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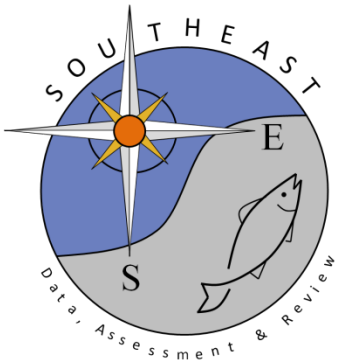

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Smoothhound Abundance Indices from NMFS Small Pelagics Surveys in the Northern Gulf of Mexico

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Abstract

The Southeast Fisheries Science Center Mississippi Laboratories Small Pelagics Survey began in October of 2002 as an outer shelf and upper slope survey in order to investigate if the distributional range of many of species collected in Southeast Area Monitoring and Assessment Program (SEAMAP) groundfish surveys extended beyond the geographical boundaries of the commercial shrimping grounds. By 2004, the survey became a mid to outer shelf and upper slope survey in order to overlap some of the area covered by the SEAMAP groundfish survey. A delta-lognormal model was used to develop an abundance index for smoothhound sharks (Mustelus sp.). The annual abundance index shows a slight increase in abundance over the course of the time series.

Introduction

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) Small Pelagics Survey began in October of 2002 as an outer shelf and upper slope survey (i.e. between 110 and 500 m station depth). It began in order to investigate if the distributional range of many of species collected in Southeast Area Monitoring and Assessment Program (SEAMAP) groundfish trawls extended beyond the geographical boundaries of the commercial shrimping grounds. Therefore, in order to more effectively evaluate these extensions of distributional range, trawling stations began to be allocated in shallower depth strata to allow geographic overlap with SEAMAP groundfish effort. By 2004, the survey became a mid to outer shelf and upper slope survey (i.e. between 50 and 500 m station depth). While this survey data has not been utilized in previous stock assessments, mainly due to the short duration of the survey, it potentially could provide an important source of fisheries independent information on many commercially and recreationally important species throughout the northern GOM, as it has been occurring for 13 years. The purpose of this document is to provide an abundance index for smoothhound sharks (*Mustelus sp.*).

Methodology

Survey Design / Data

Stations were selected with a proportional allocation based on stratum area with 30% effort between 50 and 110 m, 60% effort between 110 and 200 m and 10 % effort between 200 and 500 m. Trawl sampling was conducted using a 27.4 m (90 foot) high-opening fish trawl towed for

approximately 30 minutes. Trawl data was obtained from the SEFSC MSLABS trawl unit leader (Gilmore Pellegrin). A total of 1259 stations were sampled from 2002- 2012 (Table 1). For this document, all smoothhound sharks captured (*Mustelus sp., Mustelus canis* (smooth dogfish), *Mustelus norrisi* (Florida smoothhound), and *Mustelus sinusmexicanus* (Gulf smoothhound)) have been grouped together and were treated as a species complex.

Data Exclusions

Data was limited to only those stations that did not indicate a problem with the tow.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for smoothhound sharks (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al*. (1992) was estimated as:

(1) $$I_y = c_y p_y,$$

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

(2) $$\ln(c) = X\beta + \varepsilon$$

and

(3) $$p = \frac{e^{\mathbf{X\beta}+\varepsilon}}{1+e^{\mathbf{X\beta}+\varepsilon}},$$

respectively, where c is a vector of the positive catch data, p is a vector of the presence/absence data, X is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2. Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, SE (c_y) and SE (p_y), respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated as:

(4) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

where:

(5) $$\mathrm{Cov}(c, p) \approx \rho_{c,p}\left[\mathrm{SE}(c_y)\mathrm{SE}(p_y)\right],$$

and $\rho_{c,p}$ denotes correlation of c and p among years.

