Relative abundance of bonnethead and Atlantic sharpnose sharks based on a fishery-independent gillnet survey off Texas

Walter Bubley and John Carlson

SEDAR34-WP-05

22 May 2013

This information is distributed solely for the purpose of pre-dissemination peer review. It does not represent and should not be construed to represent any agency determination or policy.

Please cite this document as:

Bubley, W. and J. Carlson. 2013. Relative abundance of bonnethead and Atlantic sharpnose sharks based on a fishery-independent gillnet survey off Texas. SEDAR34-WP-05. SEDAR, North Charleston, SC. 16 pp.

Relative abundance of bonnethead and Atlantic sharpnose sharks based on a fishery-independent gillnet survey off Texas

Walter Bubley
Texas Parks and Wildlife Department
Coastal Fisheries Division, San Antonio Bay Ecosystem
418 South 16th St.
P.O. Box 688
Port O'Connor, TX 77982

John Carlson
National Marine Fisheries Service, Southeast Fisheries Science Center,
3500 Delwood Beach Rd. Panama City, FL 32408
John.Carlson@noaa.gov

INTRODUCTION

This paper determines a relative abundance index for bonnethead and Atlantic sharpnose sharks utilizing a fishery independent gillnet survey by the Texas Parks and Wildlife Department, Coastal Fisheries Division. The protocol for the survey, as it is constituted today, has been ongoing since 1975 with the purpose of monitoring relative abundance and size of organisms, their spatial and temporal distribution, and species composition of the community and selected environmental parameters known to influence their distribution and abundance (Martinez-Andrade and Fisher 2012). These indices are an extension of those examined during SEDAR-13 to include updated data (Fisher 2007).

MATERIAL AND METHODS

Field Data Collection

Surveys were conducted in 10 major bay systems along the Texas coast in the north- western Gulf of Mexico from 1975 to 2011 (Figure 1). Barrier islands separate these bays from the Gulf of Mexico along the majority of the coastline, and saltwater exchange occurs via 6 major tidal inlets. Texas bays are shallow subtropical estuaries that are physically dynamic, and most are located near large human population centers. Coastal fisheries resource monitoring data were collected as a stratified cluster sampling design; each bay system serves as non-overlapping strata with a fixed number of samples (Martinez-Andrade and Fisher 2012). Gill-nets were deployed during ten weeks each Spring (April, May, June) and ten weeks each Fall (September, October, November). A total of 45 gillnets for each season and 90 gillnets per year were set in each bay system. Sample locations were drawn independently and without replacement for each season. Sharks were sampled using standardized 183 m gill-nets perpendicular to shore. Nets were constructed of 4 panels with stretched mesh sizes of 76, 102, 127, and 152 mm. Gill-nets were deployed within 1 hour before sunset, fished overnight, and retrieved within 4 h of sunrise the following day, and a total set time was calculated for each sample. Each captured shark was identified to species, measured, and released. Sex of individuals was not recorded for elasmobranch species until 2012, so indices could not be differentiated by sex. Abundance data were converted to catch per unit effort (CPUE) by dividing the number of sharks captured by 'soak time', in hours, of each net.

Index Development

While these surveys were fishery-independent and factors were generally controlled, we applied a generalized linear model to correct for factors that could have influenced abundance. Several categorical variables were constructed for analysis of the survey data:

"Year" (37 levels): 1975-2011

"Area" (10 levels): locations of gillnet set with a major bay system (Figure 1).

"Season" (3 levels):
Spring=Apr-Jul
Other=Outside these periods
Fall=Sep-Nov

"Temperature" (3 levels)
<19.9° C
20.0-29.9° C
>30.0° C

"Salinity" (4 levels)
Fresh=0-5 ppt
Estuarine=6-29 ppt
Marine=30-39 ppt
Hypersaline=>40 ppt

"Dissolved oxygen" (3 levels)
Hypoxic =0-4.9 mg l^{-1}
Normoxic =5.0-10.0 mg l^{-1}
Hyperoxic >10.0 mg l^{-1}

Indices of abundance were estimated following the Delta method (Lo *et al*., 1992) by modeling the probability of the non-zero catch assuming a type-3 model with a binomial error distribution and a logit link. The distribution of the positive shark catches was modeled assuming a lognormal distribution. Catch per unit effort was the number of bonnethead and Atlantic sharpnose sharks caught per hour of soak time of the gillnet. Young of the year (YOY) sharks were excluded from analysis. The lengths at age 1 for bonnethead (551 mm STL; Lombardi-Carlson *et al*., 2007) and sharpnose sharks (725 mm STL; Carlson and Loefer, 2007) were taken from SEDAR-13 for the YOY exclusion.

