Standardized catch rates of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) in the U.S. Gulf of Mexico from the Shark Bottom Longline Observer Program, 1994-2011

John Carlson and Simon Gulak

SEDAR34-WP-01

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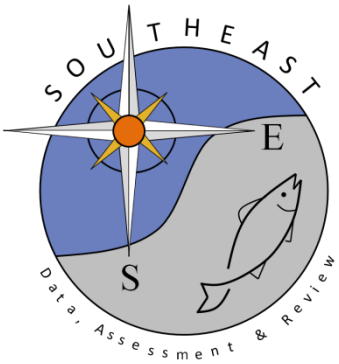

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SEDAR 34-WP-01

Abstract

Catch rate series were developed for Atlantic sharpnose shark from the data collected by on-boards observers in the shark bottom longline fishery for the period 1994-2011. Data were subjected to a Generalized Linear Model (GLM) standardization technique that treats separately the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a lognormal error distribution with a log link function. Year and bait type were significant as a main effects in the binomial model and year, bait type, area and time of day were significant in the lognormal model. Outside a peak in 2000, the relative abundance index showed a general flat trend in abundance.

Introduction

Observations by at-sea observers of the shark-directed bottom longline fishery in the Atlantic Ocean and Gulf of Mexico have been conducted since 1994 (e.g. Hale and Carlson, 2007, Hale et al., 2007, Morgan et al. 2009, Hale et al., 2009, Hale et al. 2010, Hale et al. 2011, and Hale et al. 2012). Currently 208 U.S. fishers are permitted to target sharks (excluding dogfish) in the Atlantic Ocean and Gulf of Mexico, and an additional 253 fishers are permitted to land sharks incidentally. Amendments to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan based on stock assessments have eliminated the major directed shark fishery in the U.S. Atlantic (NMFS 2007). These amendments implemented a shark research fishery, which allows NMFS to select a limited number of commercial shark vessels on an annual basis to collect life history data and catch data for future stock assessments. Since 2008, only commercial shark fishers participating in the shark research fishery are allowed to land sandbar sharks, *Carcharhinus plumbeus*, and must carry an observer on 100% of all trips (compared to a coverage level of 4-6% outside the research fishery). Outside the research fishery, fishers are permitted to land 33 non-sandbar large coastal sharks (including blacktip shark, *Carcharhinus limbatus*, bull shark, *Carcharhinus leucas*, lemon shark, *Negaprion brevirostris*, nurse shark, *Ginglymostoma cirratum*, silky shark, *Carcharhinus falciformis*, spinner shark, *Carcharhinus brevipinna*, tiger shark, *Galeocerdo cuvier*, great hammerhead shark, *Sphyrna mokarran*, and scalloped hammerhead shark, *Sphyrna lewini*).

Methods

Catch rate analysis

A combined data set was developed based on observer programs from Morgan et al. (2009) and Hale et al. (2012). With the introduction of the shark research fishery, some vessels were not subjected to random selection. whereas others outside the research fishery were not permitted to land sandbar sharks. Because of this switch, a factor (research fishery) was added to account for the differences in target and harvest of sharks. Catch rates were standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). For the purposes of analysis, several categorical variables were constructed:

● "Year"
1994-2011

● "Time of Day": the time of day the set started defined from the time the first hook was set in the water
Day = 0501-1800 hrs
Night = 1801-0500 hrs

●"Season"
Winter = January-March
Spring = April-June
Summer = July-September
Fall = October-December

●"Depth": defined as the mean depth when the first hook was set and the last hook was retrieved
0-100 ft
100-200 ft
200-300 ft
>300 ft

●"Hook type": the hook that was used by the majority of the set
Large hook (> size 13 hook)
Medium hook (size 10-13 hook)
Small hook (< size 10 hook)
Hook size undefined

●"Bait type": the bait that was used by the majority of the set
Shark or ray (Elasmobranchii)
Herring (Clupeidae) or mullet (Mugilidae)
Tuna or mackeral (Scombridae)
Other teleosts (non-Clupeidae, Mugilidae or Scombridae)
Other (undefined or multiple bait types)

● Research
Yes (a set conducted under the shark research fishery)
No (a set not conducted under the shark research fishery)

● Hooktimer
Yes (a set was conducted with hooktimers)
No (a set was conducted without hooktimers)

The proportion of sets that caught sharks (when at least one shark was caught) was modeled assuming a binomial distribution with a logit link function. Positive catches were modeled using

a dependent variable of the natural logarithm of CPUE expressed as the natural logarithm of the number of sharks caught per 10,000 hooks

$$CPUE = log\ [(sharks\ kept+sharks\ released/10{,}000\ hooks)]$$

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 provided 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 final models. After selecting the set of fixed factors and interactions for each error distribution, all interactions that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final model determination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC). Models with smaller AIC and BIC values are preferred to those with larger values. These 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). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models.

Size Information

Length information for sharks obtained from the Longline Observer Program was analyzed using regression analysis to examine trends in size with time (year).

Results and Discussion

All Areas

The final bottom longline dataset analyzed contained 2119 sets (Figure 1). Of those sets, Atlantic sharpnose sharks were reported caught on 54.2% of sets. 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 2 and the diagnostic plots assessing the fit of the models were deemed acceptable (Figure 3). The length distribution (cm FL) of sharks caught by year and sex is shown in Figure 4 and average length by year is in Table 4.

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 Atlantic sharpnose sharks (all areas). Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	**1.398**				
YEAR	1.358	2.855	2.855	104.08	<.0001
YEAR+					
BAIT	1.337	4.350	1.495	47.32	<.0001
HOOKTYPE	1.347	3.649		26.26	<.0001
SEASON	1.348	3.556		23.72	<.0001
DEPTH	1.351	3.363		18.25	0.0004
TIME	1.351	3.363		15.63	<.0001
HOOKTIMER	1.355	3.062		7.2	0.0073
SRF	1.355	3.041		6.53	0.0106
AREA				4.23	0.0398
YEAR+BAIT+					
SEASON	1.326	5.094	0.744	24.78	<.0001
DEPTH	1.327	5.087		24.68	<.0001
HOOKTYPE	1.328	4.951		20.94	0.0001
AREA	1.329	4.916		17.25	<.0001
TIME	1.332	4.730		12.07	0.0005
SRF	1.333	4.629		9.08	0.0026
HOOKTIMER	1.334	4.586		7.95	0.0048
FINAL MODEL	**AIC**				
YEAR+BAIT	**197.3**				
YEAR+BAIT YEAR*BAIT	199.6				

