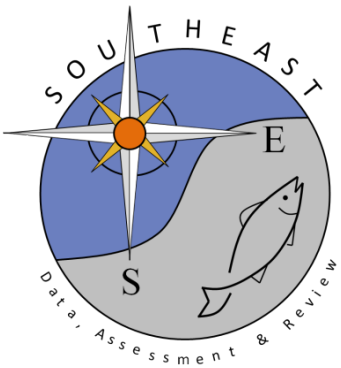
Indices of Relative Abundance for Sandbar Sharks from the SEFSC Bottom Longline Survey in the Western North Atlantic Ocean

Adam G. Pollack[1], David S. Hanisko[1], Kristin Hannan[2], and William B. Driggers III[2]

SEDAR101-DW-25

16 April 2026
Updated: 23 April 2026



Please cite this document as:

Pollack, Adam G., Hanisko, David S., Hannah, Kristin and William B. Driggers III. 2026. Indices of Relative Abundance for Sandbar Sharks from the SEFSC Bottom Longline Survey in the Western North Atlantic Ocean. SEDAR101-DW-25. SEDAR, North Charleston, SC. 40 pp.

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Abstract: *The Oceanic and Coastal Pelagics Branch of the Southeast Fisheries Science Center (SEFSC) of NOAA Fisheries has conducted bottom longline surveys in the western North Atlantic Ocean (Atlantic), including the Gulf of America (Gulf) from 1995 to 2025. In addition to the annual survey, the Congressional Supplemental Sampling Program (CSSP) was conducted in 2011, where increased levels of standardized bottom longline survey effort were maintained from April through October in the Gulf. Data from the SEFSC Bottom Longline Survey and the CSSP Survey (limited to August and September sampling) have been used during previous assessments of sandbar sharks (Carcharhinus plumbeus). A relative abundance index is presented for Atlantic and Gulf from the SEFSC and CSSP data from 1995 to 2025 for the upcoming assessment.*

Introduction

The NOAA Fisheries, Southeast Fisheries Science Center (SEFSC), Population and Ecosystem Monitoring (PEM) Division, Oceanic and Coastal Pelagics (OCP) Branch has conducted standardized bottom longline (hereafter SEFSC BLL) surveys in the western North Atlantic Ocean (Atlantic), including the Gulf of America (Gulf), since 1995. The objective of these surveys is to provide fisheries-independent data for stock assessment purposes for as many teleost and shark species as possible. These surveys are conducted annually in U.S. waters of the Atlantic and Gulf and provide an important source of fisheries-independent information on federally managed species.

In the Gulf, the SEFSC BLL survey samples in depths ranging from 9 to 366 m with 50% of samples in depths of 9 to 55 m, 40% of samples in depths of 55 to 183 m and 10% of samples in depths of 183 to 366 m, with samples allocated to defined longitude/latitude divisions within each depth strata by the proportion of spatial area within each division. In the Atlantic, the survey samples depths ranging from 9 to 183 m, with 60% in the 9 to 55 m depth stratum and 40% in the 55 to 183 m depth stratum. The surveys have maintained a standard gear configuration over the time series with the exception of hook type. In the early years of the survey (1995 – 1997), bottom longlines initially fished #3 J-hooks; a mixture of J-hooks and 15/0 circle hooks were utilized between 1999 and 2000; and 15/0 circle hooks were utilized exclusively beginning in 2001. However, Henwood *et al.* (2005) examined the difference in catch rates between the two hooks types and found no significant difference in catch rates for

sandbar sharks (*Carcharhinus plumbeus*). Details concerning the methods and evolution of the SEFSC BLL survey have been covered in previous documents (e.g., Ingram et al. 2005).

In 2011, the Congressional Supplemental Sampling Program (CSSP) focused on completing monthly gulfwide bottom longline surveys in the U.S. Gulf from April through October (for a full review of the CSSP see Campbell et al. 2012). Sampling during the CSSP program was conducted using the same gear as the SEFSC BLL survey and a similar survey design. The primary differences between the SEFSC BLL and CSSP surveys were in the depth range of coverage and the proportion of longline sets allocated to each depth strata. The CSSP survey sampled depths from 9 to 400 m with samples allocated proportionally by the spatial area of 38 strata based on longitude/latitude divisions and three depth strata (9 to 55 m, 55 to 183 m and 183 to 400 m).

This document outlines the development of a sandbar shark abundance indices for the Atlantic and Gulf.

Methodology

Data

Data for the annual SEFSC BLL survey and CSSP survey were obtained from a SEFSC ORACLE database. Sampling effort during the 2011 SEFSC BLL survey was limited in spatial coverage due to vessel breakdowns and weather delays. Therefore, we utilized data from the CSSP survey to supplement sampling effort from the SEFSC BLL survey in 2011. For this document, the combined dataset will be hereafter referred to as SEFSC BLL.

Data Exclusions

The time series utilized to develop a sandbar shark abundance index ranged between 1995 and 2025 (Table 1) and included stations where no operational problems were noted in the data. Depth was used to limit the data, with all sampling deeper than 183 m excluded since there was only one record of a sandbar shark being caught any deeper (183 m was chosen because it is the inner extent of the deepest depth stratum in the survey design). In addition, only stations with soak times between 40 to 80 minutes (60 minute standard soak) and with greater than 66 hooks fished (as defined by hooks returned intact) were used in the analysis.

Sampling coverage of the 2011 SEFSC Survey was limited due to weather and vessel breakdowns. Data from the August CSSP survey were used to supplement sampling coverage in the eastern Gulf (east of 88°N) and data from the CSSP September survey was used to supplement sampling coverage in the western (west of 93°N) and central (between 88°N and 93°N) Gulf. The August and September CSSP sampling efforts match up with the timing of the annual SEFSC BLL sampling within those areas.

Data from 2020 were not included as sampling was extremely limited due to restrictions in vessel time due to the COVID pandemic and adverse weather conditions (see Appendix Figure 1).

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for sandbar sharks (Bradu and Mundlak 1970, Pennington 1983). 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 (*cf.* Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) 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 using the delta method approximation

(4) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y).$$

A covariance term is not included in the variance estimator since there is no correlation between the estimator of the proportion positive and the mean CPUE given presence. The two estimators are derived independently and have been shown to not covary for a given year (Christman, unpublished).

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: 1995 – 1997, 1999 – 2019, 2021 – 2025
Region: Atlantic, West Gulf (west of 93°N), Central Gulf (between 88°N and 93°N), East Gulf (east of 88°N)
Depth: Continuous (9 – 183 m)
Hook: Circle Hook, J Hook
Time of Day: Day, Night – defined by time at the start of soak relative to time of local sunrise and sunset

Retrospective Analysis

Once the final delta-lognormal model was selected we performed a retrospective analysis where one year of data was removed starting at the terminal year and working backwards five years (2021 – 2025).

Results and Discussion

Spatial Distribution, Size and Age

The spatial distribution of sandbar sharks is presented in Figure 1 for the SEFSC BLL survey, with annual abundance and distribution presented in Appendix Figure 1. Annual catch and length summaries are presented in Table 2. Length distribution for the SEFSC BLL indices is presented in Figure 3, with annual plots presented in Figure 4. Both figures include both measured and estimated lengths.

Abundance Index

For the SEFSC BLL abundance index of sandbar sharks, year, depth, region and time of day were retained in the binomial submodel, while year and time of day were retained in the lognormal submodel. 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 4874.09 and 2001.10, respectively. The diagnostic plots for binomial and lognormal submodels are shown in Figures 4 and 5. Annual abundance indices are presented in Table 4 and Figure 6.

Retrospective Analysis

The results of the retrospective analysis are presented in Figure 7 and shows no significant changes when one of the last five years of data was dropped from the final model run. Results from each individual model run are shown in Appendix Tables 2 – 6.

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Table 1. Summary of the total number of SEFSC Bottom Longline Survey stations available for analysis by region per year. Note that stations with depths > 183 m (183 – 366 m depth strata) have been removed.

Year	Gulf of America			Atlantic	Total
	West Gulf	Central Gulf	East Gulf		
1995	13	25	34	30	102
1996	15	25	35	30	105
1997	70	32	60	64	226
1998	0	0	0	0	0
1999	0	104	57	0	161
2000	22	50	60	100	232
2001	77	56	113	0	246
2002	93	67	38	165	363
2003	60	50	141	0	251
2004	50	55	121	40	266
2005	0	12	66	26	104
2006	43	32	53	56	184
2007	42	32	58	0	132
2008	21	3	64	37	125
2009	46	38	77	30	191
2010	25	26	75	21	147
2011	52	39	147	49	287
2012	28	30	62	41	161
2013	39	37	61	35	172
2014	25	26	50	45	146
2015	35	28	72	43	178
2016	34	26	73	47	180
2017	46	27	55	40	168
2018	34	32	62	41	169
2019	31	21	50	49	151
2020	0	0	36	0	36
2021	22	22	48	45	137
2022	30	24	56	45	155
2023	34	24	56	44	158
2024	28	26	62	47	163
2025	51	34	63	45	193
Total	1066	1003	2005	1215	5289

Table 2. Summary of the length data for sandbar sharks collected from SEFSC Bottom Longline Survey conducted between 1995 and 2025 in the western North Atlantic Ocean, including the Gulf of America. Note that 2020 data was not used in the relative abundance index, but presented here for comparison.

Survey Year	Number of Stations	Number Collected	Number Measured	Number Estimated	Minimum Fork Length (cm)	Maximum Fork Length (cm)	Mean Fork Length (cm)	Standard Deviation
1995	102	24	21	3	85.0	183.0	140.3	29.0
1996	105	12	6	5	125.0	204.0	157.7	20.7
1997	226	59	2	57	110.0	175.0	141.2	16.8
1998								
1999	161	11	11	0	100.0	188.4	143.2	27.3
2000	232	31	10	21	91.5	167.6	132.7	18.5
2001	246	53	4	49	57.3	184.3	140.3	22.6
2002	363	59	28	31	84.4	209.3	148.8	24.8
2003	251	45	6	39	55.3	188.4	134.9	26.0
2004	266	41	16	25	76.0	220.0	145.1	32.6
2005	104	15	14	0	89.7	169.0	151.6	19.7
2006	184	16	12	4	90.5	200.9	147.7	28.0
2007	132	27	21	6	120.0	225.0	157.6	23.1
2008	125	23	17	6	119.5	163.0	142.8	12.2
2009	191	82	66	15	54.5	209.3	148.9	21.1
2010	147	93	50	43	74.0	200.0	146.7	21.8
2011	287	131	85	46	97.5	204.0	151.6	18.2
2012	161	114	94	20	73.5	215.9	151.7	15.9
2013	172	91	62	29	57.5	187.0	152.2	16.4
2014	146	76	52	23	75.5	200.0	156.9	18.2
2015	178	161	142	19	75.6	200.0	152.2	22.4
2016	180	84	66	17	114.5	184.0	160.4	14.1
2017	168	106	93	13	58.0	195.0	157.3	20.8
2018	169	96	80	15	72.2	195.4	156.9	17.1
2019	151	132	115	17	50.0	196.4	158.0	19.2
2020	36	17	16	1	130	178.0	160.1	12.1
2021	137	98	80	18	71.0	220.0	162.2	20.4
2022	155	83	69	14	122.1	182.2	158.9	10.2
2023	158	117	93	24	100.0	200.0	161.7	14.0
2024	163	111	90	21	125.0	187.0	163.4	10.3
2025	193	102	87	15	124.2	204.0	164.6	12.5

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Total Number Estimated	Overall Mean Fork Length (cm)
30	5289	2110	1508	596	151.6

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for sandbar shark index of relative abundance from 1995 to 2025.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 4876.07)*						*Lognormal Submodel Type 3 Tests (AIC 2031.11)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	28	5218	215.87	7.71	<.0001	<.0001	28	1013	1.93	0.0026
Depth	1	5218	13.59	13.59	0.0002	0.0002	1	1013	3.24	0.0722
Hook	1	5218	0.03	0.03	0.8677	0.8678	1	1013	0.14	0.7110
Region	3	5218	86.15	28.72	<.0001	<.0001	3	1013	1.14	0.3338
Time of Day	1	5218	9.24	9.24	0.0024	0.0024	1	1013	12.12	0.0005
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 4874.09)*						*Lognormal Submodel Type 3 Tests (AIC 2027.94)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	28	5219	268.62	9.59	<.0001	<.0001	28	1014	2.14	0.0005
Depth	1	5219	13.60	13.60	0.0002	0.0002	1	1014	3.25	0.0718
Hook				Dropped				Dropped		
Region	3	5219	86.93	28.98	<.0001	<.0001	3	1014	1.12	0.3417
Time of Day	1	5219	9.24	9.24	0.0024	0.0024	1	1014	12.08	0.0005
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 4874.09)*						*Lognormal Submodel Type 3 Tests (AIC 2013.27)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	28	5219	268.62	9.59	<.0001	<.0001	28	1017	2.15	0.0005
Depth	1	5219	13.60	13.60	0.0002	0.0002	1	1017	2.55	0.1107
Hook				Dropped				Dropped		
Region	3	5219	86.93	28.98	<.0001	<.0001		Dropped		
Time of Day	1	5219	9.24	9.24	0.0024	0.0024	1	1017	12.51	0.0004
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 4874.09)*						*Lognormal Submodel Type 3 Tests (AIC 2001.10)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	28	5219	268.62	9.59	<.0001	<.0001	28	1018	2.14	0.0006
Depth	1	5219	13.60	13.60	0.0002	0.0002		Dropped		
Hook				Dropped				Dropped		
Region	3	5219	86.93	28.98	<.0001	<.0001		Dropped		
Time of Day	1	5219	9.24	9.24	0.0024	0.0024	1	1018	12.44	0.0004

Table 4. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 – 2025. 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 (Scaled Index), 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	0.15686	102	0.21323	0.58865	0.27945	0.34016	1.01868
1996	0.08571	105	0.11031	0.30452	0.38131	0.14574	0.63627
1997	0.10177	226	0.20207	0.55784	0.23731	0.34931	0.89088
1998	.	.	.	.	.	.	.
1999	0.06211	161	0.09931	0.27417	0.36092	0.13617	0.55203
2000	0.09052	232	0.11495	0.31734	0.25151	0.19338	0.52077
2001	0.12195	246	0.21160	0.58415	0.20650	0.38818	0.87907
2002	0.10744	363	0.14250	0.39338	0.18539	0.27236	0.56818
2003	0.11952	251	0.17217	0.47529	0.20851	0.31461	0.71803
2004	0.10902	266	0.14432	0.39840	0.21277	0.26155	0.60686
2005	0.09615	104	0.11030	0.30449	0.36576	0.14990	0.61852
2006	0.06522	184	0.08283	0.22867	0.33312	0.11952	0.43750
2007	0.10606	132	0.21904	0.60470	0.30284	0.33438	1.09352
2008	0.13600	125	0.16216	0.44767	0.27640	0.26019	0.77026
2009	0.23560	191	0.40359	1.11416	0.16255	0.80663	1.53893
2010	0.26531	147	0.48426	1.33687	0.17381	0.94676	1.88772
2011	0.21603	287	0.37335	1.03069	0.14194	0.77706	1.36709
2012	0.34161	161	0.61096	1.68665	0.14248	1.27025	2.23955
2013	0.22093	172	0.41016	1.13231	0.17775	0.79574	1.61123
2014	0.23973	146	0.44566	1.23031	0.18650	0.84996	1.78085
2015	0.34831	178	0.71919	1.98541	0.13335	1.52243	2.58920
2016	0.26667	180	0.40853	1.12779	0.15719	0.82515	1.54144
2017	0.25595	168	0.56264	1.55324	0.16499	1.11916	2.15568
2018	0.28402	169	0.49407	1.36395	0.15542	1.00140	1.85778
2019	0.35099	151	0.75101	2.07327	0.14456	1.55503	2.76423
2020	.	.	.	.	.	.	.
2021	0.30657	137	0.58261	1.60837	0.16603	1.15653	2.23673
2022	0.32903	155	0.49985	1.37992	0.14923	1.02553	1.85676
2023	0.36076	158	0.68454	1.88977	0.13862	1.43409	2.49023
2024	0.33129	163	0.61035	1.68496	0.14510	1.26244	2.24888
2025	0.29016	193	0.47926	1.32307	0.14278	0.99585	1.75781

