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Adam G. Pollack[1], David S. Hanisko[2] 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 National Marine Fisheries Service / Southeast Fisheries Science Center / Mississippi Laboratories 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 vermilion snapper (Rhomboplites aurorubens). Following the recommendation from SEDAR 45, one abundance index was produced for vermilion snapper from the SEAMAP Summer Groundfish Survey from 2009 – 2017 using data collected in the eastern GOM.

Introduction

The National Marine Fisheries Service / Southeast Fisheries Science Center / 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.

Four abundance indices were originally produced for SEDAR 45 for vermilion snapper (*Rhomboplites aurorubens*), Summer East Gulf (2009-2014), Summer/Fall West Gulf (1987-2007), Summer/Fall West Gulf (2009-2014) and Summer Gulf-wide (2009-2014) (Pollack and Ingram 2015). During the SEDAR 45 process, only data from the eastern GOM and summer survey was used because of the scarcity of vermilion snapper in the western GOM data and the gaps in spatial coverage during the fall surveys in the eastern GOM. The purpose of this document is to provide an updated abundance index for vermilion snapper (Summer East Gulf (2009-2017)).

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 8,089 stations were sampled from 1987- 2017 during the SEAMAP Summer Groundfish Survey (Table 1). Trawl data was 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 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 – 11
(4) Sampled with a 40 ft. shrimp trawl (Texas uses a 20 ft. shrimp trawl and data are not used)
(5) Sampled between 2009 and 2017

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, 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. 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 vermilion snapper (Pennington 1983, Bradu and Mundlak 1970). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (*cf.* Lo *et al*. 1992).

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

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

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

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

and

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

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

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

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 – Summer Survey (2009 – 2017)

Year: 2009 – 2017
Depth: 5 – 60 fathoms (continuous)
SSZ: 2 – 11
Time of Day: Day, Night

Results and Discussion

Distribution, Size and Age

The distribution of vermilion snapper from the SEAMAP Summer Groundfish Survey is presented in Figures 1, with seasonal/annual abundance and distribution presented in the Appendix Figure 1. The annual number of vermilion snapper captured ranged from 411 to 2,274 in the summer (Tables 2). Of the 8,643 vermilion snapper captured during the summer survey, 3,691 were measured with an average fork length of 171 mm. The length frequency distribution of vermilion snapper captured is shown in Figure 2. Based on data from previous assessments, the vermilion snapper captured most likely represent age zero and one year old fish.

Index of Abundance

For the SEAMAP Summer Groundfish Survey (2009-2017) abundance index of vermilion snapper in the eastern GOM, year, depth zone and SSZ were retained in the binomial submodel, while year, 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 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 7829.5 and 1645.9, 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 1987-2017.

	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	6	20	19	25	20	16	25	28	19	267
1988										18	48	5	4	3	19	24	14	25	28	23	211
1989										23	31		3	18	25	7	15	20	29	24	195
1990											69	11	20	15	23	16	20	23	24	20	241
1991											46	12	24	13	23	22	24	18	23	26	231
1992										1	45	2	20	24	20	25	12	31	26	20	226
1993											46	10	19	17	24	19	14	29	24	22	224
1994											61	6	17	22	25	17	20	22	26	22	238
1995											45	10	16	18	22	23	13	27	26	21	221
1996											46	14	13	19	22	18	17	21	26	25	221
1997											44		12	16	22	23	10	28	26	26	207
1998											36	2	14	21	25	18	14	22	36	17	205
1999											44	7	20	19	20	23	13	25	32	20	223
2000											45	2	19	15	19	27	8	29	31	21	216
2001											36	7	18	18	13	3	10	9	17	21	152
2002											45	11	14	21	27	19	15	25	29	22	228
2003											44	9	10	8	2	17	20	22	26	23	181
2004											39	11	18	17	20	25	21	19	25	21	216
2005											32	11	9	12	16	21	5	28	22	27	183
2006											45	11	21	12	20	23	17	23	31	18	221
2007											41		7	16	24	23	7	29	32	21	200
2008				1	8	11	6	11	8	11	41	12	17	16	23	21	16	24	21	28	275
2009				36	23	29	16	16	18	25	65	25	20	36	39	46	50	33	29	23	529
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	8	11	8	7	14	5	13	14	22	22	22	16	17	12	297
2014		15	31	23	24	30	17	15	9	7	17	6	15	18	22	28	23	18	18	14	350
2015	1	9	32	29	22	27	22	18	10	8	16	7	15	18	21	29	27	19	20	13	363
2016		9	25	29	26	23	15	15	10	8	15	6	16	16	23	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
Total	1	75	237	246	224	238	130	143	110	182	1187	234	475	527	678	707	580	713	778	624	8089