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Variables that could be included in the submodels were:

Submodel Variables

Year: 2002 – 2012
Region: Texas, Louisiana, Mississippi/Alabama, Florida
Time of Day: Day, Night
Depth Zone: 50 – 110 m, 110 – 200 m, 200 – 500 m

Results and Discussion

The distribution of smoothhound is presented in Figure 1, with annual abundance and distribution presented in the Appendix Figure 1. The total number of smoothhound captured ranged from 15 to 64 (Table 2). Of the 366 smoothhound captured during the survey, a total of 301 were measured from 2002 – 2012 with an average total length of 807 mm. The length frequency distribution of smoothhound captured is shown in Figure 3.

For the NMFS Small Pelagics abundance index of smoothhound, the nominal CPUE and number of stations with a positive catch are presented in Figure 3. Year, depth zone, region and time of day were retained in the binomial submodel, while only year and depth zone were retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 3 summarizes the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 7217.7 and 359.1, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 4-6, and indicated the distribution of the residuals is somewhat divergent from normal. Annual abundance indices are presented in Table 4 and Figure 7.

Literature Cited

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Table 1. Number of stations sampled by shrimp statistical zone during the NMFS Small Pelagics survey from 2002-2012. (Note: No survey was conducted in 2005 due to Hurricane Katrina and in 2006, the vessel was repurposed to conduct the SEAMAP groundfish survey after leg 1)

	Shrimp Statistical Zone																		
Year	2	3	4	5	6	8	9	10	11	13	14	15	16	17	18	19	20	21	***Total***
2002	5	14	19	12	1	18	13	3	2	5	5	7	6	7	4		9	2	***132***
2003		10	21	15	2	18	18	4	4	5	4	8	7	8	5		11	6	***146***
2004			1	7	2	17	12	4	3	4	5	8	6	9	6	1	9	7	***101***
2005																			
2006							5	4	5	5	7	8	6	11	6		9	7	***73***
2007		1	22	18	5	17	12	3	4	7	7	7	7	9	7	1	12	7	***146***
2008	3	16	22	19	5	18	14	4	5	3	7	8	9	8	7		13	6	***167***
2009	1	7	10	9	4	13	13	4	3	4	8	6	6	10	7	1	11	5	***122***
2010	3	13	13	9	2	11	17	1	4	3	4	10	6	9	6	1	13	5	***130***
2011	2	13	16	12	3	12	11	7	1	3	12	8	8	6	7	2	7	1	***131***
2012		9	11	5	2	10	13	2	1	2	5	10	7	10	5	2	11	6	***111***
Total	***14***	***83***	***135***	***106***	***26***	***134***	***128***	***36***	***32***	***41***	***64***	***80***	***68***	***87***	***60***	***8***	***105***	***52***	***1259***

Table 2. Summary of the smoothhound length data collected during NMFS Small Pelagics surveys conducted between 2002 and 2012. (Note: no survey was conducted in 2005 due to Hurricane Katrina)

Survey Year	*Number of Stations*	*Number Collected*	*Number Measured*	*Minimum Total Length (mm)*	*Maximum Total Length (mm)*	*Mean Total Length (mm)*	*Standard Deviation (mm)*
2002	132	15	9	421	1078	719	223
2003	146	23	15	373	1300	842	236
2004	101	21	17	508	1226	817	244
2005	0						
2006	73	29	29	361	1257	837	240
2007	146	34	32	390	1315	893	250
2008	167	64	54	372	1334	739	240
2009	122	46	43	381	1333	735	221
2010	130	41	6	515	1463	1080	367
2011	131	38	19	620	1300	878	213
2012	111	55	55	469	1280	818	259

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Total Length (mm)
10	1259	366	279	808

