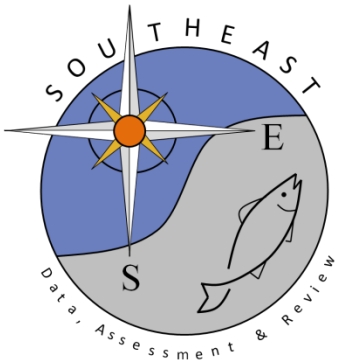
Smoothhound Abundance Indices from NMFS Bottom Longline Surveys in the Western North Atlantic and Northern Gulf of Mexico

Adam G. Pollack and G. Walter Ingram, Jr.

SEDAR39-DW-06

7 May 2014
Updated: 22 May 2014



Please cite this document as:

Pollack, A. G. and G. Walter Ingram, Jr. 2014. Smoothhound Abundance Indices from NMFS Bottom Longline Surveys in the Western North Atlantic and Northern Gulf of Mexico. SEDAR39-DW-06. SEDAR, North Charleston, SC. 18 pp.

Smoothhound Abundance Indices from NMFS Bottom Longline Surveys in the Western North Atlantic and Northern Gulf of Mexico

Adam G. Pollack[1] and G. Walter Ingram, Jr.[2]

[1] Riverside Technology, Inc.
NOAA Fisheries, Southeast Fisheries Science Center,
Mississippi Laboratories, Pascagoula, MS

[2] NOAA Fisheries, Southeast Fisheries Science Center,
Mississippi Laboratories, Pascagoula, MS

Abstract: *The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. Additionally in 2011, the Congressional Supplemental Sampling Program (CSSP) was conducted where high levels of survey effort were maintained from April through October. Data from the SEFSC Bottom Longline Survey and the CSSP Survey were used to produce abundance indices for smoothhound sharks. An abundance index was only produced for the GOM since there were only 3 stations with captures of smoothhound sharks in the Atlantic.*

Introduction

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. The objective of these surveys is to provide fisheries independent data for stock assessment purposes for as many species as possible. These surveys are conducted annually in U.S. waters of the GOM and/or the Atlantic, and provide an important source of fisheries independent information on sharks, snappers and groupers. The evolution of these surveys has been the subject of many documents [e.g., Ingram *et al*. 2005 (LCS05/06-DW-27)] and was not described again in this document.

In 2011, the Congressional Supplemental Sampling Program (CSSP) was conducted where high levels of survey effort were maintained from April through October (for a full review of the CSSP see Campbell *et al.* 2012). This program was conducted using the same gear as the annual bottom longline survey and a similar survey design. The only difference was the CSSP samples out to 400 m, whereas, the annual survey samples to a depth of 366 m. The purpose of this document is to provide abundance indices for smoothhound sharks (*Mustelus sp.*) from the Atlantic and GOM.

Methodology

Survey Design

Details concerning methodologies and evolution of the NMFS BLL have been covered in previous documents (most recently LCS05/06-DW-27) and will not be repeated in this document. Basic sample design was a proportional allocation of stations based on continental

shelf width within statistical zones and stratified by depth (50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m). The survey used 15/0 circle hooks, but in the past J-hooks had been used. Henwood *et al.* (2005) examined the difference in catch rates between the two hooks types and only found significant difference at shallow stations (< 30 fathoms). For this reason, hook type was included as a variable in all the submodels.

Data

Data for the annual bottom longline survey was obtained from the SEFSC MSLABS Shark Unit and the CSSP data was obtained from SEFSC MSLABS Information Technology Unit. Data from the CSSP was used to fill in gaps in the annual bottom longline survey due to vessel breakdowns and weather delays in 2011. As to not over represent any one area, data from the August survey was used for the Western and Central Gulf, while data from September was used for the Eastern Gulf. These time frames historically match up with when the annual bottom longline survey sampled those areas. For this document, the combined dataset will be hereafter referred to as NMFS BLL. The total number of stations sampled in the Atlantic and GOM were 729 and 2915, respectively (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

We used the time series of data between 2000 and 2012 to develop smoothhound abundance indices for the GOM (Table 1). The years 1995 – 1997 and 1999 were excluded from analysis (478 stations) due to the low frequency of occurrence of smoothhound, 3,2,0,0 occurrences respectively (no survey was conducted in 1998). The year 2005 was excluded from the analysis because Hurricane Katrina interrupted the survey, resulting in only 52 stations done during the typical survey time frame (August and September), all of which were in the East Gulf. Additional sampling was done in October and November (43 stations), but there little temporal overlap in other years (17 stations in 2004, which were also removed). No abundance index was developed for the Atlantic because there was only a record of 3 stations with captures of smoothhound.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for smoothhound (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:

(2) $I_y = c_y p_y,$

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:

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

and

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

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:

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

where:

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

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 (GOM)

Year: 2000 – 2012
Area: East Gulf (east of 88° west), Central Gulf (between 88° and 93° west),
West Gulf (west of 93° west)
Depth: 9 – 400 meters (continuous)
Hook Type: J-hook, Circle hook
Time of Day: Day, Night

Results and Discussion

The distribution of smoothhound is presented in Figure 1, with annual abundance and distribution presented in Appendix Figure 1. There were 3 smoothhound captured in the Atlantic and 3 to 222 captured per year in the GOM (Table 2). Of the 1185 smoothhound captured during the GOM survey, a total of 1151 were measured from 1995 – 2012 with an average fork length of 925 mm. Figures 2 shows the length frequency distribution of smoothhound captured in the GOM.

