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Wenchman 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 Wenchman (Pristipomoides aquilonaris). 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 Brownsville, TX and Cape San Blas, FL from 2009-2014.

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 Wenchman (*Pristipomoides aquilonaris*).

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 less than 13 fm (23.7 m) and east of Cape San Blas, FL were excluded from the analysis because of the infrequent capture of Wenchman. 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 min 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 Wenchman (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: 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
Paired SSZ: Zones 21-20, 19-18, 17-16, 15-13 and 11-10
Season: Summer and Fall
Time of Day: Day and Night

Brownsville, TX to Cape San Blas, FL (2009 - 2014) Index

Year: 2009 – 2014
Depth: 13 – 60 fm (23.7 – 110 m) (continuous variable)
SSZ: Zones 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20 and 21
Season: Summer and Fall
Time of Day: Day and Night

Results and Discussion

Distribution and Size

The distribution of Wenchman 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 Wenchman, with average lengths ranging between 118 and 148 mm in the summer survey and between 108 and 146 mm in the fall survey. The length frequency distribution of Wenchman 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 Wenchman, year, depth zone, paired SSZ, season and time of day were retained in both the binomial and lognormal submodels. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 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 34,864.5 and 7325.5, 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 / Fall Groundfish Survey (Brownsville, TX to Cape San Blas, FL (2009 - 2014)) abundance index of Wenchman, year, depth, season and SSZ were retained in the binomial submodel, while year, depth, season, SSZ and time of day were retained in the lognormal submodel. 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 13,678.0 and 2394.1, 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 Wenchman 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	2744	629	55	295	131	32
1988	234	1363	748	60	235	128	33
1989	215	663	258	50	219	148	38
1990	262	2058	717	38	240	132	35
1991	254	2243	784	28	250	140	41
1992	248	1539	825	24	245	139	43
1993	248	2780	936	54	464	132	41
1994	262	2785	1107	44	615	134	41
1995	239	2000	867	29	243	131	42
1996	245	3335	1058	46	238	124	36
1997	231	3759	1027	31	467	138	40
1998	229	2296	859	38	226	132	39
1999	246	3031	1029	34	227	129	37
2000	239	2239	838	42	470	128	40
2001	176	1984	766	13	468	129	39
2002	252	3166	963	29	247	134	39
2003	205	1807	747	46	241	132	37
2004	240	2635	1070	52	254	138	39
2005	195	1362	454	21	218	129	35
2006	239	1321	463	26	230	142	49
2007	224	1598	509	23	237	135	41
2008	307	1979	811	26	246	132	42
2009	537	1739	821	27	226	139	41
2010	381	2069	741	40	254	145	37
2011	329	1954	552	49	248	141	39
2012	399	2088	880	38	234	130	35
2013	299	2379	841	41	226	130	29
2014	355	2284	719	41	240	118	34

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
28	7,577	61,200	22,019	133

Table 4. Summary of the Wenchman 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	375	208	45	228	108	46
1988	236	1915	443	42	233	123	51
1989	249	2227	628	36	225	107	53
1990	250	1786	554	32	268	102	55
1991	247	1917	612	35	323	138	56
1992	231	741	371	35	286	150	52
1993	274	1951	666	40	226	136	52
1994	253	2188	809	31	244	124	55
1995	241	1467	499	33	267	137	53
1996	251	2728	575	39	231	146	46
1997	247	1986	677	36	235	121	51
1998	273	1840	528	41	231	137	51
1999	248	2809	878	24	471	120	67
2000	244	3059	897	33	233	105	56
2001	251	2014	549	33	470	141	55
2002	257	2031	702	26	235	106	58
2003	275	2975	1146	35	255	115	61
2004	229	1781	575	31	268	135	57
2005	255	2294	696	29	246	119	63
2006	223	1439	343	30	232	142	58
2007	230	914	335	38	232	138	62
2008	367	930	378	38	227	129	56
2009	445	1906	799	26	239	120	53
2010	315	1634	703	37	249	128	48
2011	220	1947	486	37	254	130	51
2012	199	1121	363	41	258	113	50
2013	186	918	320	37	214	130	37
2014	315	1457	472	42	215	115	47

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
28	7,219	50,350	16,212	124

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

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 34,864.5)*						*Lognormal Submodel Type 3 Tests (AIC 7325.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	5982	92.83	4.89	<.0001	<.0001	19	2266	2.19	0.0021
Depth Zone	14	5982	1029.30	73.52	<.0001	<.0001	14	2266	52.83	<.0001
Season	1	5982	209.40	209.40	<.0001	<.0001	1	2266	8.70	0.0032
Paired_SSZ	4	5982	170.01	42.50	<.0001	<.0001	4	2266	45.11	<.0001
Time of Day	1	5982	75.07	75.07	<.0001	<.0001	1	2266	393.40	<.0001

Table 6. Indices of Wenchman 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	0.37884	293	10.3492	0.76665	0.17968	0.53675	1.09502
1989	0.37895	285	15.7473	1.16652	0.17200	0.82906	1.64134
1990	0.45338	311	20.9641	1.55297	0.13553	1.18570	2.03401
1991	0.37143	315	9.2736	0.68697	0.17711	0.48338	0.97630
1992	0.34868	304	7.0315	0.52087	0.19243	0.35572	0.76271
1993	0.39688	320	15.3345	1.13595	0.15655	0.83215	1.55065
1994	0.48936	329	22.7414	1.68463	0.12752	1.30675	2.17179
1995	0.36928	306	10.7144	0.79370	0.17511	0.56067	1.12358
1996	0.41667	312	15.0963	1.11830	0.15758	0.81757	1.52965
1997	0.45875	303	22.4887	1.66591	0.14109	1.25807	2.20598
1998	0.38658	313	14.0197	1.03855	0.16584	0.74707	1.44376
1999	0.37700	313	12.8801	0.95413	0.17591	0.67295	1.35280
2000	0.38889	306	13.7882	1.02140	0.17034	0.72828	1.43249
2001	0.31365	271	13.6205	1.00897	0.20406	0.67366	1.51119
2002	0.36728	324	12.8045	0.94853	0.17525	0.66985	1.34315
2003	0.41017	295	18.5600	1.37488	0.15405	1.01215	1.86761
2004	0.42384	302	14.0873	1.04356	0.15111	0.77269	1.40938
2005	0.35227	264	11.2894	0.83629	0.18301	0.58171	1.20230
2006	0.27178	287	4.8391	0.35847	0.22891	0.22812	0.56331
2007	0.26394	269	4.3567	0.32274	0.24192	0.20031	0.51999

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

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 13,635.7)*						*Lognormal Submodel Type 3 Tests (AIC 2394.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	5	1889	7.93	1.59	0.1601	0.1607	5	753	6.64	<.0001
Depth	1	1889	135.09	135.09	<.0001	<.0001	1	753	244.82	<.0001
Season	1	1889	37.33	37.33	<.0001	<.0001	1	753	3.99	0.0460
Statistical Zone	12	1889	67.98	5.67	<.0001	<.0001	12	753	6.26	<.0001
Time of Day	1	1889	1.28	1.28	0.2587	0.2588	1	753	71.22	<.0001
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 13,678.0)*						*Lognormal Submodel Type 3 Tests (AIC 2394.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	5	1890	7.70	1.54	0.1734	0.1740	5	753	6.64	<.0001
Depth	1	1890	130.41	130.41	<.0001	<.0001	1	753	244.82	<.0001
Season	1	1890	35.15	35.15	<.0001	<.0001	1	753	3.99	0.0460
Statistical Zone	12	1890	65.51	5.46	<.0001	<.0001	12	753	6.26	<.0001
Time of Day				Dropped			1	753	71.22	<.0001

