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

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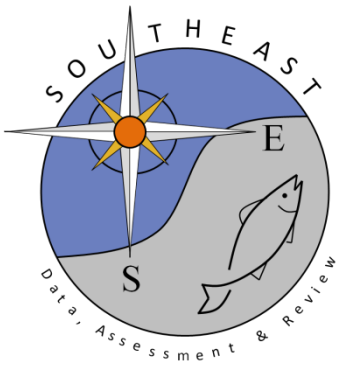

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Atlantic Sharpnose and Bonnethead Abundance Indices from NMFS Bottom Longline Surveys in the Western North Atlantic and Northern Gulf of Mexico

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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 Atlantic sharpnose. Abundance indices were produced for the Atlantic, GOM and Atlantic and GOM combined. All age 0 sharks were removed from the data at the request of the assessment scientists.*

Introduction

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. 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 Atlantic sharpnose (*Rhizoprionodon terraenovae*) from the Atlantic and GOM.

Methodology

Survey Design

Details concerning methodologies and evolution of this survey 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

For the SEDAR 31, we used the time series of data between 1995 and 2011 to develop abundance indices for sharpnose for the Atlantic and GOM. The total number of stations sampled in the Atlantic and GOM were 642 and 2890, respectively (Figure 1). Data was limited temporally to the summer months (June – September), with few stations (approximately 106) sampled outside this time frame. At the request of the assessment scientists, age 0 sharks were removed from the data and were not used to calculate catch rates. In addition, from the CSSP, only data collected during the same time period (August and September) as the annual survey were used to increase sample size and fill gaps in the annual survey in 2011.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for Bonnethead (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) $$p = \frac{e^{\mathbf{X\beta}+\varepsilon}}{1+e^{\mathbf{X\beta}+\varepsilon}},$$

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:

(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 (Atlantic)

Year: 1995 – 2011
Hook Type: J-hook, Circle hook
Depth: 9 – 366 meters (continuous)

Submodel Variables (GOM)

Year: 1995 – 2011
Hook Type: J-hook, Circle hook
Depth: 9 – 366 meters (continuous)
Region: East Gulf (east of 88° west), Central Gulf (between 88° and 93° west), West Gulf (west of 93° west)

Submodel Variables (Atlantic and GOM Combined)

Year: 1995 – 2011
Hook Type: J-hook, Circle hook
Depth: 9 – 366 meters (continuous)
Area: Atlantic, East Gulf, Central Gulf, West Gulf

Due to the extremely low catches of bonnetheads (approximately 76 individuals), no abundance indices were developed for this species.

Results and Discussion

The distribution of Atlantic sharpnose is presented in Figure 1, with seasonal/annual abundance and distribution presented in Appendix Figure 1. The total number of Atlantic sharpnose captured ranged from 32 to 2384 in the Atlantic and 80 to 1524 in the GOM (Table 2). Of the 7258 Atlantic sharpnose captured during the summer survey, a total of 7125 were measured from

1995 – 2011 with an average total length of 696 mm. While during the GOM survey 12,332 Atlantic sharpnose were captured, with 11,671 measured, with an average total length of 750 mm. Figures 2 and 3 show the length frequency distribution of Atlantic sharpnose captured in the Atlantic and GOM, respectively.

For the Atlantic NMFS Bottom Longline abundance index of Atlantic sharpnose, the nominal CPUE and number of stations with a positive catch are presented in Figure 4. Year and depth were retained in the binomial submodel while year, hook type and depth were retained in the lognormal submodel. 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 3970.6 and 1350.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 5-7, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 4 and Figure 8.

For the GOM NMFS Bottom Longline abundance index of Atlantic sharpnose, the nominal CPUE and number of stations with a positive catch are presented in Figure 9. Year, region and depth were retained in the binomial submodel while year, hook type, region and depth were retained in the lognormal submodel. Table 5 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 14,062.8 and 3580.8, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 10-12, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 6 and Figure 13.

For the Atlantic and GOM combined NMFS Bottom Longline abundance index of Atlantic sharpnose, the nominal CPUE and number of stations with a positive catch are presented in Figure 14. Year, area and depth were retained in the binomial submodel while year, hook type, area and depth were retained in the lognormal submodel. Table 7 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 17,462.1 and 4939.7, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 15-17, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 8 and Figure 18. The annual combined abundance indices mirror the GOM indices, most likely with the GOM stations and trends overshadowing the Atlantic stations and trends.

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Table 1. Number of stations sampled per year by coverage area.

		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	58	63	51	23	137	*195*
2001		130	64	83	277	*277*
2002	177	43	71	98	212	*389*
2003		163	54	63	280	*280*
2004	40	136	60	36	232	*272*
2005	27	52			52	*79*
2006	58	63	37	50	150	*208*
2007		71	38	47	156	*156*
2008	37	75	7	26	108	*145*
2009	32	91	43	51	185	*217*
2010	26	88	31	32	151	*177*
2011	50	264	94	114	472	*522*
Total	*642*	*1428*	*738*	*724*	*2890*	*3532*

Table 2. Summary of the Atlantic Sharpnose length data collected from the Atlantic Ocean (top) and Gulf of Mexico (bottom) from NMFS Bottom Longline surveys conducted between 1995 and 2011.

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	106	100	365	855	742	124
1996	30	32	32	387	830	689	120
1997	64	289	284	385	985	732	122
1998							
1999							
2000	58	325	318	396	860	672	111
2001							
2002	177	2384	2326	275	955	701	93
2003							
2004	40	720	708	325	883	680	86
2005	27	486	478	464	891	696	79
2006	58	1055	1041	339	893	679	85
2007							
2008	37	495	491	285	850	698	90
2009	32	421	415	489	840	706	63
2010	26	301	298	475	857	686	68
2011	50	644	634	379	875	707	72

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
11	642	7258	7125	696

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	141	130	540	910	766	83
1996	79	251	245	510	955	792	83
1997	164	304	285	432	945	778	93
1998							
1999	161	471	460	370	900	750	108
2000	137	543	498	298	985	779	102
2001	277	1273	1226	363	990	766	91
2002	212	1524	1475	287	943	771	93
2003	280	1423	1343	301	1083	743	99
2004	232	1300	1243	352	962	766	81
2005	52	80	79	412	885	699	95
2006	150	843	810	330	921	759	85
2007	156	451	419	333	933	730	120
2008	108	202	197	365	899	728	110
2009	185	1427	1350	353	930	731	97
2010	151	732	672	315	970	744	92
2011	472	1367	1239	334	935	713	94

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
17	2890	12,332	11,671	750

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for Atlantic Sharpnose (Atlantic) index of relative abundance from 1995 to 2011.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 3984.1)*						*Lognormal Submodel Type 3 Tests (AIC 1350.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	11	177	24.94	2.19	0.0093	0.0168	11	449	2.53	0.0042
Hook Type	1	55.9	0.85	0.85	0.3564	0.3604	1	449	4.77	0.0294
Depth	1	182	106.78	106.78	<.0001	<.0001	1	449	10.66	0.0012
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 3970.6)*						*Lognormal Submodel Type 3 Tests (AIC 1350.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	11	176	65.55	5.75	<.0001	<.0001	11	449	2.53	0.0042
Hook Type				Dropped			1	449	4.77	0.0294
Depth	1	184	107.31	107.31	<.0001	<.0001	1	449	10.66	0.0012

Table 4. Indices of Atlantic Sharpnose (Atlantic) abundance developed using the delta-lognormal model for 1995-2011. 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
1995	0.58140	43	1.6062	0.13742	0.51453	0.05213	0.36223
1996	0.40000	30	0.9435	0.08072	0.57514	0.02771	0.23513
1997	0.70313	64	2.4199	0.20703	0.50954	0.07920	0.54118
1998							
1999							
2000	0.81034	58	3.3288	0.28478	0.40739	0.13006	0.62355
2001							
2002	0.68362	177	11.3143	0.96796	0.19705	0.65513	1.43018
2003							
2004	0.95000	40	13.6883	1.17106	0.33617	0.60865	2.25315
2005	0.85185	27	24.8300	2.12425	0.29652	1.18866	3.79625
2006	0.75862	58	21.1678	1.81094	0.20416	1.20888	2.71287
2007							
2008	0.86486	37	12.4908	1.06861	0.19126	0.73145	1.56119
2009	0.65625	32	19.4066	1.66027	0.28226	0.95432	2.88843
2010	0.57692	26	13.5984	1.16337	0.34822	0.59139	2.28858
2011	0.80000	50	15.4710	1.32357	0.18944	0.90918	1.92685

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for Atlantic Sharpnose (GOM) index of relative abundance from 1995 to 2011.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 14066.1)*						*Lognormal Submodel Type 3 Tests (AIC 3580.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	840	124.35	8.20	<.0001	<.0001	15	1157	2.43	0.0017
Hook Type	1	297	1.84	1.84	0.1750	0.1760	1	1157	4.65	0.0313
Region	2	2552	377.88	188.93	<.0001	<.0001	2	1157	74.32	<.0001
Depth	1	2277	281.88	281.88	<.0001	<.0001	1	1157	4.74	0.0296
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 14062.8)*						*Lognormal Submodel Type 3 Tests (AIC 3580.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	803	207.13	13.65	<.0001	<.0001	15	1157	2.43	0.0017
Hook Type				Dropped			1	1157	4.65	0.0313
Region	2	2553	377.70	188.84	<.0001	<.0001	2	1157	74.32	<.0001
Depth	1	2277	281.99	281.99	<.0001	<.0001	1	1157	4.74	0.0296

Table 6. Indices of Atlantic Sharpnose (GOM) abundance developed using the delta-lognormal model for 1995-2011. 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
1995	0.39189	74	1.11548	0.30931	0.36995	0.15111	0.63311
1996	0.34177	79	1.86896	0.51824	0.37549	0.25065	1.07149
1997	0.37805	164	0.96793	0.26839	0.30091	0.14895	0.48361
1998							
1999	0.41615	161	0.93932	0.26046	0.26368	0.15508	0.43746
2000	0.44526	137	2.46902	0.68463	0.26312	0.40806	1.14863
2001	0.35379	277	2.83078	0.78494	0.19380	0.53463	1.15244
2002	0.52830	212	3.67705	1.01960	0.17680	0.71787	1.44814
2003	0.46429	280	4.13000	1.14520	0.14907	0.85136	1.54045
2004	0.40948	232	6.03761	1.67415	0.16489	1.20651	2.32305
2005	0.32692	52	4.71708	1.30799	0.30508	0.72025	2.37532
2006	0.46000	150	6.22507	1.72613	0.19081	1.18255	2.51957
2007	0.30769	156	2.36036	0.65450	0.24794	0.40156	1.06676
2008	0.34259	108	2.58749	0.71748	0.24446	0.44315	1.16163
2009	0.56216	185	8.65612	2.40023	0.14321	1.80508	3.19161
2010	0.45695	151	5.91037	1.63887	0.17200	1.16475	2.30598
2011	0.32203	472	3.20927	0.88989	0.12998	0.68693	1.15282

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for Atlantic Sharpnose (Atlantic/GOM) index of relative abundance from 1995 to 2011.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 17468.3)*						*Lognormal Submodel Type 3 Tests (AIC 4950.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	1111	152.24	10.07	<.0001	<.0001	15	1619	2.52	0.0011
Hook Type	1	355	2.71	2.71	0.0995	0.1004	1	1619	7.44	0.0065
Area	3	2849	463.57	154.51	<.0001	<.0001	3	1619	71.97	<.0001
Depth	1	2810	365.24	365.24	<.0001	<.0001	1	1619	0.18	0.6675
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 17462.1)*						*Lognormal Submodel Type 3 Tests (AIC 4939.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	1075	265.95	17.58	<.0001	<.0001	15	1620	2.58	0.0008
Hook Type				Dropped			1	1620	7.45	0.0064
Area	3	2851	463.08	154.34	<.0001	<.0001	3	1620	74.14	<.0001
Depth	1	2810	365.53	365.53	<.0001	<.0001		Dropped		

Table 8. Indices of Atlantic Sharpnose (Atlantic/GOM) abundance developed using the delta-lognormal model for 1995-2011. 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
1995	0.46154	117	1.0792	0.21839	0.32856	0.11511	0.41431
1996	0.35780	109	1.4590	0.29523	0.37062	0.14406	0.60503
1997	0.46930	228	1.3166	0.26642	0.27421	0.15549	0.45649
1998							
1999	0.41615	161	1.0870	0.21997	0.29207	0.12412	0.38983
2000	0.55385	195	2.5553	0.51707	0.23007	0.32831	0.81436
2001	0.35379	277	3.6227	0.73308	0.22163	0.47309	1.13593
2002	0.59897	389	4.7976	0.97082	0.14724	0.72433	1.30120
2003	0.46429	280	5.1283	1.03774	0.16545	0.74704	1.44155
2004	0.48897	272	8.4004	1.69987	0.15812	1.24142	2.32763
2005	0.50633	79	9.0700	1.83537	0.25063	1.12031	3.00684
2006	0.54327	208	9.0281	1.82690	0.16403	1.31881	2.53073
2007	0.30769	156	3.3431	0.67650	0.28135	0.38952	1.17490
2008	0.47586	145	4.7859	0.96845	0.20250	0.64856	1.44610
2009	0.57604	217	11.0653	2.23912	0.14222	1.68719	2.97161
2010	0.47458	177	7.4832	1.51426	0.17671	1.06634	2.15034
2011	0.36782	522	4.8471	0.98083	0.12880	0.75890	1.26767

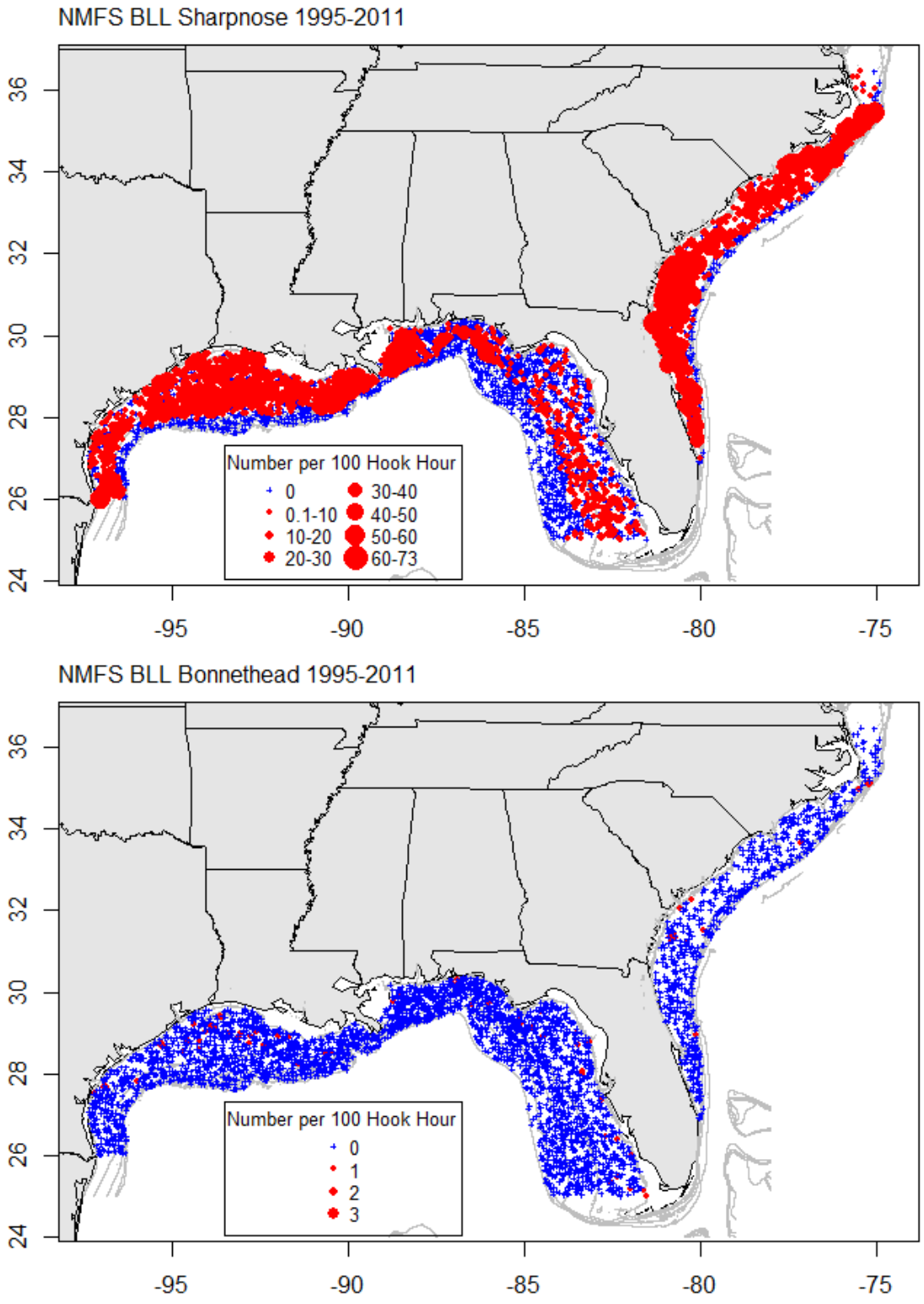


Figure 1. Stations sampled from 1995 to 2011 during the NMFS Bottom Longline Survey with the CPUE for Atlantic Sharpnose (top) and bonnethead (bottom).