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for smoothhound NMFS Small Pelagics survey index of relative abundance from 2002 to 2012.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 7217.7)*						*Lognormal Submodel Type 3 Tests (AIC 364.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	480	29.22	3.21	0.0006	0.0009	9	169	1.26	0.2607
Depth Zone	2	881	31.27	15.64	<.0001	<.0001	2	169	5.47	0.0050
Region	3	1003	65.82	21.94	<.0001	<.0001	3	169	1.51	0.2125
Time of Day	1	977	8.55	8.55	0.0035	0.0035	1	169	0.92	0.3394
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 7217.7)*						*Lognormal Submodel Type 3 Tests (AIC 362.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	480	29.22	3.21	0.0006	0.0009	9	170	1.29	0.2440
Depth Zone	2	881	31.27	15.64	<.0001	<.0001	2	170	5.15	0.0067
Region	3	1003	65.82	21.94	<.0001	<.0001	3	170	1.64	0.1820
Time of Day	1	977	8.55	8.55	0.0035	0.0035		Dropped		
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 7217.7)*						*Lognormal Submodel Type 3 Tests (AIC 359.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	480	29.22	3.21	0.0006	0.0009	9	173	1.36	0.2102
Depth Zone	2	881	31.27	15.64	<.0001	<.0001	2	173	5.87	0.0034
Region	3	1003	65.82	21.94	<.0001	<.0001		Dropped		
Time of Day	1	977	8.55	8.55	0.0035	0.0035		Dropped		

Table 4. Indices of smoothhound abundance developed using the delta-lognormal model for NMFS Small Pelagics surveys from 2004-2012. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed. (Note: No survey was conducted in 2005 due to Hurricane Katrina)

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2002	0.08333	132	0.18354	0.55852	0.32085	0.29864	1.04455
2003	0.07534	146	0.20703	0.63000	0.37986	0.30231	1.31291
2004	0.09901	101	0.19500	0.59339	0.32977	0.31208	1.12827
2005							
2006	0.24658	73	0.26196	0.79717	0.33020	0.41892	1.51696
2007	0.15068	146	0.27822	0.84662	0.24333	0.52404	1.36777
2008	0.14371	167	0.43993	1.33874	0.24148	0.83160	2.15515
2009	0.18033	122	0.42395	1.29011	0.40910	0.58741	2.83344
2010	0.13846	130	0.38573	1.17378	0.25696	0.70788	1.94634
2011	0.12977	131	0.29301	0.89164	0.27545	0.51915	1.53138
2012	0.28829	111	0.61781	1.88003	0.19562	1.27597	2.77005

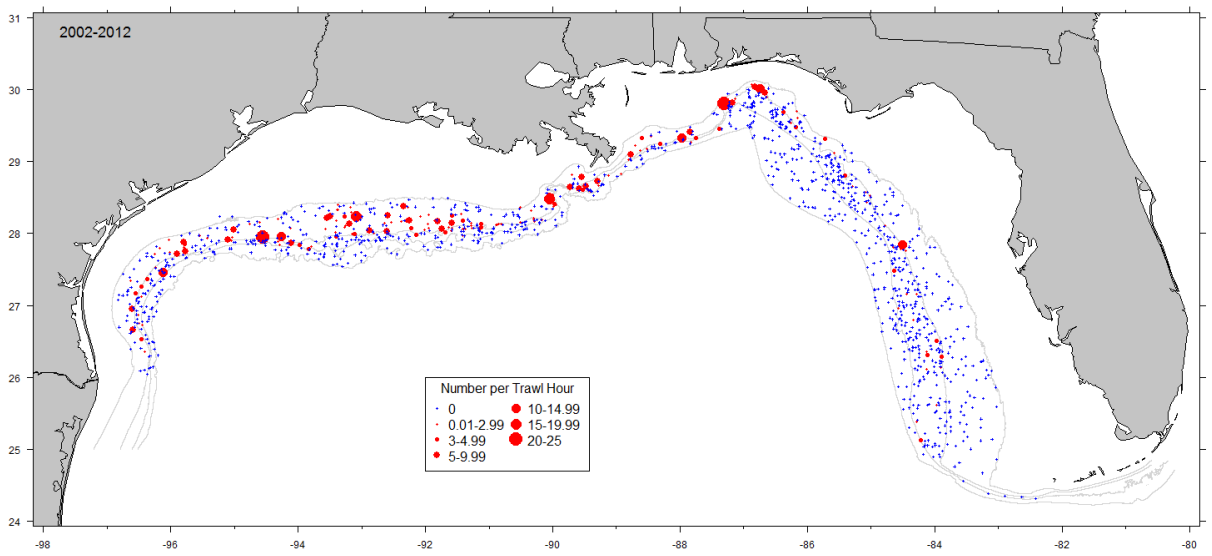

Figure 1. Stations sampled from 2002 to 2012 during the NMFS Small Pelagics Survey with the CPUE for smoothhound. Contour lines are 50, 110, 200 and 500 m.

