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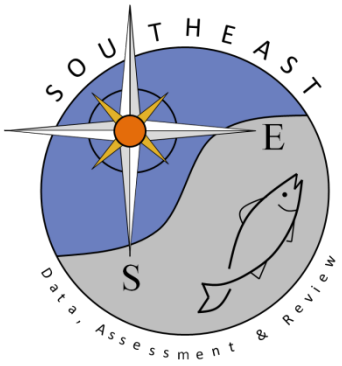

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Lane Snapper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

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Abstract

The Southeast Fisheries Science Center Mississippi Laboratories and state partners 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 (summer and fall) were brought under the Southeast Area Monitoring and Assessment Program (SEAMAP). These fisheries independent datasets were used to develop abundance indices for Lane Snapper (Lutjanus synagris). Two abundance indices were developed: one covering the area between Brownsville, TX and Mobile Bay, AL from 1988-2007 and one covering the area between Cape San Blas, FL and the Florida Keys, FL from 2009-2014 (summer survey only).

Introduction

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) and state partners 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. SEAMAP 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 Lane Snapper (*Lutjanus synagris*).

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 fm), shrimp statistical zones (SSZ) (between 88° and 97° W longitude, paired SSZ 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 SSZ with a weighting by area. Other notable changes included a standardized 30 min 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. In 2014, a new modification was added to the survey design, a depth stratification of 5 - 20 fm and 20 – 60 fm (G. Pellegrin, personal communication).

Data

A total of 14,796 stations were sampled from 1987- 2014 with 7,577 and 7,219 stations sampled during the summer and fall surveys, respectively (Tables 1 and 2). Trawl data from MSLABS was obtained from the MSLABS trawl unit leader (Gilmore Pellegrin) and combined with data from the Gulf States Marine Fisheries Commission (GSMFC) database, which contains data collected by state agencies/partners from Alabama, Florida, Louisiana, Mississippi and Texas.

Data Exclusions

Data for all the models was limited to stations where no problems were reported (i.e. net torn, doors crossed, etc.) and were sampled with a 40 ft shrimp trawl (data from the state of Texas was not utilized because of the use of a 20 ft shrimp trawl). In addition, all stations that sampled greater than 50 fm (91 m) were excluded from the analysis because of the infrequent capture of Lane Snapper. For the index covering the area between Cape San Blas, FL and the Florida Keys, FL from 2009-2014, only the summer survey was used and limited to stations east of Cape San Blas, FL. Finally, the 2008 survey year was excluded from the abundance indices because of the change in survey design that occurred halfway through the year.

Data Caveats

The survey area has been expanded throughout the course of the fall time series. Prior to 1987, the areas of East Louisiana and Mississippi/Alabama were considered the primary sampling area, areas directly west and east of the primary area were designated the secondary sampling areas; East Florida and Texas were not sampled. During this time, triplicate 10 minute tows were done at each station. For the purpose of this analysis, these stations were excluded from analysis.

From 1987 – 2008 (summer), the area sampled was from Brownsville, TX to Mobile Bay, AL. Sampling rarely extended past Mobile Bay due to an increase in the number of hangs. During this time, tow length was dependent on how long it took to cover a full depth stratum (defined above). However, single tows never exceeded 55 min. Full details about this survey can be found in Nichols (2004).

Beginning in 2008, sampling was expanded to cover the eastern GOM, down to the Florida Keys. The other changes to the survey are outlined above in the survey design section and in Pollack and Ingram (2010).

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for Lane Snapper (Pennington, 1983; Bradu and Mundlak, 1970). 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 III 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:

Brownsville, TX to Mobile Bay, AL (1988 – 2007) Index

Year: 1988 – 2007
Depth Zone: 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 and 45-50 fm
Paired SSZ: Zones 21-20, 19-18, 17-16, 15-13 and 11-10
Season: Summer and Fall
Time of Day: Day and Night

Cape San Blas, FL to Florida Keys, FL (2009 - 2014) Index

Year: 2009 – 2014
Depth: 13 – 50 fm (23.7 – 110 m) (continuous variable)
SSZ: Zones 2, 3, 4, 5, 6 and 7
Time of Day: Day and Night

Results and Discussion

Distribution and Size

The distribution of Lane Snapper is presented in Figure 1, with seasonal/annual abundance and distribution presented in the Appendix Figures 1 and 2. Tables 3 and 4 summarize the length information collected for Lane Snapper, with average fork lengths ranging between 134 and 211 mm in the summer survey and between 117 and 202 mm in the fall survey. The length frequency distribution of Lane Snapper captured is shown in Figure 2.

Index of Abundance

For the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL (1988 – 2007)) abundance index of Lane Snapper, year, depth zone, paired SSZ, season and time of day were retained in the binomial submodel, while year, depth zone, paired SSZ and season were retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 5 summarizes the backward selection process and the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 49,661.4 and 6319.0, respectively. Diagnostic plots for the lognormal submodels are shown in Figure 3, and indicate the distribution of the residuals is normal. Annual abundance indices are presented in Table 6 and Figure 4.

For the SEAMAP Summer Groundfish Survey (Cape San Blas, FL to Florida Keys, FL (2009 - 2014)) abundance index of Lane Snapper, year, depth, and SSZ were retained in both the binomial and lognormal submodels. A summary of the factors used in the analysis is presented in Appendix Table 2. Table 7 summarizes the backward selection process and the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 3674.6 and 1126.1, respectively. There was an increase in binomial submodel AIC between the first and second run, however, since time of day was not significant, we choose to proceed with the second run. Diagnostic plots for the lognormal submodels are shown in Figure 5, and indicate the distribution of the residuals is normal. Annual abundance indices are presented in Table 8 and Figure 6.

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Table 1. Number of stations sampled by shrimp statistical zone during the SEAMAP Summer Groundfish Survey from 1987-2014.

	Shrimp Statistical Zone																			
Year	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
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	31	8	13	20	25	7	15	20	29	24	*215*
1990										69	18	32	17	23	16	20	23	24	20	*262*
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										46	22	29	19	24	19	14	29	24	22	*248*
1994										61	14	27	28	25	17	20	22	26	22	*262*
1995										45	12	26	24	22	23	13	27	26	21	*239*
1996										46	14	35	21	22	18	17	21	26	25	*245*
1997										44	4	26	22	22	23	10	28	26	26	*231*
1998										36	6	28	27	25	18	14	22	36	17	*229*
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										45	15	34	21	27	19	15	25	29	22	*252*
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	11	9	24	16	21	5	28	22	27	*195*
2006										45	17	29	16	20	23	17	23	31	18	*239*
2007										41	12	11	24	24	23	7	29	32	21	*224*
2008			1	8	11	6	11	8	11	45	24	19	27	23	22	17	24	21	29	*307*
2009			36	23	29	16	17	18	24	67	25	21	37	39	47	53	33	29	23	*537*
2010		31	26	21	26	10	12	14	15	22	5	20	18	21	33	34	27	27	19	*381*
2011	11	24	22	20	29	2	14	11	8	16	7	14	17	24	29	29	18	21	13	*329*
2012	12	39	33	29	30	19	16	17	13	16	7	14	18	25	29	27	20	20	15	*399*
2013	9	27	28	23	19	9	11	9	7	14	5	13	14	21	23	22	16	17	12	*299*
2014	15	32	26	24	30	17	15	9	7	17	6	15	18	22	29	23	18	18	14	*355*
Total	***47***	***153***	***172***	***148***	***174***	***79***	***96***	***86***	***155***	***1146***	***343***	***678***	***594***	***611***	***625***	***510***	***656***	***720***	***584***	***7577***

Table 2. Number of stations sampled by shrimp statistical zone during the SEAMAP Fall Groundfish Survey from 1987-2014.