Table 2. Summary of the vermilion snapper length data collected during SEAMAP Summer Groundfish Surveys conducted between 2009 and 2017 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)
2009	224	1097	374	26	277	157	64
2010	171	678	314	33	263	171	49
2011	158	1157	441	104	334	192	43
2012	223	2274	575	34	304	156	67
2013	154	920	363	43	351	166	47
2014	185	567	376	35	295	182	41
2015	191	832	394	29	283	166	49
2016	173	707	518	89	265	171	29
2017	160	411	336	50	289	185	39
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
9	1639	8643	3691			171	

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for vermilion snapper SEAMAP Summer Groundfish Survey index of relative abundance from 2009 to 2017 in the eastern Gulf of Mexico.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 7832.9)*						*Lognormal Submodel Type 3 Tests (AIC 1654.1)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	8	1619	7.51	0.94	0.4830	0.4833	8	452	1.95	0.0506
Depth	1	1619	50.11	50.11	<.0001	<.0001	1	452	0.01	0.9222
Shrimp Statistical Zone	9	1619	83.41	9.27	<.0001	<.0001	9	452	1.99	0.0392
Time of Day	1	1619	0.20	0.20	0.6540	0.6541	1	452	6.98	0.0085
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 7829.5)*						*Lognormal Submodel Type 3 Tests (AIC 1645.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	8	1620	7.52	0.94	0.4814	0.4817	8	453	1.98	0.0470
Depth	1	1620	49.96	49.96	<.0001	<.0001	Dropped			
Shrimp Statistical Zone	9	1620	83.73	9.30	<.0001	<.0001	9	453	2.00	0.0373
Time of Day	Dropped						1	453	7.00	0.0084

Table 4. Indices of vermilion snapper abundance developed using the delta-lognormal (DL) model for SEAMAP Summer Groundfish Survey from 2009-2017 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
2009	0.23214	224	5.4612	0.87537	0.24662	0.53844	1.42315
2010	0.25146	171	5.0012	0.80164	0.27018	0.47144	1.36311
2011	0.27848	158	11.192	1.79397	0.26575	1.06394	3.02491
2012	0.32287	223	8.2098	1.31595	0.20959	0.86924	1.99223
2013	0.30519	154	5.9517	0.954	0.25804	0.57415	1.58517
2014	0.24324	185	4.9796	0.79818	0.26451	0.47448	1.3427
2015	0.31937	191	5.0059	0.8024	0.22982	0.50972	1.26313
2016	0.34104	173	5.629	0.90227	0.23124	0.5716	1.42424
2017	0.30625	160	4.7178	0.75622	0.25432	0.45836	1.24766

