

Standardized index of abundance for scalloped hammerhead sharks from the NOAA Fisheries
Cooperative Atlantic States Shark Pupping and Nursery longline survey

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SEDAR 77 DATA WORKSHOP DOCUMENT**Standardized index of abundance for scalloped hammerhead sharks from the NOAA Fisheries
Cooperative Atlantic States Shark Pupping and Nursery longline survey**

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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 100 hook hours were used to examine young-of-the-year scalloped hammerhead shark relative abundance from 2005-2019. 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 index of abundance from the COASTSPAN longline survey shows an overall decreasing trend in relative abundance for YOY scalloped hammerhead across survey 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 Popping and Nursery (COASTSPAN) program began sampling for sharks using longline and/or gillnet methods in several of their state's estuaries and nearshore waters. Sampling in South Carolina and, on a very limited basis, in Georgia began in 1998 by SCDNR and Savannah State University, respectively. GADNR took over Georgia sampling in 2000 and UNF began sampling in northern Florida in 2008. Exploratory sampling in the early years and a shift in spatial coverage in later years limit the start of the time series to 2005 for 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

Catch per unit effort (CPUE) in number of sharks per 100 hook hours was used to examine the relative abundance of young-of-the-year scalloped hammerhead sharks. The CPUEs were standardized using a delta-lognormal generalized linear mixed model, 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 (2001-2019), month (June-August), depth (<5 m, 5+ m), salinity (<20 ppt, 20-24.9 ppt, 25-29.9 ppt, 30+ ppt), temperature (<20 degC, 20-24.9 degC, 25-29.9 deg C, 30+ degC), and area (Bulls Bay, St Helena Sound, St. Simons Sound, St. Andrew Sound, Cumberland Sound, Nassau Sound, and the Tolomato River). The area factor is also expected to account for any survey effect between states. 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. 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 391 YOY scalloped hammerhead sharks were caught during the 3580 longline sets from 2005 to 2019 included in these analyses for index development. The size range of scalloped hammerhead sharks caught by year is displayed in Figure 1. The majority (92%) of the catch was YOY and any Age 1+ sharks were removed from the analyses. The proportion of sets with positive catch (at least one shark caught) was 8%. The stepwise construction of each model and the resulting statistics are detailed in Table 1. Model diagnostic plots reveal that the model fit is acceptable for YOY scalloped hammerhead sharks (Figures 2 and 3). The resulting index of abundance based on the year effect least square means, associated statistics and nominal index are reported in Tables 2 and are plotted by year in Figure 4. Nominal and standardized CPUE results from the COASTSPAN longline survey show an overall decreasing trend in YOY scalloped hammerhead shark relative abundance across survey years.

Table 1. Results of the stepwise procedure for development of the COASTSPAN longline survey catch rate model for total scalloped hammerhead 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	610	572.7020	0.9389				
AREA	604	435.5179	0.7211	23.1974		137.18	<.0001
MONTH	608	551.3481	0.9068	3.4189		21.35	<.0001
YEAR	596	542.0631	0.9095	3.1313		30.64	0.0062
DEPTH	609	558.7166	0.9174	2.2899		13.99	0.0002
SAL	607	560.8266	0.9239	1.5976		11.88	0.0078
TEMP	609	572.1310	0.9395	-0.0639		0.57	0.4499
AREA +							
YEAR	590	385.7104	0.6537	30.3760	7.1786	49.81	<.0001
SAL	601	418.0801	0.6956	25.9133	2.7159	17.44	0.0006
MONTH	602	419.3775	0.6966	25.8068	2.6094	16.14	0.0003
DEPTH	603	435.5055	0.7222	23.0802	-0.1172	0.01	0.9115
AREA +YEAR +							
MONTH	588	373.3459	0.6349	32.3783	2.0023	12.36	0.0021
SAL	587	378.4005	0.6446	31.3452	0.9692	7.31	0.0626
AREA +YEAR + MONTH +							
YEAR*AREA	522	289.1234	0.5539	41.0054	9.6602	Negative of hessian	
YEAR*MONTH	560	345.717	0.6174	34.2422	1.8639	Negative of hessian	