For the GOM NMFS BLL abundance index of smoothhound, the nominal CPUE and number of stations with a positive catch are presented in Figure 3. Year, area and depth were retained in both the binomial and lognormal submodels. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 3 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 11,864.9 and 892.8, respectively. There was an increase in the AIC between the initial binomial submodel and the final submodel (11,861.6 to 11,864.9). However, due to the insignificance of hook type and time of day, the factors were excluded from the final submodel. In the lognormal submodel, the AIC increased between the second and third submodels; however since hook type was insignificant, it was excluded from the final submodel. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 4-6, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 4 and Figure 7. The dip in abundance index in 2008 coincides with lack of station coverage in the central Gulf (Appendix Figure 1) and therefore might not be representative of a dip in the population, where the highest catches of smoothhound occur (Figure 1).

Literature Cited

Campbell, M., A. Pollack, T. Henwood, J. Provaznik and M. Cook. 2012. Summary report of the red snapper (*Lutjanus campechanus*) catch during the 2011 congressional supplemental sampling program (CSSP). SEDAR31-DW17.

Henwood, T., W. Ingram and M. Grace (2005). Shark/snapper/grouper longline surveys. SEDAR7-DW8.

Ingram, W., T. Henwood, M. Grace, L. Jones, W. Driggers, and K. Mitchell. 2005. Catch rates, distribution and size composition of large coastal sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic Ocean. LCS05/06-DW-27

Lo, N.C.H., 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 Science* 49:2515-2526.

Nichols, S. 2007. Indexes of abundance for small coastal sharks from the SEAMAP trawl surveys. SEDAR13-DW-31.

Ortiz, M. 2006. Standardized catch rates for gag grouper (*Mycteroperca microlepis*) from the marine recreational fisheries statistical survey (MRFSS). SEDAR10-DW-09.

Table 1. Summary of the total number of stations sampled per year by coverage area (top) and number of stations used in the analysis (bottom).

		Gulf of Mexico				
Year	Atlantic	East	Central	West	Subtotal	*Total*
1995	43	34	27	13	74	*117*
1996	30	37	25	17	79	*109*
1997	64	61	32	71	164	*228*
1998						
1999		57	104		161	*161*
2000	104	63	51	23	137	*241*
2001		130	64	83	277	*277*
2002	177	43	71	98	212	*389*
2003		163	54	63	280	*280*
2004	40	136	60	53	249	*289*
2005	27	80	15		95	*122*
2006	58	62	37	50	149	*207*
2007		71	38	47	156	*156*
2008	37	75	7	26	108	*145*
2009	32	91	43	51	185	*217*
2010	26	87	31	32	150	*176*
2011	50	178	54	65	297	*347*
2012	41	74	35	33	142	183
Total	*729*	*1442*	*748*	*725*	*2915*	*3644*

		Gulf of Mexico				
Year	Atlantic	East	Central	West	Subtotal	*Total*
1995						
1996						
1997						
1998						
1999						
2000		63	51	23	137	137
2001		130	64	83	277	277
2002		43	71	98	212	212
2003		163	54	63	280	280
2004		136	60	36	232	232
2005						
2006		62	37	50	149	149
2007		71	38	47	156	156
2008		75	7	26	108	108
2009		91	43	51	185	185
2010		87	31	32	150	150
2011		178	54	65	297	297
2012		74	35	33	142	142
Total		*1173*	*545*	*607*	*2325*	*2325*

Table 2. Summary of the smoothhound length data collected from the Atlantic Ocean (top) and Gulf of Mexico (bottom) from NMFS Bottom Longline surveys conducted between 1995 and 2012.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
1995	43	0					
1996	30	0					
1997	64	0					
1998							
1999							
2000	58	0					
2001							
2002	177	2	2	656	745	701	63
2003							
2004	40	0					
2005	27	0					
2006	58	1	1	540	540	540	
2007							
2008	37	0					
2009	32	0					
2010	26	0					
2011	50	0					
2012	41	0					

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
12	683	3	3	647

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
1995	74	8	8	830	1110	1009	82
1996	79	3	3	480	920	674	225
1997	164	0					
1998							
1999	161	0					
2000	137	57	55	586	1255	960	186
2001	277	83	82	505	1205	948	176
2002	212	113	111	648	1210	938	134
2003	280	100	99	578	1690	889	177
2004	249	85	81	525	1160	886	149
2005	95	11	1	847	847	847	
2006	149	93	91	509	1160	924	170
2007	156	64	60	605	1190	888	150
2008	108	12	12	842	1140	959	83
2009	185	139	136	615	1210	950	141
2010	150	86	86	590	1150	919	145
2011	297	222	212	450	1170	921	134
2012	142	109	104	500	1153	947	130