Following Ortiz and Arocha (2004), factors most likely to influence abundance were evaluated in a forward stepwise fashion. Initially, a null model was run with no factors entered into the model. Models were then fit in a stepwise forward manner adding one independent variable. Each factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $p<0.05$ based on a Chi-Square test and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all models. This allows the estimation of the annual indices, which is the main objective of the standardization process, but also accounts for the variability associated with year-interactions. After selecting the set of factors for each error distribution, all factors that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). We applied a Generalized Linear Mixed Modeling (GLMM), approach because these models can predict CPUEs for un-fished fishing cells based on the estimated effects of the explanatory variables as long as these cells were fished in some of the years. The standardized CPUE values for the Delta models were calculated as the product of the expected probability of a non-zero catch and the expected conditional catch rate for sets that had a non- zero catch. The expected probability and expected conditional catch rate were the least square means of the factor year from each of the two analyses that constitute an analysis using the Delta model approach (Lo *et al*., 1992; Stefansson, 1996). All models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX).

Final models were selected based on Akaike Information Criteria (AIC). Models of positive catches were checked for appropriate fit and diagnostics by examining the residuals plotted against the fitted values to check for systematic departures from the assumptions underlying the error distribution; the absolute values of the residuals plotted against the fitted values as a check of the assumed variance function; and the dependent variable was plotted against the linear predictor function as a check of the assumed link function (McCullagh and Nelder, 1989).

RESULTS AND DISCUSSION

Bonnethead sharks excluding YOY

A total of 25,209 gillnet sets were made since 1975. The majority of individuals captured were juveniles and the length distribution did not change significantly over the survey period (Figure 2). The proportion positive (i.e. number of sets that caught a bonnethead shark) over the survey period was 2.8%.

The stepwise construction of the model is summarized in Table 1 and the index statistics can be found in Table 2. Table 3 provides a table of the frequency of observations by factor and level. The standardized abundance index is shown in Figure 3 and the diagnostic plots assessing the fit of the models are shown in Figure 4.

Atlantic sharpnose sharks excluding YOY

A total of 25,209 gillnet sets were made since 1975. The majority of individuals captured, which were not YOY were adults and the length distribution did not change significantly over the survey period (Figure 5). The proportion positive (i.e. number of sets that caught an Atlantic sharpnose shark) over the survey period was 0.6%.

The stepwise construction of the model is summarized in Table 4 and the index statistics can be found in Table 5. Table 3 provides a table of the frequency of observations by factor and level. The standardized abundance index is shown in Figure 6 and the diagnostic plots assessing the fit of the models are shown in Figure 7. Based on the low proportion positive catch of Atlantic sharpnose sharks when YOY individuals were removed, there was some difficulty in fitting the model for standardization and the authors determined the nominal index to be most appropriate.

REFERENCES

Carlson, J.K. and J. Loefer. 2007. Life history parameters for Atlantic sharpnose sharks, *Rhizoprionodon terraenovae*, from the United States South Atlantic Ocean and northern Gulf of Mexico. Southeast Data Assessment and Review (SEDAR) Working Document S13 DW-08.

Fisher, M.R. 2007. Fishery-Independent Catch of Small Coastal Sharks in Texas Bays, 1975-2006. Southeast Data Assessment and Review (SEDAR) Working Document S13 DW-18.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences. 49: 2515-2526.

Lombardi-Carlson, L.A. 2007. Life history traits of bonnethead sharks, *Sphyrna tiburo*, from the eastern Gulf of Mexico. Southeast Data Assessment and Review (SEDAR) Working Document S13 DW-24.

Martinez-Andrade, F. and M. Fisher. 2012. Texas Parks and Wildlife Department, Coastal Fisheries Division, Marine Resource Monitoring Operations Manual.

McCullagh, P. and J.A. Nelder. 1989. Generalized Linear Models. Chapman & Hall, London.

Ortiz, M. and F. Arocha. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in theVenezuelan tuna longline fishery. Fisheries Research 70, 275–294.

Stefansson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science 53, 577–588.

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for bonnethead sharks. Final models selected are in bold. Variables which did not have the ability to converge are denoted by *.

Proportion positive-Binomial error distribution

FACTOR	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	0.648				
YEAR	0.616	4.906	4.906	162.86	<.0001
YEAR+					
AREA	0.467	27.923		*	
SALINITY	0.551	15.057	10.151	291.09	<.0001
TEMP	0.600	7.513		75.45	<.0001
DO	0.614	5.214		10.12	0.0063
SEASON	0.616	5.014		4.32	0.1155
YEAR+SALINITY+					
TEMP	0.536	17.325	2.268	65.64	<.0001
DO	0.549	15.319		8.75	0.0126
YEAR+SALINITY+TEMP+					
DO	0.535	17.464		5.09	0.0787

MIXED MODEL	**AIC**
YEAR+SALINITY+TEMP	**1295.6**
YEAR+SALINITY+TEMP YEAR*SALINITY	4065.2
YEAR+SALINITY+TEMP YEAR*TEMP	4066.7