	Shrimp Statistical Zone																				
Year	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
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											45	18	31	23	22	20	17	22	25	26	*249*
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											34	15	33	14	25	18	17	27	30	18	*231*
1993											73	14	35	21	26	18	16	25	28	18	*274*
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											45	14	31	23	26	20	14	27	28	23	*251*
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											45	21	32	18	33	18	14	23	24	27	*255*
2006										1	46	7	22	14	18	28	13	23	32	19	*223*
2007											33	15	29	26	18	28	17	20	18	26	*230*
2008					15	14	4	4	3	4	36	18	28	34	42	46	44	19	36	20	*367*
2009				20	21	25	10	21	13	12	50	12	23	23	30	49	47	31	36	22	*445*
2010				9	27	27	18	16	11	14	16	7	15	18	26	31	29	18	19	14	*315*
2011								9	11	7	15	6	15	16	27	31	28	21	19	15	*220*
2012			2	3	6	6	17	10	7	5	12	5	11	13	19	23	22	13	14	11	*199*
2013		4	14	12	10	11	10	10	6	5	10	5	11	12	4	12	16	11	14	9	*186*
2014	1	8	31	25	22	24	13	12	7	7	16	5	14	15	22	27	22	15	17	12	*315*
Total	***1***	***12***	***47***	***69***	***101***	***107***	***72***	***82***	***58***	***78***	***1103***	***392***	***755***	***598***	***653***	***667***	***545***	***624***	***706***	***549***	***7219***

Table 3. Summary of the Lane Snapper length data collected during SEAMAP Summer Groundfish Survey conducted between 1987 and 2014.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation (mm)
1987	287	89	17	101	240	159	35
1988	234	22	20	134	301	180	37
1989	215	53	43	135	295	188	40
1990	262	134	77	93	262	166	29
1991	254	128	70	31	295	186	56
1992	248	88	84	114	237	162	19
1993	248	69	58	34	299	165	37
1994	262	76	62	105	376	188	46
1995	239	180	158	123	268	171	26
1996	245	162	124	28	370	193	48
1997	231	129	110	26	282	168	36
1998	229	52	48	28	223	157	34
1999	246	76	71	40	304	172	41
2000	239	360	265	30	306	134	54
2001	176	300	166	29	358	156	68
2002	252	196	167	11	335	179	57
2003	205	105	90	120	289	192	29
2004	240	400	202	89	317	169	30
2005	195	226	172	34	337	160	49
2006	239	819	418	17	284	146	59
2007	224	487	305	28	295	174	28
2008	307	558	214	112	358	189	40
2009	537	1989	748	36	450	211	43
2010	381	3757	685	110	376	198	35
2011	329	2933	705	113	429	210	38
2012	399	4745	1306	30	389	202	41
2013	299	2570	726	112	379	200	40
2014	355	2870	1037	27	372	197	46

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
28	7,577	23,573	8,148	189

Table 4. Summary of the Lane Snapper length data collected during SEAMAP Fall Groundfish Survey conducted between 1987 and 2014.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation (mm)
1987	208	243	30	89	192	137	28
1988	236	200	142	94	225	141	32
1989	249	249	137	53	335	117	43
1990	250	177	154	56	266	147	42
1991	247	1243	620	84	268	140	22
1992	231	354	257	25	330	148	45
1993	274	442	370	41	322	145	49
1994	253	611	519	46	428	124	48
1995	241	323	288	65	320	148	47
1996	251	532	413	42	282	127	30
1997	247	1101	446	64	310	138	23
1998	273	477	283	33	222	122	22
1999	248	948	597	64	278	139	26
2000	244	2088	1042	39	301	143	26
2001	251	775	354	67	339	152	41
2002	257	460	365	30	280	141	39
2003	275	824	612	52	304	123	32
2004	229	1269	753	43	443	151	34
2005	255	2230	1081	70	319	141	30
2006	223	2480	808	57	235	135	31
2007	230	699	285	61	329	147	34
2008	367	579	489	52	410	198	44
2009	445	2016	1025	57	393	160	55
2010	315	610	408	56	386	202	58
2011	220	320	199	68	335	167	49
2012	199	717	532	70	350	151	50
2013	186	1064	365	33	417	179	58
2014	315	4785	1504	42	352	160	54

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
28	7,219	27,846	14,078	148

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for Lane Snapper SEAMAP Summer / Fall Groundfish Survey index of relative abundance from 1988 to 2007.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 49,661.4)*						*Lognormal Submodel Type 3 Tests (AIC 6321.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	9313	297.84	15.68	<.0001	<.0001	19	1943	5.28	<.0001
Depth Zone	21	9313	633.76	30.18	<.0001	<.0001	21	1943	4.42	<.0001
Season	1	9313	495.09	495.09	<.0001	<.0001	1	1943	37.11	<.0001
Paired_SSZ	4	9313	533.00	133.25	<.0001	<.0001	4	1943	18.40	<.0001
Time of Day	1	9313	33.83	33.83	<.0001	<.0001	1	1943	1.82	0.1779
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 49,661.4)*						*Lognormal Submodel Type 3 Tests (AIC 6319.0)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	9313	297.84	15.68	<.0001	<.0001	19	1944	5.25	<.0001
Depth Zone	21	9313	633.76	30.18	<.0001	<.0001	21	1944	4.43	<.0001
Season	1	9313	495.09	495.09	<.0001	<.0001	1	1944	37.50	<.0001
Paired_SSZ	4	9313	533.00	133.25	<.0001	<.0001	4	1944	18.38	<.0001
Time of Day	1	9313	33.83	33.83	<.0001	<.0001		Dropped		

Table 6. Indices of Lane Snapper abundance developed using the delta-lognormal (DL) model for SEAMAP Summer / Fall Groundfish Survey from 1988-2007. 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
1988	0.10330	455	0.48424	0.23382	0.23793	0.14624	0.37386
1989	0.15813	449	1.00933	0.48737	0.19584	0.33064	0.71840
1990	0.11222	499	0.58163	0.28085	0.21916	0.18211	0.43311
1991	0.16289	485	1.29621	0.62589	0.18513	0.43357	0.90354
1992	0.17391	460	1.02081	0.49291	0.18348	0.34255	0.70929
1993	0.15217	506	1.09867	0.53051	0.18714	0.36605	0.76886
1994	0.21242	499	1.66392	0.80345	0.15877	0.58602	1.10154
1995	0.18844	467	1.18287	0.57117	0.17518	0.40342	0.80868
1996	0.20293	478	1.60523	0.77511	0.16650	0.55684	1.07895
1997	0.15368	462	1.37130	0.66216	0.19477	0.45015	0.97401
1998	0.15670	485	0.93209	0.45007	0.18802	0.31002	0.65340
1999	0.18067	476	1.47788	0.71362	0.17768	0.50157	1.01531
2000	0.31828	465	5.34921	2.58295	0.13268	1.98323	3.36403
2001	0.24221	417	2.32574	1.12302	0.16386	0.81097	1.55514
2002	0.27347	490	2.14302	1.03479	0.13993	0.78325	1.36711
2003	0.31974	466	2.69549	1.30156	0.13270	0.99932	1.69522
2004	0.21569	459	2.33023	1.12519	0.16477	0.81108	1.56096
2005	0.30856	444	3.22835	1.55886	0.13901	1.18207	2.05575
2006	0.33921	454	5.78399	2.79289	0.12871	2.16130	3.60906
2007	0.30180	444	3.83915	1.85379	0.14018	1.40248	2.45035

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for Lane Snapper SEAMAP Summer Groundfish Survey index of relative abundance from 2009 to 2014.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 3670.1)*						*Lognormal Submodel Type 3 Tests (AIC 1127.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	5	734	11.21	2.24	0.0474	0.0486	5	339	2.97	0.0121
Depth	1	734	165.08	165.08	<.0001	<.0001	1	339	43.04	<.0001
Statistical Zone	5	734	119.25	23.85	<.0001	<.0001	5	339	74.73	<.0001
Time of Day	1	734	3.35	3.35	0.0672	0.0676	1	339	1.18	0.2780
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 3674.6)*						*Lognormal Submodel Type 3 Tests (AIC 1126.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	5	735	10.69	2.14	0.0579	0.0591	5	340	2.92	0.0134
Depth	1	735	163.80	163.80	<.0001	<.0001	1	340	44.83	<.0001
Statistical Zone	5	735	118.40	23.68	<.0001	<.0001	5	340	75.66	<.0001
Time of Day	Dropped						Dropped			

Table 8. Indices of Lane Snapper abundance developed using the delta-lognormal (DL) model for SEAMAP Summer Groundfish Survey from 2009-2014. 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
2009	0.49038	104	38.9205	1.54396	0.23132	0.97797	2.43751
2010	0.36842	114	17.6316	0.69944	0.26500	0.41540	1.17768
2011	0.50000	108	28.5888	1.13410	0.21611	0.73973	1.73872
2012	0.49383	162	23.7844	0.94351	0.17831	0.66235	1.34404
2013	0.46957	115	20.6112	0.81763	0.20972	0.53995	1.23813
2014	0.49306	144	21.7133	0.86136	0.17965	0.60308	1.23024

