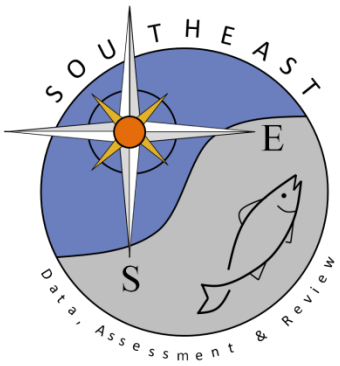
Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey

Camilla T. McCandless and Bryan S. Frazier

SEDAR77-DW32

Received: 1/7/2022



Please cite this document as:

McCandless, Camilla T. and Bryan S. Frazier. 2021. Standardized index of abundance for scalloped hammerhead sharks from the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey. SEDAR77-DW32. SEDAR, North Charleston, SC. 6 pp.

SEDAR 77 DATA WORKSHOP DOCUMENT

Standardized recruitment index for scalloped hammerhead sharks caught during the South Carolina Department of Natural Resources, Cooperative Atlantic States Shark Pupping and Nursery short-gillnet survey

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

Bryan S. Frazier
South Carolina Department of Natural Resources
Marine Resources Division
217 Ft. Johnson Rd
Charleston, SC 29412

cami.mccandless@noaa.gov
FrazierB@dnr.sc.gov

December 2021

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) short-gillnet survey (2007-2019). Catch per unit effort (CPUE) in number of sharks per net hour were used to examine the young-of-year (YOY) scalloped hammerhead sharks trend in South Carolina estuaries for use as a recruitment index in the SEDAR 77 stock assessment. The CPUE was standardized using generalized linear mixed 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 short-gillnet survey indicate an overal decreasing trend in YOY scalloped hammerhead shark relative abundance during the survey years.

Introduction

In an effort to increase sampling effort in South Carolina's estuarine waters 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 added an additional survey gear (short gillnet) in 2006 to the established longline and gillnet methods that had been ongoing in several estuaries within South Carolina since 1998.

Methods

Sampling design

The use of short gillnets allowed concurrent sampling of adjacent shorelines using gillnets in already established COASTSPAN longline survey locations that had been sampled since 1998. These had been previously selected in the lower reaches of estuaries in depths which would facilitate the deployment and retrieval of hand deployed longlines (i.e. current velocity, tidal range, vessel traffic). 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 short 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 45 m in length. The shorter length (large gillnet survey was 230m) allowed for sampling in different environments (i.e. areas too small for the larger net). The net was set in <4 m of water adjacent to shorelines and inspected for catch at approximately 20-minute intervals to reduce mortality. All sets conducted consecutively at the same station were grouped and the combined catch and soak times were considered a single set. 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. The CPUE was standardized using a delta-lognormal generalized linear mixed 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 (2007-2019), month (May-August), salinity (<20 ppt, 20-24.9 ppt, 25-29.9 ppt, 30+ ppt), temperature (<20 deg C, 20-24 deg C, ≥25 deg C) and area (stations located in Bulls Bay and St Helena Sound). 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 108 YOY scalloped hammerhead sharks were caught during the 899 gillnet sets from 2007 to 2019included in these analyses for index development. The length frequency of all captured scalloped hammerheads during the short-gillnet survey is displayed in Figure 1, with the majority (97%) of the catch as YOY. The proportion of sets with positive catch (at least one YOY scalloped hammerhead shark caught) was 10%. The stepwise construction of each model and the resulting statistics are detailed in Table 1. The binomial model did not converge, therefore CPUE was assumed to follow a lognormal distribution (Maunder and Punt 2004). Diagnostic for the lognormal model are plotted in Figure 2. 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 3. Nominal and standardized CPUE results from the COASTSPAN short-gillnet survey indicate an overall decreasing trend in YOY scalloped hammerhead relative abundance from 2007 through 2019 (Figure 3).

Reference

Maunder, MN and AE Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70:141-159.

Table 1. Results of the stepwise procedure for development of the SCDNR COASTSPAN small gillnet catch rate model for 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	117	91.8413	0.7850				
year	105	72.1054	0.6867	12.5223		Negative of hessian	
month	114	85.1367	0.7468	4.8662		6.70	0.0819
temp	115	89.2282	0.7759	1.1592		2.61	0.2708
area	116	90.8341	0.7831	0.2420		1.01	0.3156
sal	114	89.7123	0.7869	-0.2420		2.13	0.5461

FINAL MODEL: year

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQ	PR>CHI
null	18	8.8124	0.4896				
year	10	3.9811	0.3981	18.6887		15.10	0.0573
sal	15	6.6389	0.4426	9.5997		5.38	0.1459
month	15	7.4237	0.4949	-1.0825		3.26	0.3535
temp	17	8.7335	0.5137	-4.9224		0.17	0.6794
area	17	8.8120	0.5184	-5.8824		0.00	0.9770

