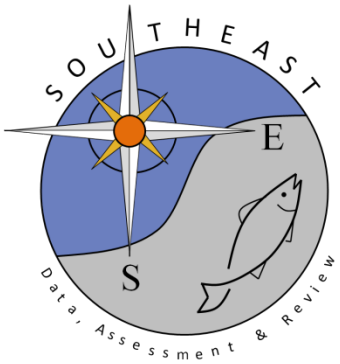
Gray Triggerfish Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

Adam G. Pollack and G. Walter Ingram, Jr.

SEDAR43-WP-11

30 March 2015



Please cite this document as:

Pollack, A.G. and G. Walter Ingram, Jr. 2015. Gray Triggerfish Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico. SEDAR43-WP-11. SEDAR, North Charleston, SC. 30 pp.

Gray Triggerfish Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

Adam G. Pollack[1] and G. Walter Ingram, Jr.[2]

[1] Riverside Technology, Inc.
NOAA Fisheries, Southeast Fisheries Science Center,
Mississippi Laboratories, Pascagoula, MS

[2] NOAA Fisheries, Southeast Fisheries Science Center,
Mississippi Laboratories, Pascagoula, MS

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 data were used to develop abundance indices for gray triggerfish (Balistes capriscus). Following previous assessments, two indices were produced using data from SEAMAP Groundfish Surveys, a summer index and a fall index. These indices represented abundance estimates for age zero and one year old gray triggerfish.

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 gray triggerfish (*Balistes capriscus*).

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 (SSZ) (between 88° and 97° W longitude, 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 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. Recently, a new modification was added to the survey design, a depth stratification of 5 - 20 fathoms and 20 – 60 fathoms.

Data

A total of 13,965 stations were sampled from 1987- 2013 with 7,142 and 6,823 stations sampled during the summer and fall survey, respectively (Tables 1 and 2). Trawl data 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 was limited by several factors:

(1) No problems with tow (i.e. net torn, doors crossed, etc.).
(2) Depths between 5 and 60 fathoms.
(3) Within SSZ 2 – 21 (excluding 12)
(4) Sampled with a 40 ft. shrimp trawl (Texas uses a 20 ft. shrimp trawl and data are not used).
(5) Sampled between 1987 and 2013 (followed data used during previous updates).

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 (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 this time, triplicate 10 minute tows were done at each station. For the purpose of this analysis, these stations were excluded, in following what had been done during previous assessments.

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 minutes. 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 gray triggerfish (Pennington, 1983; Bradu & 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 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Variables that could be included in the submodels were:

Submodel Variables

Year: 1987 – 2013
Depth: 5-60 fathoms (continuous)
Area: Florida (SSZ 2-9), Mississippi/Alabama (SSZ 10-11), Louisiana (SSZ 13-17), Texas (SSZ 18-21)
Time of Day: Day, Night
Survey: Old Design (1987-2008), New Design (2009-2013)

Results and Discussion

Distribution, Size and Age

The distribution of gray triggerfish is presented in Figure 1, with seasonal/annual abundance and distribution presented in the Appendix Figures 1 and 2. The annual number of gray triggerfish captured ranged from 29 to 440 in the summer (Table 3) and 13 to 1,783 in the fall (Table 4). Of the 3,353 gray triggerfish captured during the summer survey, a total of 1,792 were measured with an average total length of 157 mm. During the fall survey, 10,550 gray triggerfish were captured, with 5,052 measured, with an average total length of 143 mm. The length frequency distribution of gray triggerfish captured is shown in Figure 2. Based on data from previous assessments, the gray triggerfish captured most likely represent age zero and one year old fish.

Index of Abundance

For the SEAMAP Summer Groundfish Survey abundance index of gray triggerfish, the nominal CPUE and number of stations with a positive catch are presented in Figure 3. Year, area and depth were retained in the binomial submodel, while year, area, depth and time of day were retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 5 summarizes the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 39,227.0 and 2,209.7, respectively. There was an increase in AIC with between the second and third run of the binomial submodel and each run of the lognormal submodel, however since the factors removed were not significant, this increase was deemed acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 4-6, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 6 and Figure 7.

For the SEAMAP Fall Groundfish Survey abundance index of gray triggerfish, the nominal CPUE and number of stations with a positive catch are presented in Figure 8. Year, area, depth and survey were retained in both the binomial submodel, while year, area and depth were

retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 2. Table 5 summarizes the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 32,890.0 and 4,690.3, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 9-11, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 6 and Figure 12.

Literature Cited

Bradu, D. & Mundlak, Y. 1970. Estimation in Lognormal Linear Models, Journal of the American Statistical Association, 65: 198-211.

Lo, N.C.H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Science* 49: 2515-2526.

Nichols, S. 2004. Derivation of red snapper time series from SEAMAP and groundfish trawl surveys. SEDAR7-DW01.

Ortiz, M. 2006. Standardized catch rates for gag grouper (*Mycteroperca microlepis*) from the marine recreational fisheries statistical survey (MRFSS). SEDAR10-DW-09.

Pennington, M. 1983. Efficient Estimators of Abundance, for Fish and Plankton Surveys. Biometrics, 39: 281-286.

Pollack, A.G. and G. Walter Ingram Jr. 2010. Abundance indices of subadult yellowedge grouper, *Epinephelus flavolimbatus*, collected in summer and fall groundfish surveys in the northern Gulf of Mexico. SEDAR22-DW-06.

Table 1. Number of stations sampled by shrimp statistical zone during the SEAMAP Summer Groundfish Survey from 1987-2013.

	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									27	58	8	34	21	25	20	16	25	28	19	*281*
1988									17	46	10	14	9	19	24	14	25	28	23	*229*
1989									21	30	8	13	18	25	7	15	20	29	24	*210*
1990										65	18	31	17	23	16	20	23	24	20	*257*
1991										44	16	41	13	23	22	24	18	23	26	*250*
1992									1	44	2	36	30	20	25	12	31	26	20	*247*
1993										44	22	29	19	24	19	14	29	24	22	*246*
1994										60	12	27	28	25	17	20	22	26	22	*259*
1995										42	12	26	24	22	23	13	27	26	21	*236*
1996										46	14	34	19	22	18	17	21	26	25	*242*
1997										42	4	26	22	22	23	10	28	26	26	*229*
1998										34	6	28	27	25	18	14	22	36	17	*227*
1999										43	11	31	26	20	23	13	25	32	20	*244*
2000										43	11	27	19	19	27	8	29	31	21	*235*
2001										34	15	24	28	13	3	10	9	17	21	*174*
2002										44	15	34	21	27	19	15	25	29	22	*251*
2003										42	17	26	8	2	17	20	22	26	23	*203*
2004										38	19	28	21	20	25	21	19	25	21	*237*
2005										31	10	9	23	16	21	5	28	22	27	*192*
2006										45	17	29	16	20	23	17	23	31	18	*239*
2007										40	12	10	23	22	23	7	29	32	21	*219*
2008			1	8	11	6	11	8	11	42	24	19	27	23	22	17	24	21	29	*304*
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	10	7	14	17	24	29	29	18	21	13	*324*
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	24	19	10	11	9	5	11	6	12	14	21	22	22	16	17	12	*295*
Total	***32***	***121***	***146***	***125***	***144***	***63***	***82***	***77***	***142***	***1083***	***333***	***656***	***560***	***587***	***594***	***487***	***638***	***702***	***570***	***7142***

Table 2. Number of stations sampled by shrimp statistical zone during the SEAMAP Fall Groundfish Survey from 1987-2013.

	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									13	22	29	29	26	17	15	15	15	18	3	*202*
1988									8	27	10	28	24	18	26	19	21	31	20	*232*
1989										43	16	31	23	22	20	17	22	25	26	*245*
1990										52	20	22	27	22	19	18	22	19	27	*248*
1991										45	16	32	18	20	25	24	19	25	22	*246*
1992										32	15	31	14	25	18	17	27	30	18	*227*
1993										70	14	35	19	26	18	16	25	28	18	*269*
1994										49	17	24	27	25	20	21	23	24	20	*250*
1995										39	14	29	24	24	19	14	26	30	19	*238*
1996										43	11	36	21	17	28	13	25	29	24	*247*
1997										43	18	31	20	26	19	18	23	22	24	*244*
1998										43	28	50	14	34	11	15	24	29	22	*270*
1999										42	9	38	18	29	18	12	28	29	22	*245*
2000										42	10	27	28	20	26	12	30	25	21	*241*
2001										43	14	30	22	26	20	14	27	28	23	*247*
2002									1	49	16	27	26	22	23	14	26	30	21	*255*
2003									1	74	20	20	21	24	22	20	23	25	23	*273*
2004										43	6	23	24	17	27	14	24	30	21	*229*
2005										43	21	30	18	33	18	14	23	24	27	*251*
2006									1	46	7	22	14	18	28	13	23	32	19	*223*
2007										31	15	27	26	18	28	17	20	18	26	*226*
2008				15	14	4	4	3	4	34	16	28	34	42	46	44	19	36	20	*363*
2009			20	21	25	11	21	13	12	47	12	23	23	30	49	47	31	36	22	*443*
2010			9	27	27	18	16	11	14	16	7	15	18	26	31	29	18	19	14	*315*
2011							9	11	6	11	6	15	15	27	31	28	21	19	15	*214*
2012		2	3	6	6	17	10	7	4	9	5	11	13	19	22	22	13	14	11	*194*
2013	4	14	14	11	12	10	10	6	5	10	5	11	9	3	12	16	11	14	9	*186*
Total	***4***	***16***	***46***	***80***	***84***	***60***	***70***	***51***	***69***	***1048***	***377***	***725***	***566***	***630***	***639***	***523***	***609***	***689***	***537***	***6823***

Table 3. Summary of the gray triggerfish length data collected during SEAMAP Summer Groundfish Surveys conducted between 1987 and 2013.