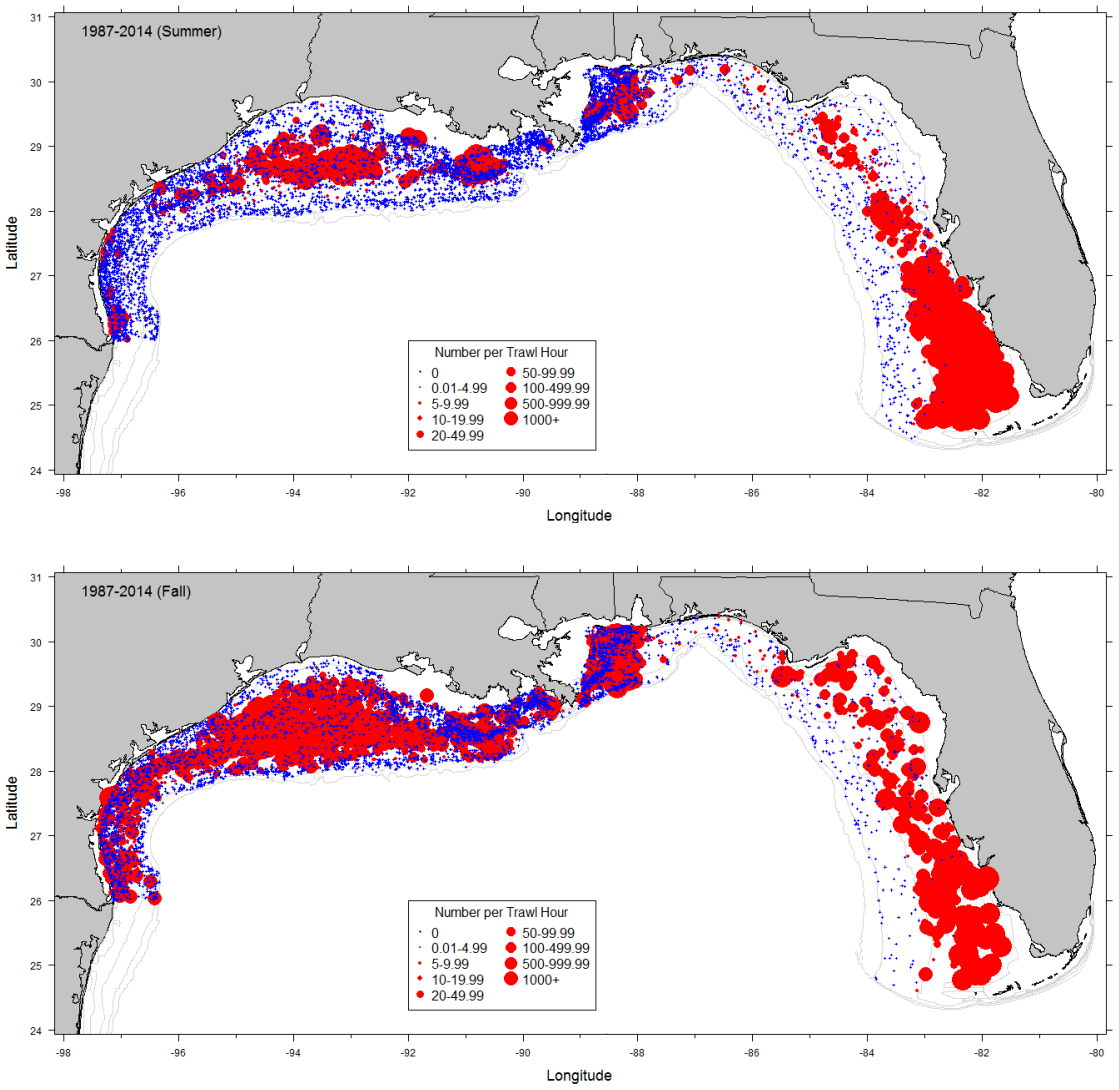


Figure 1. Stations sampled from 1987 to 2014 during the Summer (top) and Fall (bottom) SEAMAP Groundfish Survey with the CPUE for Lane Snapper.

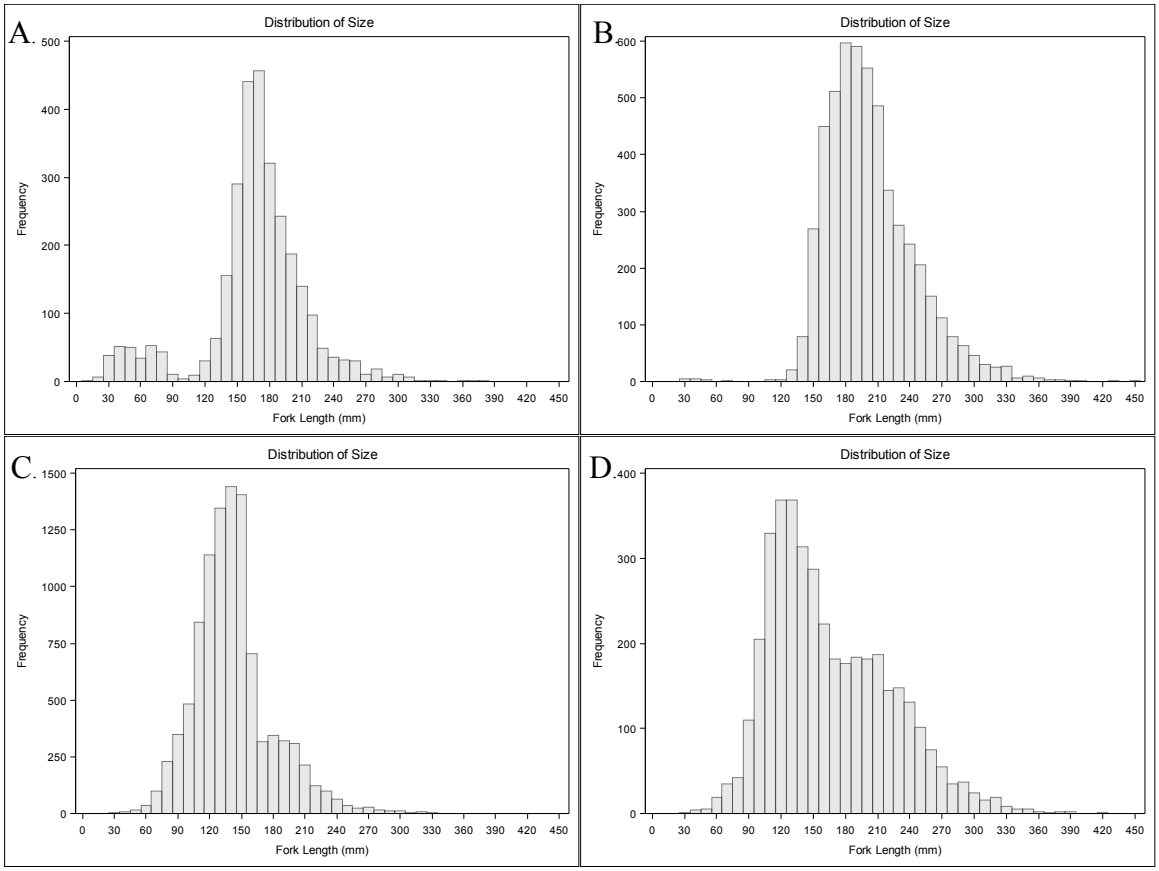


Figure 2. Length frequency histograms for Lane Snapper captured during **A.** Summer (1987-2007), **B.** Summer (2009-2014), **C.** Fall (1987-2007) and **D.** Fall (2009-2014) SEAMAP Groundfish surveys.

