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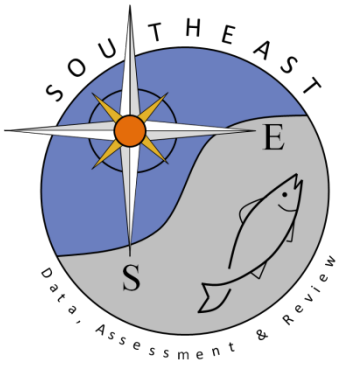

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Atlantic Sharpnose Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

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Abstract

The Southeast Fisheries Science Center Mississippi Laboratories have conducted groundfish surveys since 1972 in the northern Gulf of Mexico during the summer and fall under several sampling programs. In 1987, both groundfish surveys were brought under the Southeast Area Monitoring and Assessment Program (SEAMAP). These fisheries independent data were used to develop abundance indices for Atlantic sharpnose (Rhizoprionodon terraenovae). Separate indices were produced using the summer and fall SEAMAP groundfish survey data. Annual abundance indices were more variable in the early years of the index. Subsequently, in more recent years, they appear to show very little variation. Additionally, age 0 sharks were not able to be separated out due to the lack of lengths from the early years of the survey, but probably comprise a large number of captured individuals.

Introduction

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories have conducted standardized groundfish surveys under the Southeast Area Monitoring and Assessment Program (SEAMAP) in the Gulf of Mexico (GOM) since 1987. Prior to 1987, the summer survey was conducted under SEAMAP protocols; however, the fall survey operated independent of SEAMAP and dates back to 1972. The Southeast Area Monitoring and Assessment Program is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery independent data throughout the region. The primary objective of this trawl survey is to collect data on the abundance and distribution of demersal organisms in the northern GOM. This survey, which is conducted semi-annually (summer and fall), provides an important source of fisheries independent information on many commercially and recreationally important species throughout the GOM. The purpose of this document is to provide abundance indices for Atlantic sharpnose (*Rhizoprionodon terraenovae*).

Methodology

Survey Design

The survey methodologies and descriptions of the datasets used herein have been presented in detail by Nichols (2004) and Pollack and Ingram (2010). A change to the survey design was implemented between the summer and fall surveys of 2008. Prior to the fall survey of 2008, the basic structure of the groundfish surveys (i.e. 1987- summer of 2008) follows a stratified random station location assignment with strata derived from depth zones (5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-22, 22-25, 25-30, 30-35, 35-40, 40-45, 45-50 and 50-60 fathoms), shrimp statistical zones (between 88° and 97° W longitude, statistical zones from west to east: 21-20, 19-18, 17-16, 15-13 and 12-10), and time of day (i.e.

day or night). Survey methodology prior to 1987 was presented in detail by Nichols (2004). Starting in the fall of 2008 and continuing until the present, station allocation is randomized within each shrimp statistical zone with a weighting by area. Other notable changes included a standardized 30 minute tow and dropping the day/night stratification. The main purpose of these changes was to increase the sample size of each survey and expand the survey into the waters off of Florida.

Data

A total of 17,919 stations were sampled from 1972- 2011, with 7437 and 10,482 stations sampled during the summer and fall survey, respectively (Tables 1 and 2). Data was limited to only those stations that did not indicate a problem with the tow. Additionally, any stations in shrimp statistical zone 12, or stations that were outside the range of 5 to 60 fathoms were excluded from analysis. Trawl data was obtained from the MSLABS trawl unit leader (Gilmore Pellegrin) and combined with data from the Gulf States Marine Fisheries Commission database, which contains data collected by state agencies/partners from Alabama, Florida, Louisiana and Mississippi. Data collected by Texas was excluded because of the use of a different gear type (20 foot shrimp trawl vs. the 40 foot shrimp trawl).

Index Construction

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

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

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

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

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

and

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

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

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

where:

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

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 for the summer and fall surveys were:

Submodel Variables (Summer SEAMAP Groundfish Survey)

Year: 1982 – 2011
Area: Texas, Louisiana, Mississippi/Alabama, Florida
Depth: 5 – 60 (continuous)
Time of Day: Day, Night

Submodel Variables (Fall SEAMAP Groundfish Survey)

Year: 1972 – 2011
Region: Texas, West Louisiana, East Louisiana, Mississippi/Alabama, West Florida, East Florida (Figure 1)
Depth: 5 – 60 (continuous)
Time of Day: Day, Night

The difference in the area variables between the summer and fall survey was due to the design of the fall survey prior to 1987. During these years, the areas of East Louisiana and Mississippi/Alabama (Figure 1) were considered the primary sampling area, areas directly west and east of the primary were designated the secondary sampling areas. East Florida and Texas were not sampled during these early years.

Results and Discussion

The distribution of Atlantic sharpnose is presented in Figure 2, with seasonal/annual abundance and distribution presented in the Appendix Figure 1. The total number of Atlantic sharpnose

captured ranged from 2 to 97 in the summer (Table 3) and 22 to 191 in the fall (Table 4). Of the 1074 Atlantic sharpnose captured during the summer survey, a total of 801 were measured from 1987 – 2011 with an average total length of 476 mm. While during the fall survey 2626 Atlantic sharpnose were captured, with 999 measured, with an average total length of 608 mm. The length frequency distribution of Atlantic sharpnose captured is shown in Figure 3.

For the Summer SEAMAP abundance index of Atlantic sharpnose, the nominal CPUE and number of stations with a positive catch are presented in Figure 4. Year, area, time of day and depth were retained in the binomial submodel while year, area 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 45,737.4 and 1039.8, 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 6 and Figure 8.

For the Fall SEAMAP abundance index of Atlantic sharpnose, the nominal CPUE and number of stations with a positive catch are presented in Figure 9. Year, area, time of day and depth were retained in both the binomial and lognormal submodels. 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 60,023.3 and 2523.0, 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 8 and Figure 13.

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Table 1. Number of stations sampled by shrimp statistical zone during the Summer SEAMAP groundfish survey from 1982-2011.

	Shrimp Statistical Zone																			
Year	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
1982									14	38	24	26	8	1	11	30	10	3	23	*188*
1983							5	19	8	27		6	16	19	25	24	21	5	17	*192*
1984									13	40	10	16	16	22	17	15	23	28	14	*214*
1985									10	51	11	31	12	10	7	7	12	11	10	*172*
1986									18	49	6	21	14	8	11	8	11	14	6	*166*
1987									28	61	8	34	23	25	20	16	25	28	19	*287*
1988									18	48	10	16	9	19	24	14	25	28	23	*234*
1989									23	30	8	13	20	25	7	15	20	29	24	*214*
1990										68	18	32	17	23	16	20	23	24	20	*261*
1991										46	16	41	15	23	22	24	18	23	26	*254*
1992									1	45	2	36	30	20	25	12	31	26	20	*248*
1993										45	22	29	19	24	19	14	29	24	22	*247*
1994										61	14	27	28	25	17	20	22	26	22	*262*
1995										44	12	26	24	22	23	13	27	26	21	*238*
1996										46	14	34	21	22	18	17	21	26	25	*244*
1997										44	4	26	22	22	23	10	28	26	26	*231*
1998										35	6	28	27	25	18	14	22	36	17	*228*
1999										44	11	31	27	20	23	13	25	32	20	*246*
2000										45	13	27	19	19	27	8	29	31	21	*239*
2001										36	15	24	28	13	3	10	9	17	21	*176*
2002										44	15	34	21	27	19	15	25	29	22	*251*
2003										44	17	26	8	2	17	20	22	26	23	*205*
2004										39	19	28	23	20	25	21	19	25	21	*240*
2005										32	10	9	23	16	21	5	28	22	27	*193*
2006										45	17	29	16	20	23	17	23	31	18	*239*
2007										41	12	10	23	22	23	7	29	32	21	*220*
2008			1	8	11	6	11	8	11	43	24	19	27	23	22	17	24	21	29	*305*
2009			36	23	29	16	17	18	24	67	25	20	36	39	46	53	33	29	23	*534*
2010		31	26	21	26	10	12	14	15	22	5	20	16	21	33	34	27	27	19	*379*
2011	11	24	22	20	29	2	15	11	8	16	7	14	17	24	29	29	18	21	13	*330*
Total	*11*	*55*	*85*	*72*	*95*	*34*	*60*	*70*	*191*	*1296*	*375*	*733*	*605*	*601*	*614*	*522*	*679*	*726*	*613*	*7437*

Table 2. Number of stations sampled by shrimp statistical zone during the Fall SEAMAP groundfish survey from 1972-2011.

	Shrimp Statistical Zone																		
Year	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
1972									10	55	27	41	34	17						*184*
1973								11	17	98	34	71	39	2						*272*
1974									12	92	35	73	31							*243*
1975										93	33	80	35	32	7					*280*
1976										108	42	79	56	22						*307*
1977										97	31	76	38							*242*
1978									36	101	32	67	58	25						*319*
1979										109	35	72	55	2						*273*
1980									24	85	22	70	32							*233*
1981									21	85	33	66	49	25						*279*
1982									21	102	41	72	37							*273*
1983									17	82	35	63	25							*222*
1984										82	32	64	47	1						*226*
1985									30	76	23	39	53	32	10	20	20	19	19	*341*
1986							20	10	25	37	13	29	14	27	35	26	23	22	21	*302*
1987									13	23	30	29	30	17	15	15	15	18	3	*208*
1988									8	28	10	31	24	18	26	19	21	31	20	*236*
1989										43	18	31	23	22	20	17	22	25	26	*247*
1990										52	20	24	27	22	19	18	22	19	27	*250*
1991										46	16	32	18	20	25	24	19	25	22	*247*
1992										33	15	33	14	25	18	17	27	30	18	*230*
1993										72	14	35	21	26	18	16	25	28	18	*273*
1994										50	19	24	27	25	20	21	23	24	20	*253*
1995										40	14	29	26	24	19	14	26	30	19	*241*
1996										45	11	36	23	17	28	13	25	29	24	*251*
1997										44	18	31	22	26	19	18	23	22	24	*247*
1998										44	30	50	14	34	11	15	24	29	22	*273*
1999										42	10	40	18	29	18	12	28	29	22	*248*
2000										43	10	29	28	20	26	12	30	25	21	*244*
2001										21	14	31	23	26	20	14	27	28	23	*227*
2002									1	51	16	27	26	22	23	14	26	30	21	*257*
2003									1	76	20	20	21	24	22	20	23	25	23	*275*
2004										43	6	23	24	17	27	14	24	30	21	*229*
2005										44	21	32	18	33	18	14	23	24	27	*254*
2006									1	47	7	22	14	18	28	13	23	32	19	*224*
2007										31	15	29	26	18	28	17	20	18	26	*228*
2008				15	14	4	4	3	4	35	18	28	34	42	46	44	19	36	20	*366*
2009			20	21	25	11	21	13	12	48	12	23	23	30	49	47	31	36	22	*444*
2010			9	27	27	18	16	11	14	16	7	15	18	26	31	29	18	19	14	*315*
2011							9	11	6	14	6	15	17	27	31	28	21	19	15	*219*
Total	*0*	*0*	*29*	*63*	*66*	*33*	*70*	*59*	*273*	*2333*	*845*	*1681*	*1162*	*793*	*657*	*531*	*628*	*702*	*557*	*10482*

Table 3. Summary of the Atlantic sharpnose length data collected during Summer SEAMAP groundfish surveys conducted between 1987 and 2011. (Note that prior to 1988, no length data for Atlantic sharpnose is available.)

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Total Length (mm)	Maximum Total Length (mm)	Mean Total Length (mm)	Standard Deviation
1982	188	2					
1983	192	25					
1984	214	4					
1985	172	8					
1986	166	6					
1987	287	42					
1988	234	50	33	242	820	380	114
1989	214	22	20	348	963	580	202
1990	261	9	8	363	957	608	227
1991	254	58	43	326	890	436	124
1992	248	35	19	318	1085	566	249
1993	247	83	35	359	860	466	149
1994	262	15	13	353	840	460	158
1995	238	76	72	348	1038	504	151
1996	244	97	87	258	1030	389	120
1997	231	32	23	356	905	573	166
1998	228	52	48	314	1035	418	148
1999	246	28	21	378	950	532	201
2000	239	38	38	350	1000	533	180
2001	176	9	6	412	623	506	94
2002	251	44	39	175	992	513	173
2003	205	24	22	264	833	396	142
2004	240	32	23	323	845	505	170
2005	193	17	15	307	980	531	210
2006	239	39	39	330	711	438	113
2007	220	29	25	291	822	486	159
2008	305	67	59	320	950	511	162
2009	534	67	67	316	1001	495	175
2010	379	45	32	248	919	458	143
2011	330	19	14	363	750	497	127

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Total Length (mm)
30	7437	1074	801	476

Table 4. Summary of the Atlantic sharpnose length data collected during and Fall SEAMAP groundfish surveys conducted between 1987 and 2011. (Note that prior to 1988, no length data for Atlantic sharpnose is available.)

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Total Length (mm)	Maximum Total Length (mm)	Mean Total Length (mm)	Standard Deviation
1972	184	51					
1973	272	50					
1974	243	191					
1975	280	130					
1976	307	146					
1977	242	71					
1978	319	86					
1979	273	100					
1980	233	131					
1981	279	109					
1982	273	112					
1983	222	40					
1984	226	68					
1985	341	45					
1986	302	33					
1987	208	117					
1988	236	53	29	452	913	636	118
1989	247	47	30	496	1030	635	156
1990	250	45	41	490	940	592	106
1991	247	47	31	518	919	602	104
1992	230	21	21	444	969	696	180
1993	273	57	45	238	804	576	86
1994	253	77	74	505	1242	636	125
1995	241	36	36	496	917	596	88
1996	251	76	76	480	993	592	101
1997	247	46	46	492	832	595	80
1998	273	33	25	491	765	563	59
1999	248	59	51	507	815	602	77
2000	244	66	64	477	1035	641	131
2001	227	30	30	402	715	565	69
2002	257	30	24	513	968	610	118
2003	275	48	34	491	941	646	144
2004	229	37	30	500	943	659	153
2005	254	45	39	380	862	589	99
2006	224	30	28	529	955	684	141
2007	228	64	63	505	1025	589	92
2008	366	51	51	471	994	634	114
2009	444	88	86	419	1003	580	142
2010	315	38	34	474	865	543	90
2011	219	22	11	491	850	597	103

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Total Length (mm)	
40	10,482	2626	999			608	

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for Atlantic sharpnose Summer SEAMAP groundfish survey index of relative abundance from 1982 to 2011.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 45737.4)*						*Lognormal Submodel Type 3 Tests (AIC 1041.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	29	7402	59.51	2.05	0.0007	0.0007	29	359	1.59	0.0289
Time of Day	1	7402	64.02	64.02	<.0001	<.0001	1	359	1.24	0.2665
Area	3	7402	24.11	8.04	<.0001	<.0001	3	359	3.89	0.0094
Depth	1	7402	58.49	58.49	<.0001	<.0001	1	359	74.50	<.0001
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 45737.4)*						*Lognormal Submodel Type 3 Tests (AIC 1039.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	29	7402	59.51	2.05	0.0007	0.0007	29	360	1.60	0.0276
Time of Day	1	7402	64.02	64.02	<.0001	<.0001		Dropped		
Area	3	7402	24.11	8.04	<.0001	<.0001	3	360	3.84	0.0100
Depth	1	7402	58.49	58.49	<.0001	<.0001	1	360	73.21	<.0001

Table 6. Indices of Atlantic sharpnose abundance developed using the delta-lognormal model for Summer SEAMAP groundfish survey from 1982-2011. 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
1982	0.01064	188	0.01858	0.09735	0.75071	0.02556	0.37070
1983	0.04688	192	0.45210	2.36821	0.36675	1.16375	4.81926
1984	0.00467	214	0.02986	0.15643	1.02950	0.02857	0.85642
1985	0.02326	172	0.10014	0.52456	0.54307	0.18977	1.45000
1986	0.01205	166	0.06305	0.33025	0.75295	0.08645	1.26165
1987	0.04530	287	0.29346	1.53719	0.31129	0.83671	2.82412
1988	0.05983	234	0.27386	1.43451	0.30112	0.79581	2.58580
1989	0.05140	214	0.19881	1.04140	0.33766	0.53978	2.00921
1990	0.03065	261	0.06700	0.35095	0.39229	0.16467	0.74794
1991	0.05512	254	0.21797	1.14176	0.30351	0.63057	2.06736
1992	0.07258	248	0.19857	1.04014	0.26770	0.61458	1.76036
1993	0.04858	247	0.24233	1.26938	0.32378	0.67506	2.38695
1994	0.02672	262	0.09803	0.51349	0.41790	0.23017	1.14556
1995	0.09664	238	0.43104	2.25787	0.23834	1.41102	3.61298
1996	0.09016	244	0.36553	1.91470	0.24348	1.18482	3.09421
1997	0.06061	231	0.18834	0.98657	0.30192	0.54649	1.78106
1998	0.07456	228	0.14367	0.75257	0.27608	0.43766	1.29407
1999	0.06098	246	0.20108	1.05332	0.29146	0.59504	1.86456
2000	0.10042	239	0.21665	1.13483	0.23375	0.71548	1.79998
2001	0.02841	176	0.09657	0.50586	0.49027	0.19994	1.27985
2002	0.09163	251	0.25289	1.32471	0.23838	0.82779	2.11994
2003	0.05366	205	0.15226	0.79755	0.33804	0.41309	1.53981
2004	0.03750	240	0.09802	0.51347	0.37193	0.24996	1.05477
2005	0.04663	193	0.12449	0.65209	0.37204	0.31738	1.33980
2006	0.06276	239	0.21169	1.10885	0.29200	0.62577	1.96486
2007	0.06364	220	0.16996	0.89030	0.30094	0.49407	1.60431
2008	0.07213	305	0.29475	1.54398	0.24267	0.95690	2.49124
2009	0.04869	534	0.24473	1.28194	0.22202	0.82668	1.98792
2010	0.04485	379	0.17204	0.90119	0.26974	0.53042	1.53114
2011	0.03939	330	0.10969	0.57457	0.30839	0.31444	1.04989

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for Atlantic sharpnose Fall SEAMAP groundfish survey index of relative abundance from 1972 to 2011.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 60023.3)*						*Lognormal Submodel Type 3 Tests (AIC 2523.0)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	39	3569	164.20	4.18	<.0001	<.0001	39	990	4.38	<.0001
Time of Day	1	8671	399.21	399.21	<.0001	<.0001	1	990	19.01	<.0001
Region	5	4186	103.05	20.60	<.0001	<.0001	5	990	11.01	<.0001
Depth	1	9436	28.79	28.79	<.0001	<.0001	1	990	10.16	0.0015

Table 8. Indices of Atlantic sharpnose abundance developed using the delta-lognormal model for Fall SEAMAP groundfish survey 1972-2011. 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
1972	0.05978	184	0.20274	0.71574	0.48242	0.28671	1.78676
1973	0.09191	272	0.23160	0.81761	0.28913	0.46391	1.44097
1974	0.22634	243	1.01861	3.59602	0.23832	2.24737	5.75398
1975	0.18571	280	0.72553	2.56135	0.25204	1.55924	4.20751
1976	0.20521	307	0.67651	2.38827	0.21548	1.55970	3.65701
1977	0.15289	242	0.30188	1.06573	0.26002	0.63897	1.77752
1978	0.12539	319	0.37264	1.31554	0.28984	0.74544	2.32164
1979	0.13553	273	0.38274	1.35119	0.27390	0.78904	2.31384
1980	0.18455	233	0.68636	2.42305	0.26210	1.44701	4.05744
1981	0.17204	279	0.56548	1.99633	0.25864	1.20007	3.32090
1982	0.16484	273	0.47885	1.69048	0.27107	0.99248	2.87938
1983	0.10811	222	0.33018	1.16564	0.30321	0.64413	2.10938
1984	0.12389	226	0.27278	0.96300	0.33150	0.50485	1.83692
1985	0.06452	341	0.28423	1.00341	0.33093	0.52659	1.91199
1986	0.06291	302	0.30367	1.07204	0.31632	0.57807	1.98809
1987	0.09615	208	0.55895	1.97326	0.42295	0.87664	4.44170
1988	0.09746	236	0.17377	0.61347	0.32387	0.32619	1.15377
1989	0.06478	247	0.16759	0.59165	0.41924	0.26458	1.32305
1990	0.08000	250	0.18075	0.63809	0.34081	0.32881	1.23827
1991	0.08097	247	0.12165	0.42945	0.35568	0.21534	0.85644
1992	0.07826	230	0.07208	0.25446	0.28371	0.14586	0.44390
1993	0.07692	273	0.16411	0.57937	0.33806	0.30008	1.11862
1994	0.08696	253	0.23300	0.82256	0.34447	0.42103	1.60701
1995	0.07884	241	0.12828	0.45285	0.32774	0.23906	0.85783
1996	0.09163	251	0.31534	1.11324	0.32706	0.58842	2.10613
1997	0.08097	247	0.15418	0.54431	0.38433	0.25909	1.14353
1998	0.05495	273	0.13918	0.49134	0.45235	0.20731	1.16454
1999	0.06452	248	0.27306	0.96400	0.43456	0.41959	2.21478
2000	0.09426	244	0.20881	0.73716	0.31873	0.39572	1.37322
2001	0.07048	227	0.09185	0.32426	0.36365	0.16024	0.65615
2002	0.05447	257	0.10891	0.38449	0.35084	0.19451	0.76003
2003	0.09091	275	0.14930	0.52708	0.30549	0.29002	0.95792
2004	0.06114	229	0.13878	0.48993	0.40203	0.22591	1.06253
2005	0.06693	254	0.18661	0.65877	0.41794	0.29527	1.46976

2006	0.06696	224	0.14883	0.52542	0.38907	0.24797	1.11329
2007	0.07895	228	0.13977	0.49342	0.36342	0.24394	0.99803
2008	0.06831	366	0.16033	0.56602	0.28204	0.32548	0.98432
2009	0.07883	444	0.21874	0.77220	0.30459	0.42561	1.40105
2010	0.05714	315	0.13184	0.46542	0.30630	0.25571	0.84713
2011	0.06849	219	0.13097	0.46237	0.35042	0.23410	0.91326

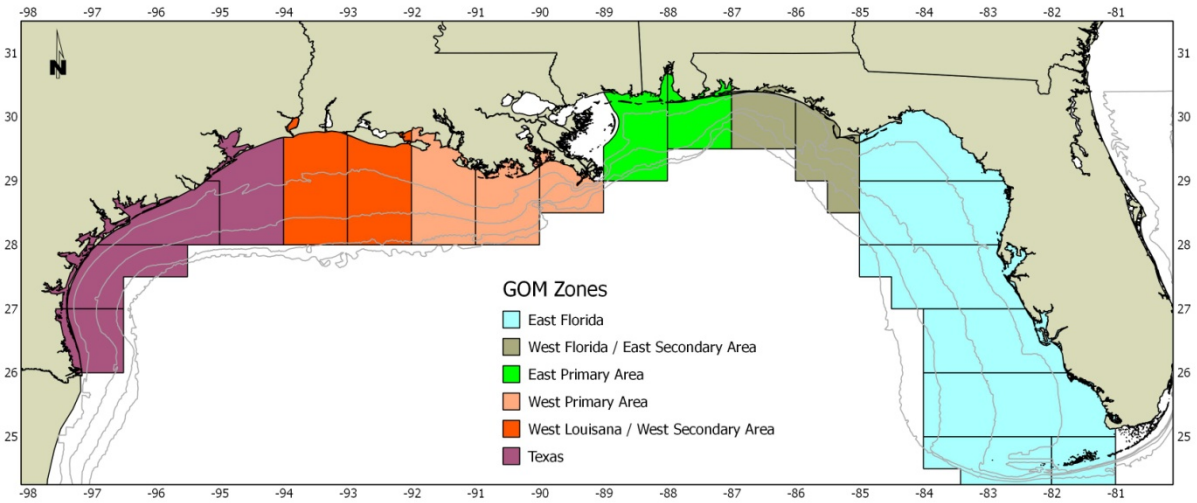

Figure 1. Combined areas for the Fall SEAMAP groundfish survey.