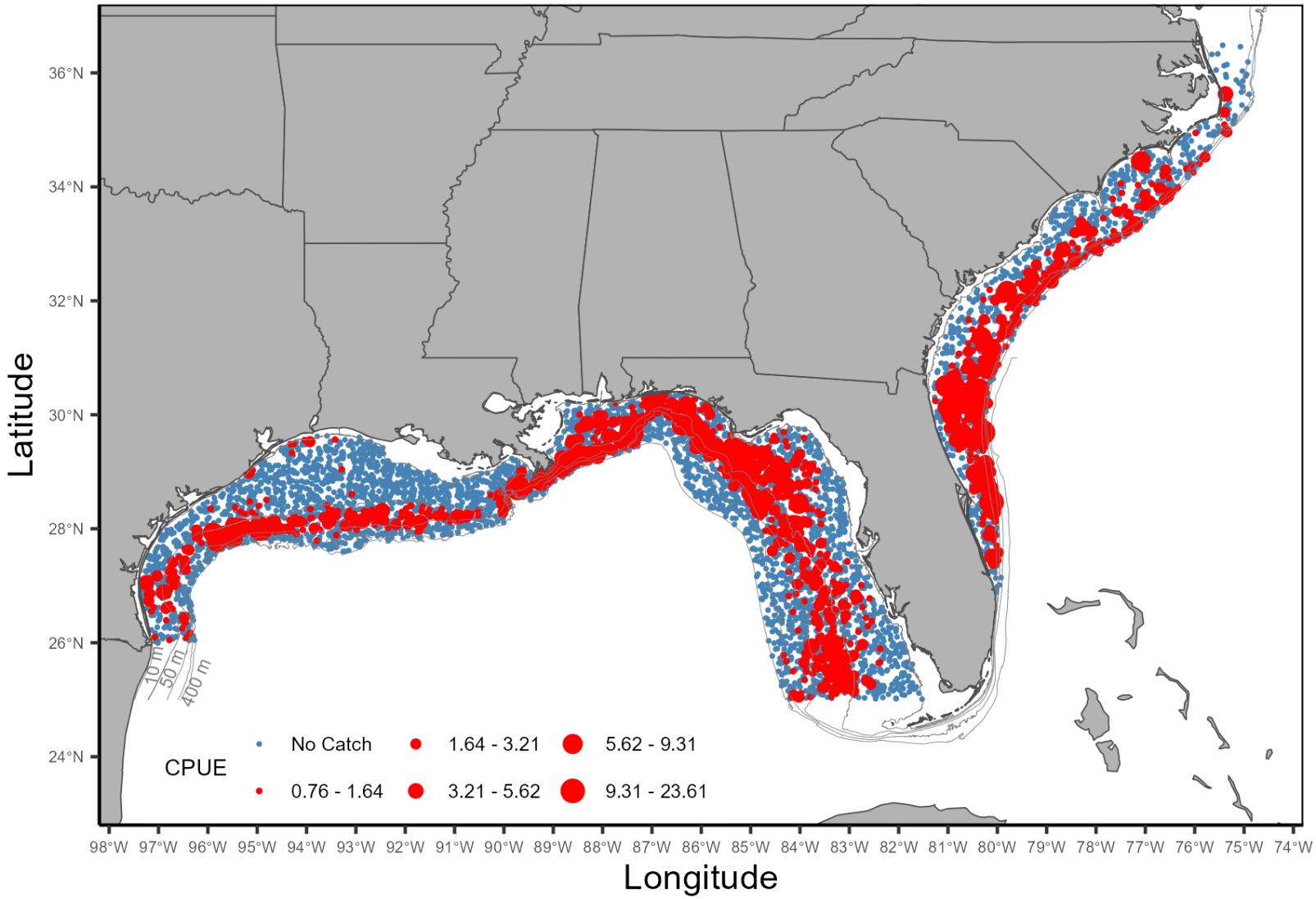


Figure 1. Stations sampled from 1995 to 2025 during the SEFSC Bottom Longline Survey with the catch per unit effort (CPUE, number per 100 hook hour) for sandbar sharks. Stations is the 183 – 366 m depth stratum in the Gulf of America have been included, but no used for the relative abundance index.

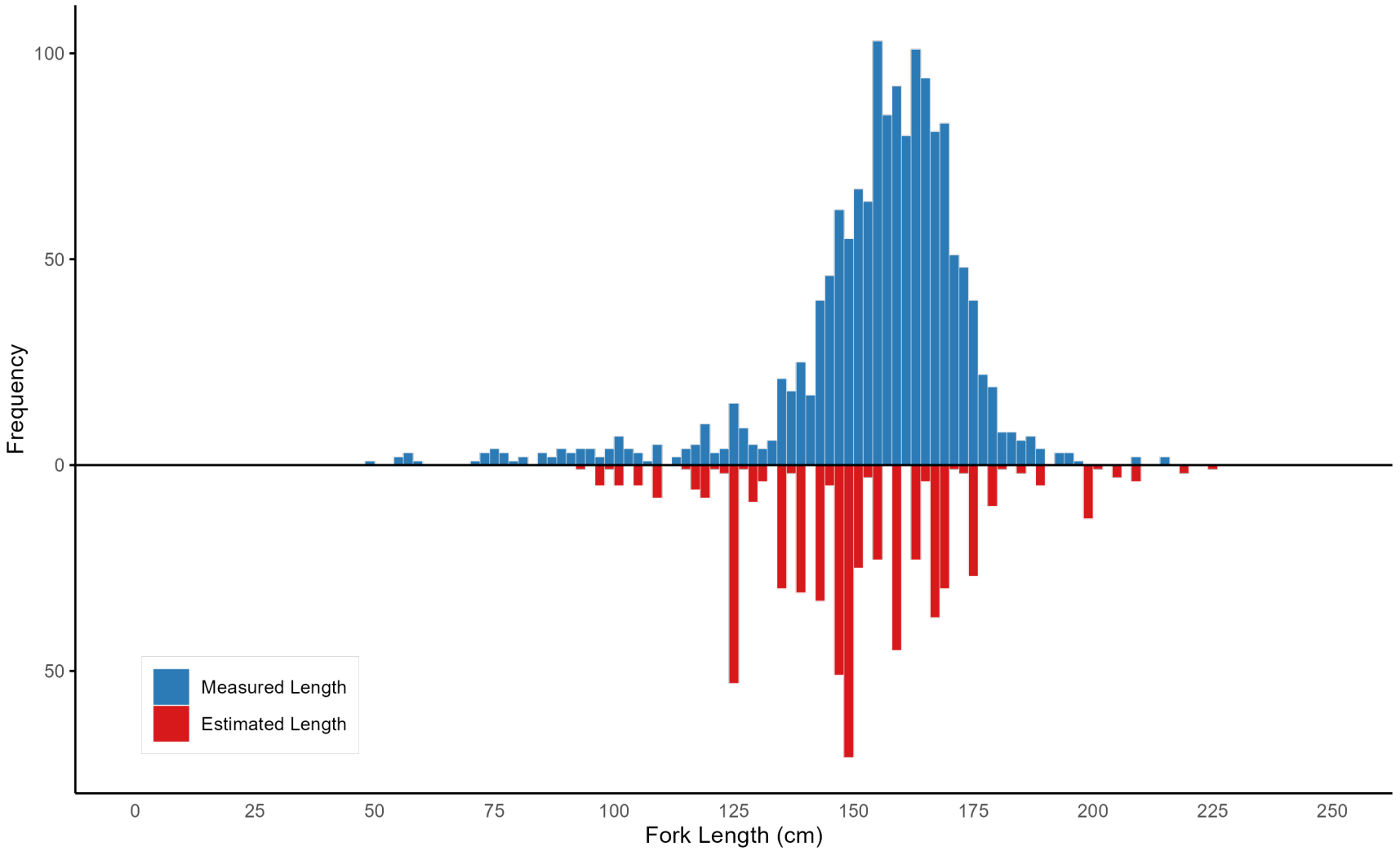


Figure 2. Length frequency histogram for sandbar sharks captured during the SEFSC Bottom Longline Survey from 1995 to 2025, including both measured and estimated lengths. Note that 2020 was not included as to show the distribution of lengths for sharks included in the relative abundance index.

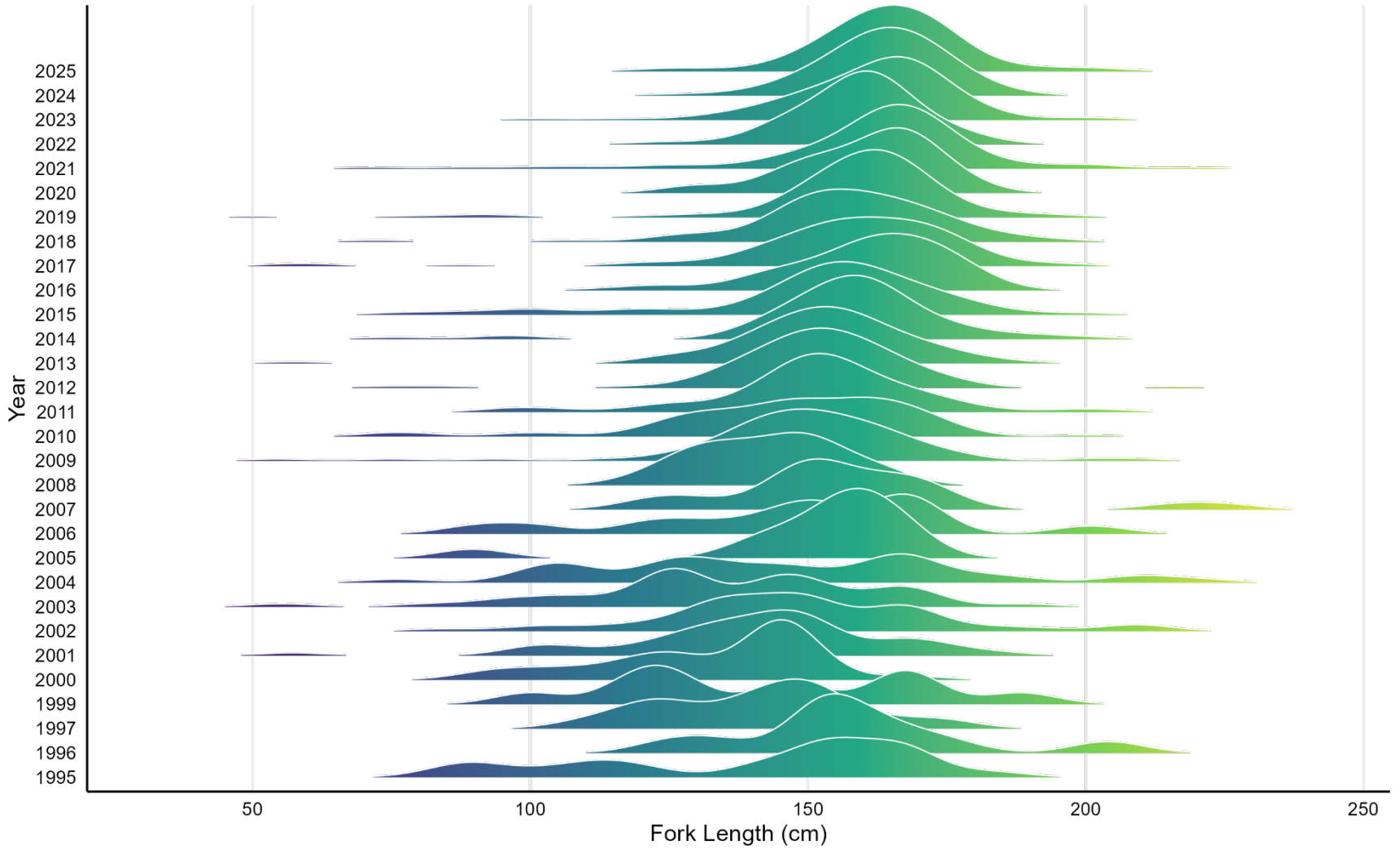


Figure 3. Annual length-frequency distributions of sandbar sharks from 1995 to 2025. Ridgeline densities represent fork length (cm) measurements collected during the SEFSC Bottom Longline Survey. The shaded gradient corresponds to fork length, and distributions are normalized to a joint bandwidth (bw = 6.37) to facilitate year-to-year comparison. Note that 2020 data was not used in the relative abundance index, but presented here for comparison.

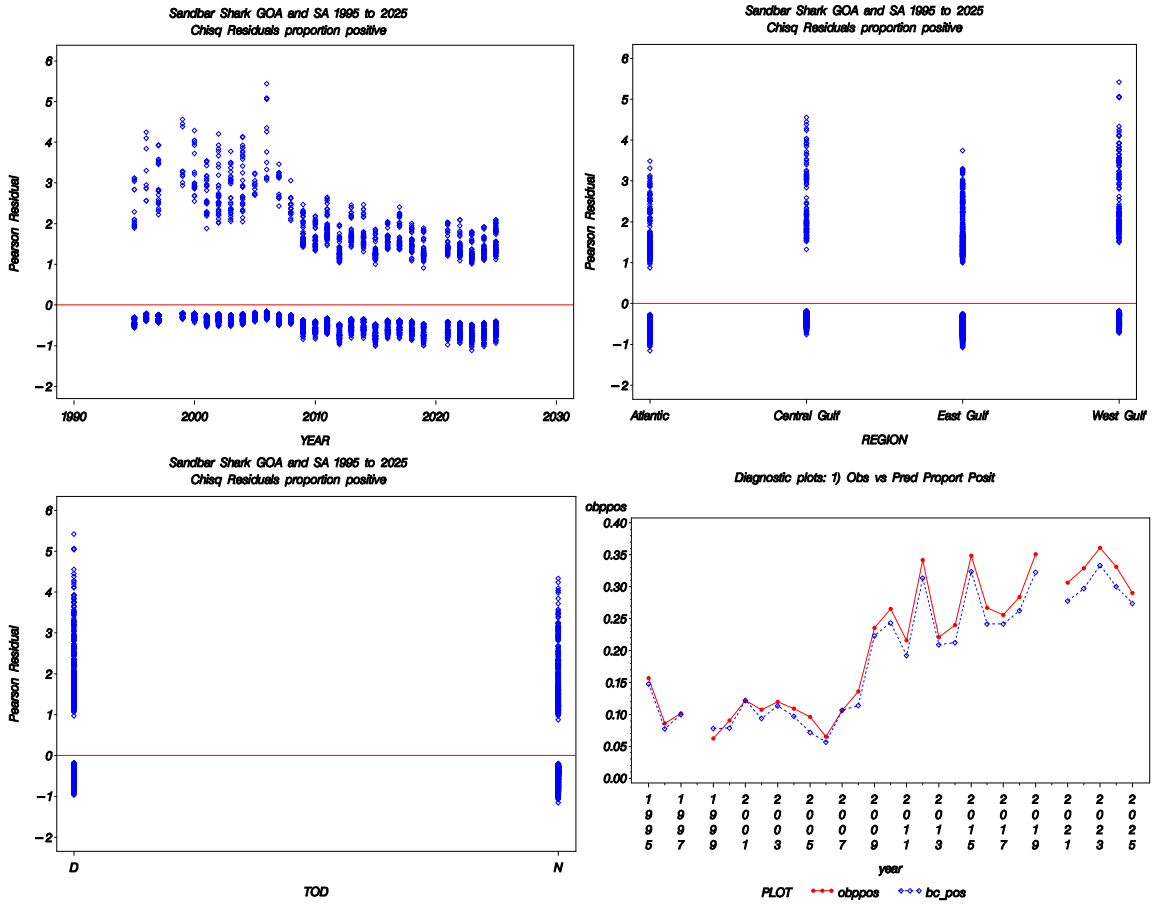


Figure 4. Diagnostic plots for binomial component of the sandbar shark SEFSC Bottom Longline Surveys model.