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
18	2915	1185	1151	925

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for smoothhound index of relative abundance from 2000 to 2012.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 11861.6)*						*Lognormal Submodel Type 3 Tests (AIC 893.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	11	808	27.00	2.43	0.0046	0.0055	11	335	2.22	0.0132
Area	2	2073	92.29	46.14	<.0001	<.0001	2	335	11.15	<.0001
Depth	1	2141	137.43	137.43	<.0001	<.0001	1	335	15.90	<.0001
Hook Type	1	145	0.82	0.82	0.3661	0.3676	1	335	2.16	0.1426
Time of Day	1	2151	0.88	0.88	0.3471	0.3472	1	335	0.17	0.6794
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 11863.7)*						*Lognormal Submodel Type 3 Tests (AIC 890.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	11	809	28.60	2.58	0.0026	0.0032	11	336	2.35	0.0085
Area	2	2072	92.24	46.12	<.0001	<.0001	2	336	11.17	<.0001
Depth	1	2140	136.84	136.84	<.0001	<.0001	1	336	16.34	<.0001
Hook Type				Dropped			1	336	2.28	0.1316
Time of Day	1	2151	0.87	0.87	0.3513	0.3514		Dropped		
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 11864.9)*						*Lognormal Submodel Type 3 Tests (AIC 892.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	11	810	28.73	2.59	0.0025	0.0031	11	337	2.16	0.0164
Area	2	2066	92.51	46.26	<.0001	<.0001	2	337	10.94	<.0001
Depth	1	2141	136.71	136.71	<.0001	<.0001	1	337	16.67	<.0001
Hook Type				Dropped				Dropped		
Time of Day				Dropped				Dropped		

Table 4. Indices of smoothhound abundance developed using the delta-lognormal model for 2000-2012. 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.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2000	0.10219	137	0.42513	0.99776	0.35868	0.49757	2.00074
2001	0.09747	277	0.25131	0.58980	0.23829	0.36862	0.94371
2002	0.18396	212	0.39857	0.93541	0.19600	0.63440	1.37925
2003	0.12143	280	0.34470	0.80900	0.22384	0.51987	1.25892
2004	0.12500	232	0.31980	0.75055	0.24821	0.46026	1.22394
2005							
2006	0.20805	149	0.51170	1.20092	0.19804	0.81125	1.77777
2007	0.18590	156	0.37294	0.87528	0.22110	0.56544	1.35489
2008	0.09259	108	0.13215	0.31015	0.37098	0.15124	0.63602
2009	0.20541	185	0.66155	1.55263	0.21503	1.01484	2.37538
2010	0.20667	150	0.57672	1.35353	0.22918	0.86089	2.12808
2011	0.15825	297	0.51040	1.19787	0.21817	0.77822	1.84381
2012	0.16197	142	0.60807	1.42710	0.28264	0.81971	2.48455

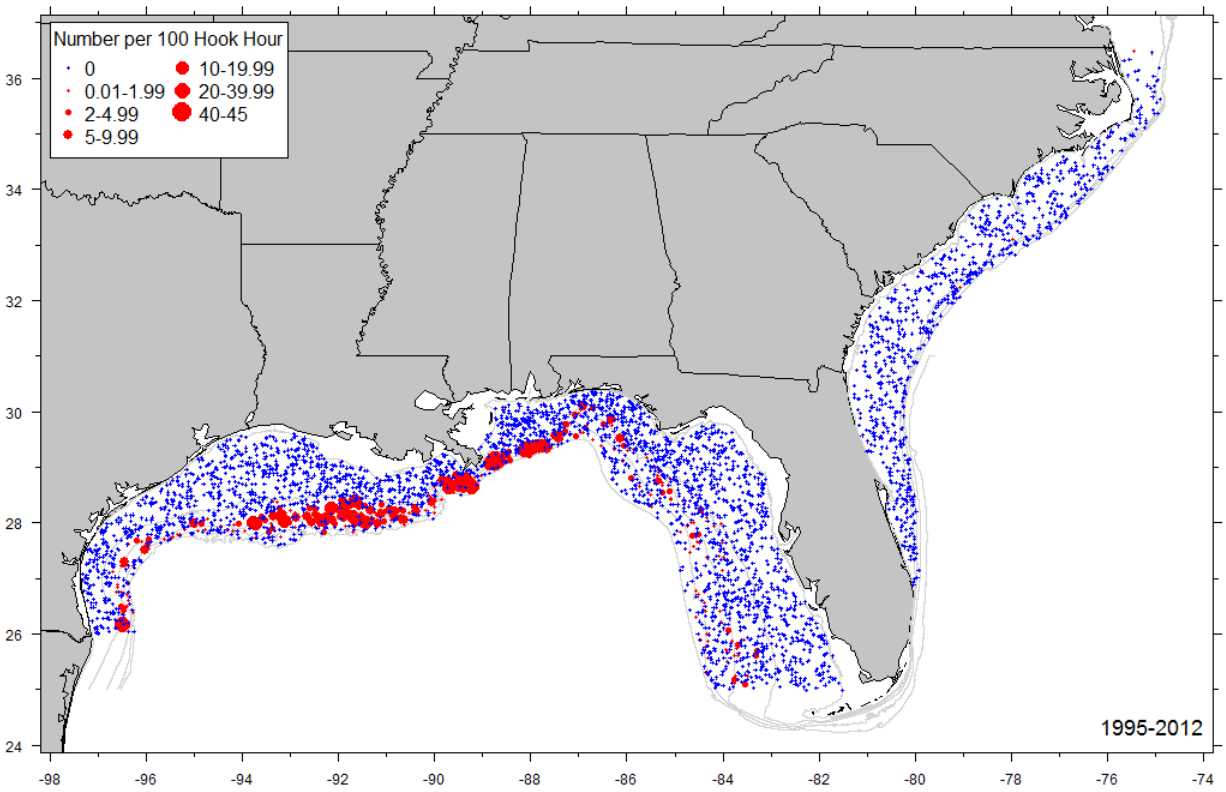


Figure 1. Stations sampled from 1995 to 2012 during the NMFS Bottom Longline Survey with the CPUE for smoothhound.