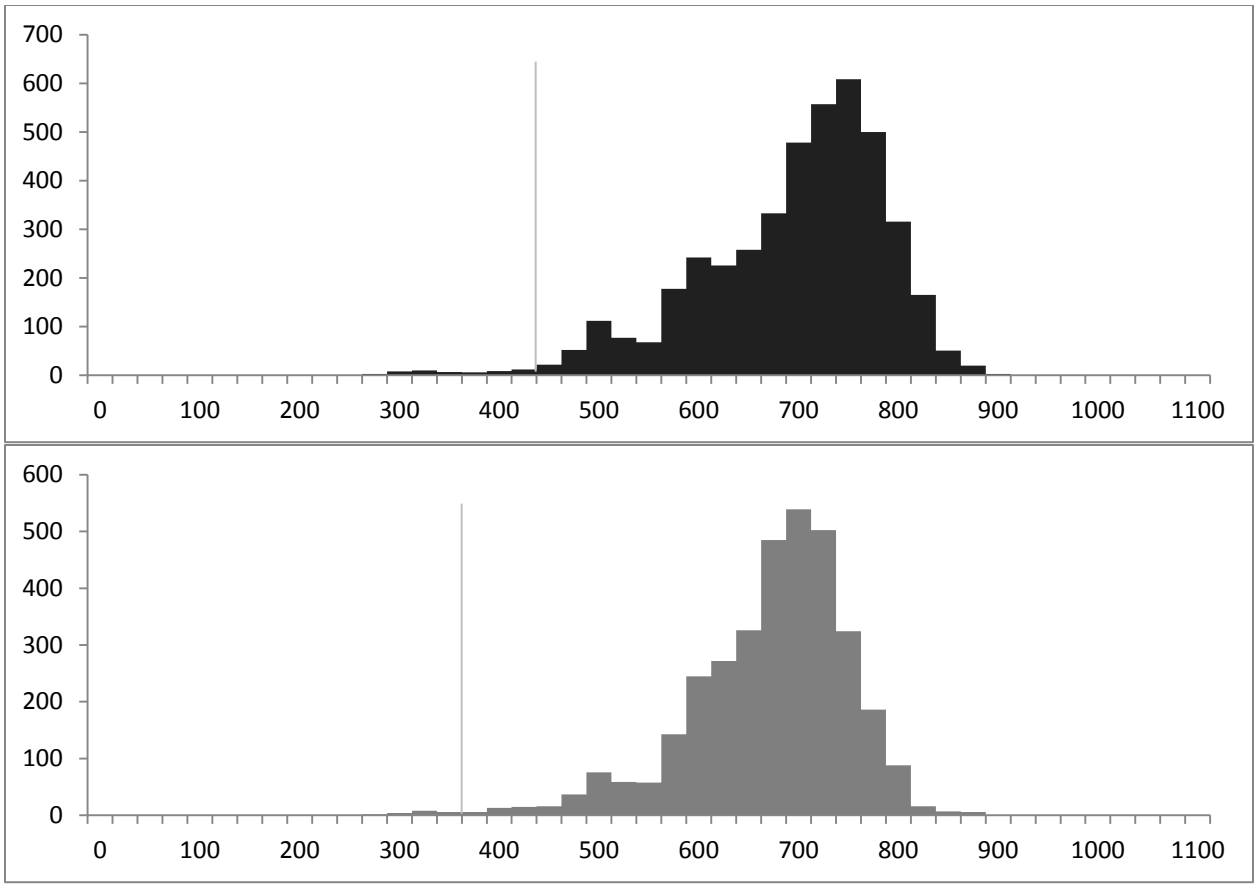


Figure 2. Length frequency histograms for female (top) and male (bottom) Atlantic sharpnose captured in the Atlantic Ocean during the NMFS Bottom Longline Survey from 1995-2011. All sharks to the right of the gray line were identified as age 0 and removed from the indices.

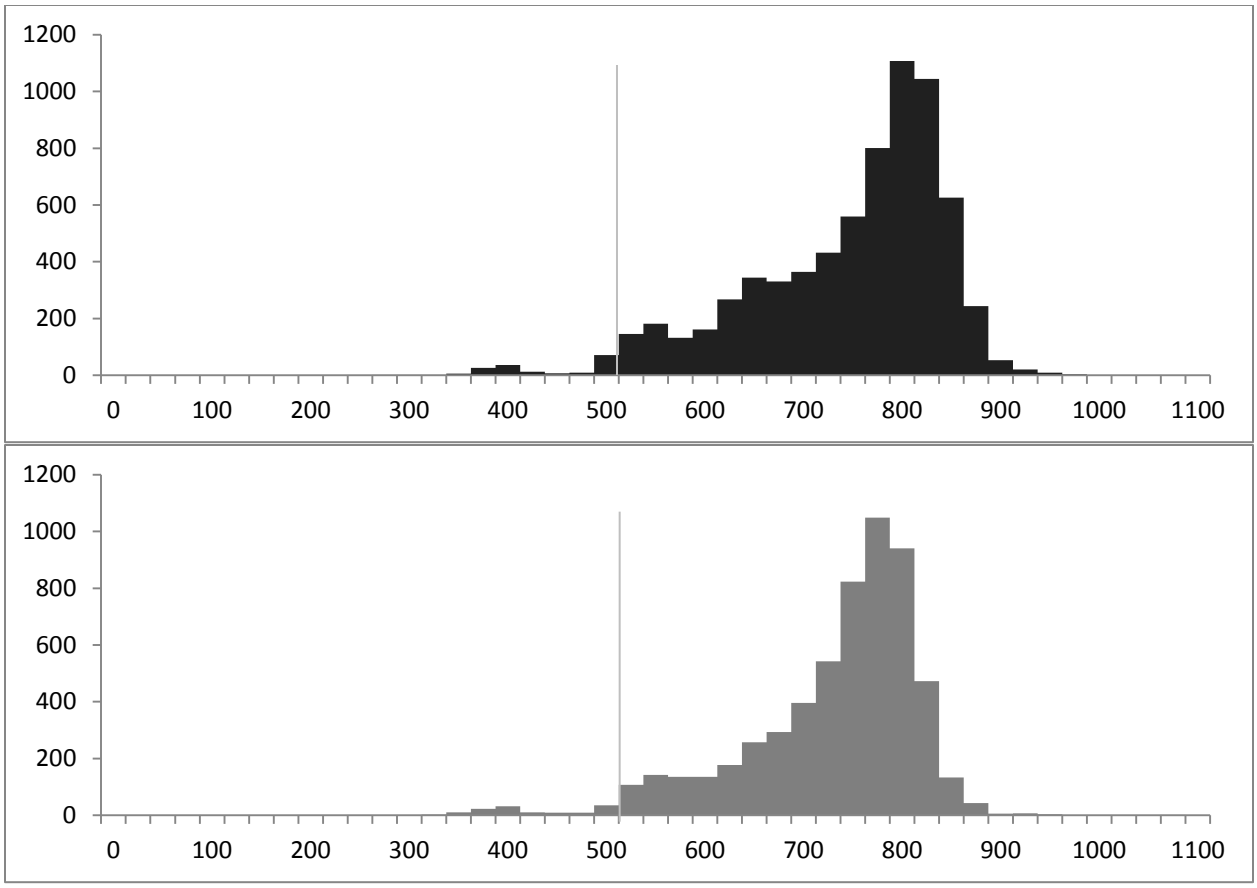


Figure 3. Length frequency histograms for female (top) and male (bottom) Atlantic sharpnose captured in the Gulf of Mexico during the NMFS Bottom Longline Survey from 1995-2011. All sharks to the right of the gray line were identified as age 0 and removed from the indices.

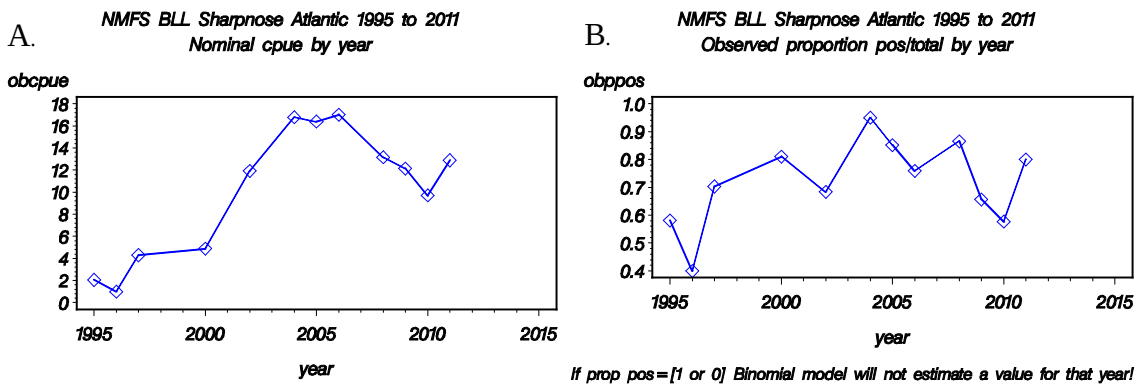


Figure 4. Annual trends for Atlantic Sharpnose (Atlantic) captured during NMFS Bottom Longline Surveys from 1995 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

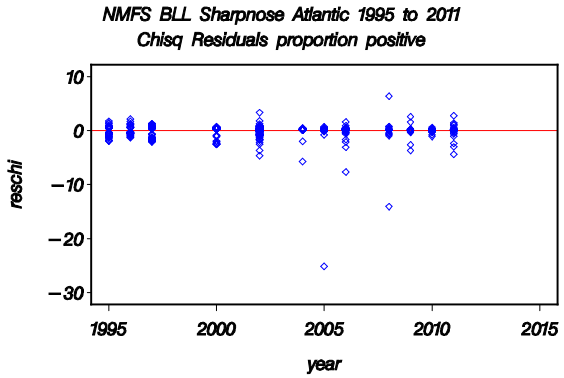


Figure 5. Diagnostic plot for binomial component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic) model: the Chi-Square residuals by year.

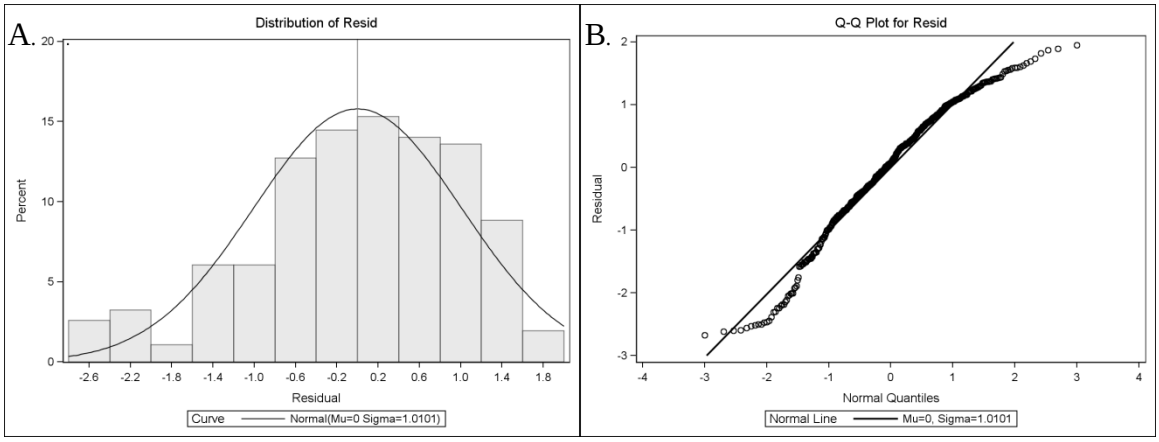


Figure 6. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

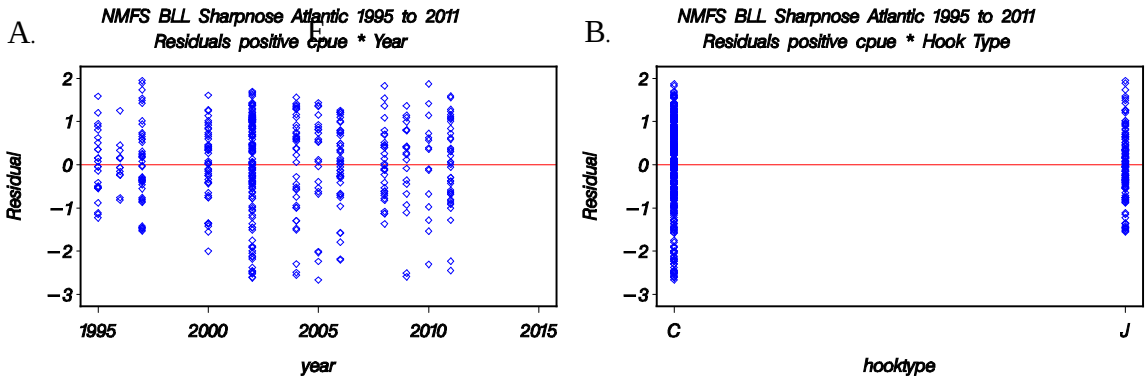


Figure 7. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic) model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by hook type.

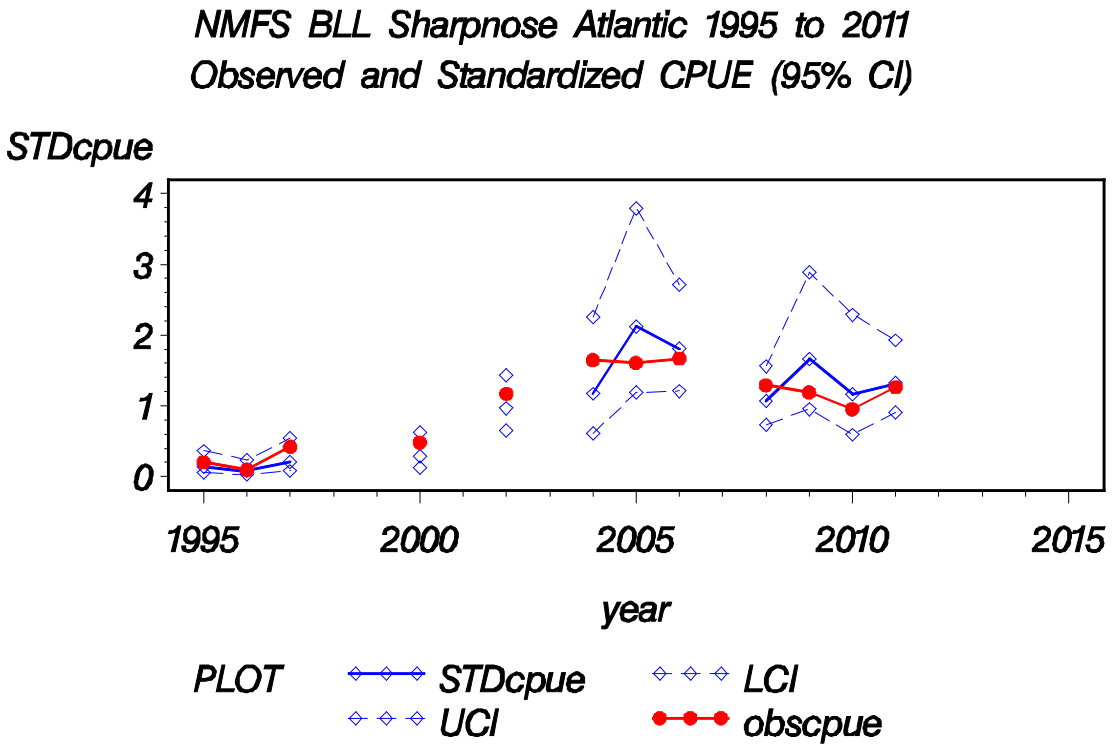


Figure 8. Annual index of abundance for Atlantic Sharpnose (Atlantic) from the NMFS Bottom Longline Surveys from 1995 – 2011.

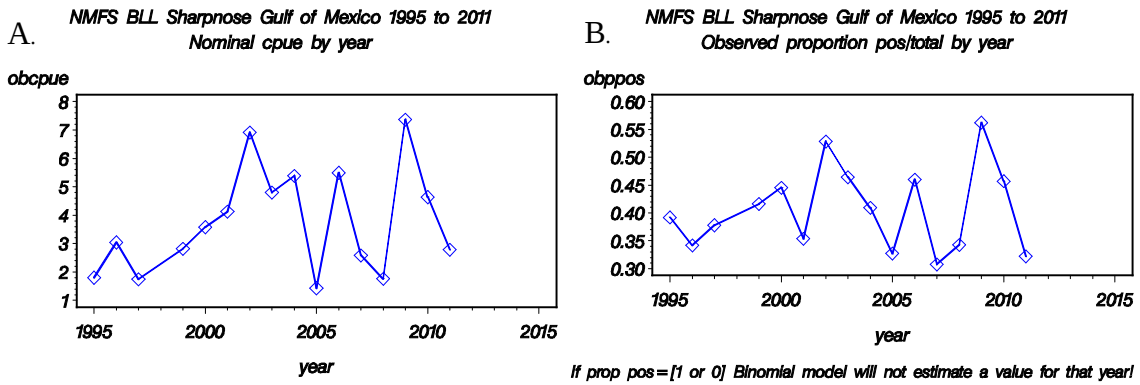


Figure 9. Annual trends for Atlantic Sharpnose (GOM) captured during NMFS Bottom Longline Surveys from 1995 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

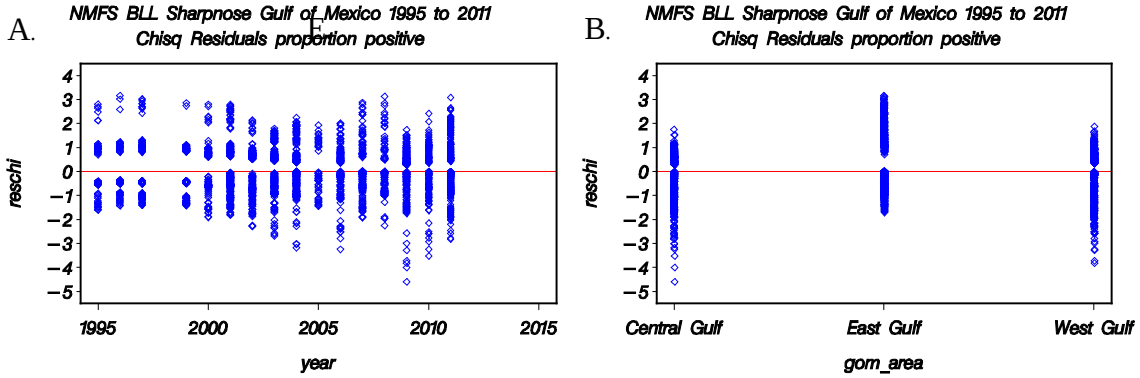


Figure 10. Diagnostic plots for binomial component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (GOM) model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