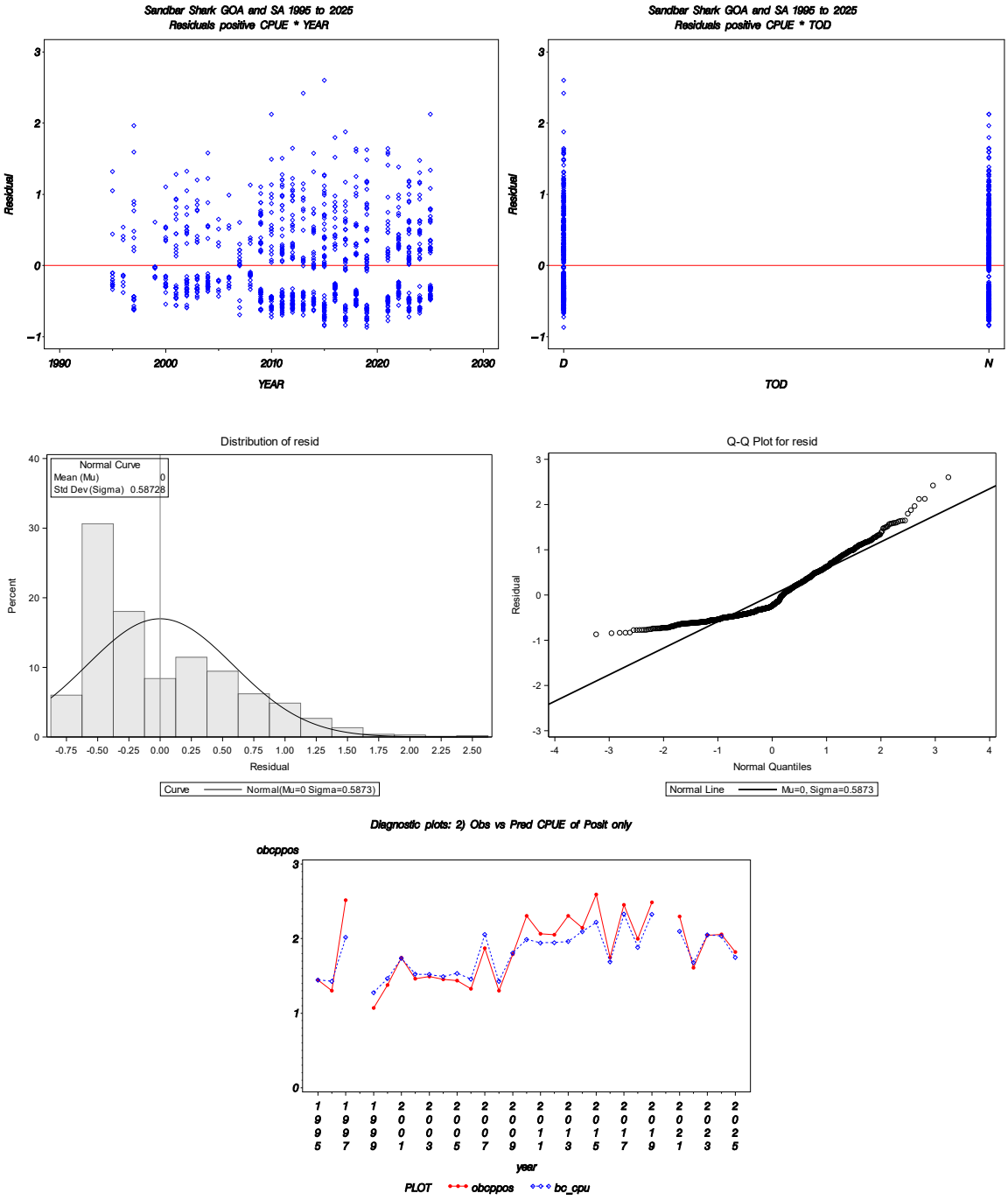


Figure 5. Diagnostic plots for lognormal component of the sandbar shark SEFSC Bottom Longline Surveys model.

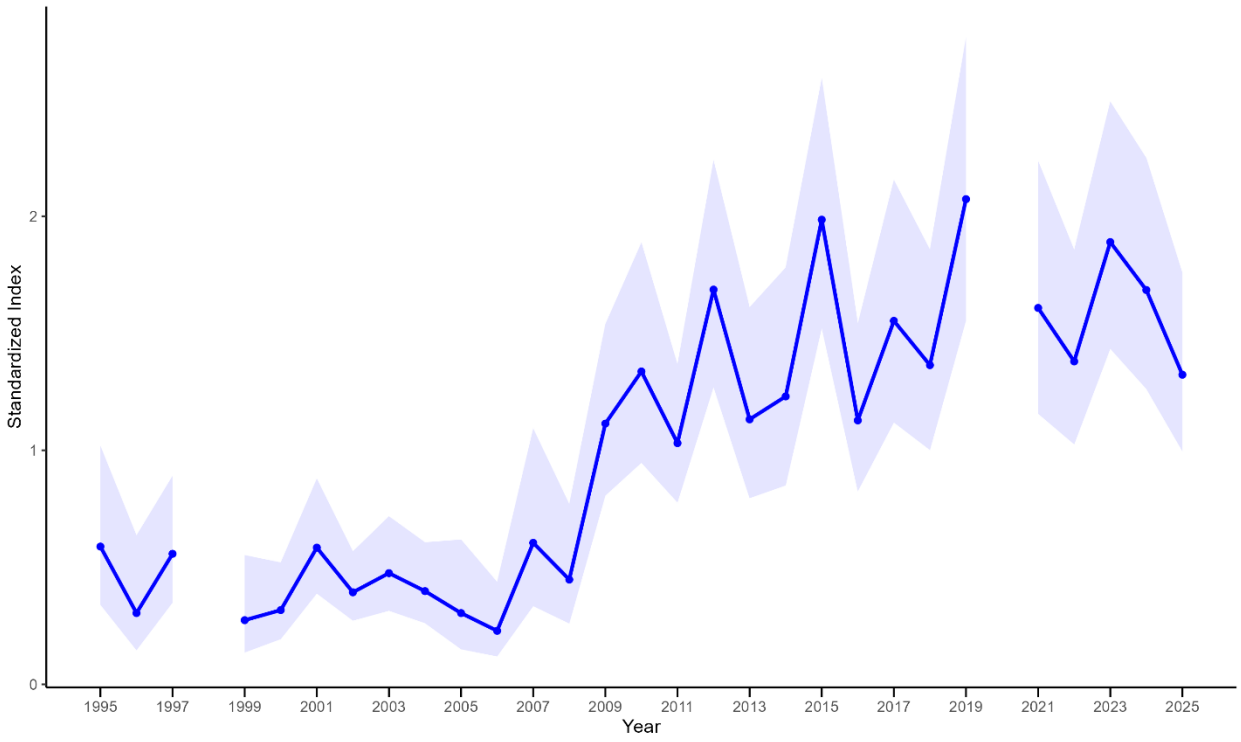


Figure 6. Annual index of abundance (blue line) and 95% confidence interval (shaded area) for sandbar sharks from the SEFSC Bottom Longline Surveys from 1995 – 2025.

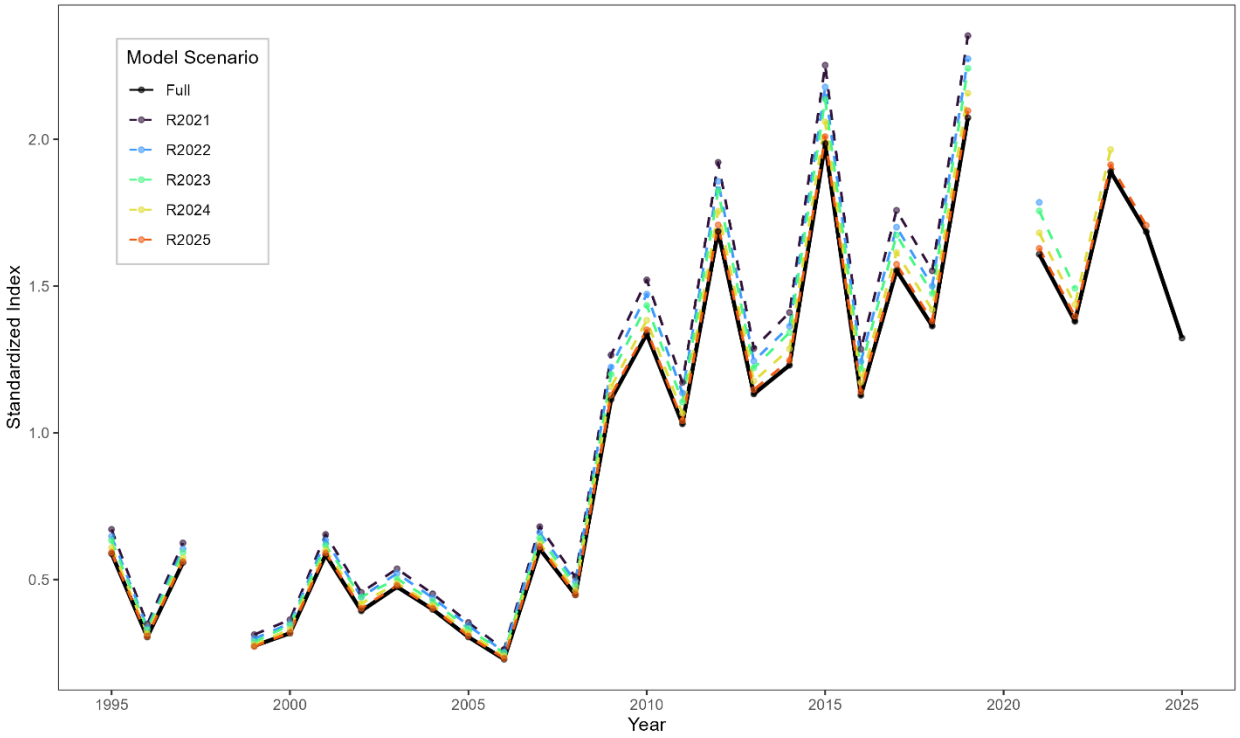


Figure 7. Retrospective analysis of the annual index of abundance (black line) and models with an increasing number of years removed (2021 – 2025, dashed lines) for sandbar sharks from the SEFSC Bottom Longline Surveys from 1995 – 2025.

Appendix

Appendix Table 1. Summary of the factors used in constructing the sandbar shark abundance index from the SEFSC Bottom Longline Survey data for the western North Atlantic Ocean, including the Gulf of America. Note the year 2020 were excluded from the index due to limited spatial coverage and no data were collected in 1998.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	1995	102	16	0.15686	0.22666
Year	1996	105	9	0.08571	0.11149
Year	1997	226	23	0.10177	0.25600
Year	1998				
Year	1999	161	10	0.06211	0.06656
Year	2000	232	21	0.09052	0.12470
Year	2001	246	30	0.12195	0.21275
Year	2002	363	39	0.10744	0.15721
Year	2003	251	30	0.11952	0.17832
Year	2004	266	29	0.10902	0.15847
Year	2005	104	10	0.09615	0.13830
Year	2006	184	12	0.06522	0.08652
Year	2007	132	14	0.10606	0.19864
Year	2008	125	17	0.13600	0.17691
Year	2009	191	45	0.23560	0.42149
Year	2010	147	39	0.26531	0.61179
Year	2011	287	62	0.21603	0.44606
Year	2012	161	55	0.34161	0.70052
Year	2013	172	38	0.22093	0.50952
Year	2014	146	35	0.23973	0.51403
Year	2015	178	62	0.34831	0.90238
Year	2016	180	48	0.26667	0.46606
Year	2017	168	43	0.25595	0.62829
Year	2018	169	48	0.28402	0.56727
Year	2019	151	53	0.35099	0.87354
Year	2020				
Year	2021	137	42	0.30657	0.70466
Year	2022	155	51	0.32903	0.53016
Year	2023	158	57	0.36076	0.73753
Year	2024	163	54	0.33129	0.68200
Year	2025	193	56	0.29016	0.52861

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Region	Atlantic	1215	312	0.25679	0.52350
Region	West Gulf	1066	146	0.13696	0.24714
Region	Central Gulf	1003	126	0.12562	0.27235
Region	East Gulf	1969	464	0.23565	0.45445
Hook	Circle Hook	4524	981	0.21684	0.43133
Hook	J Hook	729	67	0.09191	0.15933
Time of Day	Day	2920	535	0.18322	0.33623
Time of Day	Night	2333	513	0.21989	0.46537

Appendix Table 2. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 -2025, with 2025 removed for retrospective analysis. 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 (Scaled Index), 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	0.15686	102	0.21173	0.59195	0.28043	0.34143	1.0263
1996	0.08571	105	0.10987	0.30717	0.38234	0.14674	0.64301
1997	0.10177	226	0.20082	0.56145	0.23811	0.35102	0.89803
1998			.	.	.	.	.
1999	0.06211	161	0.09735	0.27216	0.36237	0.13481	0.54944
2000	0.09052	232	0.11429	0.31952	0.2523	0.19441	0.52514
2001	0.12195	246	0.21118	0.59043	0.20718	0.39184	0.88968
2002	0.10744	363	0.14374	0.40187	0.18577	0.27803	0.58086
2003	0.11952	251	0.17175	0.48018	0.20925	0.31739	0.72646
2004	0.10902	266	0.14383	0.40213	0.2134	0.26367	0.61329
2005	0.09615	104	0.11013	0.3079	0.36669	0.15132	0.62649
2006	0.06522	184	0.08289	0.23174	0.33386	0.12096	0.44399
2007	0.10606	132	0.21922	0.61289	0.30363	0.33841	1.10999
2008	0.13600	125	0.16087	0.44977	0.27735	0.26094	0.77526
2009	0.23560	191	0.40373	1.12875	0.16302	0.81644	1.56052
2010	0.26531	147	0.48323	1.35102	0.17448	0.95553	1.91021
2011	0.21603	287	0.3723	1.0409	0.1425	0.78389	1.38216
2012	0.34161	161	0.61105	1.7084	0.14294	1.28546	2.27048
2013	0.22093	172	0.41033	1.1472	0.17824	0.80543	1.63399
2014	0.23973	146	0.446	1.24693	0.18698	0.86065	1.80658
2015	0.34831	178	0.71861	2.00911	0.13385	1.53907	2.6227
2016	0.26667	180	0.40786	1.1403	0.15772	0.83343	1.56017
2017	0.25595	168	0.56304	1.57415	0.16545	1.13321	2.18667
2018	0.28402	169	0.49401	1.38117	0.15588	1.01312	1.88293
2019	0.35099	151	0.7501	2.09716	0.14503	1.5715	2.79864
2020			.	.	.	.	.
2021	0.30657	137	0.58242	1.62835	0.16648	1.16986	2.26653
2022	0.32903	155	0.49984	1.39748	0.14969	1.03763	1.88212
2023	0.36076	158	0.68431	1.91322	0.13907	1.4506	2.52338
2024	0.33129	163	0.61044	1.70669	0.1455	1.27772	2.27966
2025				Removed			