Proportion positive-Lognormal error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	2.170				
YEAR	2.000	7.822	7.822	110.82	<.0001
YEAR+					
BAIT	1.815	16.354	8.532	115.74	<.0001
TIME	1.893	12.736		64.02	<.0001
DEPTH	1.955	9.873		28.95	<.0001
HOOKTYPE	1.969	9.246		20.95	0.0001
AREA	1.974	9.025		16.11	<.0001
SEASON	1.992	8.205		7.86	0.049
HOOKTIMER	1.993	8.126		4.8	0.0284
SRF	1.997	7.960		2.73	0.0983
YEAR+BAIT+					
AREA	1.741	19.756	3.402	48.76	<.0001

TIME	1.752	19.253		41.61	<.0001
DEPTH	1.787	17.640		20.88	0.0001
SEASON	1.804	16.870		10.2	0.0169
HOOKTIMER	1.807	16.709		5.91	0.0151
HOOKTYPE	1.808	16.663		7.35	0.0616
YEAR+BAIT+AREA+					
TIME	1.687	22.236	2.480	37.18	<.0001
DEPTH	1.718	20.807		18.28	0.0004
SEASON	1.729	20.304		10.97	0.0119
HOOKTIMER	1.732	20.157		6.83	0.0089
YEAR+BAIT+AREA+TIME+					
DEPTH	1.667	23.148	0.913	16.59	0.0009
SEASON	1.678	22.650		9.2	0.0268
HOOKTIMER	1.685	22.351		2.67	0.1023
FINAL MODEL	**AIC**				
YEAR+BAIT+AREA+TIME	3907.9				
YEAR+BAIT+AREA+TIME YEAR*BAIT	**3857.7**				
YEAR+BAIT+AREA+TIME YEAR*AREA	3903.1				
YEAR+BAIT+AREA+TIME YEAR*TIME	3871.7				

Table 2. The standardized and nominal index (number of sharks per hook hour) of absolute abundance, and coefficients of variation (CV) for Atlantic sharpnose sharks (all areas). N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1994	102	20.70	0.56	17.88	0.65
1995	162	176.21	0.43	234.51	0.32
1996	126	97.37	0.41	155.86	0.26
1997	80	247.49	0.41	362.53	0.28
1998	110	297.62	0.38	466.63	0.24
1999	99	376.28	0.39	707.65	0.21
2000	64	554.07	0.38	886.01	0.24
2001	77	248.81	0.42	515.84	0.20
2002	132	156.63	0.39	189.41	0.32
2003	174	101.47	0.40	178.71	0.23
2004	122	213.52	0.38	218.98	0.37
2005	127	202.40	0.35	257.18	0.27
2006	117	76.94	0.39	97.51	0.30
2007	63	174.58	0.42	149.99	0.49
2008	61	254.16	0.40	225.98	0.45
2009	114	151.87	0.41	101.32	0.61
2010	170	200.69	0.35	234.07	0.30
2011	228	118.62	0.35	116.61	0.35

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	1994	4.8
	1995	7.6
	1996	5.9
	1997	3.8
	1998	5.2
	1999	4.7
	2000	3.0
	2001	3.6
	2002	6.2
	2003	8.2
	2004	5.7
	2005	6.0
	2006	5.5
	2007	3.0
	2008	2.9
	2009	5.4
	2010	8.0
	2011	10.7
Research Fishery	Yes	25.1
	No	74.9
Area	Atlantic	56.9
	Gulf of Mexico	43.1
Season	Fall	7.8
	Spring	12.0
	Summer	41.8
	Winter	38.4
Time of Day	Day	31.3
	Night	68.7
Hook Type	Large	63.5
	Medium	6.5
	Other	27.2
	Small	2.7
Bait type	Clupeids+Mugilids	3.9
	Elasmobranchs	20.8
	Other	43.7
	Other Teleosts	13.8
	Scombrids	17.8
Set Depth	0-100	58.7
	100-200	25.6
	200-300	9.9
	300>	5.7
Hooktimer	Yes	5.1
	No	94.9

Table 4. Average Atlantic sharpnose shark fork lengths by year and area from the shark directed bottom longline fishery observations from 1994 through 2011 (n = 21,357). n/a=no observations of that species for that year.

Year	n	Combined (cm)	SE	n	Atlantic (cm)	SE	n	Gulf of Mexico (cm)	SE
1993	16	78.55	0.98	16	78.55	0.98	n/a	n/a	n/a
1994	109	71.94	1.00	108	71.82	1.01	1	85.00	n/a
1995	2184	78.16	0.14	2169	78.20	0.14	15	71.60	2.55
1996	1239	77.66	0.16	1224	77.93	0.15	15	55.53	2.22
1997	1549	76.26	0.17	1287	77.49	0.16	262	70.22	0.51
1998	1791	74.79	0.23	1589	74.80	0.25	202	74.73	0.50
1999	2040	75.28	0.16	1823	75.38	0.16	217	74.46	0.66
2000	1587	78.18	0.12	1587	78.18	0.12	n/a	n/a	n/a
2001	1230	75.58	0.24	1172	75.63	0.25	58	74.50	0.94
2002	1507	72.47	0.23	779	71.21	0.34	728	73.81	0.28
2003	2140	74.29	0.19	1073	71.34	0.30	1067	77.25	0.18
2004	2026	74.43	0.17	1038	72.82	0.24	988	76.12	0.23
2005	1150	77.02	0.22	658	77.70	0.29	492	76.11	0.34
2006	399	76.01	0.40	139	75.27	0.68	260	76.41	0.49
2007	398	73.45	0.37	256	72.38	0.43	142	75.39	0.64
2008	543	73.02	0.28	271	74.51	0.39	272	71.53	0.39
2009	217	75.09	0.51	4	76.00	2.16	213	75.08	0.52
2010	785	76.20	0.27	258	76.66	0.38	527	75.98	0.36
2011	447	77.12	0.49	239	74.56	0.54	208	80.07	0.81

Figure 1. Distribution of observed fishing effort for the directed shark bottom longline fishery 1993-2011.