Table 8. Indices of Wenchman abundance developed using the delta-lognormal (DL) model for SEAMAP Summer / Fall 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	0.35130	501	5.2163	0.46720	0.26108	0.27955	0.78081
2010	0.40120	334	10.4883	0.93939	0.27898	0.54332	1.62418
2011	0.36039	308	9.6619	0.86537	0.30576	0.47592	1.57353
2012	0.43103	290	12.2293	1.09532	0.27666	0.63629	1.88550
2013	0.46818	220	13.4625	1.20578	0.33426	0.62890	2.31181
2014	0.48638	257	15.9317	1.42694	0.23973	0.88937	2.28942

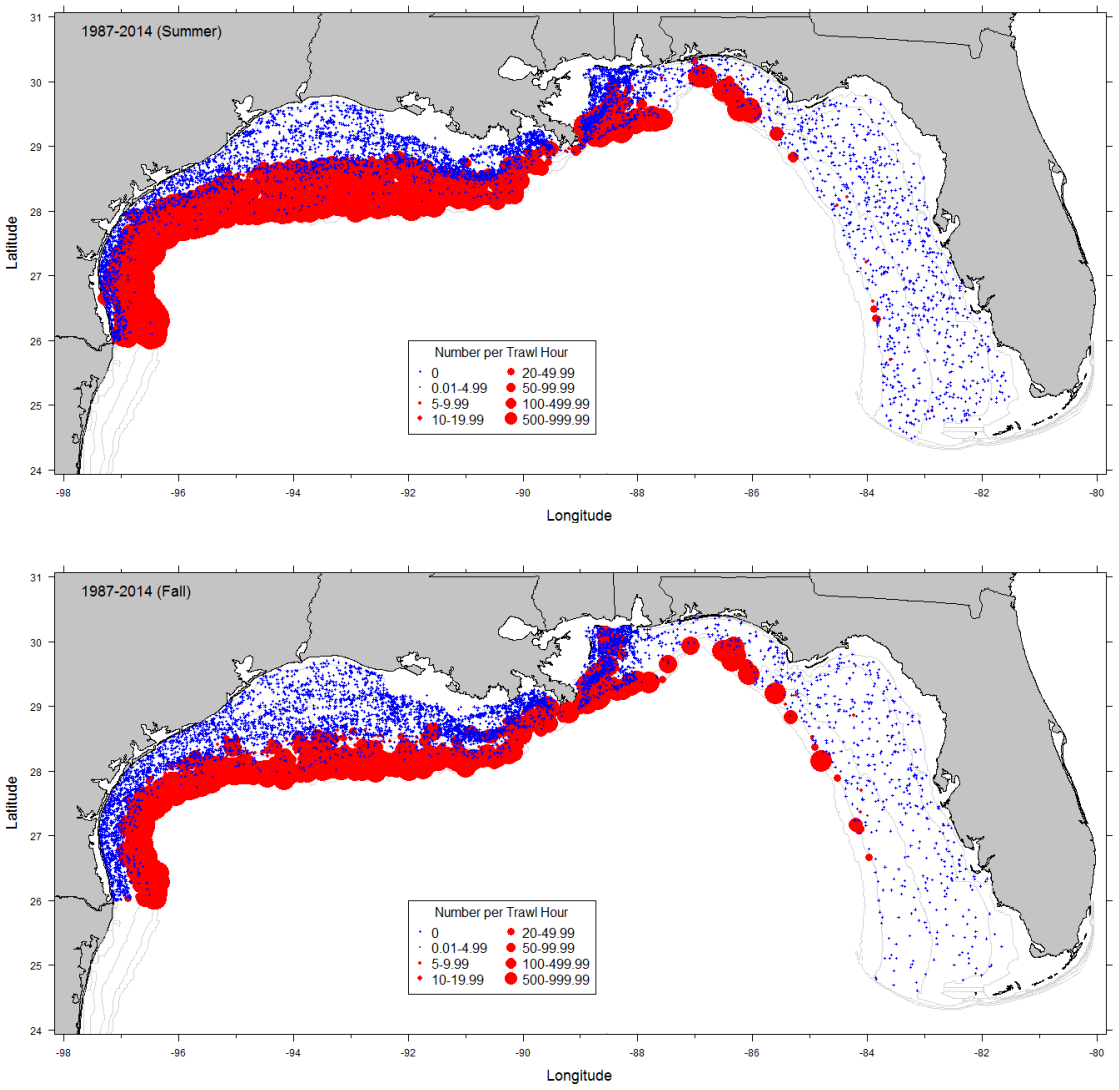


Figure 1. Stations sampled from 1987 to 2014 during the Summer (top) and Fall (bottom) SEAMAP Groundfish Survey with the CPUE for Wenchman.