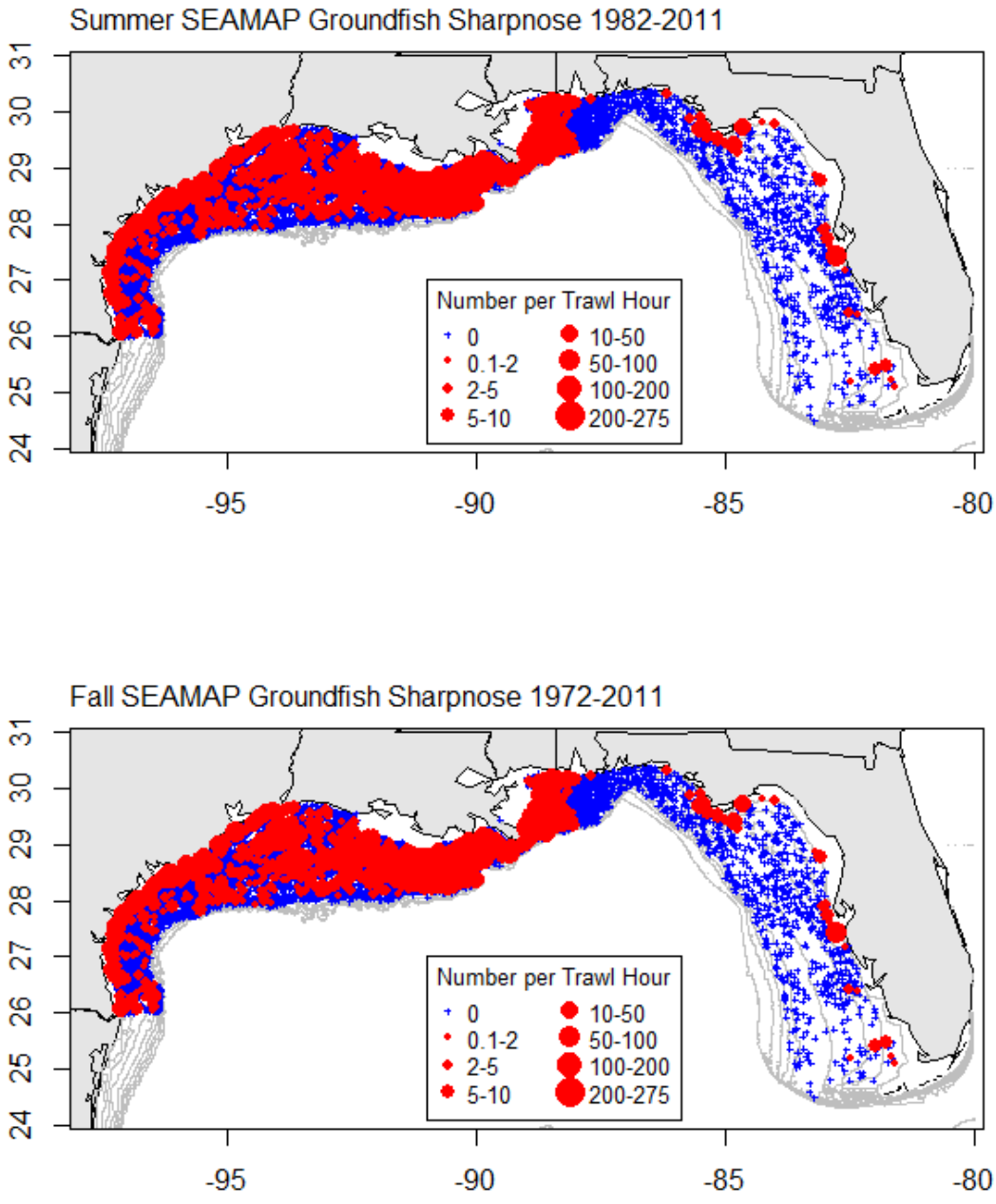

Figure 2. Stations sampled from 1982 to 2011 during the Summer (top) and from 1972 to 2011 during the Fall (bottom) SEAMAP Groundfish Survey with the CPUE for Atlantic Sharpnose.

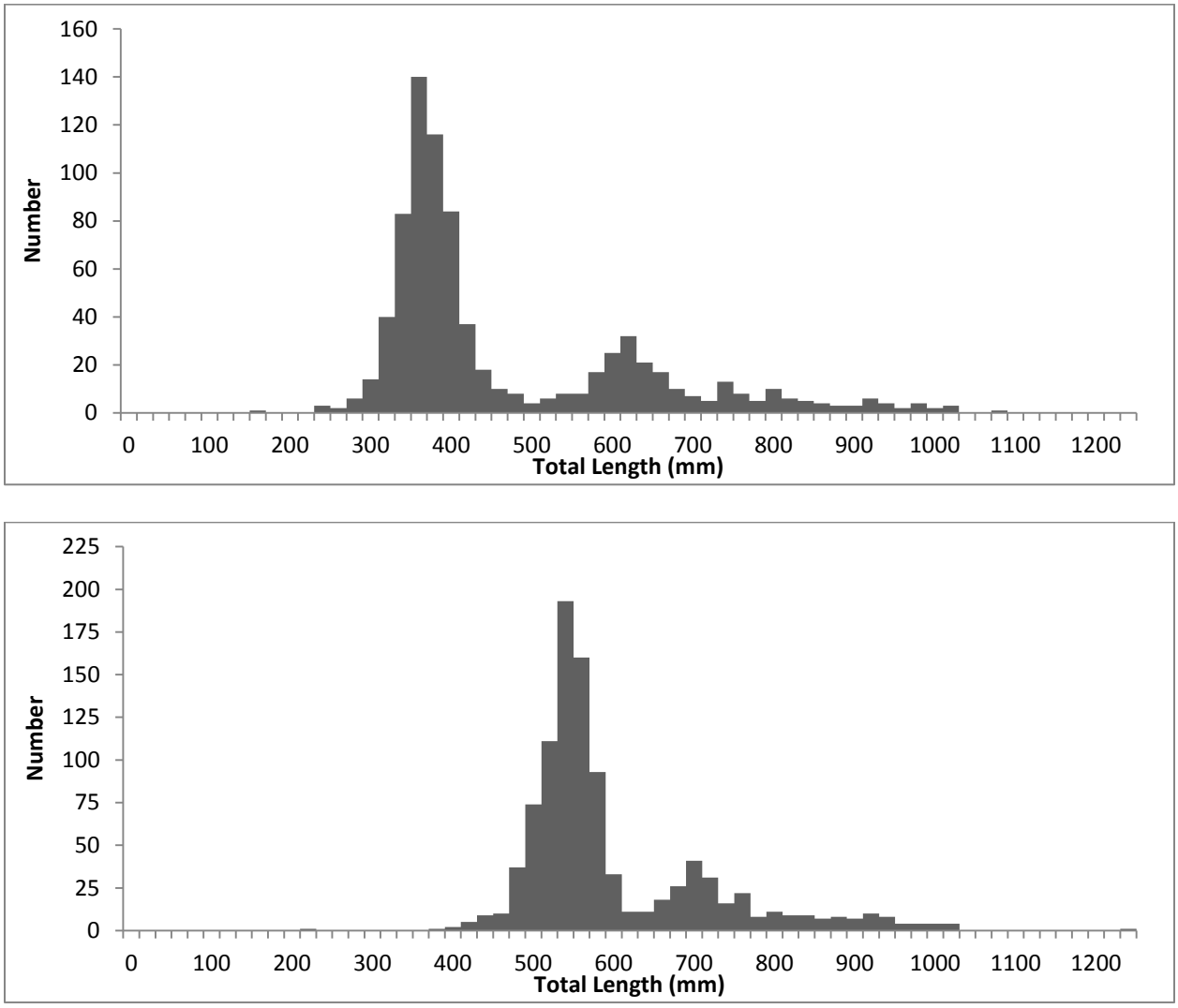

Figure 3. Length frequency histograms for Atlantic sharpnose captured Summer (top) and Fall (bottom) SEAMAP Groundfish surveys from 1987-2010.

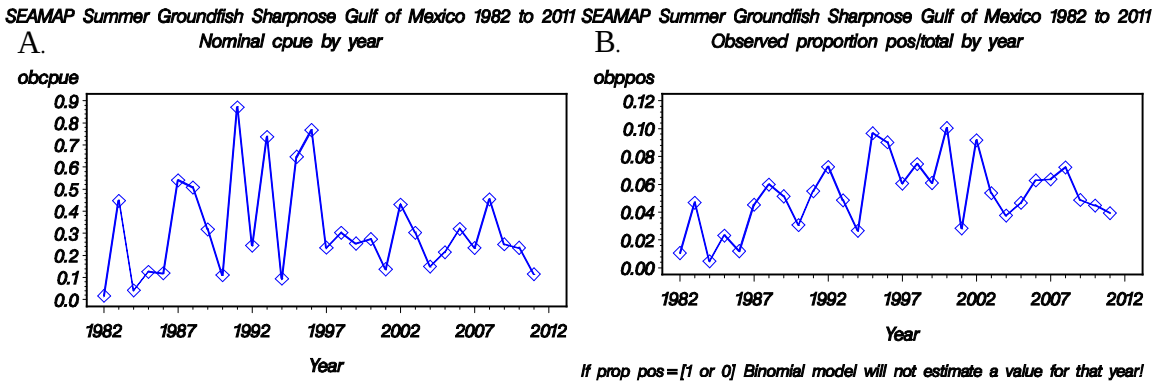

Figure 4. Annual trends for Atlantic sharpnose captured during Summer SEAMAP Groundfish Surveys from 1982 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

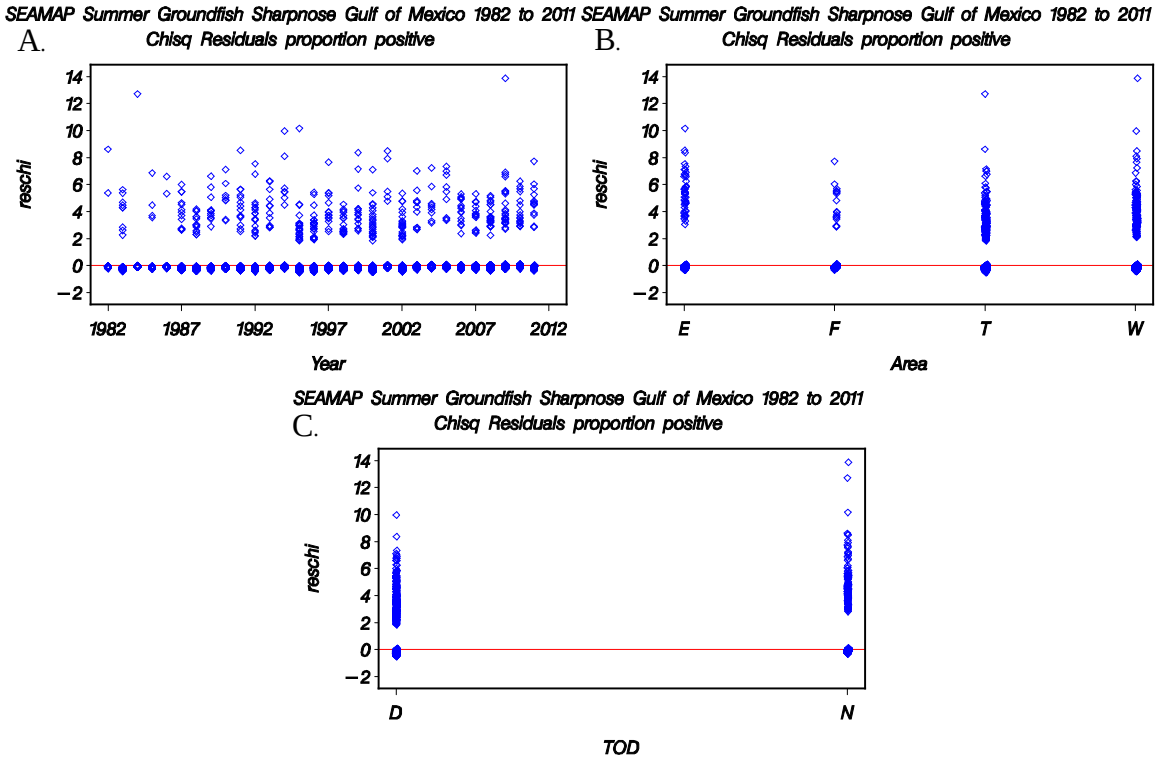

Figure 5. Diagnostic plots for binomial component of the Atlantic sharpnose Summer SEAMAP Groundfish Survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, and **C.** the Chi-Square residuals by time of day.

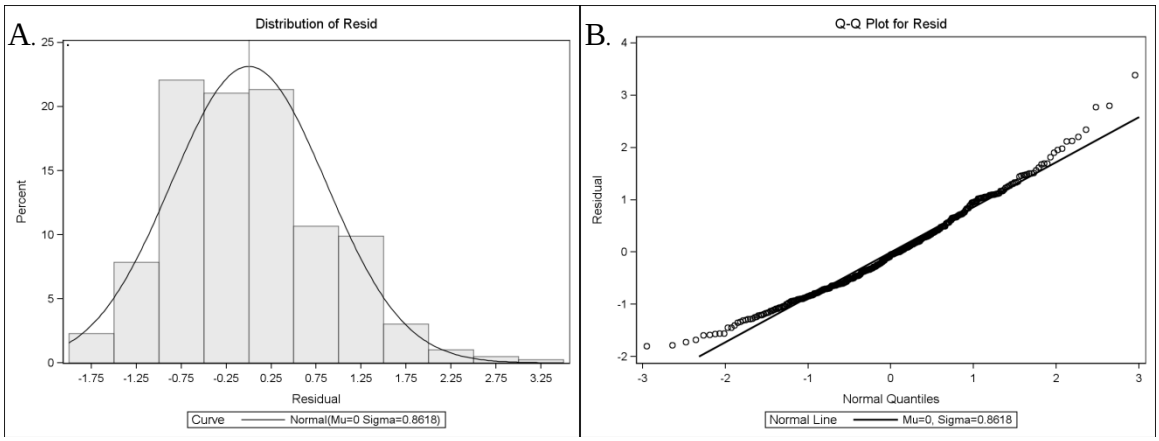

Figure 6. Diagnostic plots for lognormal component of the Atlantic sharpnose Summer SEAMAP Groundfish Survey model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

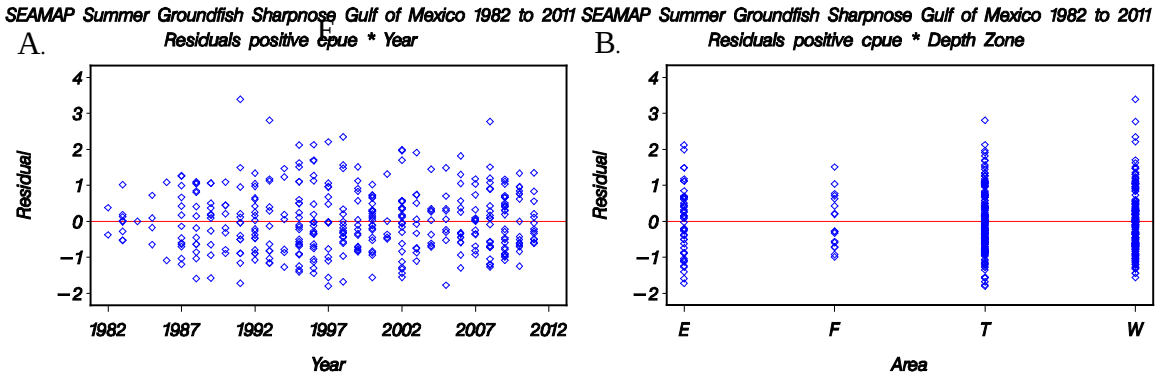

Figure 7. Diagnostic plots for lognormal component of the Atlantic sharpnose Summer SEAMAP Groundfish Survey model: **A.** the Chi-Square residuals by year, and **B.** the Chi-Square residuals by area.

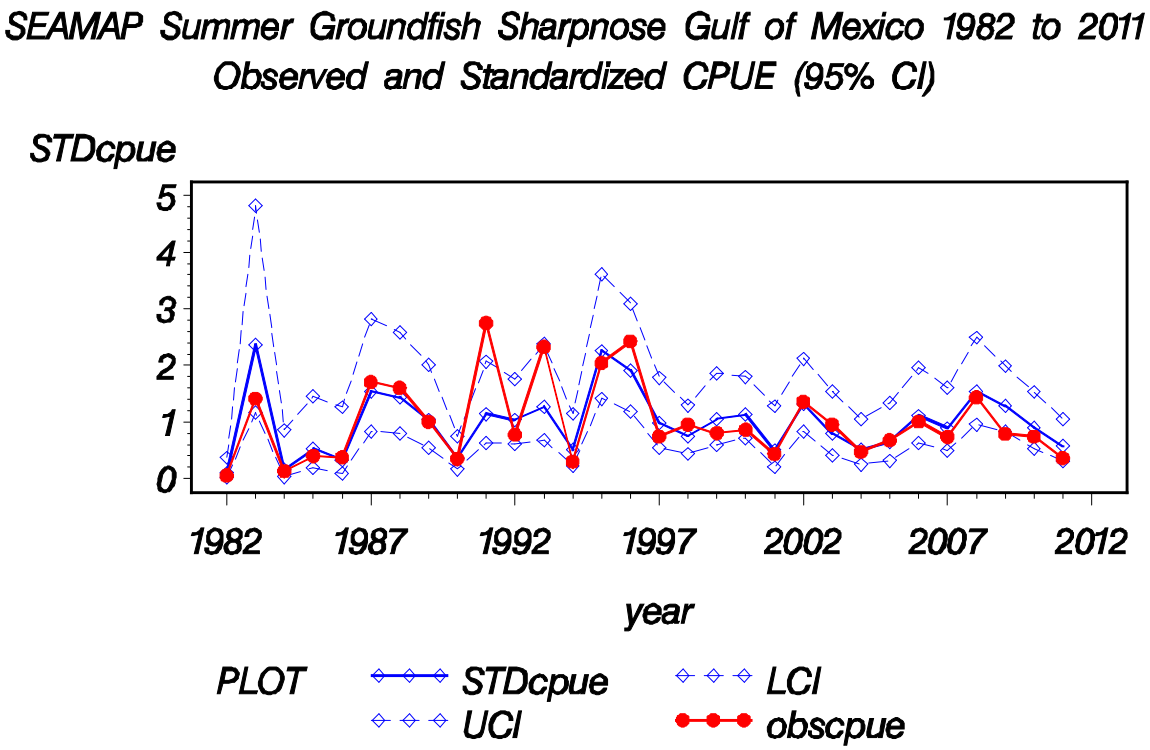

Figure 8. Annual index of abundance for Atlantic sharpnose from the Summer SEAMAP Groundfish Survey from 1982 – 2011.

