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Trawl and Plankton Branch
Population and Ecosystem Monitoring Division
NOAA Fisheries - Southeast Fisheries Science Center

Abstract

The NOAA Fisheries Southeast Fisheries Science Center (SEFSC), Population and Ecosystem Monitoring Division, Trawl and Plankton Branch and state partners have conducted groundfish surveys since 1972 in the northern Gulf of Mexico (GOM) 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 snapper (Lutjanus griseus). Following the recommendation from SEDAR 51, one abundance index was produced for gray snapper from the SEAMAP Summer Groundfish Survey from 2010 – 2019 using data collected in the eastern GOM.

Introduction

The NOAA Fisheries Southeast Fisheries Science Center (SEFSC), Population and Ecosystem Monitoring Division, Trawl and Plankton Branch 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 independently 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.

Following the recommendation of the SEDAR 51 Indices Workgroup, a single abundance index was produced for gray snapper (*Lutjanus griseus*) (Pollack et al. 2017). The index utilized data solely from summer surveys in the eastern GOM due to the scarcity of gray snapper in the western GOM (Figure 1) and the gaps in spatial coverage during the fall surveys (Pollack et al. 2017). The purpose of this document is to provide an updated abundance index for gray snapper from the SEAMAP Summer Groundfish Survey in the eastern GOM.

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 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 9,193 stations were sampled from 1987- 2019 during the SEAMAP Summer Groundfish Survey (Table 1). Trawl data were obtained from the MSLABS database 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 were limited by several factors:

(1) No problems with tow (i.e. net torn, doors crossed, etc.)
(2) Depths between 9 and 110 m
(3) Within SSZ 2 – 8
(4) Sampled with a 40 ft. shrimp trawl (Texas uses a 20 ft. shrimp trawl and data are not used)
(5) Sampled between 2010 and 2019

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 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, stations from the early surveys 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. Therefore, in some cases multiple tows were needed to cover a depth stratum. For purposes of this analysis, these multiple tows were collapsed into a single station. 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 snapper (Bradu and Mundlak 1970, Pennington 1983). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model, which describes proportion of positive abundance values (i.e. presence/absence), and a lognormal model, which describes variability in only the nonzero abundance data (*cf.* Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) was estimated as:

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

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

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

and

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

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

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

A covariance term is not included in the variance estimator since there is no correlation between the estimator of the proportion positive and the mean CPUE given presence. The two estimators are derived independently and have been shown not to 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 – Summer Survey (2010 – 2019)

Year: 2010 – 2019
Depth: 9 – 110 m (continuous)
Area: 1 (SSZ 2, 3), 2 (SSZ 4, 5), 3 (SSZ 6, 7)
Time of Day: Day, Night

Results and Discussion

Distribution, Size and Age

The distribution and abundance of gray snapper from the SEAMAP Summer Groundfish Survey is presented in Figure 1, with seasonal/annual abundance and distribution presented in the Appendix Figure 1. The annual number of gray snapper captured ranged from 66 to 210 in the summer (Table 2). Of the 1,316 gray snapper captured during the summer survey, 1,233 were measured with an average fork length of 265 mm. The length frequency distribution of gray snapper captured is shown in Figure 2.

Index of Abundance

For the SEAMAP Summer Groundfish Survey (2010-2019) abundance index of gray snapper in the eastern GOM, year, depth, time of day and area were retained in 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 1. Table 3 summarizes the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6,105.8 and 812.0, respectively. The diagnostic plots for the lognormal submodel are shown in Figure 3, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 4 and Figure 4.

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Table 1. Number of stations sampled by shrimp statistical zone during the SEAMAP Summer Groundfish Survey from 1987-2019.

	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										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	26	23	21	16	24	21	28	303
2009				36	23	29	16	17	18	25	67	25	20	36	39	46	50	33	29	23	532
2010			31	26	21	26	10	12	14	15	21	5	19	18	21	33	34	27	27	19	379
2011		11	24	22	20	29	2	15	11	8	16	7	14	17	23	29	29	18	21	13	329
2012		12	39	33	29	30	19	16	16	13	16	7	14	18	25	30	27	20	20	15	399
2013		9	27	28	23	19	9	11	9	7	14	5	13	14	22	22	22	16	17	12	299
2014		15	32	26	25	30	17	15	9	7	17	6	15	18	22	28	23	18	18	14	355
2015	1	9	32	29	23	27	24	18	10	8	16	7	15	18	21	29	27	19	20	13	366
2016		9	25	29	27	23	15	15	10	8	15	6	16	16	22	30	23	19	17	14	339
2017		10	28	19	28	14	15	14	6	10	17	7	14	13	23	26	24	19	21	14	322
2018		8	30	28	24	23	16	12	5	7	14	7	12	14	21	26	19	11	11	14	302
2019		11	31	24	21	15	5	15	8	9	14	3	12	13	20	27	22	16	20	12	298
Total	***1***	***94***	***299***	***301***	***272***	***276***	***154***	***171***	***124***	***198***	***1221***	***373***	***745***	***666***	***718***	***760***	***621***	***740***	***809***	***650***	***9193***

