Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery long-gillnet survey

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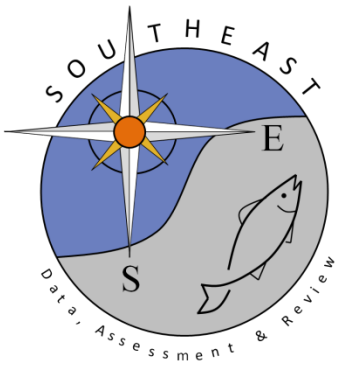

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SEDAR 77 DATA WORKSHOP DOCUMENT

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Summary

This document details scalloped hammerhead shark catches from the South Carolina Department of Natural Resources (SCDNR), Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) long-gillnet survey (2001-2019). Catch per unit effort (CPUE) in number of sharks per net hour were used to examine young-of-the-year (YOY) scalloped hammerhead shark relative abundance in South Carolina's estuarine waters. The CPUE was standardized using generalized linear models in 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 COASTSPAN long-gillnet survey indicate a slight increasing trend in YOY scalloped hammerhead relative abundance across survey years.

Introduction

In an effort to examine the use of South Carolina's estuarine waters as nursery areas for coastal shark species the South Carolina Department of Natural Resources (SCDNR) Marine Resources Division, 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 gillnet methods in several estuaries within South Carolina in 1998.

Methods

Sampling gear and data collection

SC COASTSPAN estuarine sampling locations were selected in the lower reaches of estuaries in depths which would facilitate the deployment and retrieval of gillnets. All gillnet sampling occurred inside of inlets and sampling locations varied with regard to distance from nearshore waters. Sampling was conducted primarily from April through October with the majority of the effort occurring between May and September.

Sampling gear and data collection

The SC COASTSPAN long gillnet survey used an anchored gillnet, 3 m deep and constructed of #177 monofilament twine with a stretched mesh of 10.3 cm. This net was approximately 230 m in length. The net was set in <4 m of water adjacent to shorelines and inspected for catch at approximately 20-minute intervals to reduce mortality. Station location, water temperature, salinity, dissolved oxygen set and pickup time and time of day were recorded for each sex. The sex, 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 either a NMFS blue rototag or steel tipped dart tag (M-tag) and released.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per net hour was used to examine the relative abundance of young-of the-year (YOY) scalloped hammerhead sharks. Since the net is set on station and inspected (hauled) multiple times and re-set to reduce bycatch before the final haulback, there were records of short soak times (<5 minutes). This occurs when the end set gillnet anchor was deployed and then the net was immediately retrieved at the start set anchor to inspect the net. To avoid unreasonably high catch rates due to these short soak times, all sets conducted consecutively at the same station were grouped and the combined catch and soak times were considered a single set. The CPUEs were standardized using a delta-lognormal generalized linear model, which models the proportion of positive sets separately from the positive catch. After initial exploratory analyses, factors considered as potential influences on the catch were year (2001-2019), month (May-September), salinity (<28 ppt, ≥28 ppt), temperature (<25 deg C, ≥25 deg C) and area (stations located in Bulls Bay and North Edisto estuarine waters). 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 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 1080 scalloped hammerhead sharks were caught during 201 gillnet sets from 2001 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 (99%) 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 scalloped hammerhead shark caught) was 47%. 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 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. Nominal and standardized CPUE results from the COASTSPAN long-gillnet survey indicate a slight increasing trend in YOY scalloped hammerhead relative abundance across survey years.

Table 1. Results of the stepwise procedure for development of the SCDNR COASTSPAN large-gillnet catch rate model for YOY 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	156	245.6288	1.5745				
area	155	149.9821	0.9676	38.5456		96.55	<.0001
sal	155	215.2083	1.3884	11.8196		30.42	<.0001
temp	155	245.3624	1.5830	-0.5399		0.27	0.6057
month	152	242.0805	1.5926	-1.1496		3.55	0.4706
year	138	230.4626	1.6700	-6.0654		15.17	0.6505
area +							
sal	154	147.8904	0.9603	39.0092	0.4636	2.09	0.1481
year	137	133.5847	0.9751	38.0692	-0.4763	16.40	0.5648