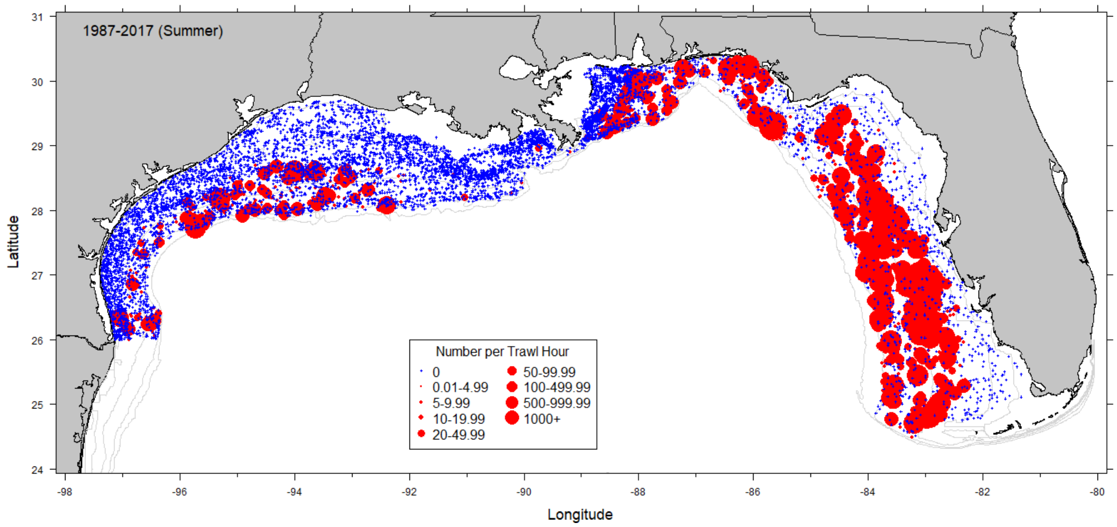


Figure 1. Stations sampled during the Summer SEAMAP Groundfish Survey with the CPUE for vermilion snapper from 1987 –2017.

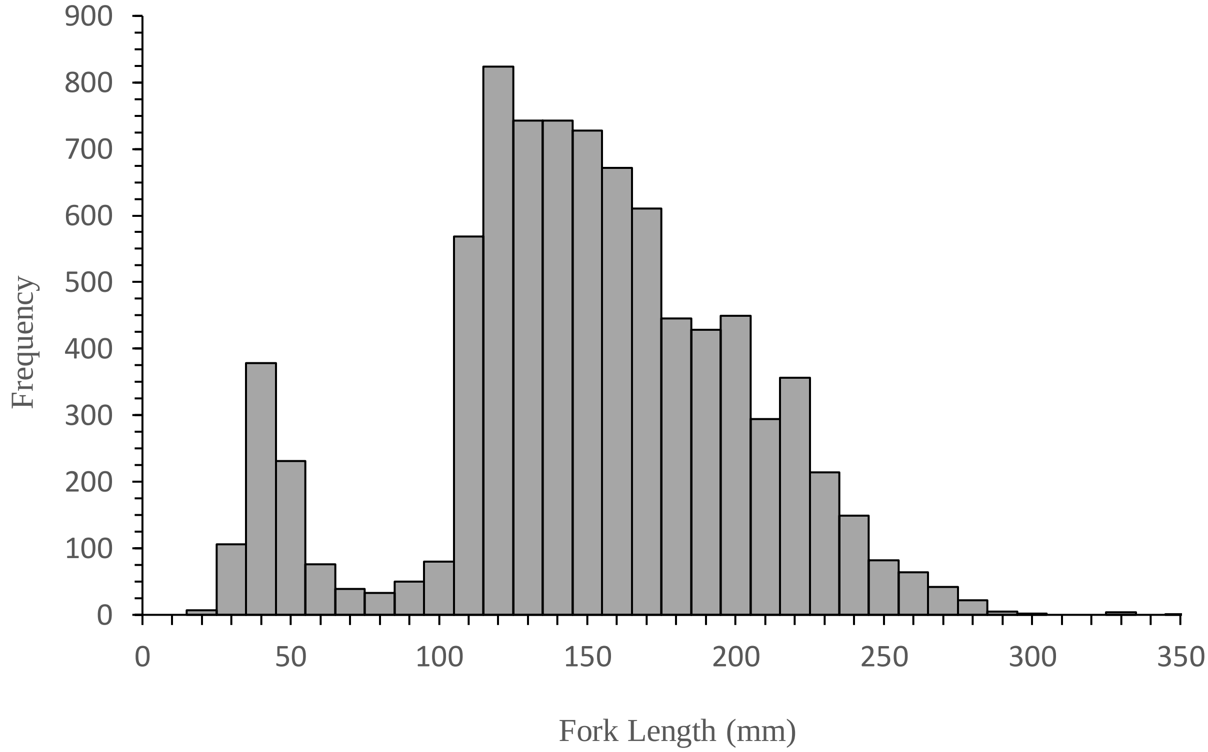


Figure 2. Length frequency histograms for vermilion snapper captured during SEAMAP Summer Groundfish surveys (2009-2017).