Table 2. Summary of the gray snapper length data collected during SEAMAP Summer Groundfish Survey conducted between 2010 and 2019 in the eastern Gulf of Mexico.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation (mm)
2010	114	114	113	162	424	261	50
2011	108	111	101	171	461	266	53
2012	162	163	155	166	566	266	75
2013	115	97	97	171	516	271	70
2014	145	210	195	174	446	260	43
2015	145	170	144	28	451	264	51
2016	128	105	105	210	481	298	57
2017	114	98	98	173	439	269	52
2018	129	66	66	168	571	262	61
2019	107	182	159	164	505	249	54
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
10	1267	1316	1233			265	

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for gray snapper SEAMAP Summer Groundfish Survey index of relative abundance from 2010 to 2019 in the eastern Gulf of Mexico.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6105.8)*						*Lognormal Submodel Type 3 Tests (AIC 814.6)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	1252	8.12	0.90	0.5223	0.5226	9	293	1.48	0.1557
Depth	1	1252	107.70	107.70	<.0001	<.0001	1	293	5.17	0.0237
Zone	2	1252	40.57	20.28	<.0001	<.0001	2	293	7.31	0.0008
Time of Day	1	1252	27.08	27.08	<.0001	<.0001	1	293	0.17	0.6822
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6105.8)*						*Lognormal Submodel Type 3 Tests (AIC 812.0)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	1252	8.12	0.90	0.5223	0.5226	9	294	1.47	0.1603
Depth	1	1252	107.70	107.70	<.0001	<.0001	1	294	5.16	0.0239
Zone	2	1252	40.57	20.28	<.0001	<.0001	2	294	7.49	0.0007
Time of Day	1	1252	27.08	27.08	<.0001	<.0001	Dropped			

Table 4. Indices of gray snapper abundance developed using the delta-lognormal (DL) model for SEAMAP Summer Groundfish Survey from 2010-2019 in the eastern Gulf of Mexico. 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
2010	0.28947	114	1.74462	1.10065	0.22976	0.69926	1.73244
2011	0.23148	108	1.29604	0.81765	0.27042	0.48064	1.39096
2012	0.22222	162	1.30354	0.82238	0.23123	0.52100	1.29810
2013	0.21739	115	1.30796	0.82517	0.26715	0.48807	1.39508
2014	0.27586	145	1.83882	1.16008	0.21239	0.76215	1.76577
2015	0.19444	144	1.51358	0.95489	0.25317	0.58005	1.57198
2016	0.27344	128	1.74145	1.09865	0.22068	0.71032	1.69927
2017	0.22807	114	1.50602	0.95012	0.25865	0.57114	1.58057
2018	0.23256	129	1.03749	0.65453	0.24104	0.40693	1.05280
2019	0.27103	107	2.56133	1.61589	0.24720	0.99283	2.62995

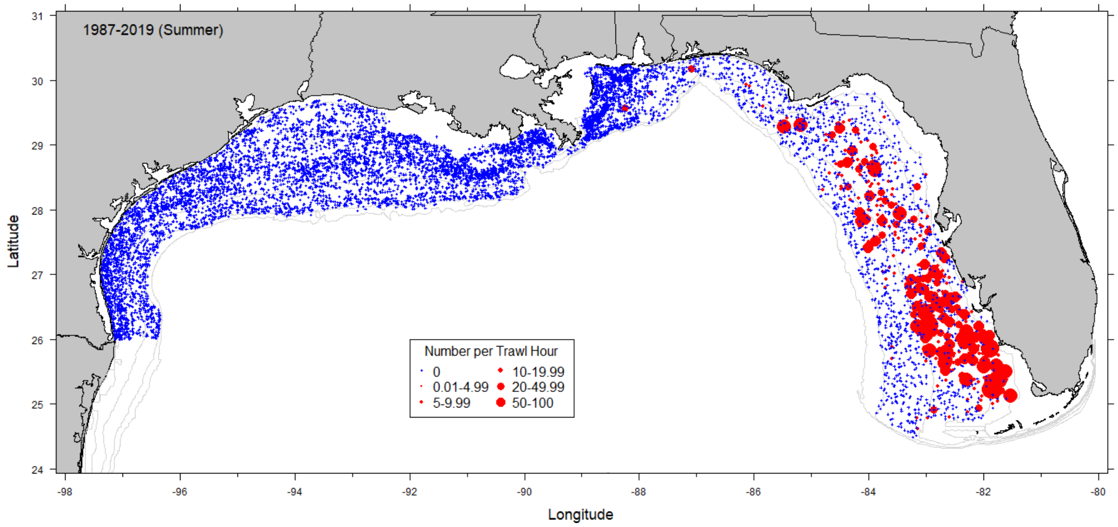


Figure 1. Stations sampled during the Summer SEAMAP Groundfish Survey with the CPUE for gray snapper from 1987-2019.