Appendix Table 3. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 - 2023, with 2024 - 2025 removed for retrospective analysis. 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 (Scaled Index), 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	0.15686	102	0.21258	0.60899	0.28007	0.35149	1.05512
1996	0.08571	105	0.11042	0.31634	0.38188	0.15124	0.66165
1997	0.10177	226	0.20036	0.57398	0.23795	0.35897	0.91778
1998			.	.	.	.	.
1999	0.06211	161	0.09708	0.27812	0.36249	0.13773	0.56158
2000	0.09052	232	0.11529	0.33028	0.25199	0.20108	0.54249
2001	0.12195	246	0.20953	0.60026	0.20725	0.3983	0.90461
2002	0.10744	363	0.14606	0.41842	0.18537	0.2897	0.60432
2003	0.11952	251	0.17042	0.4882	0.2093	0.32266	0.73868
2004	0.10902	266	0.14401	0.41255	0.21326	0.27058	0.62901
2005	0.09615	104	0.11098	0.31794	0.36632	0.15636	0.64649
2006	0.06522	184	0.08367	0.23971	0.33345	0.12521	0.45889
2007	0.10606	132	0.21758	0.62332	0.30356	0.34421	1.12872
2008	0.13600	125	0.1614	0.46239	0.27712	0.26837	0.79666
2009	0.23560	191	0.4038	1.15681	0.16285	0.83702	1.59876
2010	0.26531	147	0.48298	1.38363	0.17439	0.97878	1.95594
2011	0.21603	287	0.37236	1.06672	0.14243	0.80345	1.41625
2012	0.34161	161	0.6127	1.75525	0.14265	1.32148	2.33141
2013	0.22093	172	0.41064	1.1764	0.17798	0.82636	1.67472
2014	0.23973	146	0.44886	1.28589	0.18653	0.88832	1.86139
2015	0.34831	178	0.71884	2.05933	0.13367	1.5781	2.68729
2016	0.26667	180	0.40914	1.1721	0.15747	0.8571	1.60288
2017	0.25595	168	0.5635	1.61432	0.16521	1.16267	2.2414
2018	0.28402	169	0.49539	1.4192	0.15561	1.04158	1.93372
2019	0.35099	151	0.753	2.15718	0.14471	1.61749	2.87693
2020			.	.	.	.	.
2021	0.30657	137	0.58686	1.68124	0.16601	1.20896	2.33801
2022	0.32903	155	0.5014	1.43641	0.14939	1.06717	1.93342
2023	0.36076	158	0.68593	1.96505	0.13881	1.49066	2.5904
2024				Removed			
2025				Removed			

Appendix Table 4. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 - 2022, with 2023 - 2025 removed for retrospective analysis. 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 (Scaled Index), 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	0.15686	102	0.21351	0.63326	0.28016	0.36544	1.09735
1996	0.08571	105	0.11109	0.32948	0.38198	0.1575	0.68925
1997	0.10177	226	0.19978	0.59255	0.2382	0.3704	0.94793
1998			.	.	.	.	.
1999	0.06211	161	0.097	0.28769	0.363	0.14234	0.58145
2000	0.09052	232	0.11631	0.34498	0.25208	0.20999	0.56674
2001	0.12195	246	0.20792	0.6167	0.20766	0.40888	0.93014
2002	0.10744	363	0.1487	0.44103	0.18518	0.30547	0.63674
2003	0.11952	251	0.16948	0.50268	0.20969	0.33198	0.76114
2004	0.10902	266	0.14405	0.42726	0.21346	0.28012	0.65169
2005	0.09615	104	0.11208	0.33241	0.36645	0.16344	0.67608
2006	0.06522	184	0.08438	0.25026	0.33348	0.13072	0.47912
2007	0.10606	132	0.21636	0.64172	0.30394	0.35413	1.16288
2008	0.13600	125	0.16161	0.47934	0.27734	0.2781	0.8262
2009	0.23560	191	0.40447	1.19966	0.16293	0.86789	1.65825
2010	0.26531	147	0.48352	1.43409	0.17458	1.01409	2.02805
2011	0.21603	287	0.37265	1.10527	0.14261	0.83218	1.46796
2012	0.34161	161	0.61533	1.82505	0.1426	1.37415	2.42391
2013	0.22093	172	0.41178	1.22132	0.178	0.85789	1.73872
2014	0.23973	146	0.45232	1.34158	0.18637	0.92708	1.94141
2015	0.34831	178	0.7202	2.13608	0.13374	1.63669	2.78785
2016	0.26667	180	0.41075	1.21827	0.15747	0.89084	1.66604
2017	0.25595	168	0.56443	1.67408	0.16526	1.2056	2.32461
2018	0.28402	169	0.49728	1.47493	0.15559	1.0825	2.0096
2019	0.35099	151	0.75582	2.24174	0.14465	1.68109	2.98938
2020			.	.	.	.	.
2021	0.30657	137	0.59207	1.75606	0.16575	1.26341	2.44083
2022	0.32903	155	0.50321	1.49252	0.14938	1.10888	2.00888
2023				Removed			
2024				Removed			
2025				Removed			

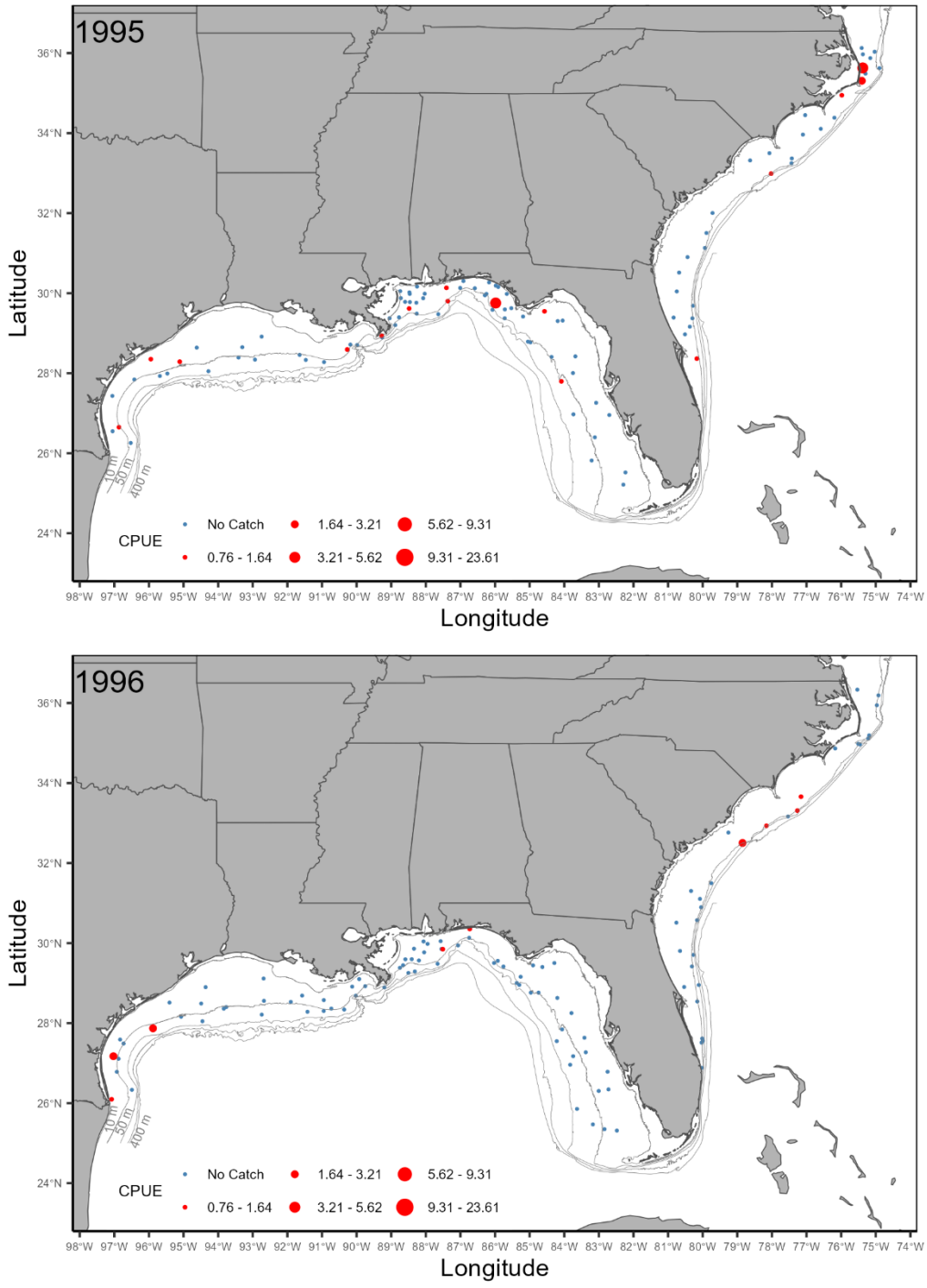
Appendix Table 5. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 - 2021, with 2022 - 2025 removed for retrospective analysis. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series (Scaled Index), the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

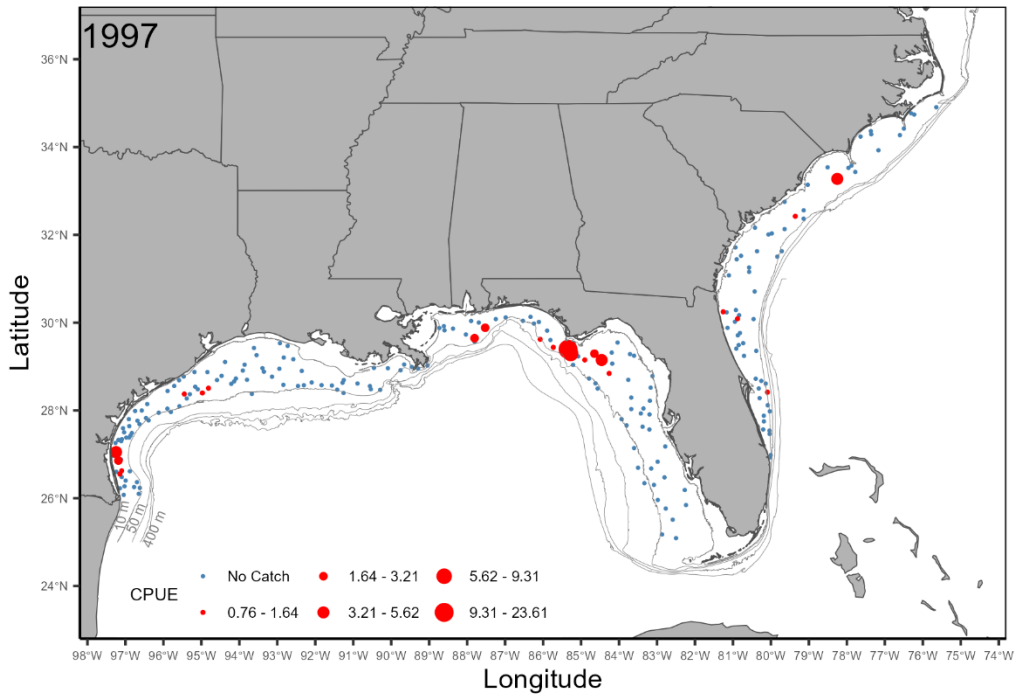
Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1995	0.15686	102	0.21707	0.64745	0.28037	0.37348	1.12239
1996	0.08571	105	0.11271	0.33619	0.3826	0.16052	0.70408
1997	0.10177	226	0.20274	0.60471	0.23861	0.37771	0.96815
1998			.	.	.	.	.
1999	0.06211	161	0.10014	0.29869	0.36324	0.14772	0.60395
2000	0.09052	232	0.11752	0.35053	0.25269	0.21312	0.57653
2001	0.12195	246	0.21264	0.63426	0.20771	0.42049	0.95671
2002	0.10744	363	0.14758	0.44019	0.18602	0.3044	0.63656
2003	0.11952	251	0.17476	0.52125	0.20967	0.34426	0.78924
2004	0.10902	266	0.1468	0.43786	0.21367	0.28696	0.66813
2005	0.09615	104	0.11521	0.34364	0.36687	0.16883	0.69945
2006	0.06522	184	0.08491	0.25327	0.33419	0.13212	0.48553
2007	0.10606	132	0.22118	0.65973	0.3041	0.36395	1.19588
2008	0.13600	125	0.16549	0.4936	0.27749	0.28629	0.85103
2009	0.23560	191	0.41042	1.22418	0.16297	0.88556	1.69229
2010	0.26531	147	0.49366	1.47247	0.17434	1.04171	2.08136
2011	0.21603	287	0.38078	1.13577	0.14253	0.85529	1.50825
2012	0.34161	161	0.6225	1.85676	0.14269	1.39778	2.46647
2013	0.22093	172	0.4173	1.2447	0.17813	0.87407	1.77249
2014	0.23973	146	0.45691	1.36284	0.18668	0.94119	1.97338
2015	0.34831	178	0.73029	2.17827	0.13372	1.66908	2.84281
2016	0.26667	180	0.4168	1.24321	0.15751	0.90901	1.70028
2017	0.25595	168	0.57019	1.70073	0.16546	1.2243	2.36256
2018	0.28402	169	0.50295	1.50018	0.15573	1.10074	2.04455
2019	0.35099	151	0.76252	2.27438	0.14485	1.70492	3.03405
2020			.	.	.	.	.
2021	0.30657	137	0.59848	1.78512	0.16592	1.28389	2.48203
2022				Removed			
2023				Removed			
2024				Removed			
2025				Removed			

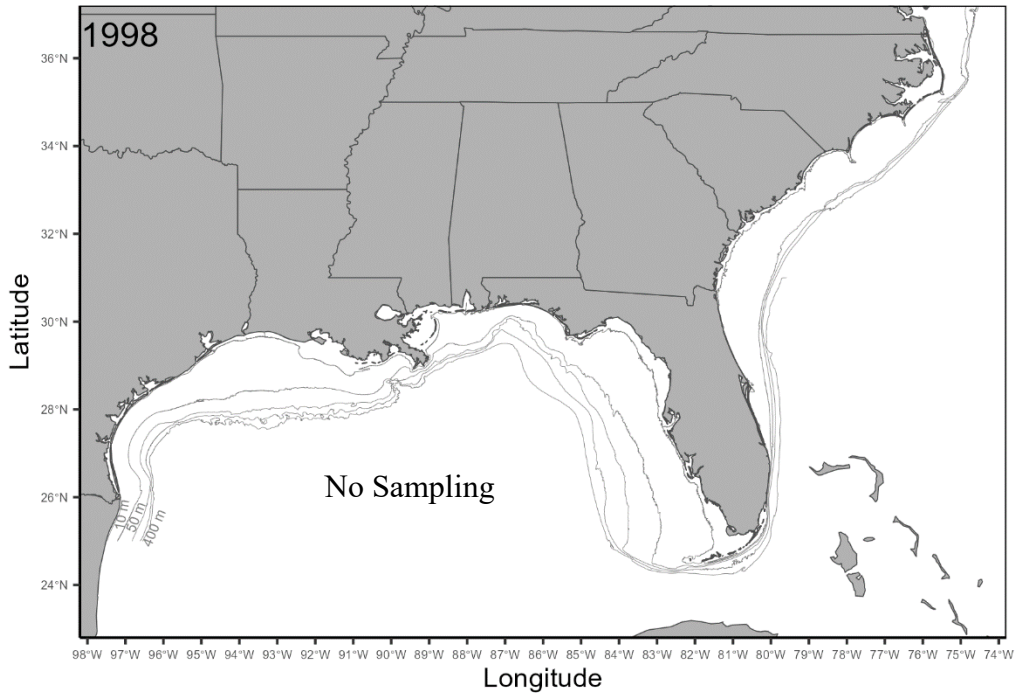
Appendix Table 6. Indices of sandbar shark abundance developed using the delta-lognormal (DL) model for 1995 -2019, with 2021 - 2025 removed for retrospective analysis. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series (Scaled Index), the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