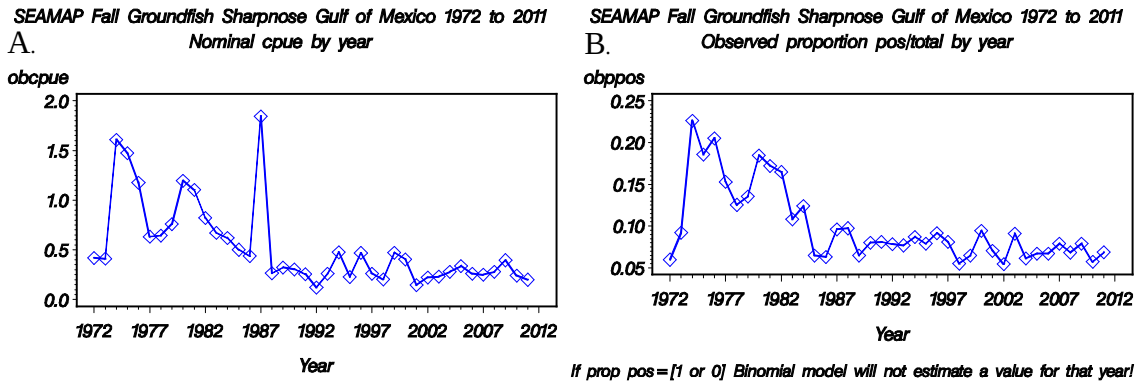

Figure 9. Annual trends for Atlantic sharpnose captured during Fall SEAMAP Groundfish Surveys from 1972 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

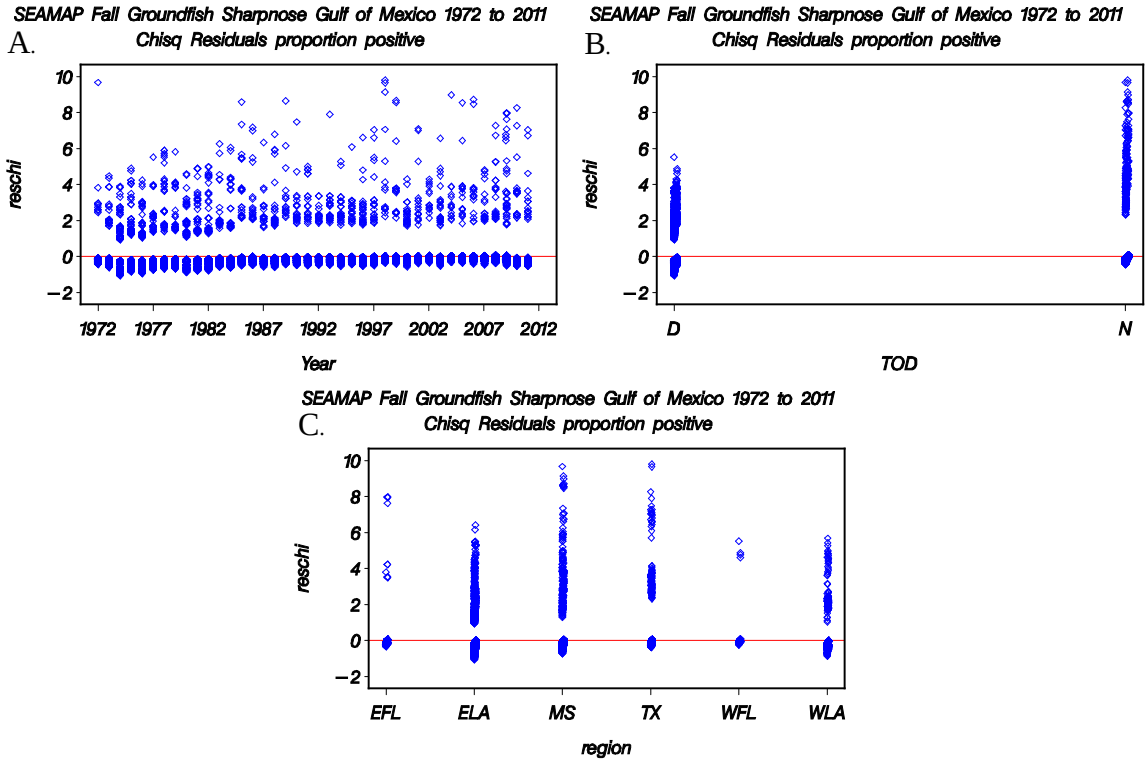

Figure 10. Diagnostic plots for binomial component of the Atlantic Sharpnose SEAMAP Groundfish Survey (GOM / all ages) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day, and **C.** the Chi-Square residuals by region.

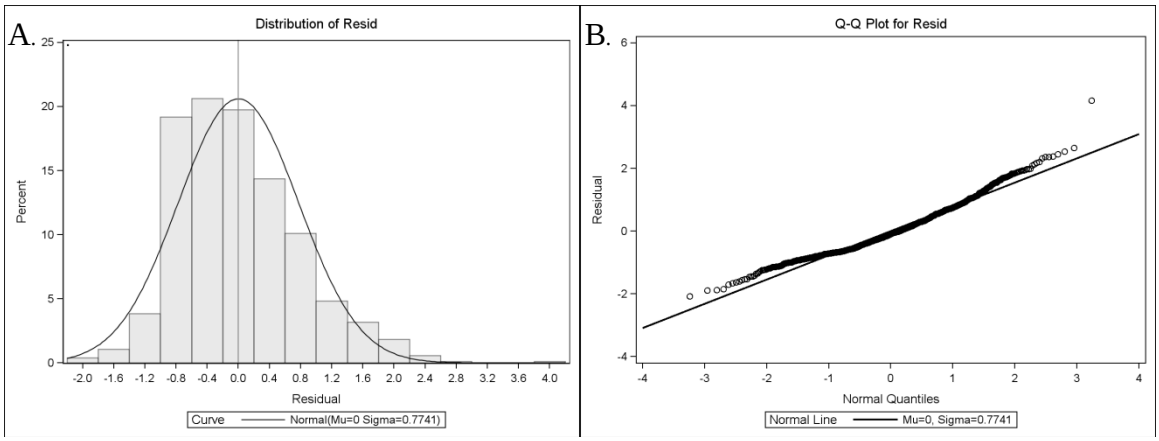

Figure 11. Diagnostic plots for lognormal component of the Atlantic sharpnose Fall SEAMAP Groundfish Survey model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

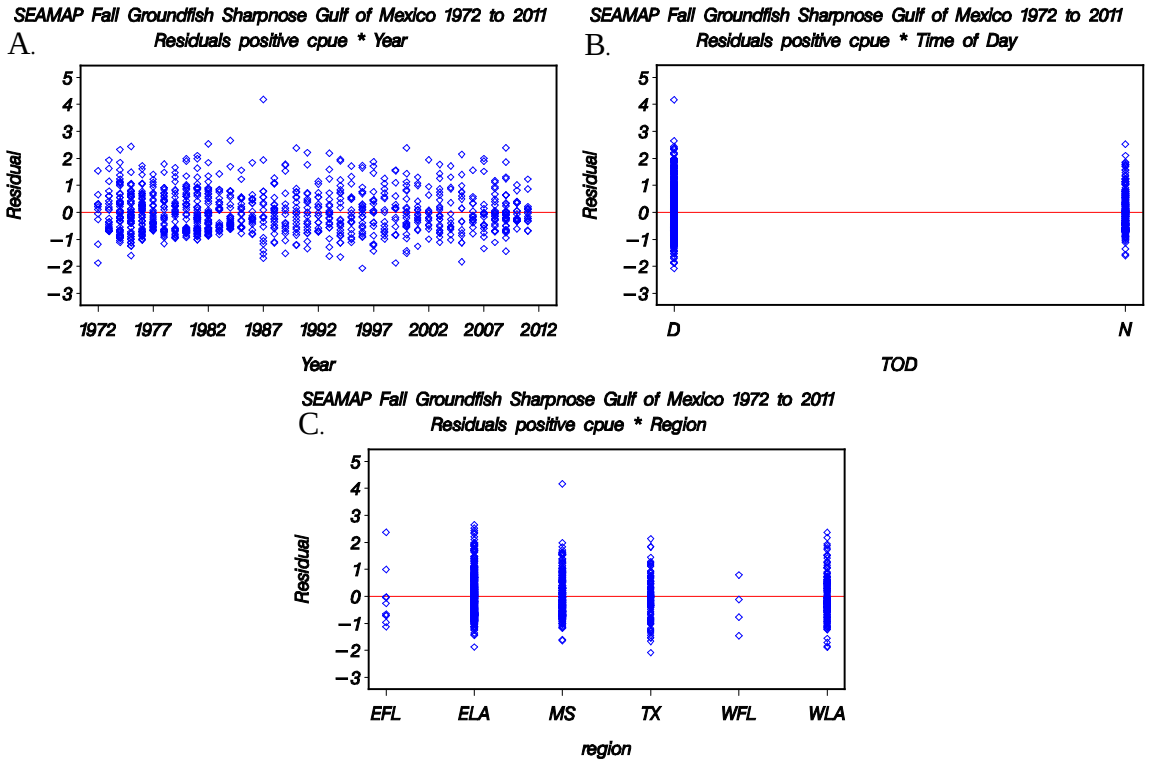

Figure 12. Diagnostic plots for lognormal component of the Atlantic Sharpnose SEAMAP Groundfish Survey (GOM / all ages) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day, and **C.** the Chi-Square residuals by region.

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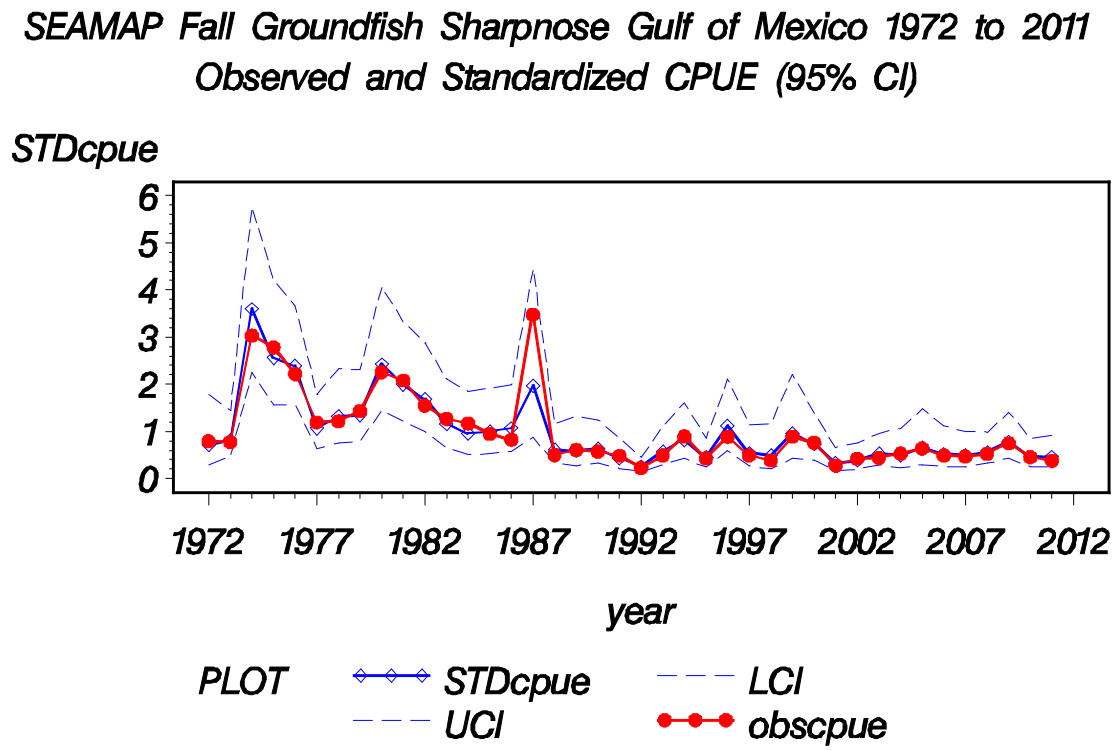
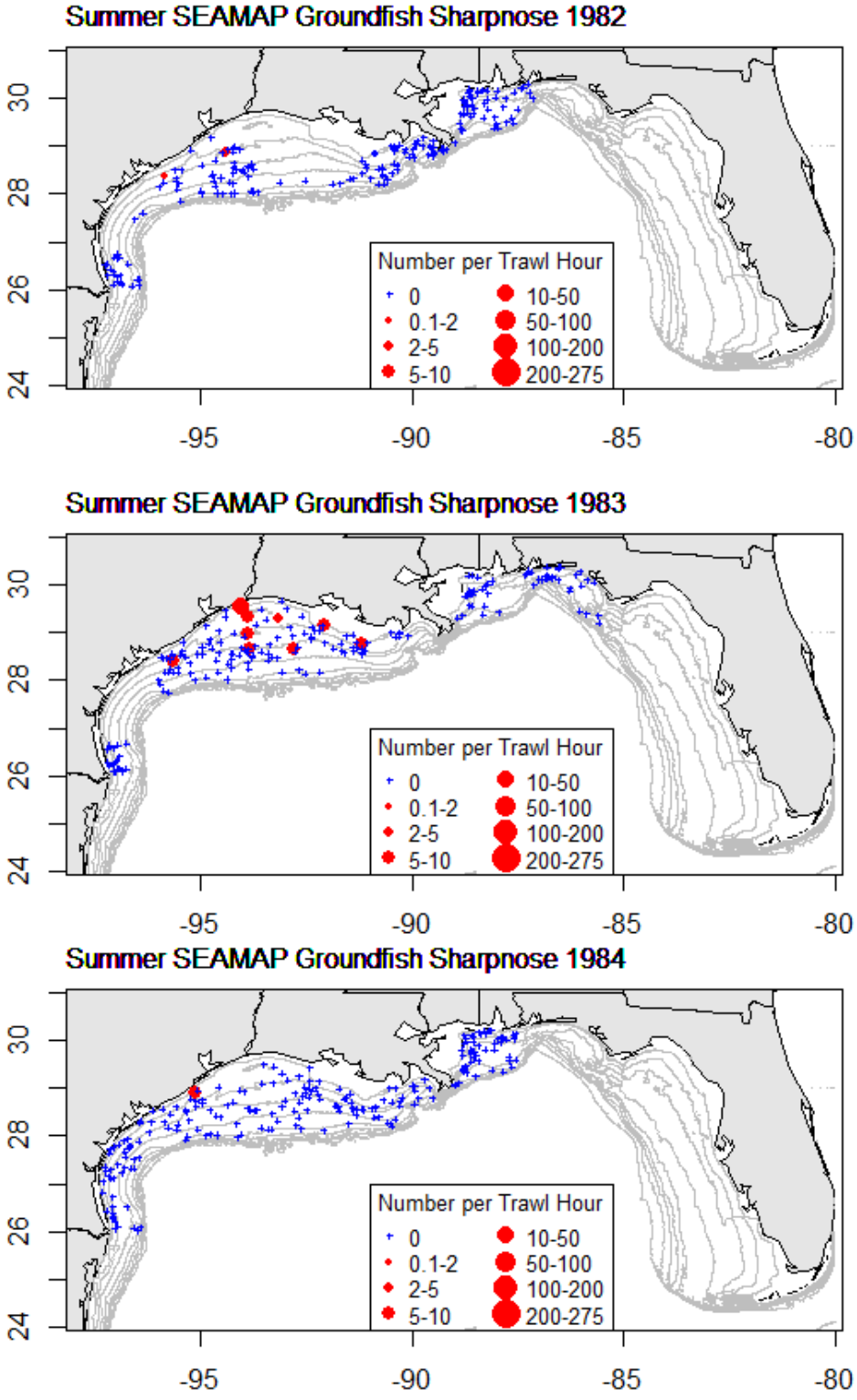
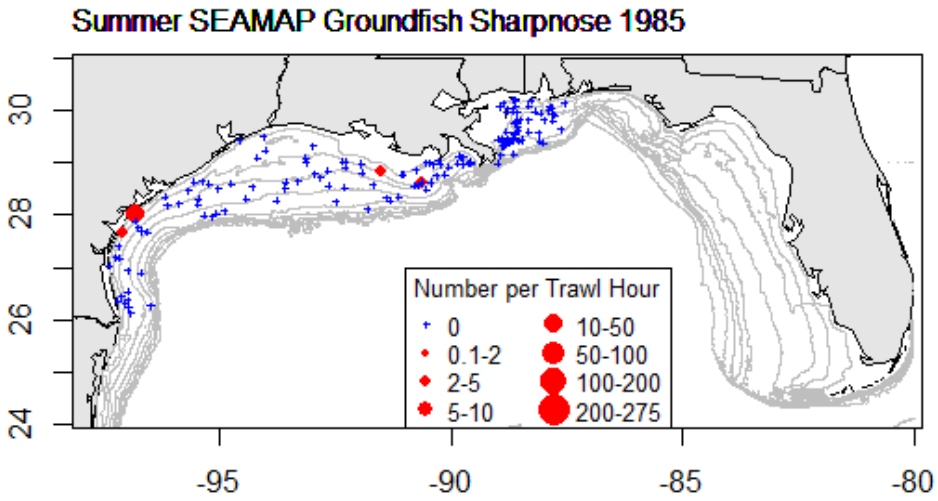


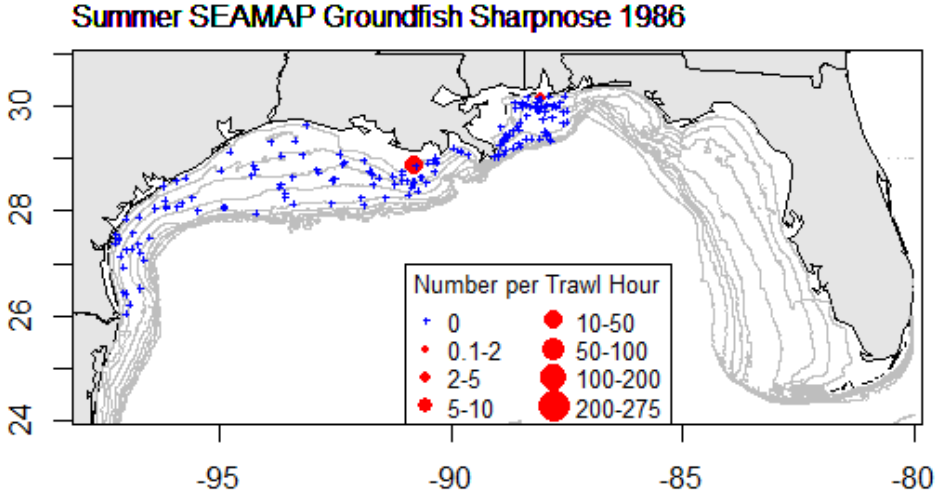
Figure 13. Annual index of abundance for Atlantic Sharpnose from the Fall SEAMAP Groundfish Survey from 1972 – 2011.

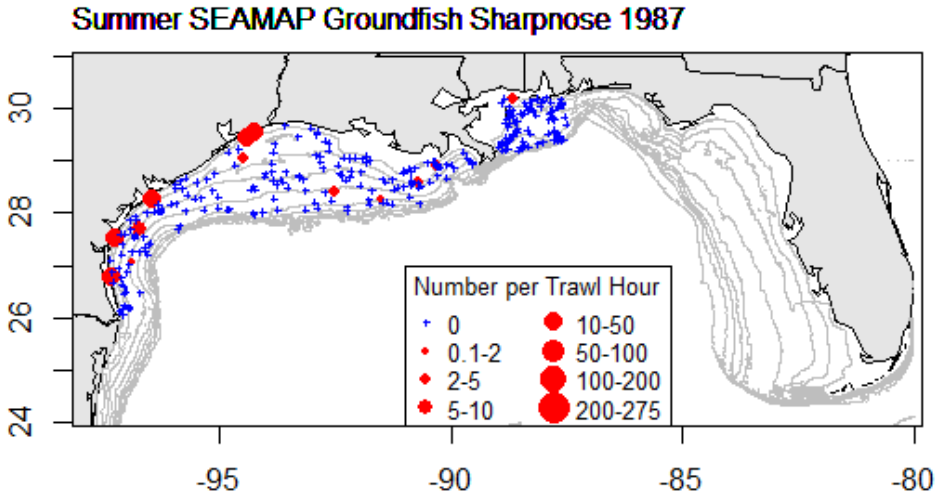
Appendix

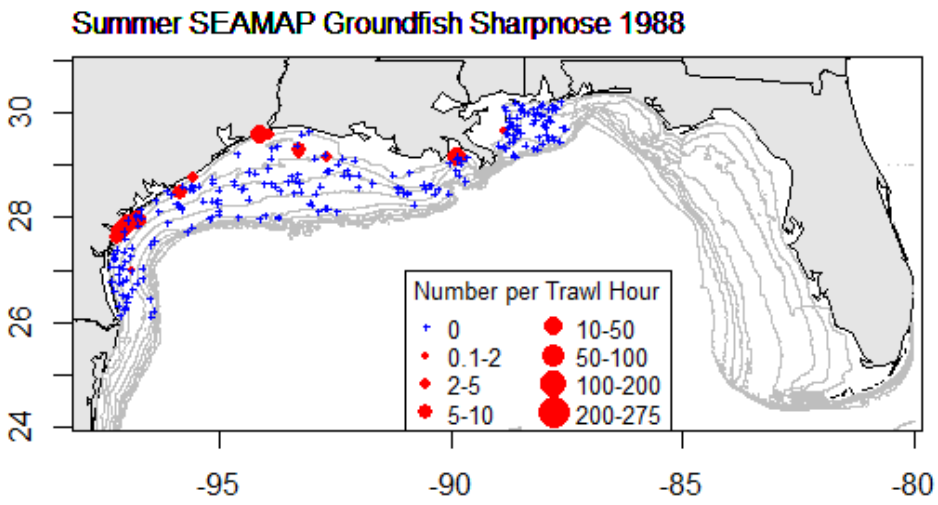
Appendix Figure 1. Annual survey effort and catch of Atlantic Sharpnose from the SEAMAP groundfish survey during the summer (1982-2011) and fall (1972-2011).