FINAL MODEL: AREA + YEAR + MONTH

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
NULL	158	465.1994	2.9443				
AREA	152	65.4720	0.4307	85.3717		311.77	<.0001
DEPTH	157	244.2792	1.5559	47.1555		102.42	<.0001
YEAR	144	377.7429	2.6232	10.9058		33.11	0.0028
SAL	155	429.7210	2.7724	5.8384		12.61	0.0056
MONTH	156	448.3238	2.8739	2.3911		5.88	0.0530
TEMP	157	436.7692	2.9539	-0.3261		0.49	0.4841
AREA +							
YEAR	138	53.2557	0.3859	86.8933	1.5216	32.84	0.0030
DEPTH	151	63.4970	0.4205	85.7182	0.3464	4.87	0.0273
MONTH	150	64.9730	0.4332	85.2868	-0.0849	1.22	0.5443
SAL	149	64.7673	0.4347	85.2359	-0.1359	1.72	0.6324
AREA + YEAR +							
DEPTH	137	52.7413	0.3850	86.9239	0.0306	1.54	0.2142
YEAR*AREA	108	40.8851	0.3786	87.1413	0.2479	42.03	0.0712

FINAL MODEL: AREA + YEAR

Table 2. COASTSPAN longline survey YOY scalloped hammerhead shark analysis number of model observations per year (n obs), 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).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
2005	69	9	0.1304	0.7199	5.4638	2.0240	14.7498	0.5288
2006	58	13	0.2241	1.1964	8.1187	3.6544	18.0368	0.4156
2007	29	2	0.0690	0.2342	1.9764	0.3230	12.0957	1.1276
2008	44	2	0.0455	0.1818	1.7300	0.2715	11.0251	1.1650
2009	98	6	0.0612	0.2920	3.4816	1.0551	11.4886	0.6543
2010	114	23	0.2018	22.8235	9.3760	4.9594	17.7257	0.3267
2011	139	22	0.1583	13.0123	3.8756	1.8856	7.9656	0.3722
2012	138	14	0.1014	4.6388	1.9065	0.7820	4.6479	0.4686
2013	146	18	0.1233	7.4185	2.0521	0.9056	4.6500	0.4267
2014	76	10	0.1316	5.7362	2.4430	0.8760	6.8130	0.5484
2015	109	11	0.1009	6.1651	1.1579	0.4117	3.2569	0.5536
2016	149	17	0.1141	4.5891	1.8986	0.8493	4.2444	0.4191
2017	134	12	0.0896	8.2661	1.1227	0.4224	2.9841	0.5195
2018	159	10	0.0629	3.3650	0.7381	0.2576	2.1150	0.5650
2019	40	2	0.0500	0.1615	1.0289	0.1597	6.6286	1.1753

Figure 1. Fork lengths (cm) of scalloped hammerhead sharks caught during the COASTSPAN longline survey from 2005-2019.