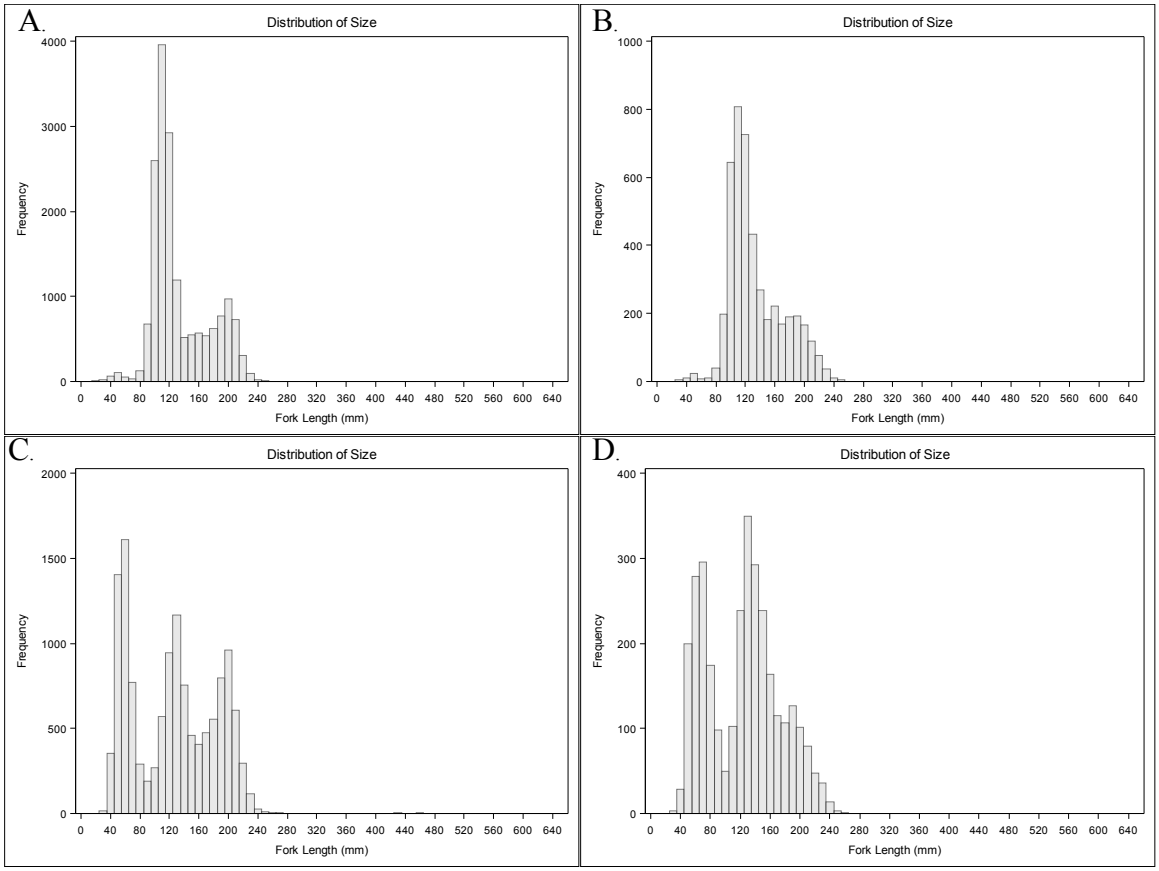


Figure 2. Length frequency histograms for Wenchman captured during **A.** Summer (1987-2007), **B.** Summer (2009-2014), **C.** Fall (1987-2007) and **D.** Fall (2009-2014) SEAMAP Groundfish surveys.

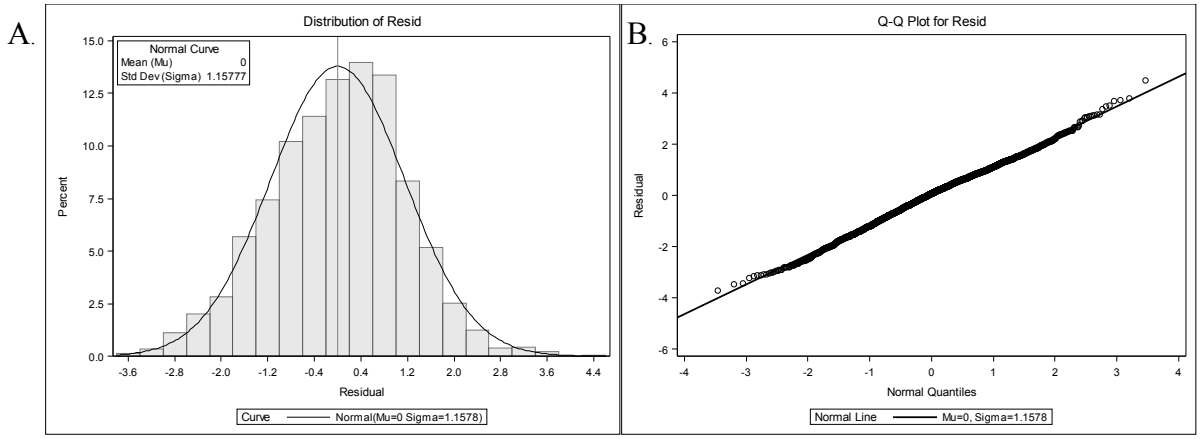


Figure 3. Diagnostic plots for lognormal component of the Wenchman SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL (1988 – 2007)) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

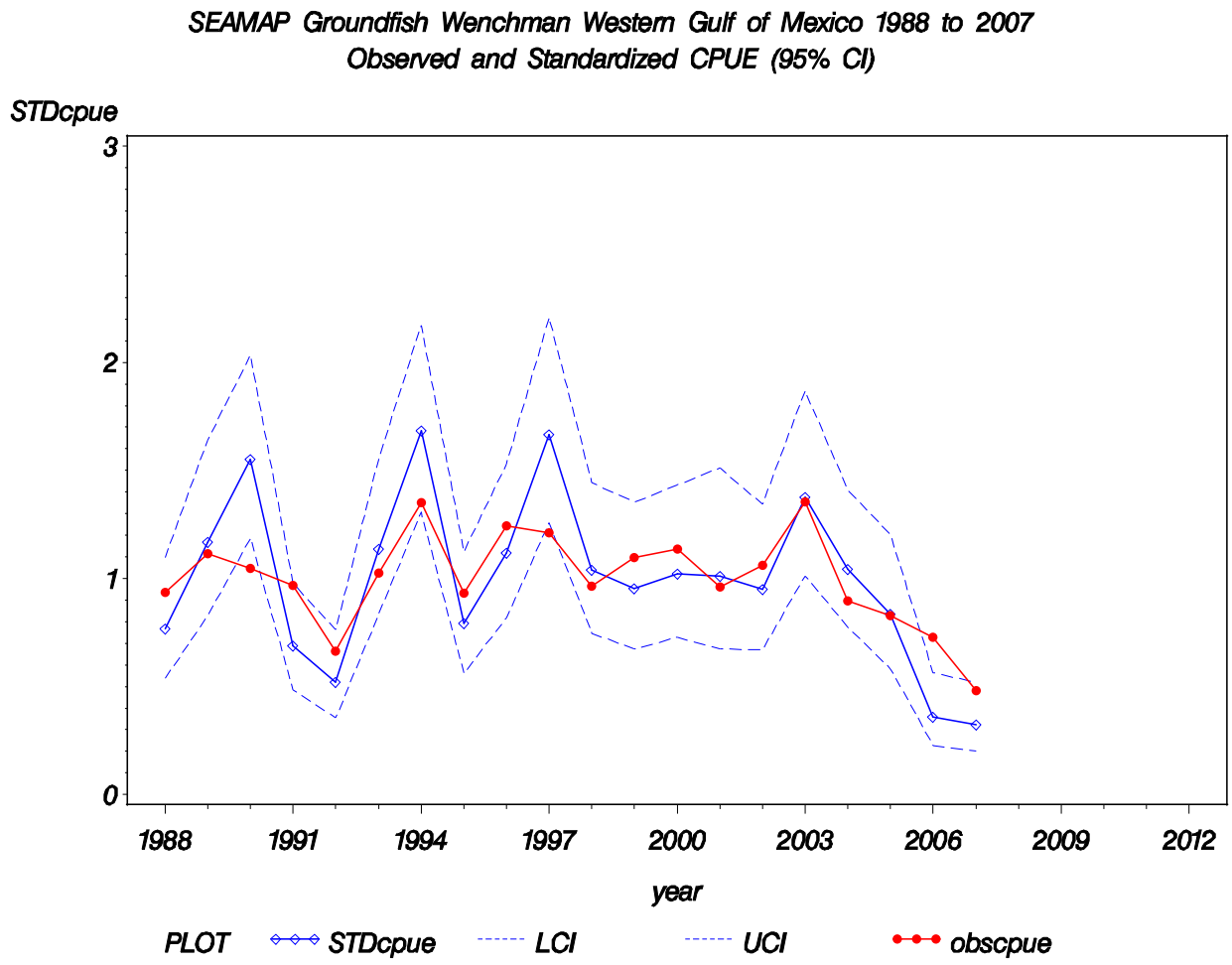


Figure 4. Annual index of abundance for Wenchman from the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Mobile Bay, AL) from 1988 – 2007.

