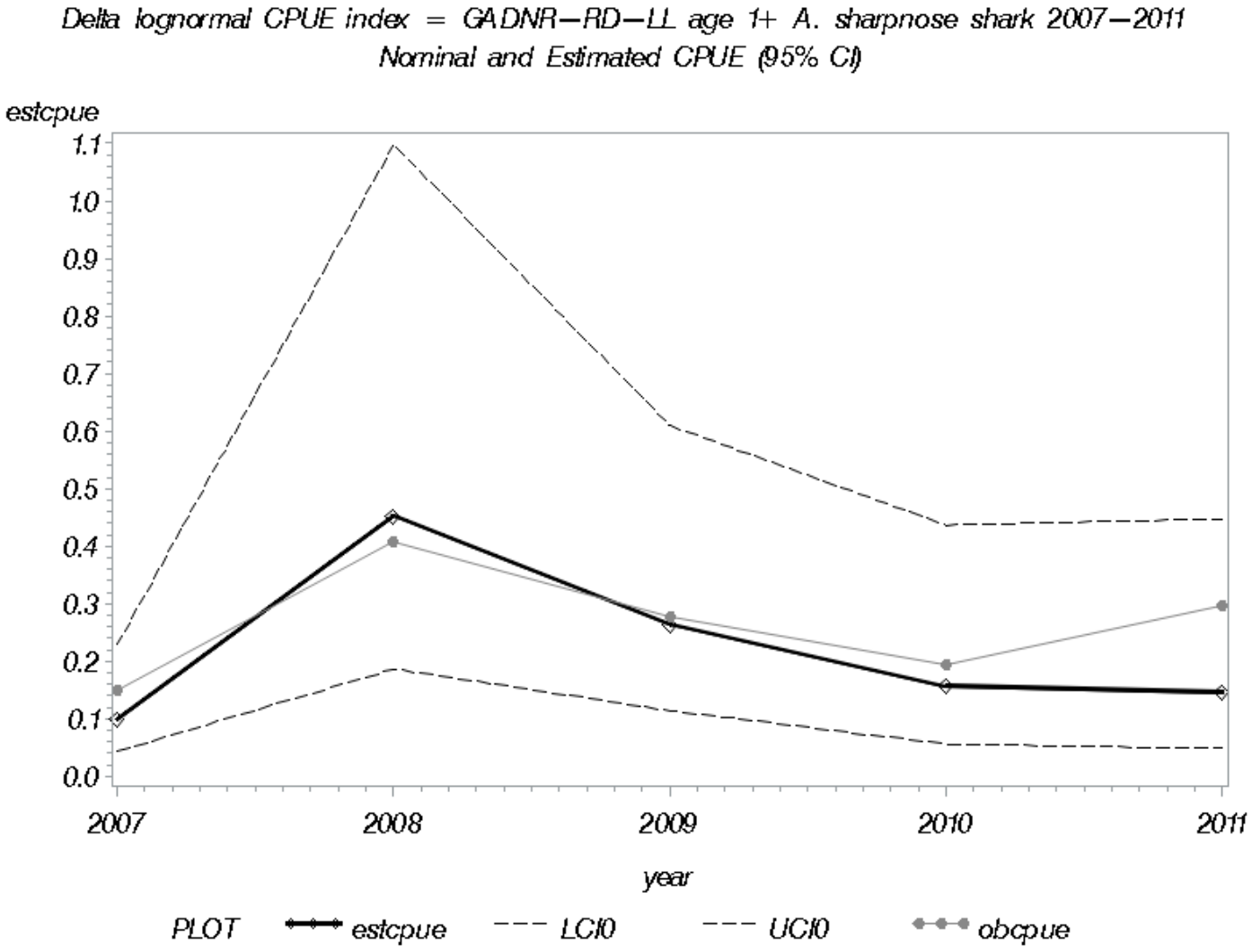


Figure 4. GADNR red drum survey Atlantic sharpnose shark nominal (obscpue2) and estimated (STDCPUE2) indices with 95% confidence limits (LCL2, UCL2).