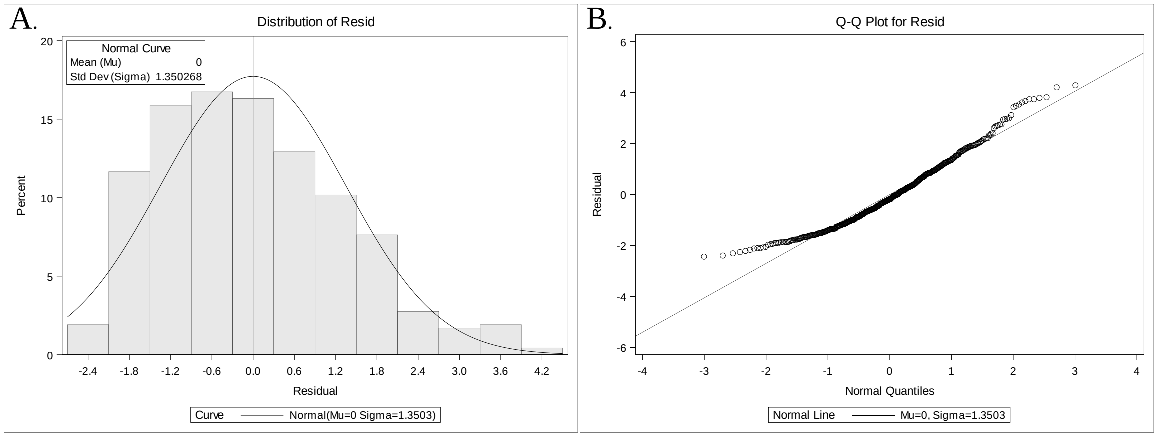


Figure 3. Diagnostic plots for lognormal component of the vermilion snapper SEAMAP Summer Groundfish Survey (2009-2017) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