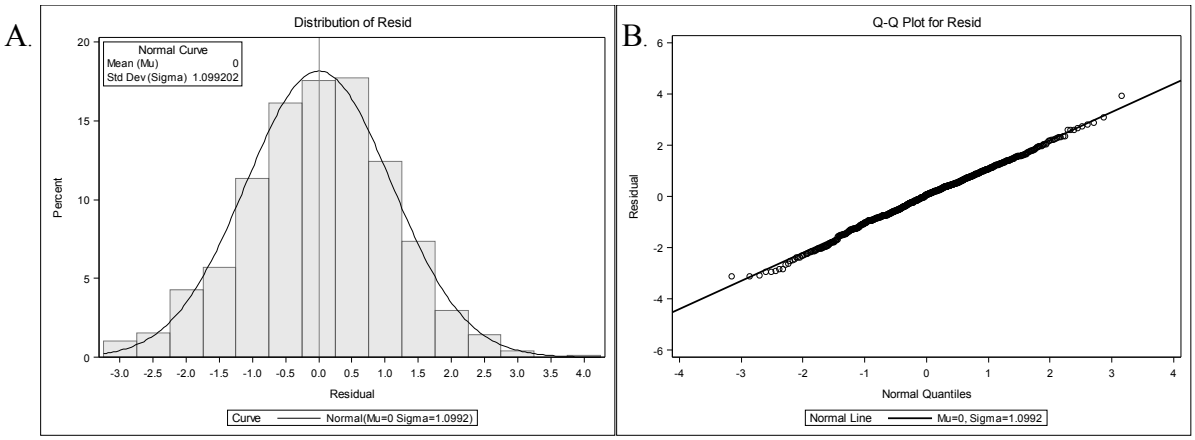


Figure 5. Diagnostic plots for lognormal component of the Wenchman SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Cape San Blas, FL (2009 - 2014)) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

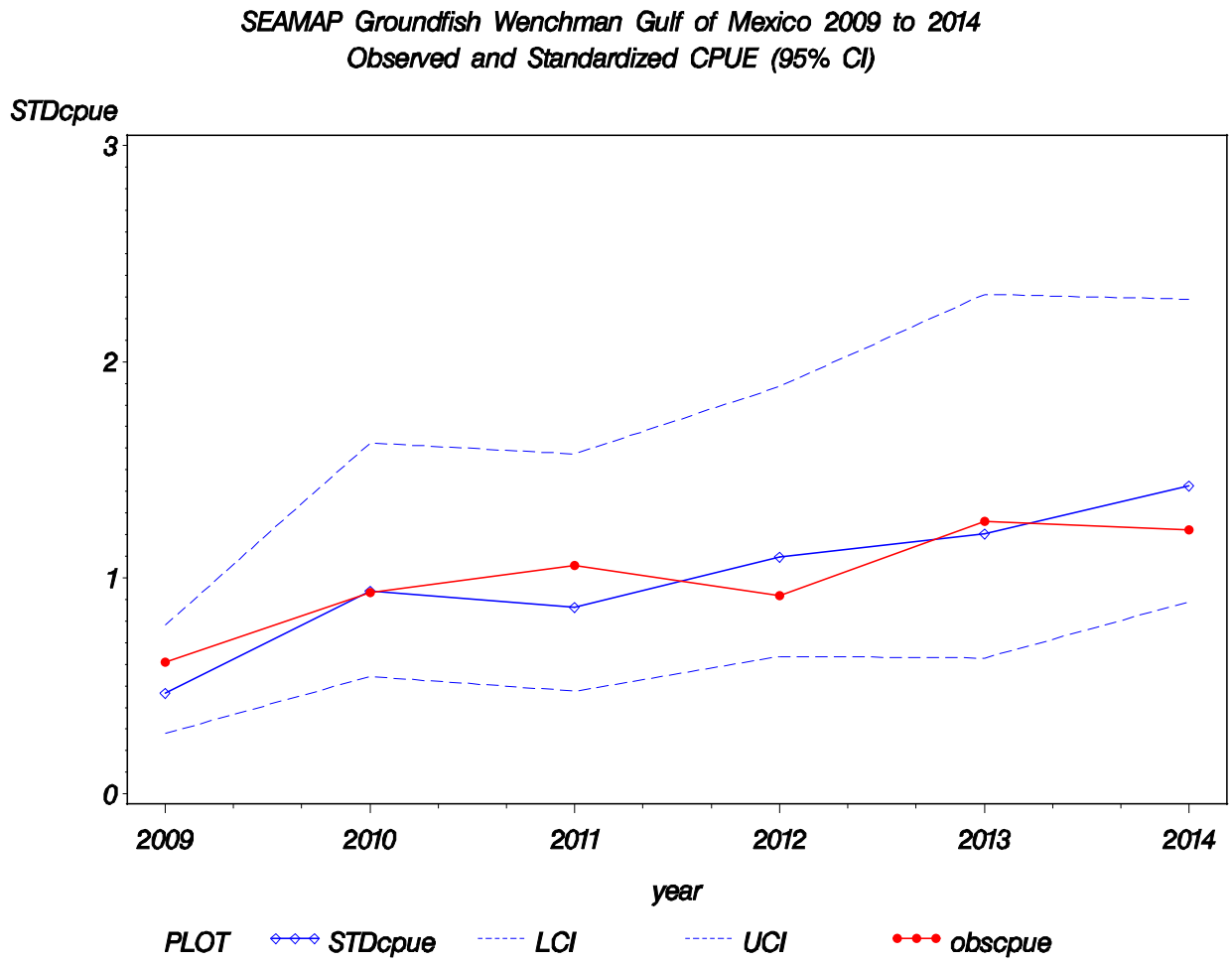


Figure 6. Annual index of abundance for wenchman from the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Cape San Blas, FL) from 2009 – 2014.