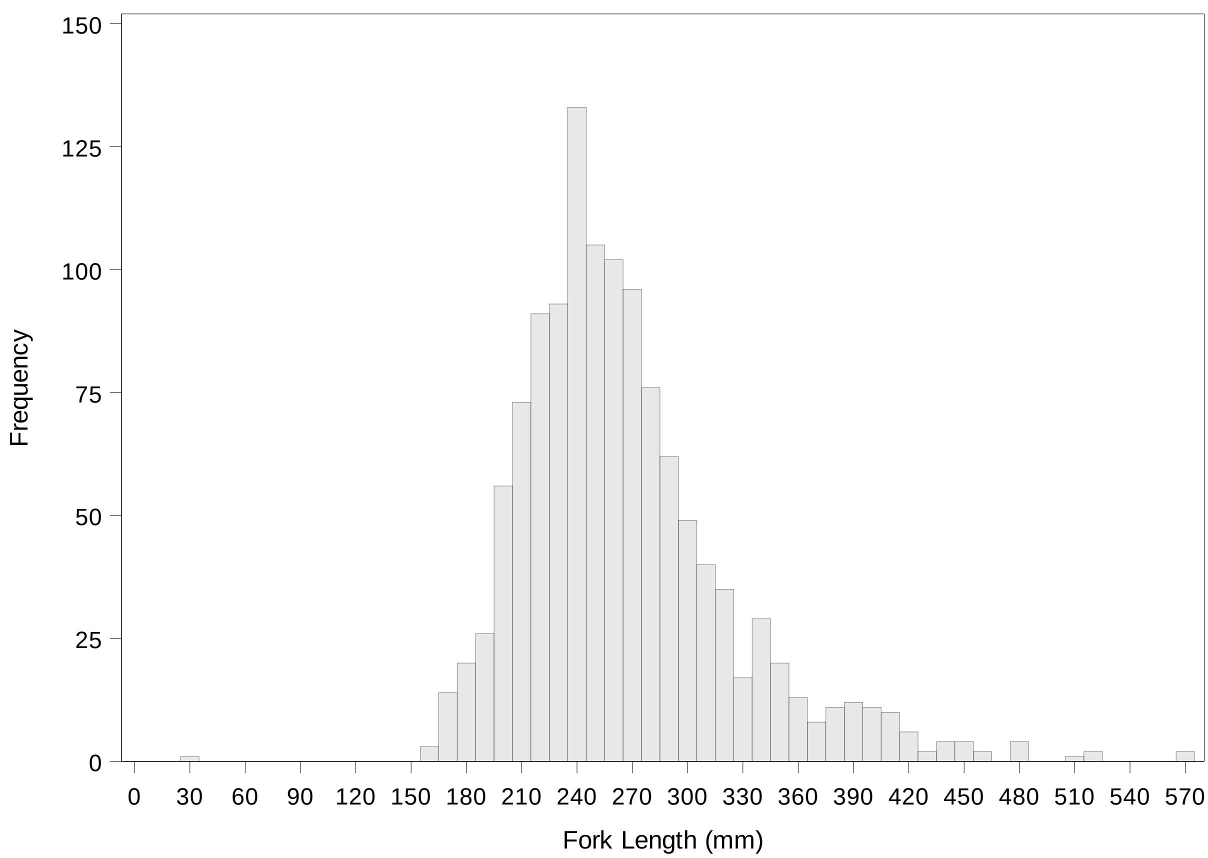


Figure 2. Length frequency histogram for gray snapper captured during SEAMAP Summer Groundfish Survey (2010-2019).