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	281	59	2	135	165	150	21
1988	229	159	17	93	356	189	66
1989	210	96	44	45	290	112	59
1990	257	111	38	55	320	161	79
1991	250	136	52	42	384	178	92
1992	247	69	61	106	406	209	61
1993	246	35	23	110	374	217	72
1994	259	162	107	57	461	153	75
1995	236	135	81	42	455	188	76
1996	242	70	57	105	346	229	57
1997	229	94	46	64	415	191	78
1998	227	29	21	64	342	211	102
1999	244	177	140	30	356	114	59
2000	235	440	200	56	396	109	45
2001	174	273	133	49	360	145	55
2002	251	107	82	83	303	181	54
2003	203	34	27	79	318	169	81
2004	237	35	24	115	271	197	44
2005	192	56	44	61	339	142	74
2006	239	399	204	44	356	83	38
2007	219	64	30	75	325	194	66
2008	304	98	58	62	415	211	67
2009	534	123	57	68	361	194	63
2010	379	75	49	83	359	206	63
2011	324	148	61	76	471	194	101
2012	399	116	82	68	455	214	90
2013	295	53	52	116	394	178	56

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
27	7142	3353	1792	157

Table 4. Summary of the gray triggerfish length data collected during SEAMAP Fall Groundfish Surveys conducted between 1987 and 2013.

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	202	241	47	93	176	134	21
1988	232	168	47	67	363	116	46
1989	245	319	157	25	372	139	38
1990	248	79	55	21	454	152	71
1991	246	1455	587	76	350	155	34
1992	227	87	70	65	367	166	71
1993	269	848	393	54	421	154	65
1994	250	634	383	66	392	147	41
1995	238	322	184	68	334	135	53
1996	247	228	109	60	452	137	68
1997	244	176	111	86	288	170	37
1998	270	13	8	79	338	169	90
1999	245	410	226	76	305	142	34
2000	241	608	401	60	369	143	36
2001	247	1783	538	73	450	125	32
2002	255	405	247	64	374	112	41
2003	273	225	99	86	395	144	43
2004	229	204	170	82	364	150	39
2005	251	419	176	84	346	143	35
2006	223	310	114	76	381	161	61
2007	226	280	96	77	300	142	41
2008	363	339	320	67	404	135	44
2009	443	117	103	64	362	180	63
2010	315	195	73	79	370	149	53
2011	214	144	74	99	390	174	57
2012	194	459	224	71	407	123	35
2013	186	82	40	90	264	137	45

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
27	6823	10,550	5052	143

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for gray triggerfish SEAMAP Summer Groundfish Survey index of relative abundance from 1987 to 2013.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 39,226.6)*						*Lognormal Submodel Type 3 Tests (AIC 2208.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	7192	105.52	4.06	<.0001	<.0001	26	776	4.12	<.0001
Area	3	7192	118.62	39.54	<.0001	<.0001	3	776	3.28	0.0204
Depth	1	7192	37.78	37.78	<.0001	<.0001	1	776	136.27	<.0001
Survey	1	7192	1.93	1.93	0.1646	0.1646	1	776	1.72	0.1899
Time of Day	1	7192	0.42	0.42	0.5181	0.5181	1	776	19.91	<.0001
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 39,217.3)*						*Lognormal Submodel Type 3 Tests (AIC 2209.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	7193	105.70	4.07	<.0001	<.0001	26	777	4.05	<.0001
Area	3	7193	118.81	39.60	<.0001	<.0001	3	777	2.83	0.0377
Depth	1	7193	37.89	37.89	<.0001	<.0001	1	777	136.76	<.0001
Survey	1	7193	1.92	1.92	0.1662	0.1663		Dropped		
Time of Day				Dropped			1	777	19.31	<.0001
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 39,227.0)*						*Lognormal Submodel Type 3 Tests (AIC 2209.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	7194	112.88	4.34	<.0001	<.0001	26	777	4.05	<.0001
Area	3	7194	126.24	42.08	<.0001	<.0001	3	777	2.83	0.0377
Depth	1	7194	37.00	37.00	<.0001	<.0001	1	777	136.76	<.0001
Survey				Dropped				Dropped		
Time of Day				Dropped			1	777	19.31	<.0001

Table 6. Indices of gray triggerfish abundance developed using the delta-lognormal (DL) model for SEAMAP Summer Groundfish Survey from 1987-2013. 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
1987	0.06272	287	0.37313	0.57670	0.32561	0.30565	1.08811
1988	0.07265	234	0.32130	0.49660	0.33494	0.25869	0.95331
1989	0.08372	215	0.62867	0.97166	0.32666	0.51397	1.83690
1990	0.10305	262	0.75562	1.16787	0.26568	0.69271	1.96897
1991	0.13386	254	0.83304	1.28753	0.23726	0.80629	2.05601
1992	0.10081	248	0.29227	0.45172	0.27808	0.26171	0.77970
1993	0.07258	248	0.27029	0.41775	0.32642	0.22108	0.78940
1994	0.15267	262	0.92033	1.42245	0.21762	0.92511	2.18714
1995	0.12971	239	0.74365	1.14936	0.24849	0.70444	1.87528
1996	0.05306	245	0.27757	0.42901	0.38317	0.20463	0.89939
1997	0.12554	231	0.59487	0.91941	0.25665	0.55480	1.52365
1998	0.05677	229	0.15592	0.24098	0.38306	0.11497	0.50510
1999	0.17480	246	1.20209	1.85792	0.21140	1.22296	2.82254
2000	0.20502	239	1.45877	2.25463	0.19716	1.52566	3.33191
2001	0.15341	176	2.39310	3.69871	0.26327	2.20391	6.20736
2002	0.16270	252	0.75689	1.16984	0.21641	0.76261	1.79452
2003	0.08780	205	0.19801	0.30604	0.32579	0.16215	0.57763
2004	0.06667	240	0.21486	0.33208	0.34617	0.16945	0.65080
2005	0.12308	195	0.41817	0.64632	0.28310	0.37091	1.12620
2006	0.18828	239	1.82851	2.82610	0.20636	1.87849	4.25174
2007	0.10714	224	0.42919	0.66335	0.28237	0.38121	1.15431
2008	0.09446	307	0.39106	0.60441	0.25766	0.36401	1.00355
2009	0.13035	537	0.54508	0.84247	0.17680	0.59316	1.19656
2010	0.07874	381	0.27588	0.42639	0.26210	0.25463	0.71399
2011	0.11212	330	0.47865	0.73979	0.23876	0.46195	1.18475
2012	0.11779	399	0.44709	0.69101	0.21697	0.44998	1.06115
2013	0.08638	301	0.26523	0.40994	0.28288	0.23536	0.71402

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for gray triggerfish SEAMAP Fall Groundfish Survey index of relative abundance from 1987 to 2013.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 32,895.1)*						*Lognormal Submodel Type 3 Tests (AIC 4693.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	6875	291.20	11.20	<.0001	<.0001	26	1616	5.66	<.0001
Area	3	6875	150.83	50.28	<.0001	<.0001	3	1616	25.96	<.0001
Depth	1	6875	10.29	10.29	0.0013	0.0013	1	1616	222.25	<.0001
Survey	1	6875	5.82	5.82	0.0159	0.0159	1	1616	0.20	0.6514
Time of Day	1	6875	1.64	1.64	0.2002	0.2003	1	1616	0.97	0.3240
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 32,890.0)*						*Lognormal Submodel Type 3 Tests (AIC 4693.6)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	6876	291.24	11.20	<.0001	<.0001	26	1617	5.97	<.0001
Area	3	6876	150.88	50.29	<.0001	<.0001	3	1617	26.23	<.0001
Depth	1	6876	10.35	10.35	0.0013	0.0013	1	1617	223.00	<.0001
Survey	1	6876	5.76	5.76	0.0163	0.0164		Dropped		
Time of Day				Dropped			1	1617	0.94	0.3320
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 32,890.0)*						*Lognormal Submodel Type 3 Tests (AIC 4690.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	26	6876	291.24	11.20	<.0001	<.0001	26	1618	5.96	<.0001
Area	3	6876	150.88	50.29	<.0001	<.0001	3	1618	26.26	<.0001
Depth	1	6876	10.35	10.35	0.0013	0.0013	1	1618	222.91	<.0001
Survey	1	6876	5.76	5.76	0.0163	0.0164		Dropped		
Time of Day				Dropped				Dropped		

Table 8. Indices of gray triggerfish abundance developed using the delta-lognormal (DL) model for SEAMAP Fall Groundfish Survey from 1987-2013. 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
1987	0.24038	208	2.15650	0.90083	0.23661	0.56484	1.43671
1988	0.20339	236	1.88733	0.78839	0.24720	0.48440	1.28316
1989	0.30522	249	3.20725	1.33977	0.19562	0.90930	1.97402
1990	0.14000	250	0.77001	0.32166	0.28505	0.18392	0.56256
1991	0.44534	247	6.77340	2.82945	0.15013	2.09905	3.81401
1992	0.10823	231	0.73973	0.30901	0.32752	0.16319	0.58511
1993	0.32117	274	5.09751	2.12938	0.18035	1.48888	3.04543
1994	0.34783	253	3.94531	1.64808	0.17844	1.15665	2.34830
1995	0.24896	241	2.35196	0.98248	0.22203	0.63356	1.52356
1996	0.21514	251	2.53146	1.05747	0.23525	0.66478	1.68211
1997	0.16194	247	1.28328	0.53606	0.26942	0.31571	0.91022
1998	0.02930	273	0.15758	0.06582	0.52936	0.02436	0.17787
1999	0.25806	248	2.33338	0.97472	0.21574	0.63624	1.49329
2000	0.33607	244	4.75210	1.98509	0.18532	1.37457	2.86678
2001	0.34661	251	6.77044	2.82822	0.18026	1.97785	4.04420
2002	0.23735	257	3.14099	1.31209	0.22150	0.84697	2.03263
2003	0.16364	275	1.89129	0.79005	0.25597	0.47735	1.30758
2004	0.27511	229	1.79693	0.75063	0.21182	0.49369	1.14130
2005	0.27843	255	2.45666	1.02622	0.20513	0.68376	1.54021
2006	0.21076	223	2.23927	0.93541	0.24437	0.57785	1.51422
2007	0.23043	230	2.35459	0.98358	0.23508	0.61854	1.56406
2008	0.37057	367	1.71363	0.71584	0.19332	0.48801	1.05001
2009	0.14607	445	0.41563	0.17362	0.25527	0.10504	0.28697
2010	0.16190	315	0.60368	0.25218	0.28378	0.14453	0.43998
2011	0.22273	220	0.74443	0.31097	0.27853	0.18001	0.53721
2012	0.32663	199	2.02047	0.84401	0.24804	0.51774	1.37589
2013	0.14737	190	0.50024	0.20897	0.33624	0.10859	0.40211