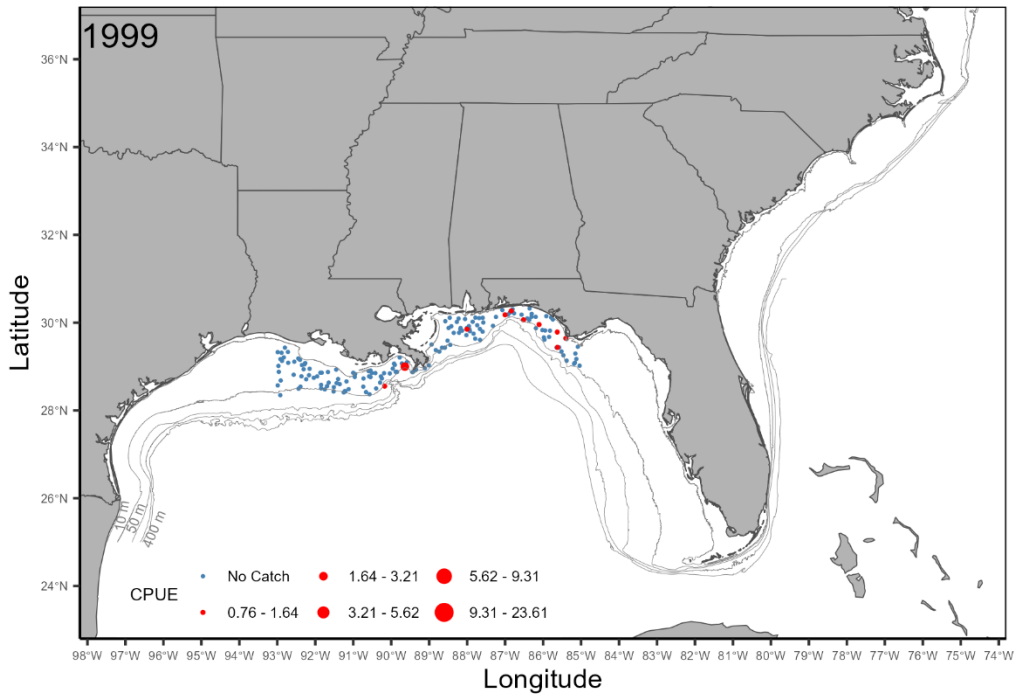
Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1995	0.15686	102	0.21639	0.67097	0.28005	0.38729	1.16245
1996	0.08571	105	0.11224	0.34803	0.38214	0.16632	0.72827
1997	0.10177	226	0.20151	0.62485	0.2384	0.39044	1
1998			.	.	.	.	.
1999	0.06211	161	0.10081	0.31258	0.36275	0.15473	0.63148
2000	0.09052	232	0.11713	0.36319	0.25245	0.22092	0.59709
2001	0.12195	246	0.21083	0.65373	0.20769	0.43342	0.98604
2002	0.10744	363	0.14719	0.45641	0.18594	0.31566	0.65991
2003	0.11952	251	0.17311	0.53678	0.20969	0.35451	0.81278
2004	0.10902	266	0.14563	0.45157	0.21358	0.29599	0.68892
2005	0.09615	104	0.11413	0.3539	0.36663	0.17395	0.72003
2006	0.06522	184	0.08441	0.26174	0.33381	0.13663	0.50142
2007	0.10606	132	0.21939	0.68027	0.30394	0.3754	1.23273
2008	0.13600	125	0.16395	0.50837	0.27733	0.29494	0.87624
2009	0.23560	191	0.40811	1.26547	0.16289	0.91558	1.74907
2010	0.26531	147	0.49051	1.52098	0.17432	1.07608	2.14982
2011	0.21603	287	0.37779	1.17145	0.14258	0.88207	1.55577
2012	0.34161	161	0.61968	1.9215	0.14261	1.44675	2.55203
2013	0.22093	172	0.41522	1.28753	0.17799	0.90439	1.83297
2014	0.23973	146	0.4547	1.40994	0.18656	0.97395	2.0411
2015	0.34831	178	0.72645	2.25257	0.13367	1.72618	2.93948
2016	0.26667	180	0.41443	1.28507	0.15745	0.93974	1.75731
2017	0.25595	168	0.56695	1.758	0.16536	1.26578	2.44164
2018	0.28402	169	0.50051	1.55197	0.15564	1.13895	2.11476
2019	0.35099	151	0.75887	2.35311	0.14477	1.7642	3.13861
2020							
2021				Removed			
2022				Removed			
2023				Removed			
2024				Removed			
2025				Removed			

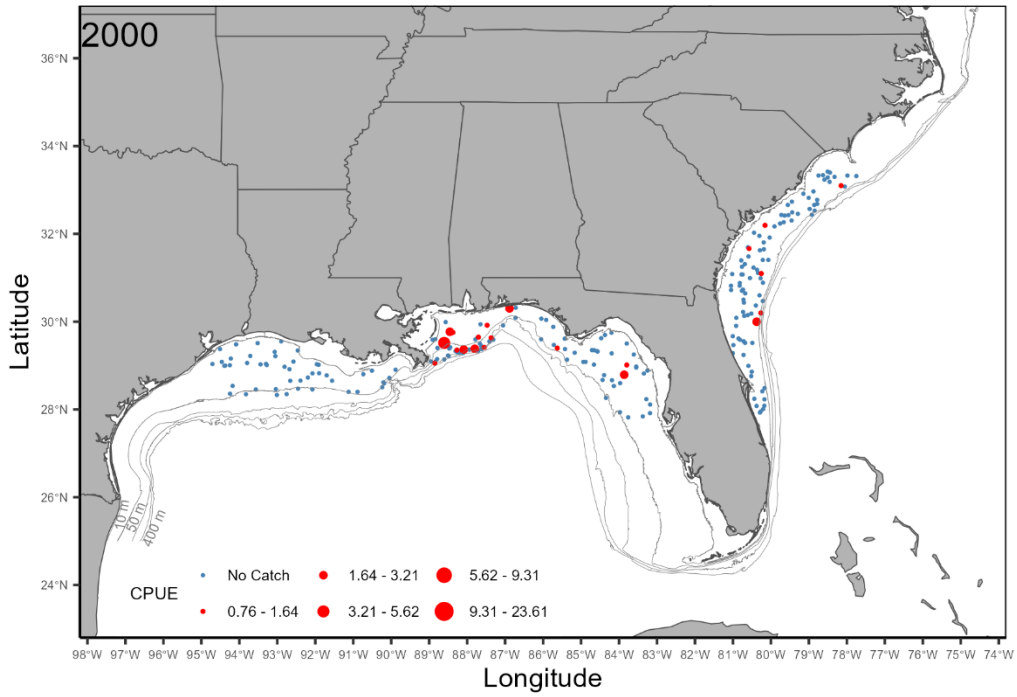
Appendix Figure 1. Annual survey effort and catch of sandbar sharks from the SEFSC Bottom Longline Survey (1995-2025). Note that data from the CSSP Bottom Longline Survey were used to supplement data collected in 2011.