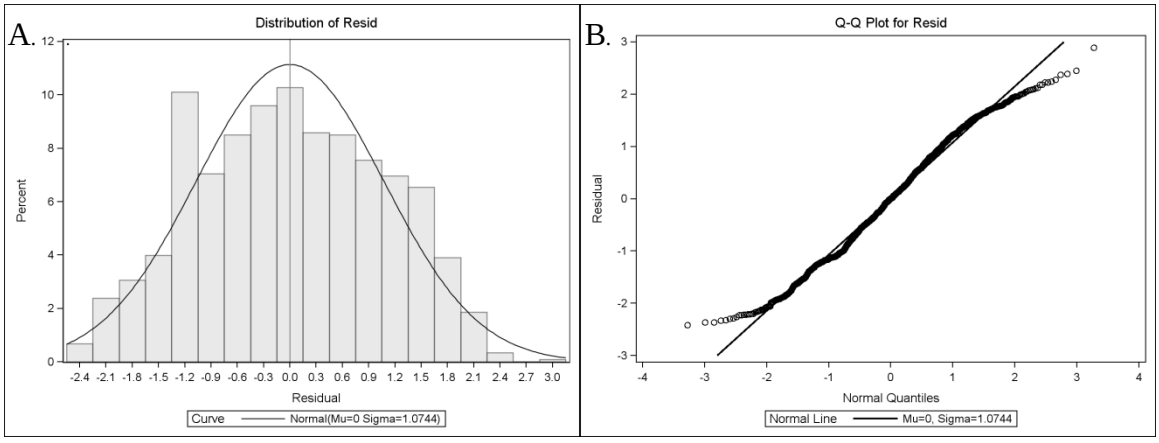


Figure 11. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (GOM) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

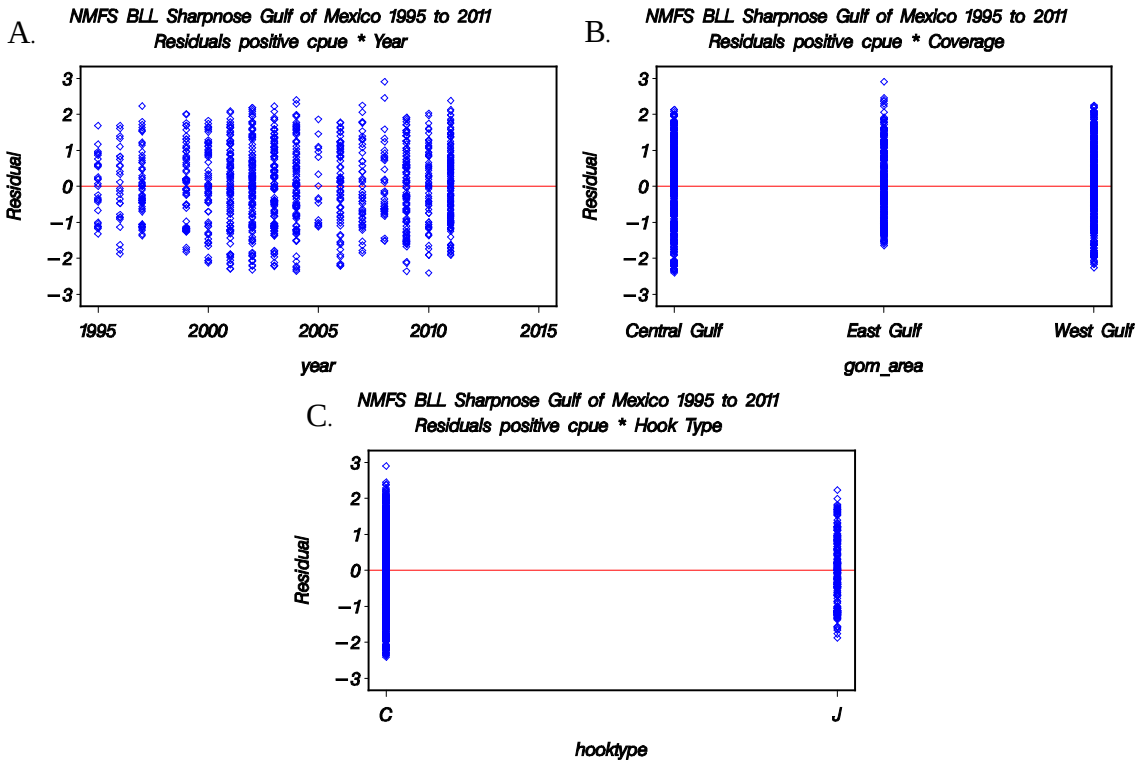


Figure 12. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (GOM) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, and **C.** the Chi-Square residuals by hook type.

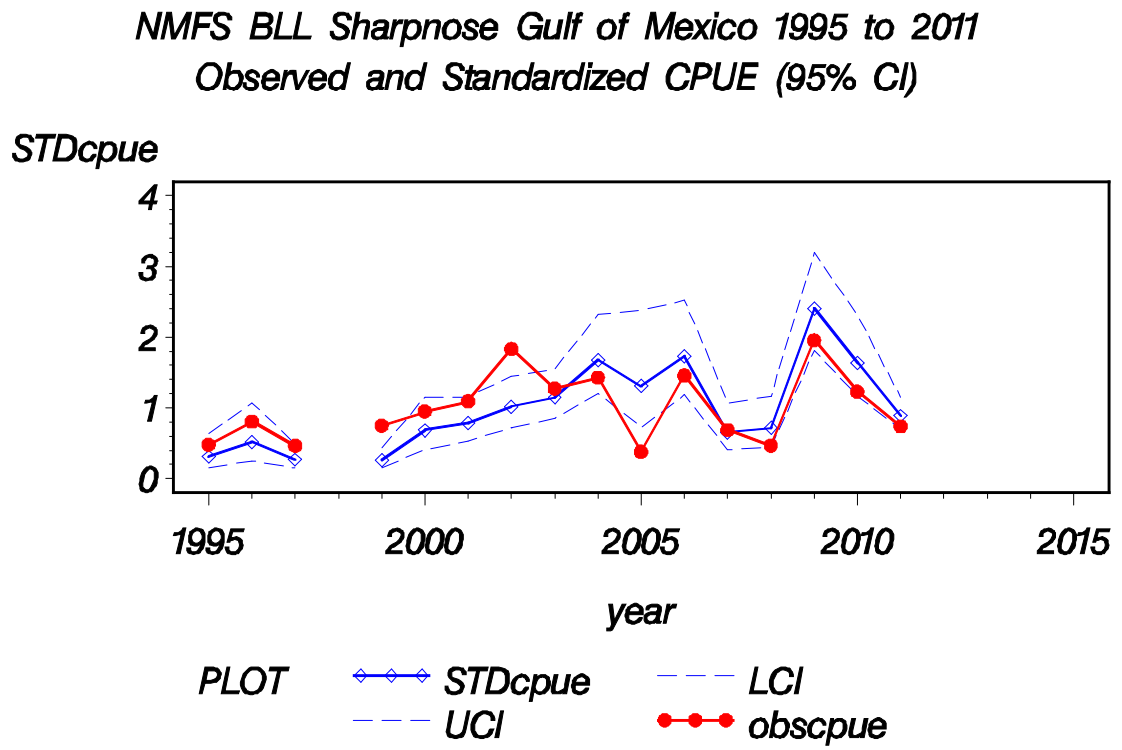


Figure 13. Annual index of abundance for Atlantic Sharpnose (GOM) from the NMFS Bottom Longline Surveys from 1995 – 2011.

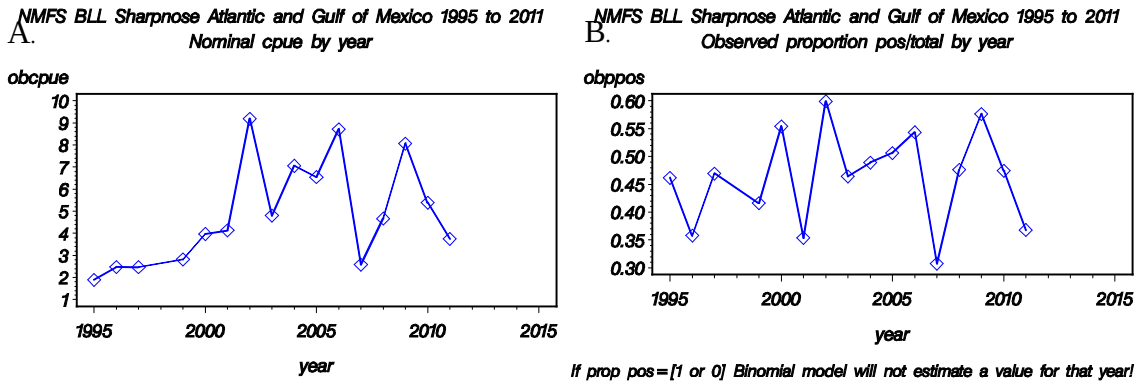


Figure 14. Annual trends for Atlantic Sharpnose (Atlantic / GOM) captured during NMFS Bottom Longline Surveys from 1995 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

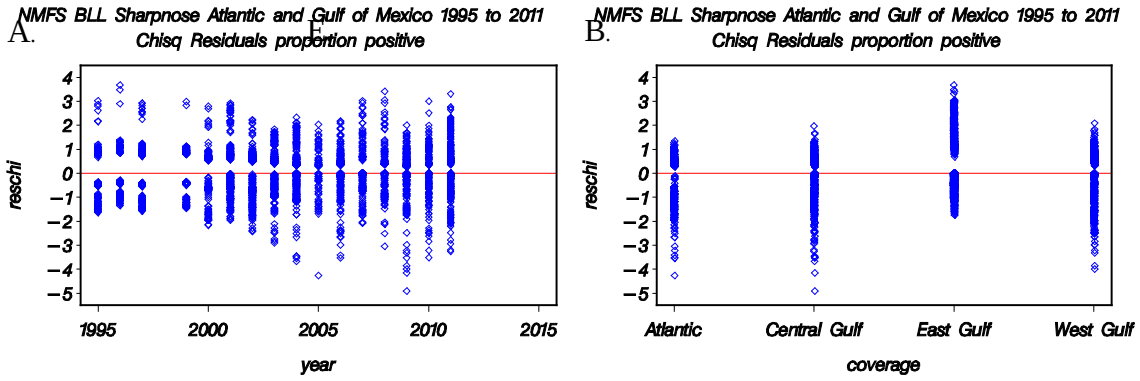


Figure 15. Diagnostic plots for binomial component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic / GOM) model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

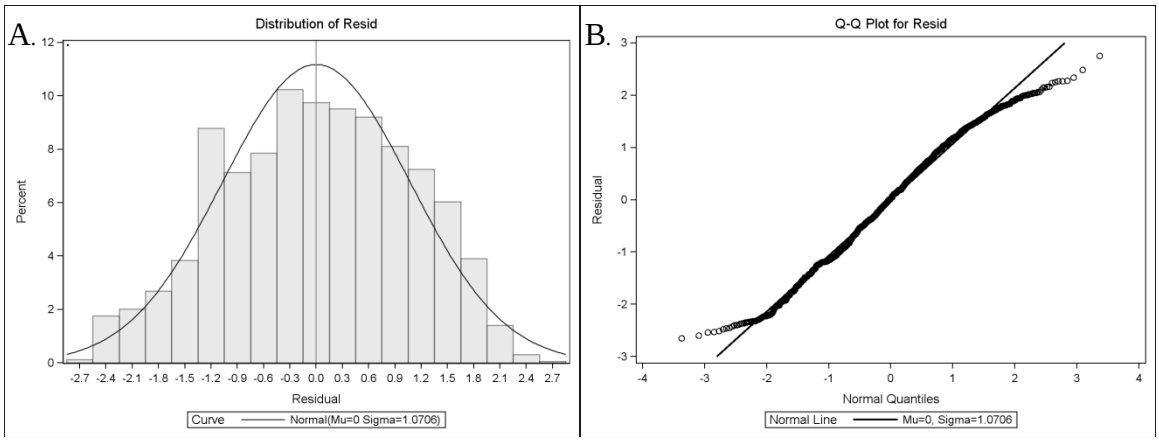


Figure 16. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic / GOM) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

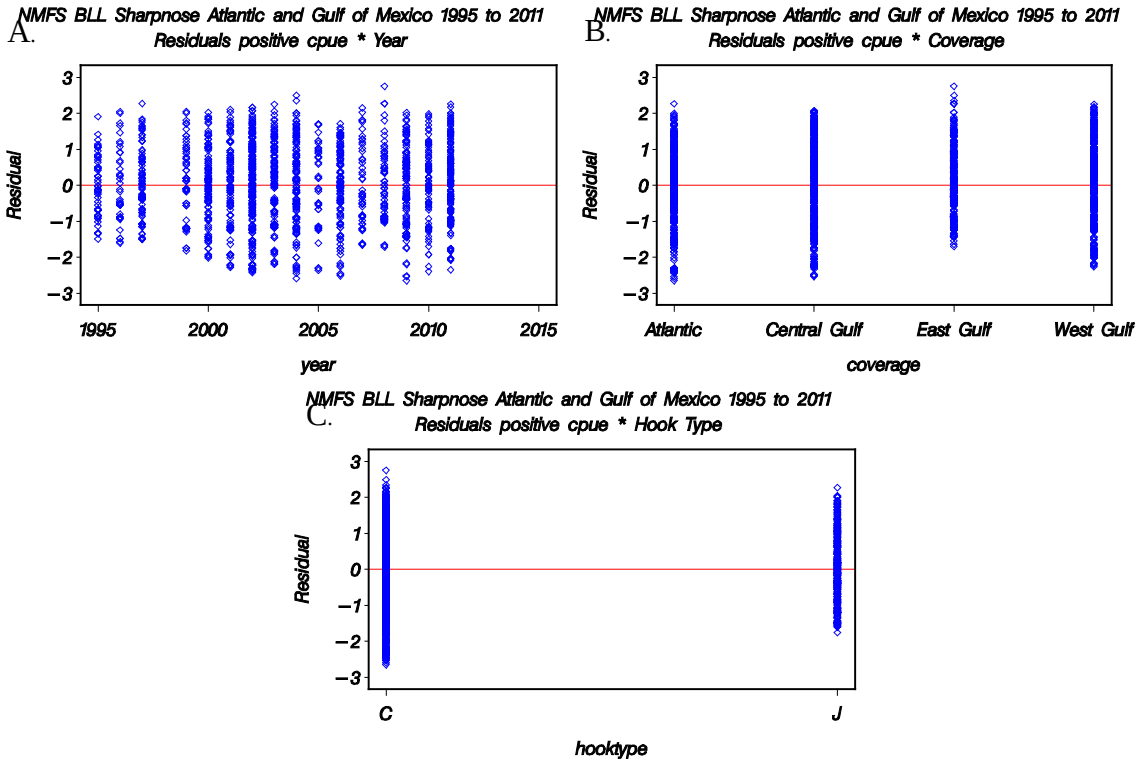


Figure 17. Diagnostic plots for lognormal component of the Atlantic Sharpnose NMFS Bottom Longline Surveys (Atlantic / GOM) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, and **C.** the Chi-Square residuals by hook type.