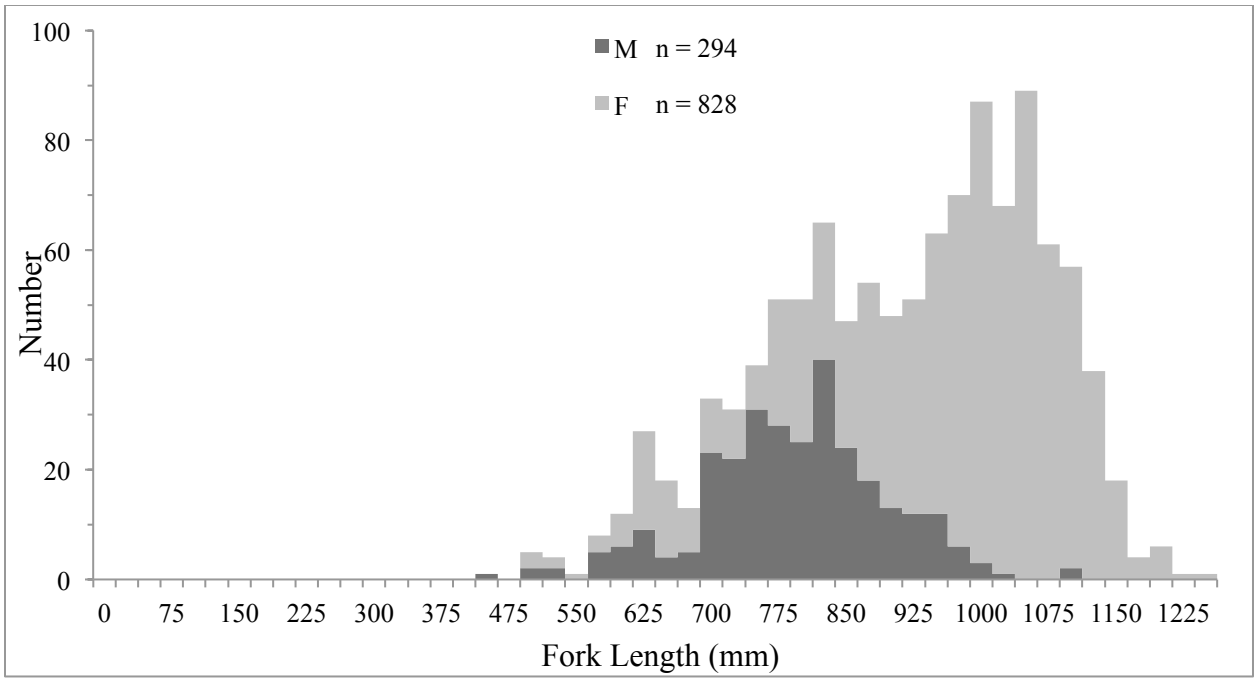


Figure 2. Length frequency histogram for smoothhound captured in the Gulf of Mexico during the NMFS Bottom Longline Survey from 2000-2012.

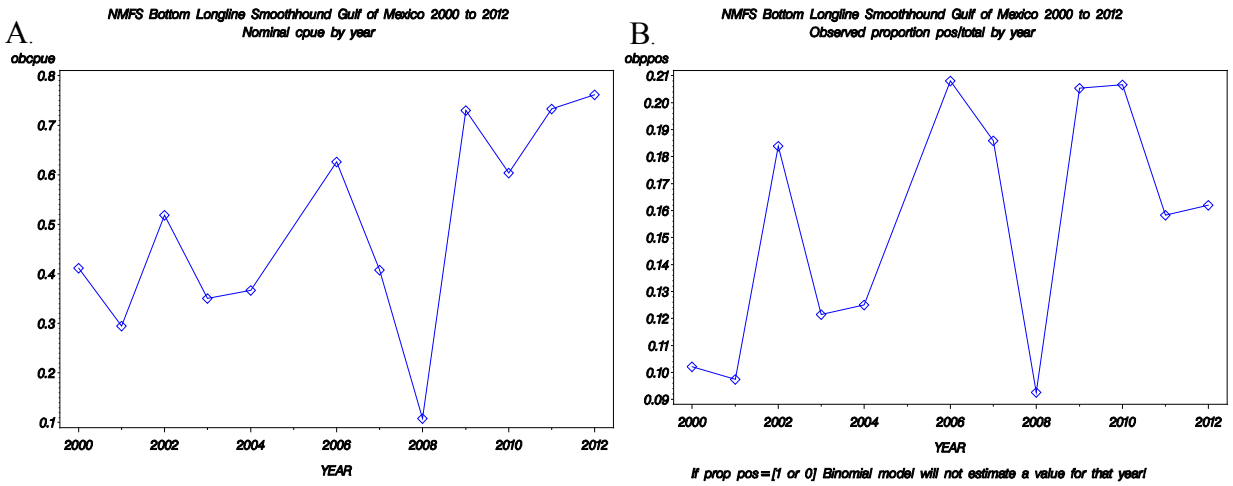


Figure 3. Annual trends for smoothhound captured during NMFS Bottom Longline Surveys from 2000 to 2012 in **A.** nominal CPUE and **B.** proportion of positive stations.