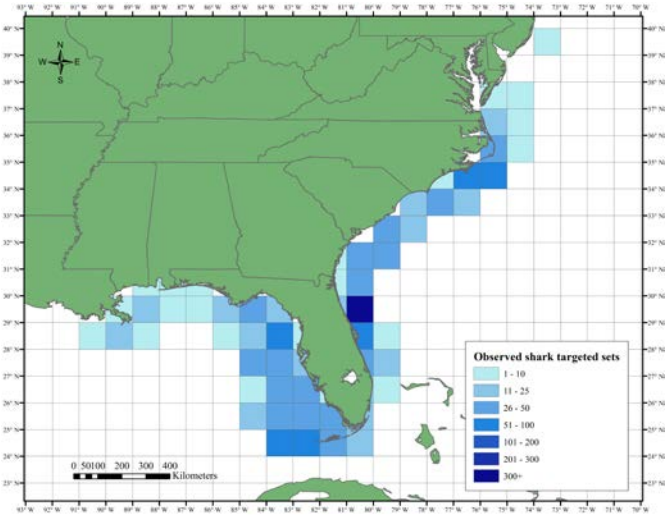
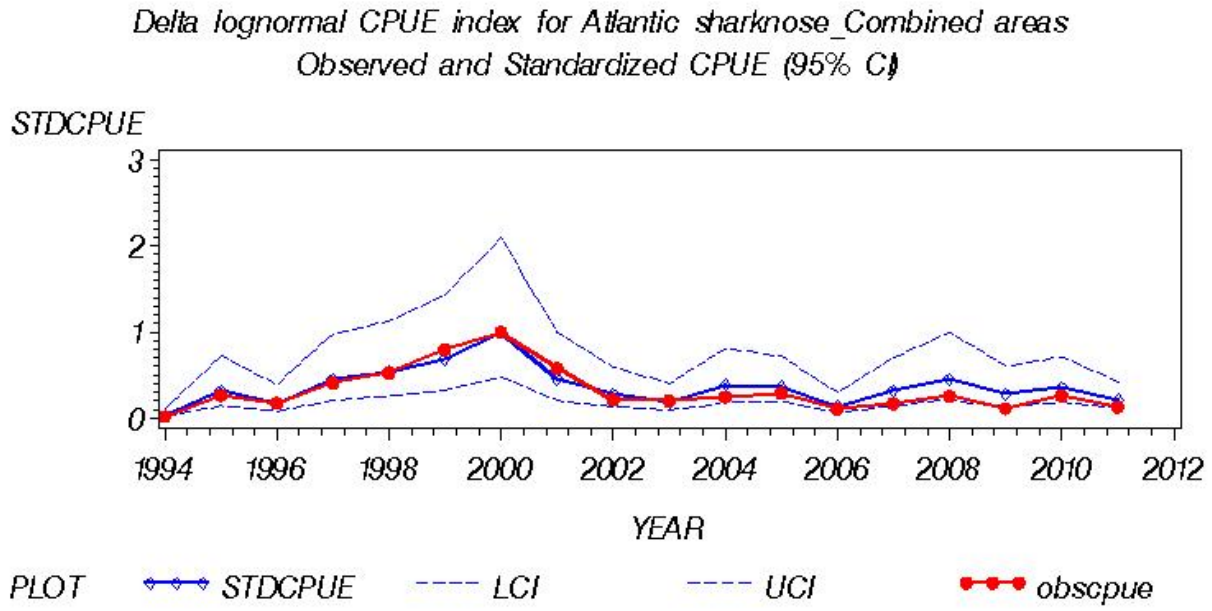


Figure 2. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for Atlantic sharpnose sharks from the Shark Bottom Longline Observer Program (all areas). The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index. For comparison, the index determined at SEDAR13 is provided to demonstrate continuity.