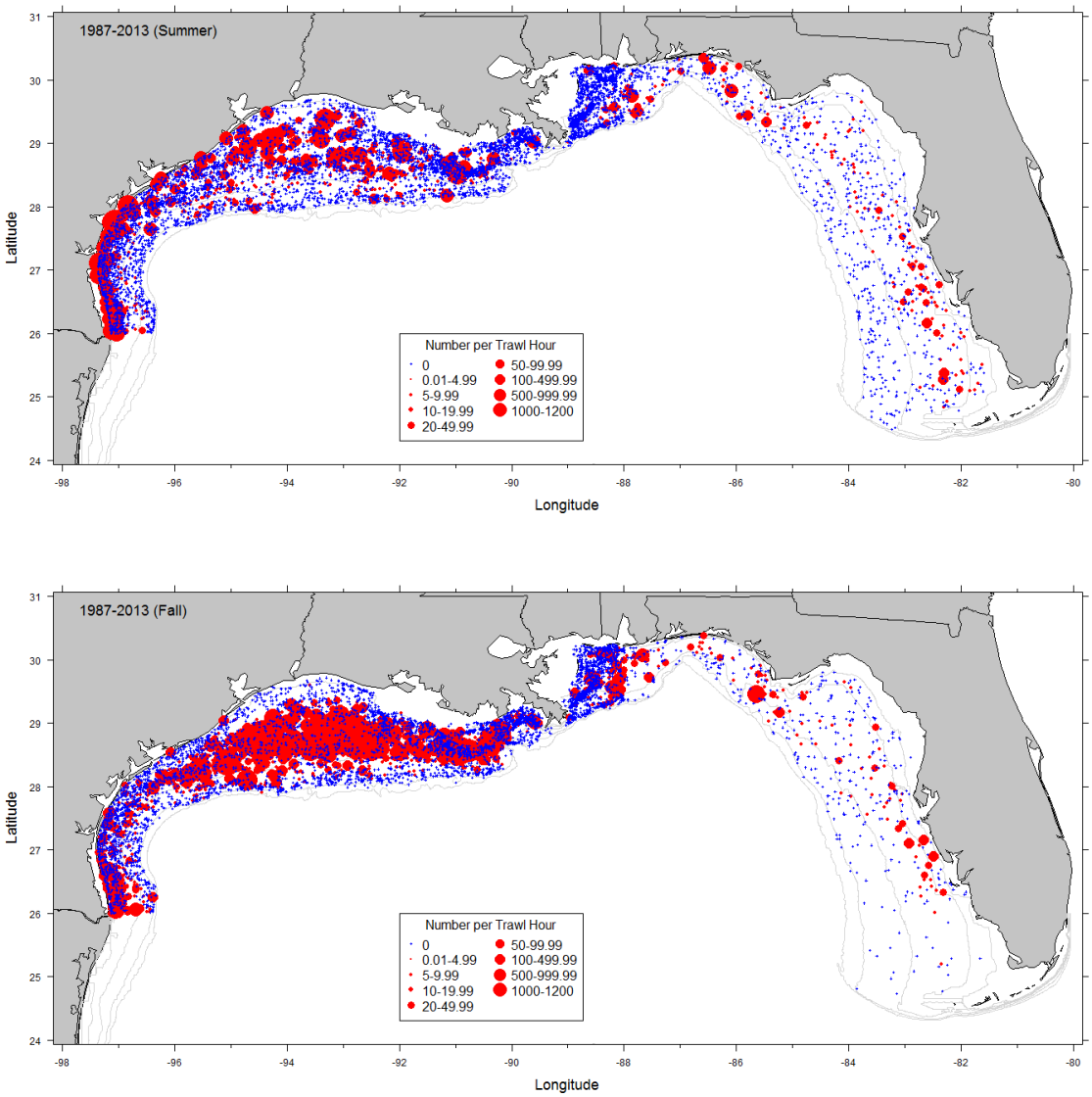


Figure 1. Stations sampled from 1987 to 2013 during the Summer (top) and Fall (bottom) SEAMAP Groundfish Survey with the CPUE for gray triggerfish.

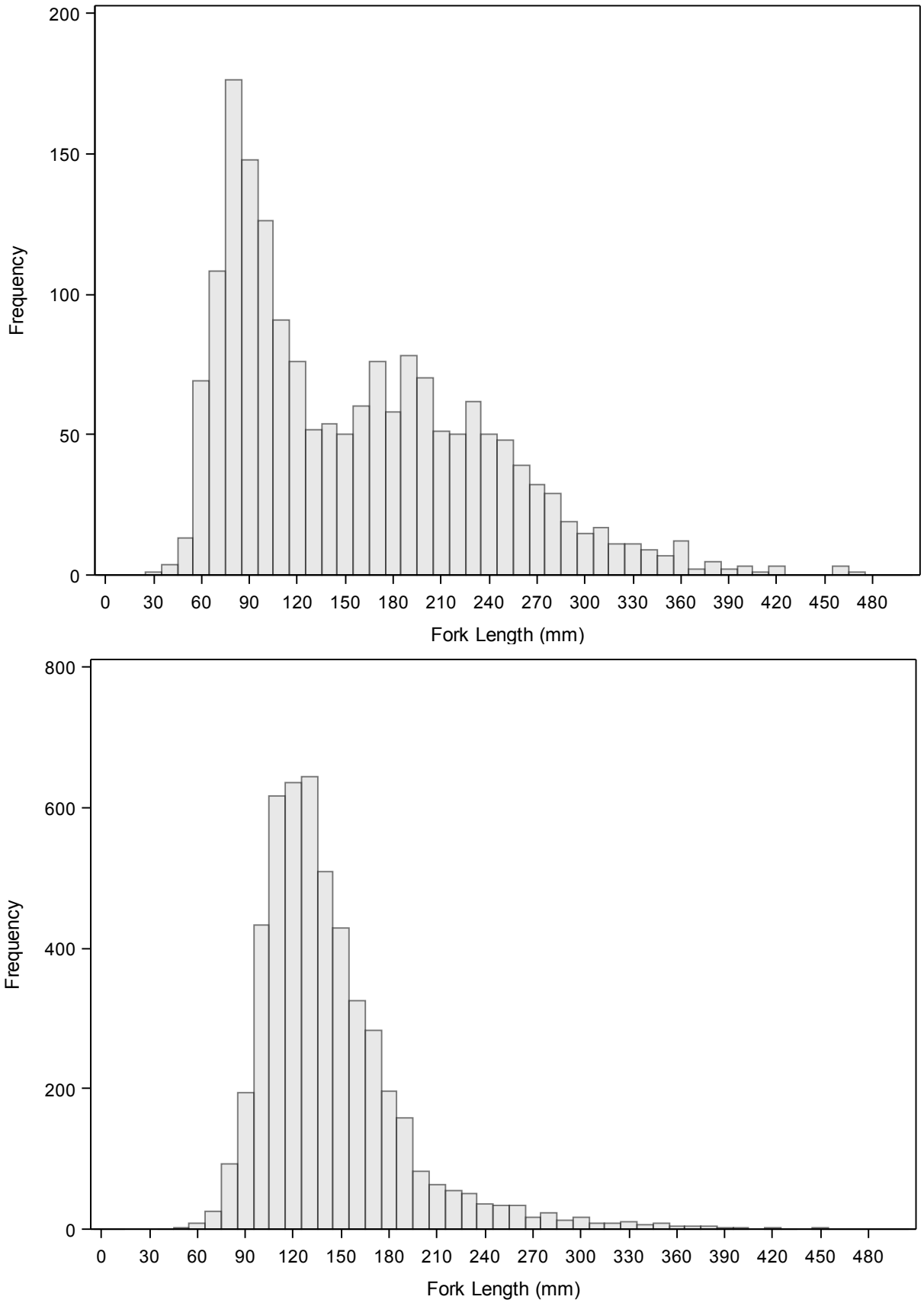


Figure 2. Length frequency histograms for gray triggerfish captured during Summer (top) and Fall (bottom) SEAMAP Groundfish surveys from 1987 - 2013.

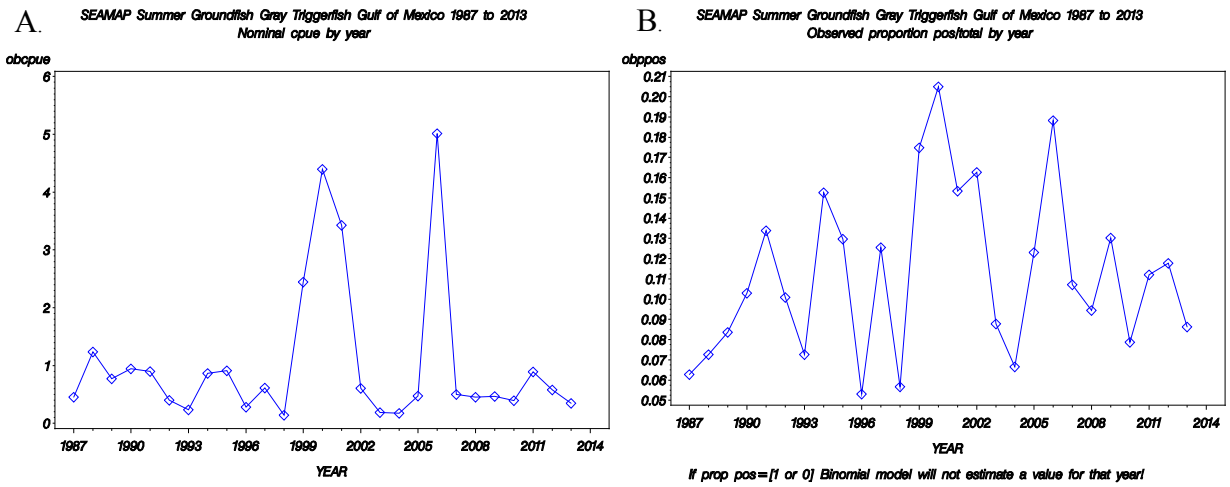


Figure 3. Annual trends for gray triggerfish captured during SEAMAP Summer Groundfish Surveys from 1987 to 2013 in **A.** nominal CPUE and **B.** proportion of positive stations.