Proportion positive-Lognormal error distribution

FACTOR	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	0.680				
YEAR	0.667	1.867	1.867	50.39	0.0562
YEAR+					
AREA	0.653	4.058	2.191	23.58	0.0014
DO	0.665	2.220		4.75	0.0929
TEMP	0.666	2.147		4.2	0.1226
SEASON	0.669	1.662		0.68	0.7123
SALINITY	0.669	1.588		0.08	0.9612
YEAR+AREA+					
DO	0.651	4.323	0.265	4.07	0.1304

MIXED MODEL	**AIC**
YEAR+AREA	**1749.6**
YEAR+AREA YEAR*AREA	1749.6

Table 2. The standardized and nominal index (number of sharks per net hour) of absolute abundance, and coefficients of variation (CV) for all bonnethead sharks from both surveys. N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1975	96	0.002	1.94	0.001	5.86
1976	289	0.013	0.50	0.008	0.79
1977	312	0.001	1.84	0.000	4.00
1978	256	0.002	0.99	0.001	2.86
1979	440	0.005	0.55	0.003	0.94
1980	384	0.010	0.34	0.006	0.60
1981	515	0.009	0.63	0.007	0.80
1982	750	0.005	0.31	0.005	0.34
1983	666	0.006	0.25	0.006	0.27
1984	671	0.009	0.21	0.008	0.23
1985	670	0.003	0.33	0.002	0.40
1986	760	0.008	0.22	0.006	0.29
1987	760	0.001	0.56	0.001	0.91
1988	760	0.009	0.24	0.008	0.27
1989	760	0.005	0.27	0.004	0.33
1990	760	0.012	0.23	0.013	0.22
1991	760	0.006	0.25	0.005	0.35
1992	760	0.003	0.34	0.002	0.65
1993	760	0.006	0.27	0.004	0.35
1994	760	0.005	0.31	0.005	0.29
1995	760	0.004	0.33	0.004	0.37
1996	800	0.004	0.25	0.003	0.31
1997	800	0.002	0.43	0.001	0.87
1998	800	0.005	0.29	0.006	0.23
1999	800	0.003	0.34	0.002	0.39
2000	780	0.009	0.22	0.010	0.20
2001	780	0.008	0.22	0.005	0.33
2002	780	0.009	0.26	0.011	0.22
2003	780	0.008	0.22	0.007	0.26
2004	780	0.010	0.25	0.007	0.35
2005	780	0.007	0.22	0.007	0.22
2006	780	0.008	0.20	0.006	0.27
2007	780	0.007	0.26	0.007	0.29
2008	780	0.008	0.23	0.007	0.24
2009	780	0.008	0.18	0.008	0.18
2010	780	0.018	0.17	0.016	0.19
2011	780	0.010	0.18	0.013	0.14

Table 3. Frequency of observations by factor and level used in the development of the standardized catch rate series.

Factor	Level	Frequency of Total
Year	1975	0.4
	1976	1.1
	1977	1.2
	1978	1.0
	1979	1.7
	1980	1.5
	1981	2.0
	1982	3.0
	1983	2.6
	1984	2.7
	1985	2.7
	1986	3.0
	1987	3.0
	1988	3.0
	1989	3.0
	1990	3.0
	1991	3.0
	1992	3.0
	1993	3.0
	1994	3.0
	1995	3.0
	1996	3.2
	1997	3.2
	1998	3.2
	1999	3.2
	2000	3.1
	2001	3.1
	2002	3.1
	2003	3.1
	2004	3.1
	2005	3.1
	2006	3.1
	2007	3.1
	2008	3.1
	2009	3.1
	2010	3.1
	2011	3.1
Area	1	9.3
	2	12.1
	3	11.9
	4	11.9
	5	11.9
	6	11.9
	7	11.9
	8	11.9
	9	5.5
	11	1.6
Season	F	48.5
	S	46.7
	O	4.9
Temperature	< 19.9	9.2
	20.0 - 29.9	74.4
	>30.0	16.4
Salinity	Fresh	10.4
	Estuarine	57.3
	Marine	25.0
	Hypersaline	6.4
DO	Hypoxic	3.5
	Normoxic	82.8
	Hyperoxic	13.8

Table 4. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for Atlantic sharpnose sharks. Final models selected are in bold. Variables which did not have the ability to converge due to low sample size are denoted by *.