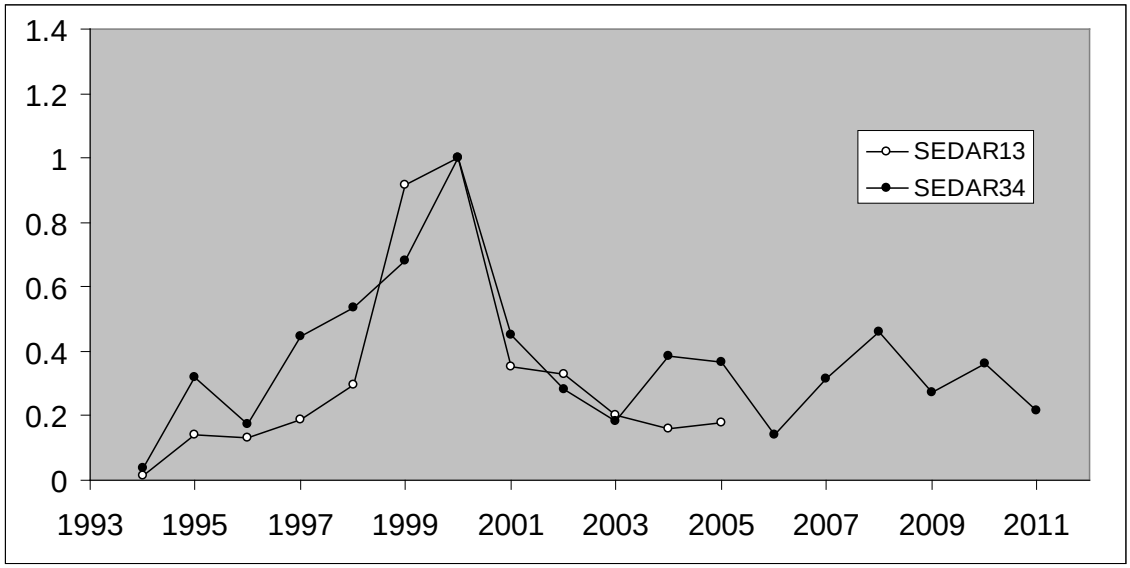
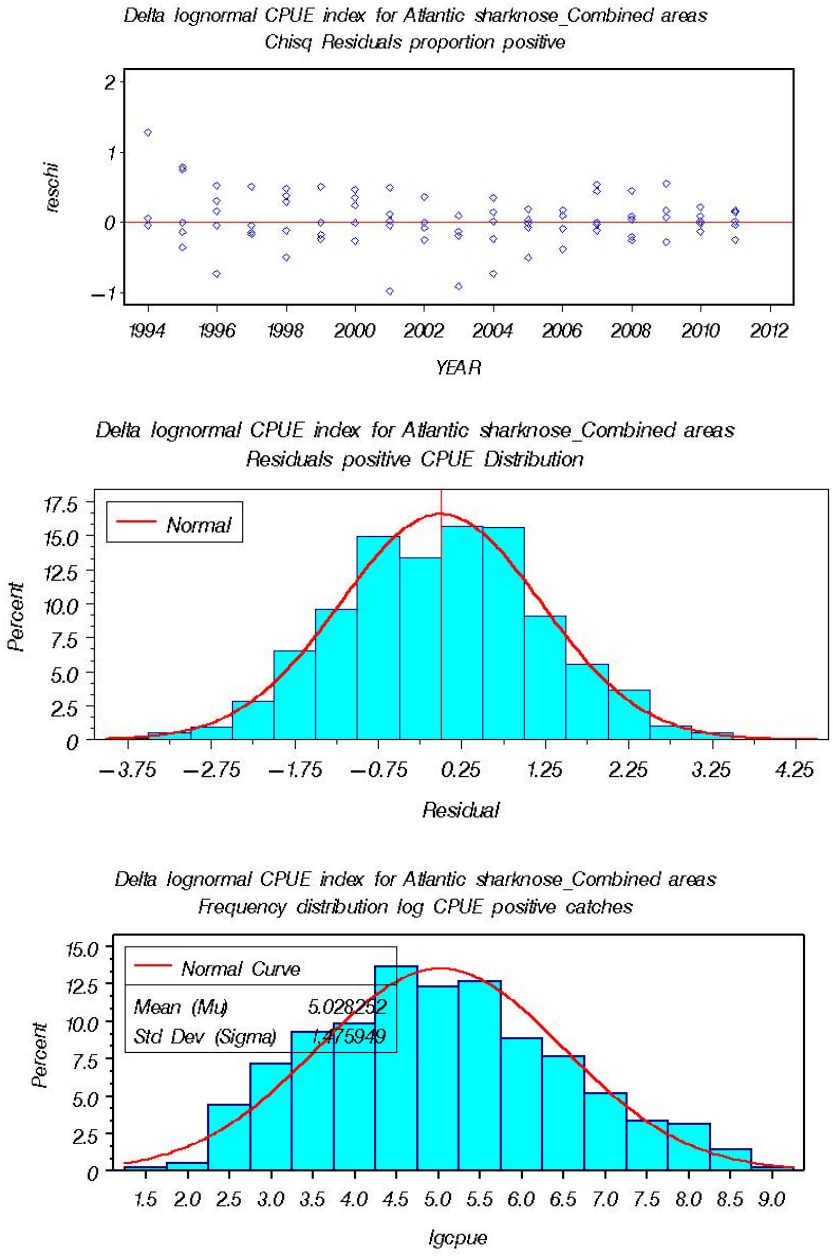
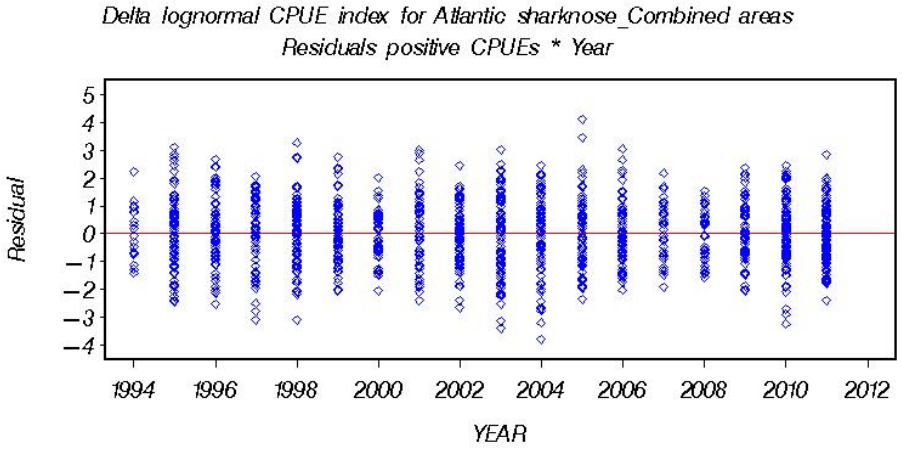


Figure 3. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year.




Delta lognormal CPUE index for Atlantic sharknose_Combined areas
Residuals positive CPUEs * Year
Residual
5
4
3
2
1
0
−1
−2
−3
−4
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
YEAR

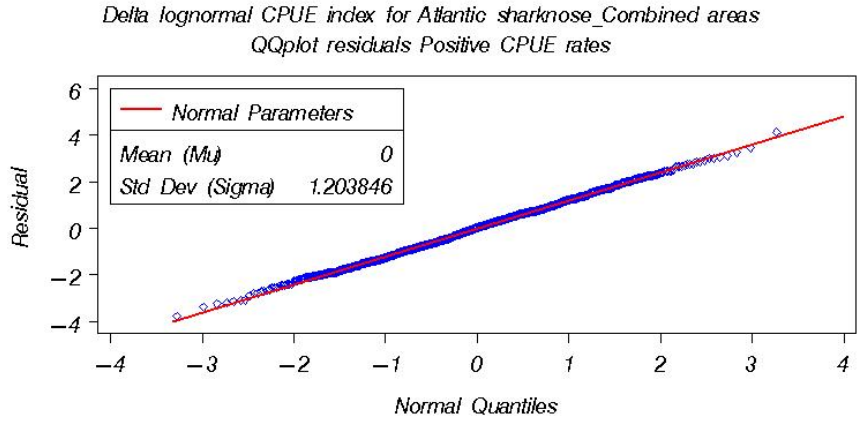
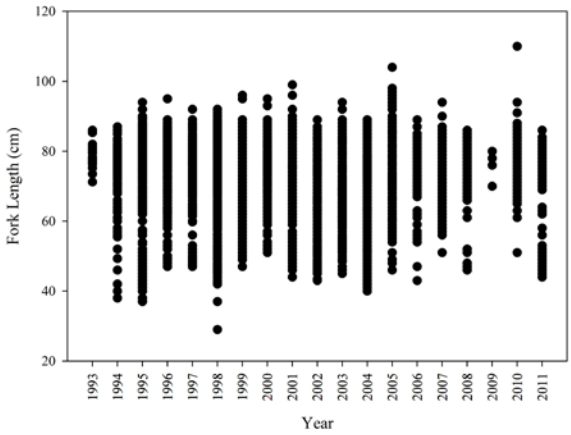
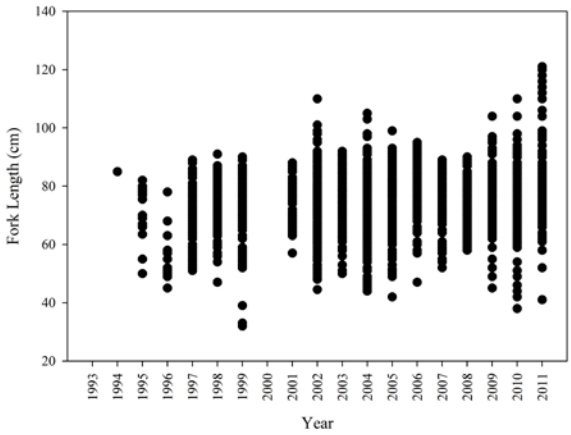