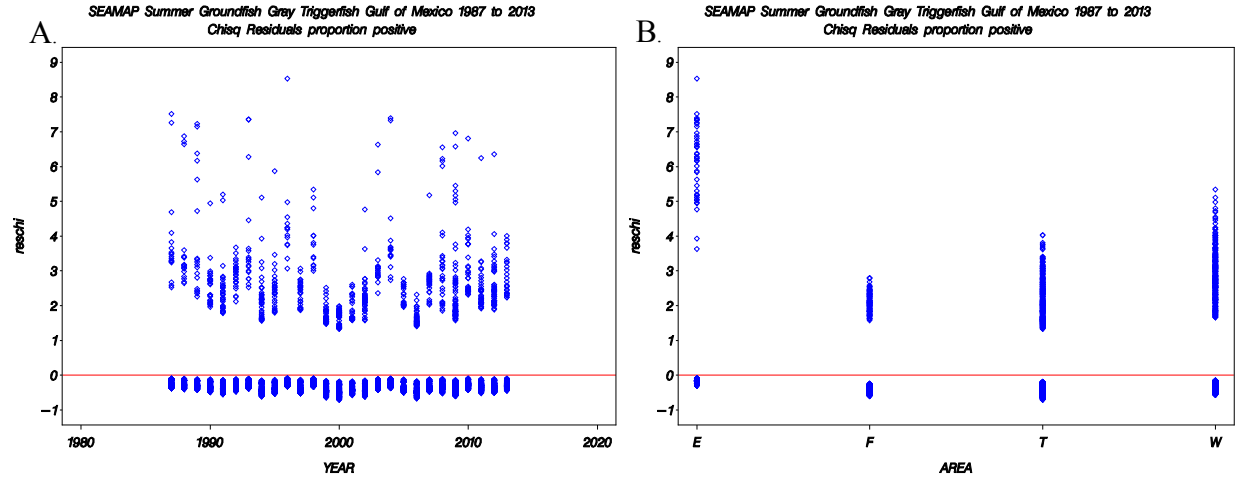


Figure 4. Diagnostic plots for binomial component of the gray triggerfish SEAMAP Summer Groundfish Survey model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

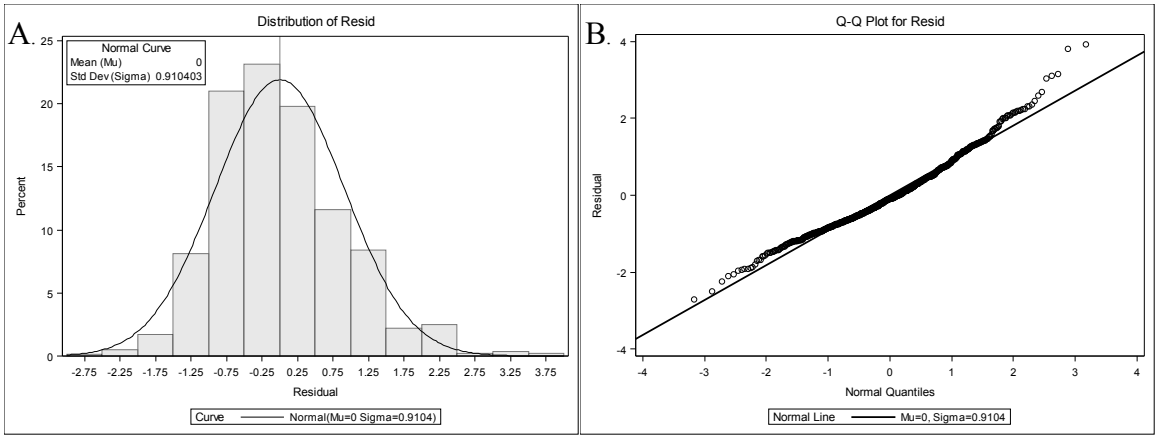


Figure 5. Diagnostic plots for lognormal component of the gray triggerfish SEAMAP Summer Groundfish Survey model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

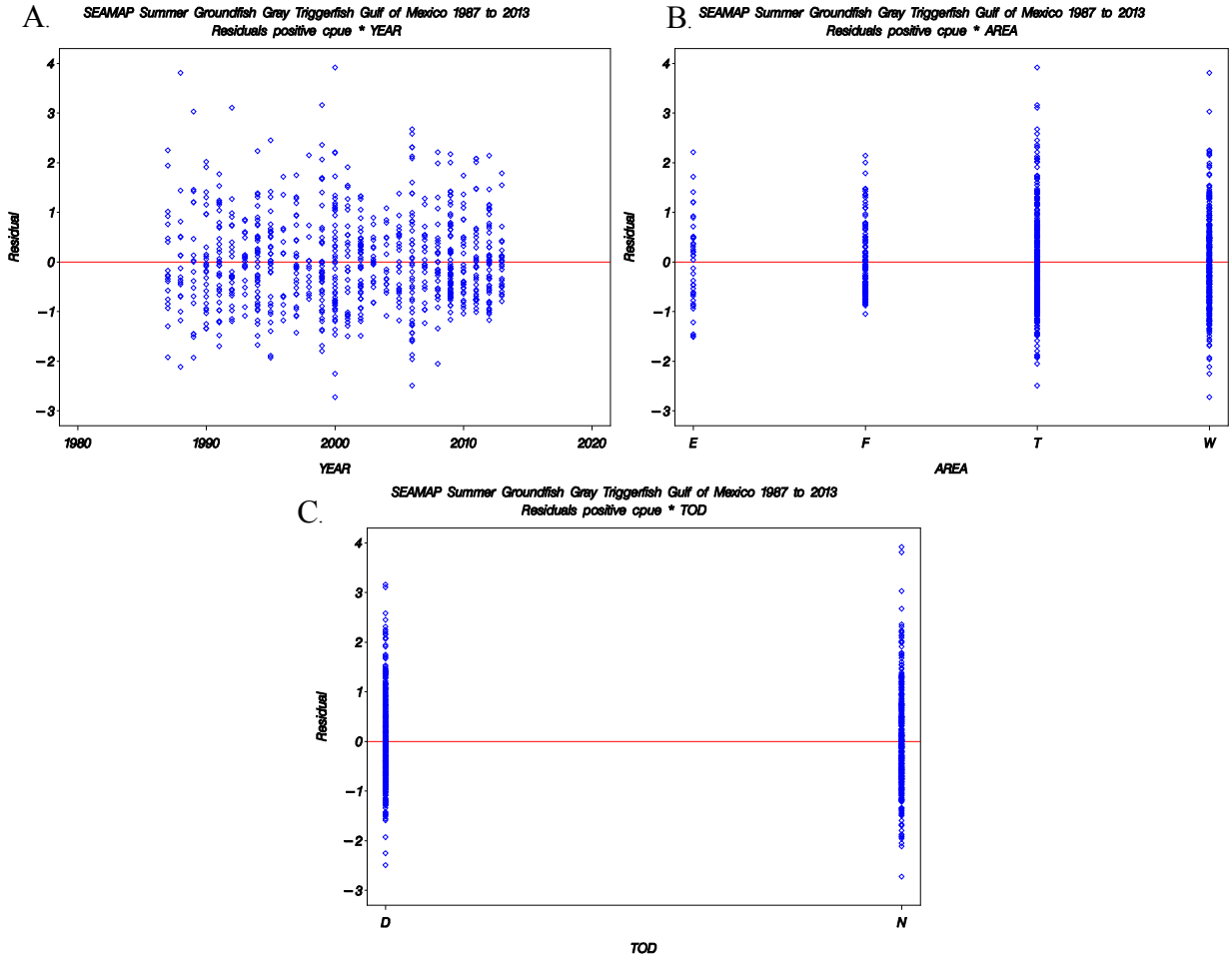


Figure 6. Diagnostic plots for lognormal component of the gray triggerfish SEAMAP Summer Groundfish Survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area and **C.** the Chi-Square residuals by time of day.

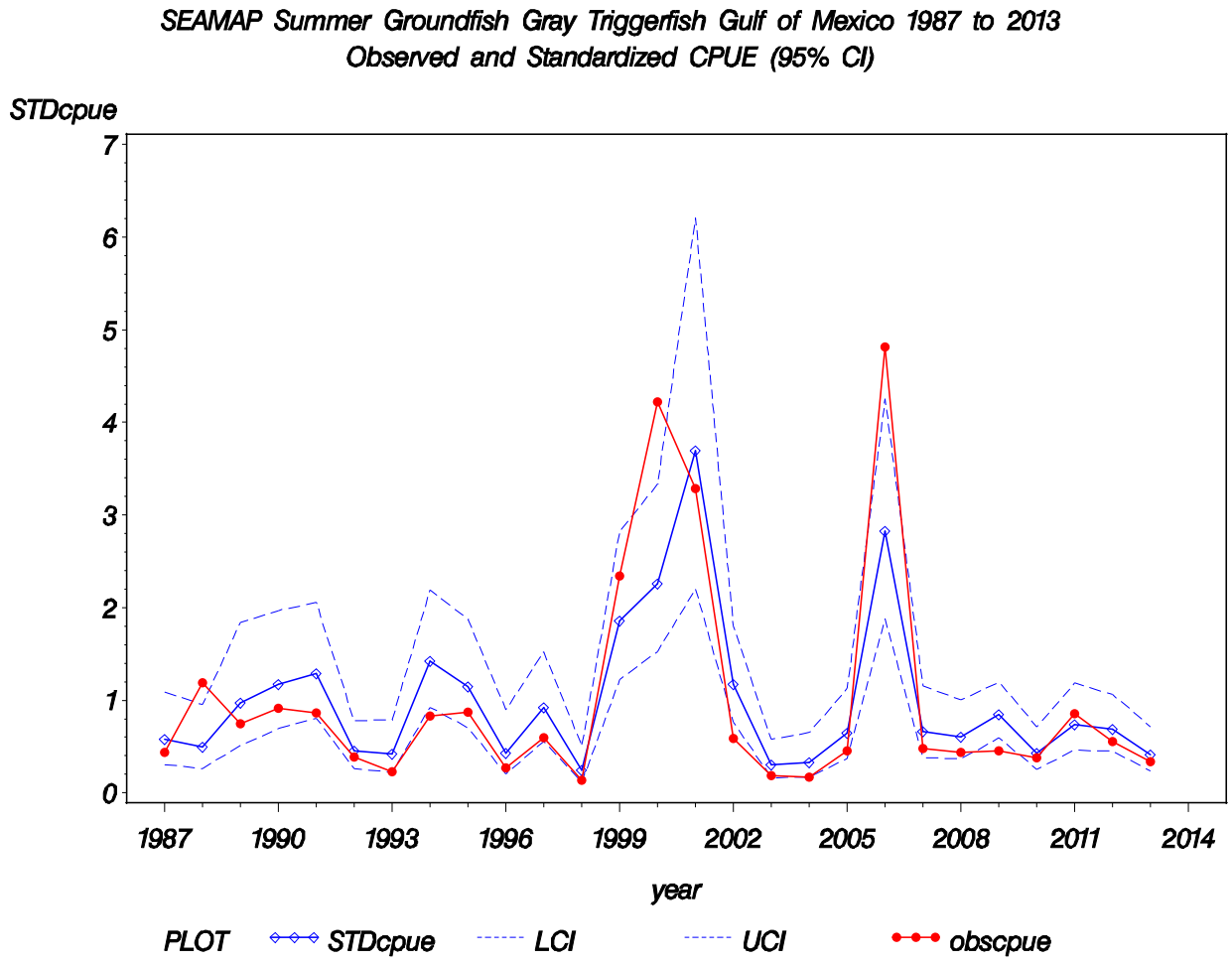


Figure 7. Annual index of abundance for gray triggerfish from the SEAMAP Summer Groundfish Survey from 1987 – 2013.