Proportion positive-Binomial error distribution

FACTOR	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	0.227				
YEAR	0.203	10.563	10.563	*	
YEAR+					
AREA	0.168	25.968		*	
SALINITY	0.190	16.593		*	
SEASON	0.200	11.972		*	
DO	0.201	11.488		*	
TEMP	0.201	11.356		*	

Proportion positive-Lognormal error distribution

FACTOR	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	0.418				
YEAR	0.393	5.977	5.977	43.14	0.057
YEAR+					
AREA	0.394	5.809	-0.167	10.08	0.2595
DO	0.395	5.594		1.89	0.3878
SEASON	0.395	5.570		0.58	0.4446
SALINITY	0.395	5.475		1.7	0.4265
TEMP	0.397	5.020		0.95	0.6213

Table 5. The standardized and nominal index (number of sharks per net hour) of absolute abundance, and coefficients of variation (CV) for all Atlantic sharpnose sharks from both surveys. N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1975	96			0.000	
1976	289	0.002	0.57	0.002	0.57
1977	312	0.000	0.57	0.000	0.57
1978	256			0.000	
1979	440			0.000	
1980	384			0.000	
1981	515	0.000	0.57	0.000	0.57
1982	750	0.000	0.42	0.000	0.44
1983	666	0.000	0.35	0.000	0.40
1984	671	0.001	0.23	0.001	0.26
1985	670	0.000	0.42	0.000	0.43
1986	760	0.003	0.16	0.004	0.13
1987	760	0.000	0.42	0.000	0.46
1988	760	0.004	0.18	0.005	0.13
1989	760	0.001	0.23	0.001	0.20
1990	760	0.000	0.42	0.000	0.47
1991	760	0.000	0.42	0.000	0.46
1992	760	0.000	0.42	0.000	0.47
1993	760			0.000	
1994	760	0.001	0.31	0.001	0.27
1995	760			0.000	
1996	800	0.002	0.18	0.002	0.16
1997	800			0.000	
1998	800			0.000	
1999	800	0.002	0.18	0.002	0.19
2000	780	0.001	0.22	0.001	0.26
2001	780			0.000	
2002	780	0.001	0.22	0.001	0.22
2003	780	0.001	0.31	0.001	0.33
2004	780	0.001	0.22	0.001	0.25
2005	780	0.001	0.28	0.001	0.31
2006	780	0.002	0.21	0.002	0.22
2007	780	0.001	0.31	0.001	0.24
2008	780	0.001	0.28	0.001	0.31
2009	780	0.000	0.35	0.000	0.40
2010	780	0.001	0.31	0.000	0.34
2011	780	0.002	0.25	0.002	0.22

Figure 1. Distribution of sampling effort along Texas coast from 1975-2011 (Total gillnets set = 25,209). Major areas (Bays) sampled are denoted. The N value indicates the number of gillnet sets over the study period.