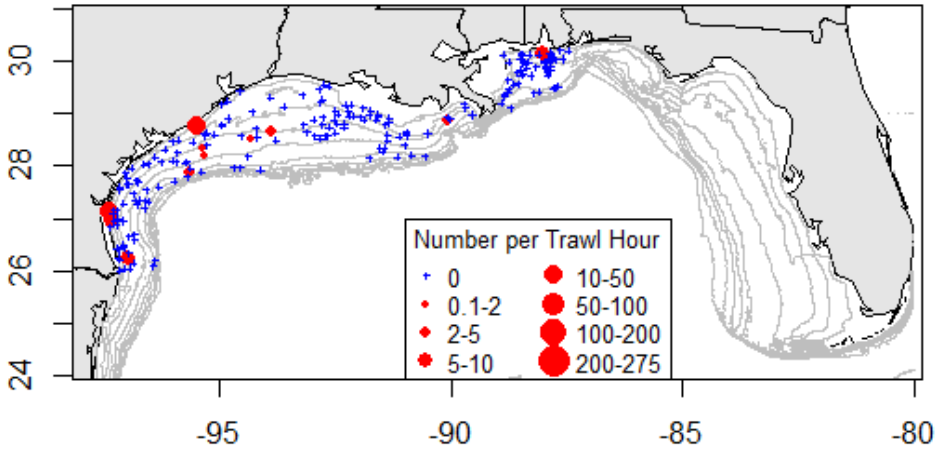


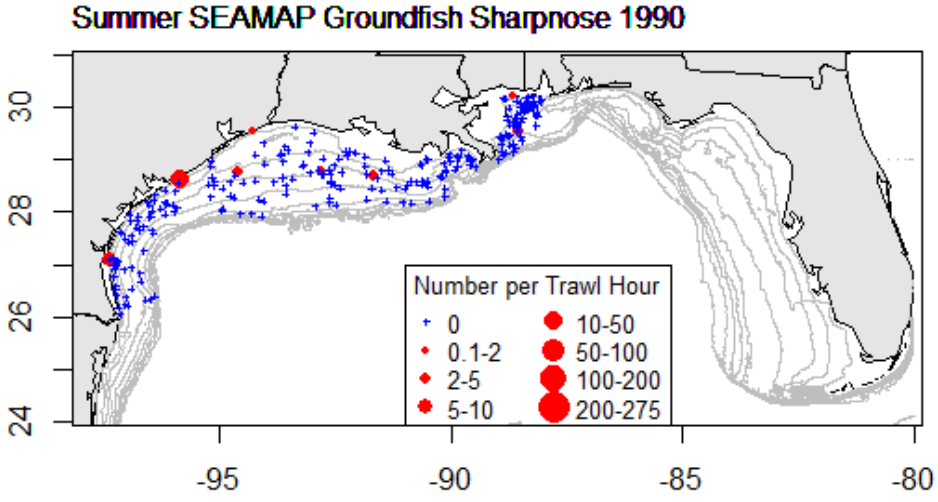

Summer SEAMAP Groundfish Sharpnose 1985
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

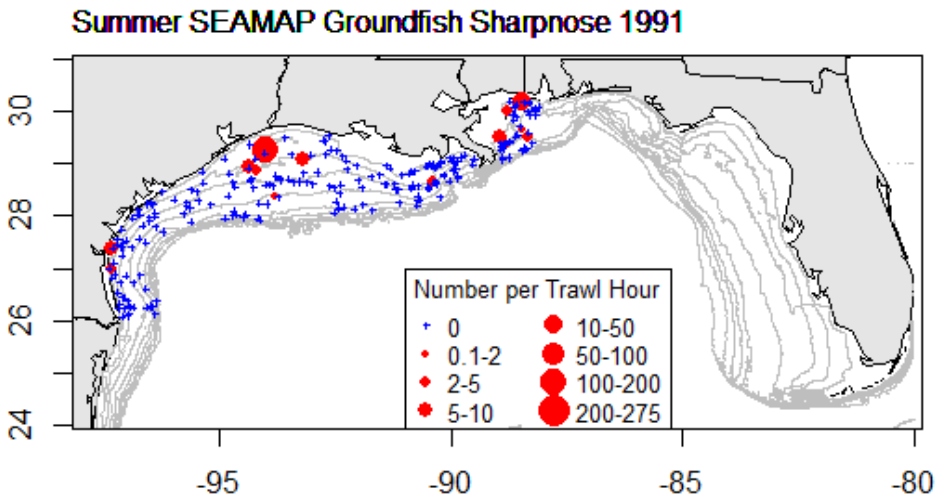

Summer SEAMAP Groundfish Sharpnose 1986
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

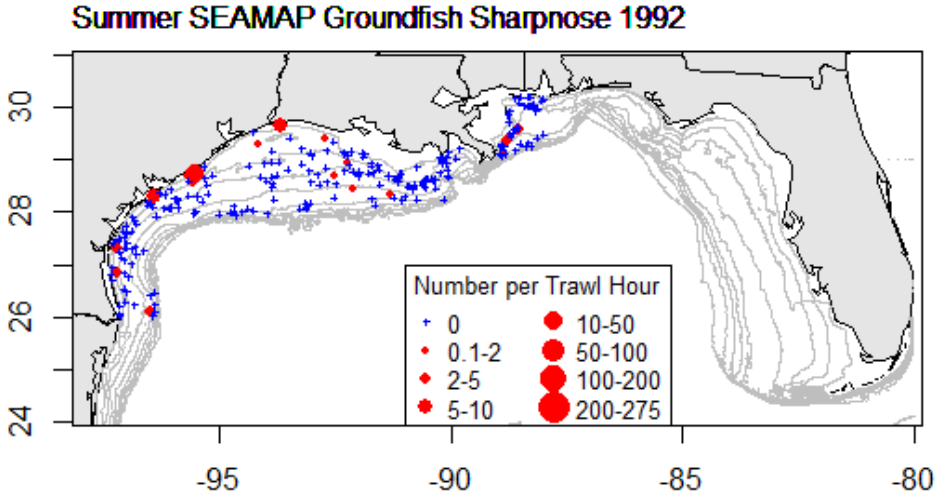

Summer SEAMAP Groundfish Sharpnose 1987
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

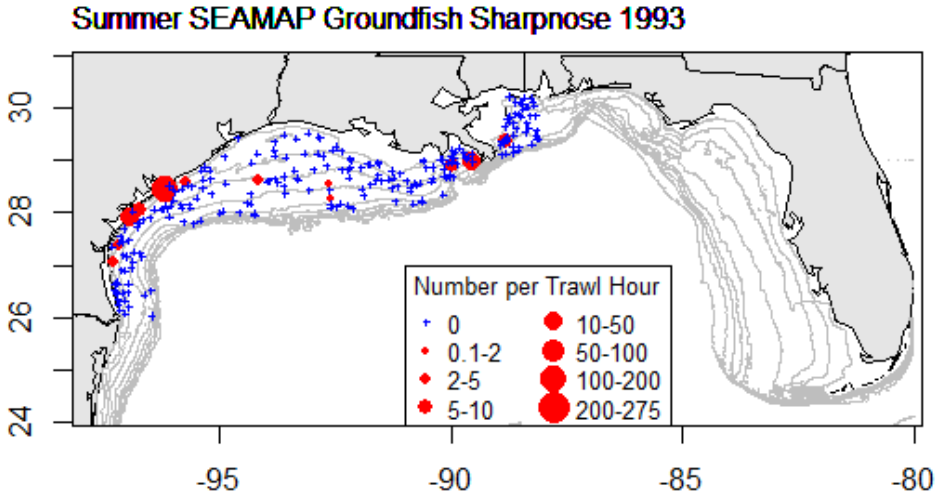

Summer SEAMAP Groundfish Sharpnose 1988
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 1989
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

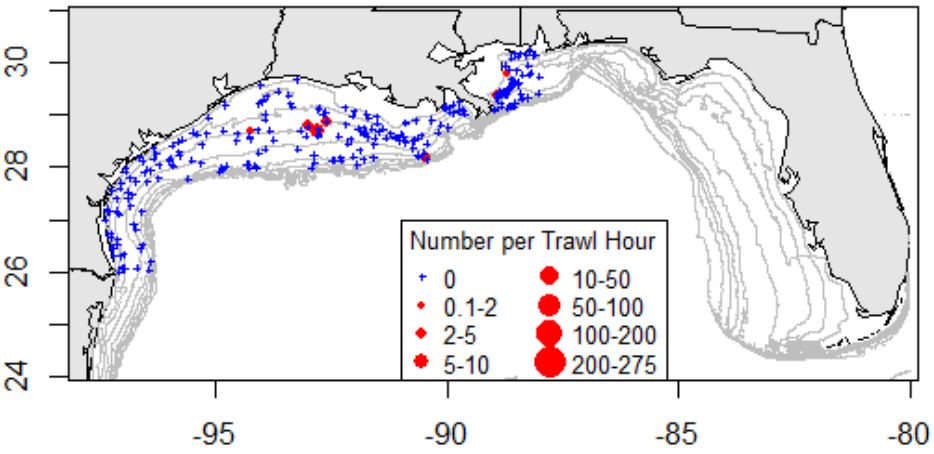

Summer SEAMAP Groundfish Sharpnose 1990
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 1991
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

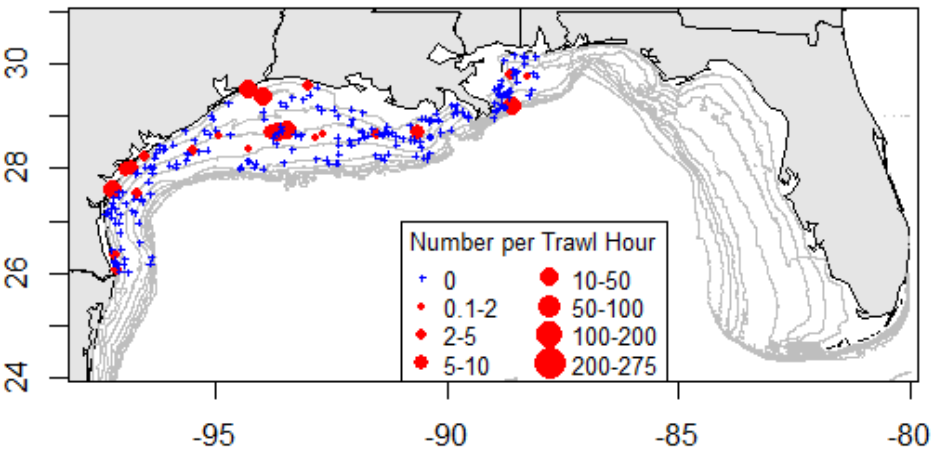

Summer SEAMAP Groundfish Sharpnose 1992
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 1993
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80

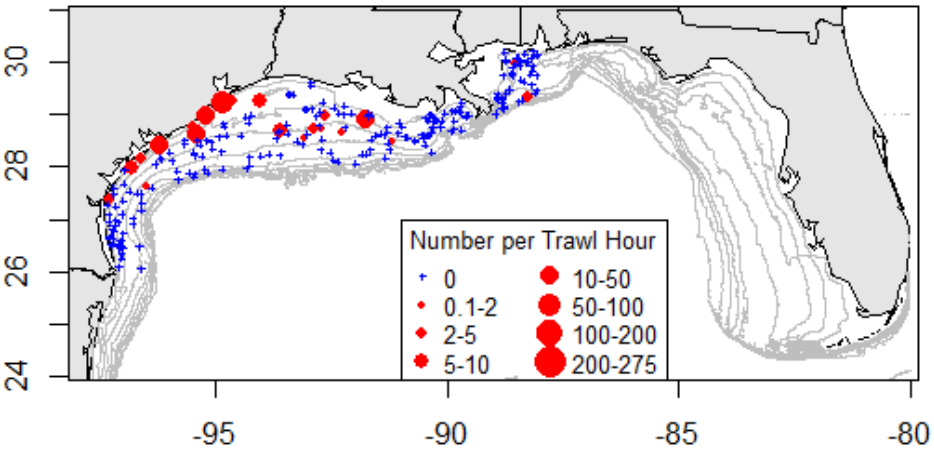
Summer SEAMAP Groundfish Sharpnose 1994



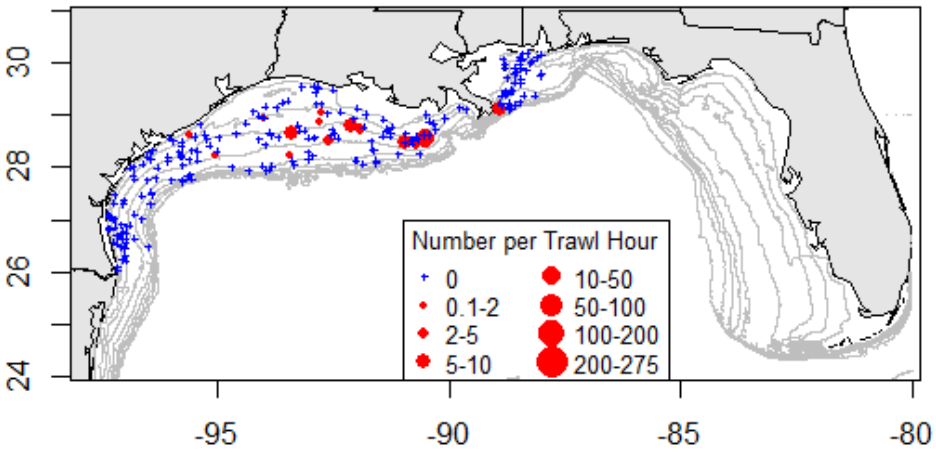
Summer SEAMAP Groundfish Sharpnose 1995



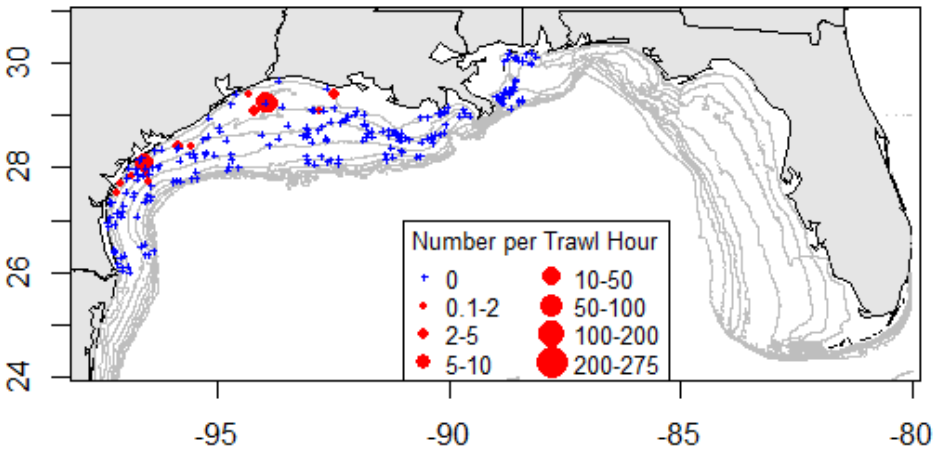
Summer SEAMAP Groundfish Sharpnose 1996



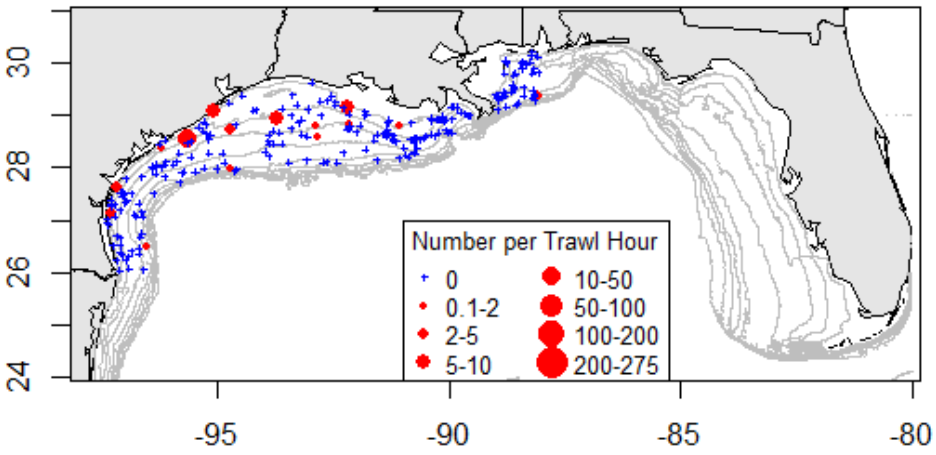
Summer SEAMAP Groundfish Sharpnose 1997

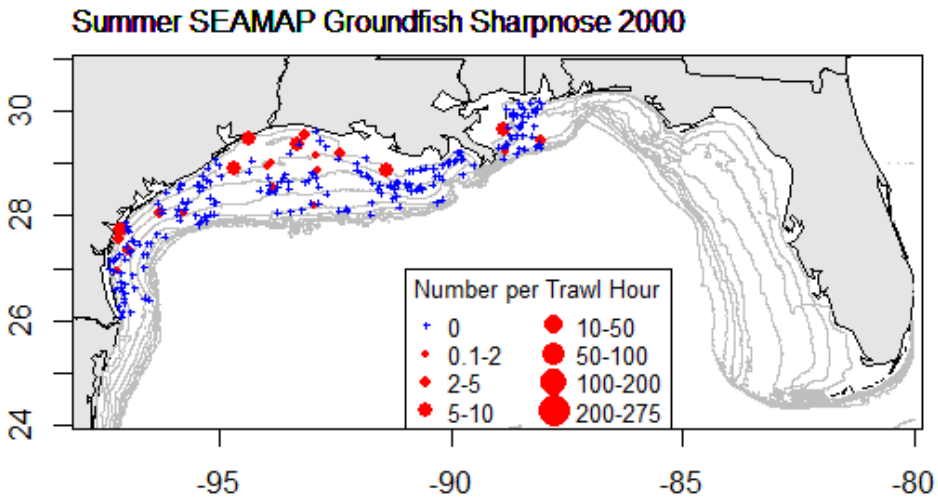


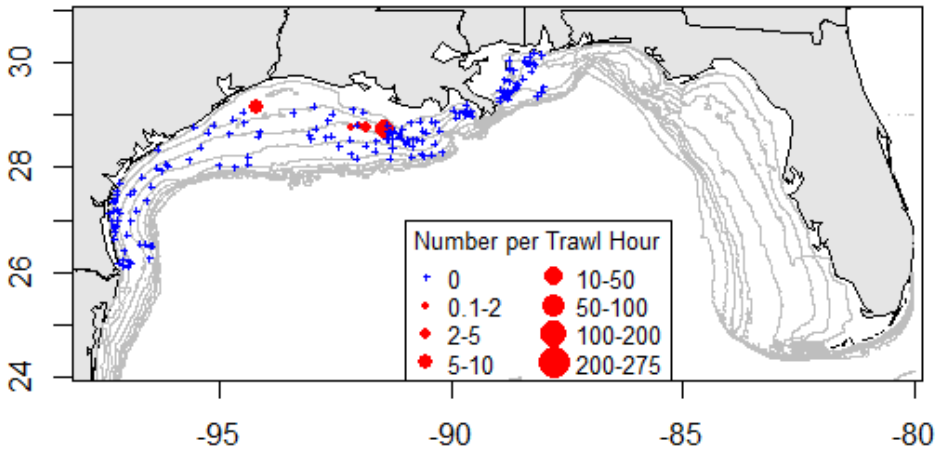
Summer SEAMAP Groundfish Sharpnose 1998

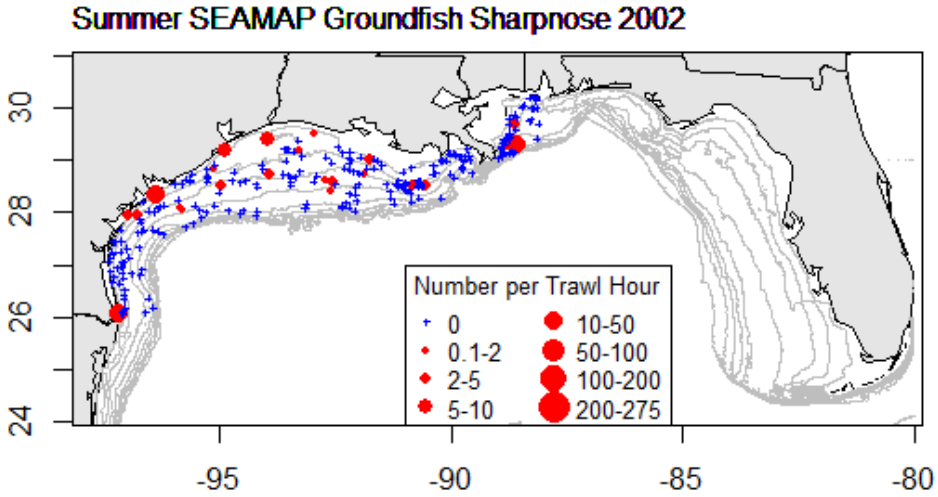


Summer SEAMAP Groundfish Sharpnose 1999




Summer SEAMAP Groundfish Sharpnose 2000
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 2001
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 2002
Number per Trawl Hour
0
0.1-2
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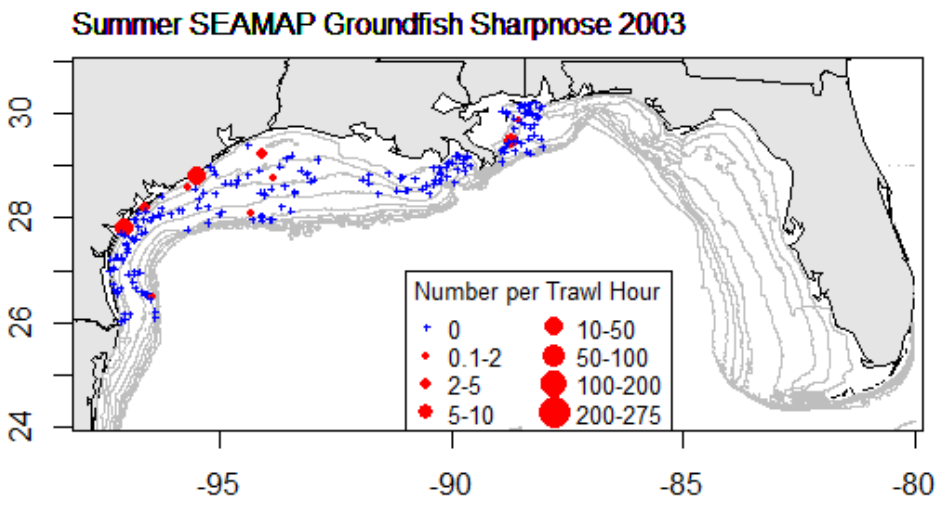
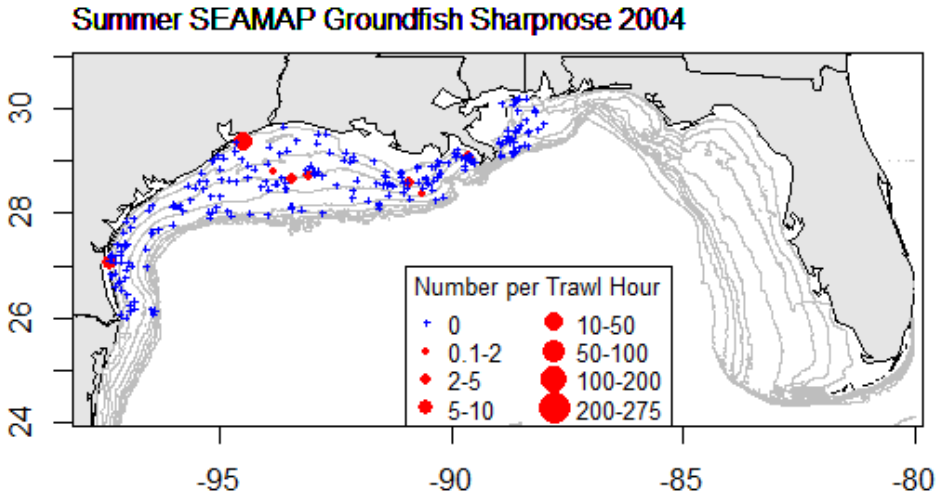
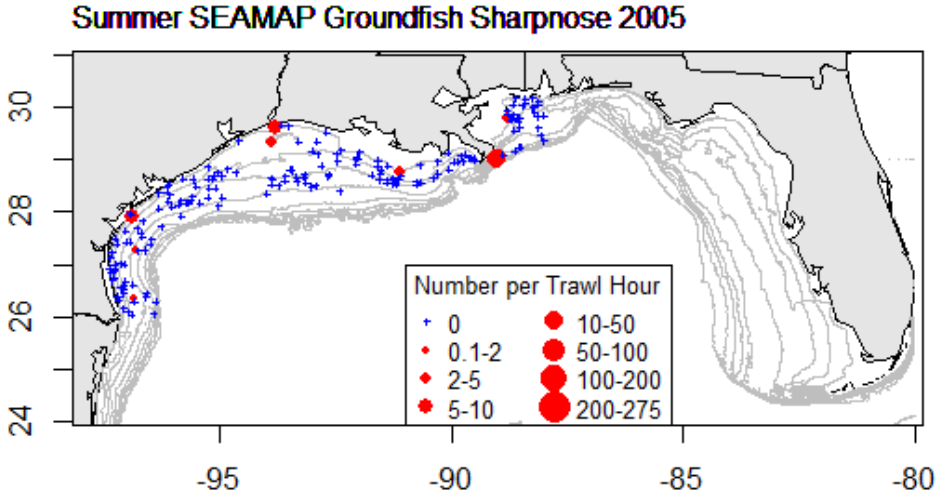
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 2003
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 2004
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
30
28
26
24
-95
-90
-85
-80