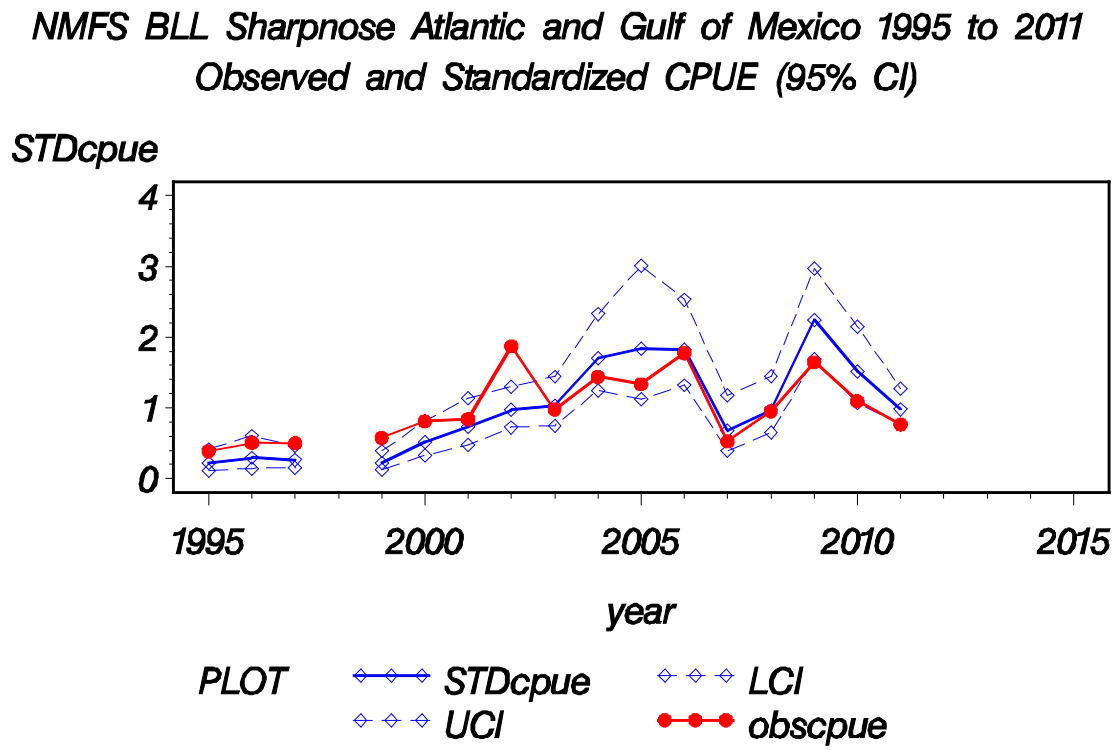
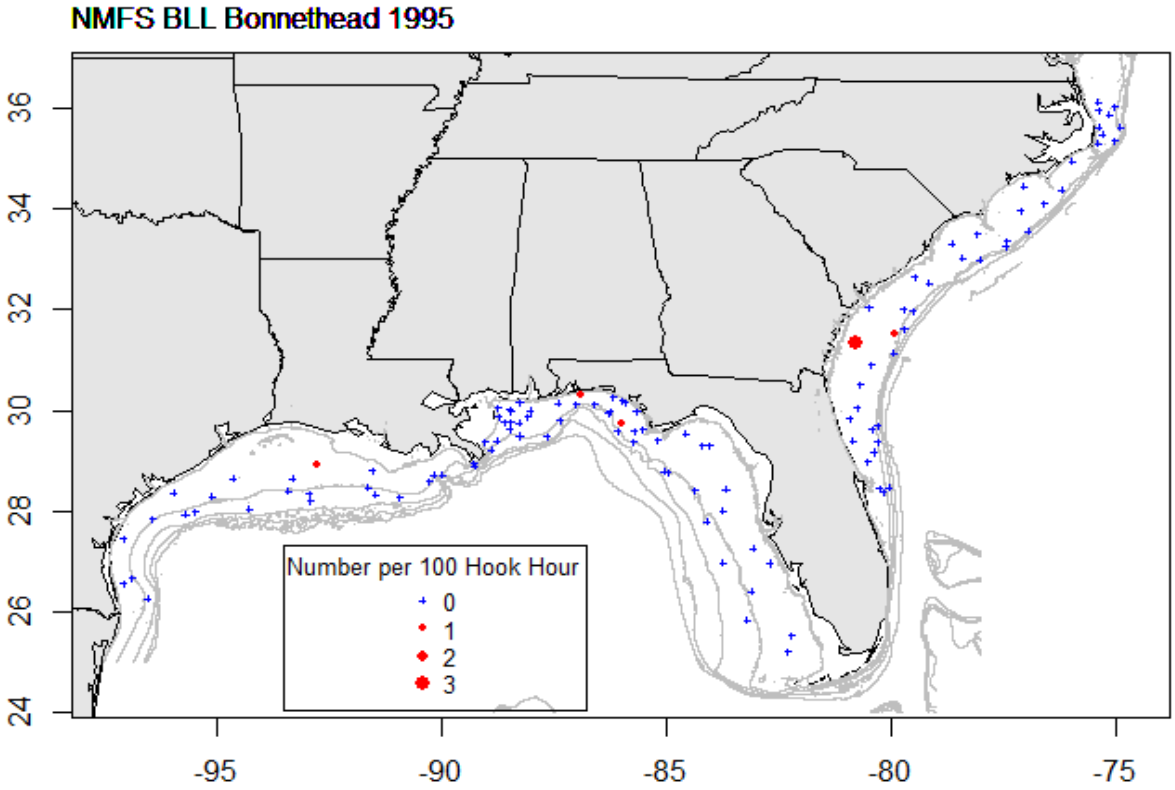
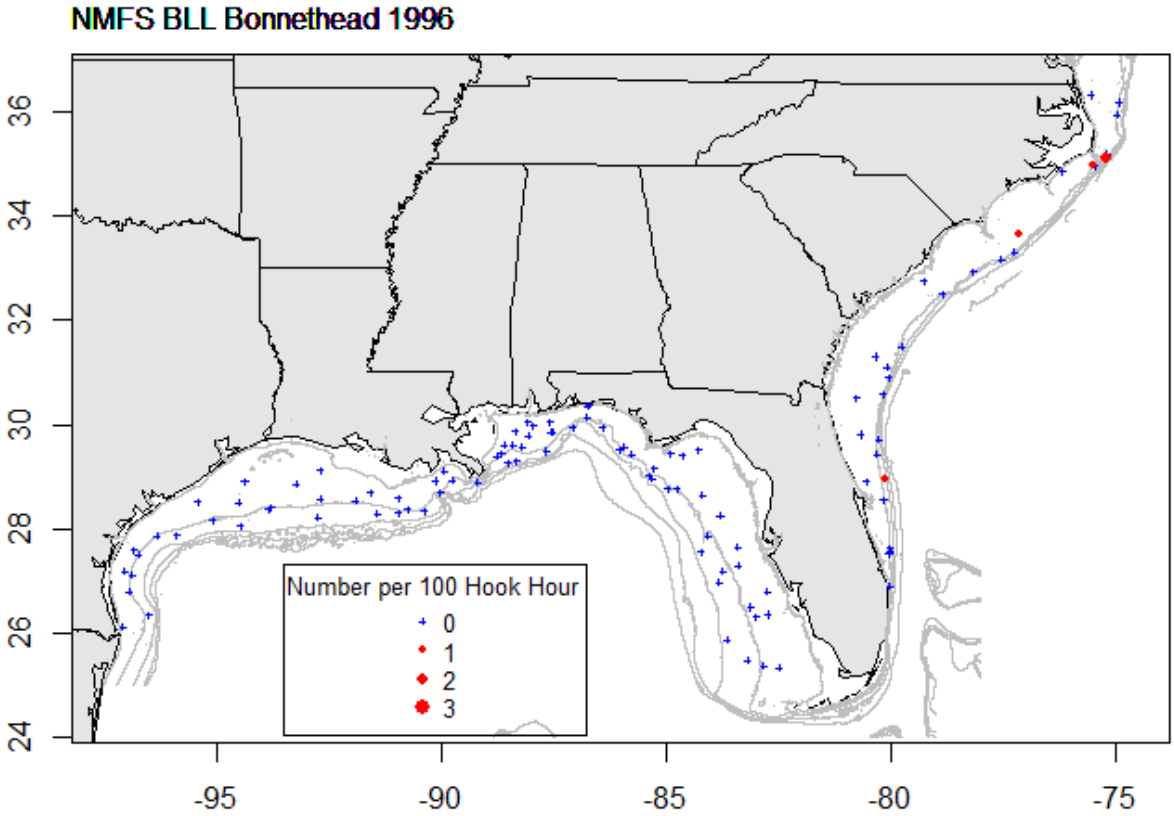


Figure 18. Annual index of abundance for Atlantic Sharpnose (Atlantic / GOM) from the NMFS Bottom Longline Surveys from 1995 – 2011.

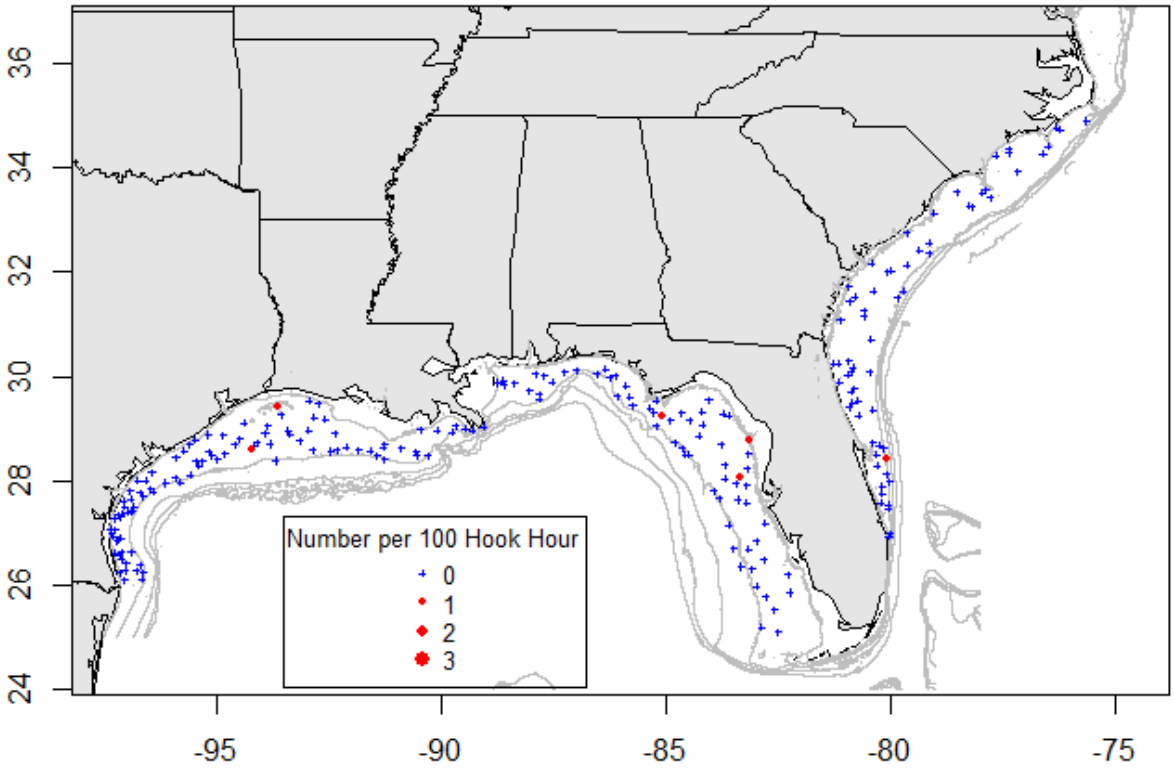
Appendix

Appendix Figure 1. Annual survey effort and catch of Atlantic Sharpnose from the SEAMAP groundfish survey during the summer (1982-2011) and fall (1972-2011)