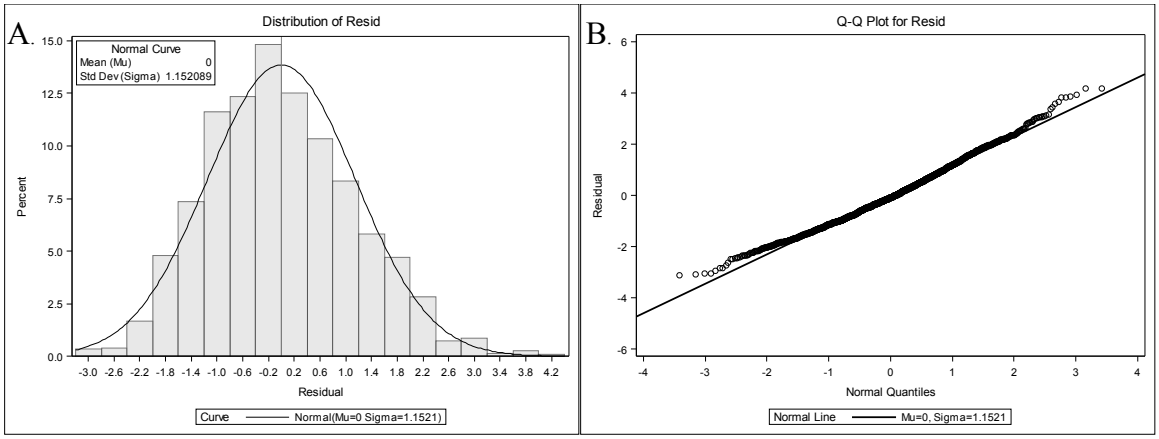


Figure 3. Diagnostic plots for lognormal component of the Lane Snapper SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL (1988 – 2007)) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

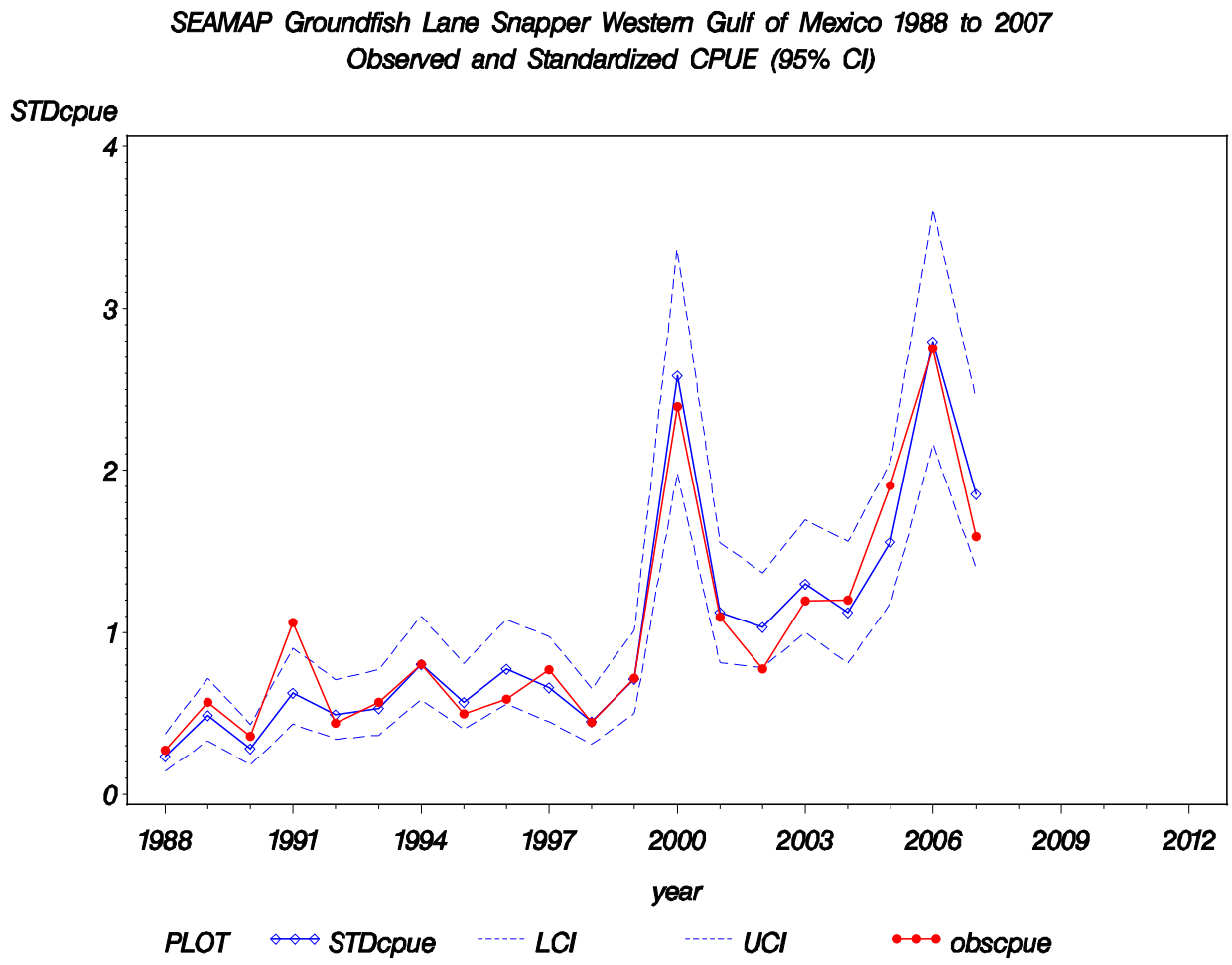


Figure 4. Annual index of abundance for Lane Snapper from the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL) from 1988 – 2007.

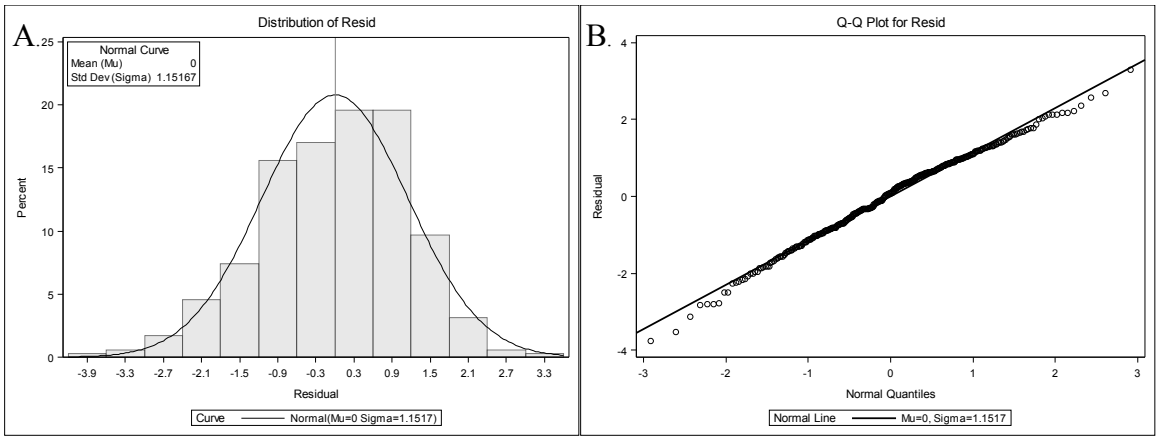


Figure 5. Diagnostic plots for lognormal component of the Lane Snapper SEAMAP Summer Groundfish Survey (Cape San Blas, FL to Florida Keys, FL (2009 - 2014)) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