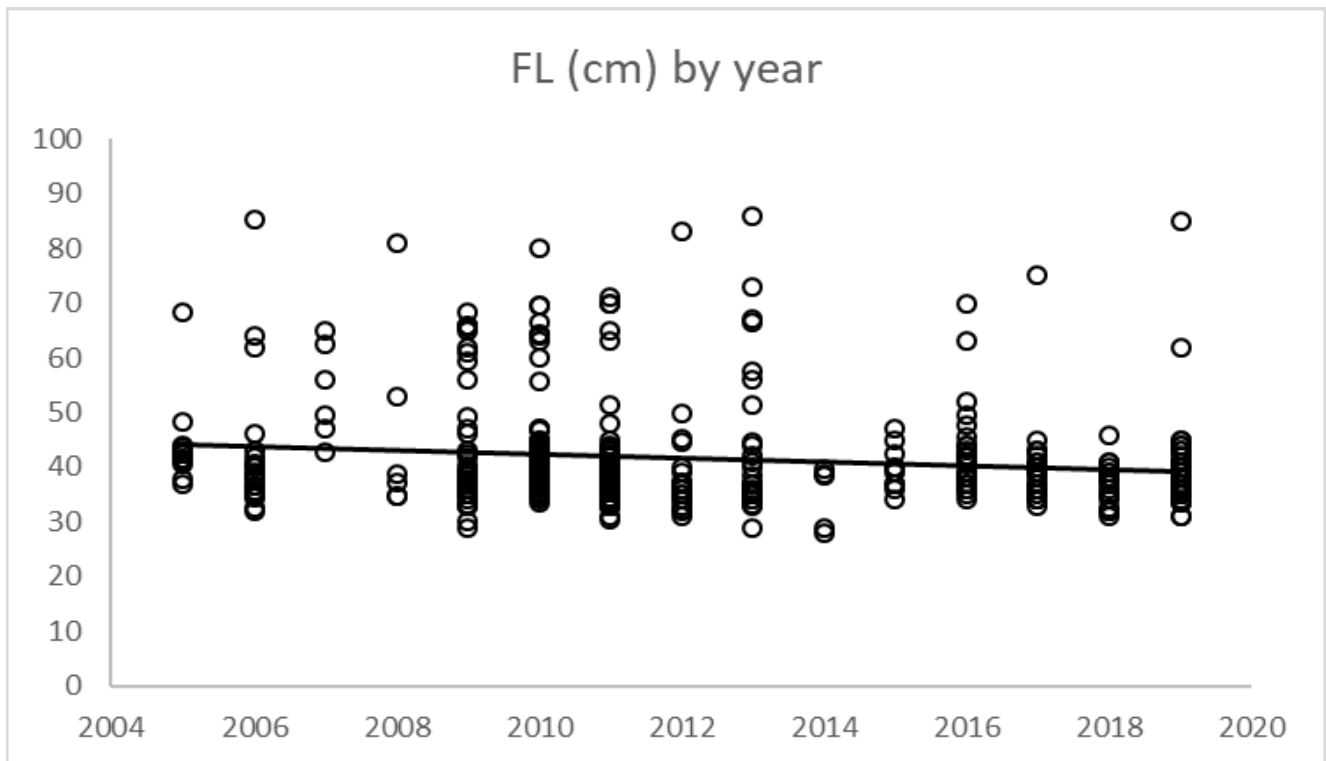


Figure 2. YOY scalloped hammerhead shark model diagnostic plots for the binomial component.