FINAL MODEL: area + year

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	91	173.6263	1.9080				
area	90	135.2827	1.5031	21.2212		22.96	<.0001
year	74	115.2388	1.5573	18.3805		37.71	0.0027
temp	90	168.6369	1.8737	1.7977		2.68	0.1015
sal	90	168.8411	1.8760	1.6771		2.57	0.1088
month	87	163.4419	1.8789	1.5252		5.56	0.2344
area +							
year	73	88.1029	1.2069	36.7453	18.3648	39.46	0.0015
area + year +							
area*year	65	81.8108	1.2586	34.0356	-2.7096	6.82	0.5565

FINAL MODEL: area + year

Table 2. SCDNR COASTSPAN large-gillnet YOY scalloped hammerhead shark analysis number of model observations per year (n obs), number of positive model observtions per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per 100 hook hours (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
2001	14	8	0.5714	1.3297	1.2498	0.5034	3.1032	0.4793
2002	13	7	0.5385	0.8291	0.7881	0.2973	2.0888	0.5178
2003	15	9	0.6000	2.7642	2.7417	1.1623	6.4672	0.4496
2004	3	1	0.3333	1.3725	0.5413	0.0655	4.4733	1.4316
2005	11	5	0.4545	0.5945	0.6254	0.2280	1.7155	0.5384
2006	6	2	0.3333	1.1934	0.9807	0.1816	5.2958	1.0179
2007	10	5	0.5000	1.5570	1.9521	0.7183	5.3051	0.5328
2008	9	3	0.3333	0.4727	1.3839	0.3876	4.9412	0.7066
2009	6	1	0.1667	10.3509	7.2980	0.9232	57.6907	1.3825
2010	7	2	0.2857	1.5028	2.2974	0.5231	10.0897	0.8537
2011	5	3	0.6000	0.3223	1.4874	0.5407	4.0913	0.5401
2012	9	5	0.5556	12.0444	8.1799	3.0375	22.0282	0.5273
2013	13	7	0.5385	5.4036	4.0580	1.7148	9.6036	0.4515
2014	8	3	0.3750	4.9612	2.2039	0.6275	7.7402	0.6955
2015	13	5	0.3846	1.2346	0.9686	0.3116	3.0108	0.6158
2016	11	5	0.4545	1.9206	1.6754	0.6107	4.5958	0.5384
2017	13	8	0.6154	5.2434	6.8082	3.5100	13.2056	0.3406
2018	16	7	0.4375	4.9323	3.7252	1.3382	10.3700	0.5473
2019	15	8	0.5333	3.0341	3.3050	1.4682	7.4399	0.4230

Figure 1. Fork lengths (cm) of scalloped hammerhead sharks caught during the SCDNR COASTSPAN long-gillnet survey from 2001-2019.