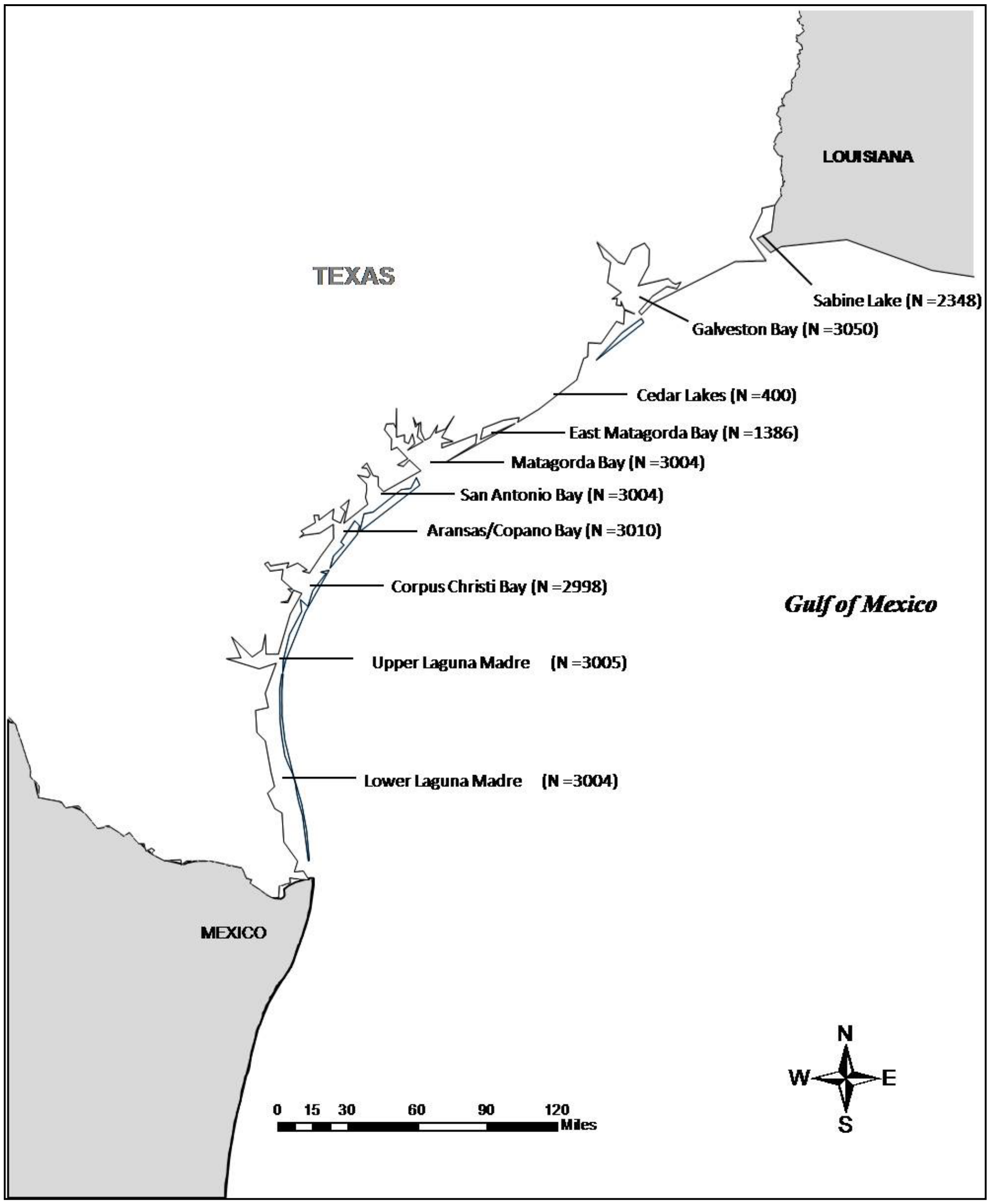
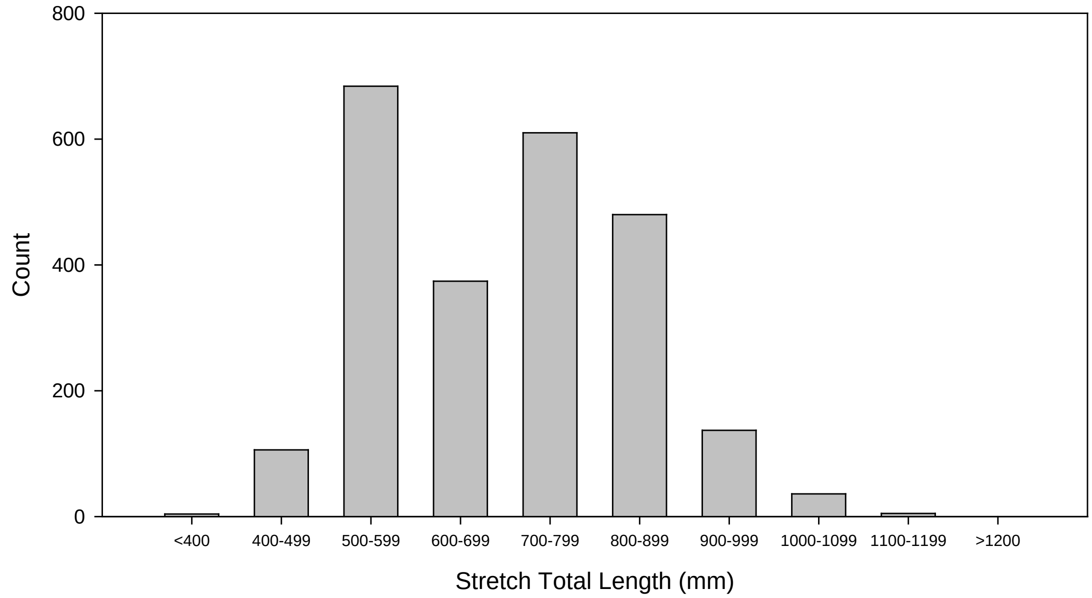


Figure 2. Frequency distribution of stretch total lengths and lengths by year for all bonnethead sharks.