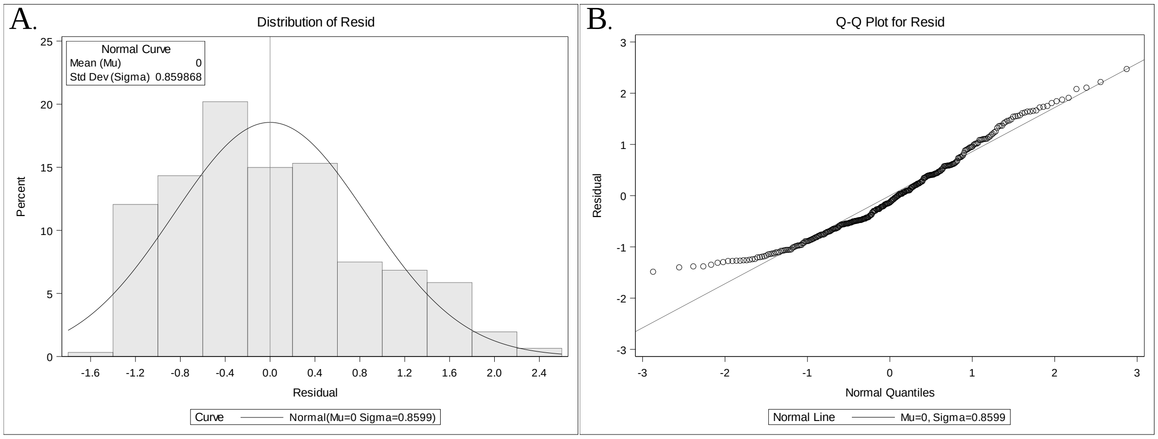


Figure 3. Diagnostic plots for lognormal component of the gray snapper SEAMAP Summer Groundfish Survey (2010-2019) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