Appendix

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

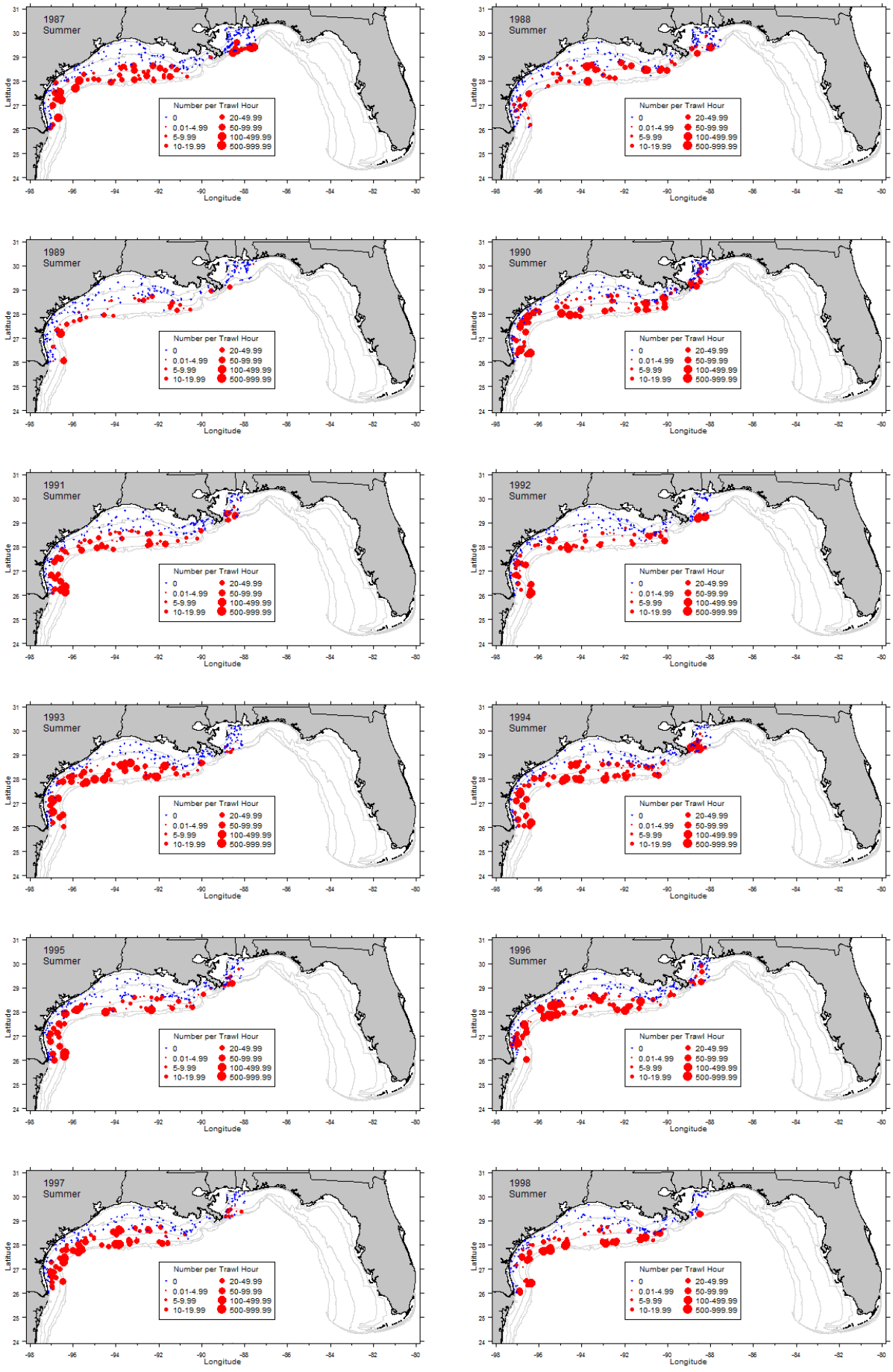
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
DEPTH ZONE	1314	574	22	0.03833	1.542
DEPTH ZONE	1415	449	27	0.06013	1.299
DEPTH ZONE	1516	343	19	0.05539	0.734
DEPTH ZONE	1617	460	53	0.11522	2.379
DEPTH ZONE	1718	550	86	0.15636	5.077
DEPTH ZONE	1819	444	104	0.23423	6.166
DEPTH ZONE	1920	342	93	0.27193	11.527
DEPTH ZONE	2022	406	136	0.33498	10.320
DEPTH ZONE	2225	379	164	0.43272	12.103
DEPTH ZONE	2530	356	210	0.58989	11.489
DEPTH ZONE	3035	386	253	0.65544	15.272
DEPTH ZONE	3540	357	279	0.78151	25.581
DEPTH ZONE	4045	349	296	0.84814	39.208
DEPTH ZONE	4550	340	305	0.89706	59.908
DEPTH ZONE	5060	287	259	0.90244	103.268
SEASON	Fall	3096	945	0.30523	16.424
SEASON	Summer	2926	1361	0.46514	18.121
PAIRED_SSZ	1011	1170	312	0.26667	11.166
PAIRED_SSZ	1315	1514	428	0.28269	8.318
PAIRED_SSZ	1617	1086	471	0.43370	16.124
PAIRED_SSZ	1819	955	402	0.42094	16.909
PAIRED_SSZ	2021	1297	693	0.53431	34.353
TIME OF DAY	Day	3041	1024	0.33673	9.189
TIME OF DAY	Night	2981	1282	0.43006	25.470
YEAR	1988	293	111	0.37884	16.057
YEAR	1989	285	108	0.37895	19.119
YEAR	1990	311	141	0.45338	17.935
YEAR	1991	315	117	0.37143	16.574
YEAR	1992	304	106	0.34868	11.369
YEAR	1993	320	127	0.39688	17.573
YEAR	1994	329	161	0.48936	23.175
YEAR	1995	306	113	0.36928	15.989
YEAR	1996	312	130	0.41667	21.307
YEAR	1997	303	139	0.45875	20.747
YEAR	1998	313	121	0.38658	16.533
YEAR	1999	313	118	0.37700	18.796
YEAR	2000	306	119	0.38889	19.483

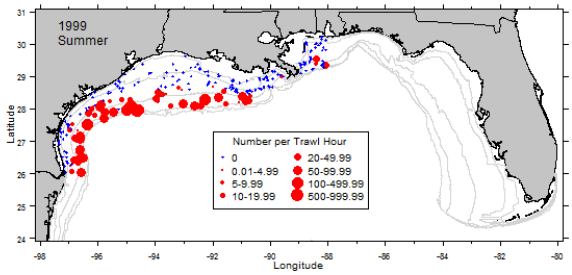
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
YEAR	2001	271	85	0.31365	16.479
YEAR	2002	324	119	0.36728	18.157
YEAR	2003	295	121	0.41017	23.204
YEAR	2004	302	128	0.42384	15.344
YEAR	2005	264	93	0.35227	14.212
YEAR	2006	287	78	0.27178	12.448
YEAR	2007	269	71	0.26394	8.236

Appendix Table 2. Summary of the factors used in constructing the Wenchman abundance index from the SEAMAP Summer / Fall Groundfish Survey (Brownsville, TX to Cape San Blas, FL (2009 - 2014)) data.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
SEASON	Fall	885	276	0.31186	20.0511
SEASON	Summer	1025	498	0.48585	24.1633
STATISTICAL ZONE	8	122	4	0.03279	0.7049
STATISTICAL ZONE	9	113	26	0.23009	39.9202
STATISTICAL ZONE	10	81	11	0.13580	11.7527
STATISTICAL ZONE	11	154	20	0.12987	4.1252
STATISTICAL ZONE	13	60	14	0.23333	8.1171
STATISTICAL ZONE	14	100	44	0.44000	10.2034
STATISTICAL ZONE	15	148	80	0.54054	29.8898
STATISTICAL ZONE	16	190	92	0.48421	32.3420
STATISTICAL ZONE	17	214	106	0.49533	21.7766
STATISTICAL ZONE	18	197	74	0.37563	11.3681
STATISTICAL ZONE	19	158	55	0.34810	10.0690
STATISTICAL ZONE	20	211	144	0.68246	44.9125
STATISTICAL ZONE	21	162	104	0.64198	38.7974
TIME OF DAY	Day	1015	408	0.40197	15.3155
TIME OF DAY	Night	895	366	0.40894	30.1311
YEAR	2009	501	176	0.35130	14.4192
YEAR	2010	334	134	0.40120	21.9801
YEAR	2011	308	111	0.36039	25.0006
YEAR	2012	290	125	0.43103	21.6689
YEAR	2013	220	103	0.46818	29.7425
YEAR	2014	257	125	0.48638	28.8705