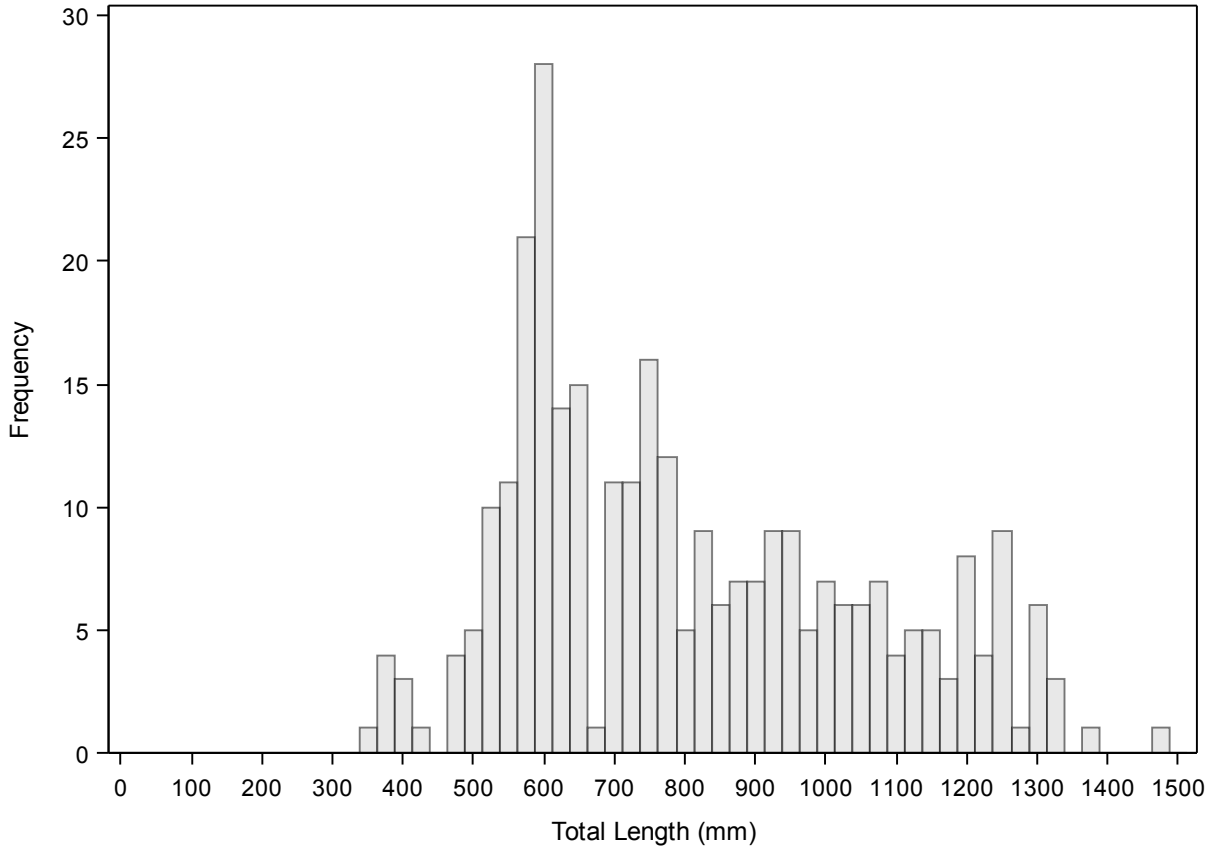

Figure 2. Length frequency histograms for smoothhound captured during NMFS Small Pelagics surveys from 2002-2012.