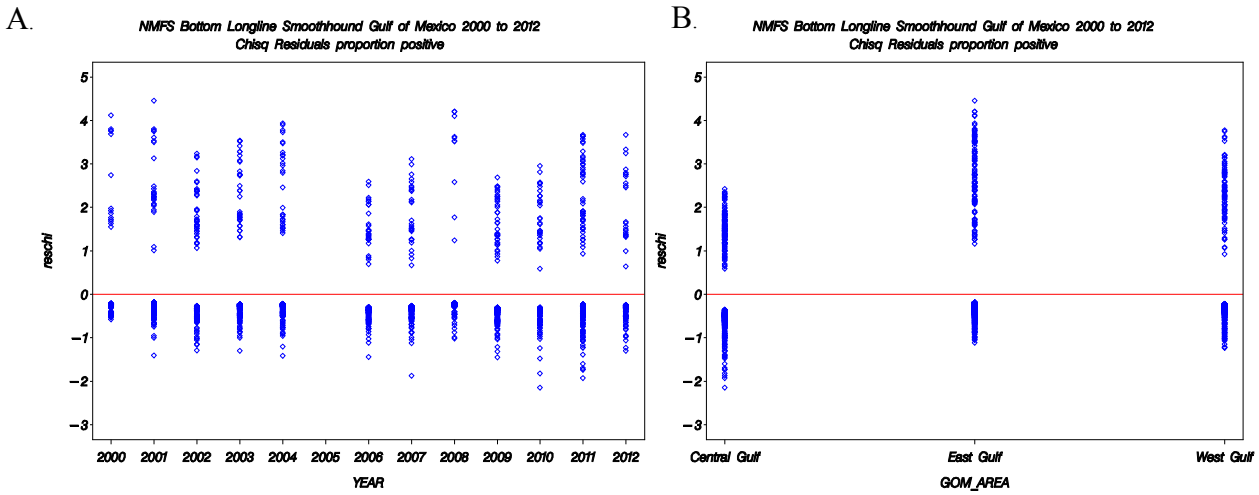


Figure 4. Diagnostic plot for binomial component of the smoothhound NMFS Bottom Longline Surveys model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

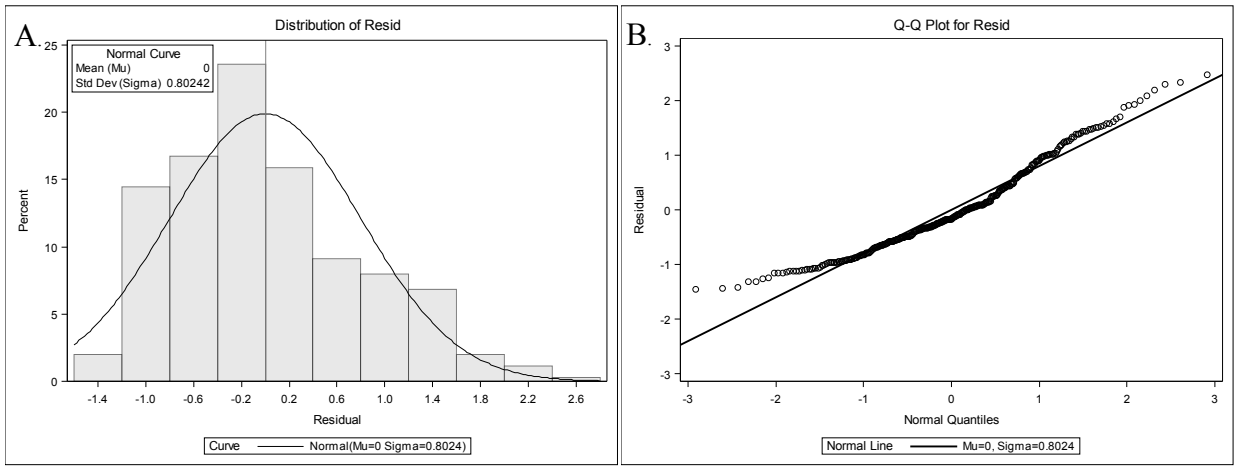


Figure 5. Diagnostic plots for lognormal component of the smoothhound NMFS Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