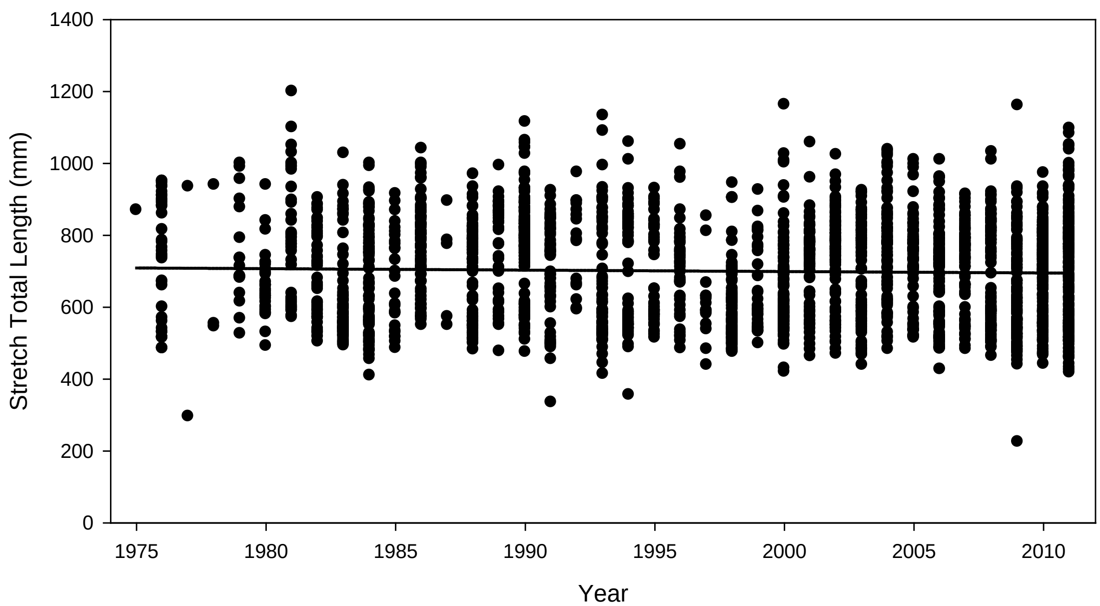


Figure 3. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for all bonnethead sharks. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index.

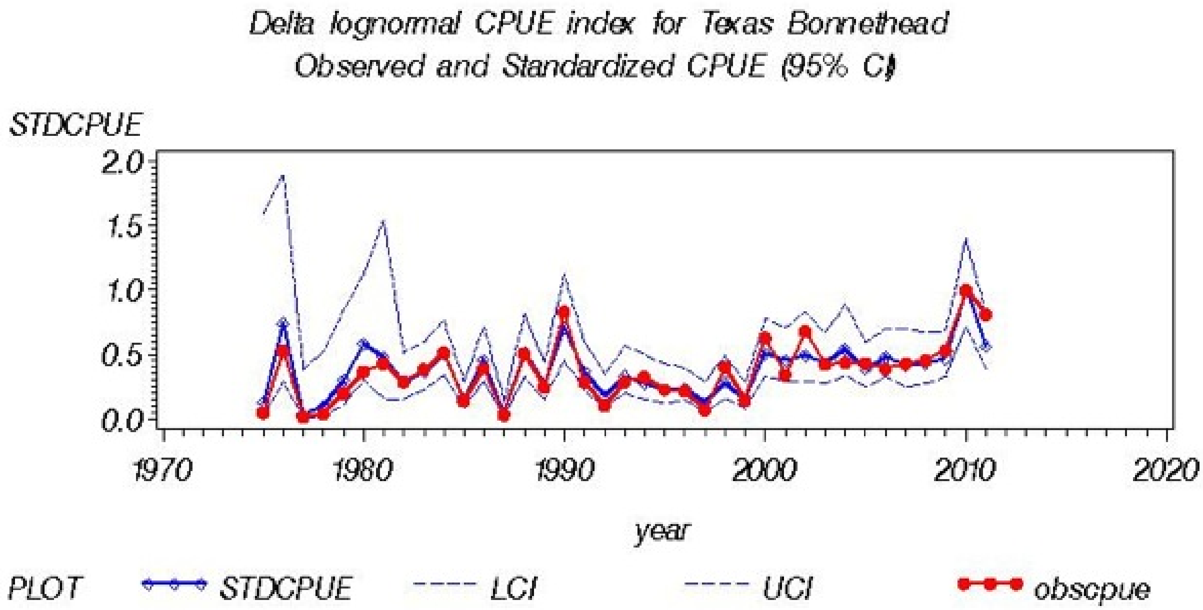


Figure 4. Diagnostic plots of the frequency distribution of positive catch, positive catch residuals, quantile-quantile plot, and distribution of residuals by year for standardized index of bonnethead sharks in TPWD gillnet surveys.

.