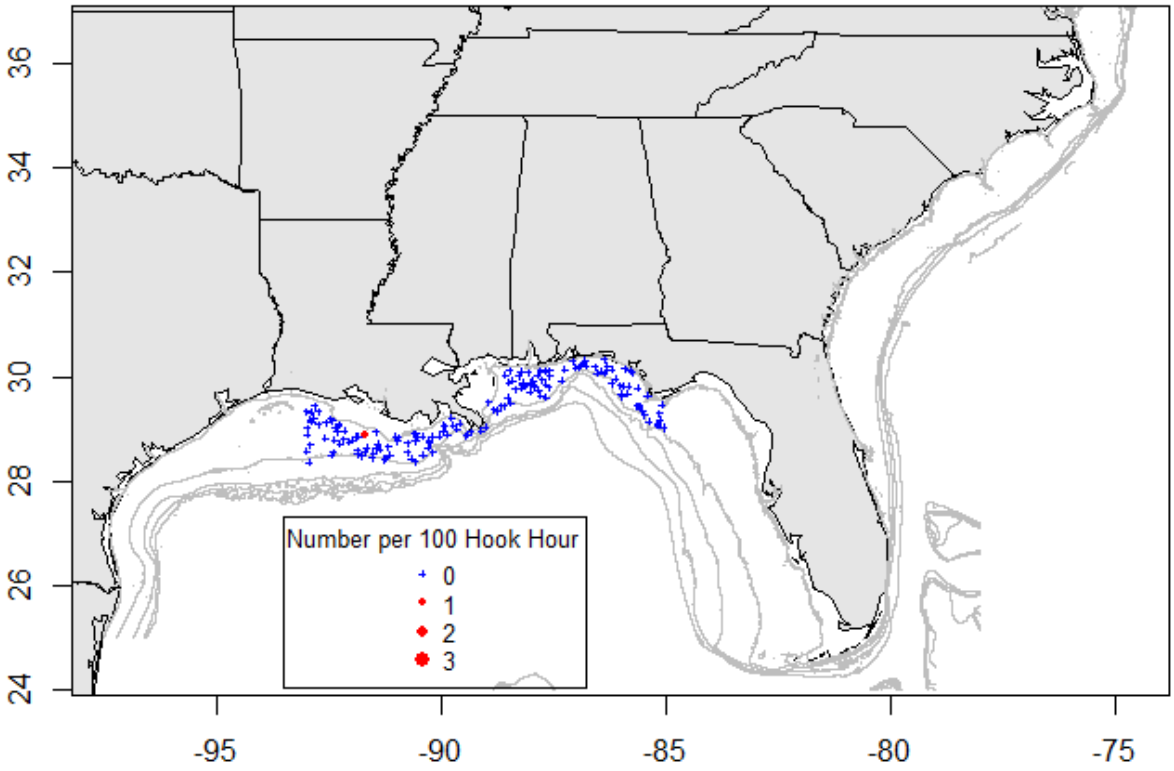




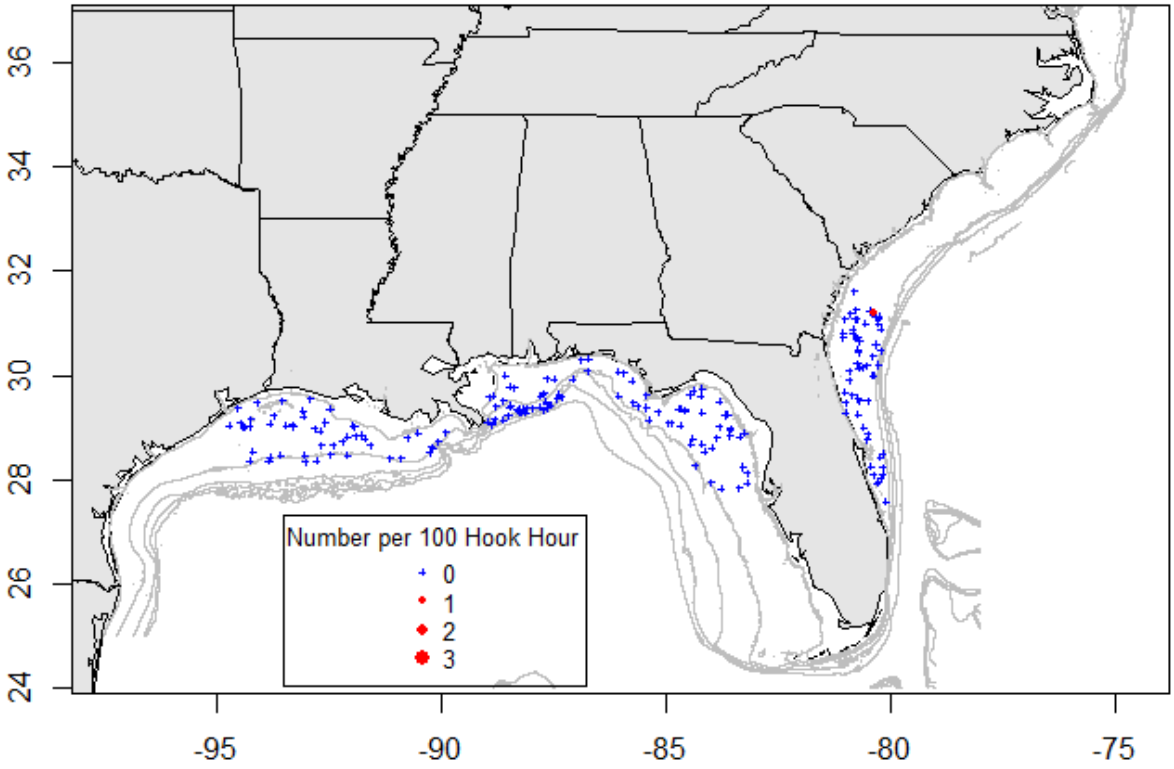
NMFS BLL Bonnethead 1997



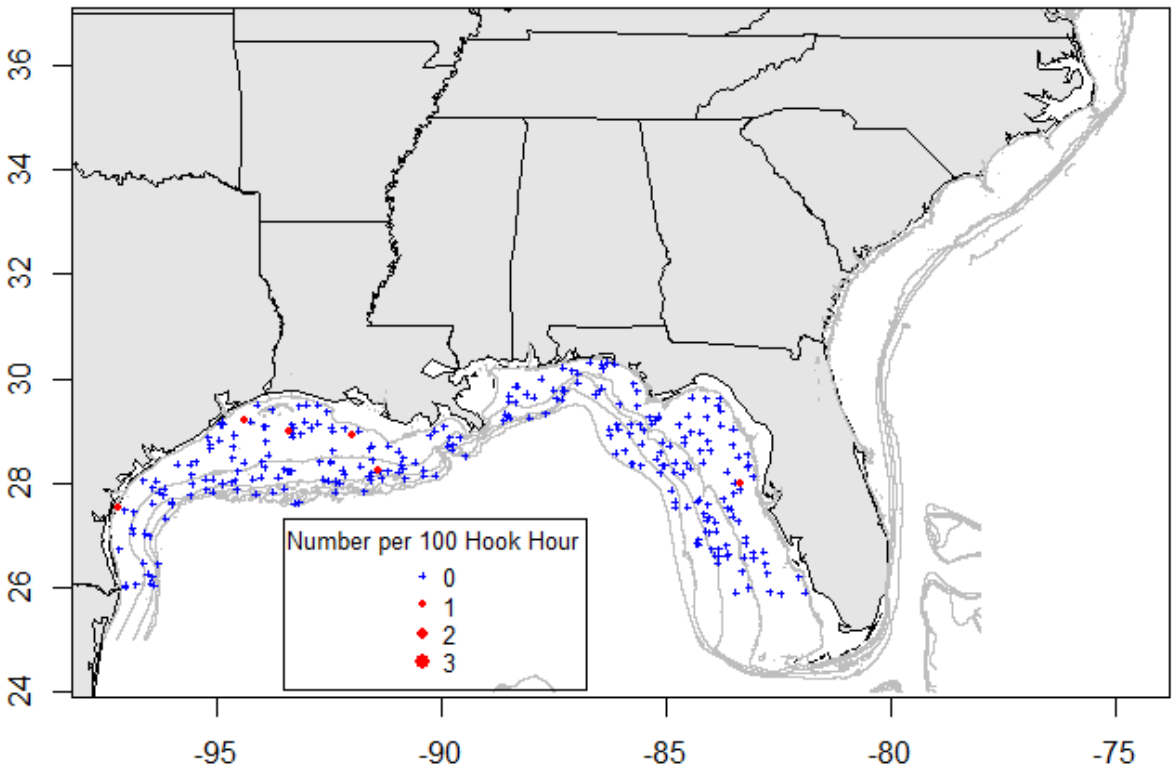
NMFS BLL Bonnethead 1999



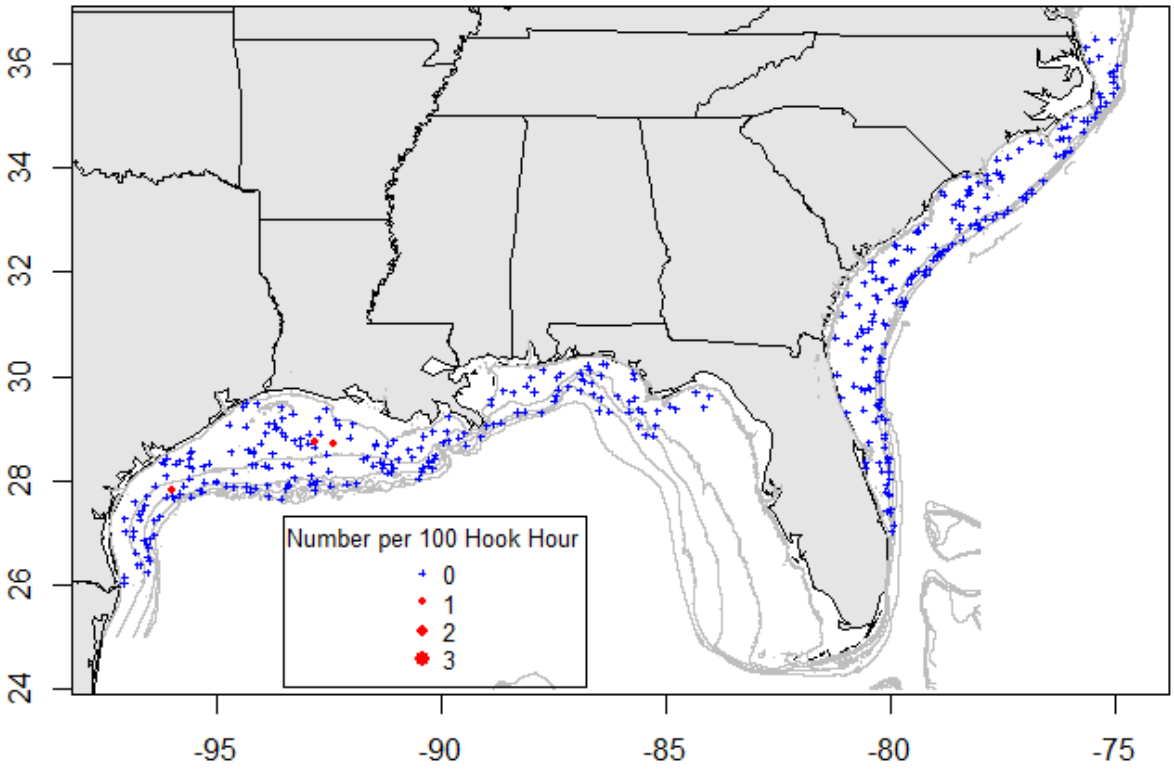
NMFS BLL Bonnethead 2000



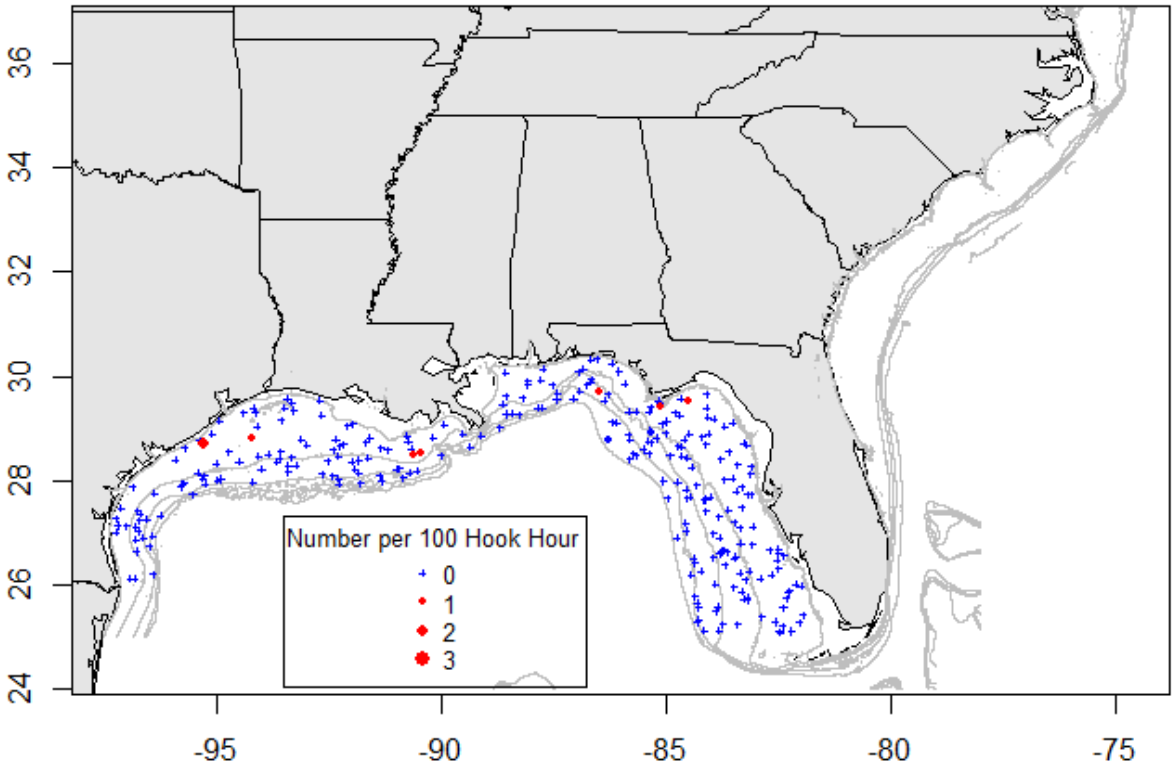
NMFS BLL Bonnethead 2001



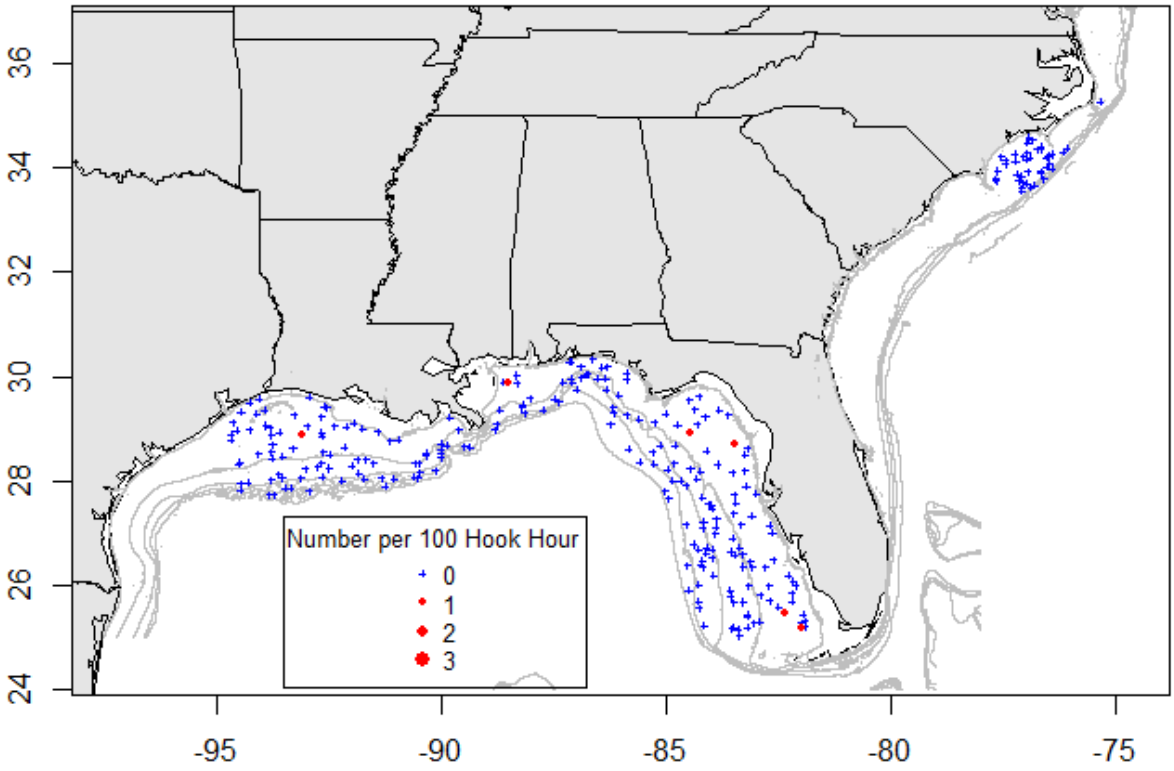
NMFS BLL Bonnethead 2002



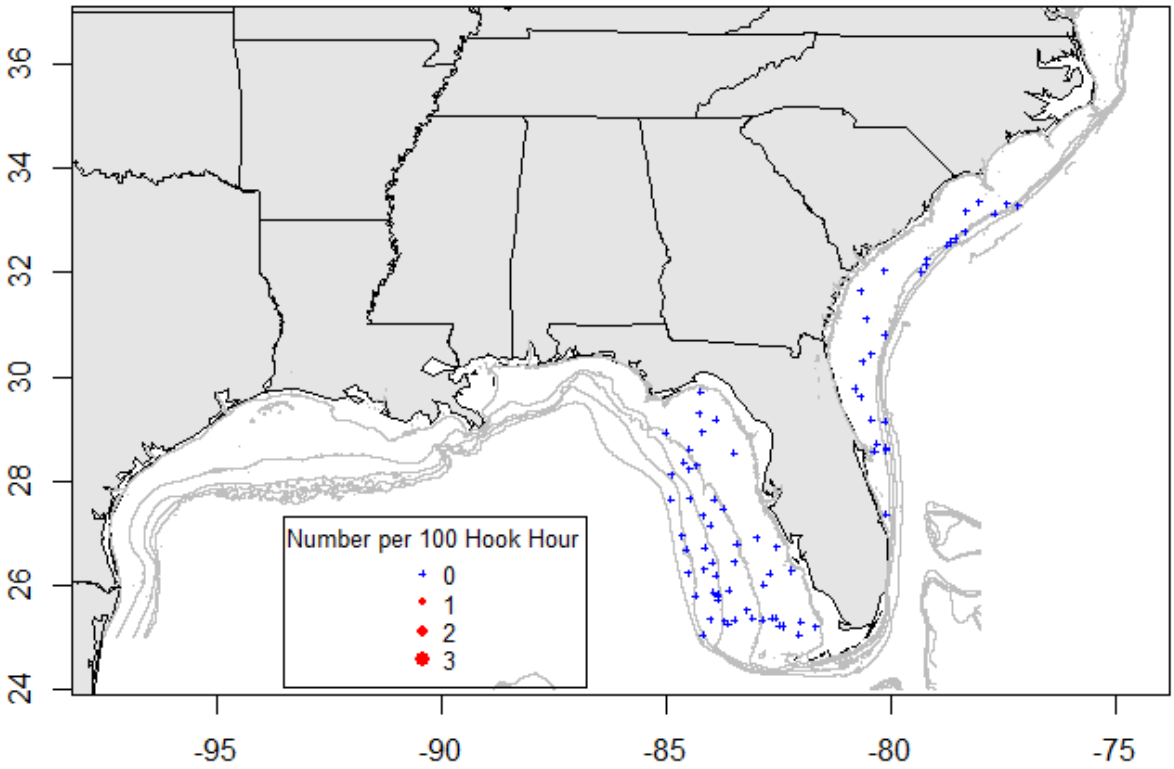
NMFS BLL Bonnethead 2003



NMFS BLL Bonnethead 2004



NMFS BLL Bonnethead 2005



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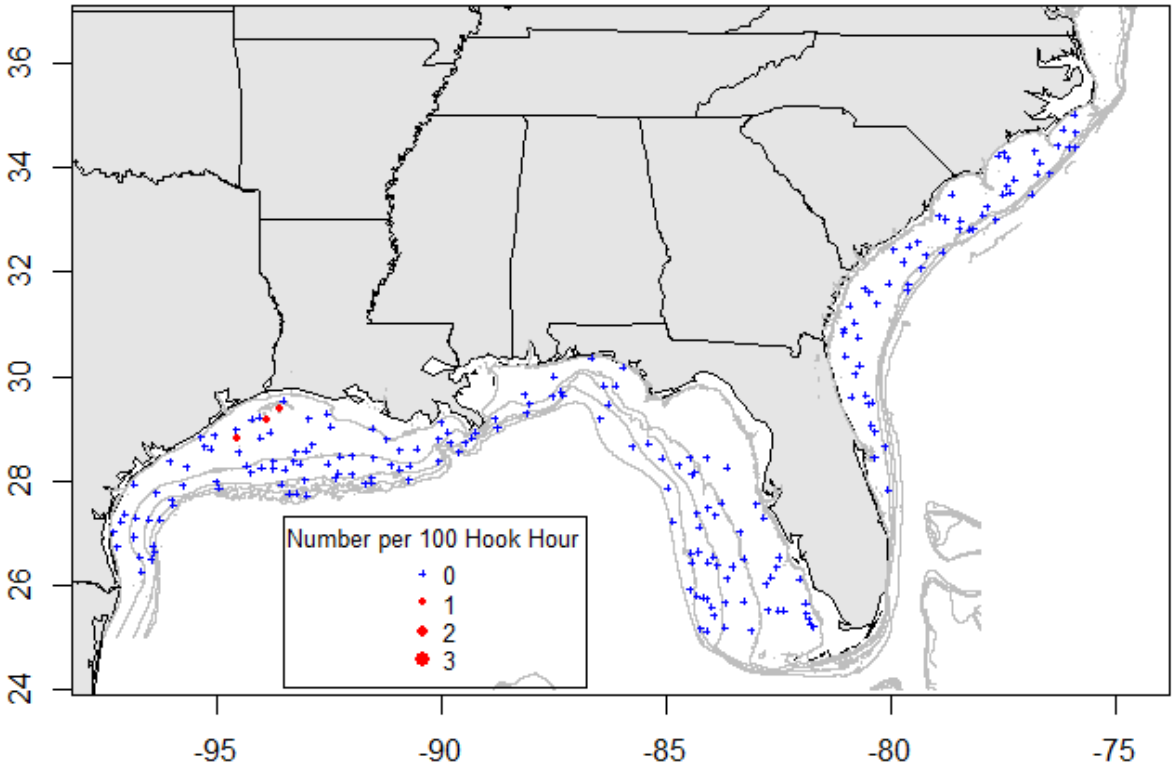
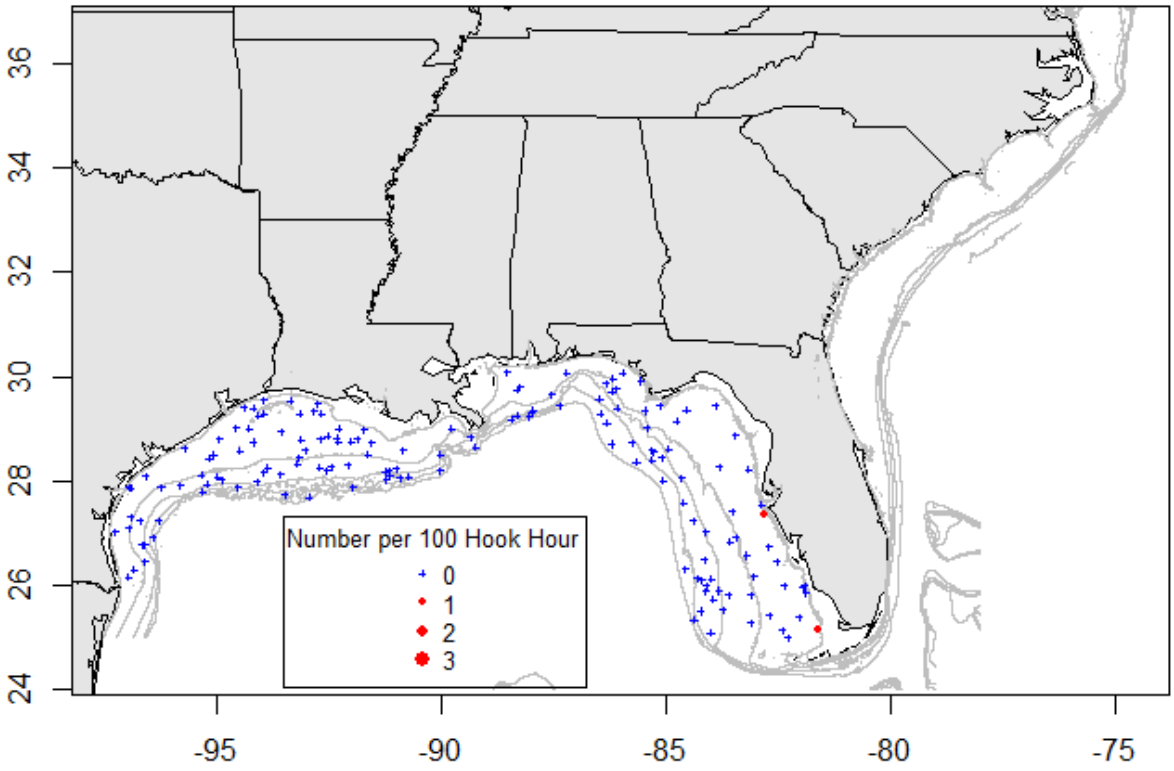
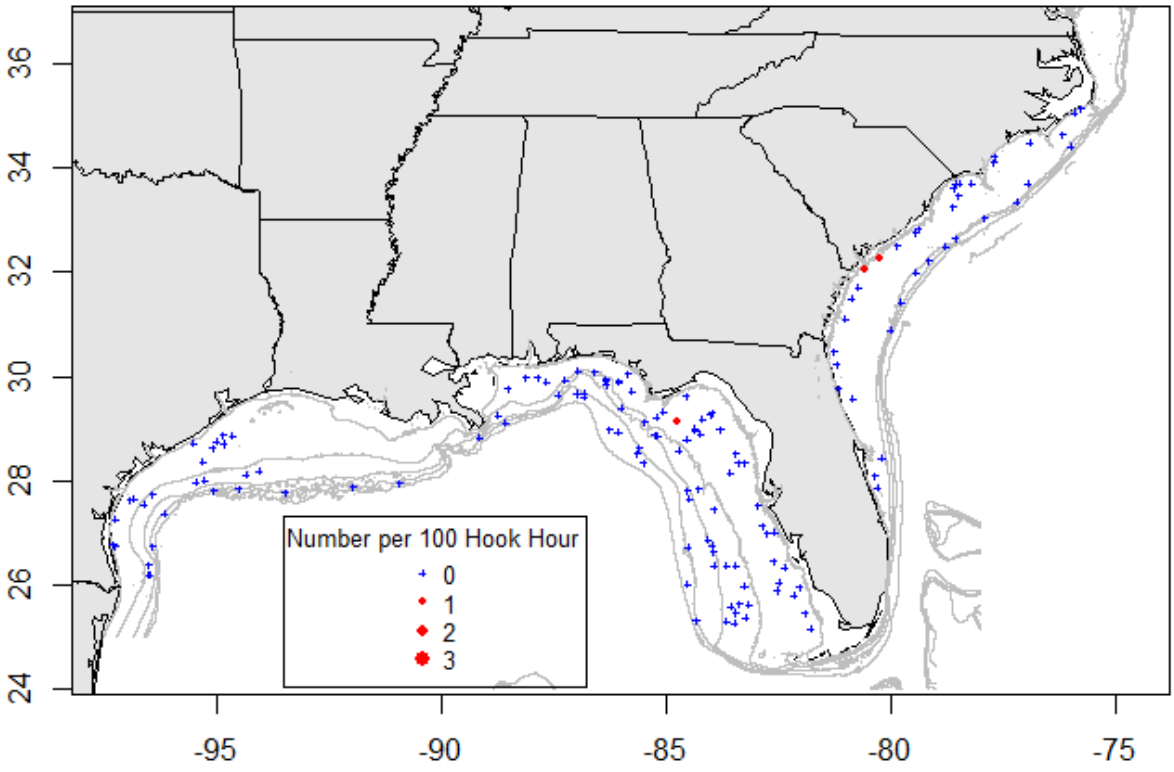