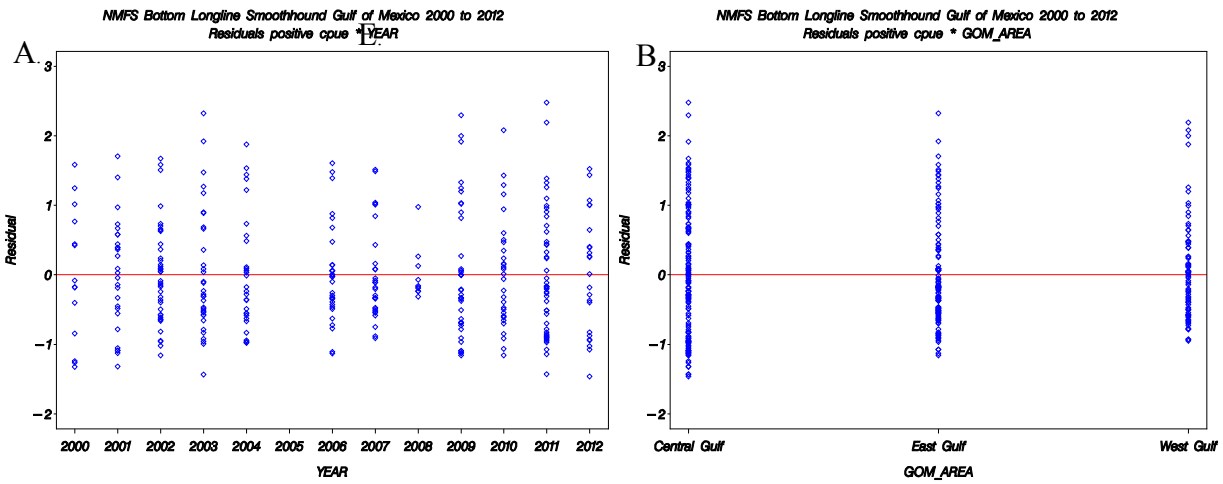


Figure 6. Diagnostic plots for lognormal component of the smoothhound NMFS Bottom Longline Surveys model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