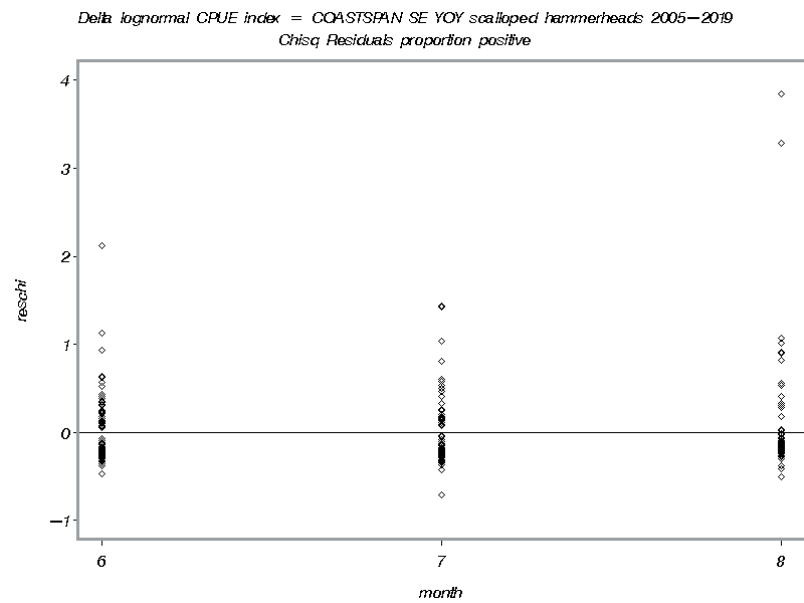
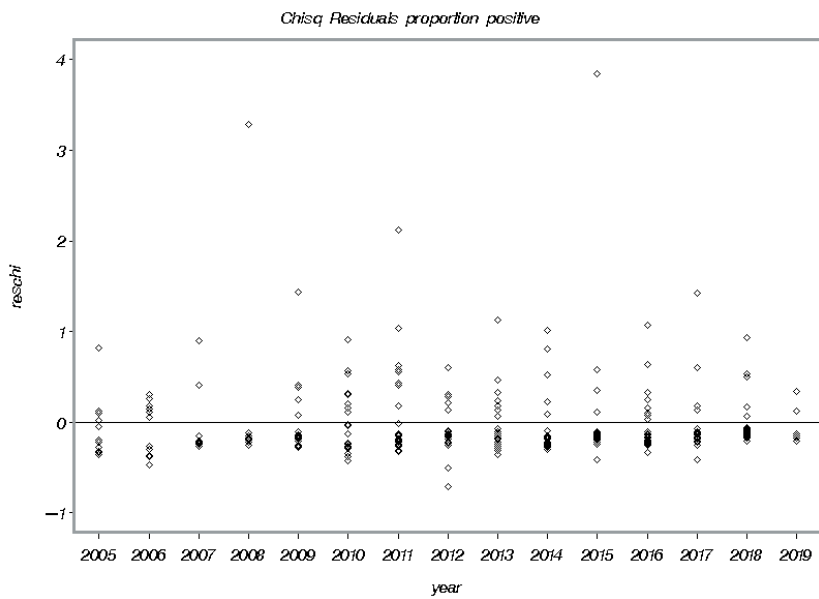
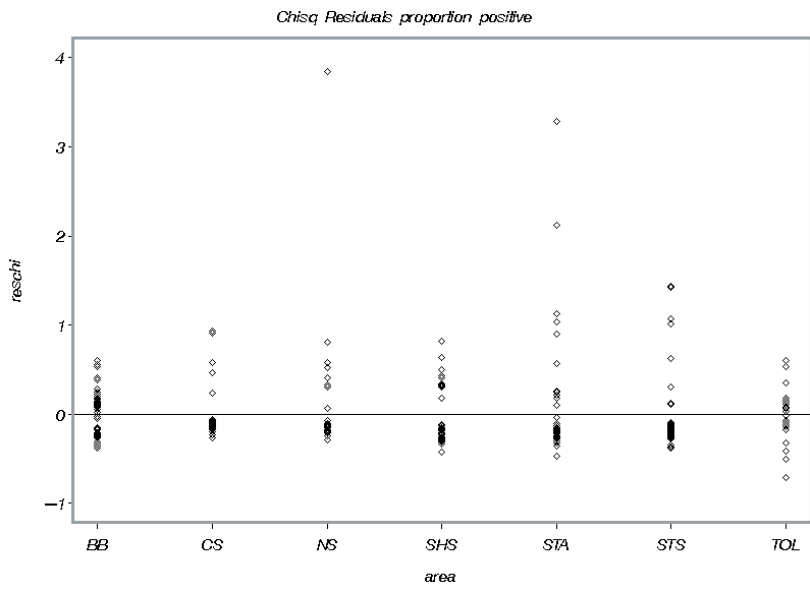