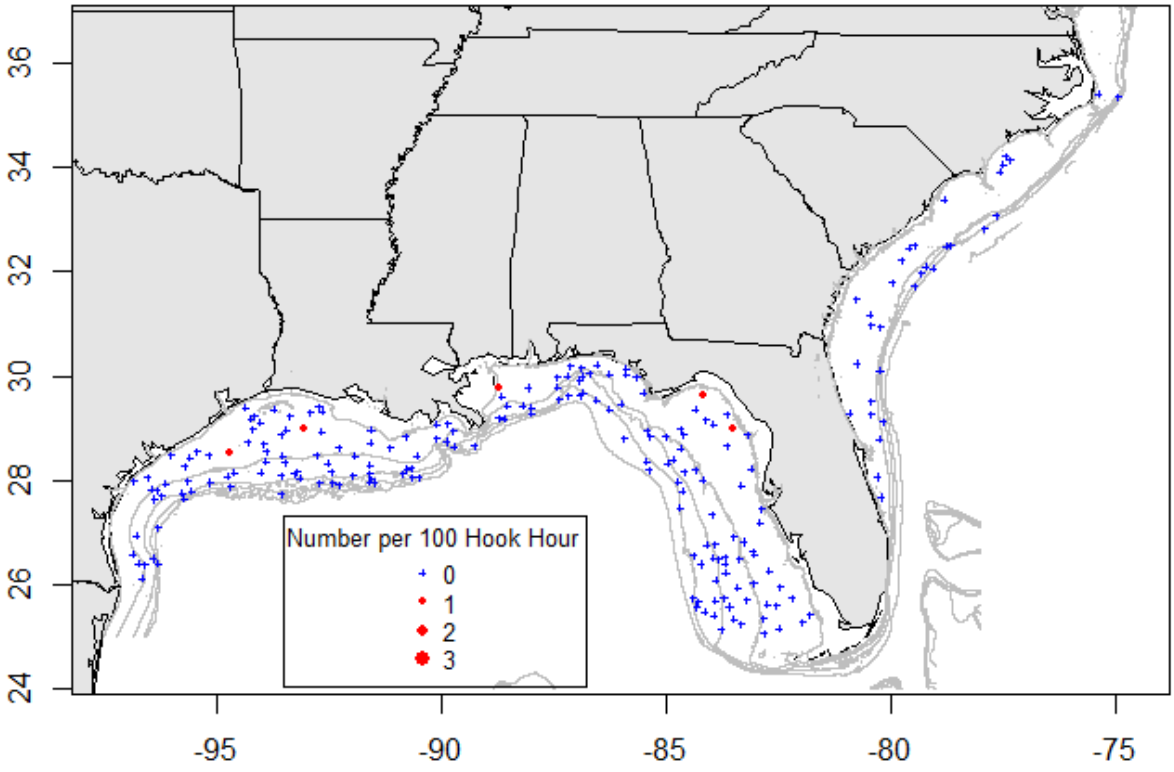
NMFS BLL Bonnethead 2007



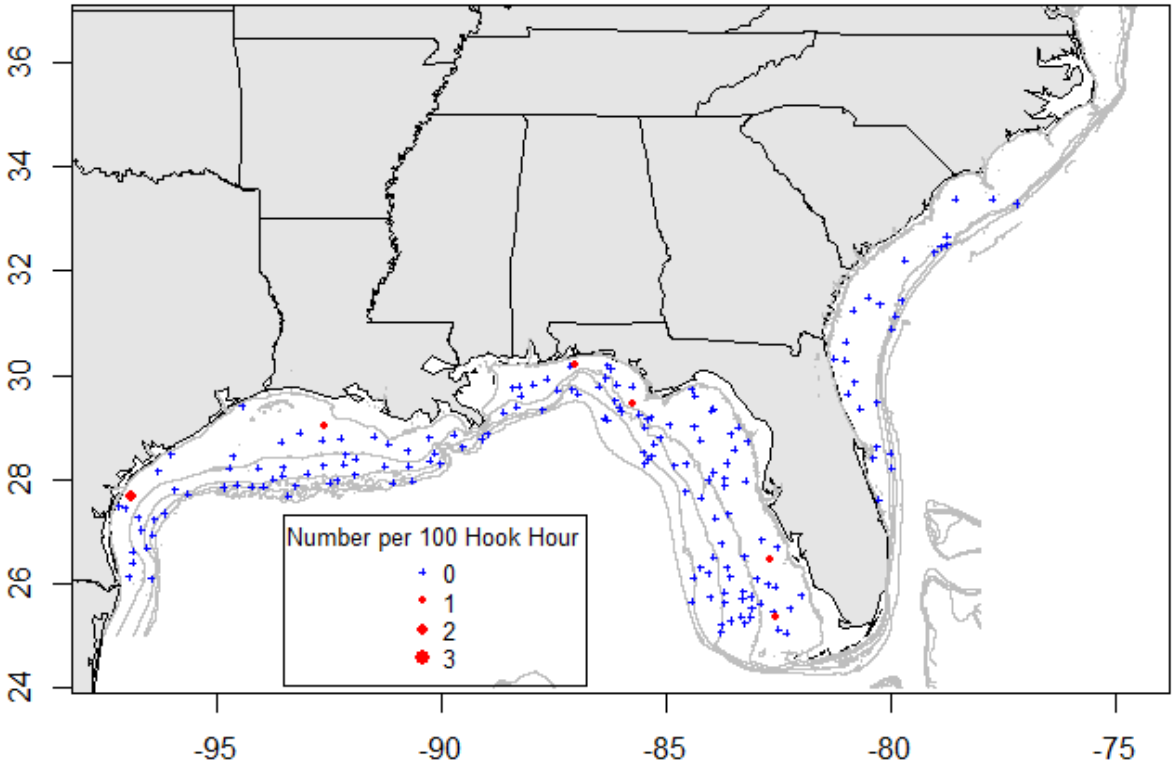
NMFS BLL Bonnethead 2008



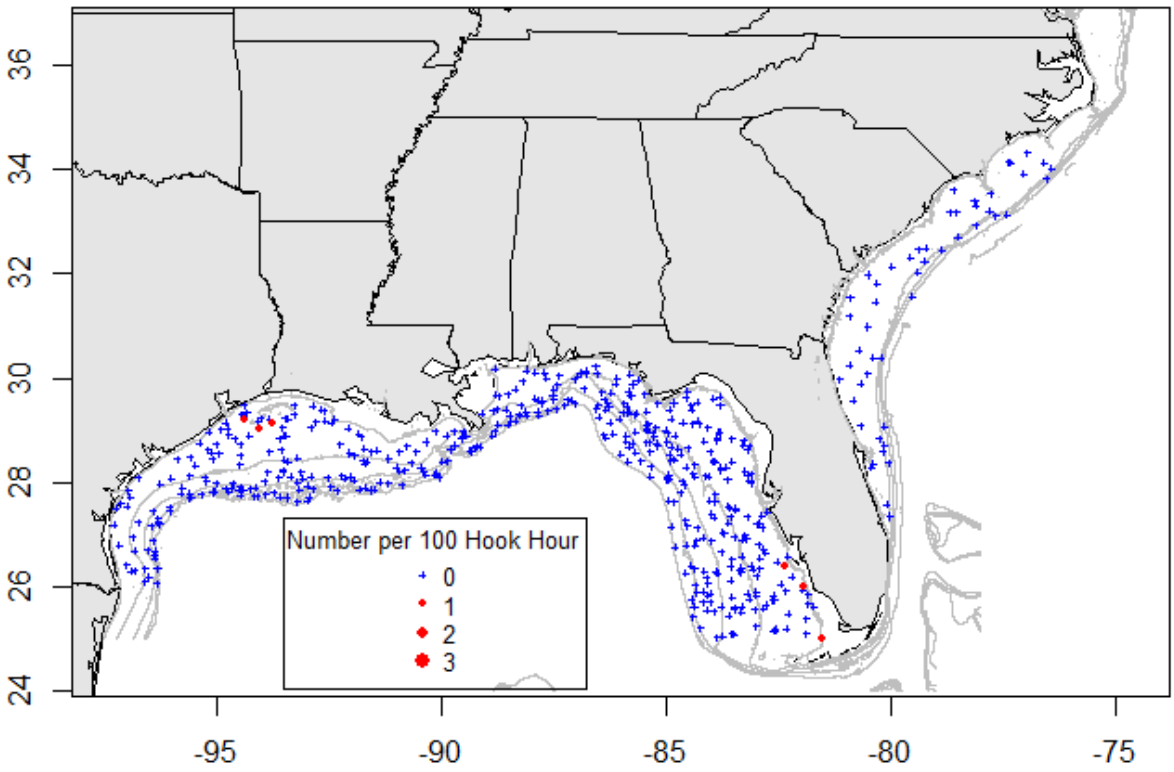
NMFS BLL Bonnethead 2009



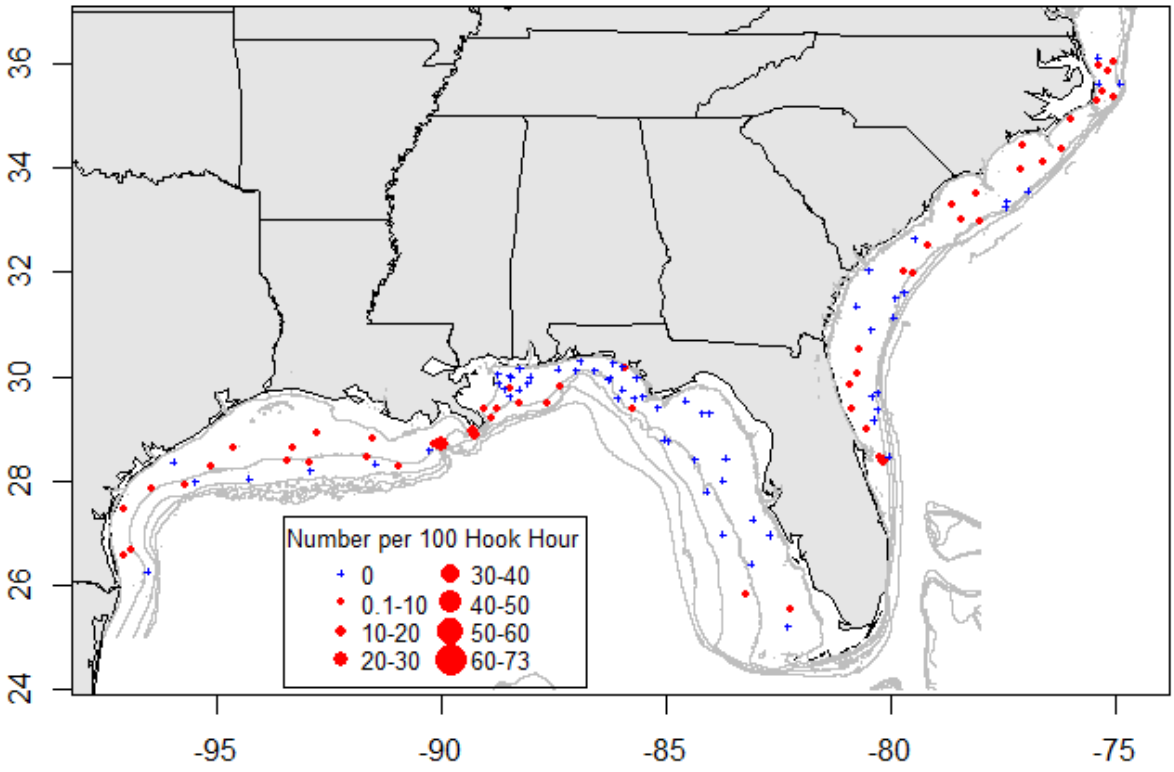
NMFS BLL Bonnethead 2010



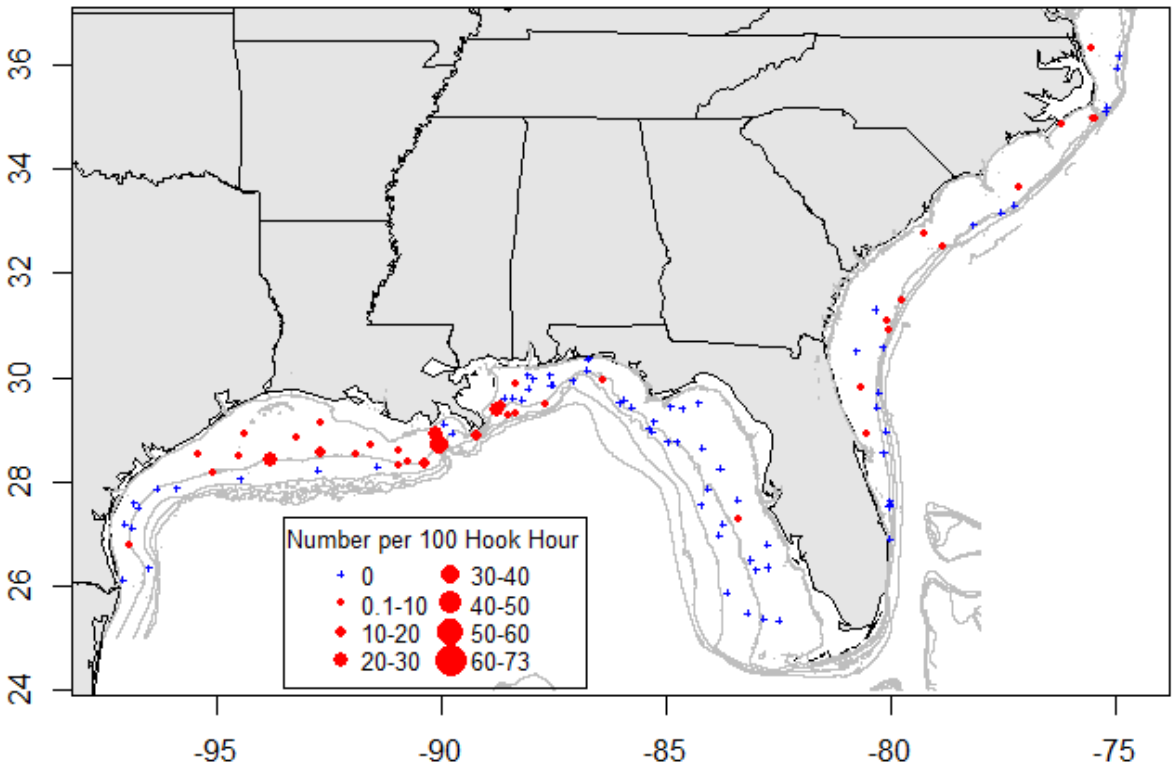
NMFS BLL Bonnethead 2011



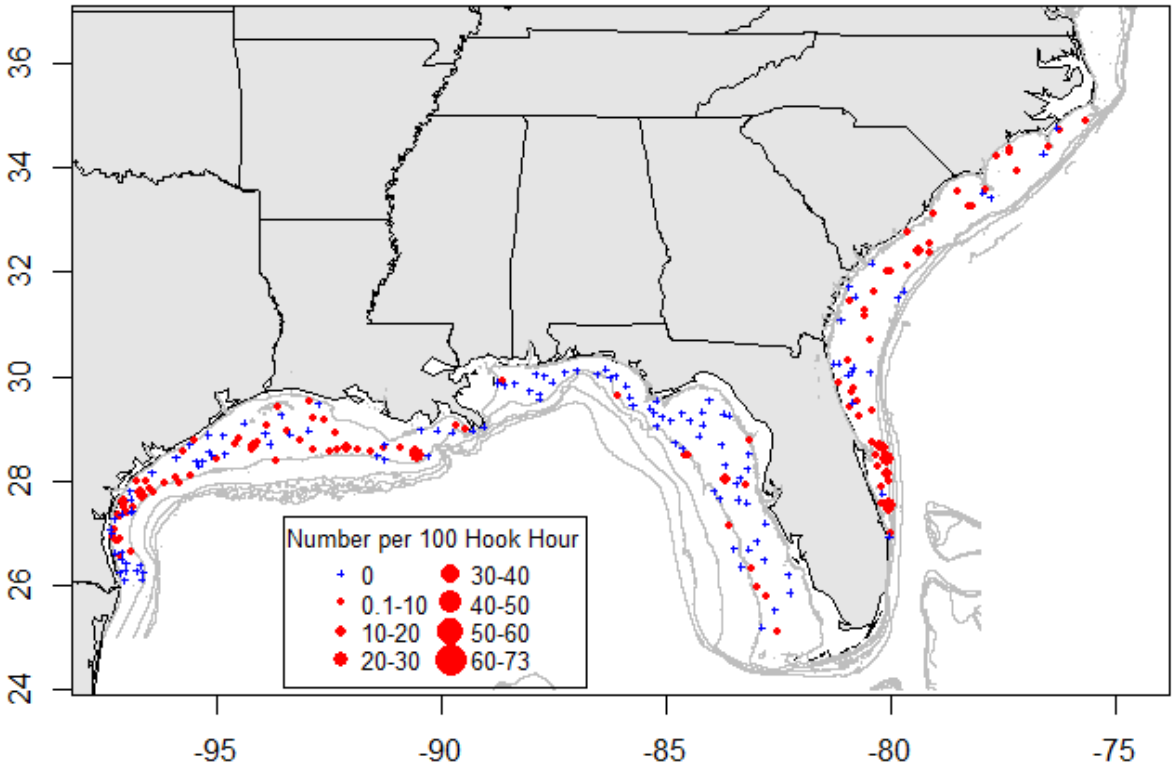
NMFS BLL Sharpnose 1995



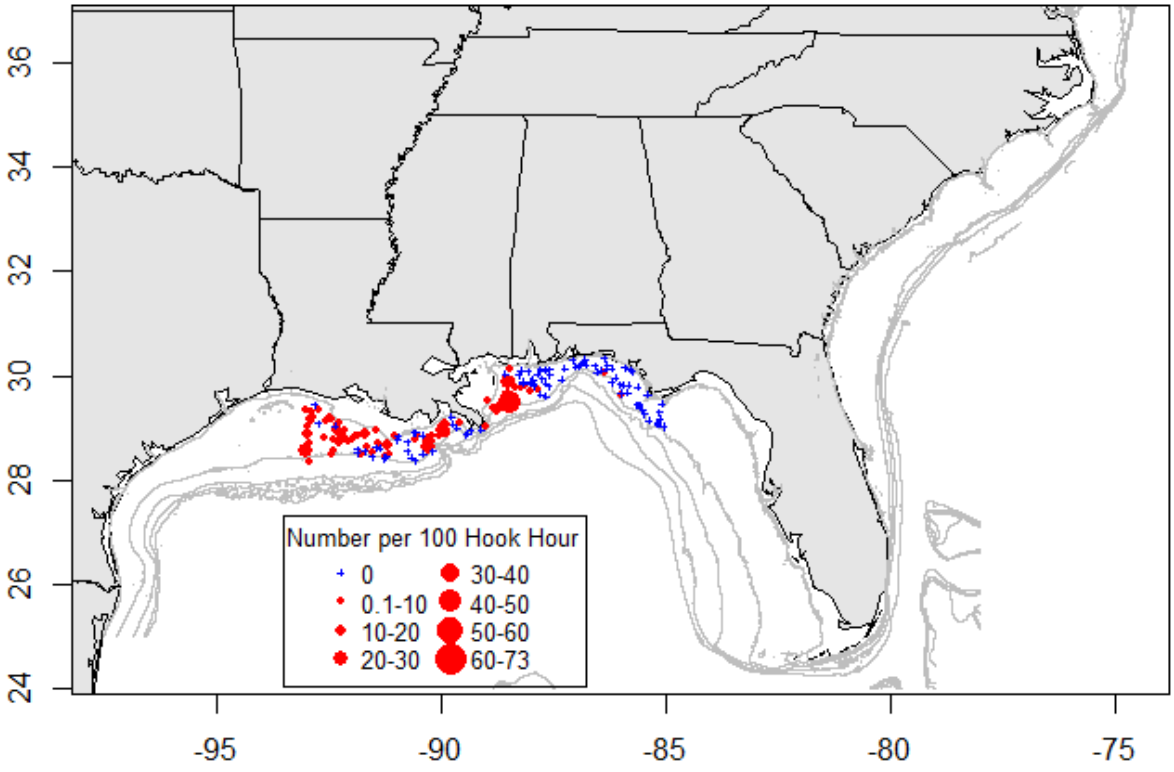