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

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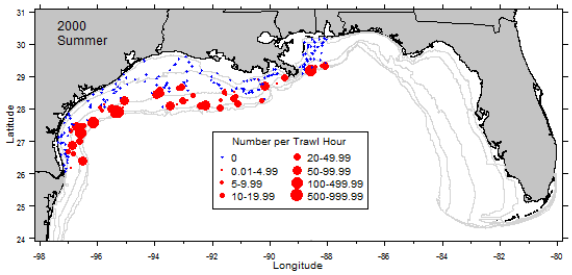
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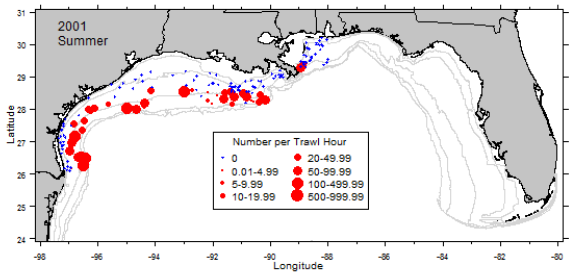
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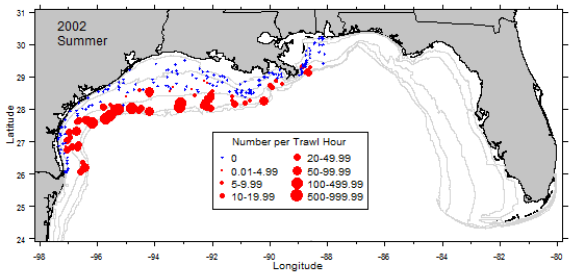
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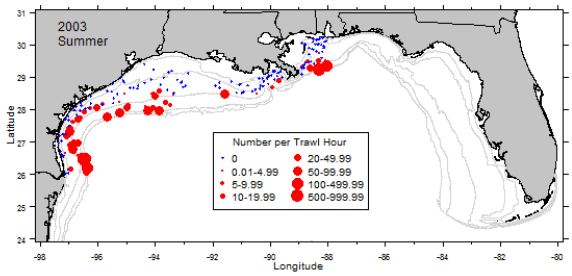
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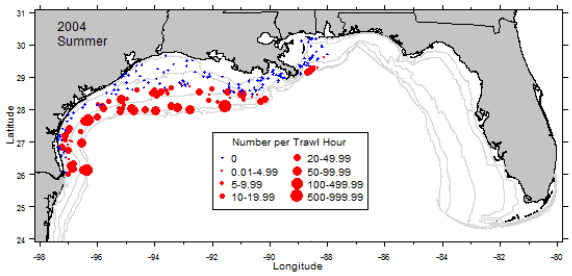
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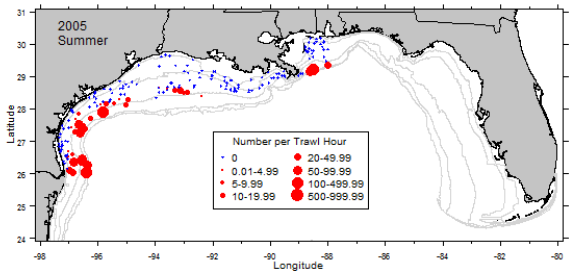
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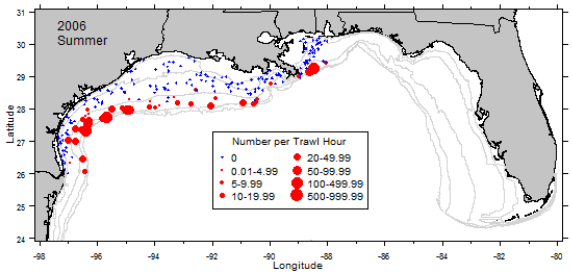
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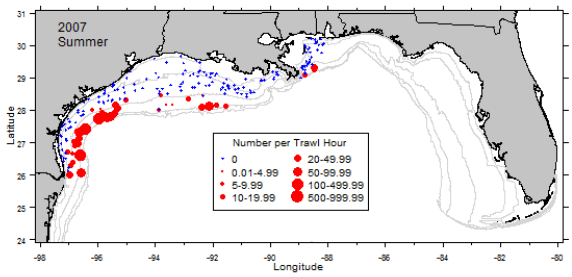
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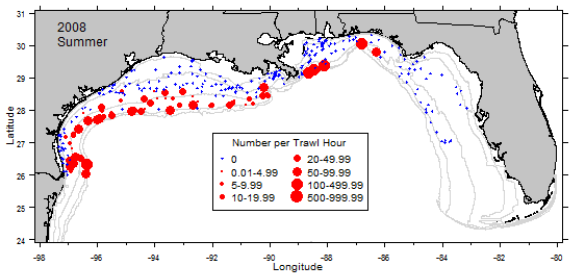
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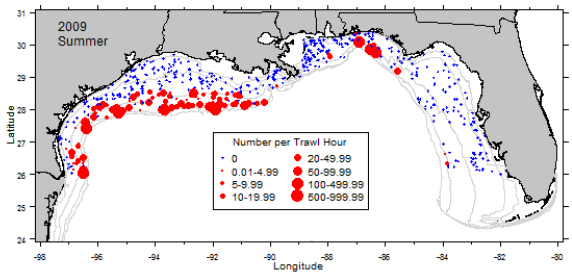
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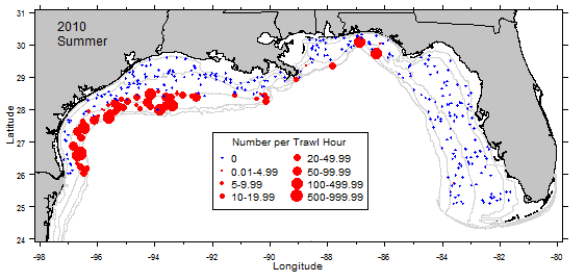
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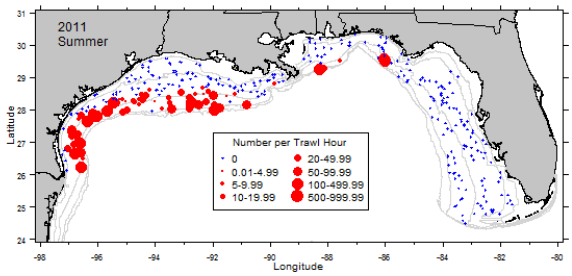
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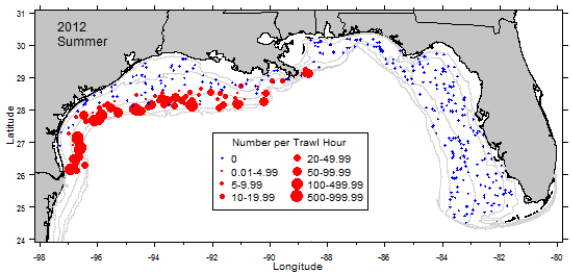
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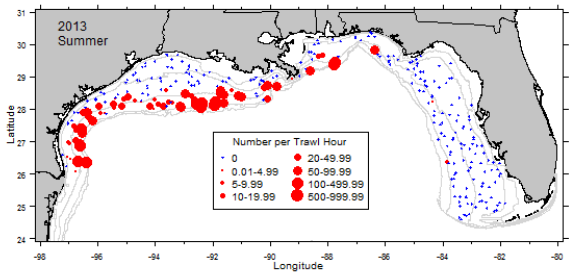
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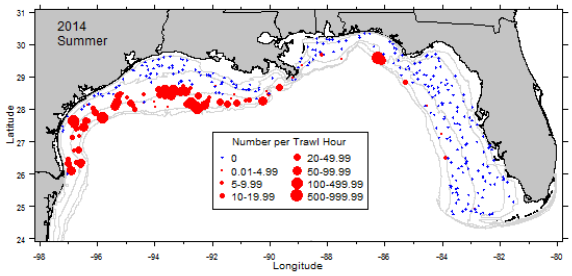
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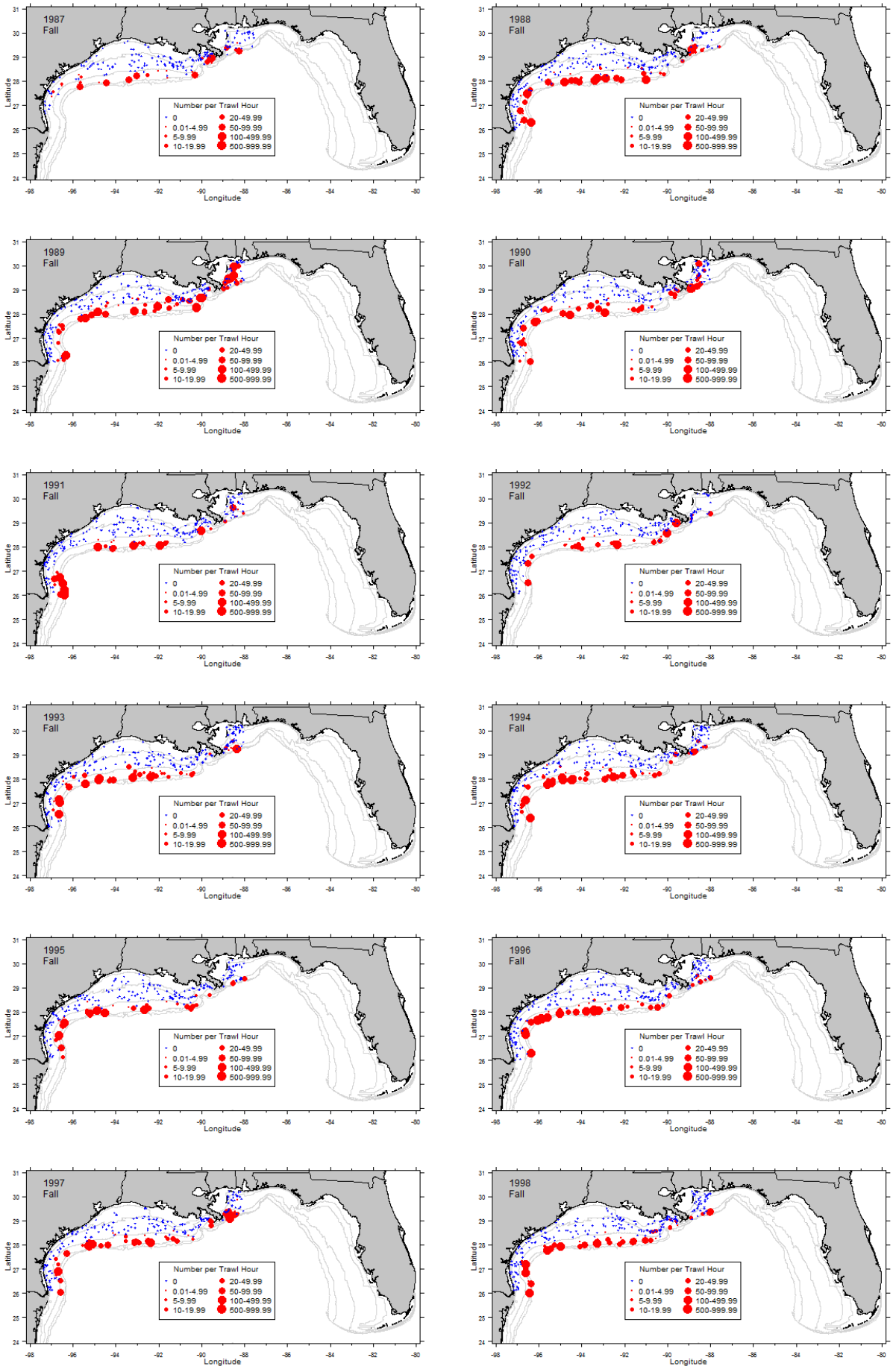
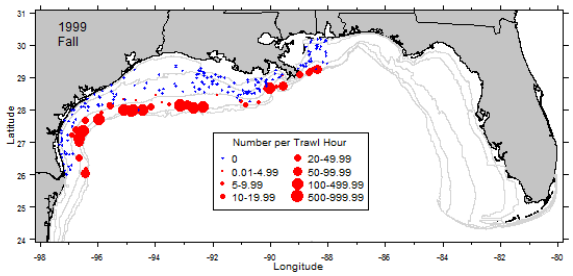
Appendix Figure 2. Annual survey effort and catch of Wenchman from the SEAMAP Fall Groundfish Survey.