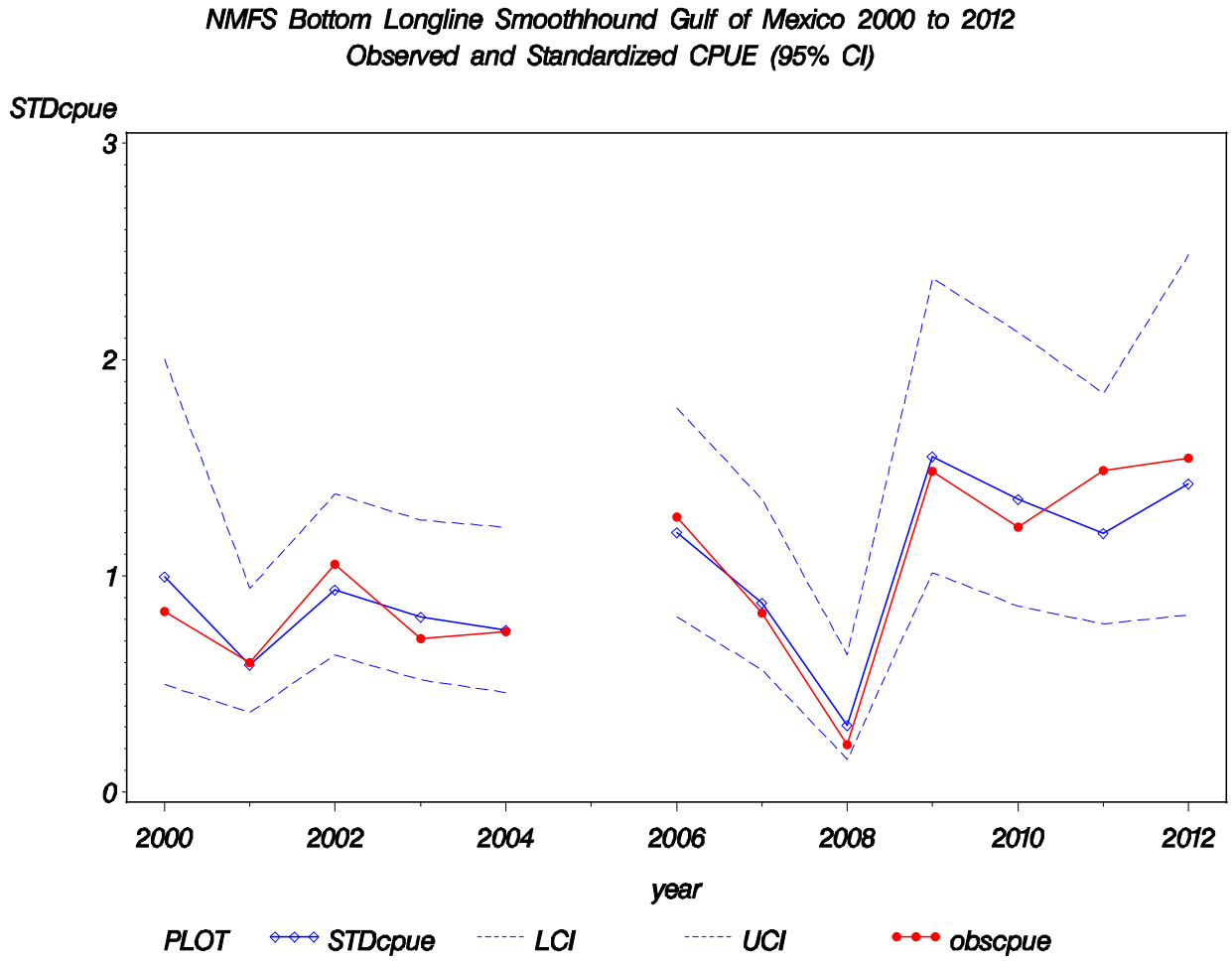


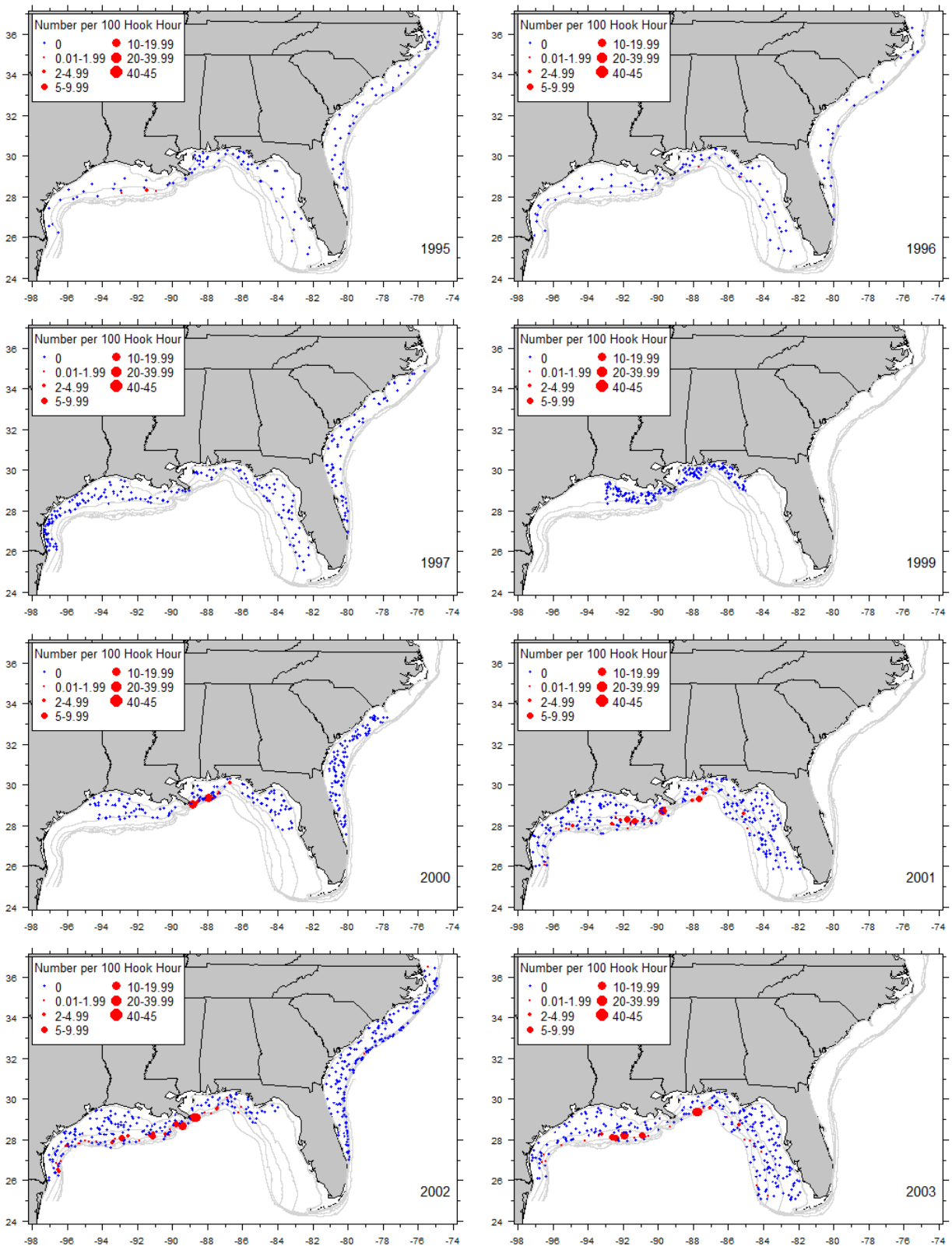
Figure 7. Annual index of abundance for smoothhound from the NMFS Bottom Longline Surveys from 2000 – 2012.