Delta lognormal CPUE index for Atlantic sharknose_Combined areas
QQplot residuals Positive CPUE rates
Normal Parameters
Mean (Mu) 0
Std Dev (Sigma) 1.203846
Residual
6
4
2
0
−2
−4
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles

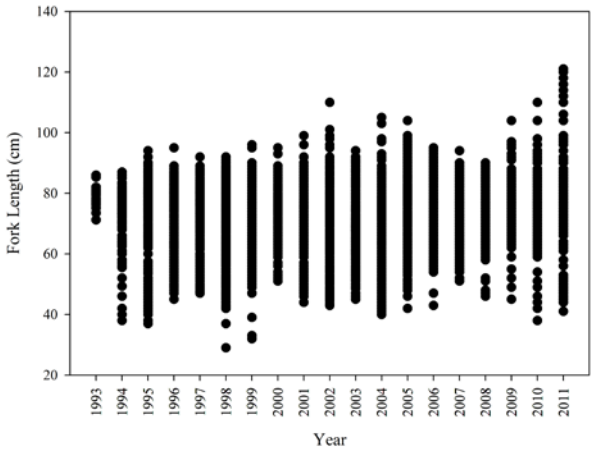
Figure 4. Observed fork lengths (FL) for all Atlantic sharpnose sharks captured by year for a) South Atlantic (n=15,690), b) Gulf of Mexico (n=5,667), and c) both areas combined (n=21,357)



a)



b)



c)

Atlantic Ocean

The final bottom longline dataset for the Atlantic Ocean analyzed contained 1211 sets. Of those sets, Atlantic sharpnose sharks were reported caught on 56.4% of sets. The stepwise construction of the model is summarized in Table 7 and the index statistics can be found in Table 8. The standardized abundance index is shown in Figure 5 and the diagnostic plots assessing the fit of the models were deemed acceptable (Figure 7).

Table 7. 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 (Atlantic). Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	1.375				
YEAR	1.294	5.864	5.864	115.79	<.0001
YEAR+					
DEPTH	1.233	10.330	4.467	74.26	<.0001
BAIT	1.258	8.519		46.94	<.0001
SEASON	1.281	6.795		18.61	0.0003
SRF	1.287	6.344		8.94	0.0028
HOOKTIMER	1.292	6.016		3.74	0.0532
TIME	1.294	5.849		1.13	0.2870
HOOKTYPE	1.295	5.791		3.2	0.3616
YEAR+DEPTH+					
BAIT	1.1983	12.826	2.495	44.08	<.0001
SEASON	1.2201	11.240		17.99	0.0004
SRF	1.2274	10.709		7.14	0.0075
YEAR+DEPTH+BAIT+					
SEASON	1.1857	13.742	0.917	17.85	0.0005
SRF	1.1917	13.306		8.74	0.0031
MODEL	**AIC**				
YEAR+DEPTH+BAIT	**456.0**				
YEAR+DEPTH+BAIT YEAR*DEPTH	458.5				
YEAR+DEPTH+BAIT YEAR*BAIT	463.6				

Proportion positive-Lognormal error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	2.475				
YEAR	2.295	7.281	7.281	68.73	<.0001
YEAR+					
BAIT	1.819	26.516	19.236	162.46	<.0001
TIME	2.076	16.133		69.36	<.0001
HOOKTYPE	2.150	13.147		47.61	<.0001
DEPTH	2.160	12.735		44.38	<.0001

SRF	2.296	7.228		0.63	0.4271
HOOKTIMER	2.298	7.163		0.18	0.6713
SEASON	2.300	7.083		1.63	0.6534
YEAR+BAIT+					
TIME	1.7328	29.991	3.475	34.04	<.0001
DEPTH	1.7486	29.352		29.93	<.0001
HOOKTYPE	1.7796	28.100		17.95	0.0005
YEAR+BAIT+TIME+					
DEPTH	1.6861	31.877	1.887	21.71	<.0001
HOOKTYPE	1.6959	31.482		17.76	0.0005
MODEL	**AIC**				
YEAR+BAIT+TIME+DEPTH	**2308.6**				
YEAR+BAIT+TIME+DEPTH YEAR*BAIT	2295.3				
YEAR+BAIT+TIME+DEPTH YEAR*TIME	2293.3				
YEAR+BAIT+TIME+DEPTH YEAR*DEPTH	2308.4				

Table 8. The standardized and nominal index (number of sharks per hook hour) of absolute abundance, and coefficients of variation (CV) for Atlantic sharpnose sharks (Atlantic). N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1994	55	55.89	0.36	33.00	0.61
1995	109	199.43	0.20	346.94	0.12
1996	86	178.08	0.21	225.70	0.16
1997	54	215.22	0.28	419.46	0.14
1998	72	415.10	0.20	650.46	0.13
1999	68	379.49	0.24	961.30	0.09
2000	64	600.22	0.23	886.01	0.16
2001	54	352.50	0.23	712.37	0.12
2002	68	365.00	0.23	288.28	0.29
2003	93	218.39	0.24	184.47	0.28
2004	52	277.85	0.30	253.33	0.33
2005	52	435.15	0.23	205.14	0.49
2006	49	105.70	0.36	119.87	0.32
2007	35	168.49	0.35	166.51	0.35
2008	26	373.63	0.34	373.86	0.34
2009	38	475.71	0.43	100.26	2.03
2010	101	171.86	0.24	226.79	0.18
2011	135	79.34	0.27	90.78	0.24

Figure 5. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for Atlantic sharpnose sharks from the Shark Bottom Longline Observer Program (Atlantic Ocean). 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.