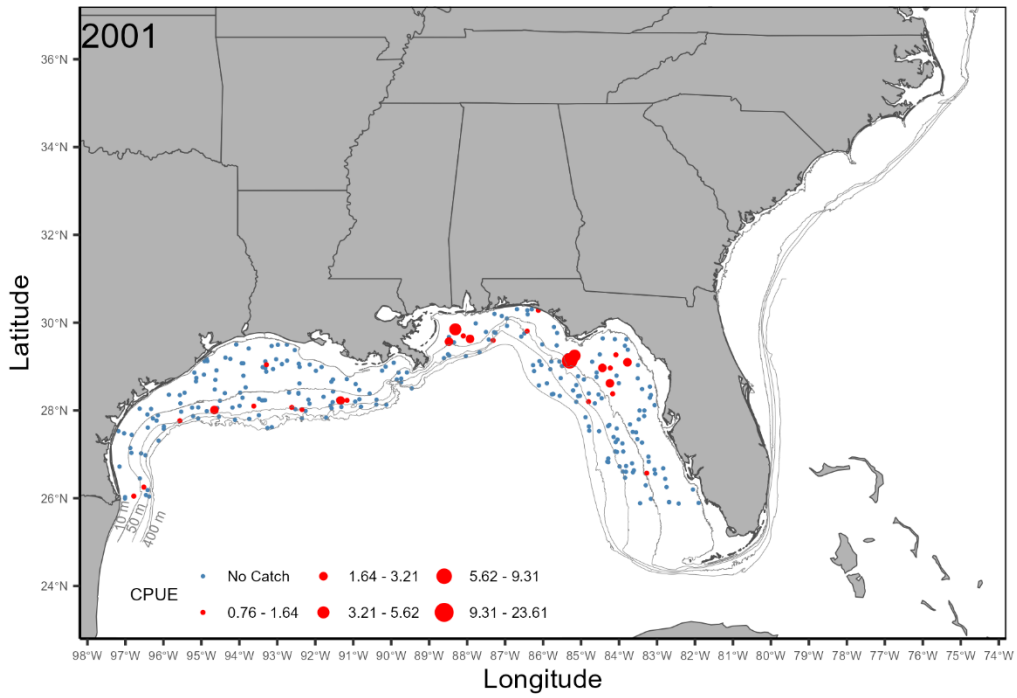


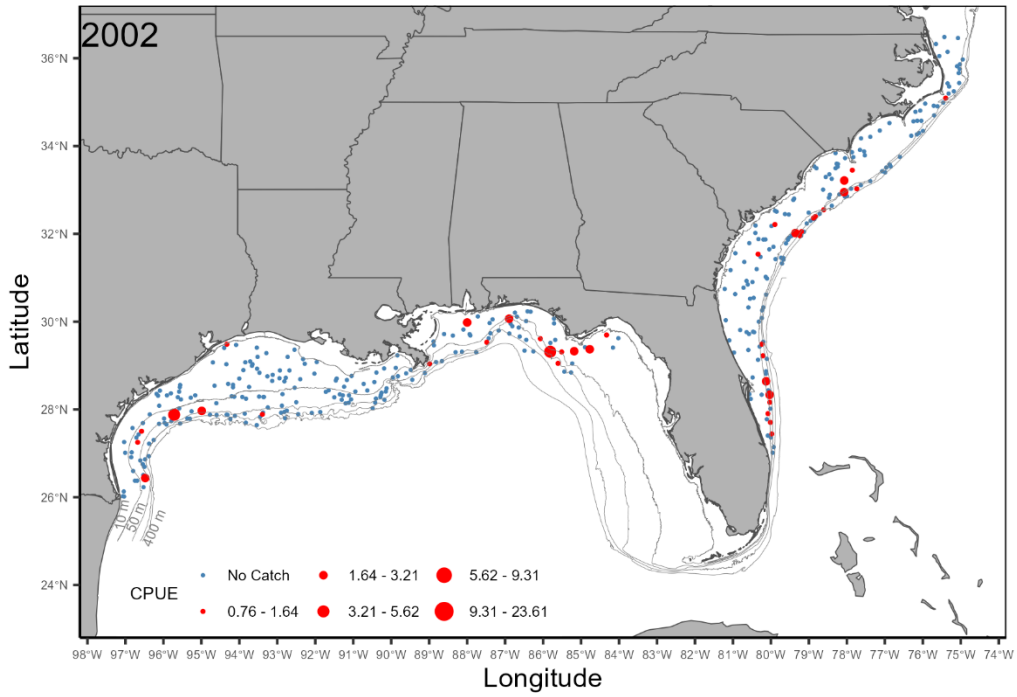

1997
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

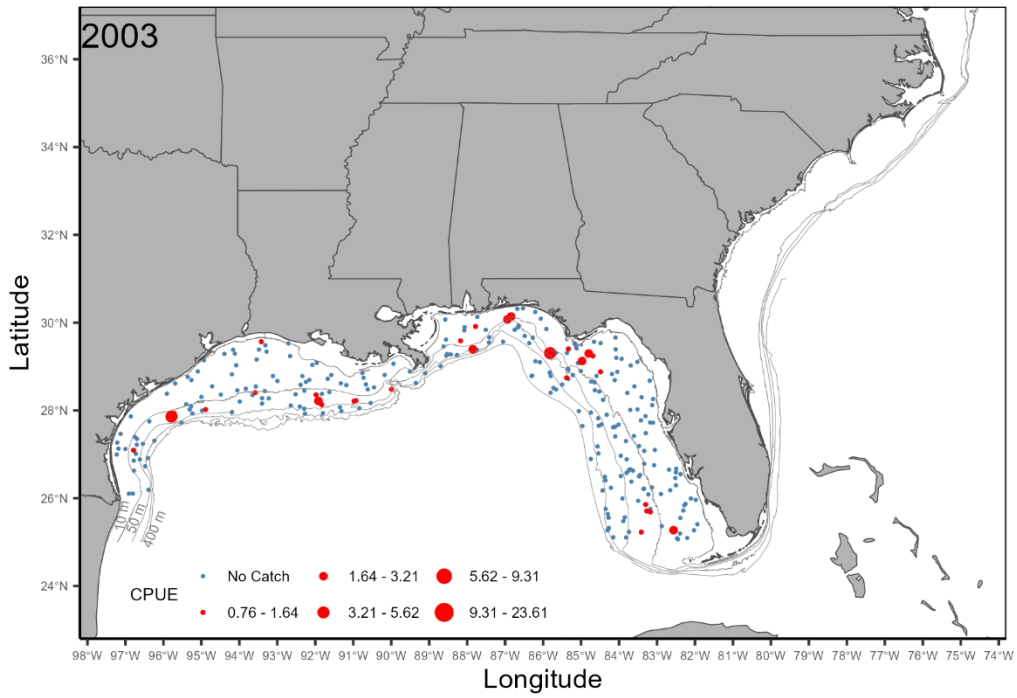

1998
Latitude
Longitude
No Sampling
10 m
50 m
400 m

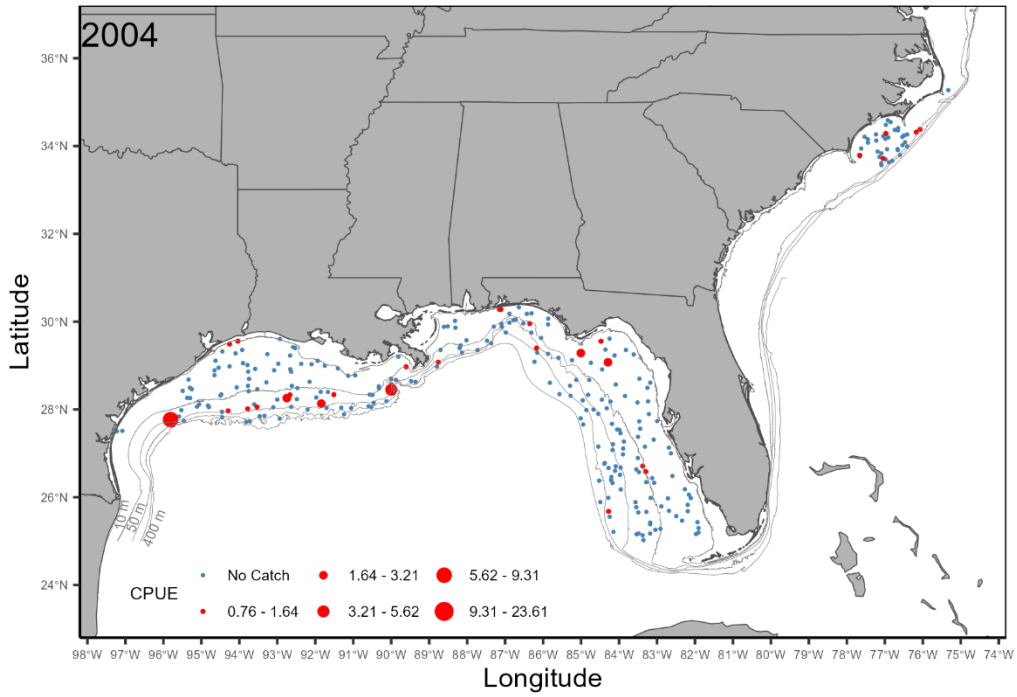

1999
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

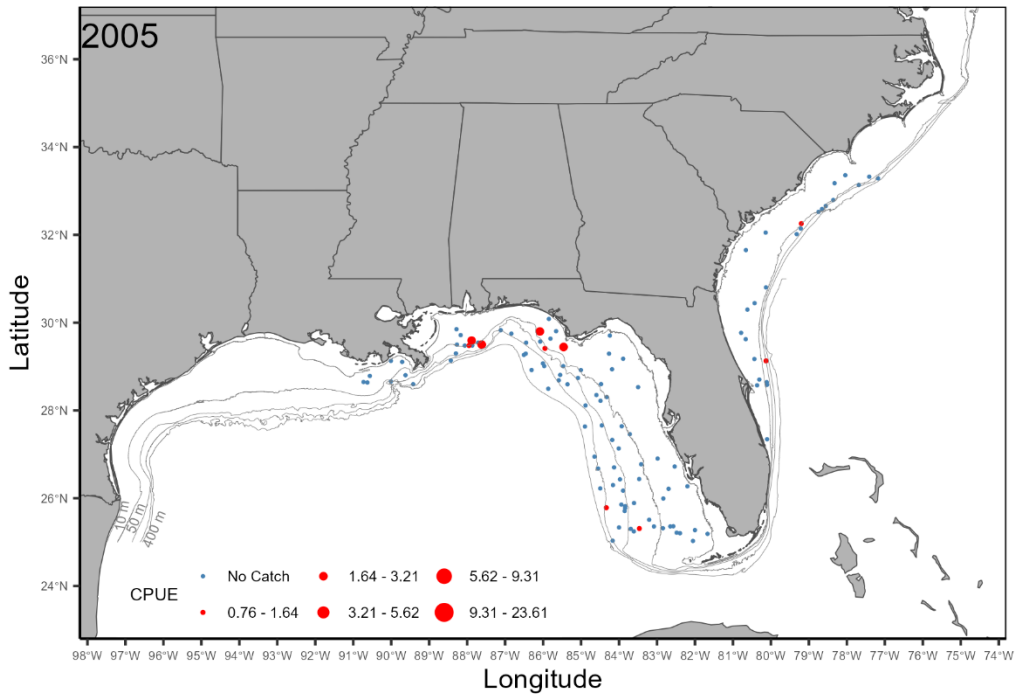

2000
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

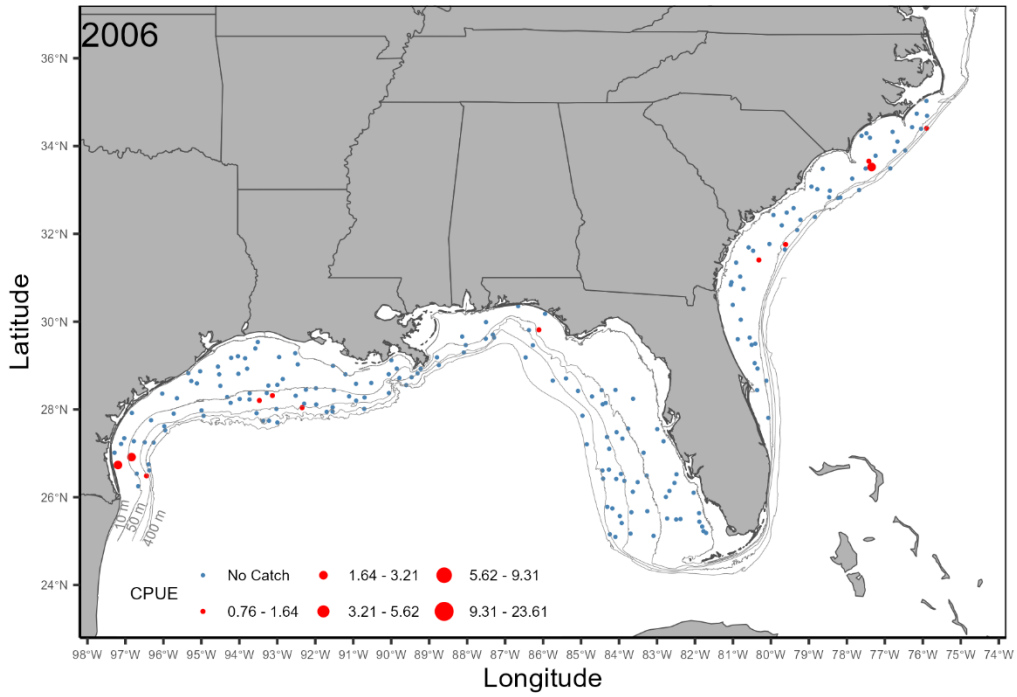

2001
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

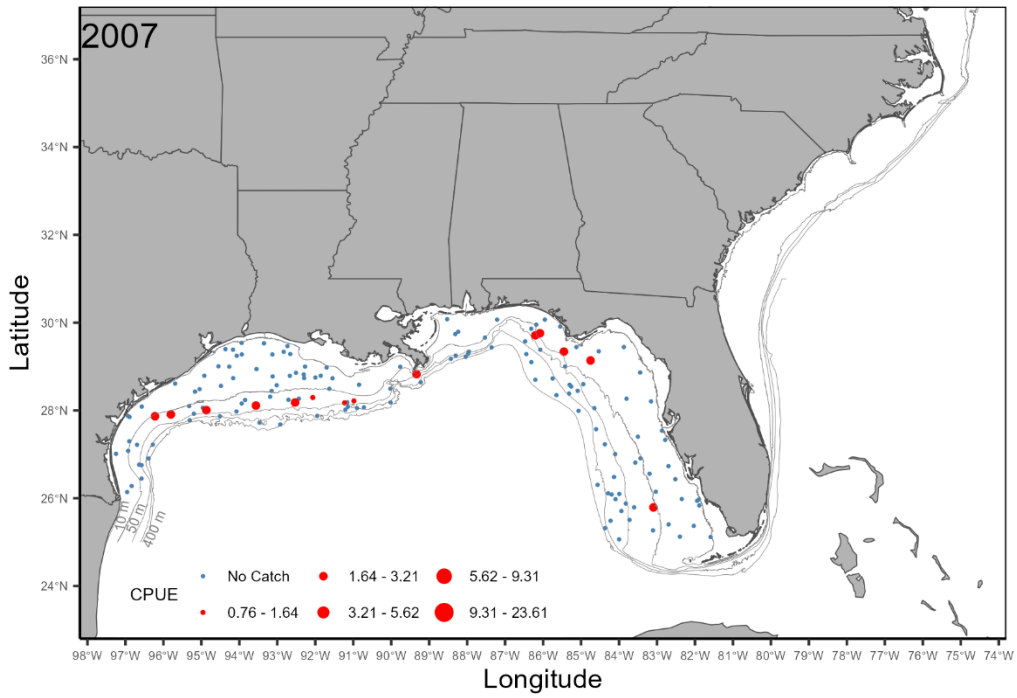

2002
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

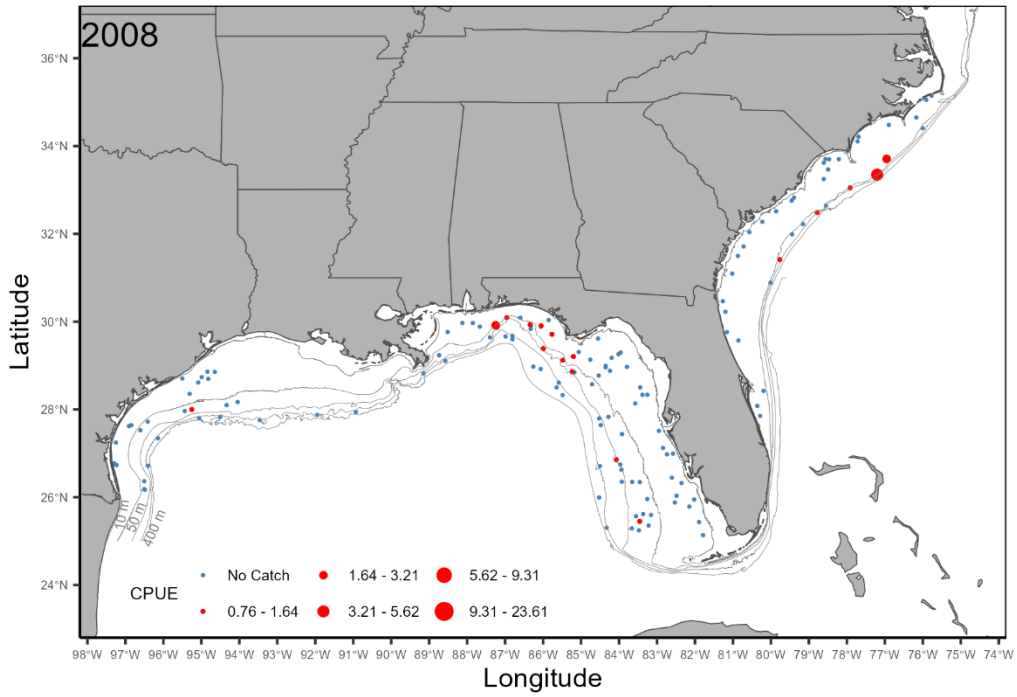

2003
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2004
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2005
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2006
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2007
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m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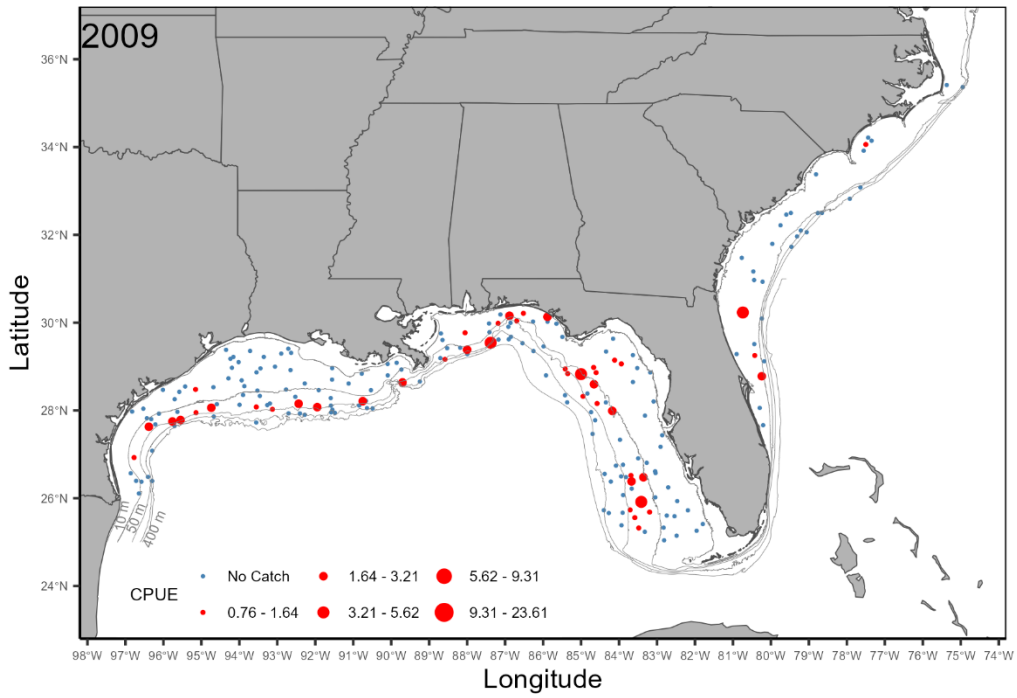
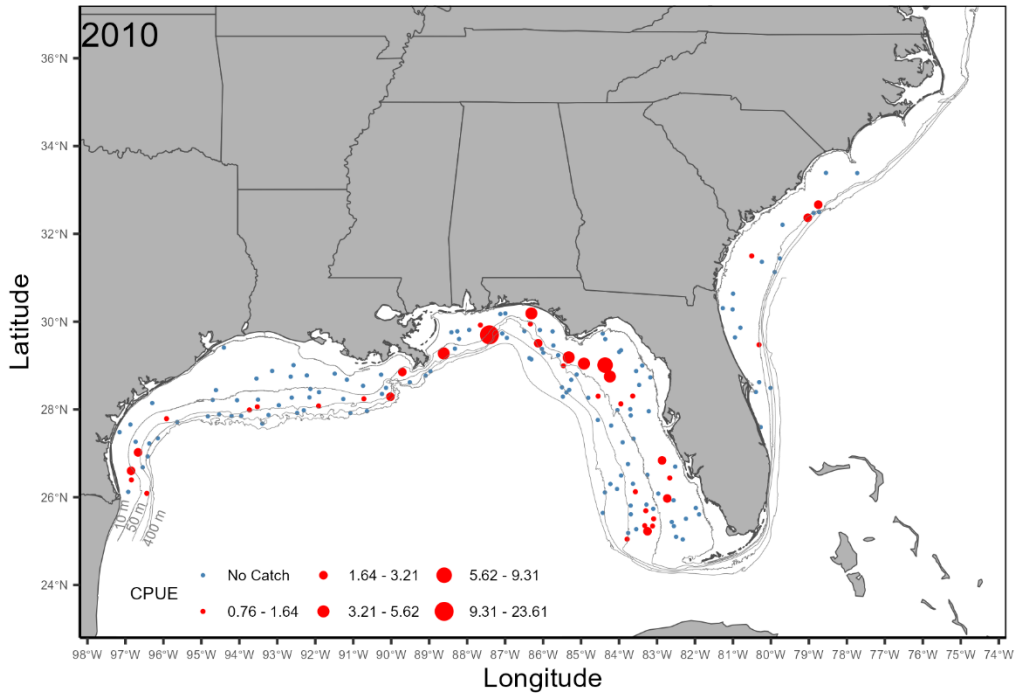
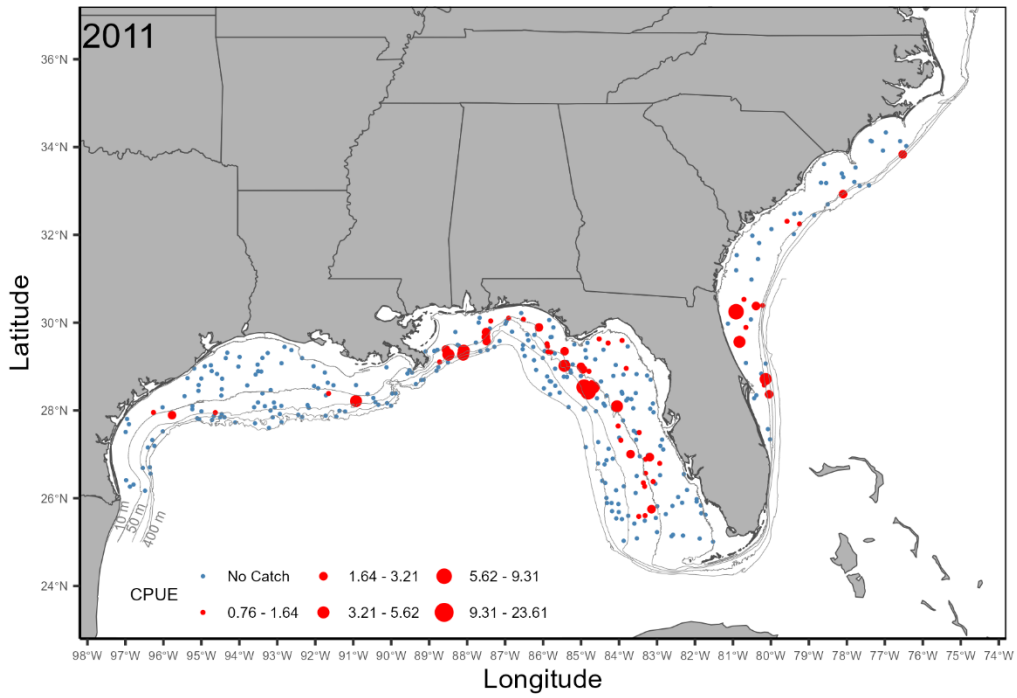
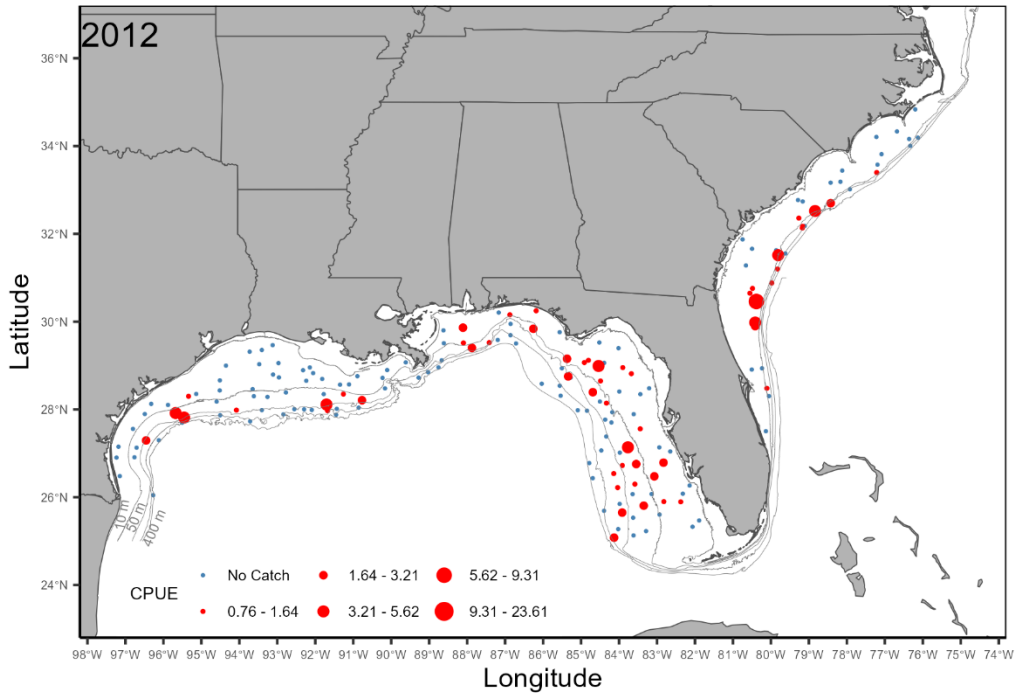
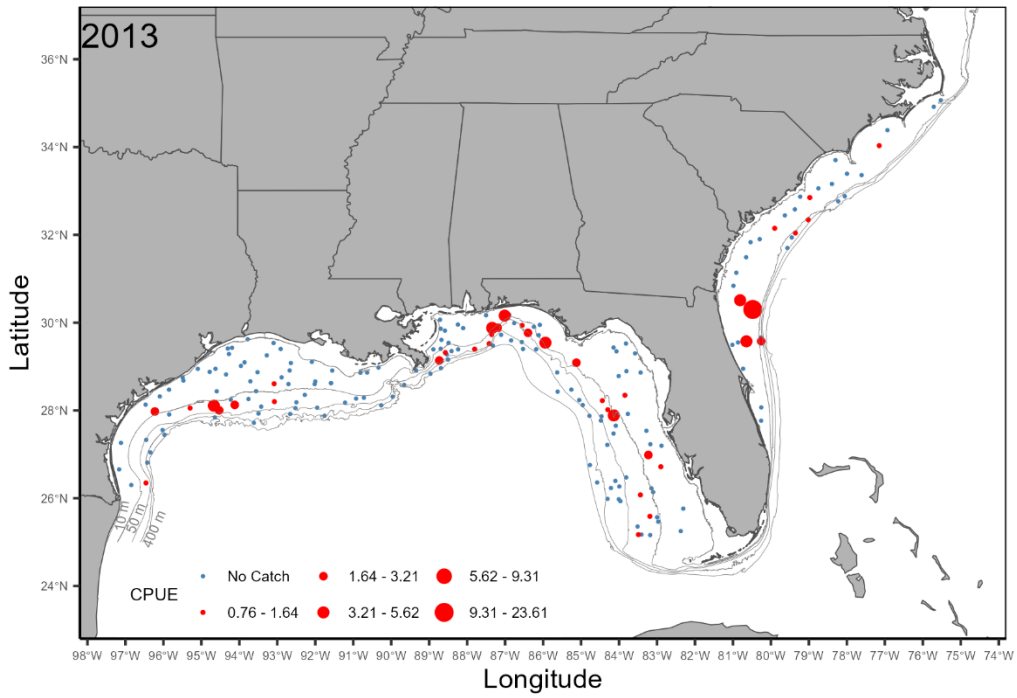
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