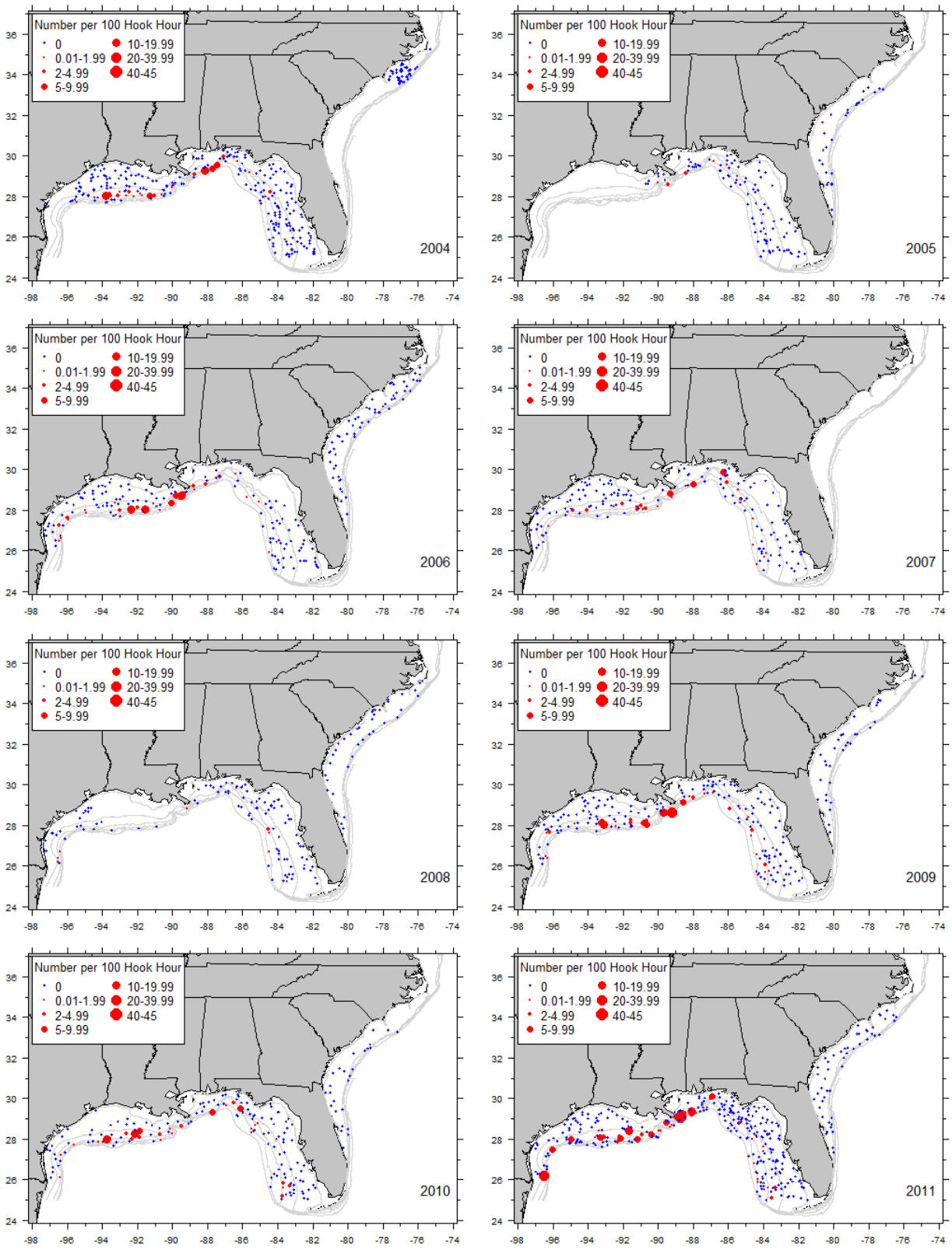
Appendix

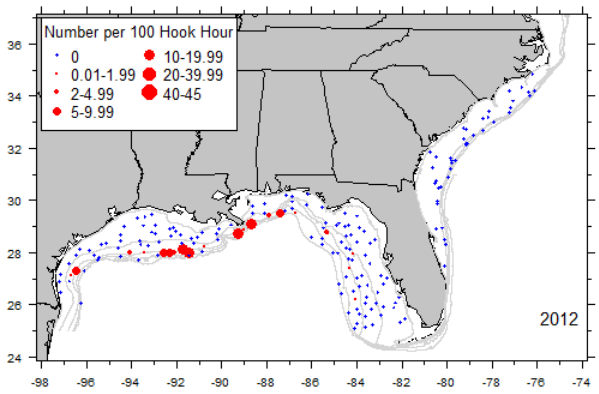
Appendix Table 1. Summary of the factors used in constructing the smoothhound abundance index from the NMFS bottom longline survey data.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2000	137	14	0.10219	0.41175
Year	2001	277	27	0.09747	0.29474
Year	2002	212	39	0.18396	0.51859
Year	2003	280	34	0.12143	0.35018
Year	2004	232	29	0.12500	0.36644
Year	2006	149	31	0.20805	0.62575
Year	2007	156	29	0.18590	0.40794
Year	2008	108	10	0.09259	0.10789
Year	2009	185	38	0.20541	0.73020
Year	2010	150	31	0.20667	0.60365
Year	2011	297	47	0.15825	0.73284
Year	2012	142	23	0.16197	0.76124
Area	Central Gulf	545	149	0.27339	1.19886
Area	East Gulf	1173	123	0.10486	0.23911
Area	West Gulf	607	80	0.13180	0.35769
Hook type	C	2226	343	0.15409	0.50559
Hook type	J	99	9	0.09091	0.25795
Time of day	D	1133	162	0.14298	0.42521
Time of day	N	1192	190	0.15940	0.56141

Appendix Figure 1. Annual survey effort and catch of smoothhound from the NMFS bottom longline survey (1995-2012).




Number per 100 Hook Hour
0
0.01-1.99
2-4.99
5-9.99
10-19.99
20-39.99
40-45
2004
2005
2006
2007
2008
2009
2010
2011


Number per 100 Hook Hour
0
0.01-1.99
2-4.99
5-9.99
10-19.99
20-39.99
40-45
2012
36
34
32
30
28
26
24
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80
-78
-76
-74