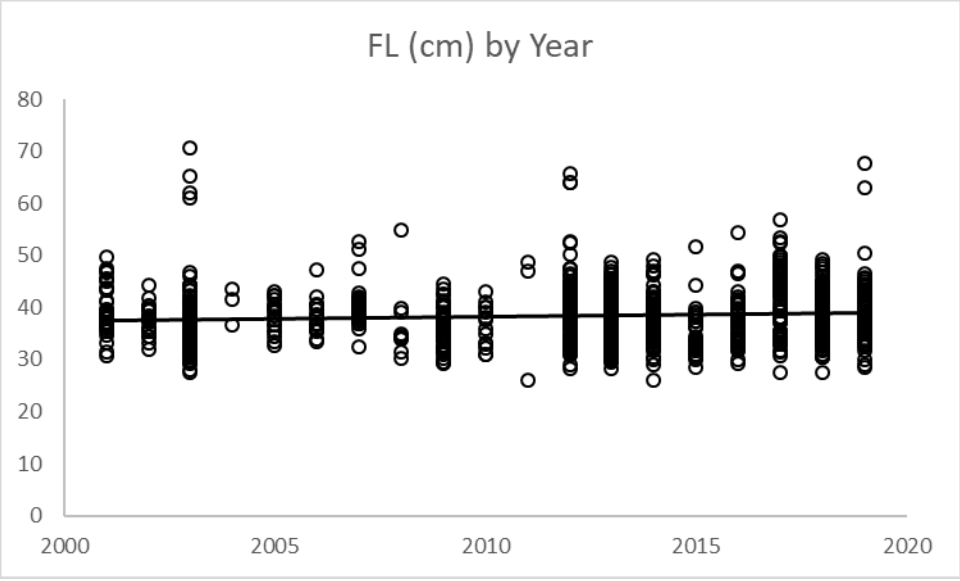
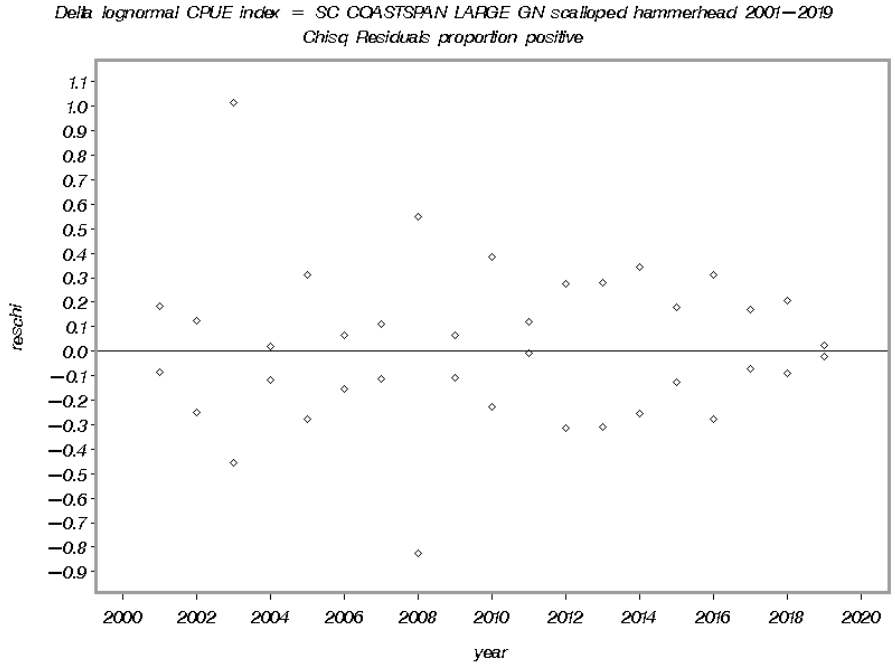


Figure 2. YOY scalloped hammerhead shark model diagnostic plots for the binomial component.



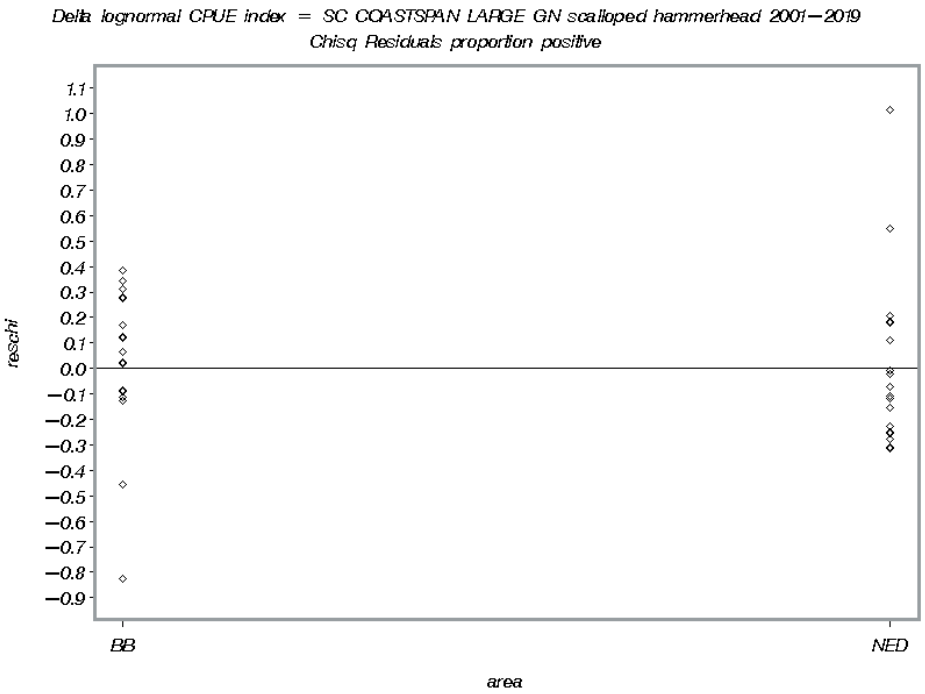


Figure 3. YOY scalloped hammerhead shark model diagnostic plots for the lognormal component