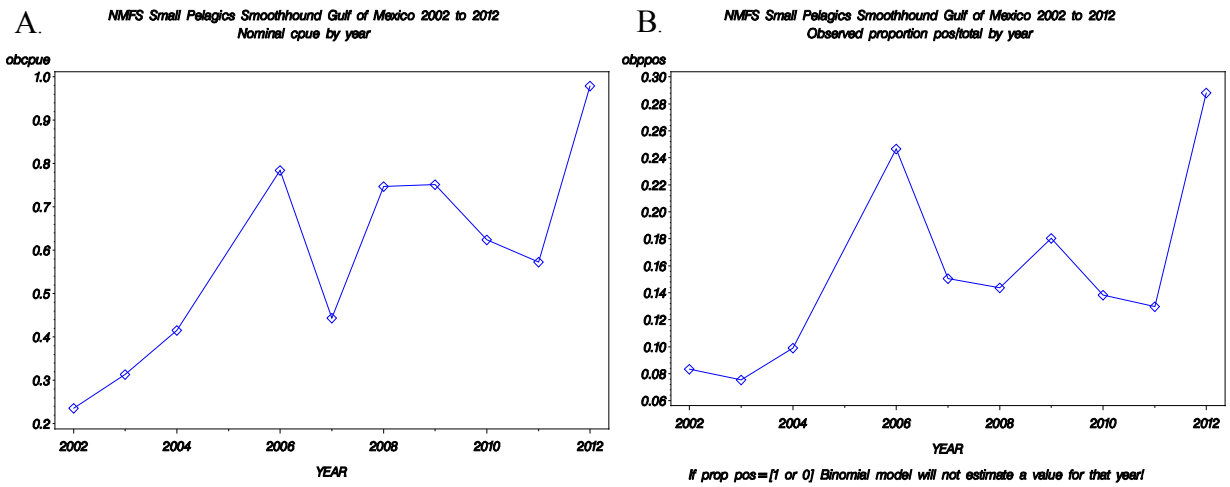

Figure 3. Annual trends for smoothhound captured during NMFS Small Pelagics surveys from 2002 to 2012 in **A.** nominal CPUE and **B.** proportion of positive stations.