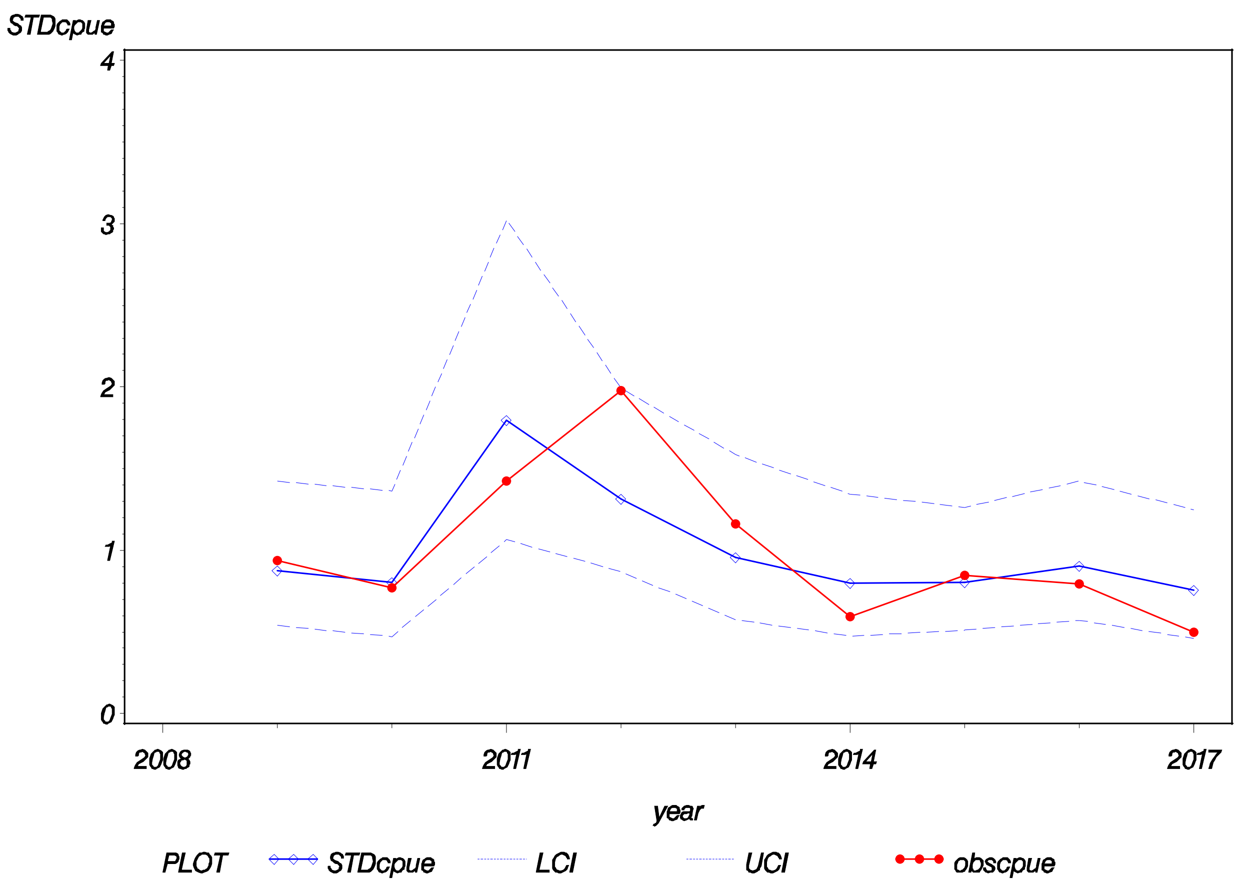


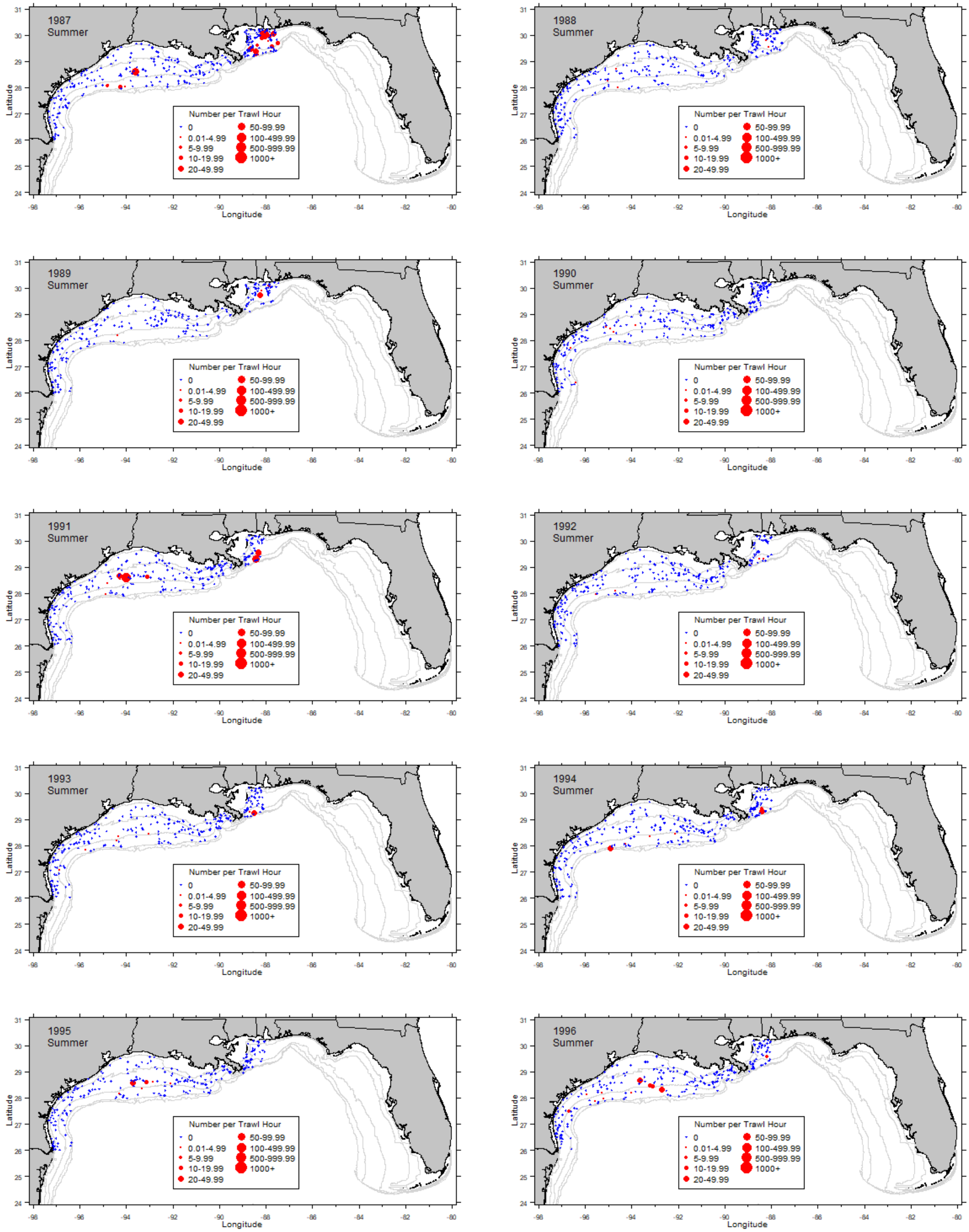
Figure 4. Annual index of abundance for vermilion snapper from the SEAMAP Summer Groundfish Survey from 1987 – 2008.