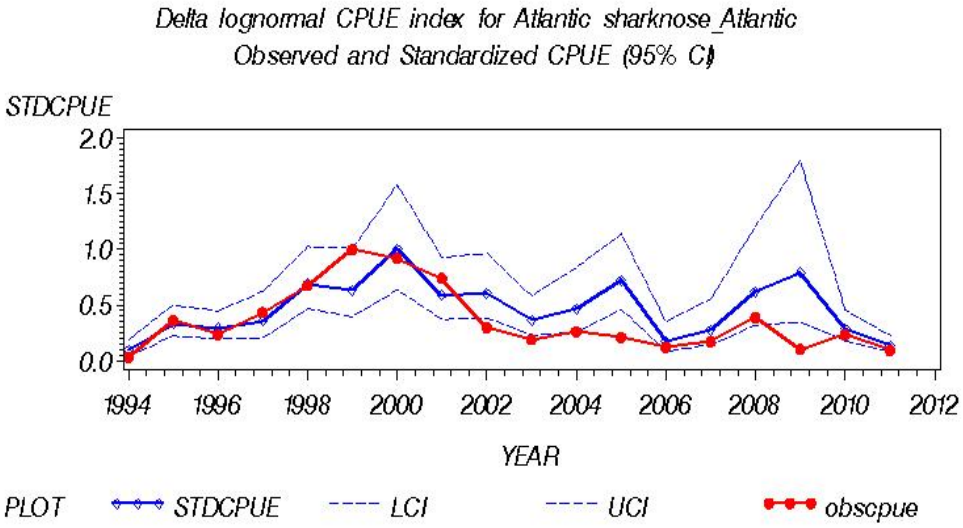
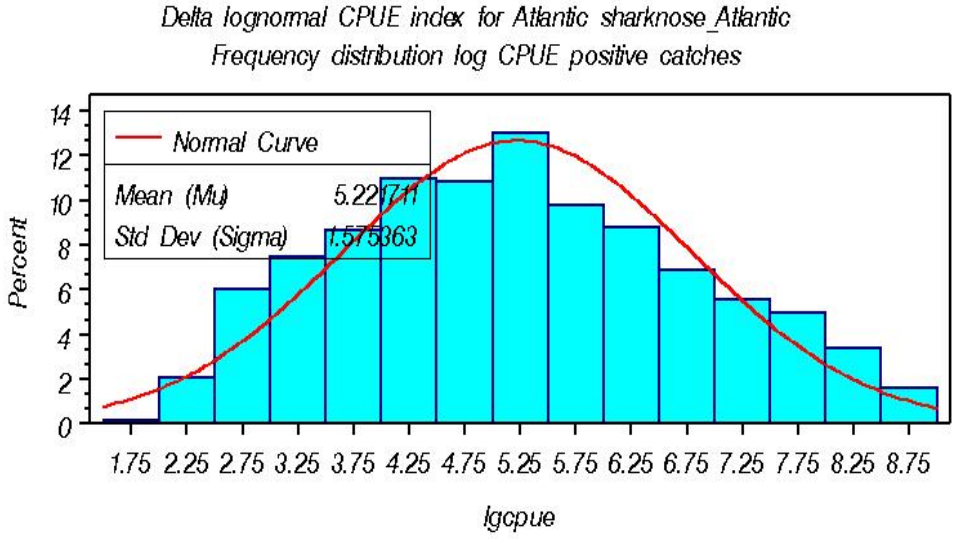
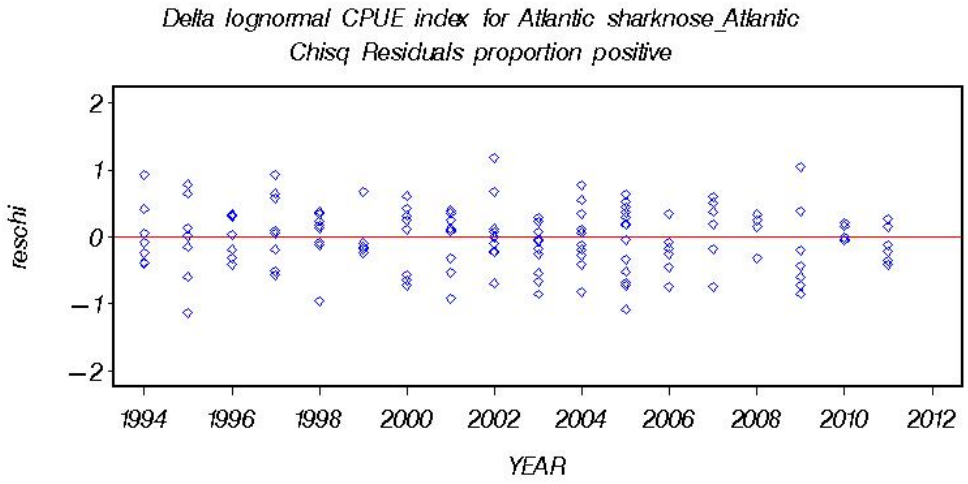
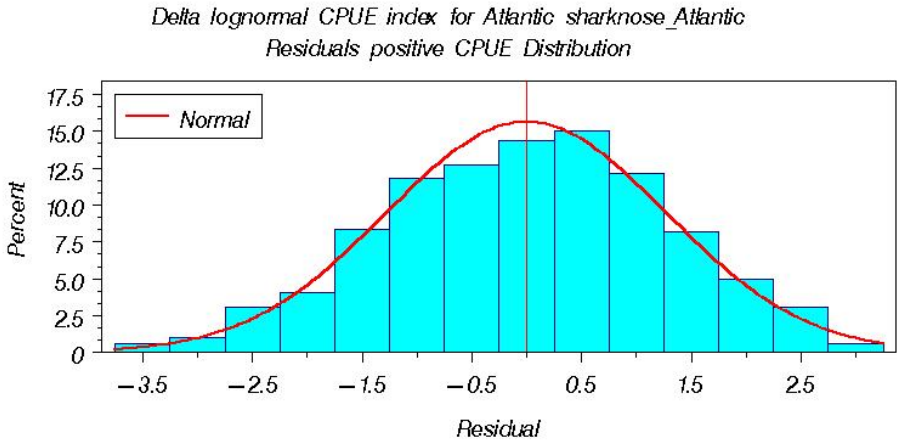
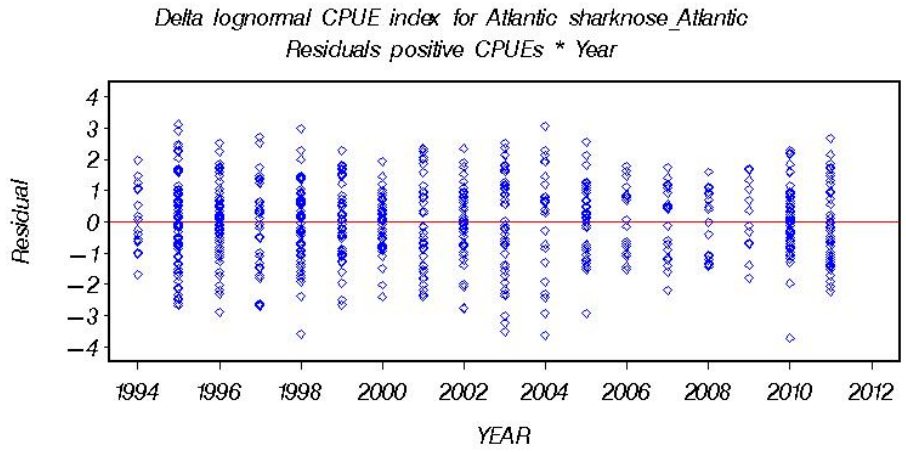