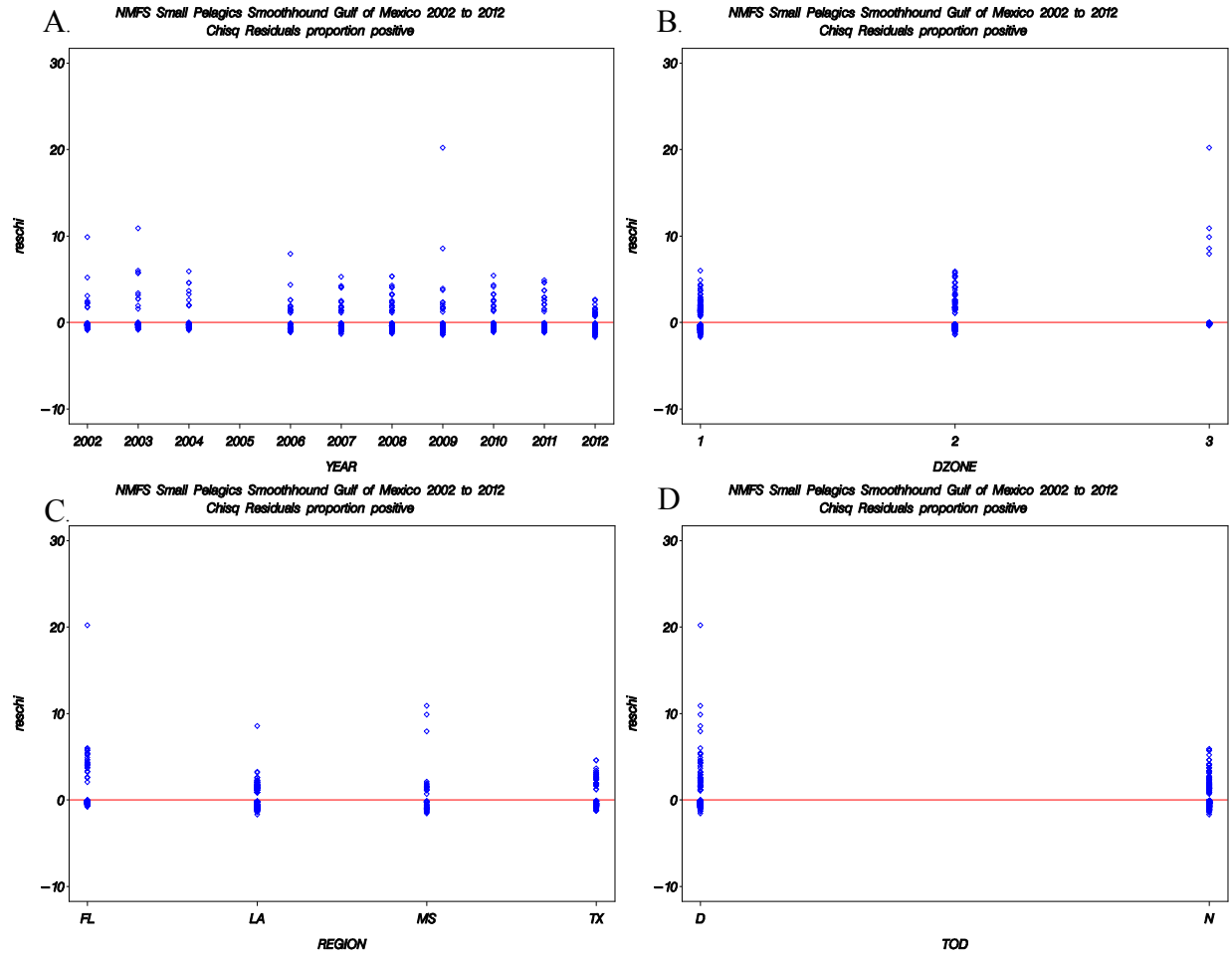

Figure 4. Diagnostic plots for binomial component of the smoothhound NMFS Small Pelagics surveys model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by depth zone, **C.** the Chi-Square residuals by region, and **D.** the Chi-Square residuals by time of day.

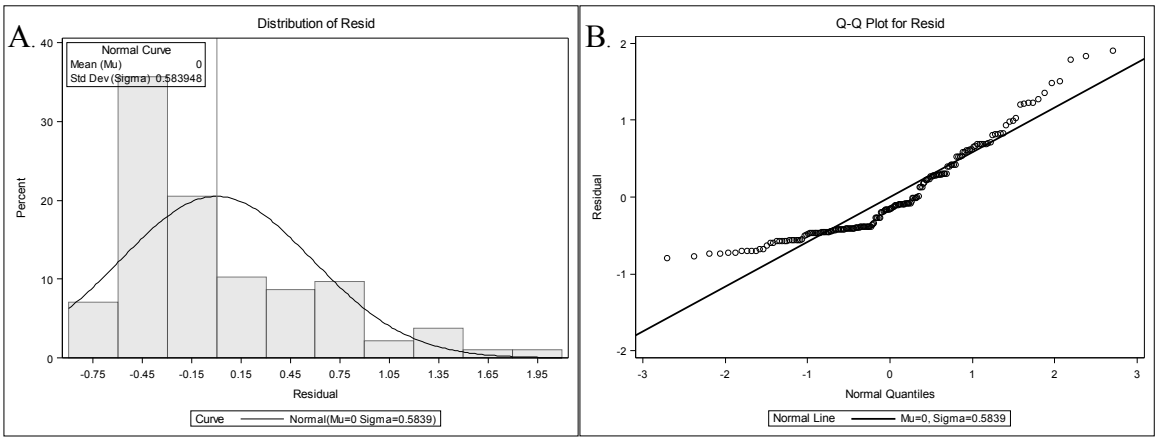

Figure 5. Diagnostic plots for lognormal component of the smoothhound NMFS Small Pelagics survey model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