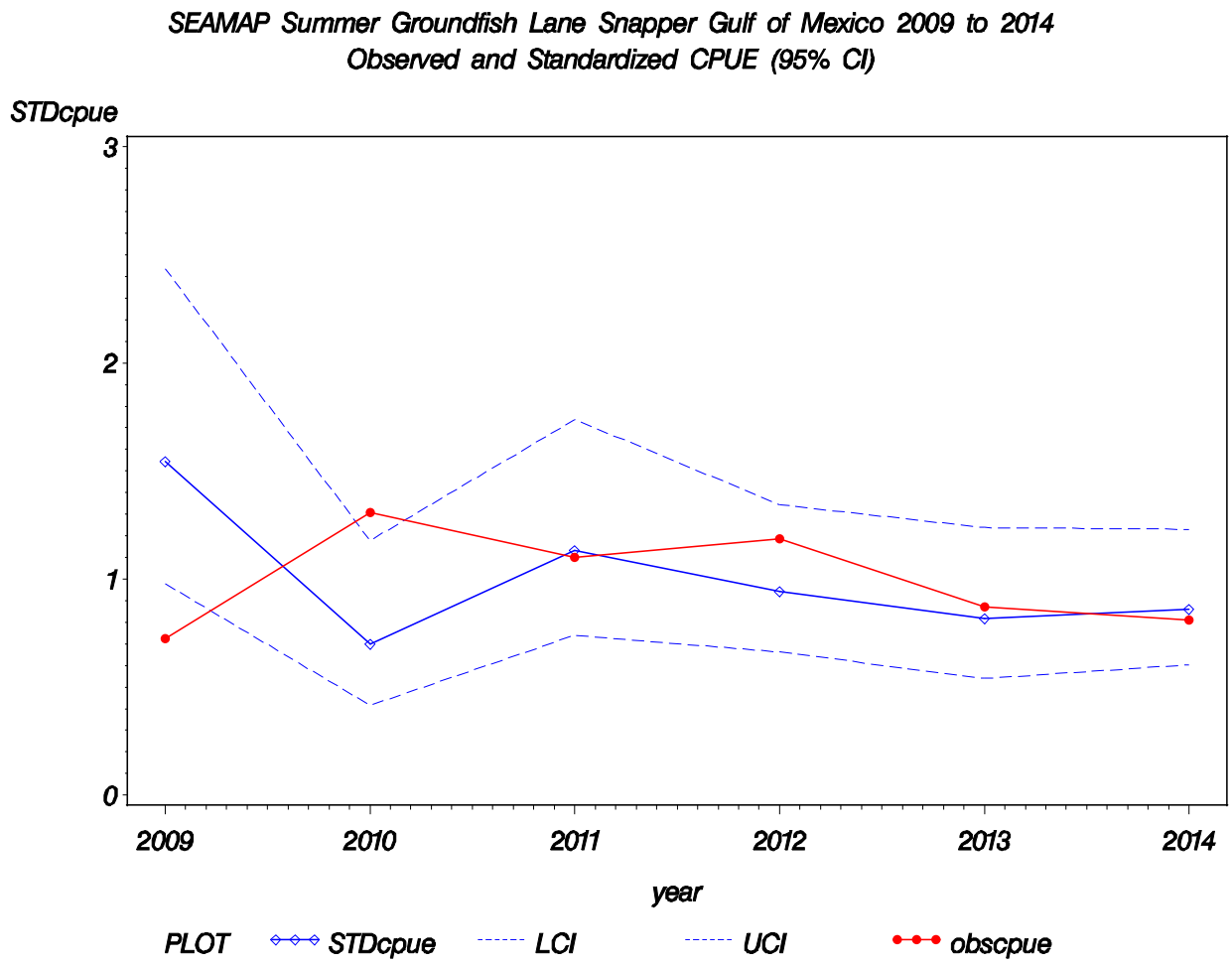


Figure 6. Annual index of abundance for lane Snapper from the SEAMAP Summer Groundfish Survey (Cape San Blas, FL to Florida Keys, FL) from 2009 – 2014.

Appendix

Appendix Table 1. Summary of the factors used in constructing the Lane Snapper abundance index from the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL (1988 – 2007)) data.

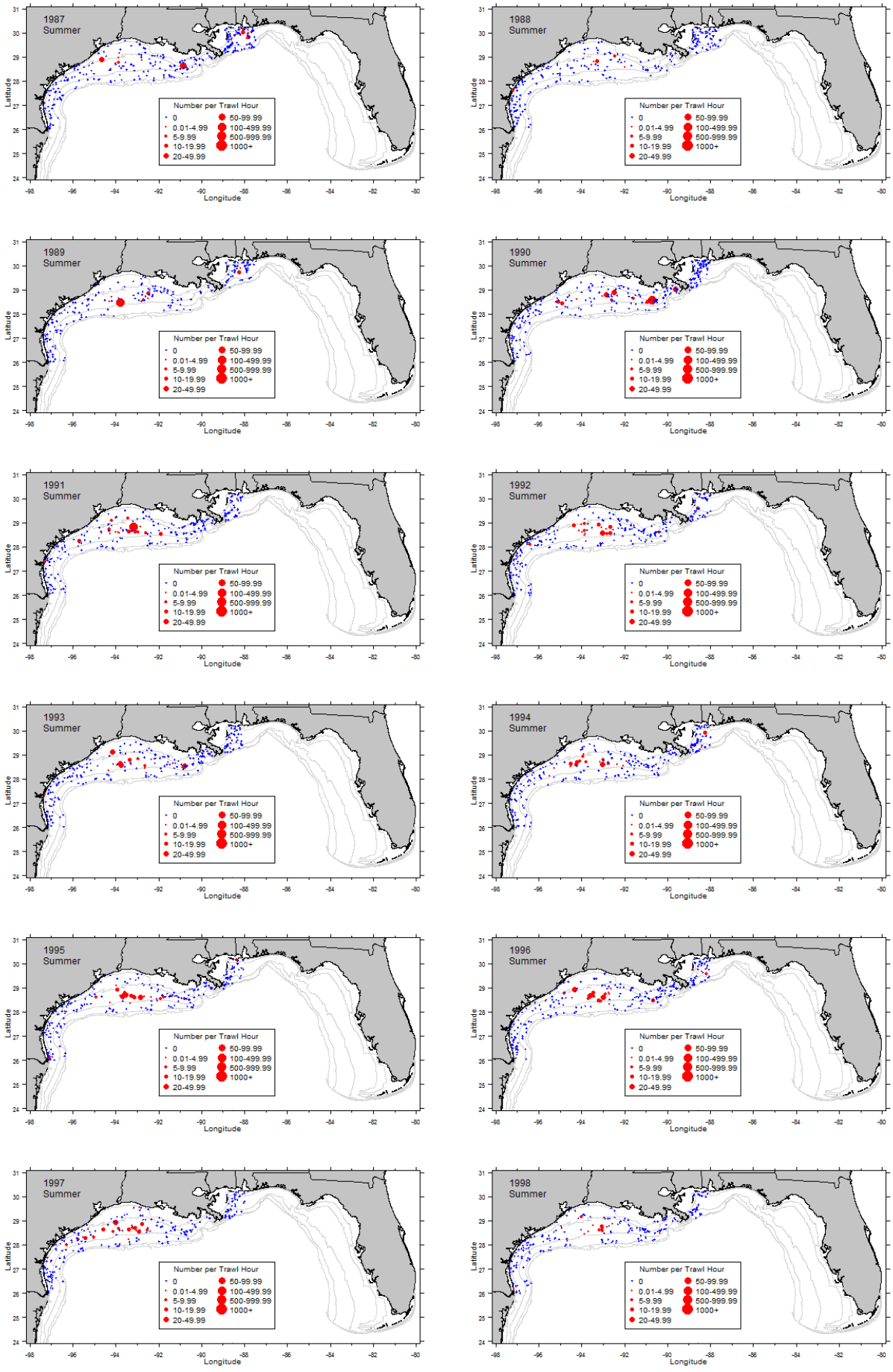
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
DEPTH ZONE	0506	456	32	0.07018	1.70654
DEPTH ZONE	0607	565	46	0.08142	0.88966
DEPTH ZONE	0708	446	49	0.10987	1.32084
DEPTH ZONE	0809	329	37	0.11246	1.06537
DEPTH ZONE	0910	463	68	0.14687	2.68622
DEPTH ZONE	1011	585	95	0.16239	2.69479
DEPTH ZONE	1112	456	83	0.18202	2.76140
DEPTH ZONE	1213	325	73	0.22462	2.56791
DEPTH ZONE	1314	574	113	0.19686	2.97721
DEPTH ZONE	1415	449	99	0.22049	3.12616
DEPTH ZONE	1516	343	99	0.28863	5.29834
DEPTH ZONE	1617	460	123	0.26739	3.54683
DEPTH ZONE	1718	550	144	0.26182	3.94369
DEPTH ZONE	1819	444	131	0.29505	4.07014
DEPTH ZONE	1920	342	130	0.38012	5.21513
DEPTH ZONE	2022	406	171	0.42118	6.61407
DEPTH ZONE	2225	379	163	0.43008	4.95526
DEPTH ZONE	2530	356	150	0.42135	6.43389
DEPTH ZONE	3035	386	106	0.27461	5.06425
DEPTH ZONE	3540	357	53	0.14846	0.84633
DEPTH ZONE	4045	349	19	0.05444	0.37457
DEPTH ZONE	4550	340	6	0.01765	0.14794
SEASON	Fall	4811	1455	0.30243	4.45050
SEASON	Summer	4549	535	0.11761	1.61267
PAIRED_SSZ	1011	1815	300	0.16529	2.68637
PAIRED_SSZ	1315	2487	303	0.12183	1.59159
PAIRED_SSZ	1617	1647	664	0.40316	7.39403
PAIRED_SSZ	1819	1537	422	0.27456	3.50695
PAIRED_SSZ	2021	1874	301	0.16062	1.25142
TIME OF DAY	Day	4716	897	0.19020	2.75912
TIME OF DAY	Night	4644	1093	0.23536	3.38832
YEAR	1988	455	47	0.10330	0.85102
YEAR	1989	449	71	0.15813	1.76708
YEAR	1990	499	56	0.11222	1.11612
YEAR	1991	485	79	0.16289	3.29919
YEAR	1992	460	80	0.17391	1.36837
YEAR	1993	506	77	0.15217	1.77149