Summer SEAMAP Groundfish Sharpnose 2005
Number per Trawl Hour
0
0.1-2
2-5
5-10
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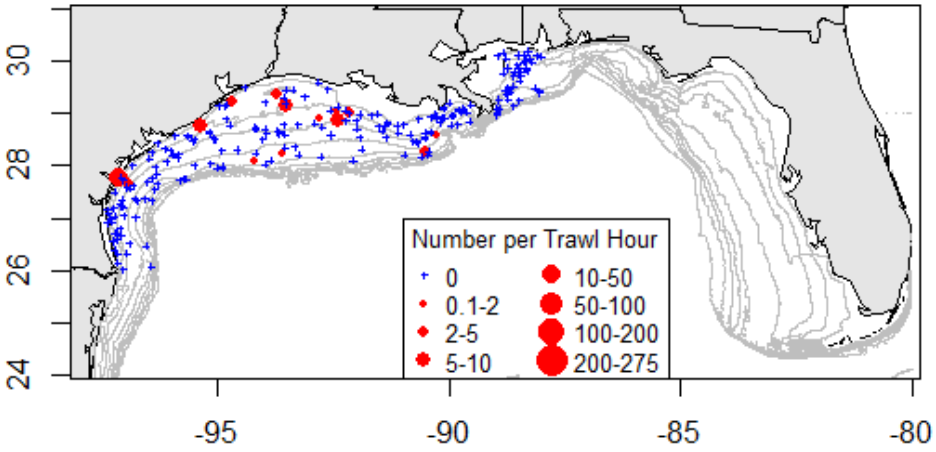
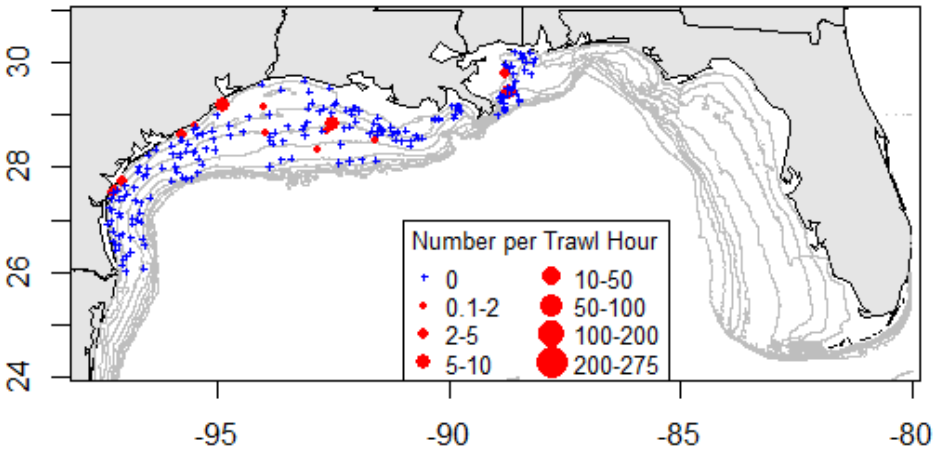
-85
-80