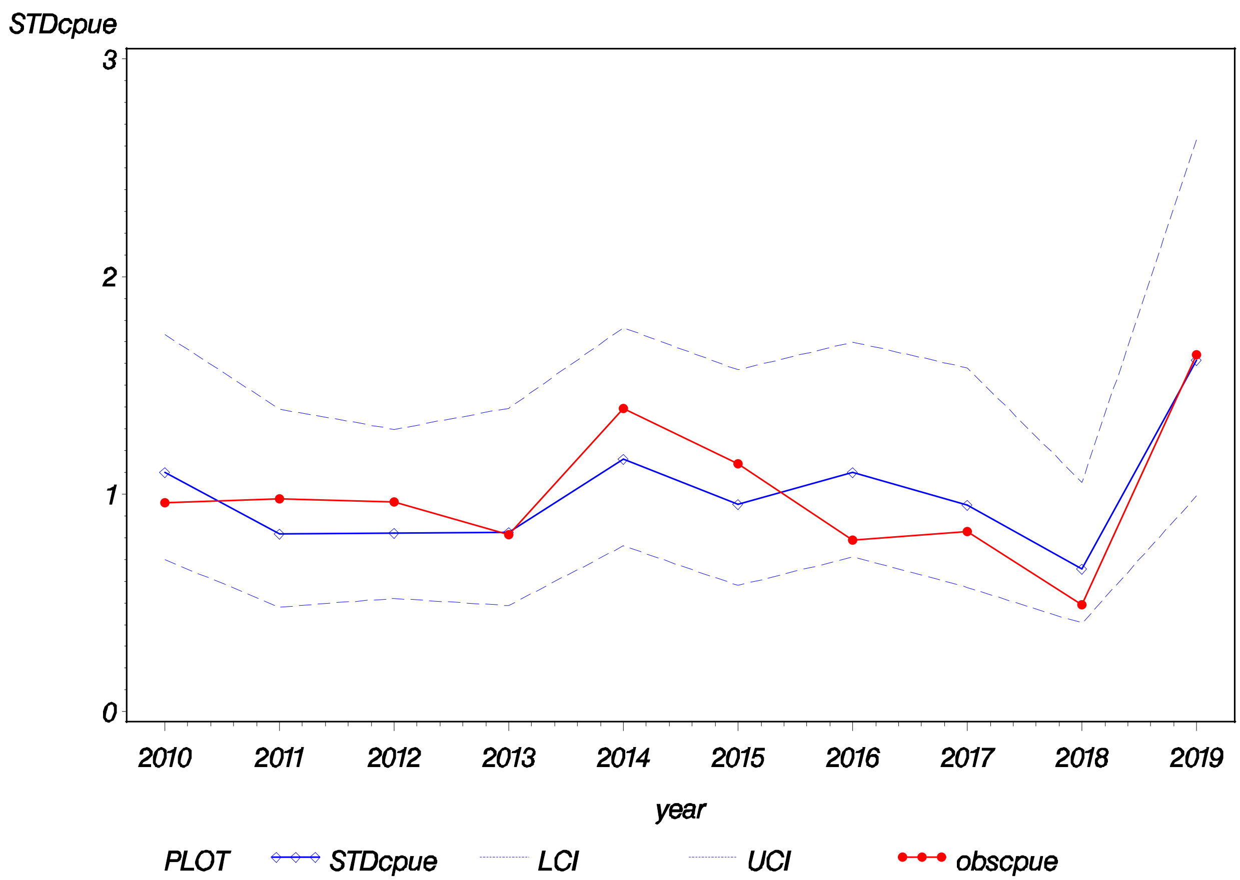


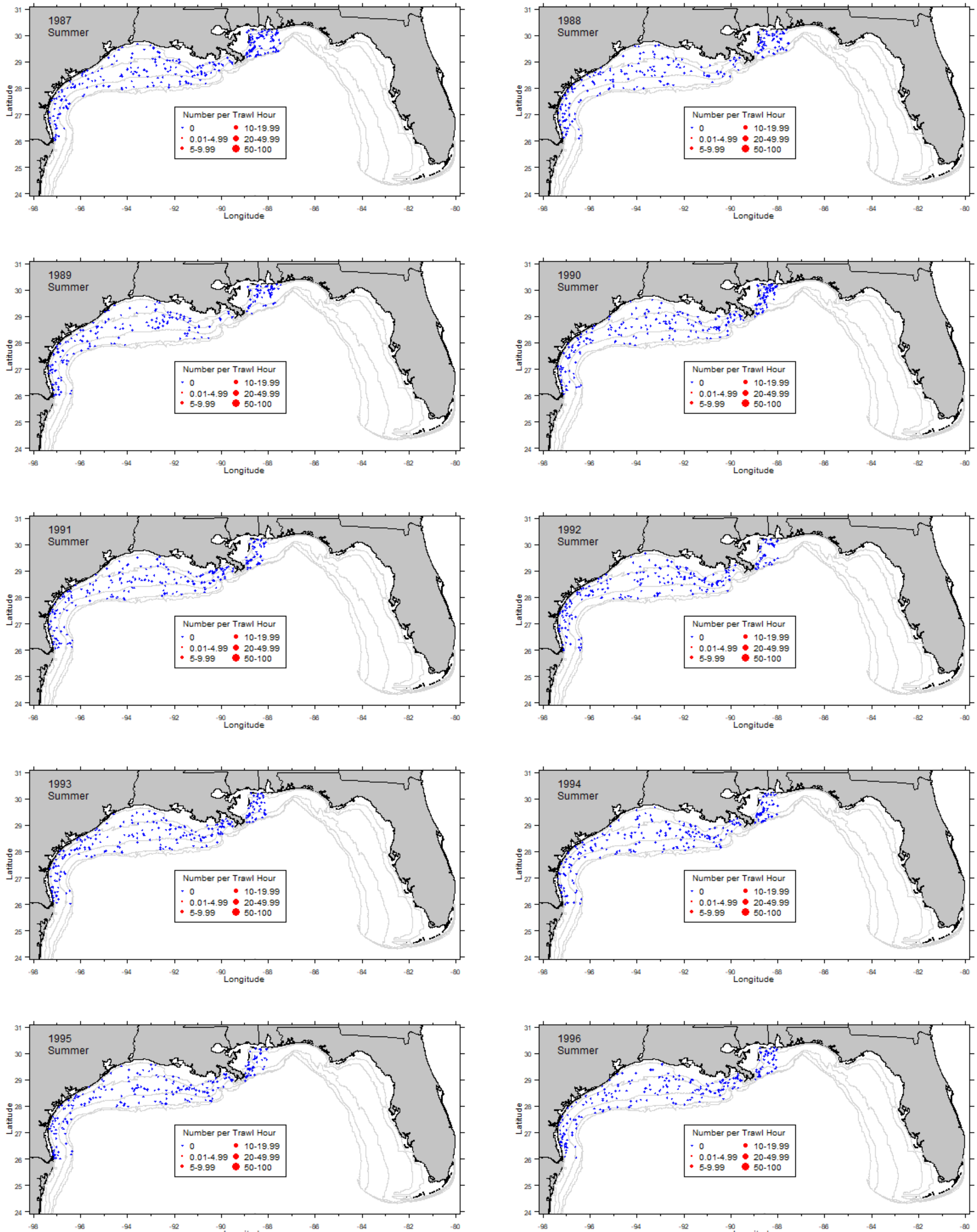
Figure 4. Annual index of abundance for gray snapper from the SEAMAP Summer Groundfish Survey from 2010-2019.