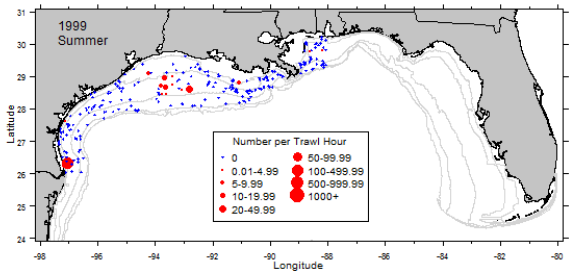
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
YEAR	1994	499	106	0.21242	2.50087
YEAR	1995	467	88	0.18844	1.54581
YEAR	1996	478	97	0.20293	1.82199
YEAR	1997	462	71	0.15368	2.39484
YEAR	1998	485	76	0.15670	1.38707
YEAR	1999	476	86	0.18067	2.22953
YEAR	2000	465	148	0.31828	7.44073
YEAR	2001	417	101	0.24221	3.40133
YEAR	2002	490	134	0.27347	2.40423
YEAR	2003	466	149	0.31974	3.70900
YEAR	2004	459	99	0.21569	3.73145
YEAR	2005	444	137	0.30856	5.92922
YEAR	2006	454	154	0.33921	8.54661
YEAR	2007	444	134	0.30180	4.93801

Appendix Table 2. Summary of the factors used in constructing the Lane Snapper abundance index from the SEAMAP Summer Groundfish Survey (Cape San Blas, FL to Florida Keys, FL (2009 - 2014)) data.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
STATISTICAL ZONE	2	47	27	0.57447	76.585
STATISTICAL ZONE	3	153	89	0.58170	143.858
STATISTICAL ZONE	4	171	103	0.60234	53.824
STATISTICAL ZONE	5	140	59	0.42143	7.340
STATISTICAL ZONE	6	163	53	0.32515	2.231
STATISTICAL ZONE	7	73	21	0.28767	2.818
TIME OF DAY	Day	431	186	0.43155	43.132
TIME OF DAY	Night	316	166	0.52532	56.394
YEAR	2009	104	51	0.49038	35.066
YEAR	2010	114	42	0.36842	63.266
YEAR	2011	108	54	0.50000	53.264
YEAR	2012	162	80	0.49383	57.472
YEAR	2013	115	54	0.46957	42.154
YEAR	2014	144	71	0.49306	39.171

Appendix Figure 1. Annual survey effort and catch of Lane Snapper from the SEAMAP Summer Groundfish Survey.