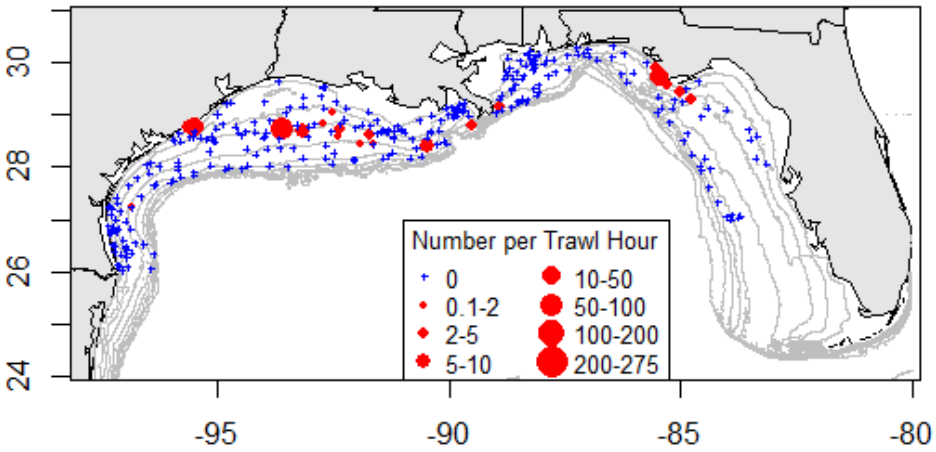
Summer SEAMAP Groundfish Sharpnose 2006

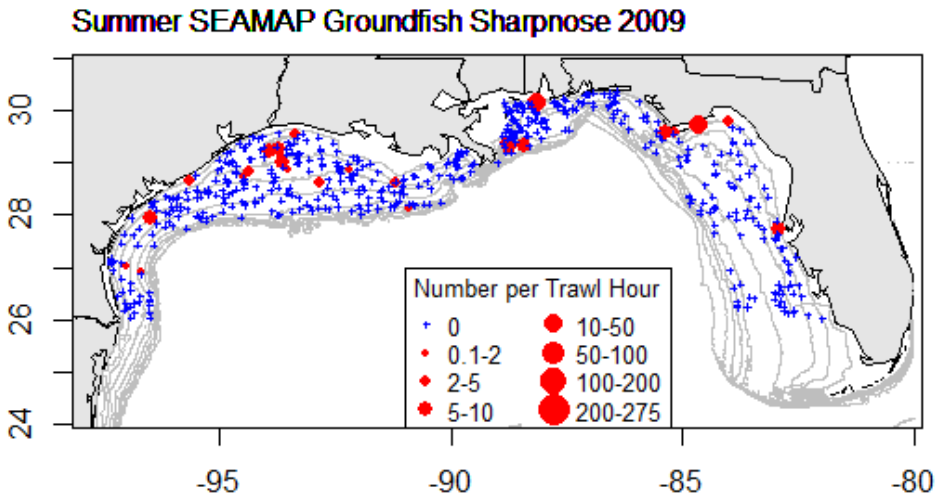


Summer SEAMAP Groundfish Sharpnose 2007



Summer SEAMAP Groundfish Sharpnose 2008




Summer SEAMAP Groundfish Sharpnose 2009
Number per Trawl Hour
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200-275
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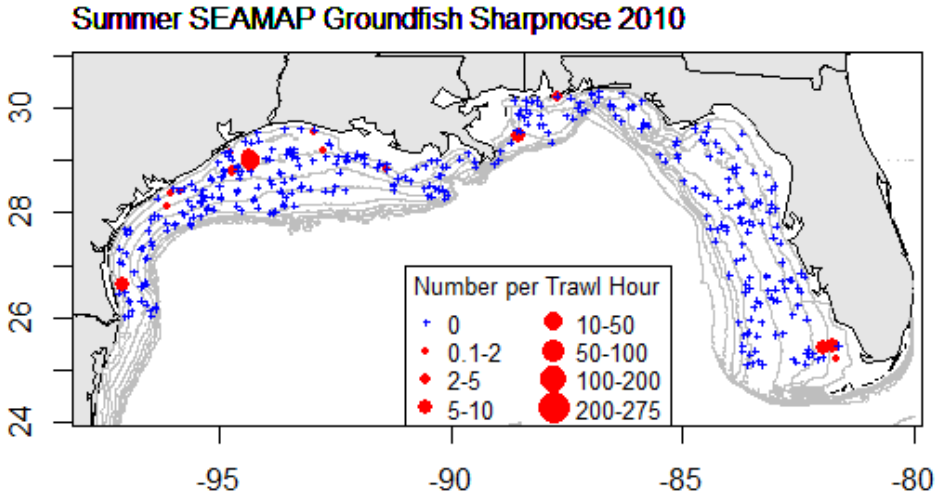
Summer SEAMAP Groundfish Sharpnose 2010
Number per Trawl Hour
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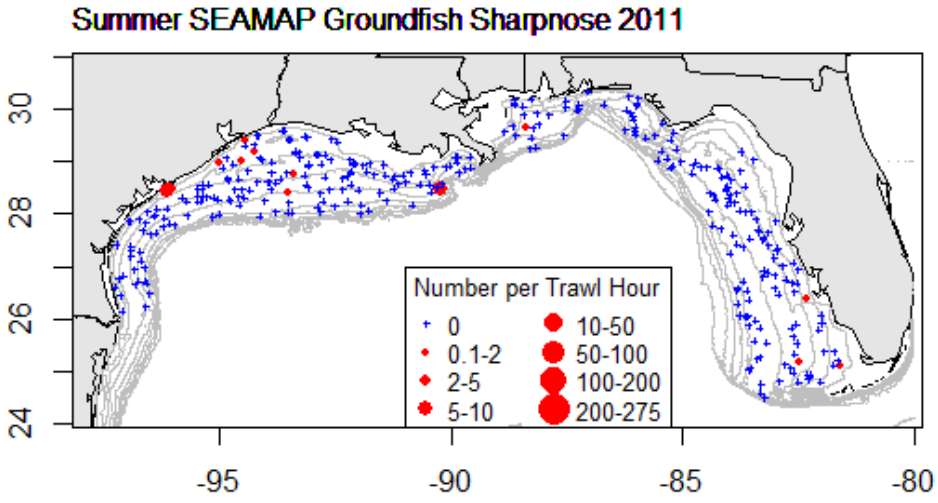
Summer SEAMAP Groundfish Sharpnose 2011
Number per Trawl Hour
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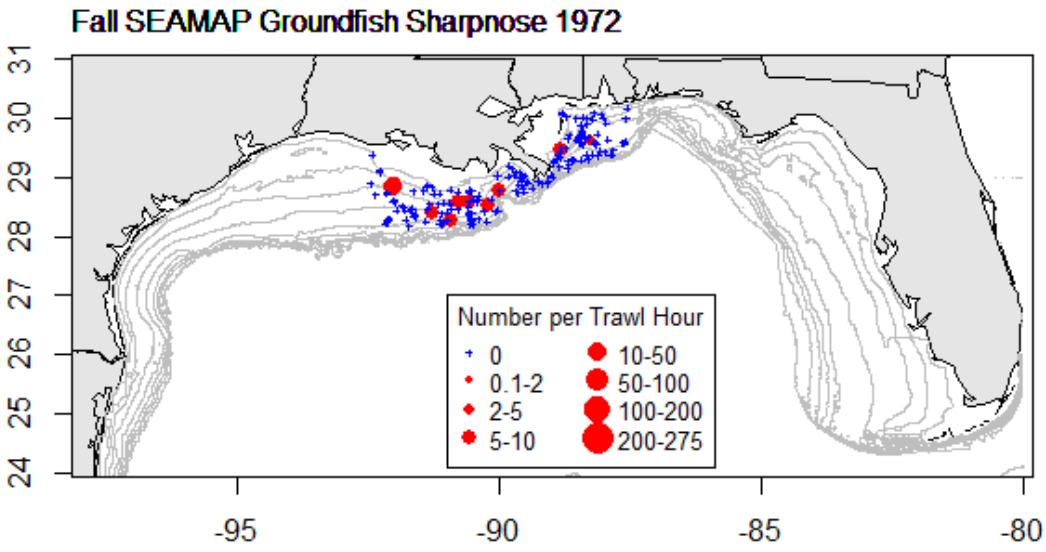
Fall SEAMAP Groundfish Sharpnose 1972
Number per Trawl Hour
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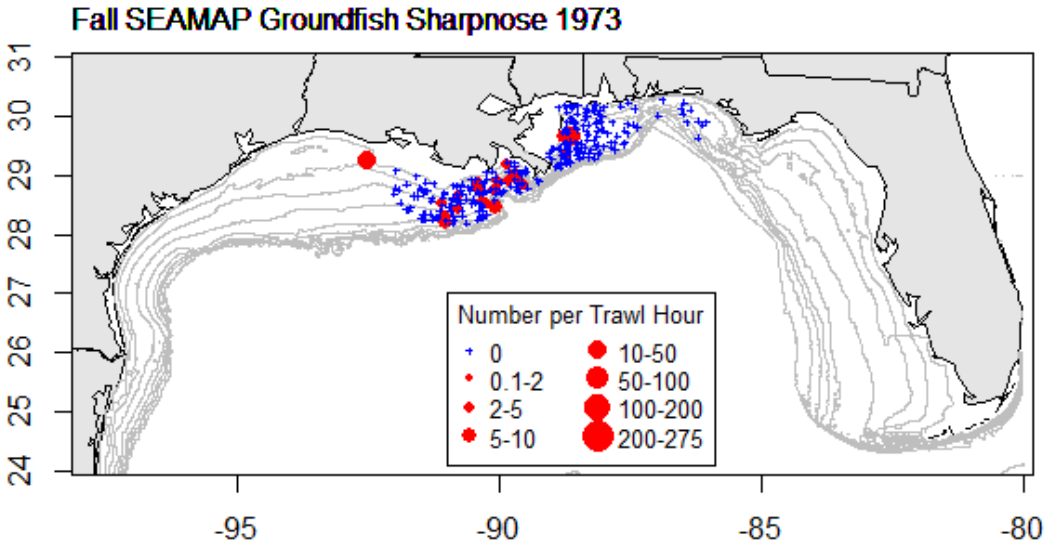
Fall SEAMAP Groundfish Sharpnose 1973
Number per Trawl Hour
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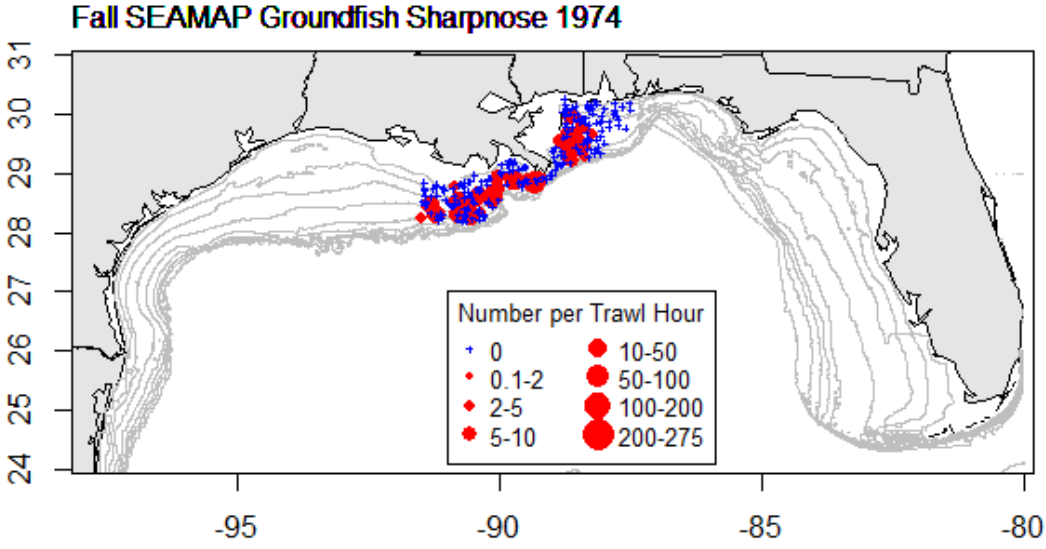
Fall SEAMAP Groundfish Sharpnose 1974
Number per Trawl Hour
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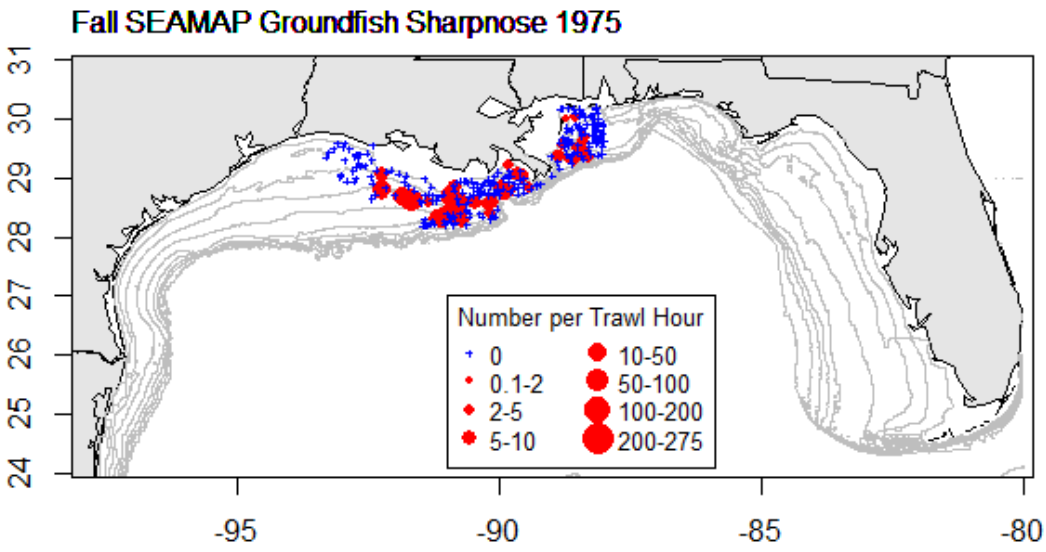
Fall SEAMAP Groundfish Sharpnose 1975
Number per Trawl Hour
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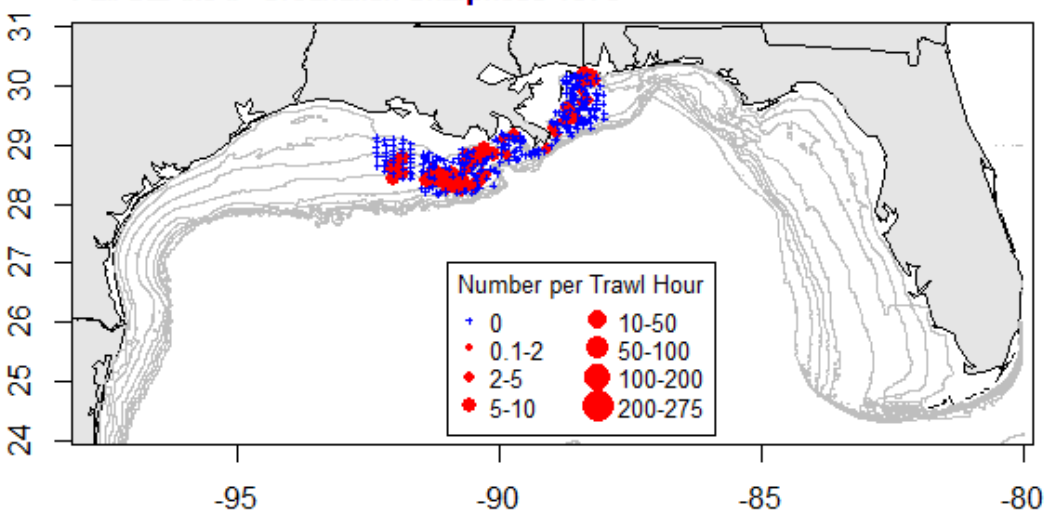
Fall SEAMAP Groundfish Sharpnose 1976
Number per Trawl Hour
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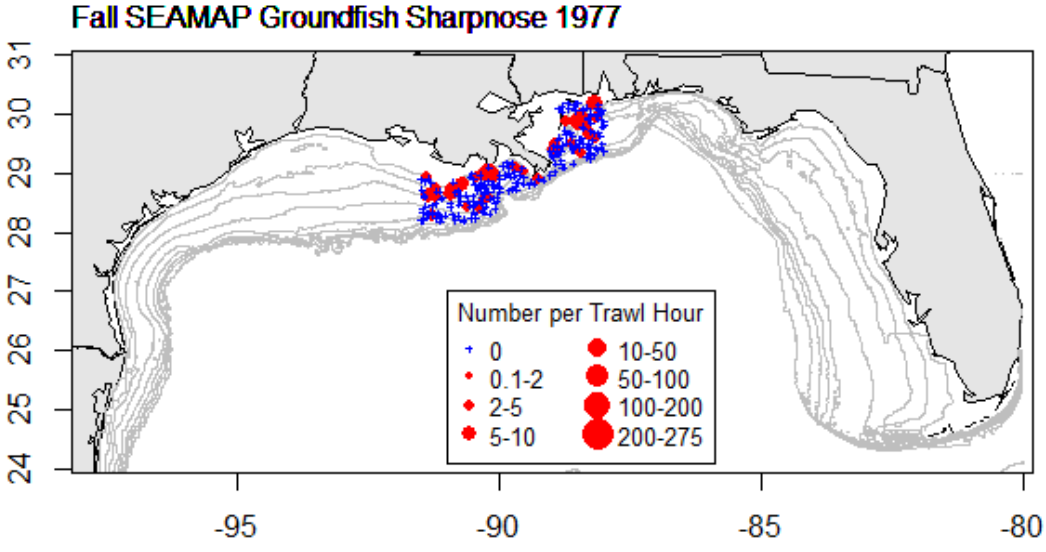
Fall SEAMAP Groundfish Sharpnose 1977
Number per Trawl Hour
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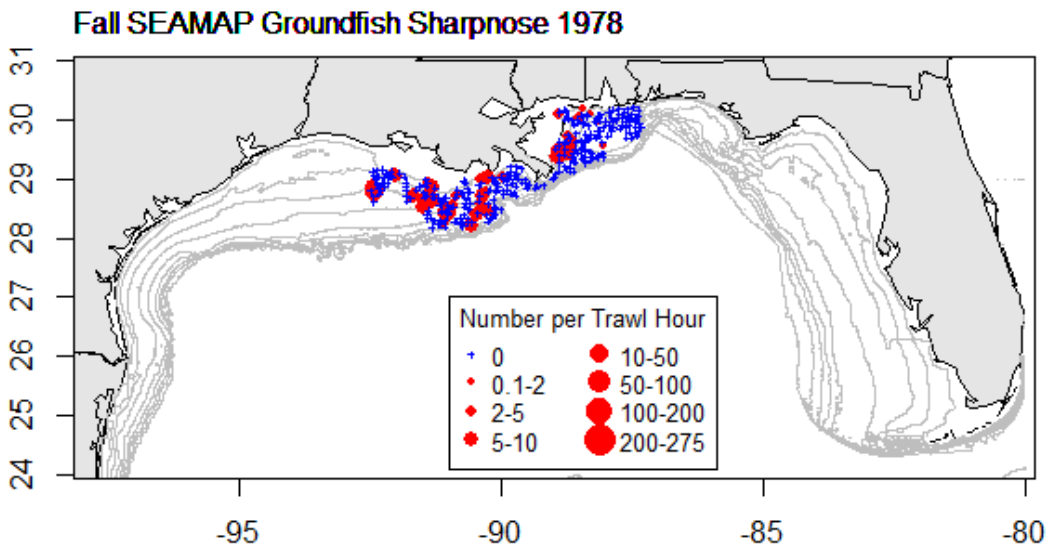
Fall SEAMAP Groundfish Sharpnose 1978
Number per Trawl Hour
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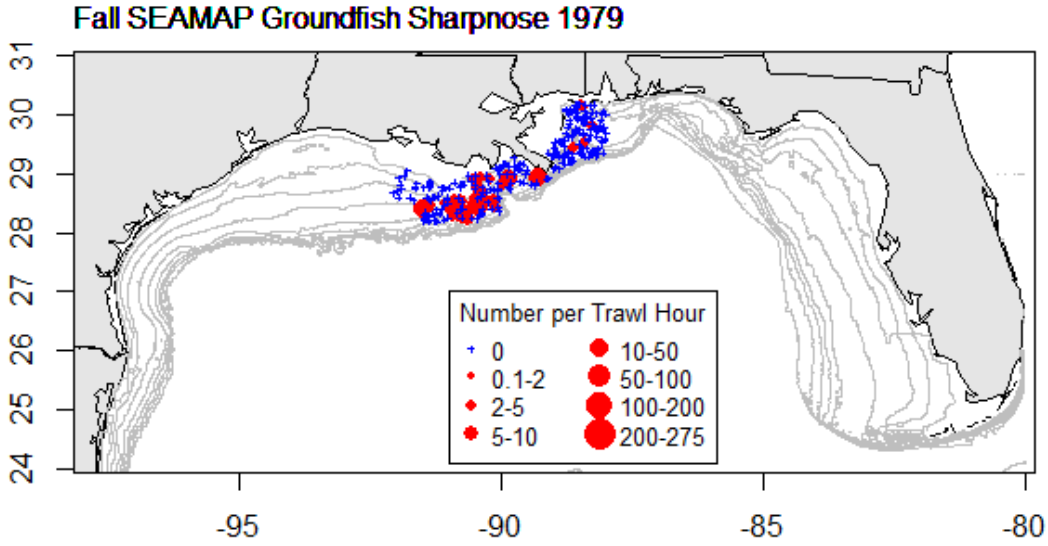
Fall SEAMAP Groundfish Sharpnose 1979
Number per Trawl Hour
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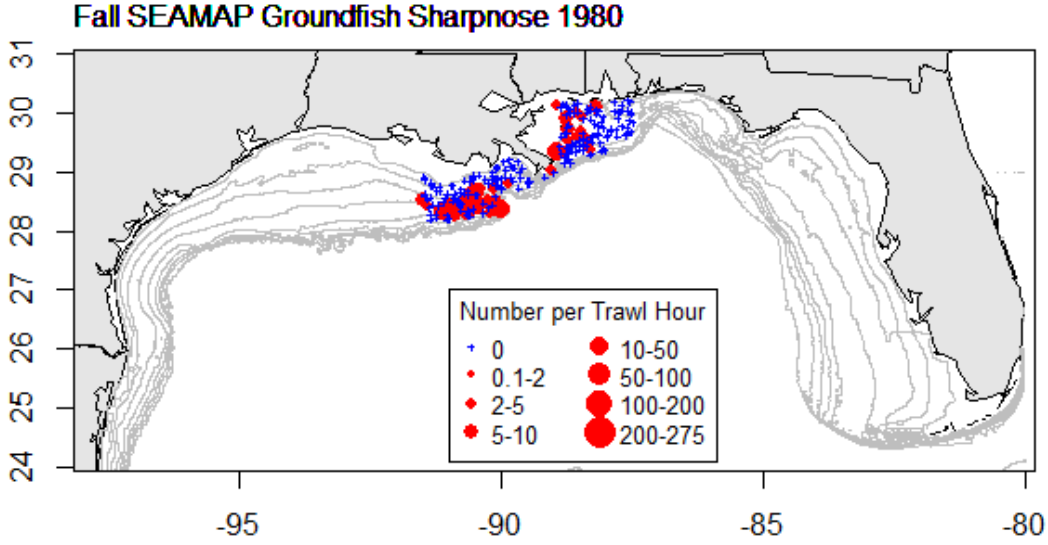
Fall SEAMAP Groundfish Sharpnose 1980
Number per Trawl Hour
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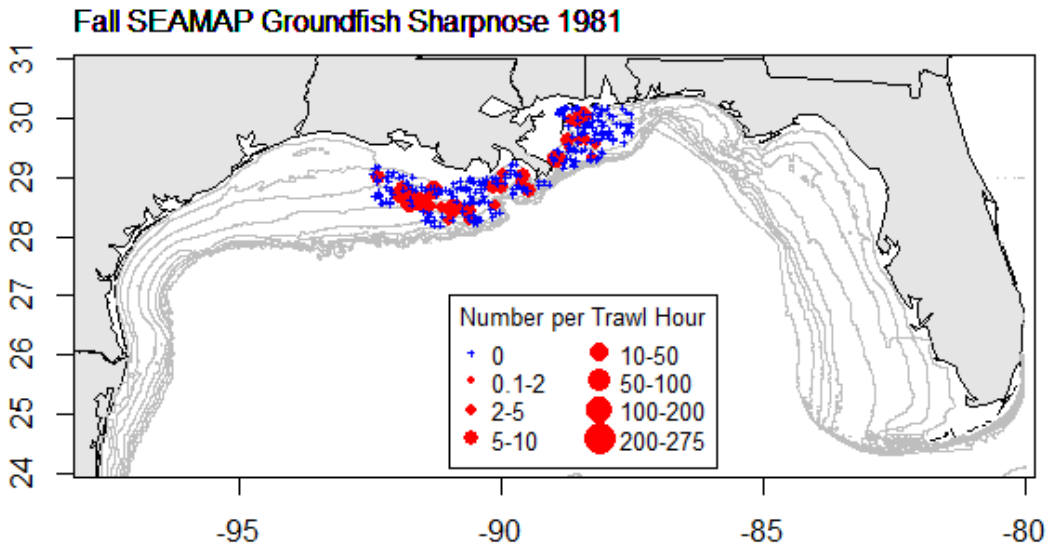
Fall SEAMAP Groundfish Sharpnose 1981
Number per Trawl Hour
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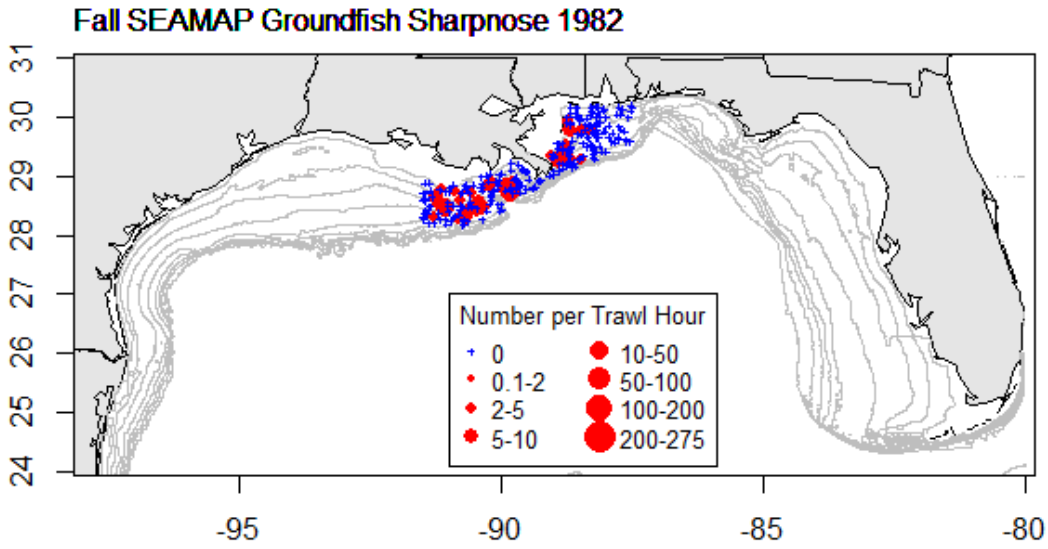
Fall SEAMAP Groundfish Sharpnose 1982
Number per Trawl Hour
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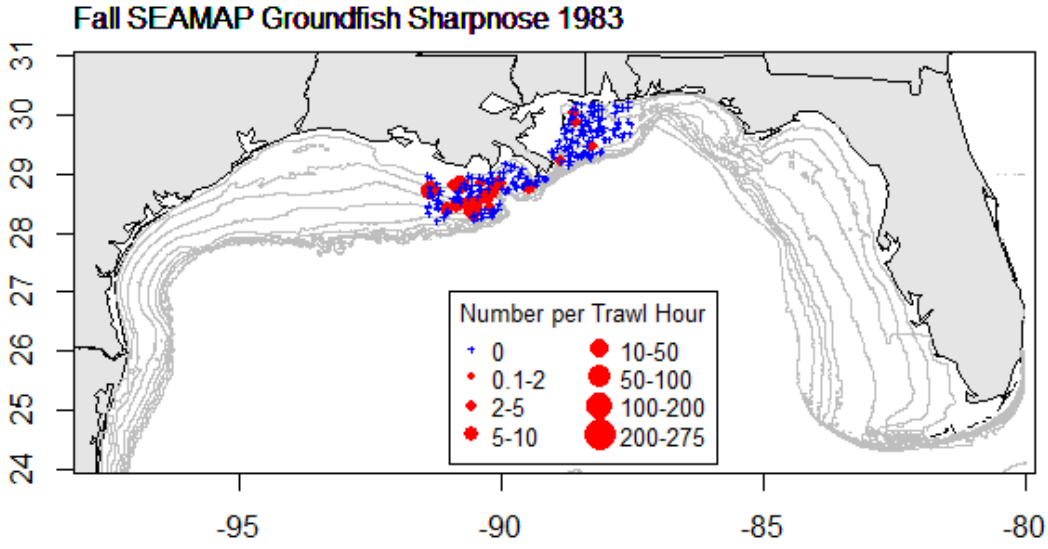
Fall SEAMAP Groundfish Sharpnose 1983
Number per Trawl Hour
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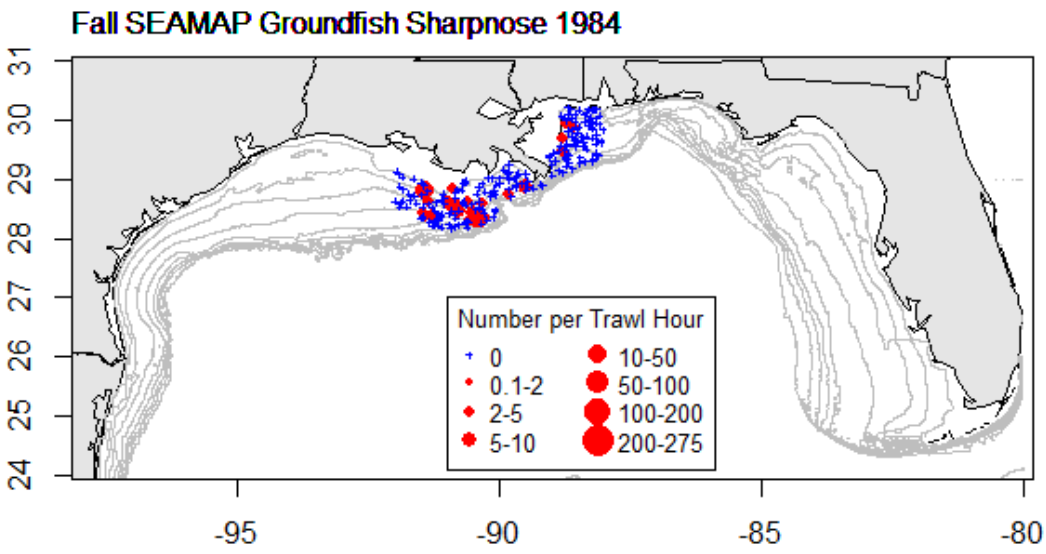
Fall SEAMAP Groundfish Sharpnose 1984
Number per Trawl Hour
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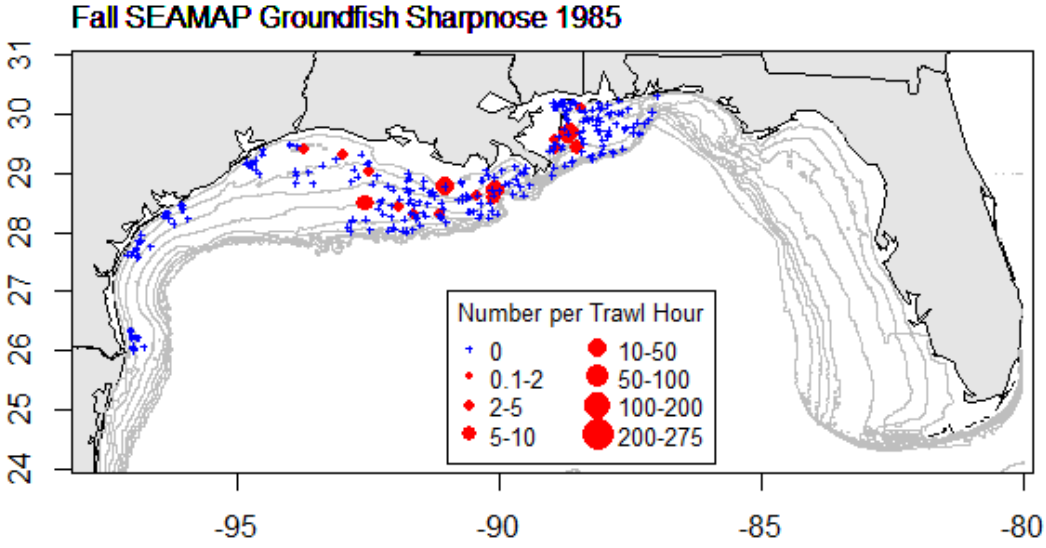
Fall SEAMAP Groundfish Sharpnose 1985