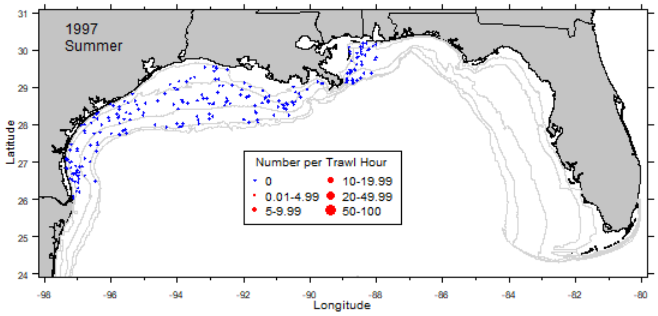
Appendix

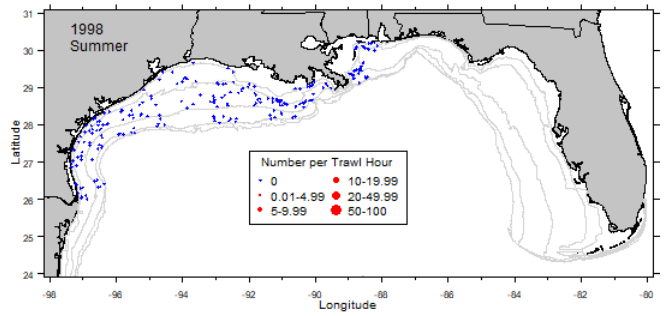
Appendix Table 1. Summary of the factors used in constructing the gray snapper abundance index from the SEAMAP Summer Groundfish Survey (2010-2019) data.

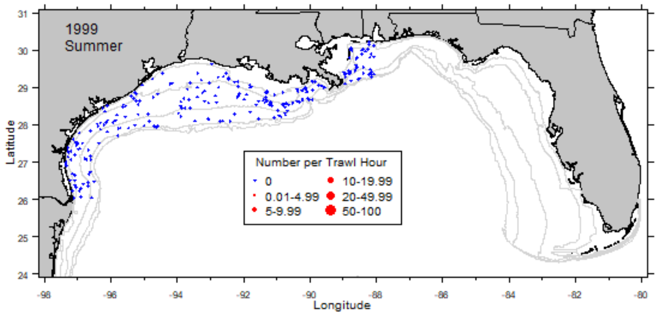
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Zone	1	393	95	0.24173	2.95773
Zone	2	505	149	0.29505	2.36172
Zone	3	368	63	0.17120	0.73773
Time of Day	Day	726	135	0.18595	1.71536
Time of Day	Night	540	172	0.31852	2.55776
Year	2010	114	33	0.28947	1.99333
Year	2011	108	25	0.23148	2.03047
Year	2012	162	36	0.22222	2.00252
Year	2013	115	25	0.21739	1.68587
Year	2014	145	40	0.27586	2.89402
Year	2015	144	28	0.19444	2.36337
Year	2016	128	35	0.27344	1.63992
Year	2017	114	26	0.22807	1.71807
Year	2018	129	30	0.23256	1.02326
Year	2019	107	29	0.27103	3.40187

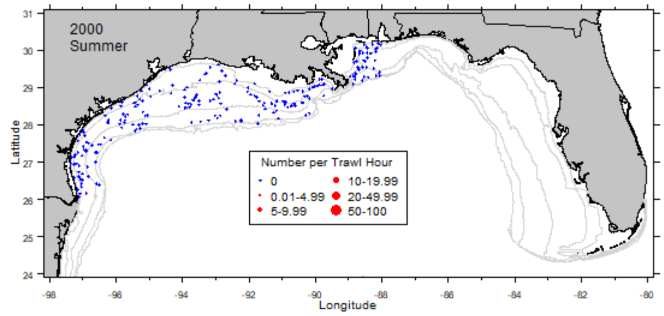
Appendix Figure 1. Annual survey effort and catch of gray snapper from the SEAMAP Summer Groundfish Survey.