Addendum to SEDAR34-WP-34 and 36
by C.T. McCandless, B.S. Frazier, and C.B. Belcher

After initial review of the SCDNR and GADNR red drum longline surveys it was requested to run the analyses on Atlantic sharpnose sharks combining the two surveys and compare results to the separate indices. The catch per unit effort in sharks per hook was modeled using the same methods as in SEDAR34-WP-34 and 36, using the following variables: year (2007 – 2011), month (April-December), depth (<10 m, 10+ m), salinity (<25 ppt, 25-29 ppt, 30-34 ppt, 35+ ppt), temperature (<20 degC, 20-24 degC, 25+ degC), and area (Winyah Bay, Charleston Harbor, St Helena Sound, Port Royal Sound, southern Georgia, and northern Florida). The results are presented here:

Table 1a. Results of the stepwise procedure for development of the combined red drum longline survey binomial 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	2288	3171.3250	1.3861				
month	2279	2851.3537	1.2511	9.7396	9.7396	319.97	<.0001
temp	2286	2946.9762	1.2891	6.9981		224.35	<.0001
year	2284	3161.0024	1.3209	4.7038		10.32	0.0353
sal	2285	3047.3289	1.3336	3.7876		124.00	<.0001
depth	2287	3162.9527	1.3343	3.7371		8.37	0.0038
area	2283	3085.3667	1.3515	2.4962		85.96	<.0001
survey	2287	3136.0132	1.3712	1.0750		35.31	<.0001
set	2270	3159.5019	1.3919	-0.4184		11.82	0.8562
month +							
sal	2276	2713.2817	1.1921	13.9961	4.2565	138.07	<.0001
area	2274	2732.3314	1.2016	13.3107	3.5712	119.02	<.0001
survey	2278	2781.4253	1.2210	11.9111	2.1716	69.93	<.0001
temp	2277	2809.2581	1.2338	10.9877	1.2481	42.10	<.0001
year	2275	2833.5239	1.2455	10.1436	0.4040	17.83	0.0013
depth	2278	2845.3093	1.2490	9.8911	0.1515	6.04	0.0140
month + sal +							
area	2271	2594.3633	1.1424	17.5817	3.5856	118.92	<.0001
survey	2275	2628.3282	1.1553	16.6510	2.6549	84.95	<.0001
temp	2274	2671.9930	1.1750	15.2298	1.2337	41.29	<.0001
year	2272	1686.6211	1.1825	14.6887	0.6926	26.66	<.0001
month + sal + area							
survey						0.00	.
temp	2269	2535.7828	1.1176	19.3709	1.7892	58.58	<.0001
year	2267	2573.4441	1.1352	18.1011	0.5194	20.92	0.0003

FINAL MODEL: month + year

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

Table 1b. Results of the stepwise procedure for development of the combined red drum longline survey lognormal 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.

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	1119	929.4294	0.8306				
month	1111	861.2449	0.7752	6.6699	6.6699	85.33	<.0001
sal	1116	889.8685	0.7974	3.9971		48.72	<.0001
area	1114	890.0372	0.7990	3.8045		48.50	<.0001
year	1115	910.7366	0.8168	1.6614		22.76	0.0001
depth	1118	927.6955	0.8298	0.0963		2.09	0.1481
survey	1118	920.4433	0.8233	0.8789		10.88	0.0010
temp	1117	920.7692	0.8243	0.7585		10.48	0.0053
set	1101	911.5231	0.8279	0.3251		21.79	0.2415
month +							
area	1106	796.2166	0.7199	13.3277	6.6578	87.93	<.0001
year	1107	849.7287	0.7676	7.5849	0.9150	15.08	0.0045
sal	1108	823.1681	0.8922	-7.4163		50.64	<.0001
month + area +							
year	1102	792.1946	0.7189	13.4481	0.1204	5.67	0.2250

FINAL MODEL: month + area + 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 2. Combined red drum 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
2007	429	220	0.5128	0.0462	0.0507	0.0410	0.0628	0.1068
2008	624	312	0.5000	0.0597	0.0445	0.0359	0.0552	0.1081
2009	398	205	0.5151	0.0540	0.0553	0.0438	0.0698	0.1166
2010	496	212	0.4274	0.0354	0.0353	0.0275	0.0453	0.1253
2011	420	198	0.4714	0.0400	0.0455	0.0358	0.0579	0.1206

Figure 1. Combined red drum longline survey age 1+ Atlantic sharpnose shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI1), UCI1).