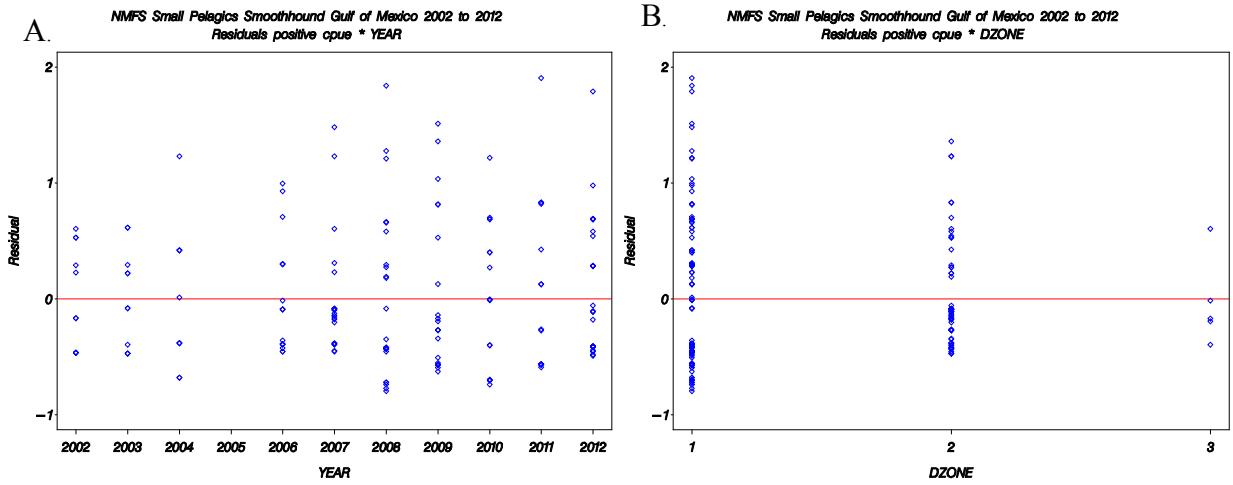

Figure 6. Diagnostic plots for lognormal component of the smoothhound NMFS Small Pelagics survey model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals depth zone.