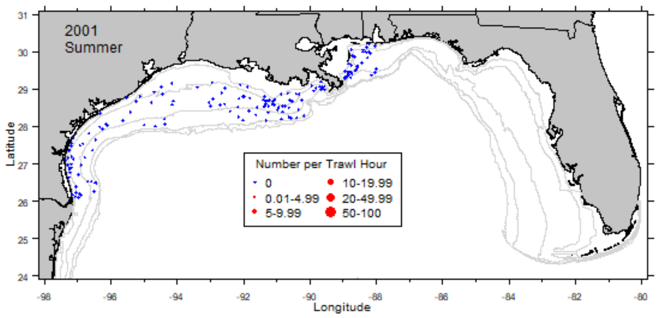


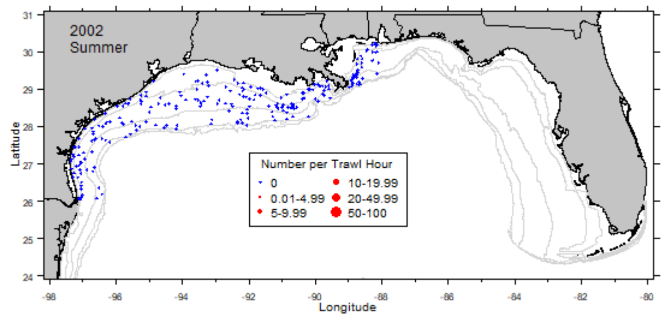

1997
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude

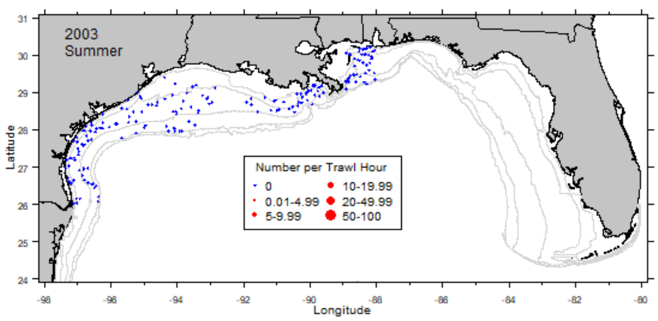

1998
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude

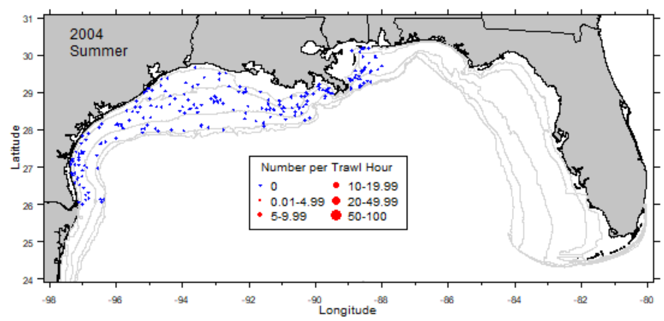

1999
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude

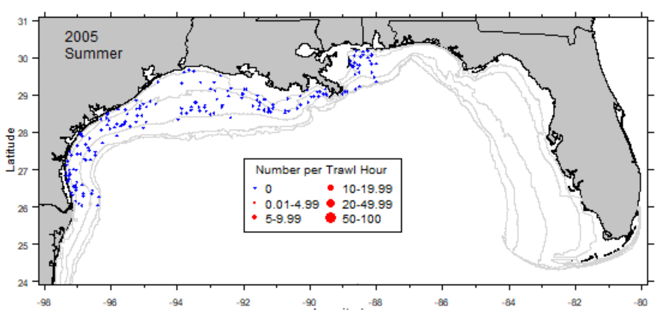

2000
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2001
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2002
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2003
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2004
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2005
Summer
Number per Trawl Hour
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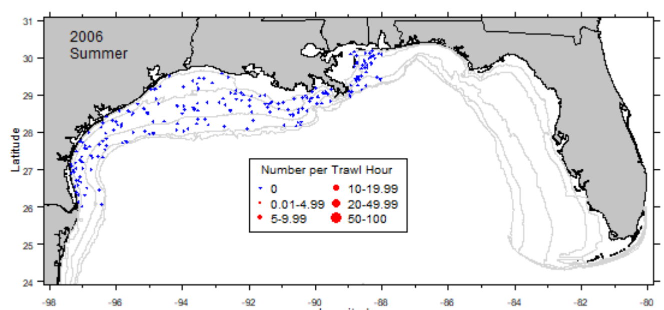
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2006
Summer
Number per Trawl Hour