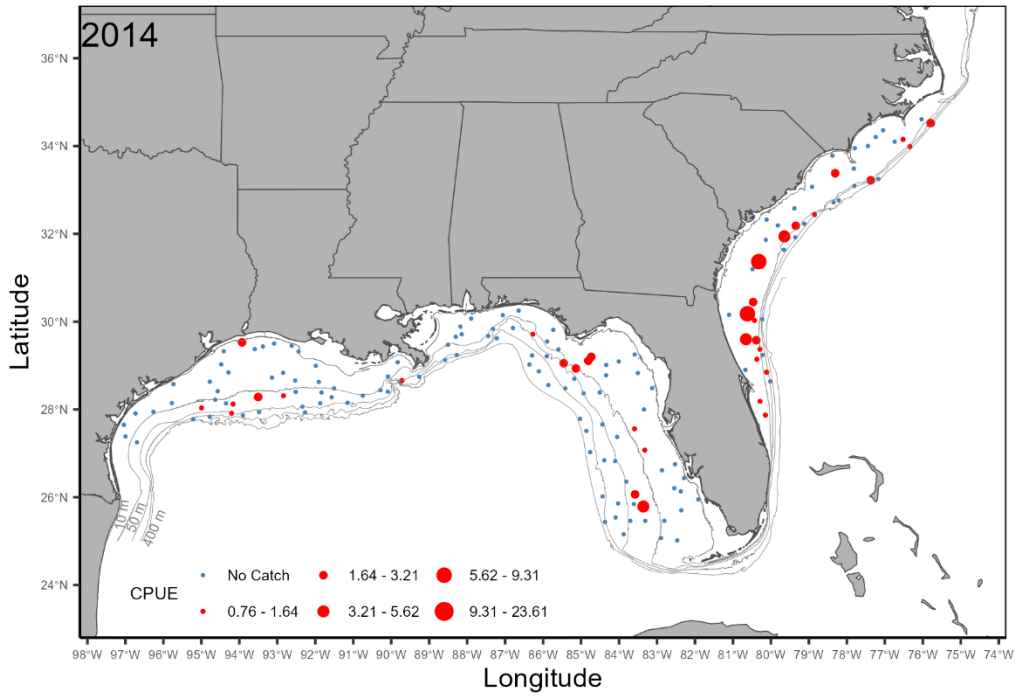

2009
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2010
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2011
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2012
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2013
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2014
Latitude
Longitude
CPUE
No Catch
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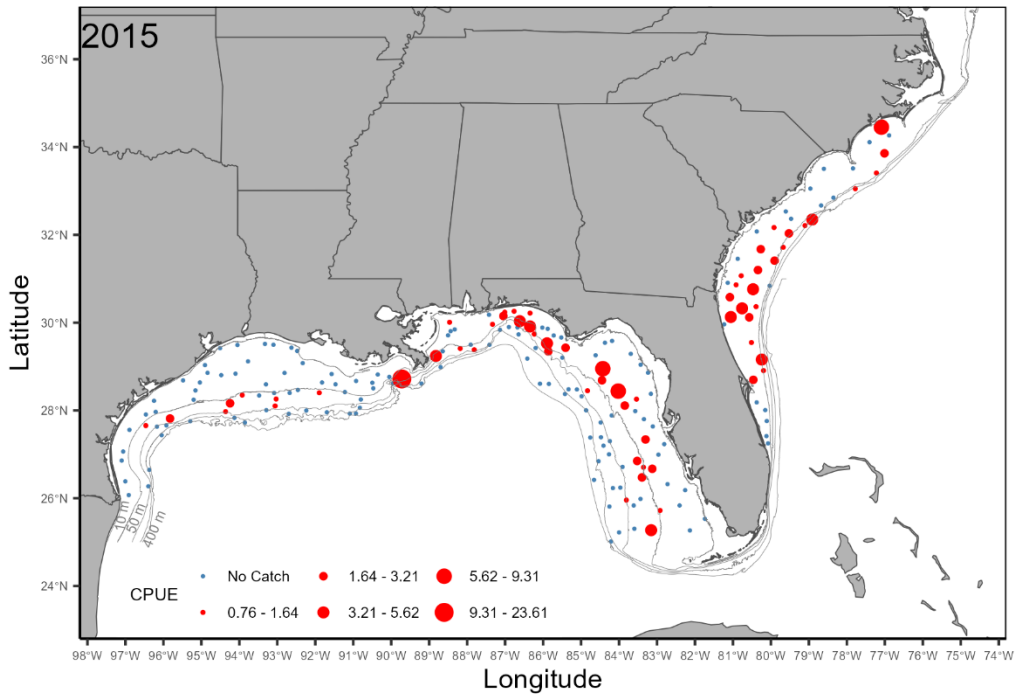
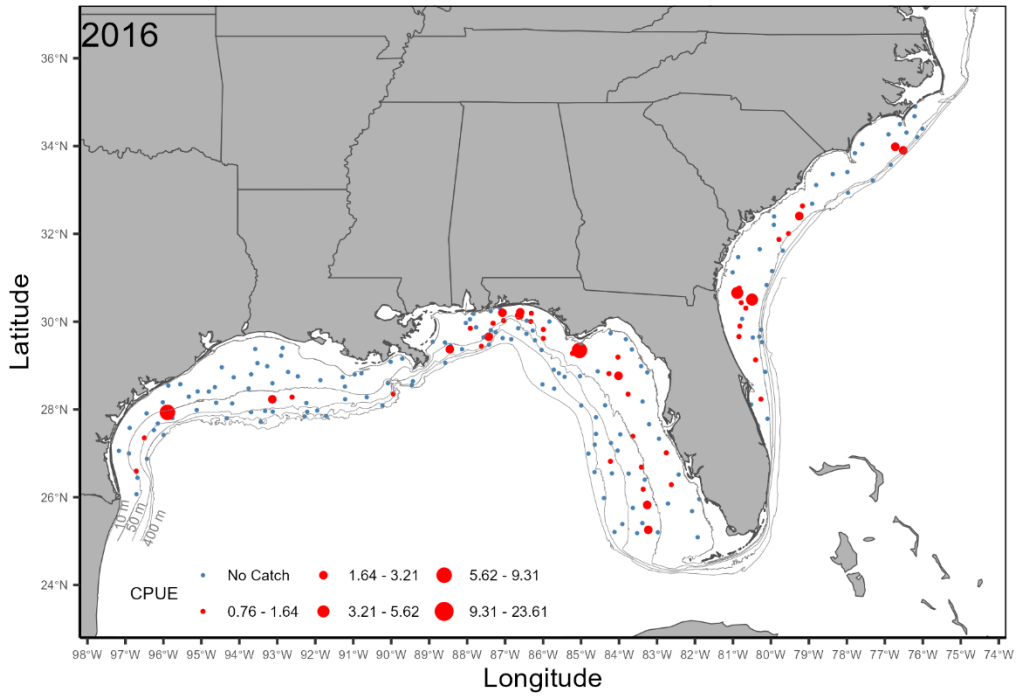
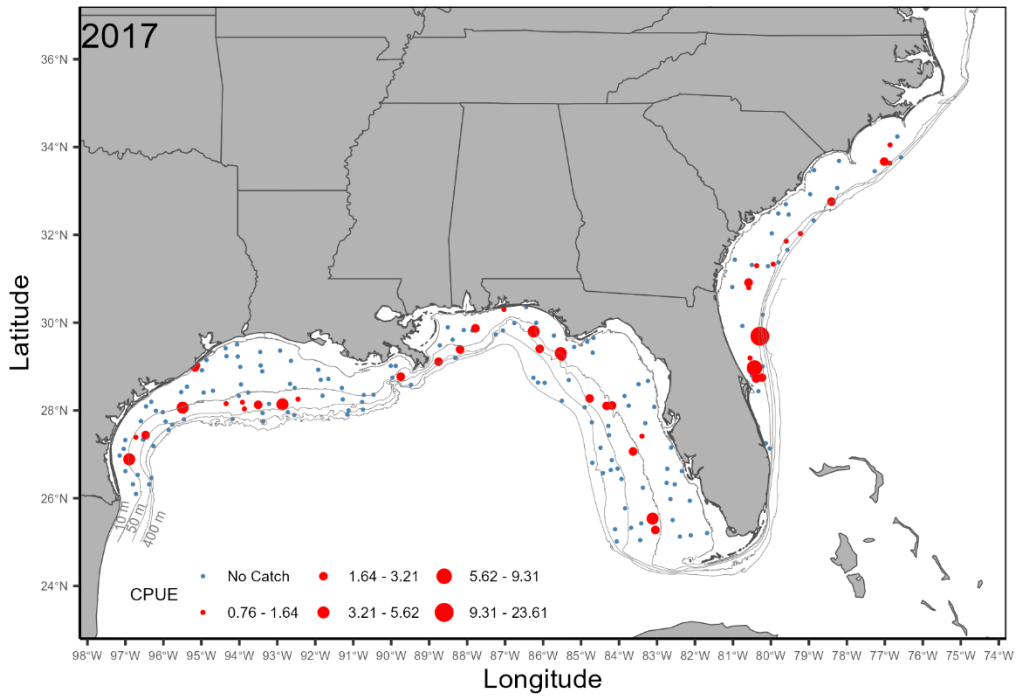
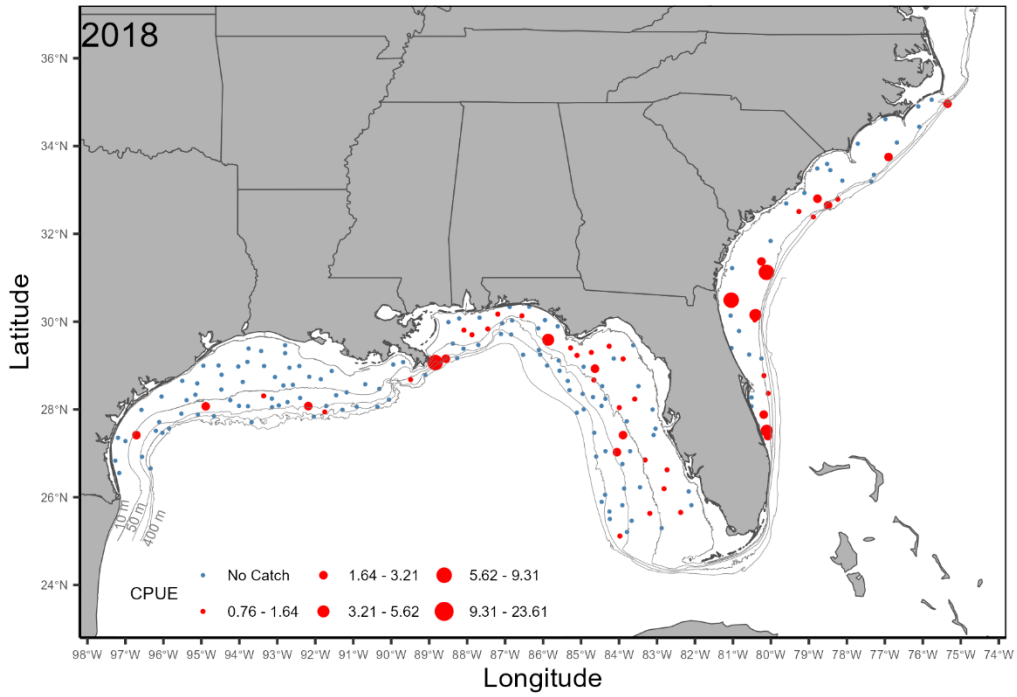
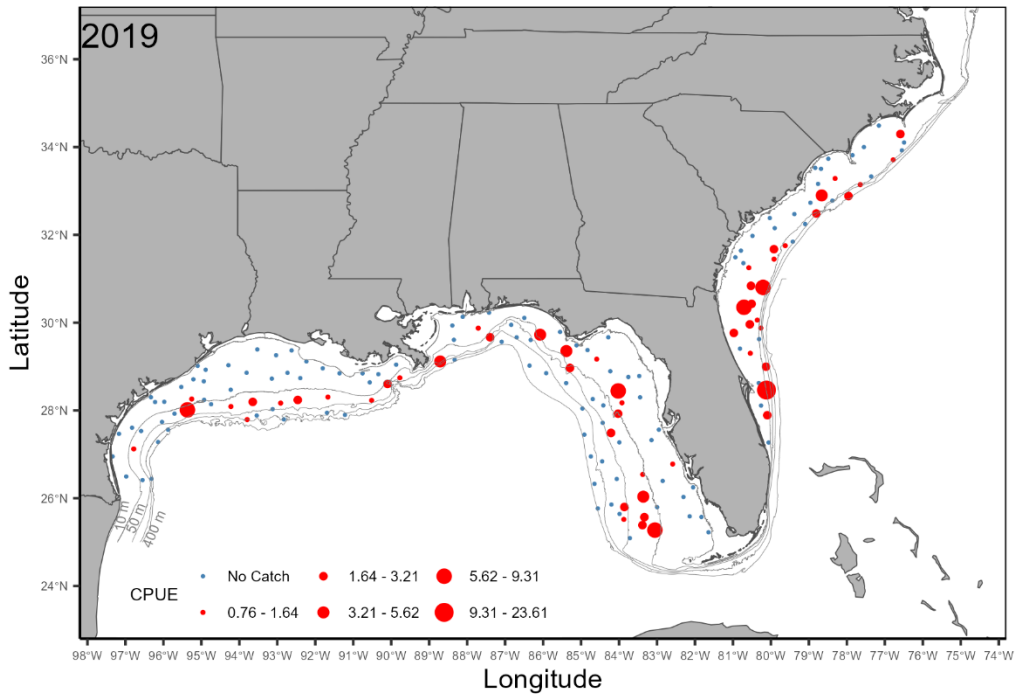
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