NMFS BLL Sharpnose 1996



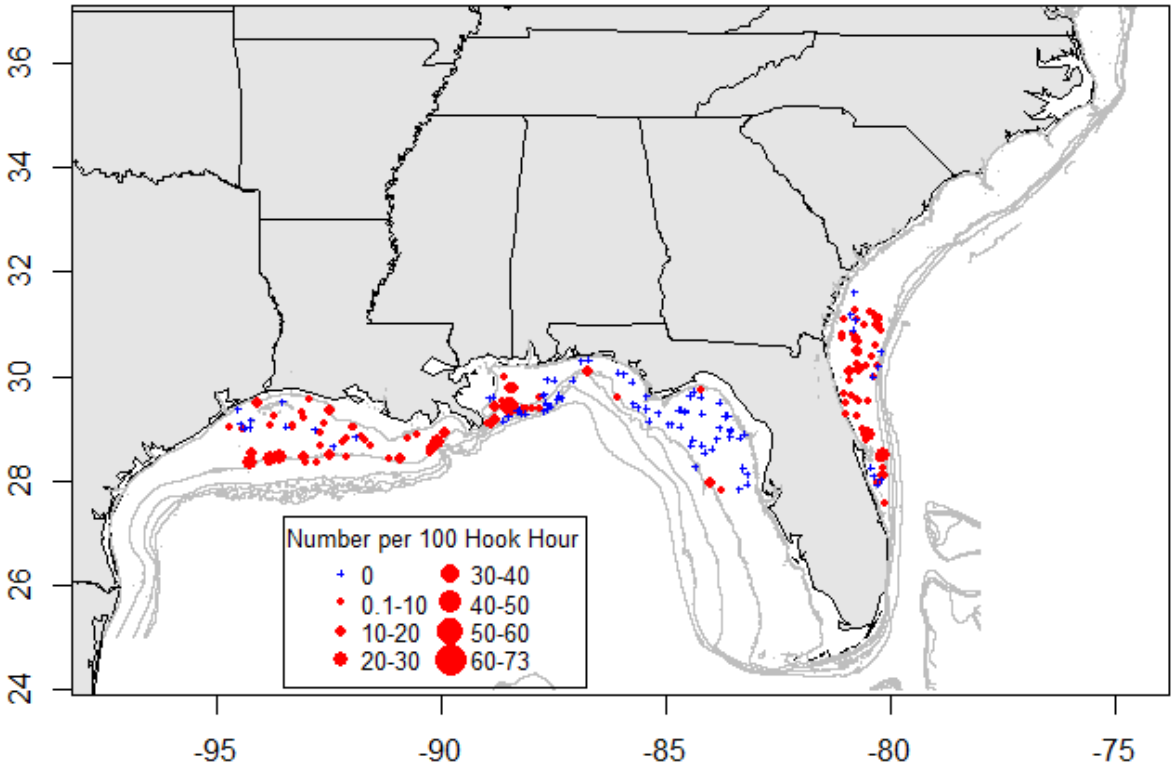
NMFS BLL Sharpnose 1997



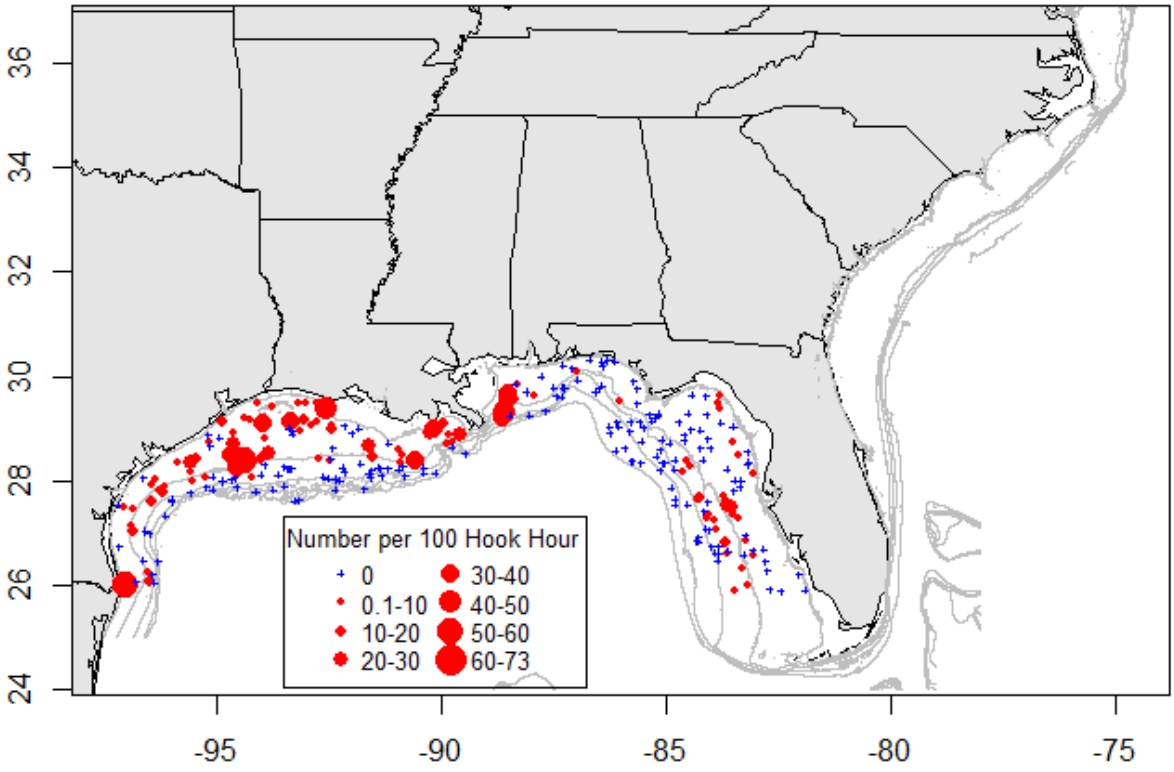
NMFS BLL Sharpnose 1999



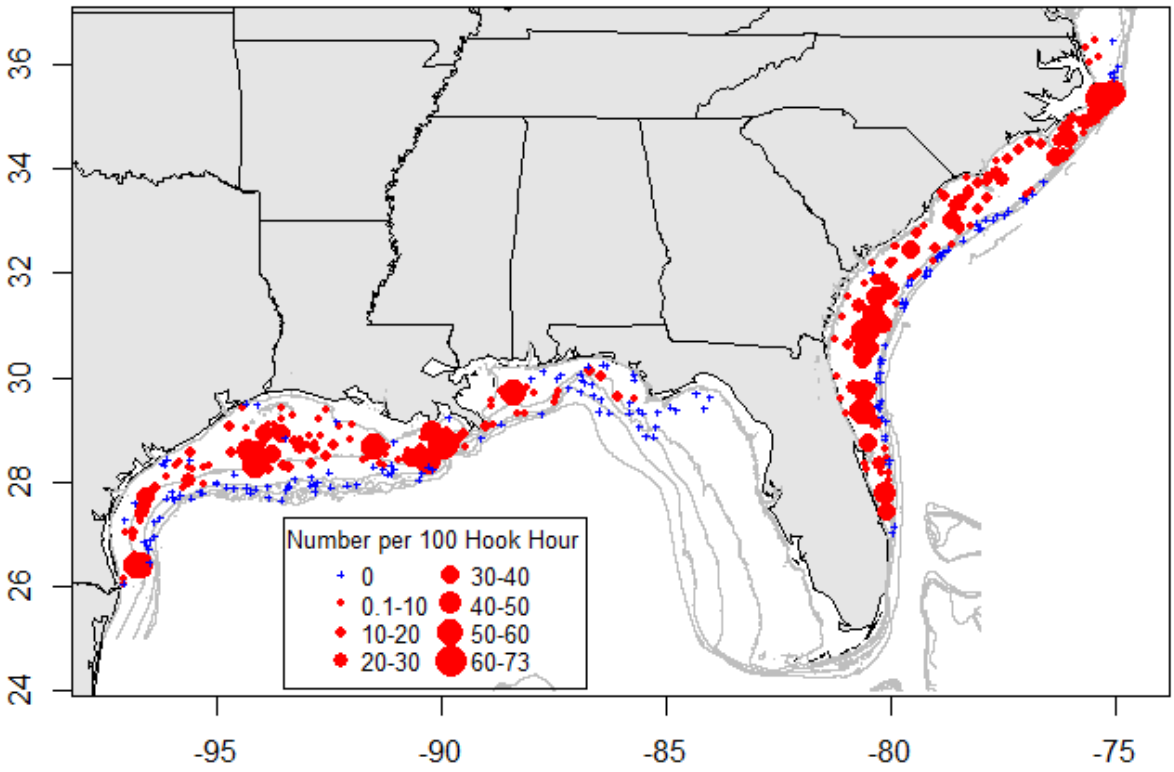
NMFS BLL Sharpnose 2000



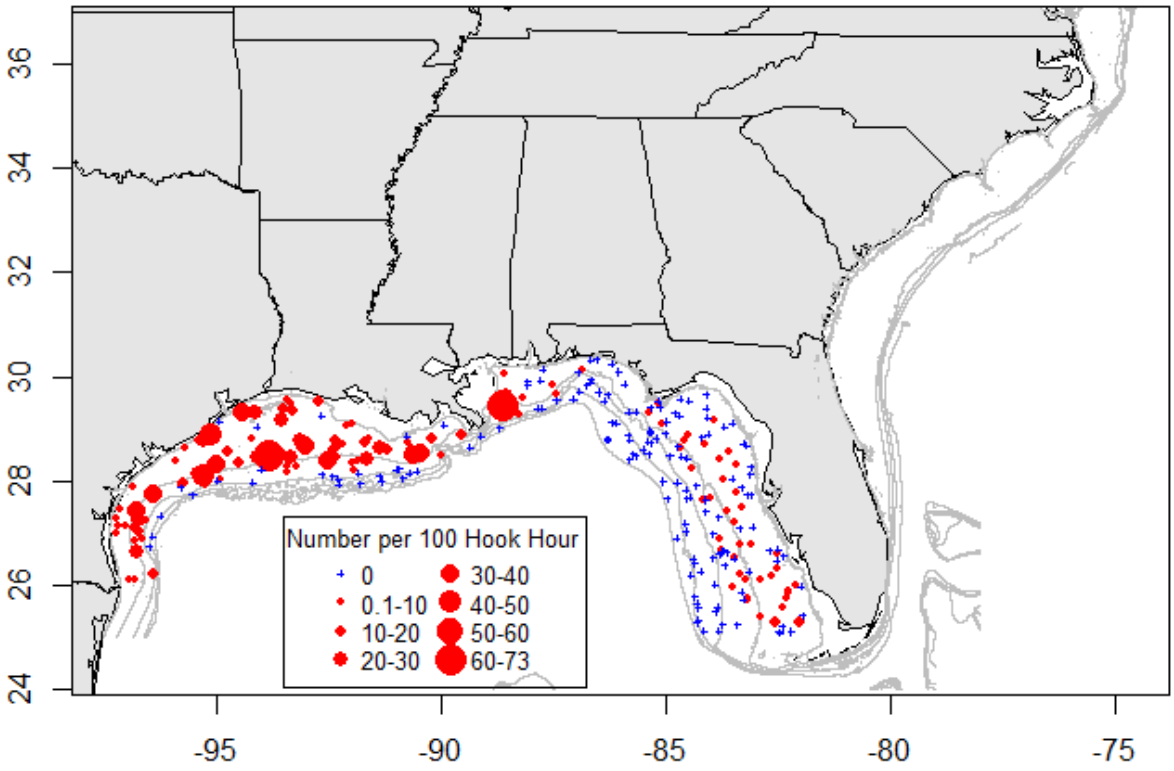
NMFS BLL Sharpnose 2001



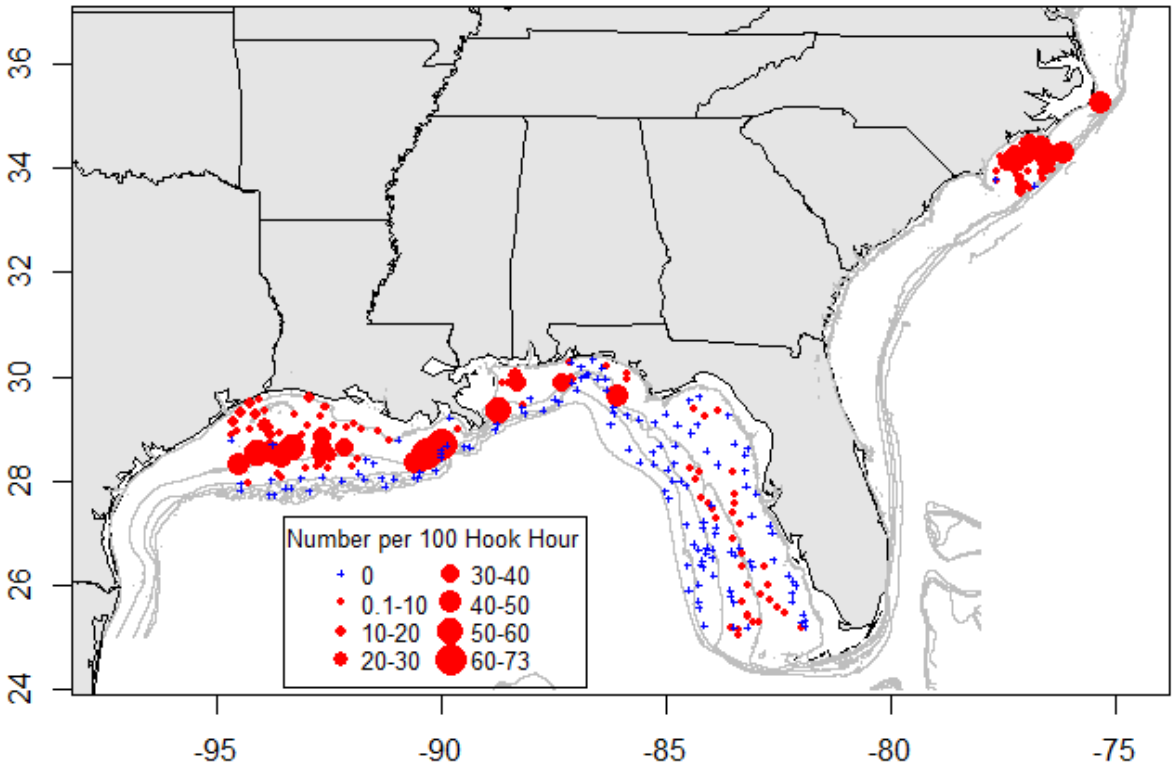
NMFS BLL Sharpnose 2002



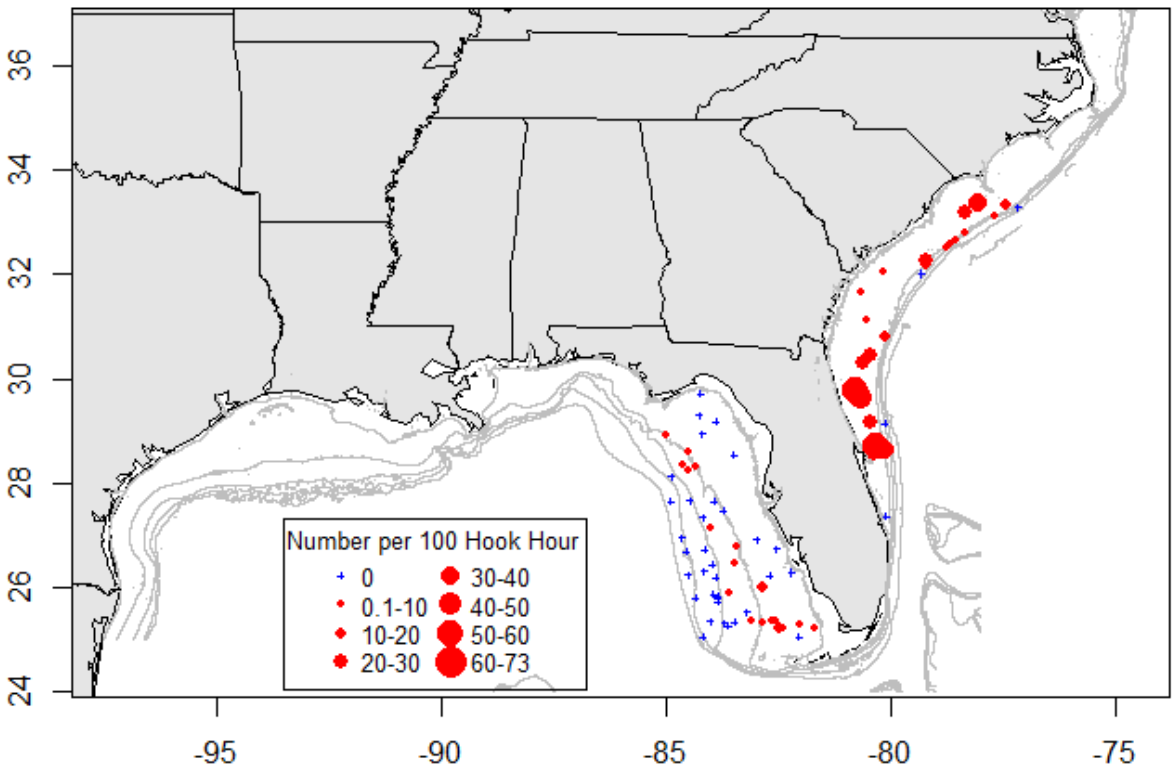