Figure 3. YOY scalloped hammerhead shark model diagnostic plots for the lognormal component.

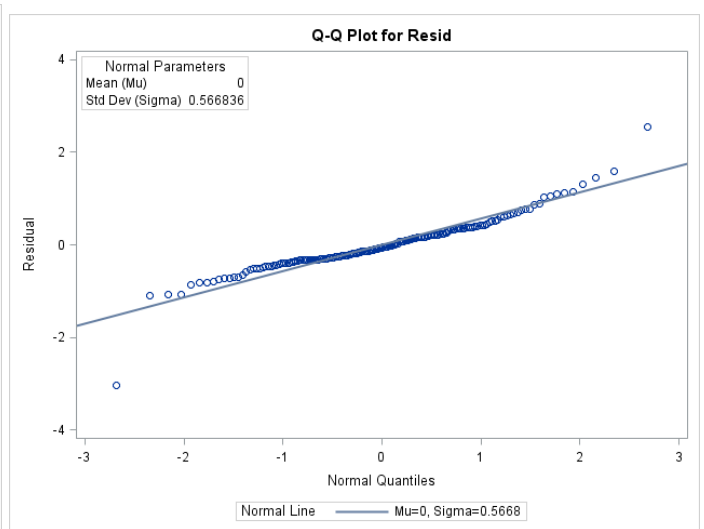
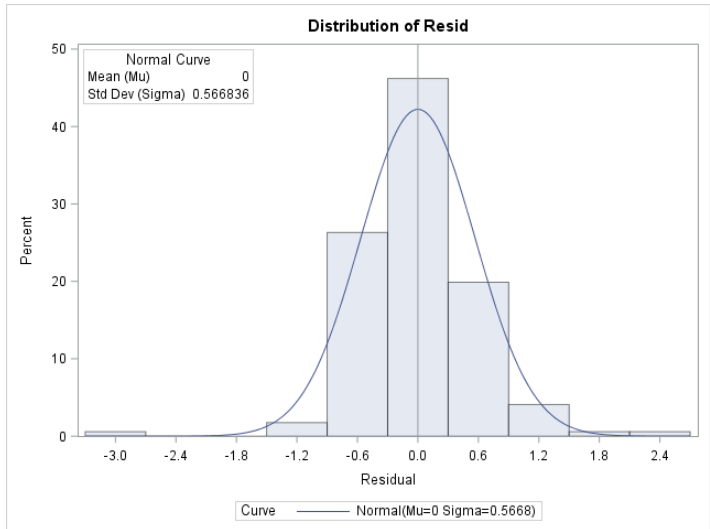
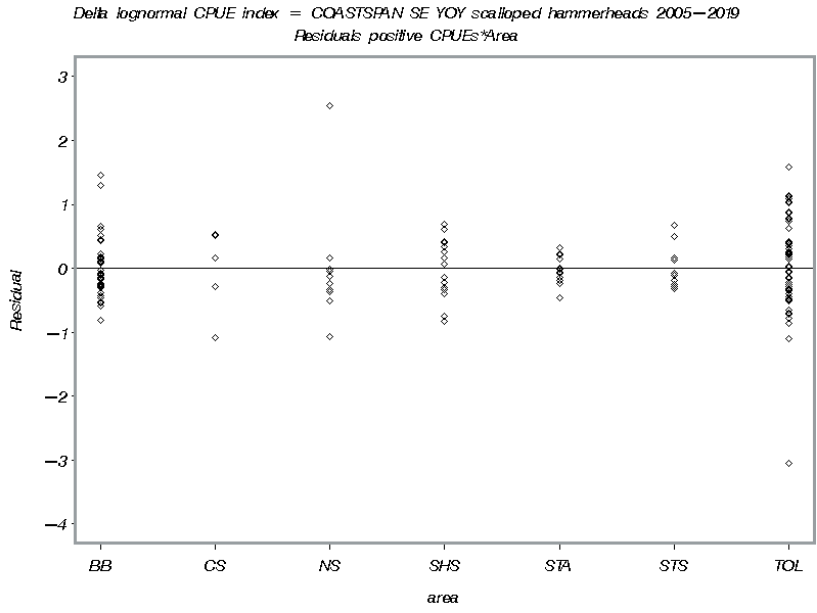
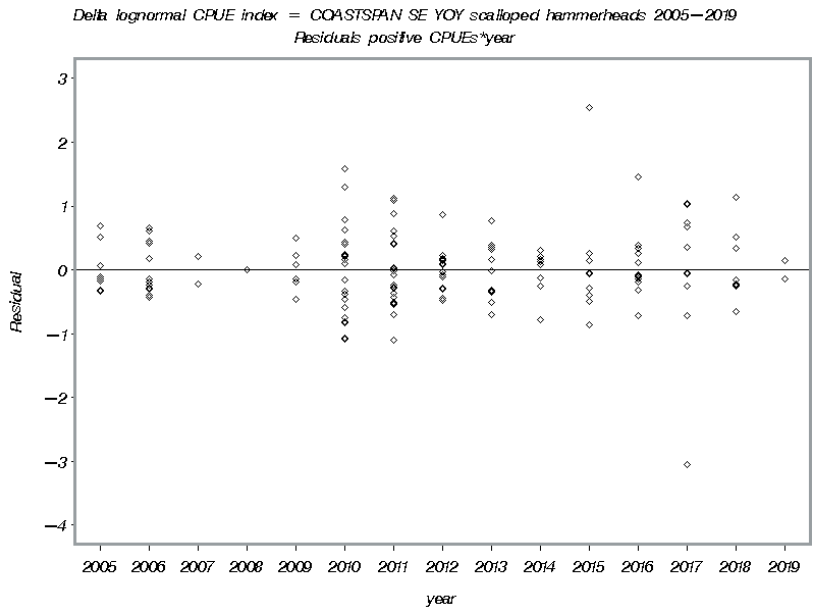


Figure 4. COASTSPAN longline survey YOY scalloped hammerhead shark nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0), (UCI0).

*Delta lognormal CPUE index = COASTSPAN SE YOY scalloped hammerheads 2005–2019
Nominal and Estimated CPUE (95% CI)*