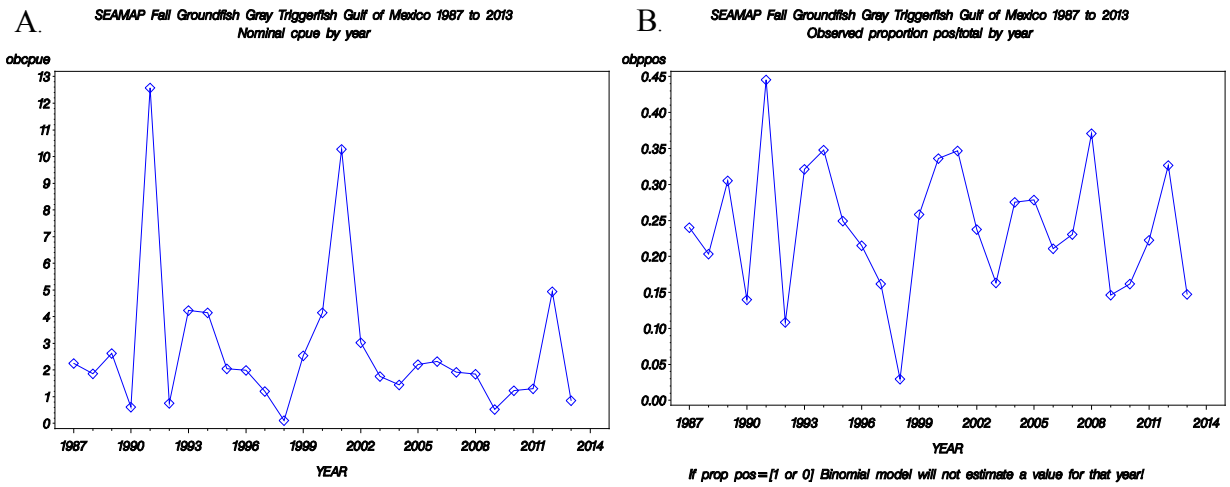


Figure 8. Annual trends for gray triggerfish captured during SEAMAP Fall Groundfish Surveys from 1987 to 2013 in **A.** nominal CPUE and **B.** proportion of positive stations.

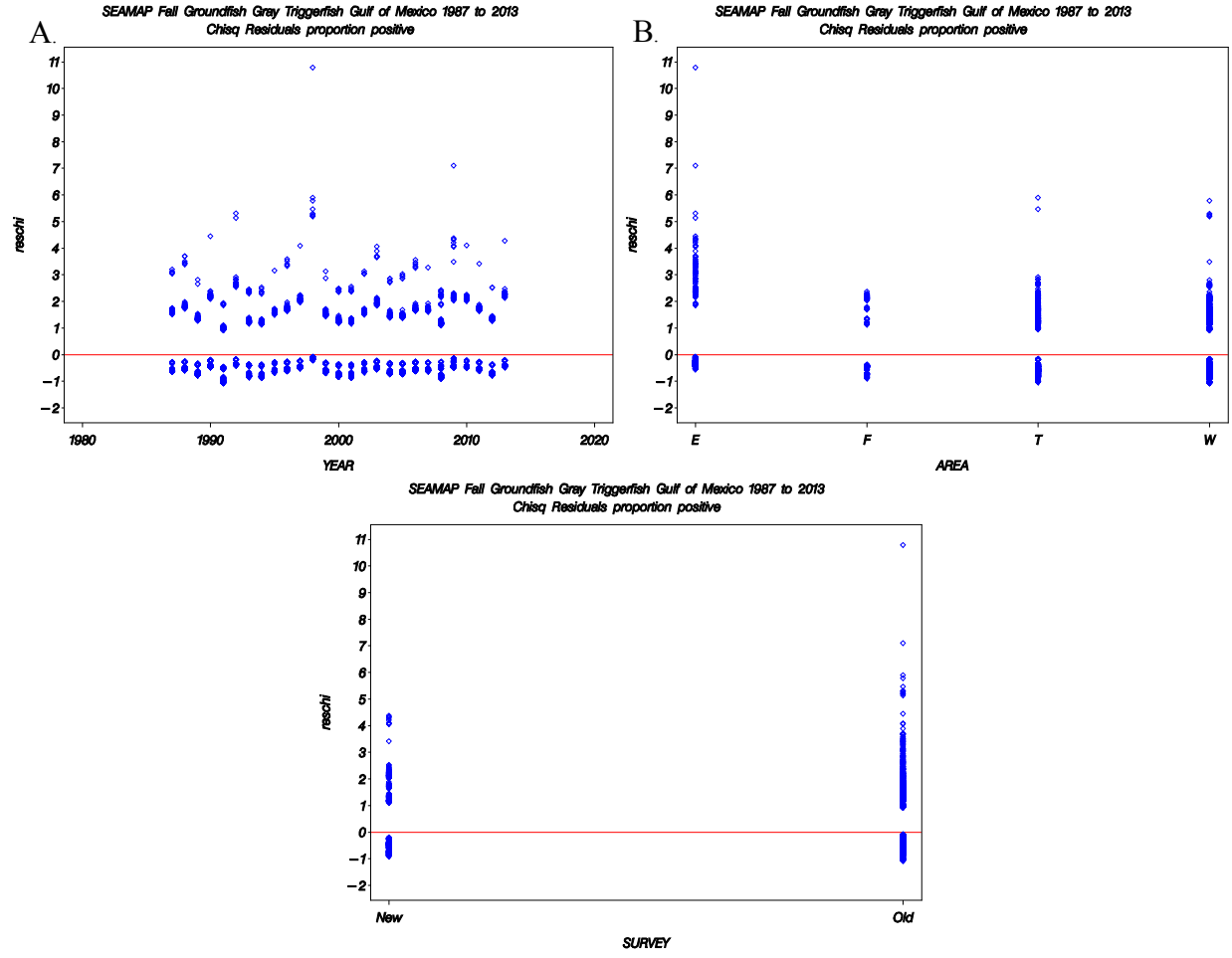


Figure 9. Diagnostic plots for binomial component of the gray triggerfish SEAMAP Fall Groundfish Survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area and **C.** the Chi-Square residuals by survey.

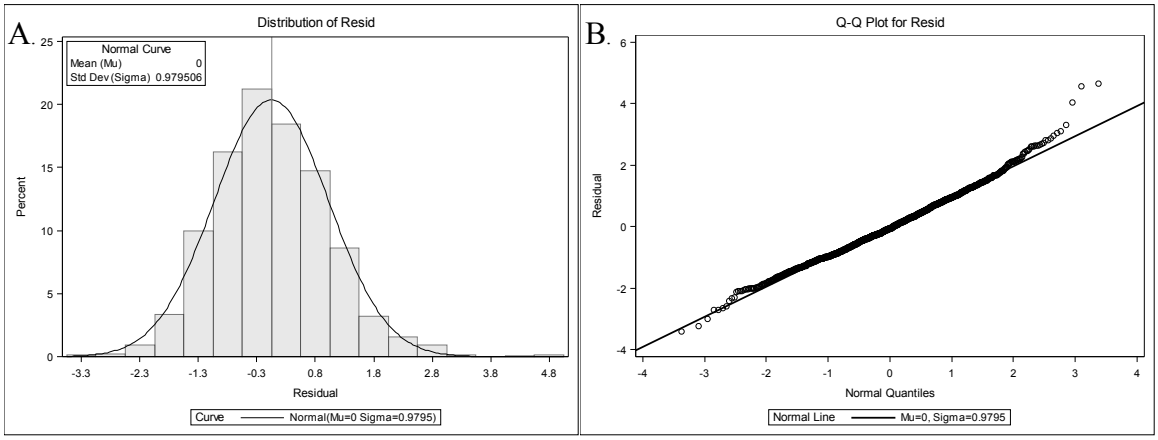


Figure 10. Diagnostic plots for lognormal component of the gray triggerfish SEAMAP Fall Groundfish Survey model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

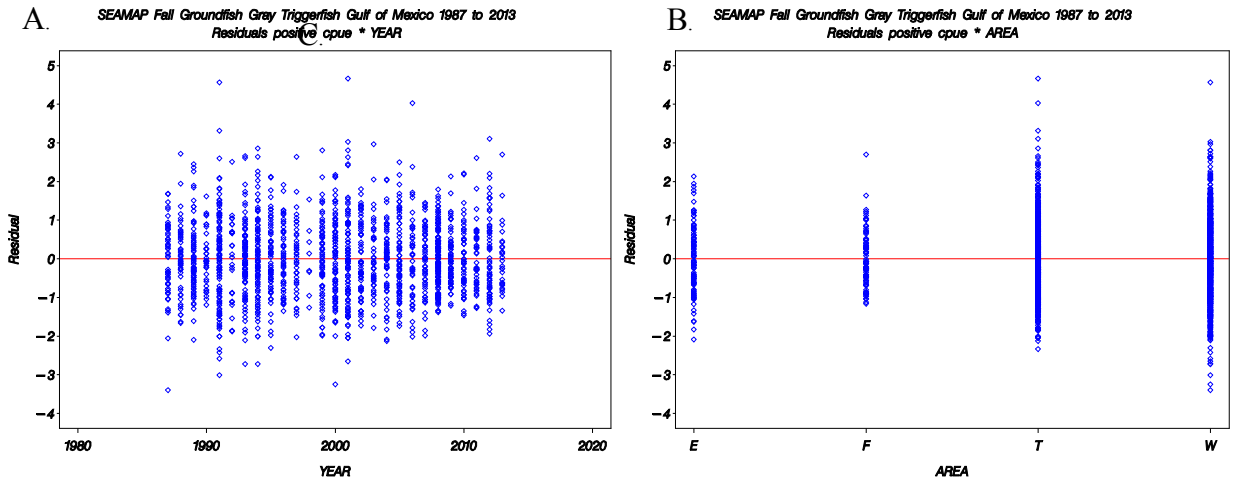


Figure 11. Diagnostic plots for lognormal component of the gray triggerfish SEAMAP Fall Groundfish Survey model: **A.** the Chi-Square residuals by year and **B.** the Chi-Square residuals by area.