Number per Trawl Hour
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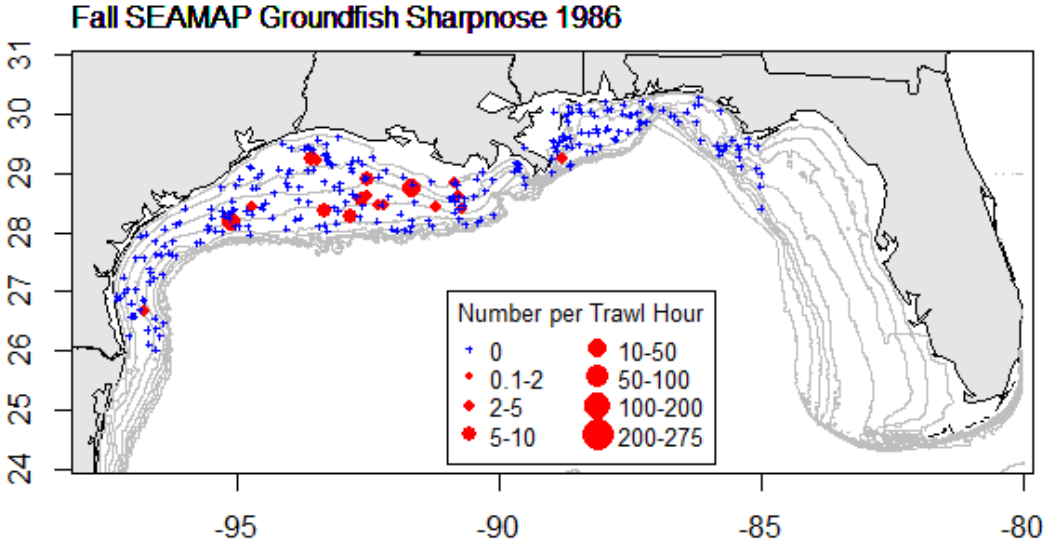
Fall SEAMAP Groundfish Sharpnose 1986
Number per Trawl Hour
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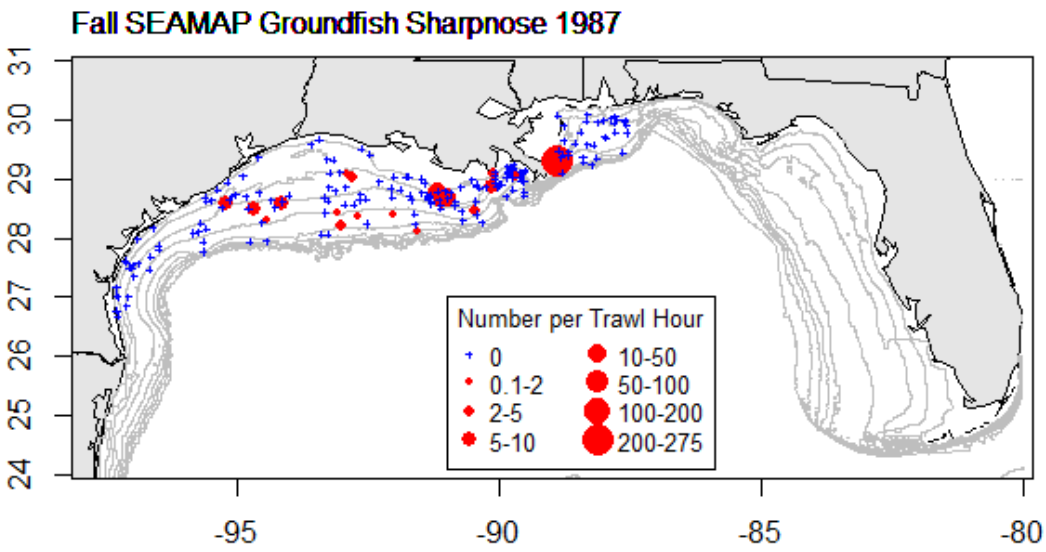
Fall SEAMAP Groundfish Sharpnose 1987
Number per Trawl Hour
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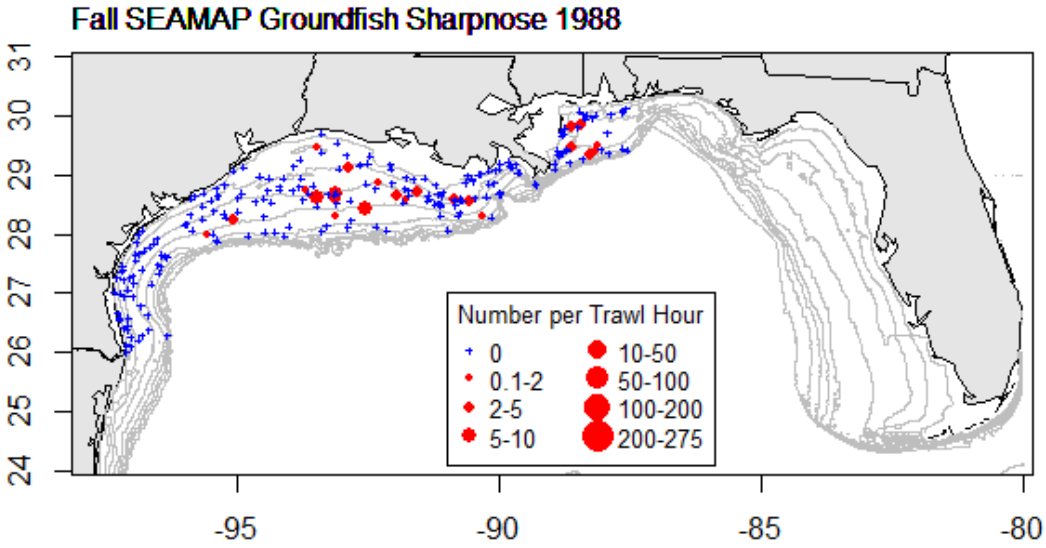
Fall SEAMAP Groundfish Sharpnose 1988
Number per Trawl Hour
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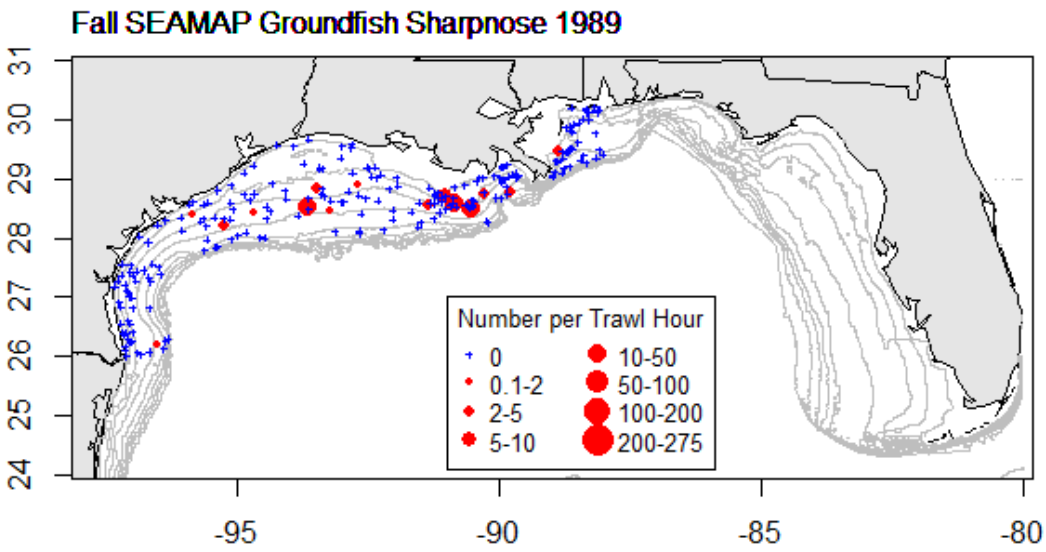
Fall SEAMAP Groundfish Sharpnose 1989
Number per Trawl Hour
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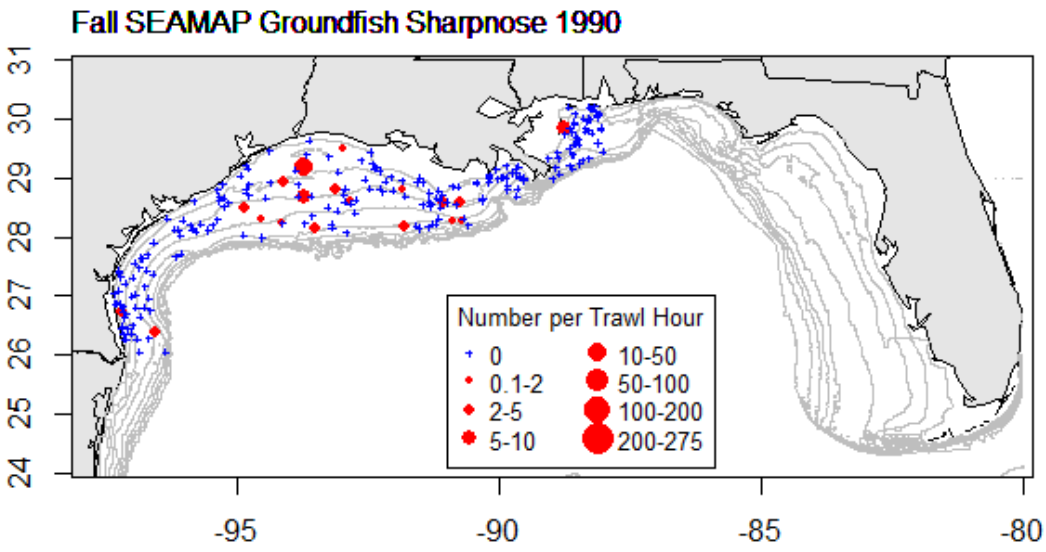
Fall SEAMAP Groundfish Sharpnose 1990
Number per Trawl Hour
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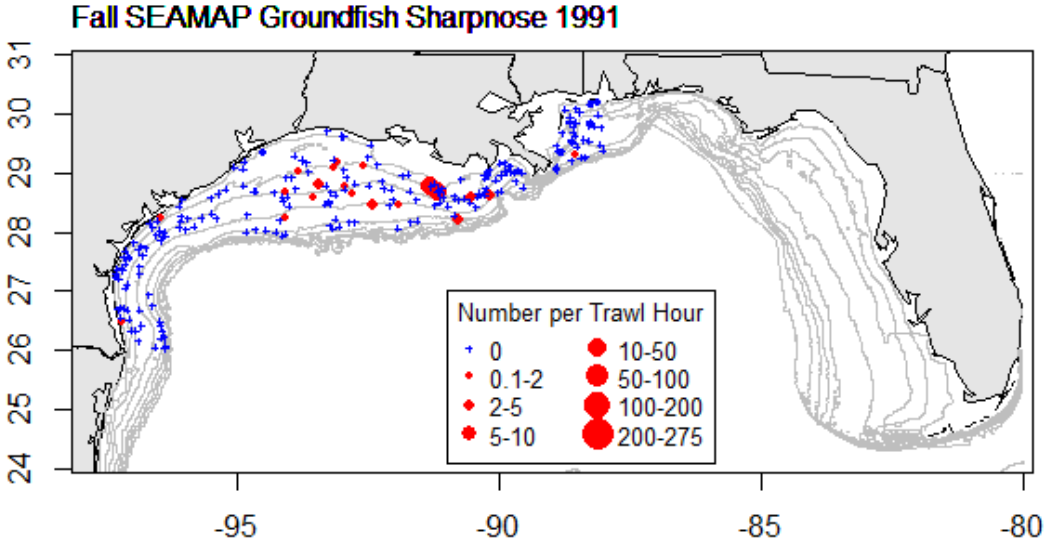
Fall SEAMAP Groundfish Sharpnose 1991
Number per Trawl Hour
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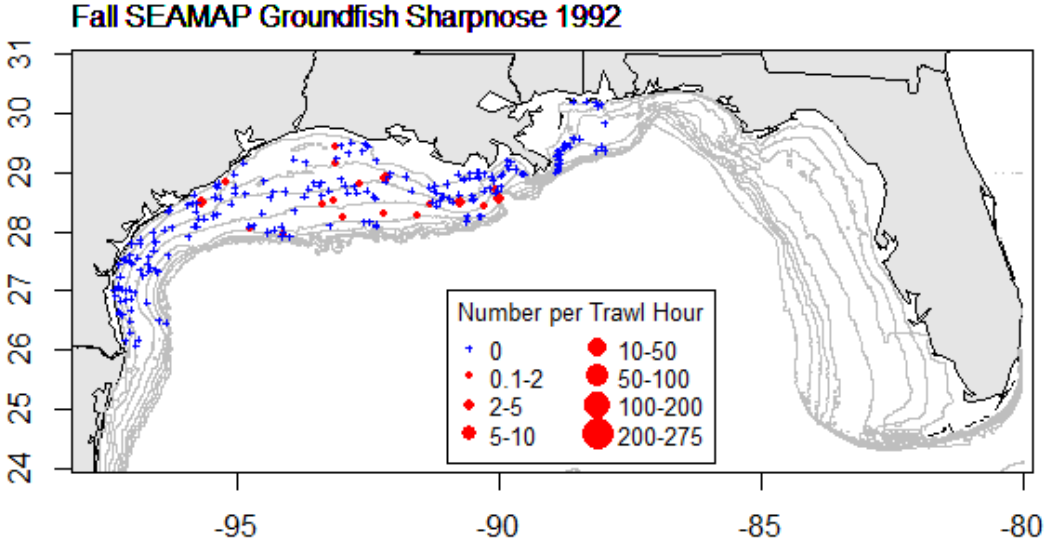
Fall SEAMAP Groundfish Sharpnose 1992
Number per Trawl Hour
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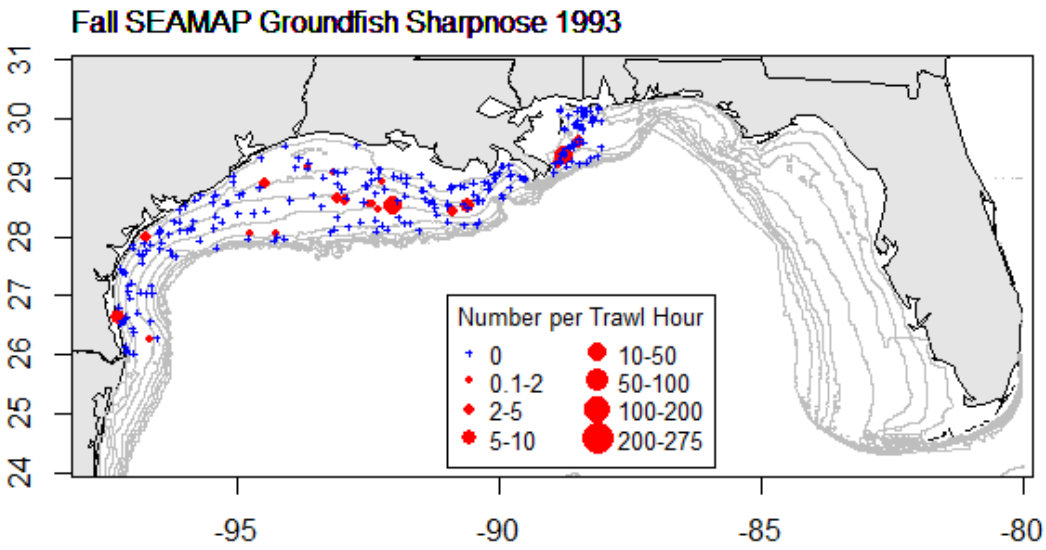
Fall SEAMAP Groundfish Sharpnose 1993
Number per Trawl Hour
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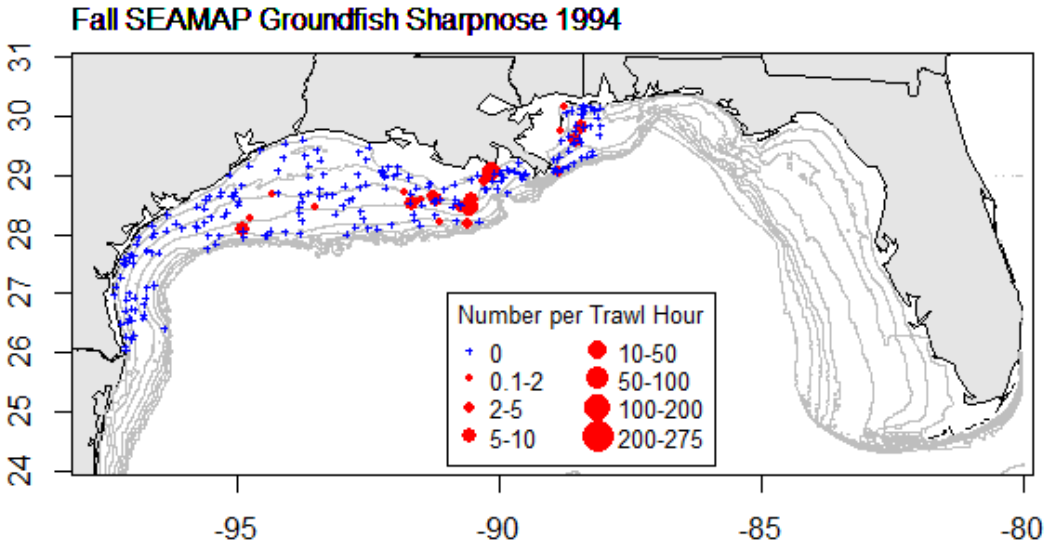
Fall SEAMAP Groundfish Sharpnose 1994
Number per Trawl Hour
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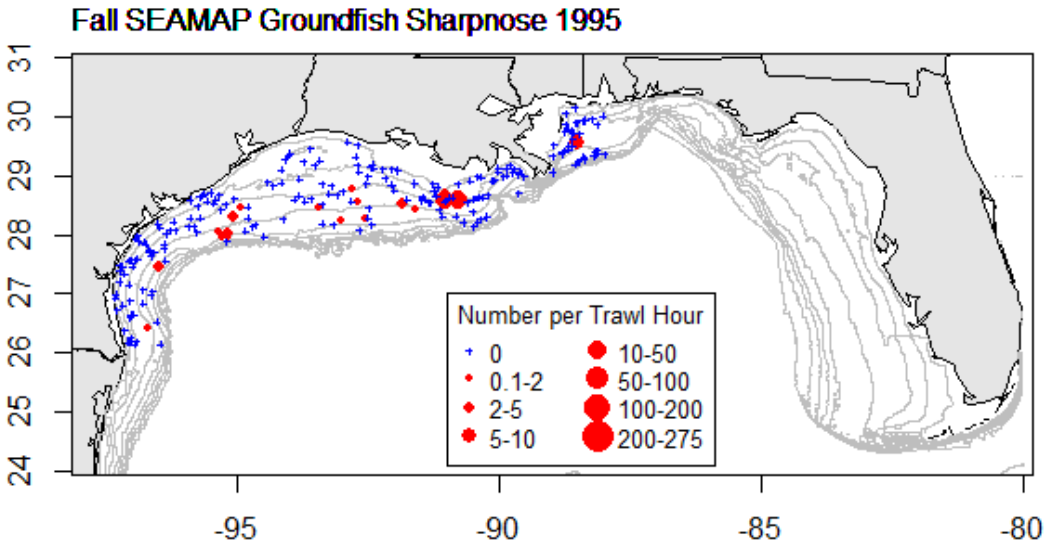
Fall SEAMAP Groundfish Sharpnose 1995
Number per Trawl Hour
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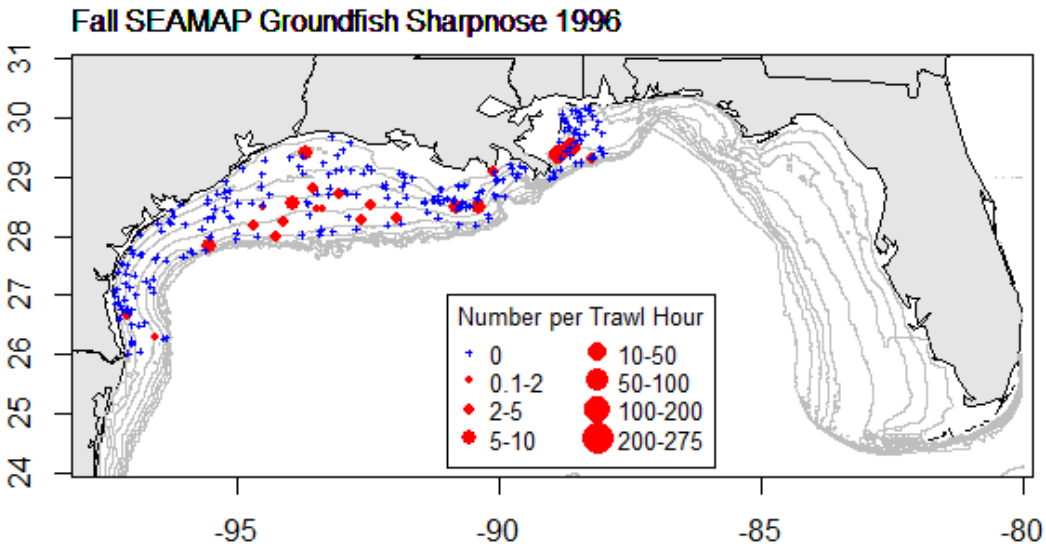
Fall SEAMAP Groundfish Sharpnose 1996
Number per Trawl Hour
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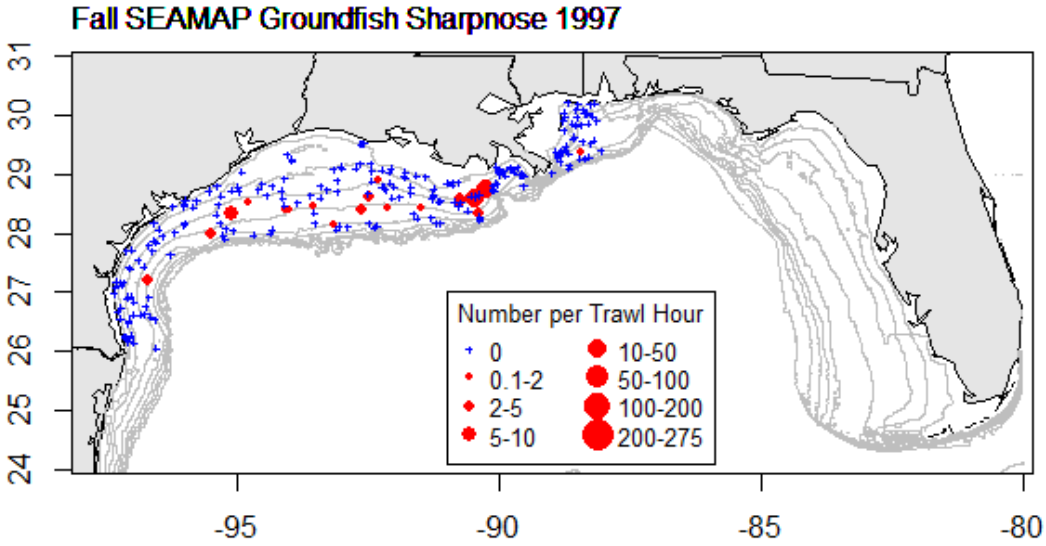
Fall SEAMAP Groundfish Sharpnose 1997
Number per Trawl Hour
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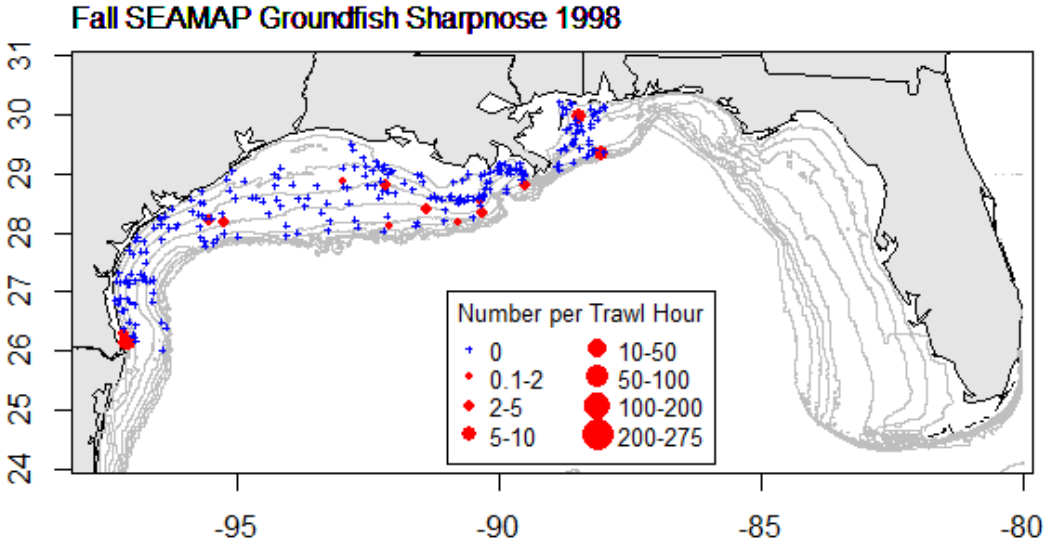
Fall SEAMAP Groundfish Sharpnose 1998
Number per Trawl Hour
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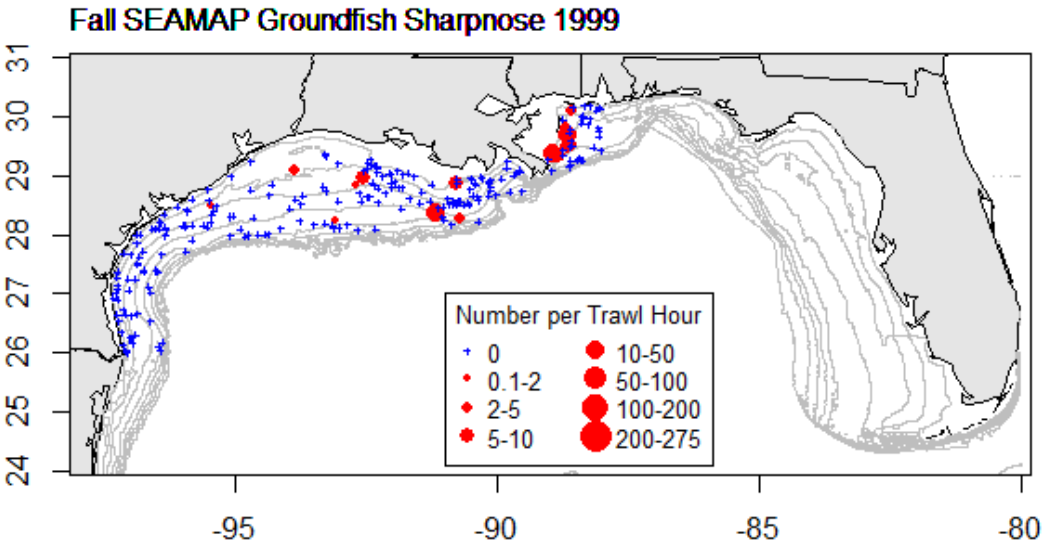
Fall SEAMAP Groundfish Sharpnose 1999
Number per Trawl Hour
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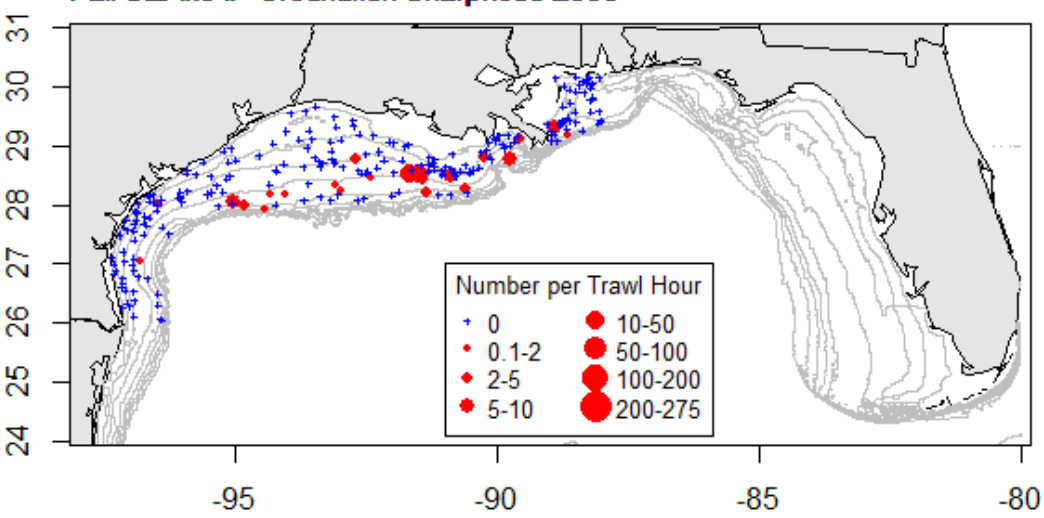
Fall SEAMAP Groundfish Sharpnose 2000
Number per Trawl Hour
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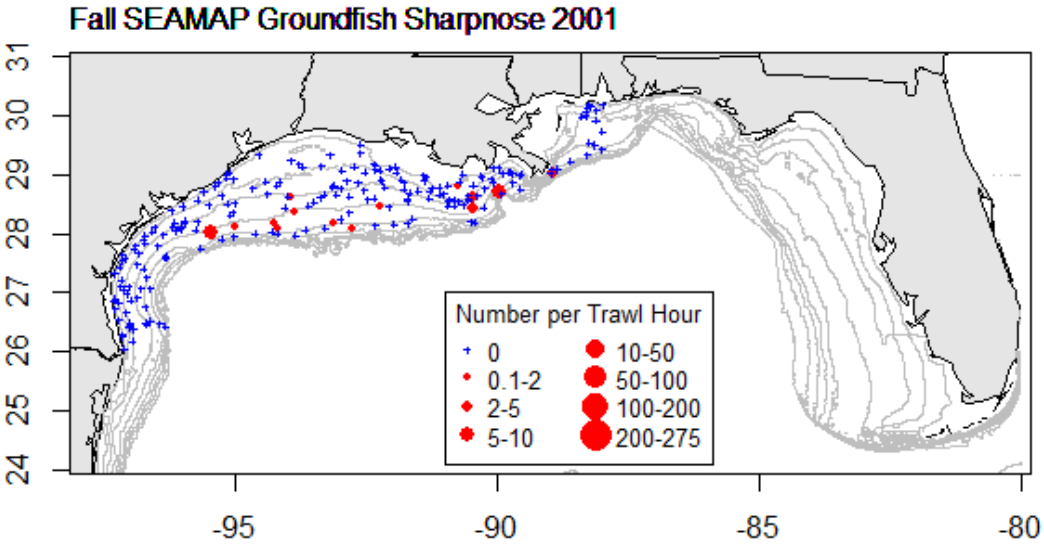
Fall SEAMAP Groundfish Sharpnose 2001
Number per Trawl Hour
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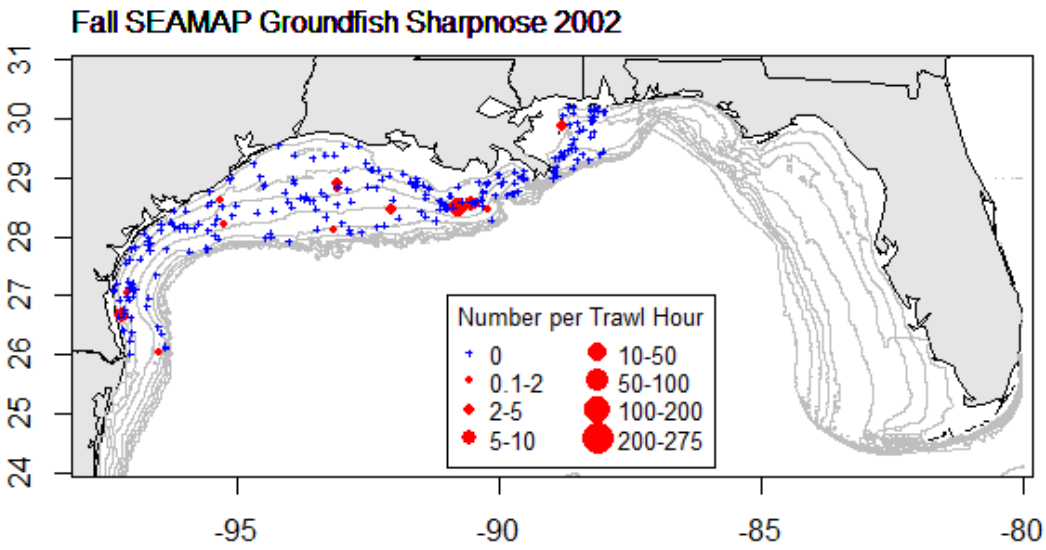
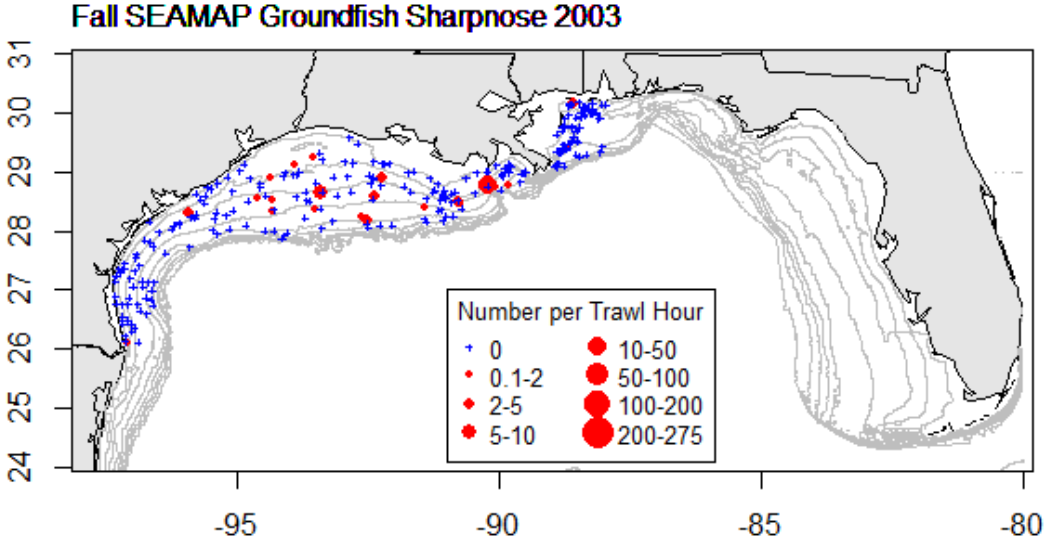
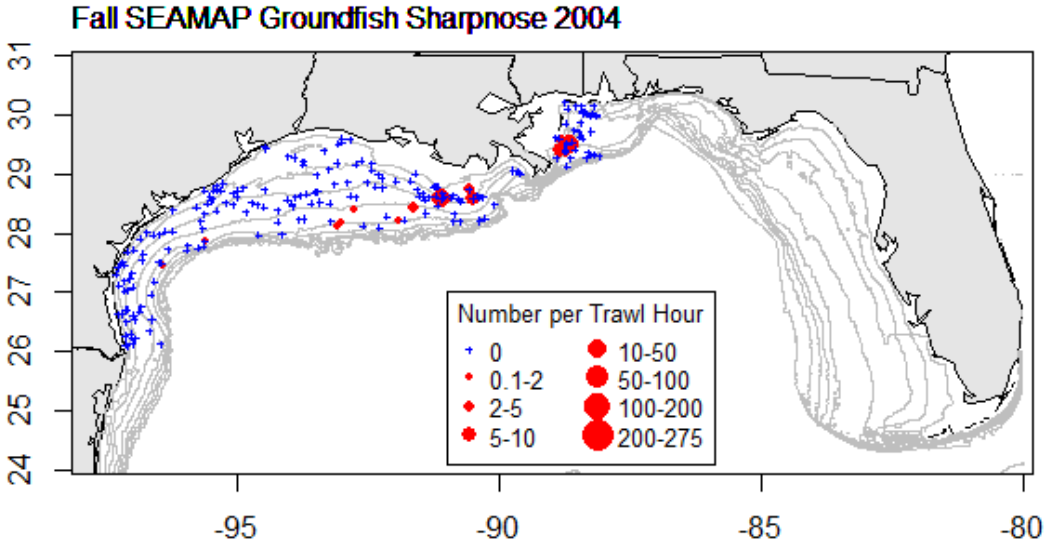
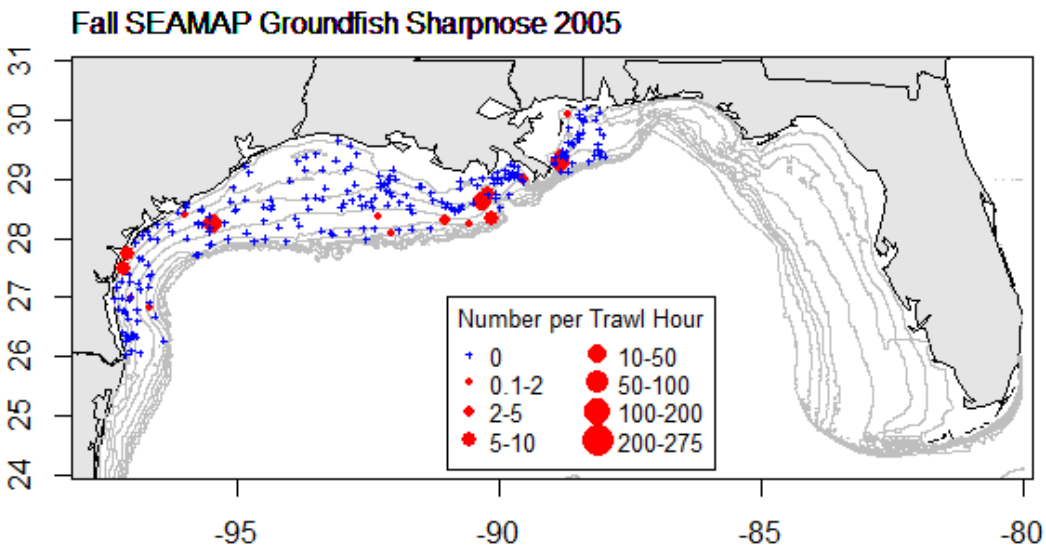
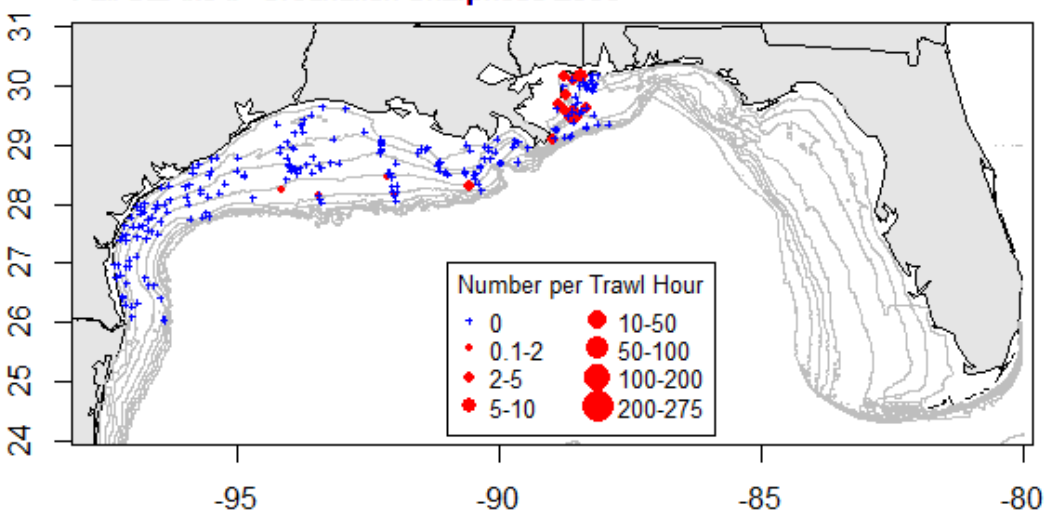