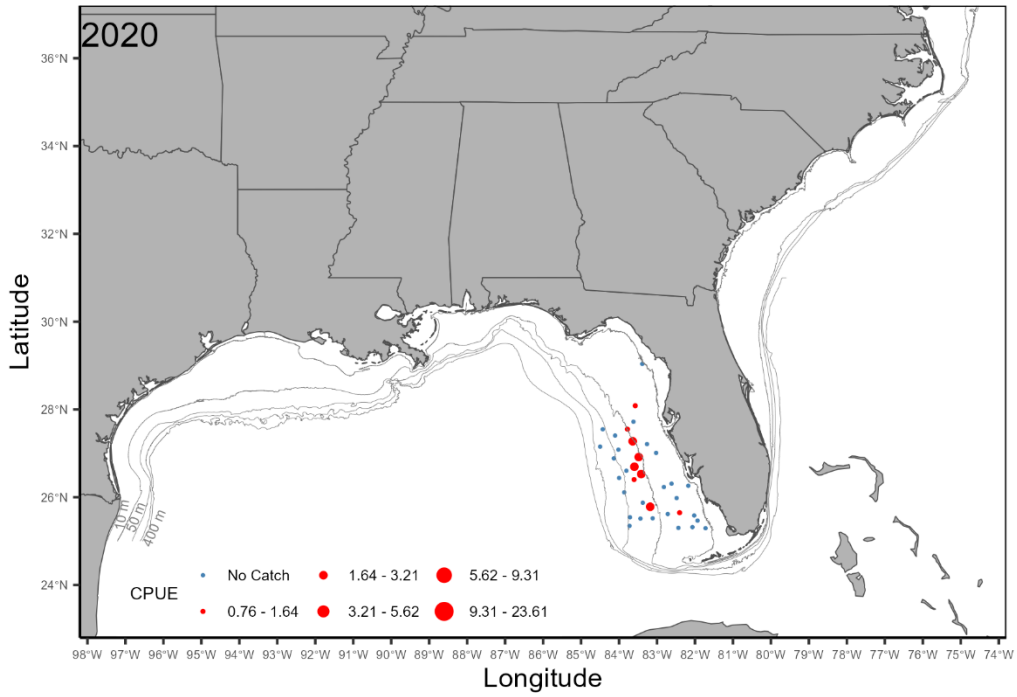

2015
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

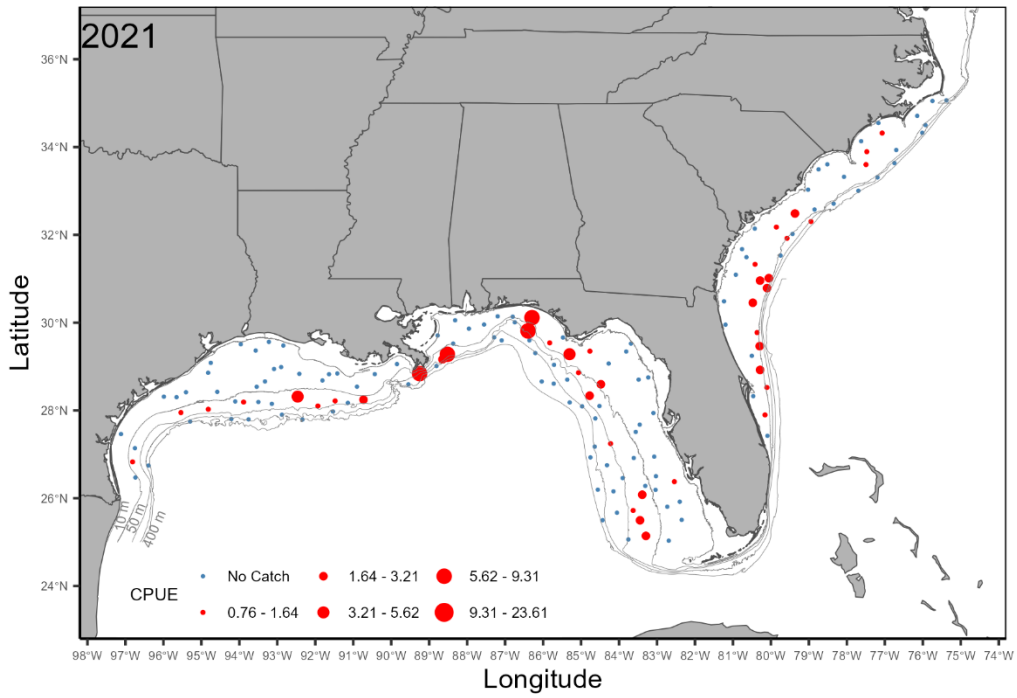

2016
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

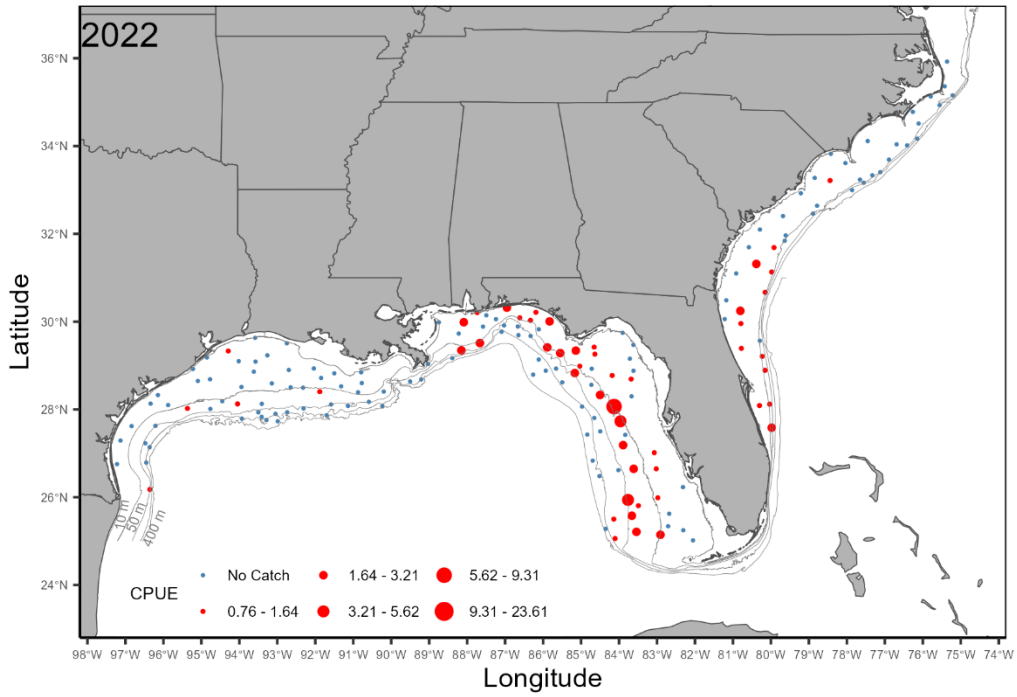

2017
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

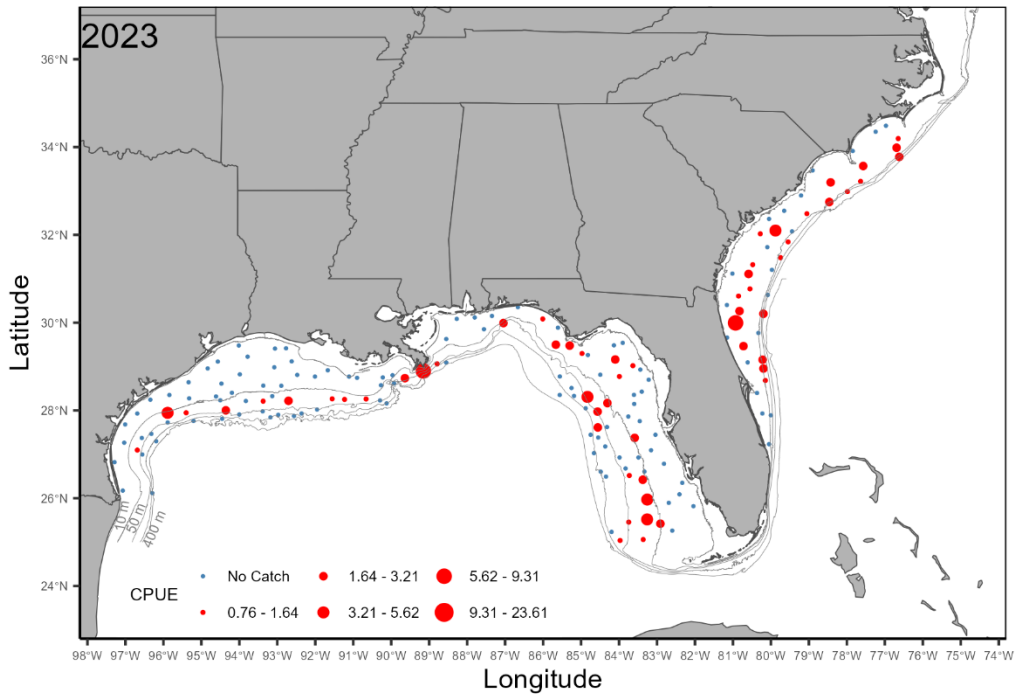

2018
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

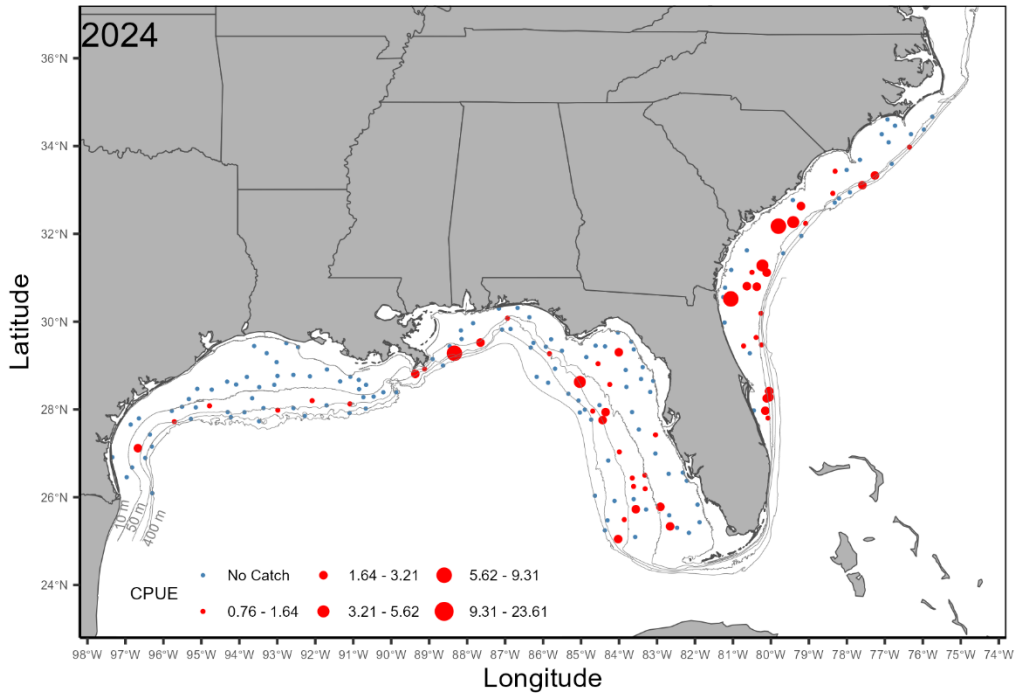

2019
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m

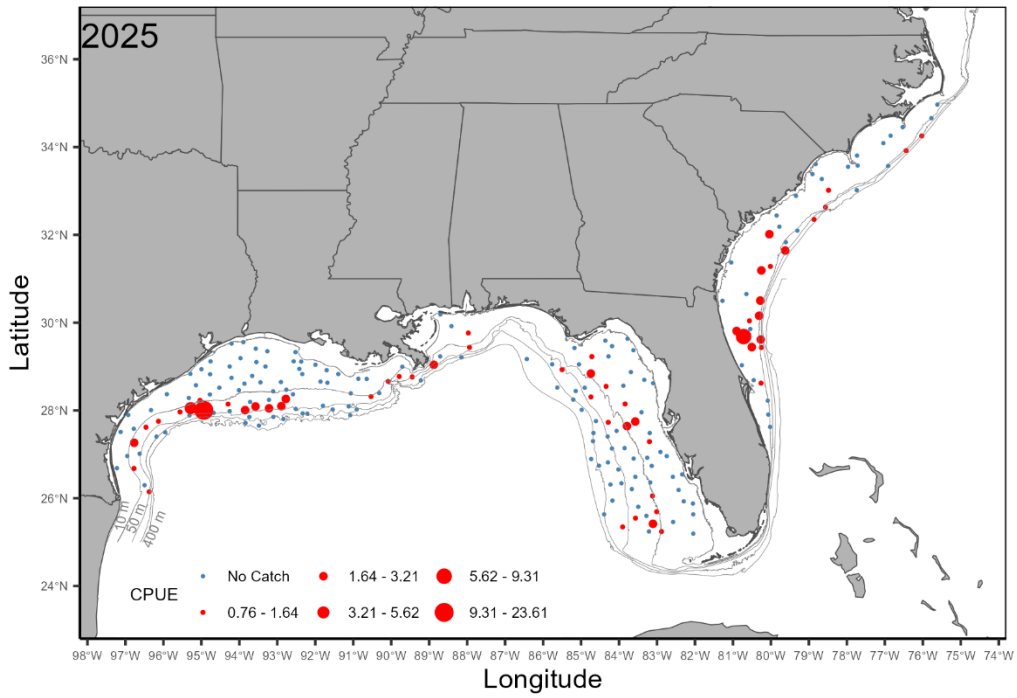

2020
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2021
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2022
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2023
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2024
Latitude
Longitude
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61
10 m
50 m
400 m


2025
Latitude
Longitude
36°N
34°N
32°N
30°N
28°N
26°N
24°N
98°W 97°W 96°W 95°W 94°W 93°W 92°W 91°W 90°W 89°W 88°W 87°W 86°W 85°W 84°W 83°W 82°W 81°W 80°W 79°W 78°W 77°W 76°W 75°W 74°W
10 m
50 m
400 m
CPUE
No Catch
0.76 - 1.64
1.64 - 3.21
3.21 - 5.62
5.62 - 9.31
9.31 - 23.61