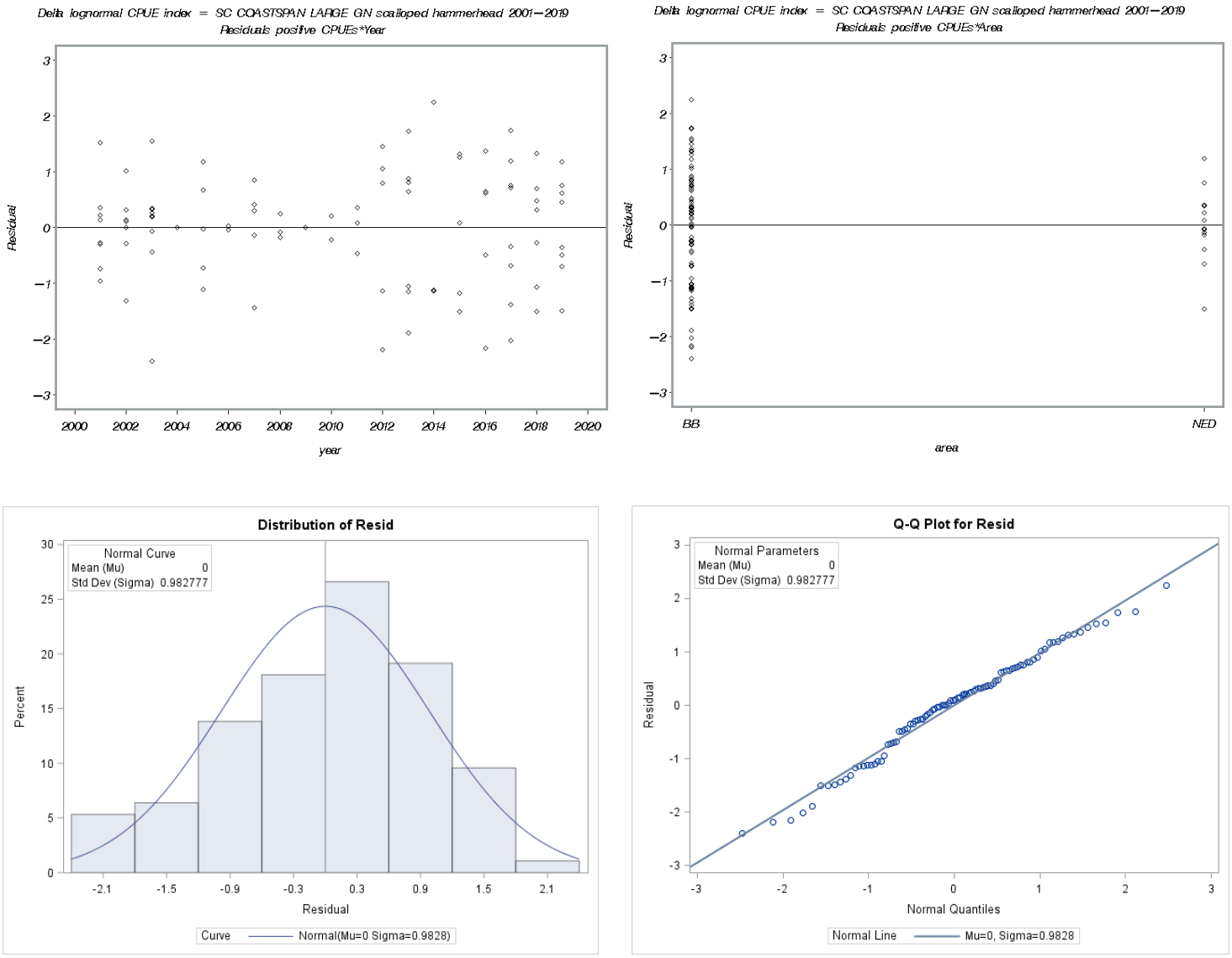


Figure 4. SCDNR COASTSPAN large-gillnet YOY scalloped hammerhead shark nominal (obscpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).