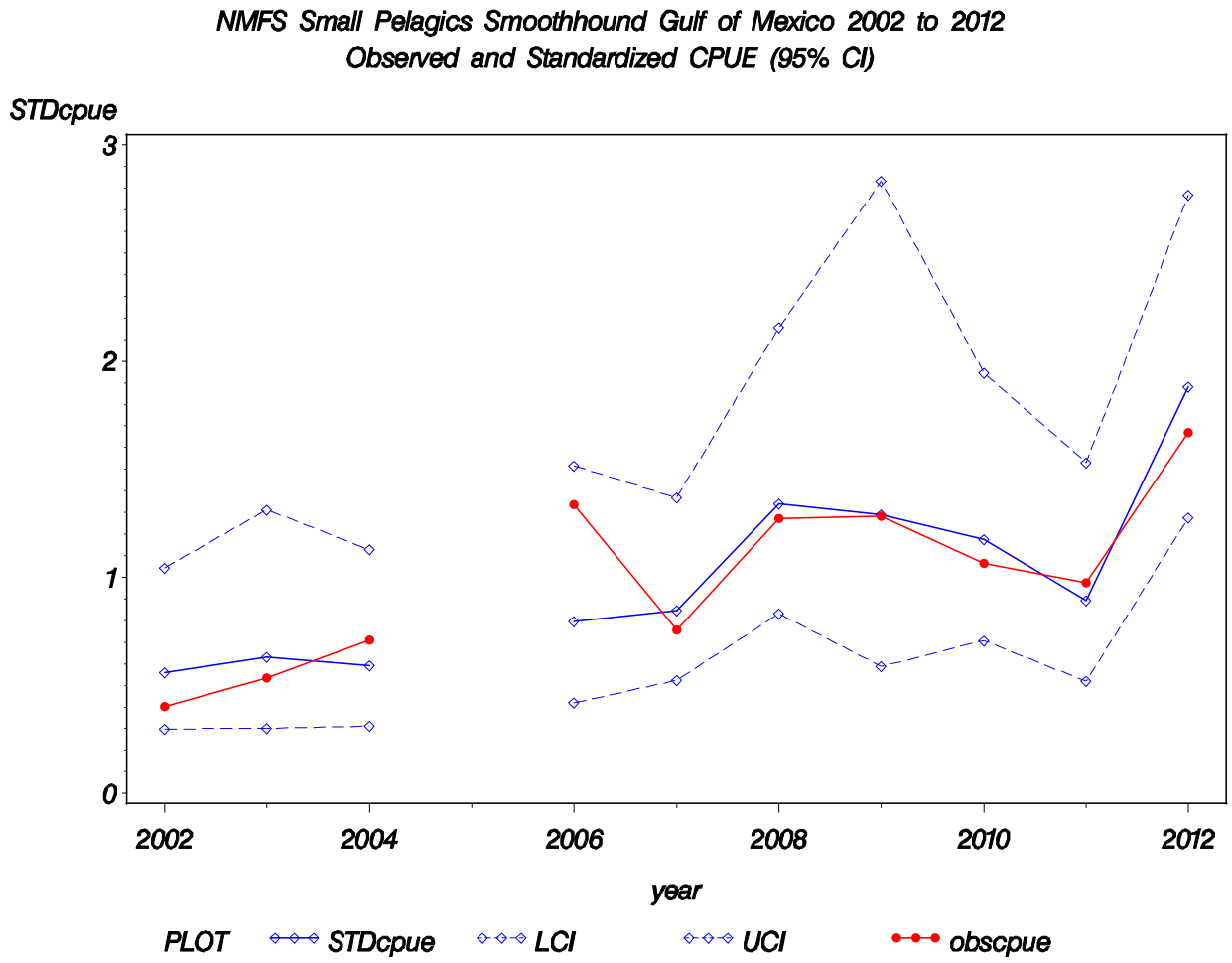

Figure 7. Annual index of abundance for smoothhound from the NMFS Small Pelagics surveys from 2002 – 2012.

Appendix

Appendix Table 1. Summary of the factors used in constructing the smoothhound abundance index from the NMFS Small Pelagics survey data.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2002	132	11	0.08333	0.23604
Year	2003	146	11	0.07534	0.31374
Year	2004	101	10	0.09901	0.41584
Year	2006	73	18	0.24658	0.78431
Year	2007	146	22	0.15068	0.44371
Year	2008	167	24	0.14371	0.74708
Year	2009	122	22	0.18033	0.75214
Year	2010	130	18	0.13846	0.62464
Year	2011	131	17	0.12977	0.57282
Year	2012	111	32	0.28829	0.97882
Depth Zone	50 – 110	455	117	0.25714	1.16385
Depth Zone	110 – 200	561	63	0.11230	0.32236
Depth Zone	200 - 500	243	5	0.02058	0.04947
Region	Florida	626	37	0.05911	0.19866
Region	Louisiana	340	90	0.26471	0.96962
Region	Mississippi/Alabama	68	18	0.26471	1.37123
Region	Texas	225	40	0.17778	0.77841
Time of Day	Day	583	71	0.12178	0.48956
Time of Day	Night	676	114	0.16864	0.64645

Appendix Figure 1. Annual survey effort and catch of smoothhound from the NMFS Small Pelagics Survey from 2002 - 2012. Contour lines are 50, 110, 200 and 500 m.