NMFS BLL Sharpnose 2003



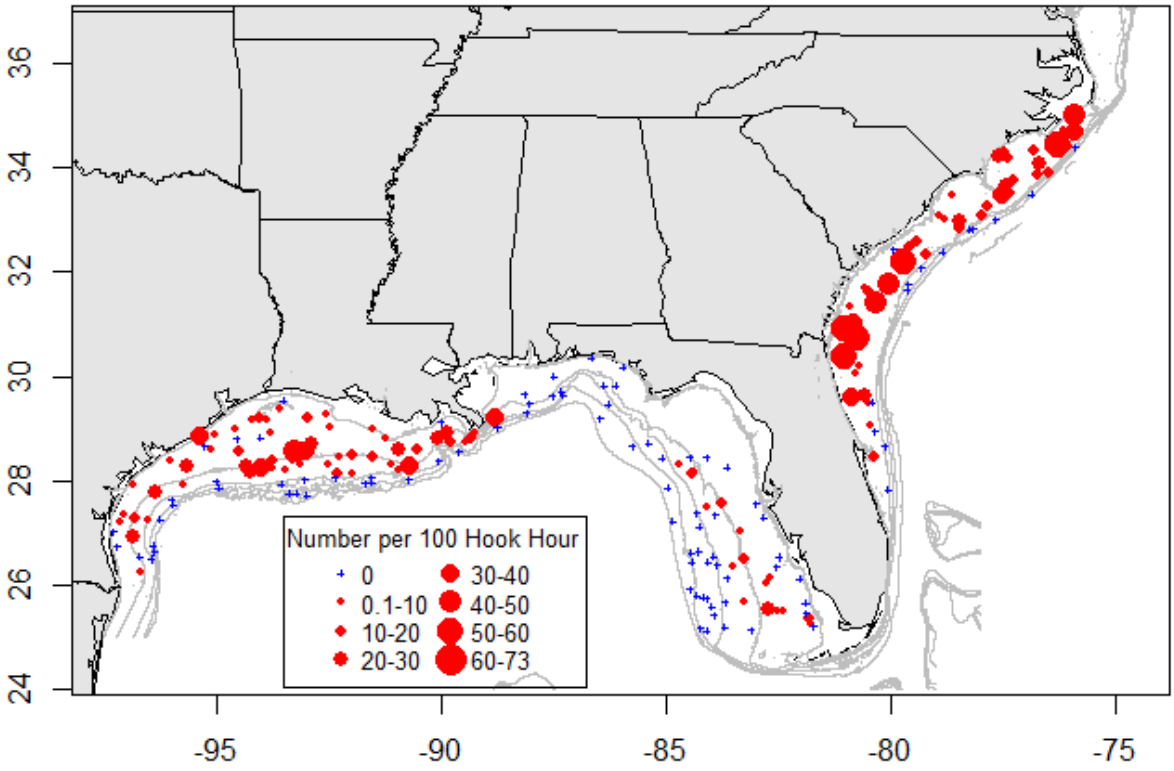
NMFS BLL Sharpnose 2004



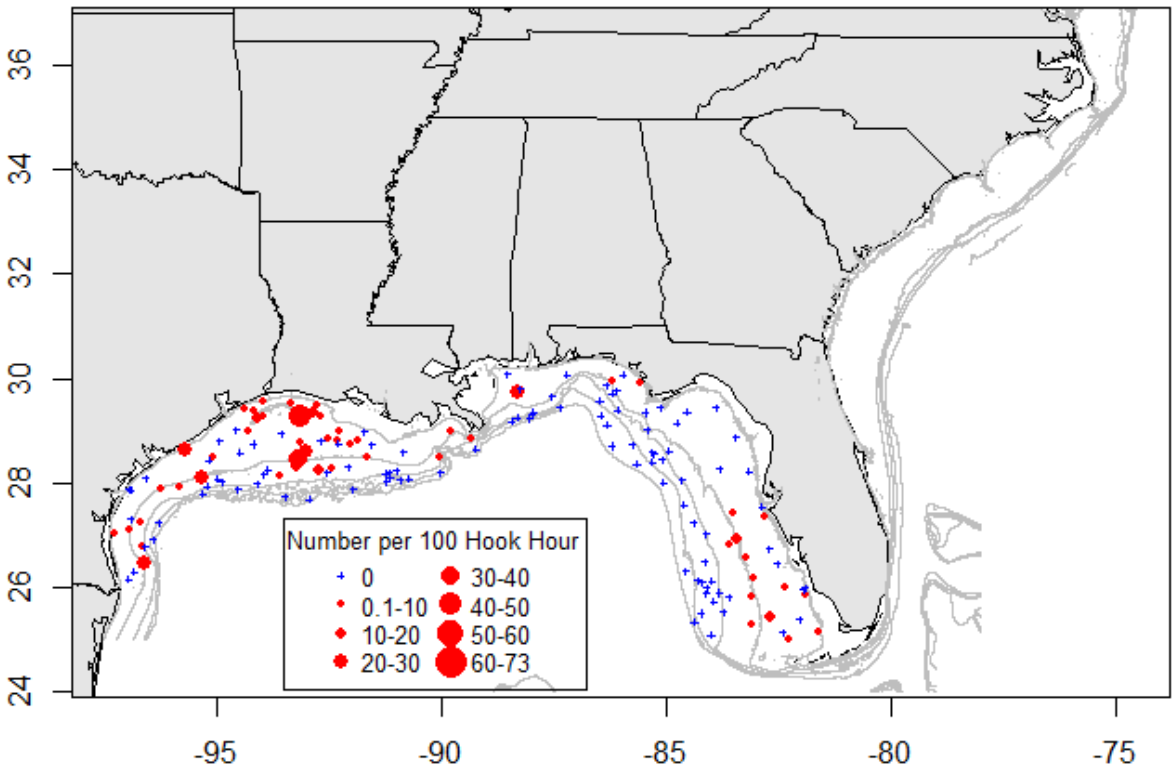
NMFS BLL Sharpnose 2005



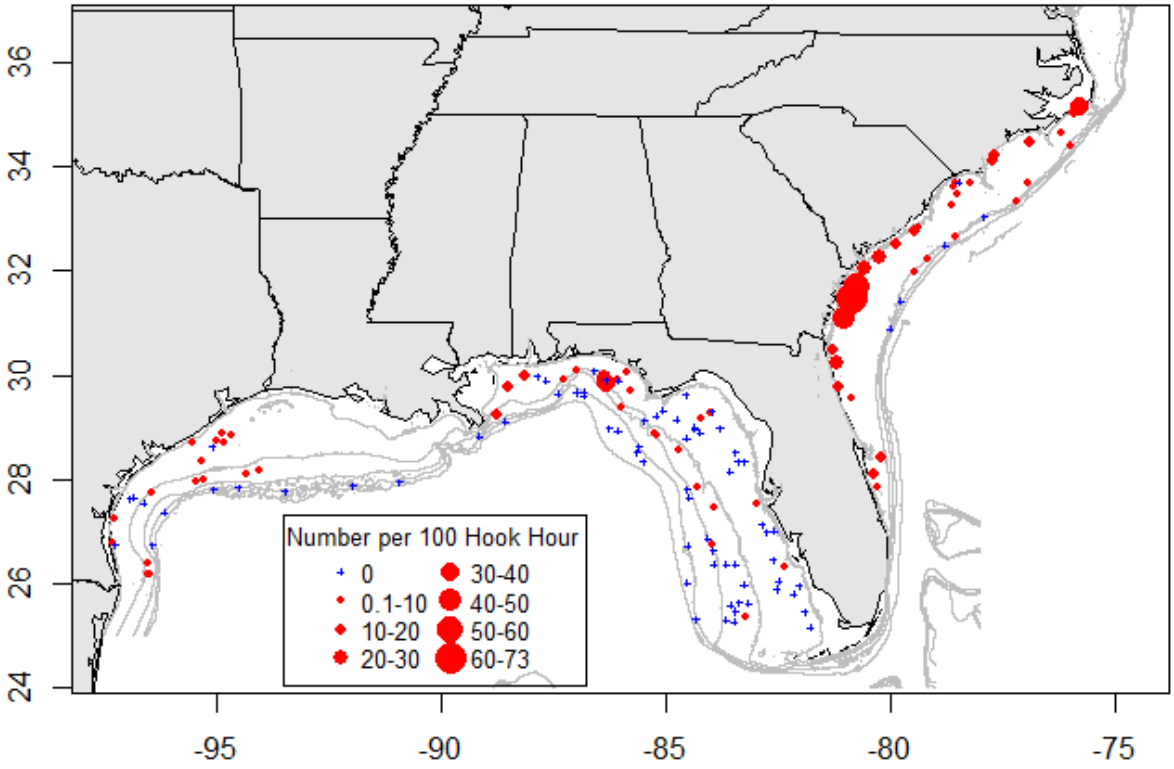
NMFS BLL Sharpnose 2006



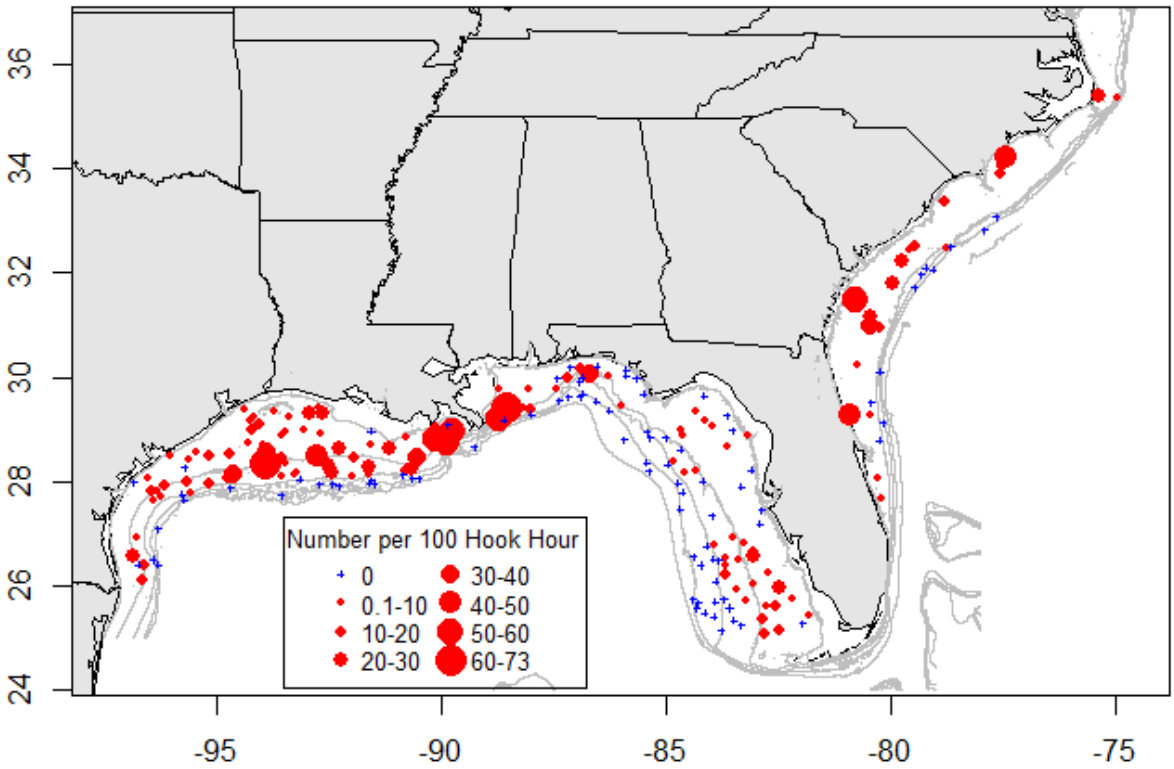
NMFS BLL Sharpnose 2007



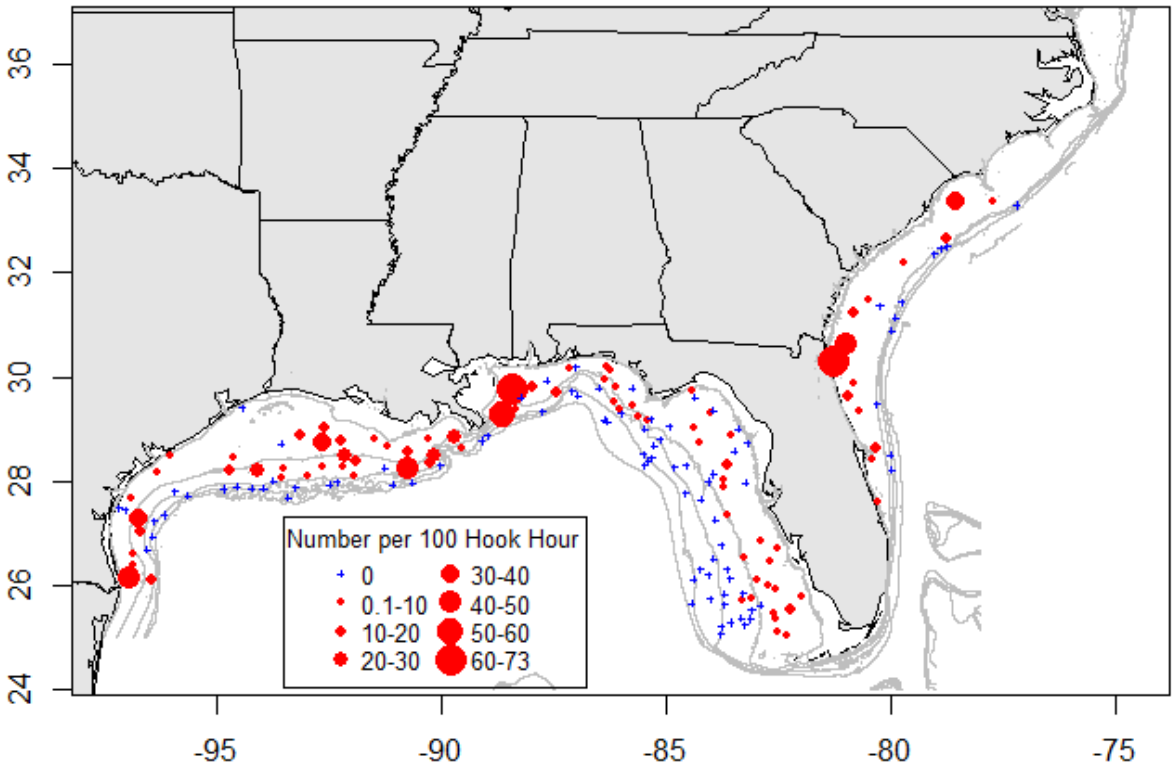
NMFS BLL Sharpnose 2008



NMFS BLL Sharpnose 2009



NMFS BLL Sharpnose 2010



NMFS BLL Sharpnose 2011