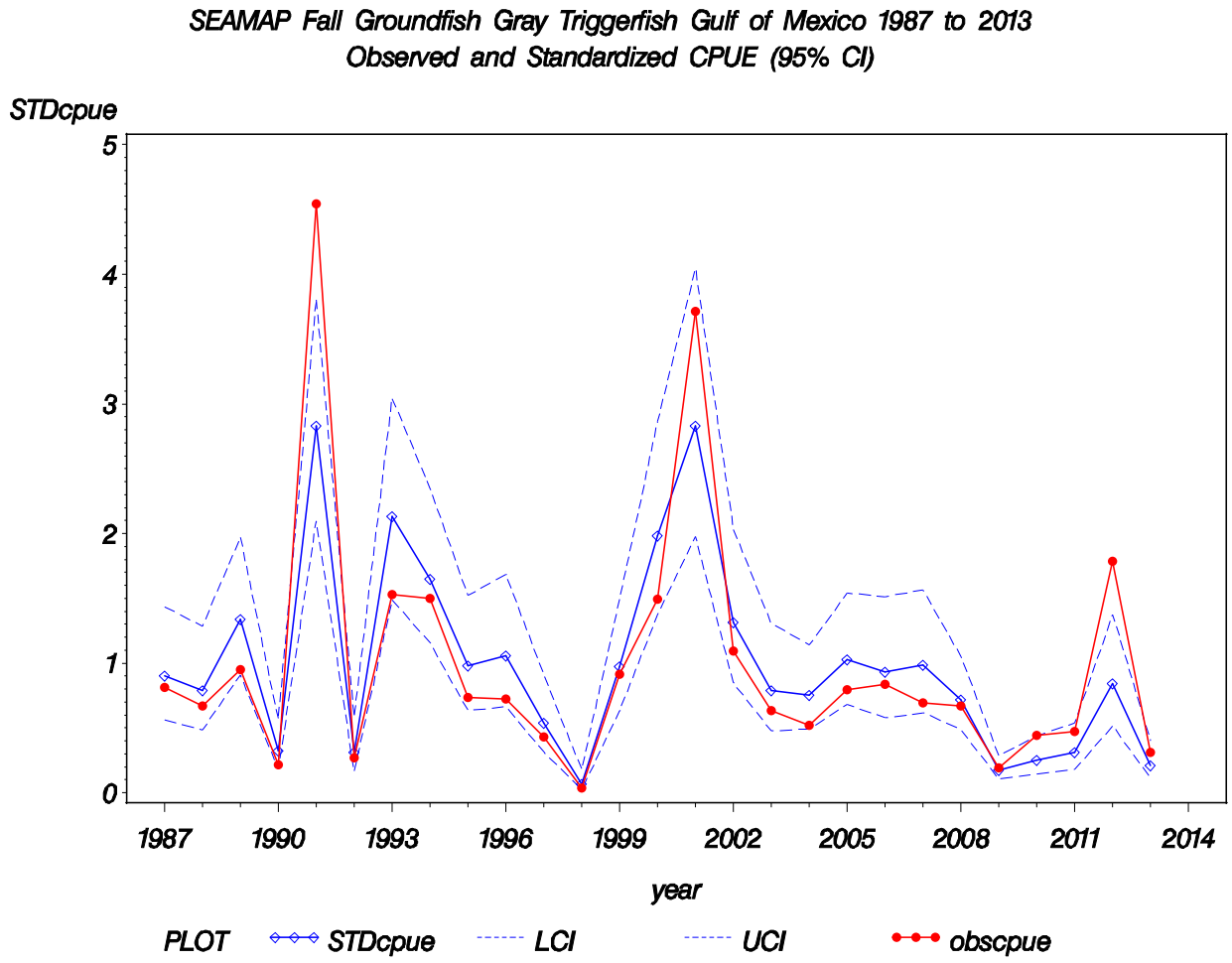


Figure 12. Annual index of abundance for gray triggerfish from the SEAMAP Fall Groundfish Survey from 1987 – 2013.

Appendix

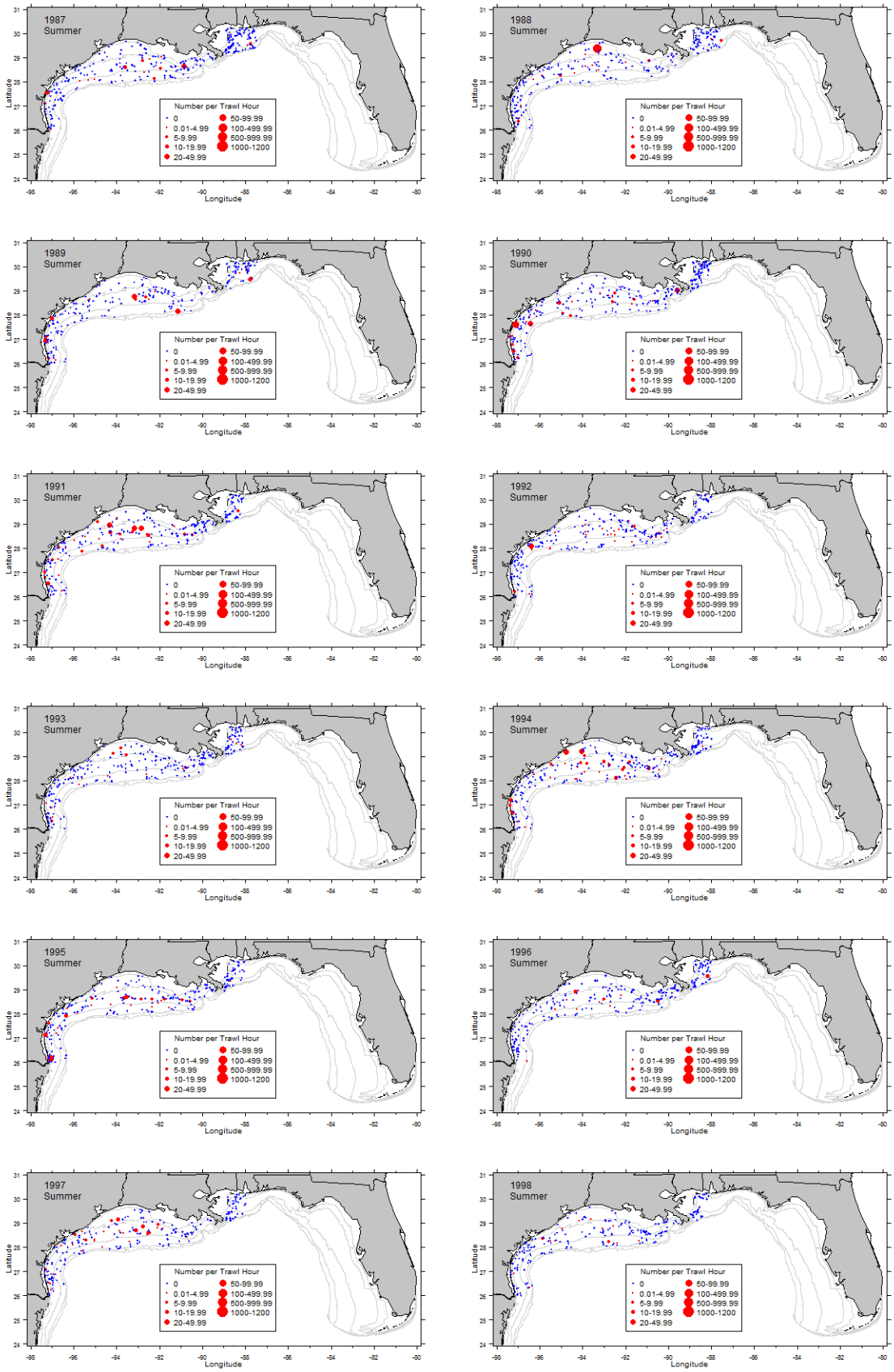
Appendix Table 1. Summary of the factors used in constructing the gray triggerfish abundance index from the SEAMAP Summer Groundfish Survey data.

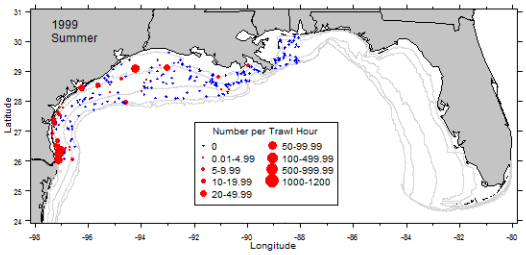
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
AREA	Mississippi/Alabama	1278	41	0.03208	0.15262
AREA	Florida	790	120	0.15190	0.57561
AREA	Texas	2397	356	0.14852	1.81048
AREA	Louisiana	2760	292	0.10580	0.71838
SURVEY	New	1945	217	0.11157	0.55262
SURVEY	Old	5280	592	0.11212	1.11693
TOD	Day	3803	413	0.10860	0.67193
TOD	Night	3422	396	0.11572	1.29074
YEAR	1987	287	18	0.06272	0.45749
YEAR	1988	234	17	0.07265	1.23627
YEAR	1989	215	18	0.08372	0.77572
YEAR	1990	262	27	0.10305	0.94725
YEAR	1991	254	34	0.13386	0.90187
YEAR	1992	248	25	0.10081	0.39993
YEAR	1993	248	18	0.07258	0.23348
YEAR	1994	262	40	0.15267	0.86469
YEAR	1995	239	31	0.12971	0.91138
YEAR	1996	245	13	0.05306	0.28206
YEAR	1997	231	29	0.12554	0.61715
YEAR	1998	229	13	0.05677	0.13935
YEAR	1999	246	43	0.17480	2.44363
YEAR	2000	239	49	0.20502	4.39395
YEAR	2001	176	27	0.15341	3.42727
YEAR	2002	252	41	0.16270	0.60961
YEAR	2003	205	18	0.08780	0.19229
YEAR	2004	240	16	0.06667	0.17554
YEAR	2005	195	24	0.12308	0.47437
YEAR	2006	239	45	0.18828	5.01445
YEAR	2007	224	24	0.10714	0.49866
YEAR	2008	307	29	0.09446	0.45195
YEAR	2009	537	70	0.13035	0.46888
YEAR	2010	381	30	0.07874	0.39157
YEAR	2011	330	37	0.11212	0.89284
YEAR	2012	399	47	0.11779	0.57765
YEAR	2013	301	26	0.08638	0.35028

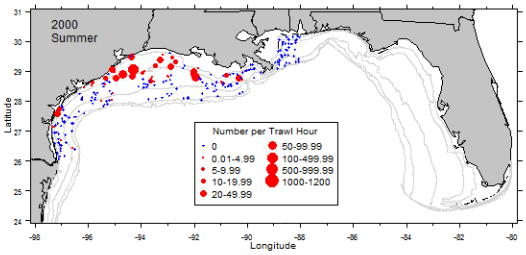
Appendix Table 2. Summary of the factors used in constructing the gray triggerfish abundance index from the SEAMAP Fall Groundfish Survey data.