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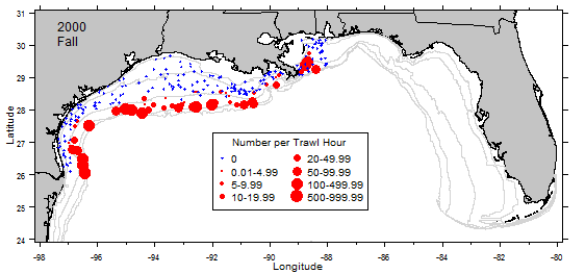
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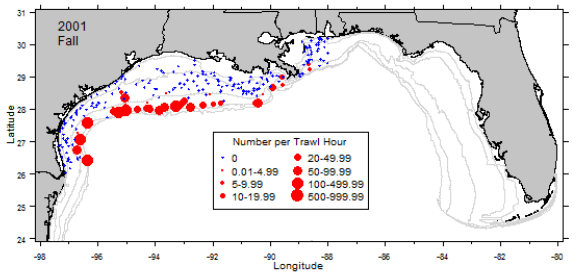
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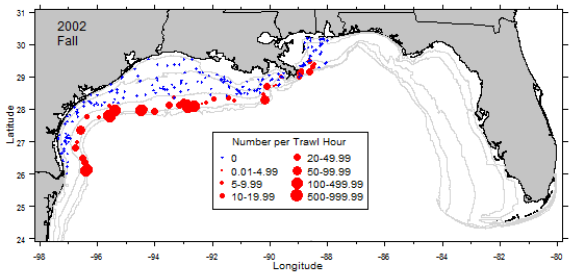
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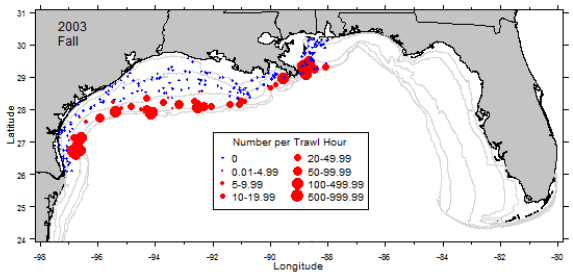
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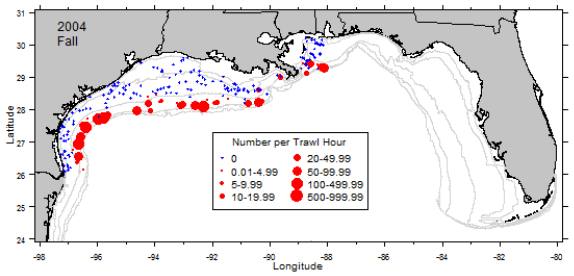
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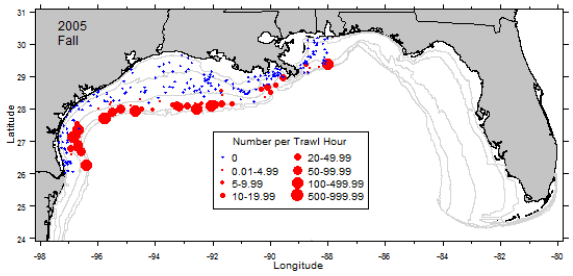
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Fall
Number per Trawl Hour
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20-49.99
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100-499.99
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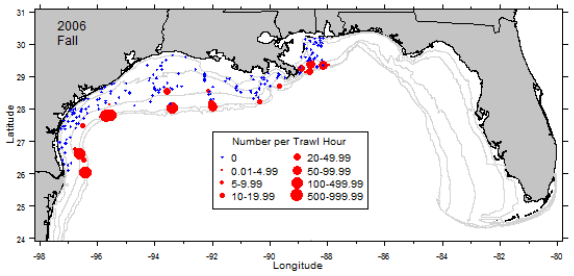
Latitude
Longitude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Latitude
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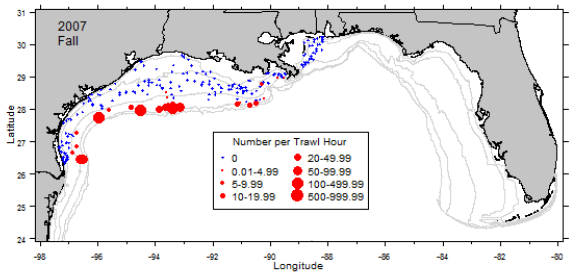
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Fall
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Latitude
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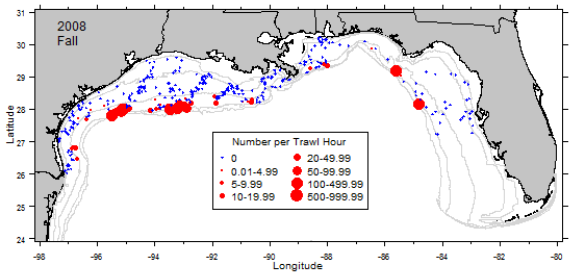
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Fall
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Latitude
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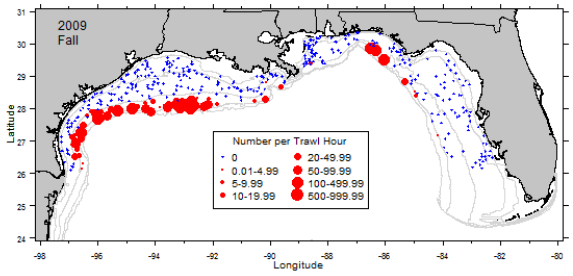
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Fall
Number per Trawl Hour
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Latitude
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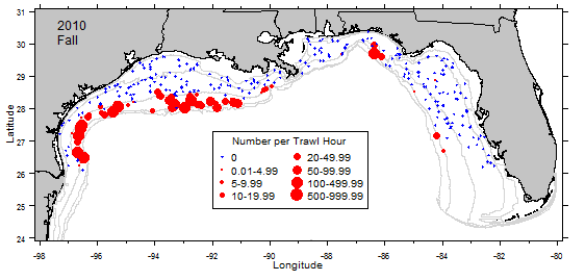
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Fall
Number per Trawl Hour
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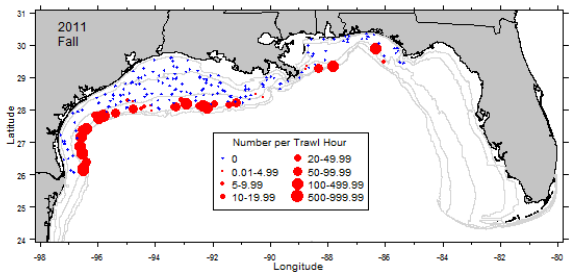
Latitude
Longitude