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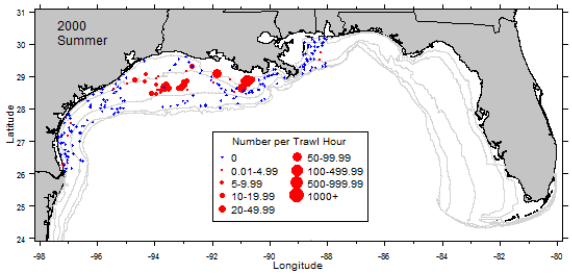
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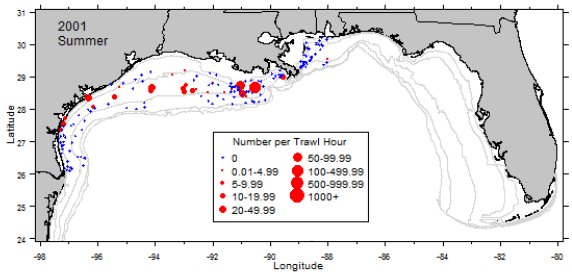
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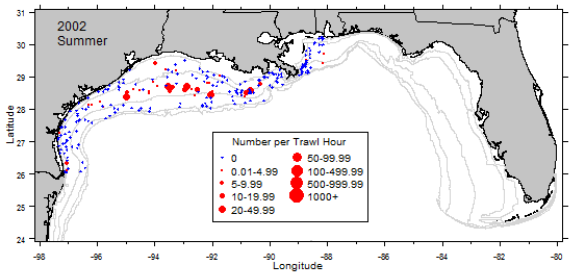
1000+
Latitude
Longitude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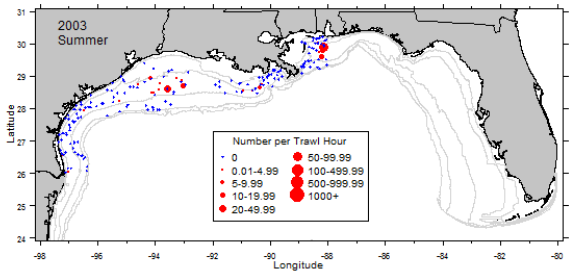
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1000+
Latitude
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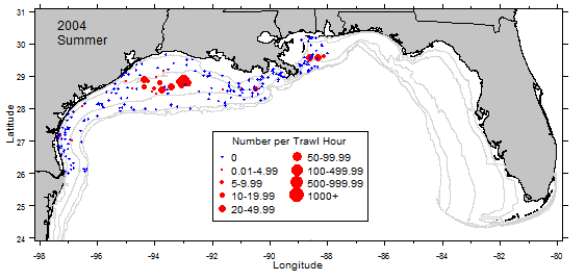
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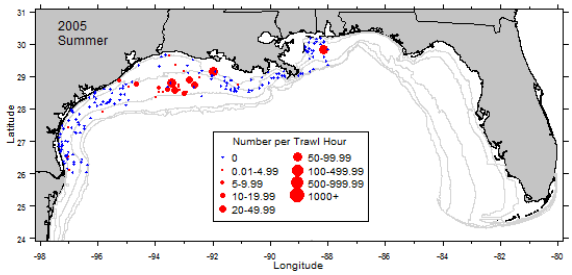
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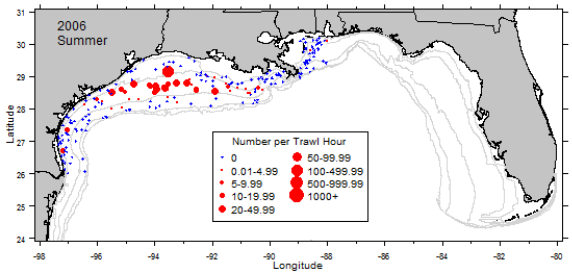
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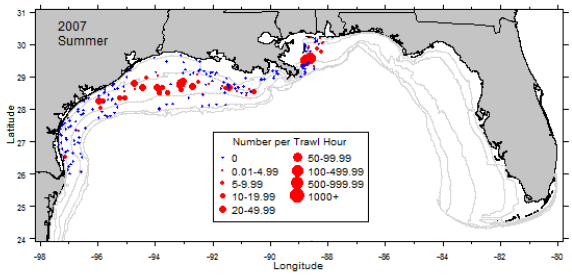
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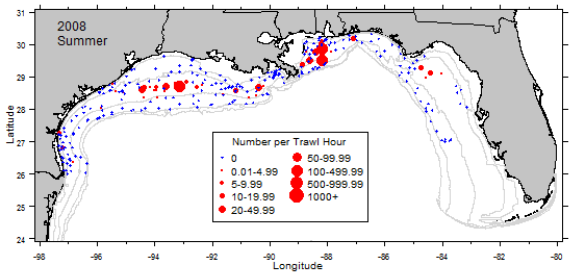
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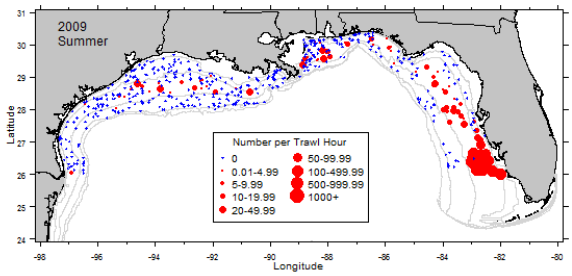
Latitude
Longitude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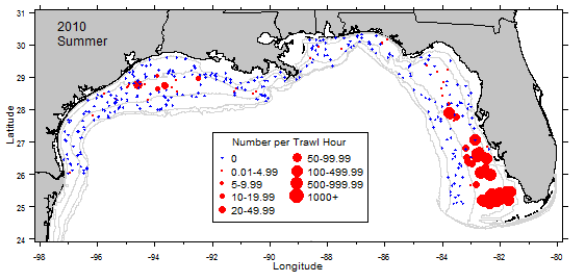
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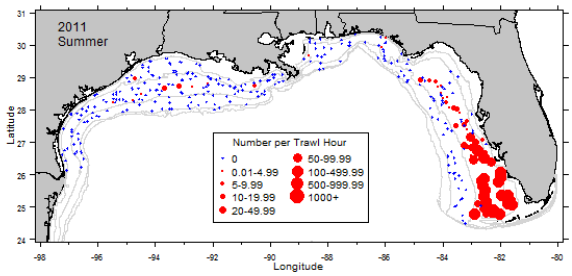
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Summer
Number per Trawl Hour
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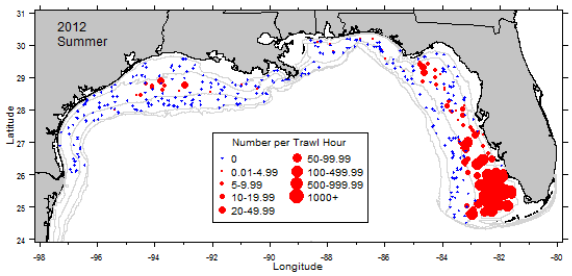
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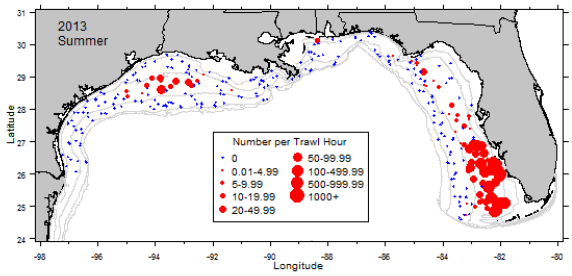
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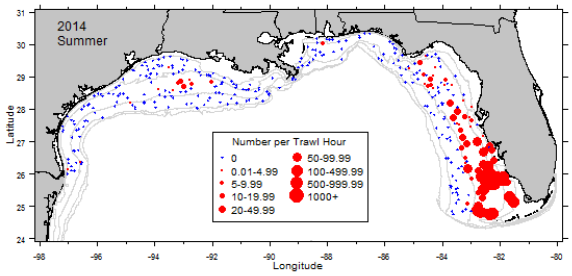
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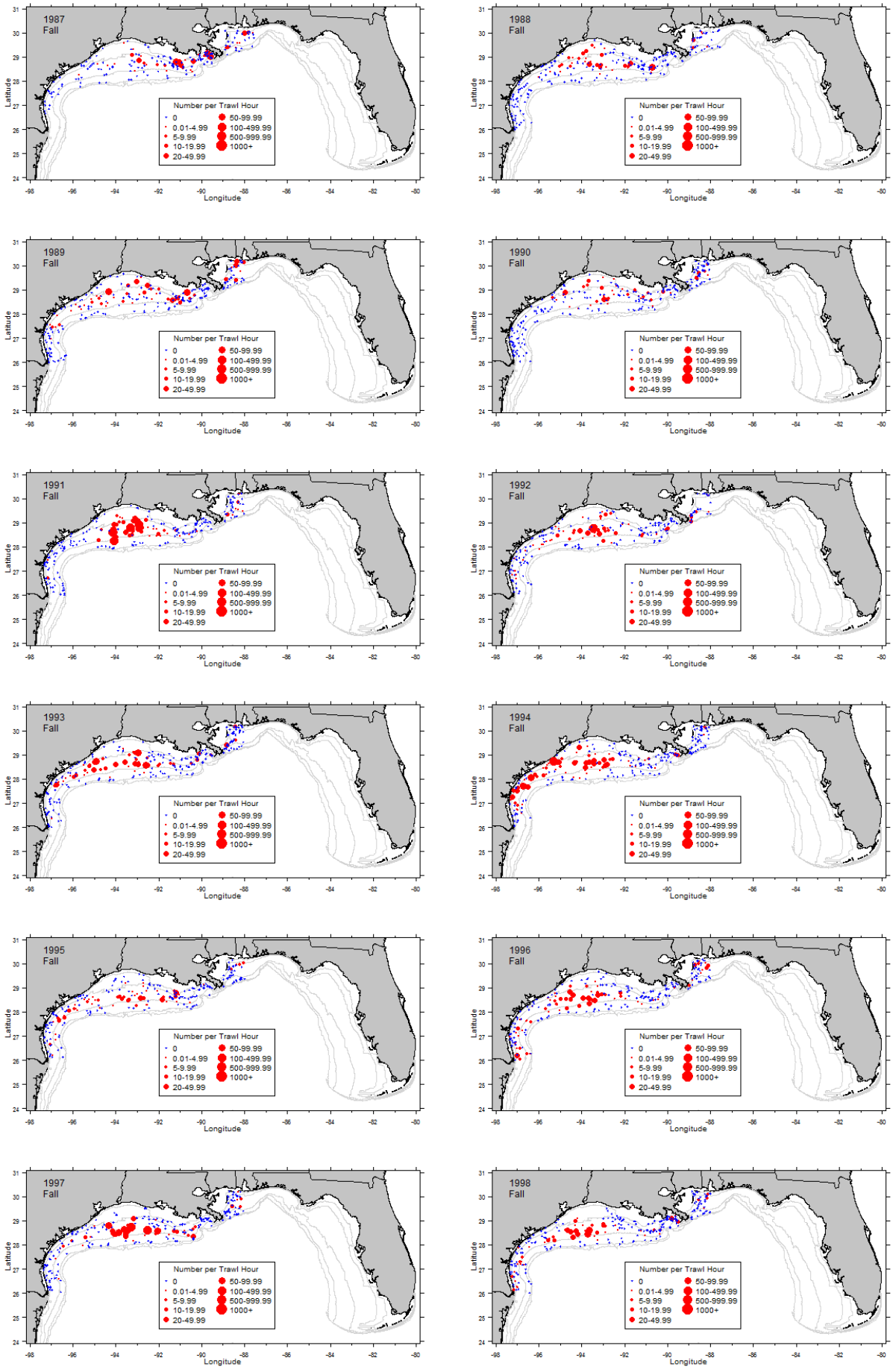
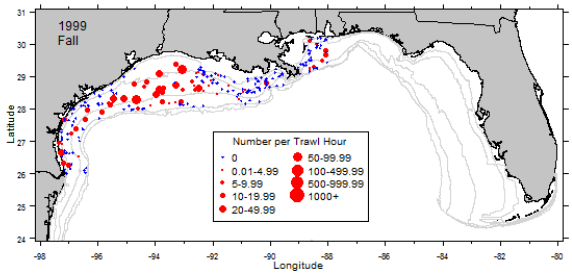
500-999.99
1000+
Latitude
Longitude

Appendix Figure 2. Annual survey effort and catch of Lane Snapper from the SEAMAP Fall Groundfish Survey.