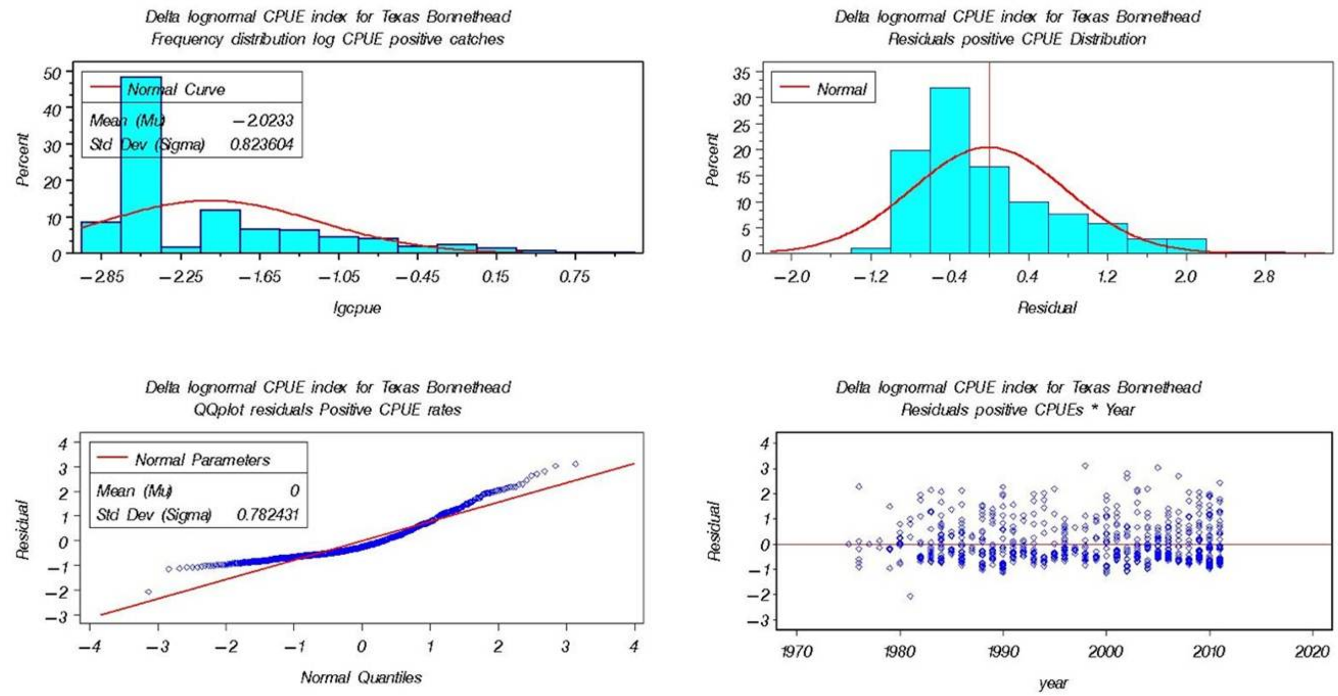
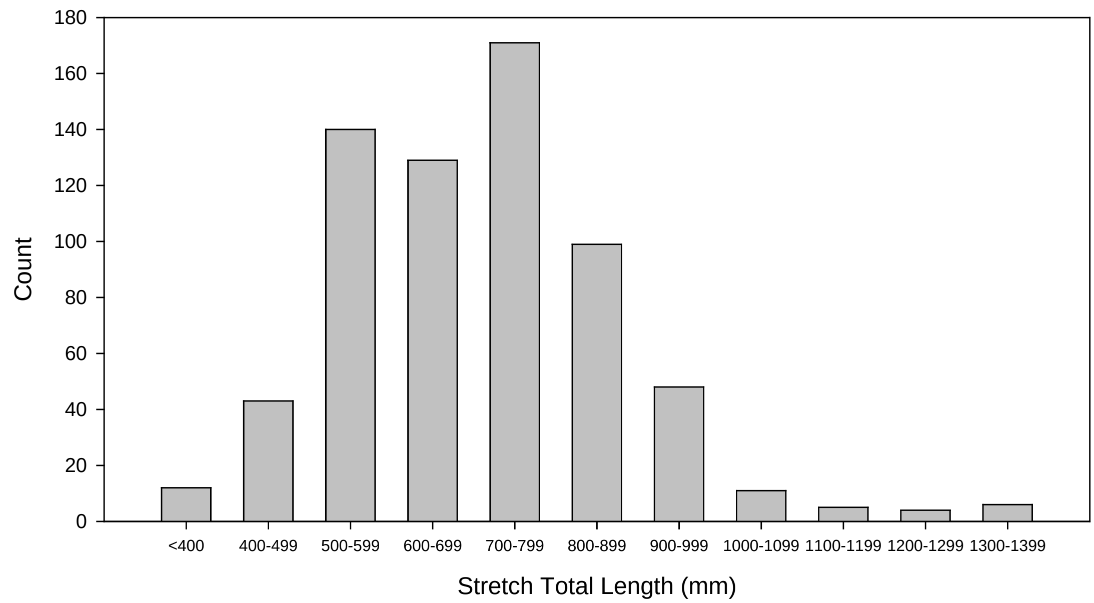


Figure 5. Frequency distribution of stretch total lengths and lengths by year for all Atlantic sharpnose sharks.