2011
Fall
Number per Trawl Hour
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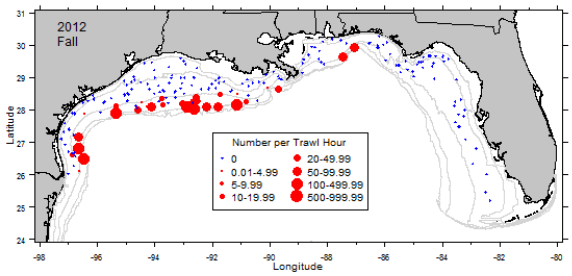
500-999.99
Latitude
Longitude


2012
Fall
Number per Trawl Hour
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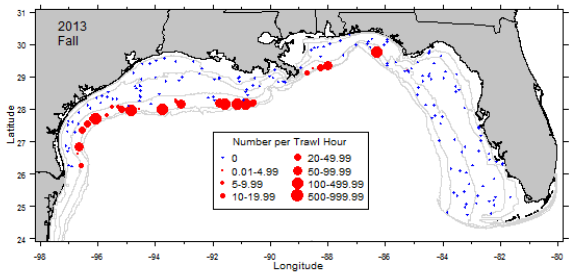
Latitude
Longitude


2013
Fall
Number per Trawl Hour
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0.01-4.99
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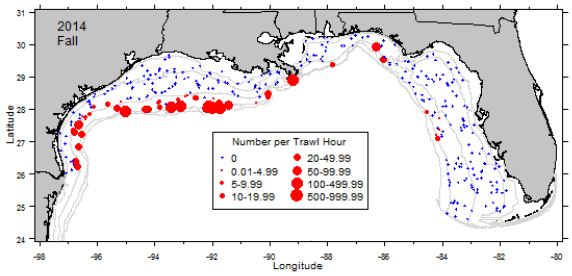
20-49.99
50-99.99
100-499.99
500-999.99
Latitude
Longitude


2014
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
Latitude
Longitude