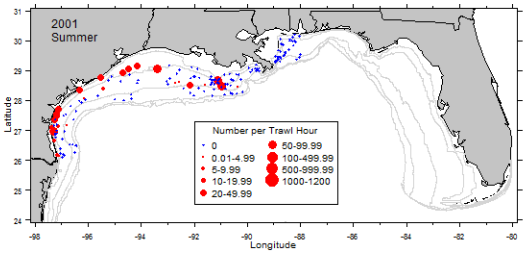
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
AREA	Mississippi/Alabama	1160	110	0.09483	0.4748
AREA	Florida	411	89	0.21655	0.9569
AREA	Texas	2359	624	0.26452	2.5653
AREA	Louisiana	2978	826	0.27737	3.8944
SURVEY	New	1657	387	0.23355	1.6187
SURVEY	Old	5251	1262	0.24034	3.0301
TOD	Day	3427	842	0.24570	2.8469
TOD	Night	3481	807	0.23183	2.5386
YEAR	1987	208	50	0.24038	2.2450
YEAR	1988	236	48	0.20339	1.8574
YEAR	1989	249	76	0.30522	2.6272
YEAR	1990	250	35	0.14000	0.6073
YEAR	1991	247	110	0.44534	12.5764
YEAR	1992	231	25	0.10823	0.7533
YEAR	1993	274	88	0.32117	4.2413
YEAR	1994	253	88	0.34783	4.1495
YEAR	1995	241	60	0.24896	2.0432
YEAR	1996	251	54	0.21514	1.9960
YEAR	1997	247	40	0.16194	1.1997
YEAR	1998	273	8	0.02930	0.1093
YEAR	1999	248	64	0.25806	2.5393
YEAR	2000	244	82	0.33607	4.1427
YEAR	2001	251	87	0.34661	10.2739
YEAR	2002	257	61	0.23735	3.0233
YEAR	2003	275	45	0.16364	1.7626
YEAR	2004	229	63	0.27511	1.4499
YEAR	2005	255	71	0.27843	2.2045
YEAR	2006	223	47	0.21076	2.3245
YEAR	2007	230	53	0.23043	1.9147
YEAR	2008	367	136	0.37057	1.8509
YEAR	2009	445	65	0.14607	0.5269
YEAR	2010	315	51	0.16190	1.2330
YEAR	2011	220	49	0.22273	1.3019
YEAR	2012	199	65	0.32663	4.9439
YEAR	2013	190	28	0.14737	0.8607

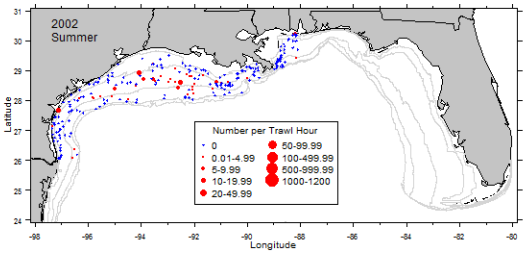
Appendix Figure 1. Annual survey effort and catch of gray triggerfish from the SEAMAP Summer Groundfish Survey.