Fall SEAMAP Groundfish Sharpnose 2002
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2003
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2004
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2005
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2006
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
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28
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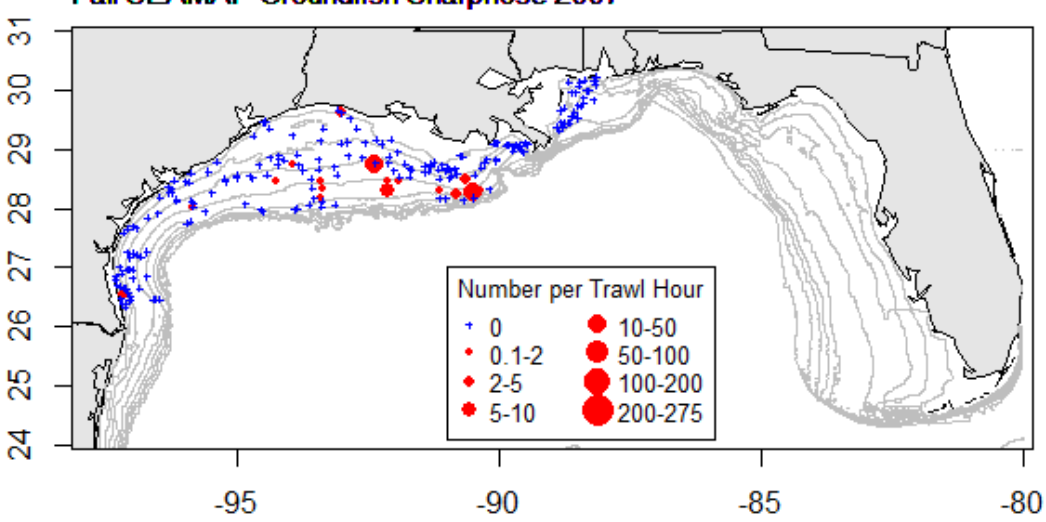
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2007
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
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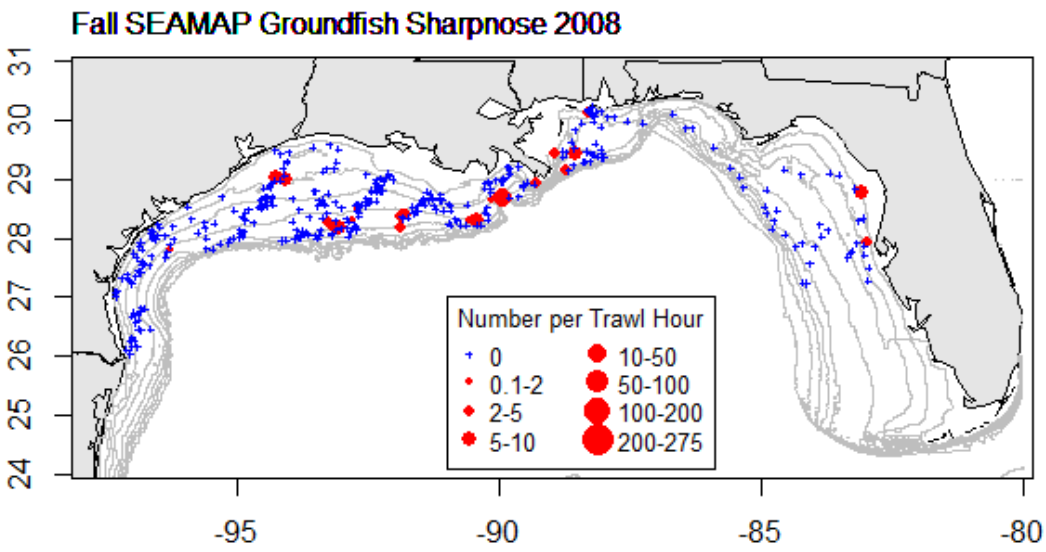
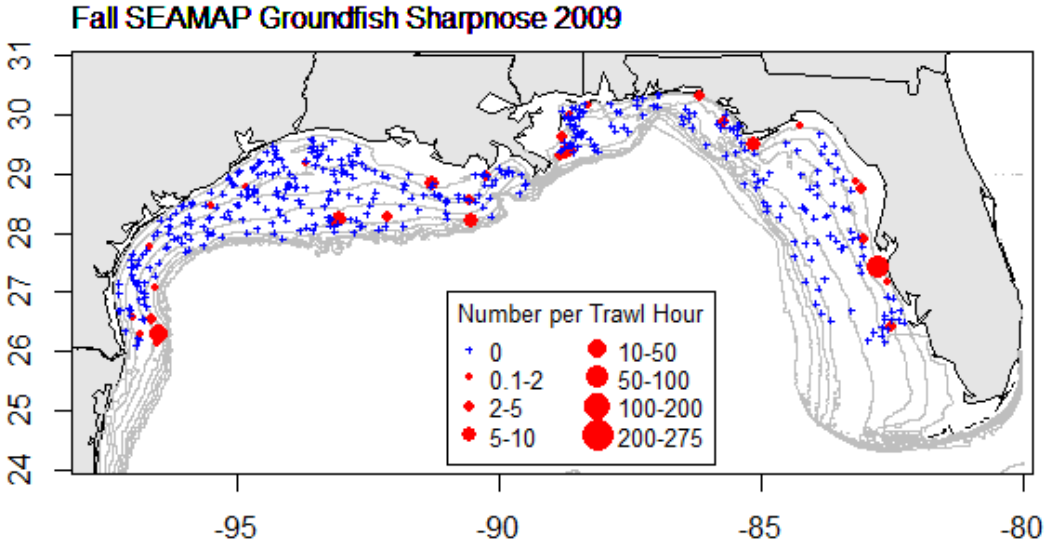
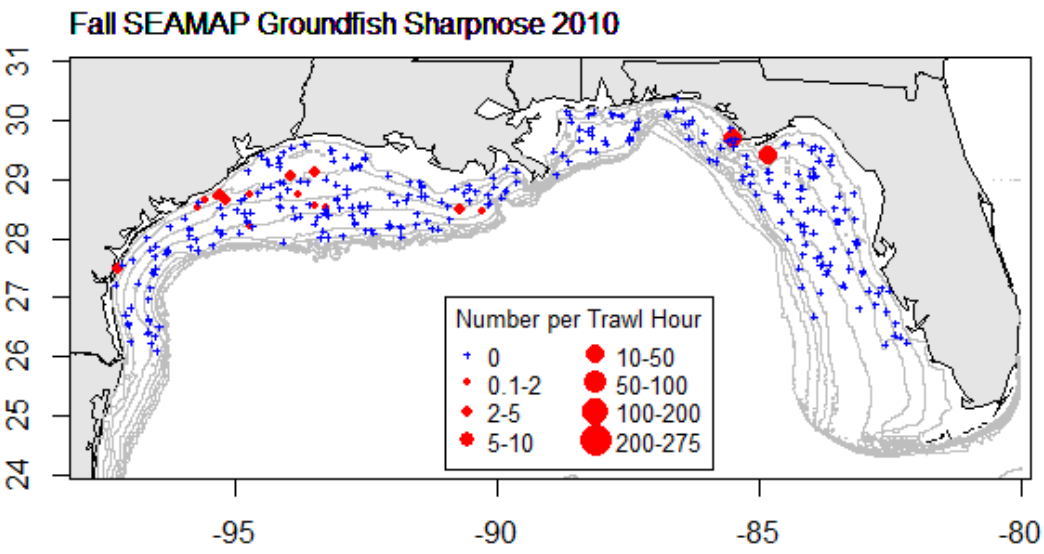
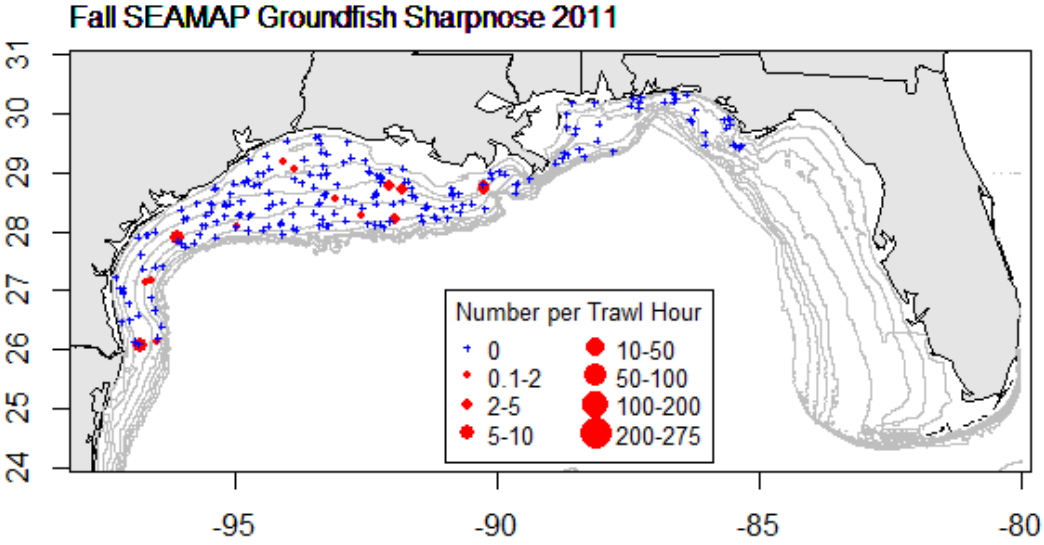
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2008
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2009
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2010
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80


Fall SEAMAP Groundfish Sharpnose 2011
Number per Trawl Hour
0
0.1-2
2-5
5-10
10-50
50-100
100-200
200-275
31
30
29
28
27
26
25
24
-95
-90
-85
-80