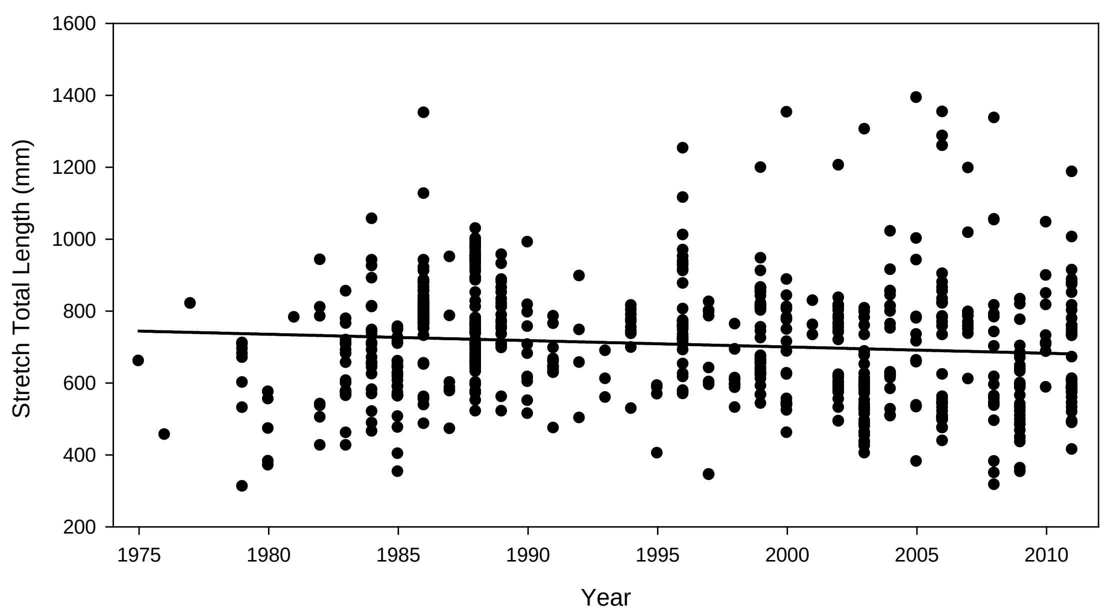


Figure 6. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for all Atlantic sharpnose sharks. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index.

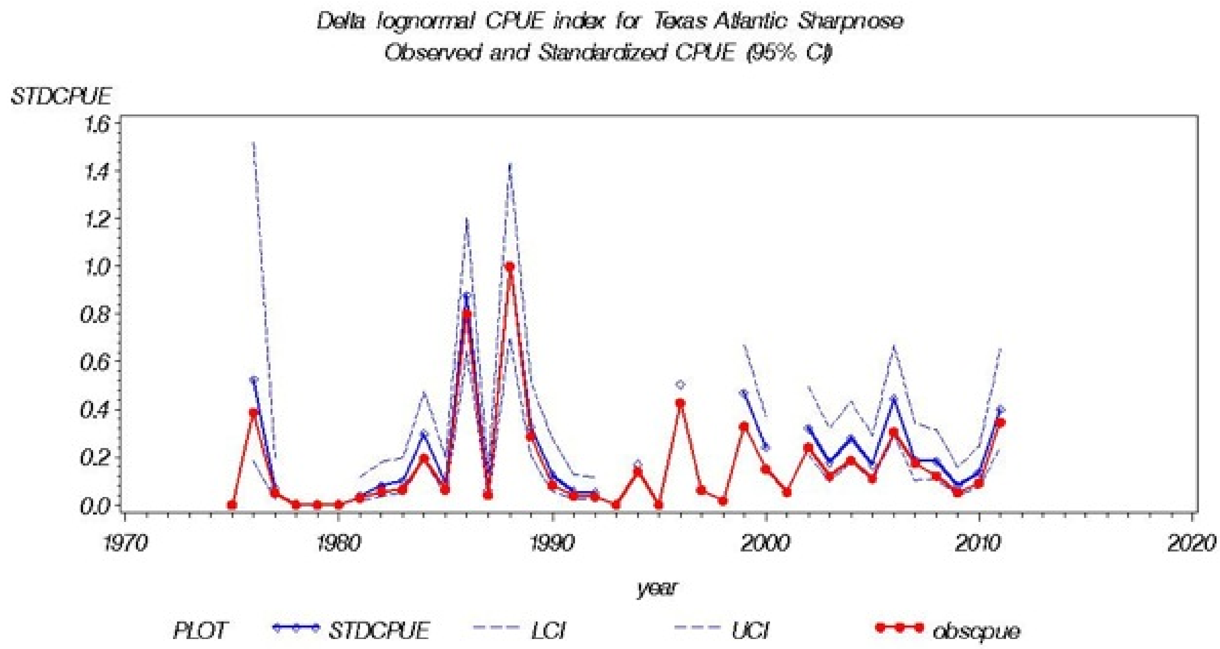


Figure 7. Diagnostic plots of the frequency distribution of positive catch, positive catch residuals, quantile-quantile plot, and distribution of residuals by year for standardized index of Atlantic sharpnose sharks in TPWD gillnet surveys.