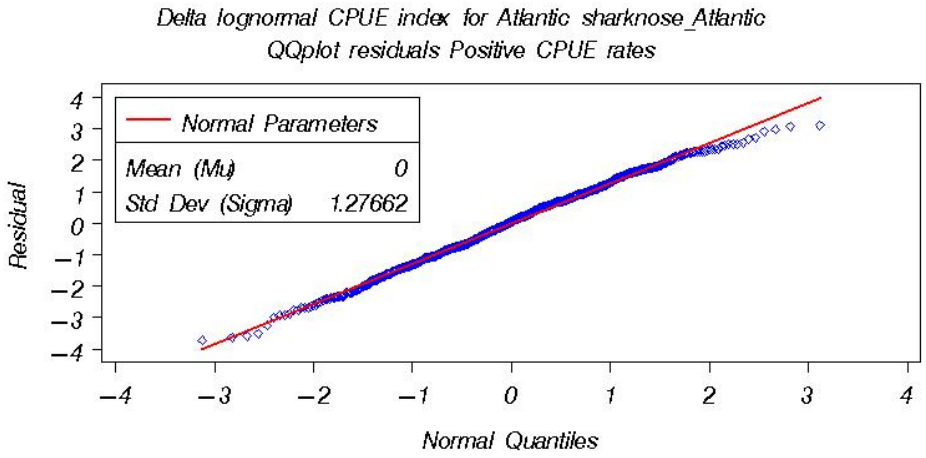
Figure 6. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year.




Delta lognormal CPUE index for Atlantic sharknose_Atlantic
Chisq Residuals proportion positive
reschi
2
1
0
−1
−2
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
YEAR


Delta lognormal CPUE index for Atlantic sharknose_Atlantic
Residuals positive CPUE Distribution
Normal
Percent
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0
−3.5
−2.5
−1.5
−0.5
0.5
1.5
2.5
Residual





Gulf of Mexico

The final bottom longline dataset for the Gulf of Mexico analyzed contained 917 sets. Of those sets, Atlantic sharpnose sharks were reported caught on 51.0% of sets. The stepwise construction of the model is summarized in Table 9 and the index statistics can be found in Table 10. The standardized abundance index is shown in Figure 7 and the diagnostic plots assessing the fit of the models were deemed acceptable (Figure 8).

Table 9. 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 (Gulf of Mexico). Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	1.424				
YEAR	1.255	11.856	11.856	165.61	<.0001
YEAR+					
DEPTH	1.179	17.172	5.317	67.58	<.0001
BAIT	1.241	12.874		17.26	0.0017
TIME	1.244	12.635		10.62	0.0011
SEASON	1.251	12.172		7.57	0.0557
HOOKTIMER	1.255	11.849		1.2	0.273
HOOKTYPE	1.256	11.813		3.28	0.351
SRF	1.256	11.764		0.18	0.6699
YEAR+DEPTH+					
BAIT	1.1549	18.886	1.714	25.18	<.0001
TIME	1.1731	17.608		6.37	0.0116
FINAL MODEL	**AIC**				
YEAR+DEPTH+BAIT	**458.9**				
YEAR+DEPTH+BAIT YEAR*DEPTH	458.9				
YEAR+DEPTH+BAIT YEAR*BAIT	458.9				

Proportion positive-Lognormal error distribution					
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	1.605				
YEAR	1.443	10.071	10.071	66.1	<.0001
YEAR+					
DEPTH	1.312	18.248	8.176	47.83	<.0001
SEASON	1.417	11.673		11.55	0.0091
HOOKTYPE	1.424	11.249		9.29	0.0257
HOOKTIMER	1.428	10.987		5.83	0.0157
SRF	1.429	10.919		5.47	0.0193
TIME	1.442	10.133		1.36	0.243
BAIT	1.447	9.853		3.02	0.5541
YEAR+DEPTH+					
HOOKTYPE	1.2827	20.061	1.814	13.65	0.0034
SRF	1.2891	19.662		9.22	0.0024
SEASON	1.2907	19.563		10.73	0.0133
HOOKTIMER	1.299	19.045		5.65	0.0175
YEAR+DEPTH+HOOKTYPE+					
SEASON	1.2547	21.806	1.745	13.52	0.0036
SRF	1.2596	21.501		9.58	0.002
HOOKTIMER	1.2644	21.202		7.81	0.0052

FINAL MODEL	**AIC**				
YEAR+DEPTH+HOOKTYPE+SEASON	1444.4				
YEAR+DEPTH+HOOKTYPE+SEASON YEAR*DEPTH	1444.0				
YEAR+DEPTH+HOOKTYPE+SEASON YEAR*HOOKTYPE	1442.8				
YEAR+DEPTH+HOOKTYPE+SEASON YEAR*SEASON	**1438.7**				

Table 10. The standardized and nominal index (number of sharks per hook hour) of absolute abundance, and coefficients of variation (CV) for Atlantic sharpnose sharks (Gulf of Mexico). N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1994	47	0.07	3.39	0.19	0.81
1995	53	2.86	0.79	3.30	1.46
1996	40	10.46	0.76	5.71	0.72
1997	26	163.69	0.51	244.29	2.95
1998	38	49.79	0.52	118.32	4.56
1999	31	95.31	0.40	151.26	3.97
2000					
2001	23	48.57	0.57	54.41	1.96
2002	64	62.94	0.45	84.36	2.98
2003	81	85.46	0.36	172.09	5.61
2004	70	110.84	0.37	193.47	4.65
2005	75	91.19	0.37	293.26	8.70
2006	68	124.19	0.35	81.40	1.89
2007	28	191.99	0.44	129.35	1.53
2008	35	48.19	0.46	116.13	5.28
2009	76	53.82	0.38	101.84	4.92
2010	69	313.44	0.30	244.73	2.57
2011	93	328.63	0.30	154.11	1.56

Figure 7. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for Atlantic sharpnose sharks from the Shark Bottom Longline Observer Program (Gulf of Mexico). 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.