FINAL MODEL: year

Table 2. SCDNR COASTSPAN small gillnet 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 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
2007	5	2	0.4000	0.1793	0.1709	0.0759	0.3849	0.4233
2008	8	1	0.1250	0.2857	0.2857	0.0971	0.8406	0.5813
2009	4	0	0.0000	0.0000				
2010	14	1	0.0714	0.1135	0.1135	0.0386	0.3340	0.5813
2011	16	4	0.2500	0.1017	0.1129	0.0619	0.2059	0.3072
2012	18	4	0.2222	0.1047	0.1155	0.0634	0.2106	0.3072
2013	14	2	0.1429	0.1182	0.0897	0.0398	0.2020	0.4233
2014	10	0	0.0000	0.0000				
2015	13	1	0.0769	0.0199	0.0199	0.0068	0.0585	0.5813
2016	17	3	0.1765	0.1006	0.0978	0.0495	0.1933	0.3507
2017	16	0	0.0000	0.0000				
2018	18	0	0.0000	0.0000				
2019	14	1	0.0714	0.0208	0.0208	0.0071	0.0612	0.5813

Figure 1. Fork lengths (cm) of scalloped hammerhead sharks caught during the SCDNR COASTSPAN long-gillnet survey from 2007-2019.

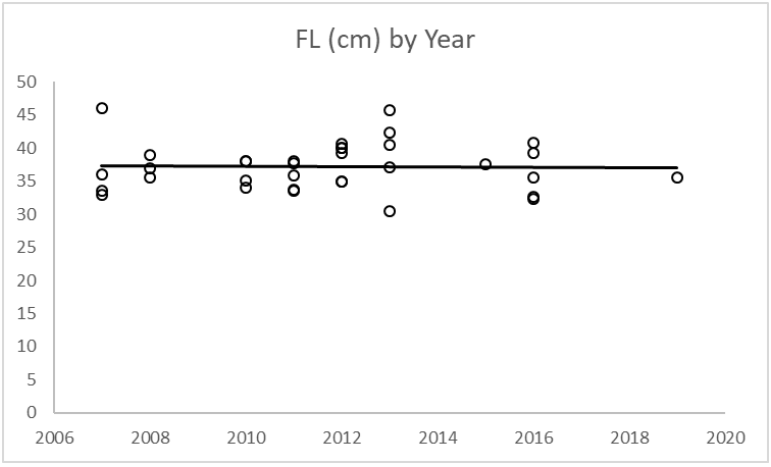
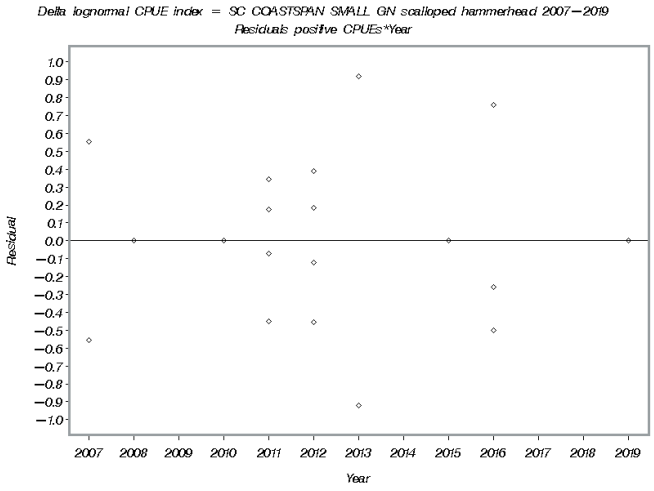
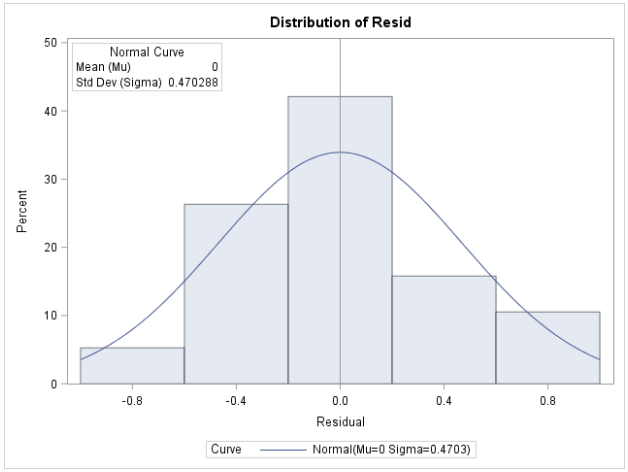


Figure 2. Lognormal model diagnostic plots





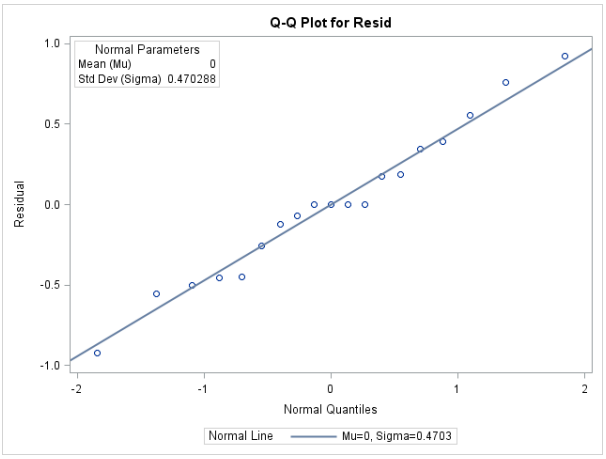


Figure 3. SCDNR COASTSPAN small gillnet scalloped hammerhead shark nominal (obscpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).