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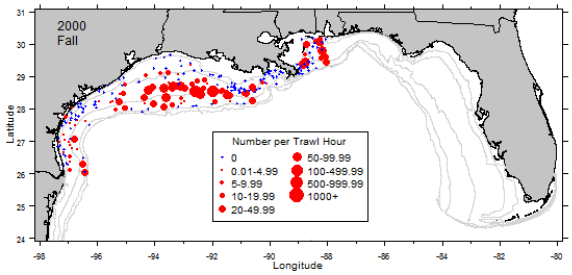
1000+
Latitude
Longitude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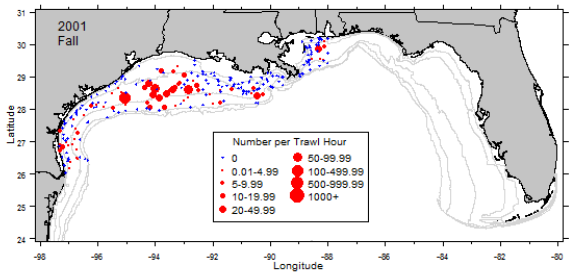
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Number per Trawl Hour
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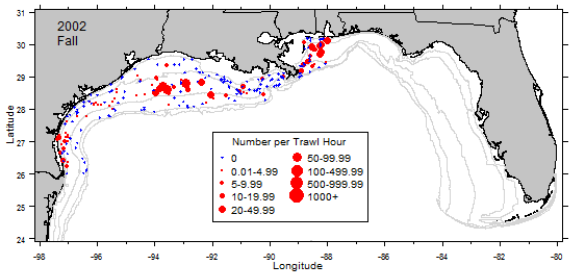
1000+
Latitude
Longitude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Fall
Number per Trawl Hour
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10-19.99
20-49.99
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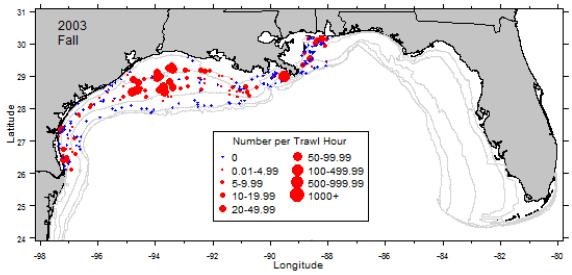
1000+
Latitude
Longitude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Fall
Number per Trawl Hour
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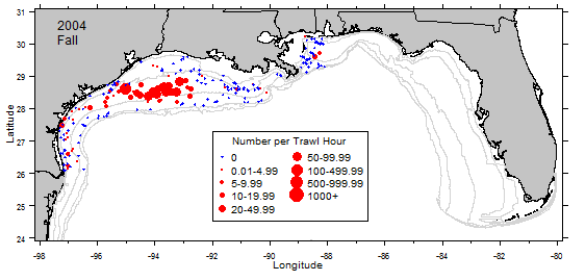
1000+
Latitude
Longitude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Fall
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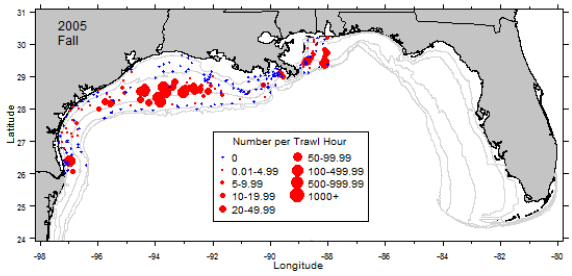
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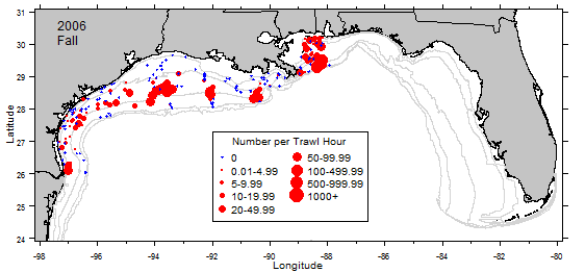
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Latitude
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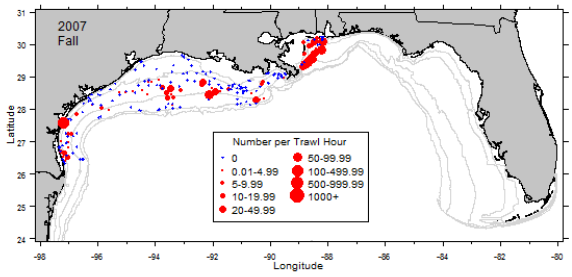
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Fall
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Latitude
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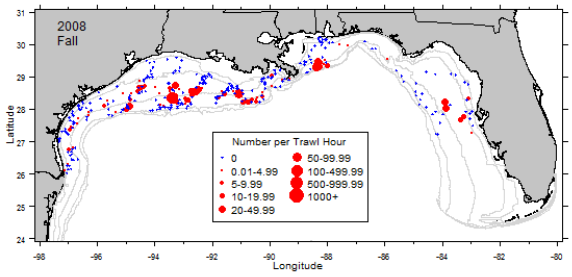
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Fall
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Latitude
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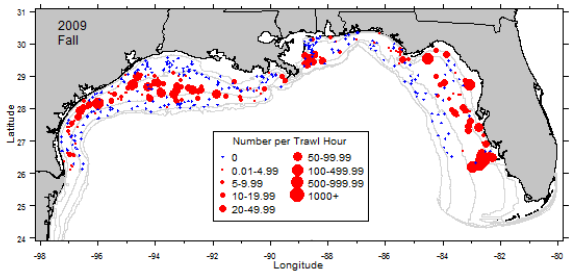
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Fall
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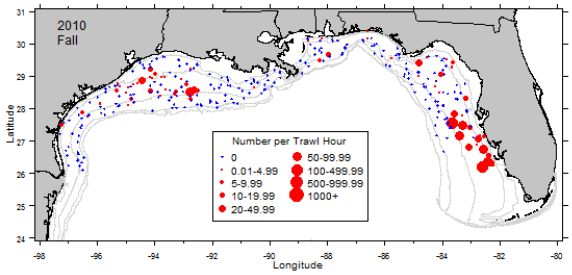
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Fall
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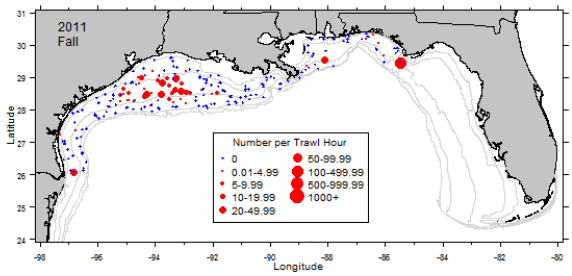
2011
Fall
Number per Trawl Hour
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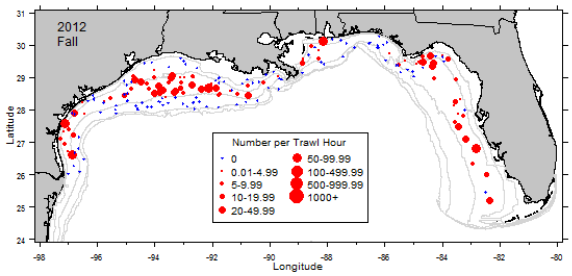
Latitude
Longitude


2012
Fall
Number per Trawl Hour
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1000+
Latitude
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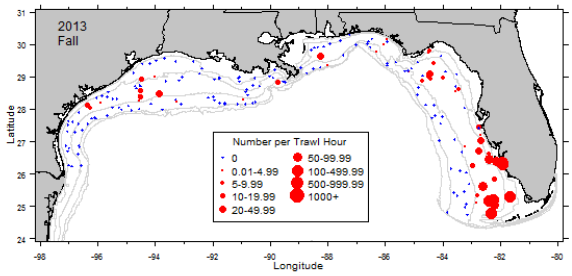
2013
Fall
Number per Trawl Hour
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1000+
Latitude
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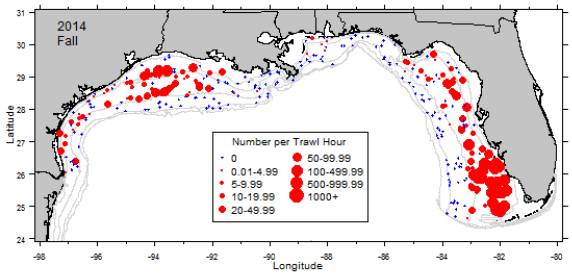
2014
Fall
Number per Trawl Hour
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50-99.99
100-499.99
500-999.99
1000+
Latitude
Longitude