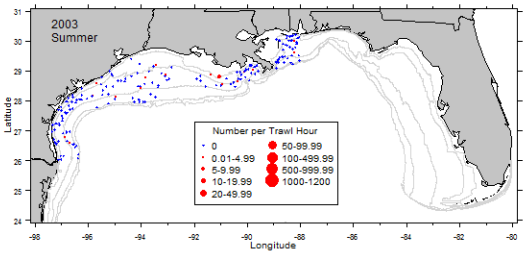


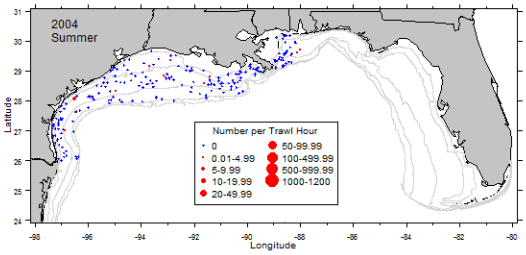

1999
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

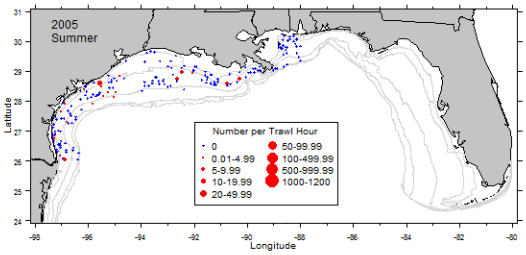

2000
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

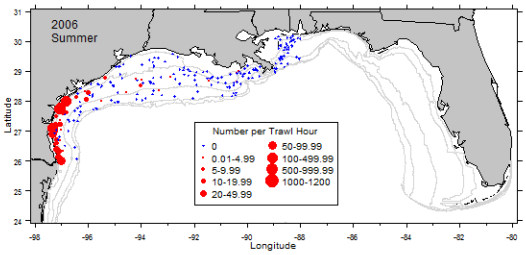

2001
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

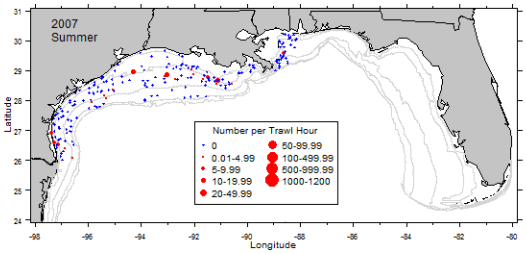

2002
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

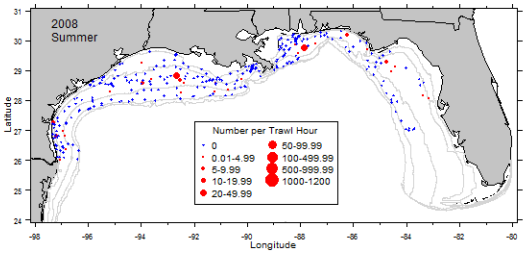

2003
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

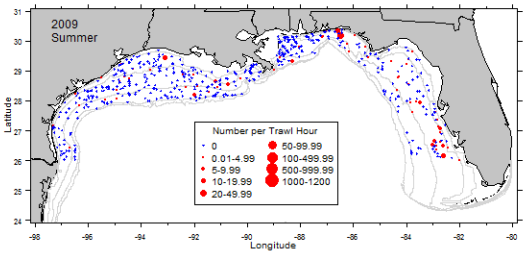

2004
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

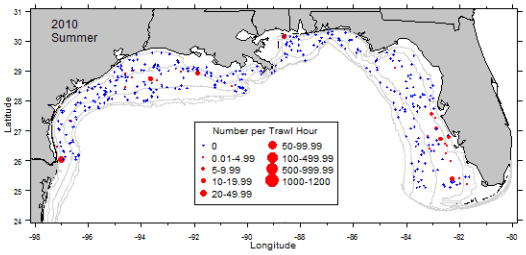

2005
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

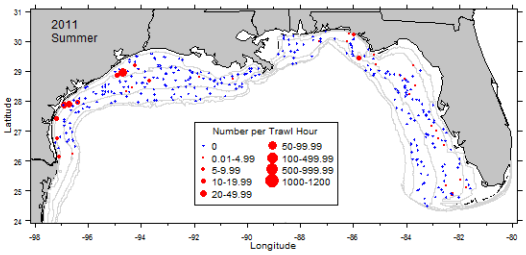

2006
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

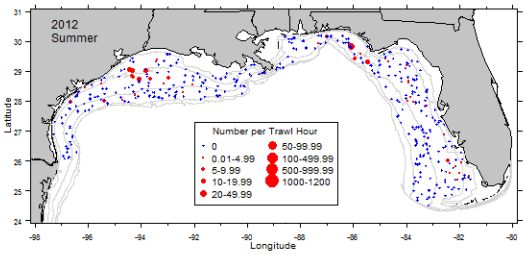

2007
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

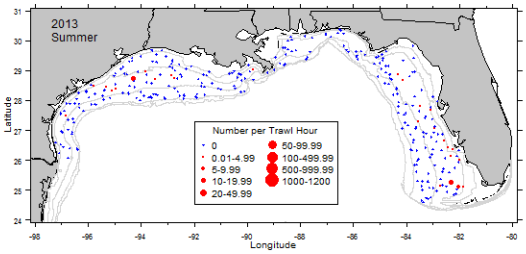

2008
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude


2009
Summer
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
1000-1200
Latitude
Longitude

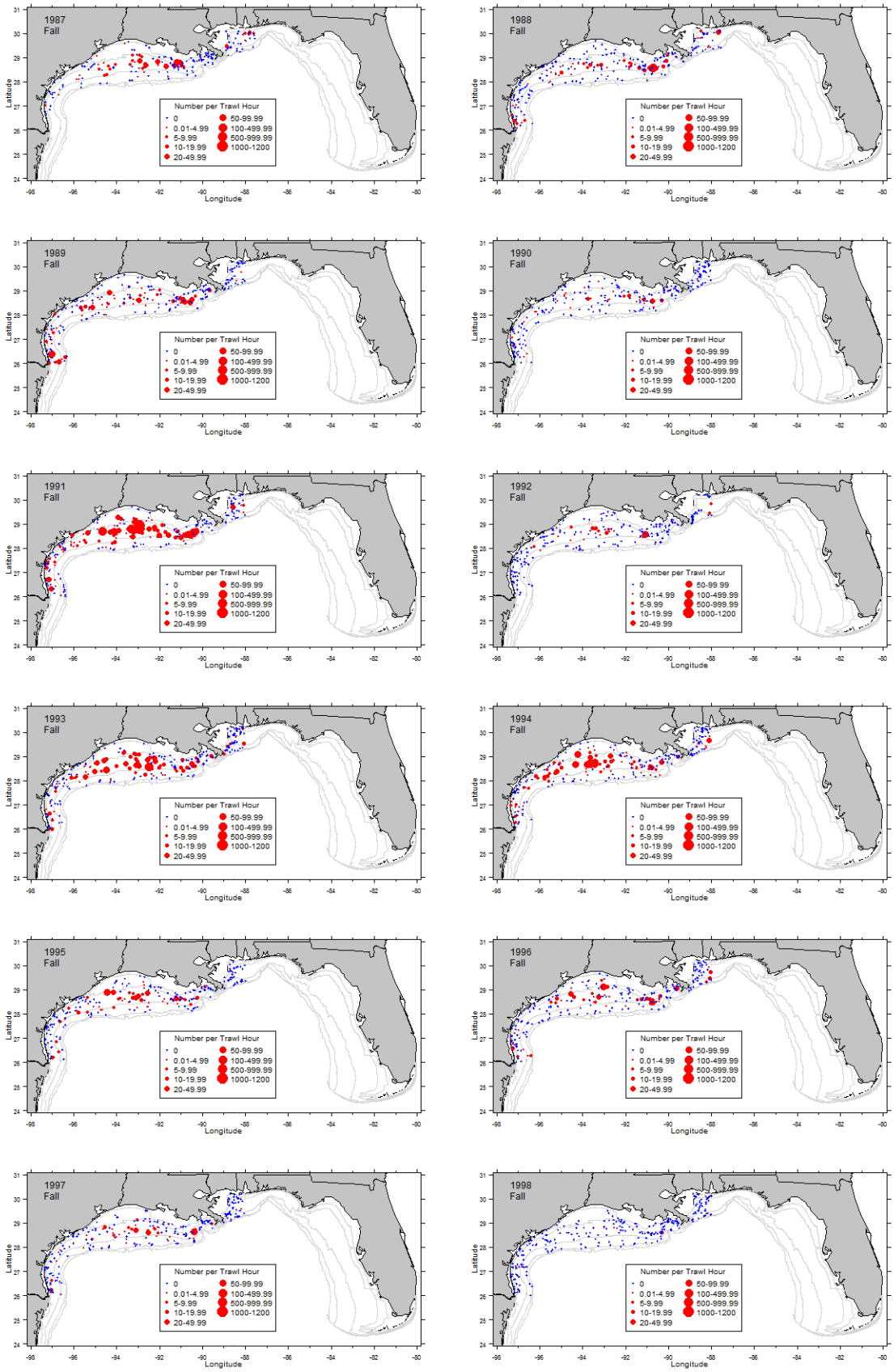

2010
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

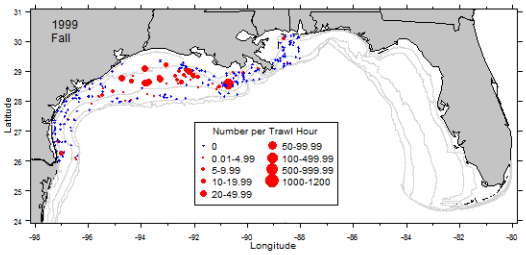

2011
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

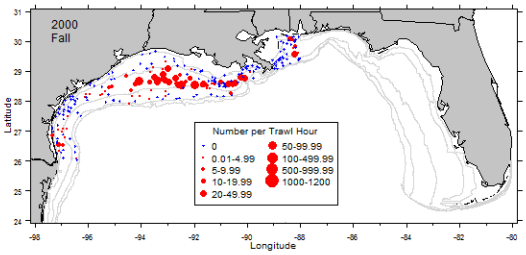

2012
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

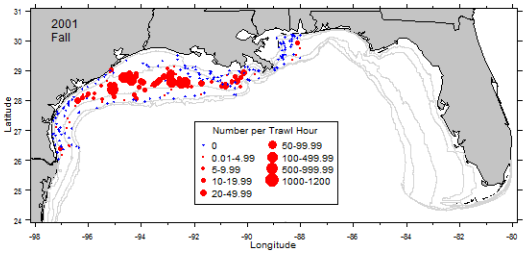

2013
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

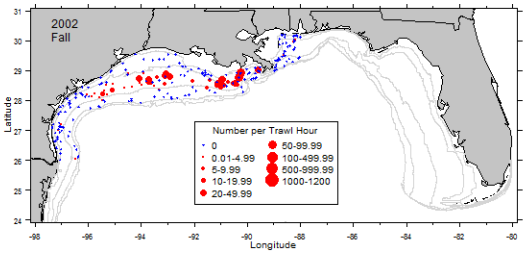
Appendix Figure 2. Annual survey effort and catch of gray triggerfish from the SEAMAP Fall Groundfish Survey.

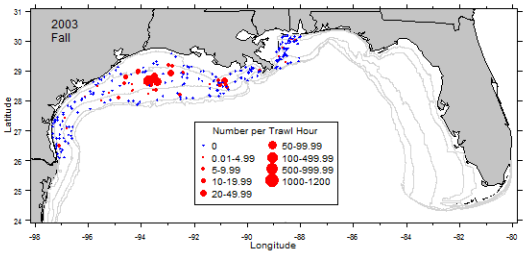


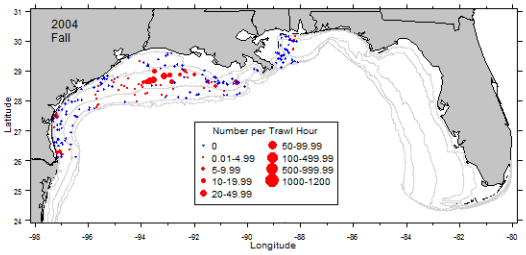

1999
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

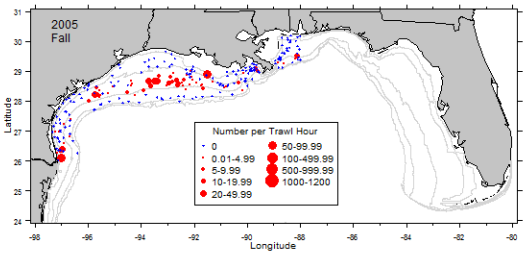

2000
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

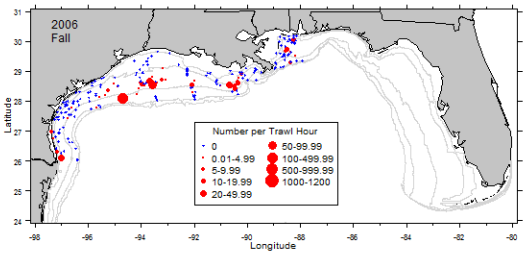

2001
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

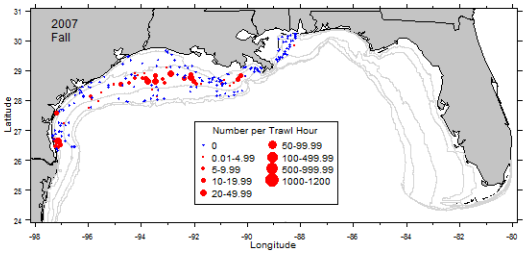

2002
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

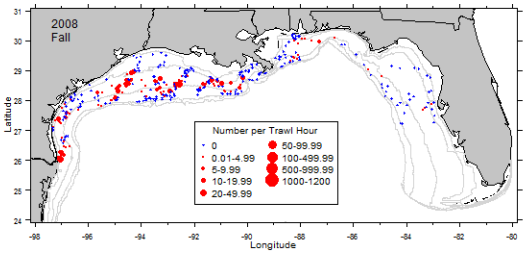

2003
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

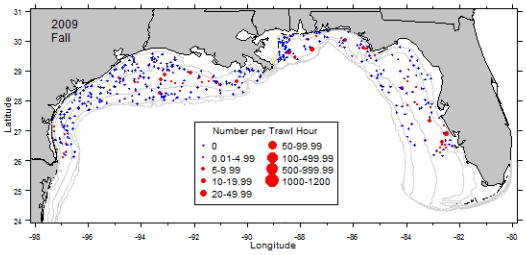

2004
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

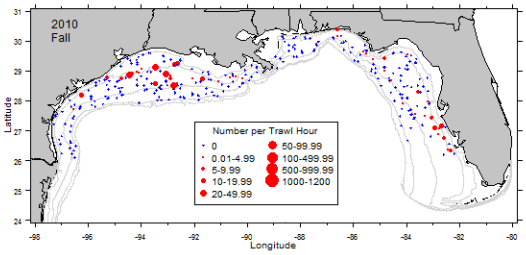

2005
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

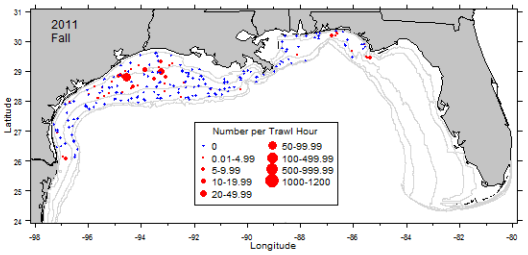

2006
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

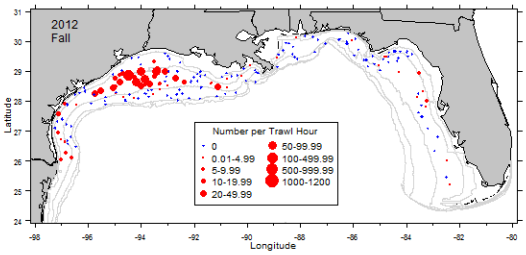

2007
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude

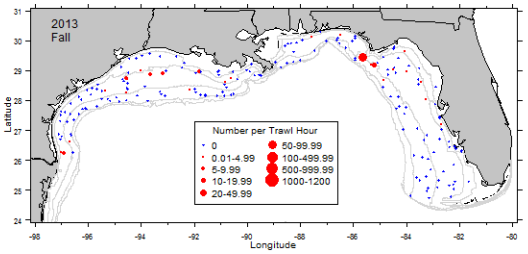

2008
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000-1200
Latitude
Longitude


2009
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
1000-1200
Latitude
Longitude


2010
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
1000-1200
Latitude
Longitude


2011
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
1000-1200
Latitude
Longitude


2012
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
1000-1200
Latitude
Longitude


2013
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
1000-1200
Latitude
Longitude