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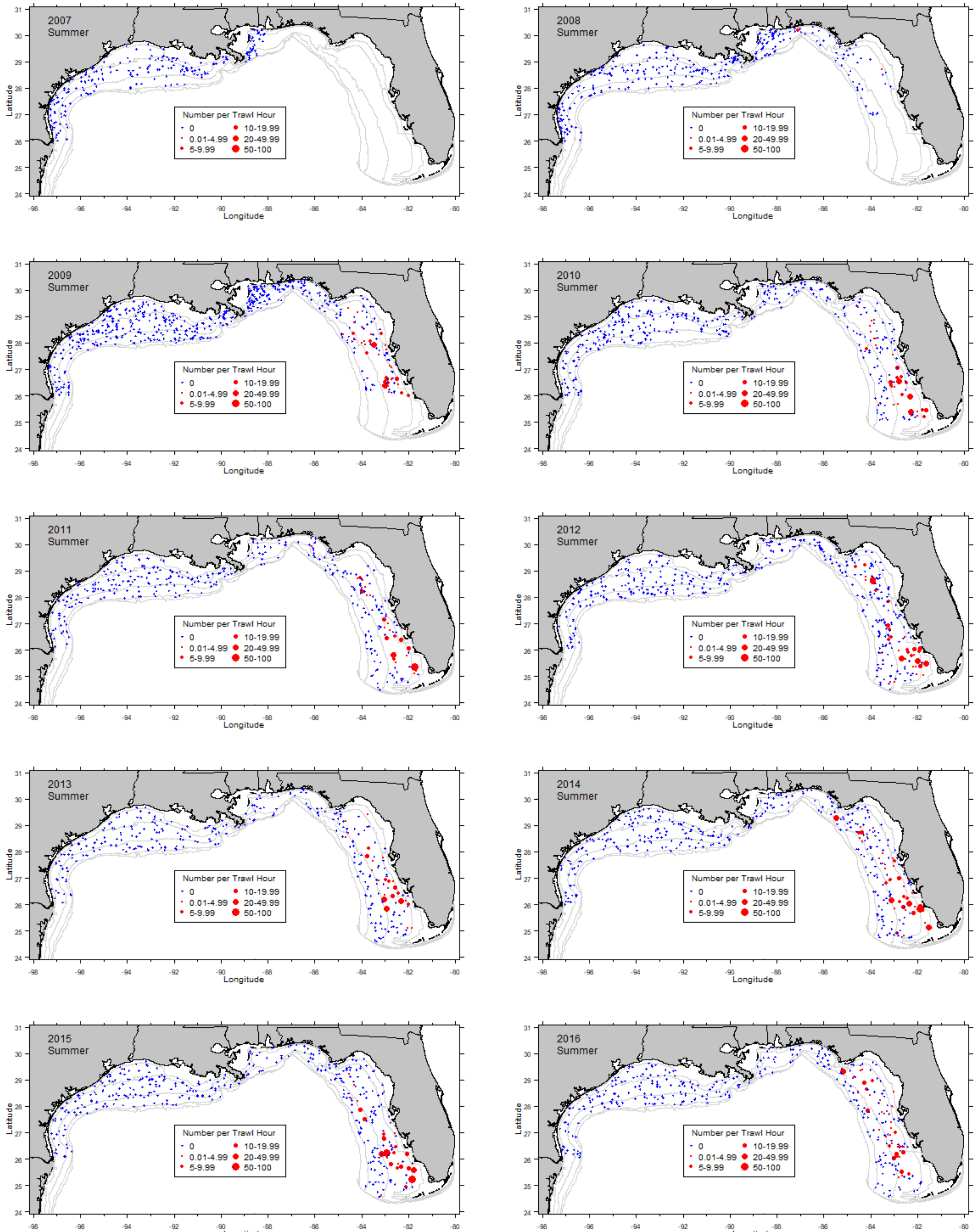
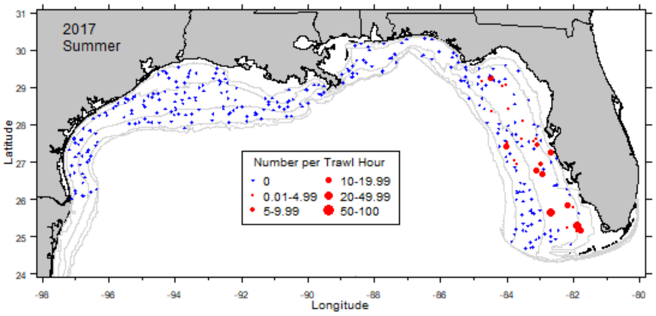
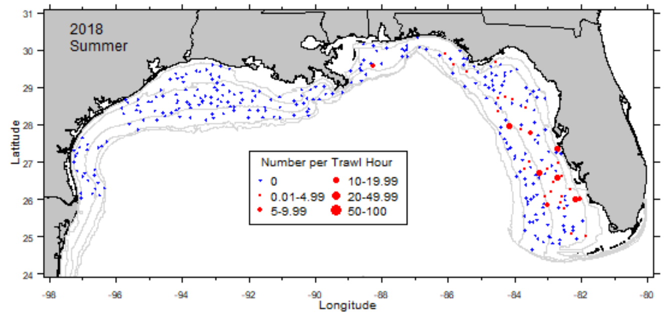
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude


2007
Summer
2008
Summer
2009
Summer
2010
Summer
2011
Summer
2012
Summer
2013
Summer
2014
Summer
2015
Summer
2016
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude
31
30
29
28
27
26
25
24
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80


2017
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude
31
30
29
28
27
26
25
24
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80


2018
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude
31
30
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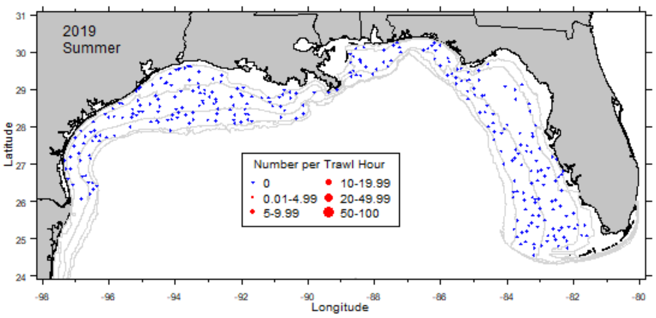
-86
-84
-82
-80


2019
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-100
Latitude
Longitude
31
30
29
28
27
26
25
24
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80