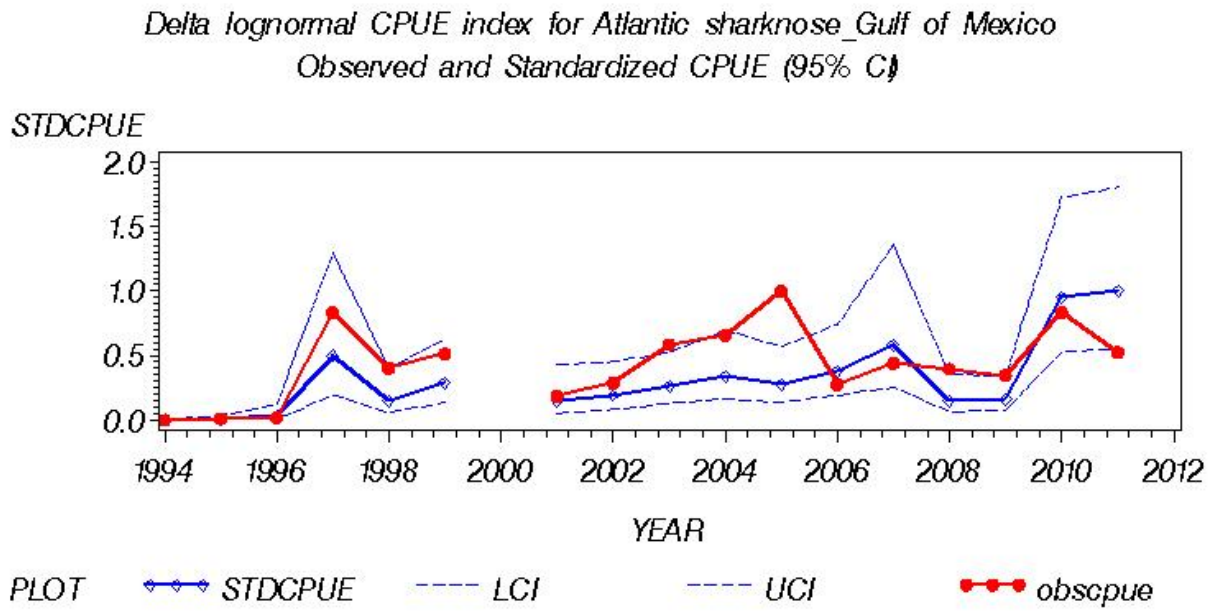
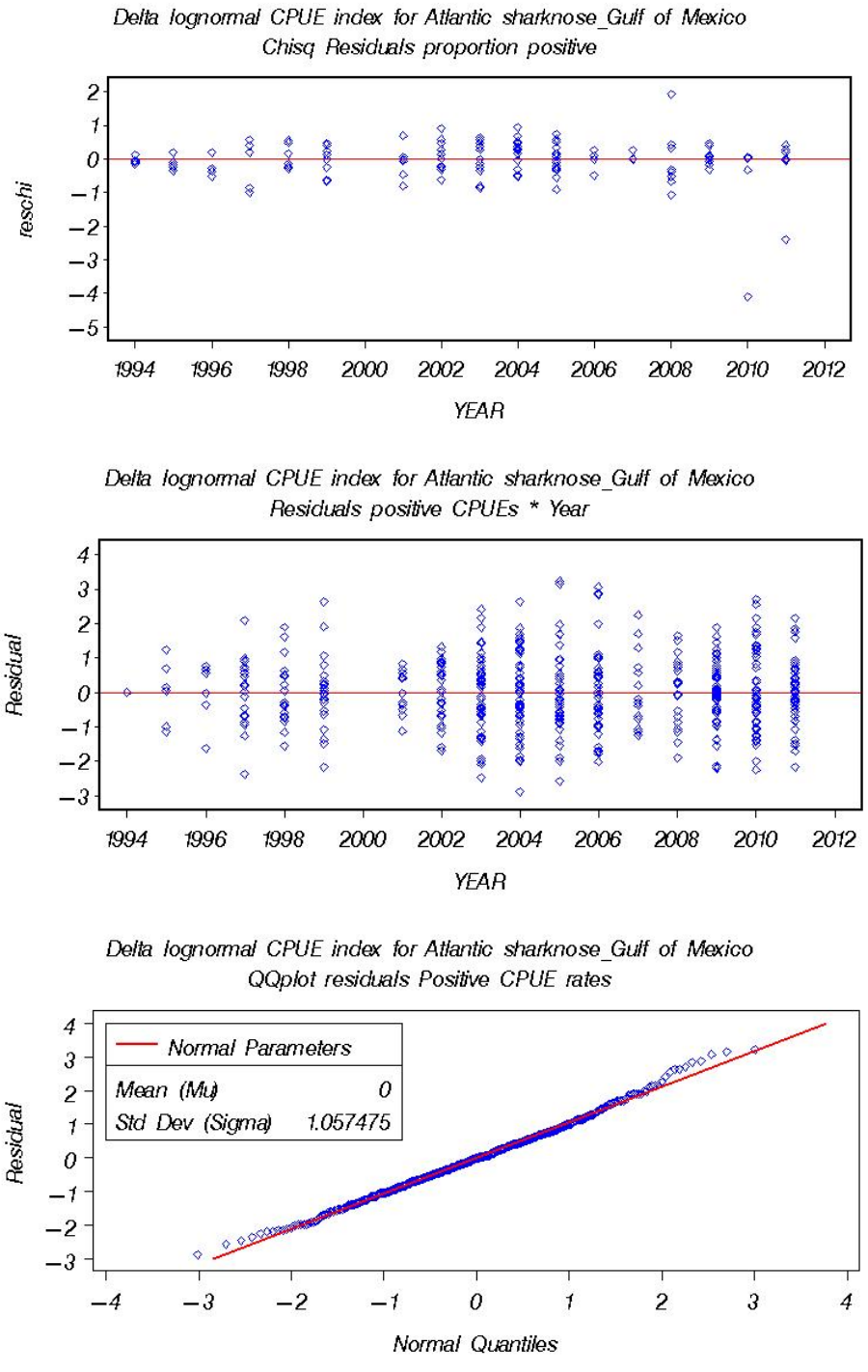


Figure 8. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year.



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