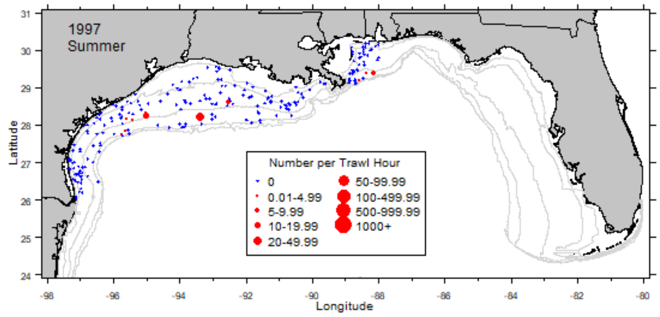
Appendix

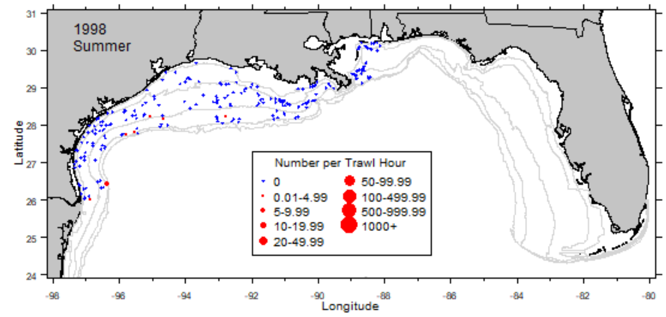
Appendix Table 1. Summary of the factors used in constructing the vermilion snapper abundance index from the SEAMAP Summer Groundfish Survey (2009-2017) data.

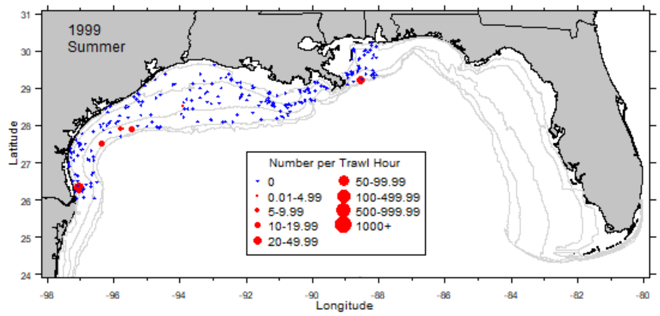
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Shrimp Statistical Zone	2	75	21	0.28000	10.3996
Shrimp Statistical Zone	3	237	74	0.31224	7.7309
Shrimp Statistical Zone	4	245	103	0.42041	21.9592
Shrimp Statistical Zone	5	212	90	0.42453	14.9263
Shrimp Statistical Zone	6	224	86	0.38393	11.0033
Shrimp Statistical Zone	7	121	29	0.23967	5.8029
Shrimp Statistical Zone	8	130	15	0.11538	13.7215
Shrimp Statistical Zone	9	101	29	0.28713	7.6039
Shrimp Statistical Zone	10	98	21	0.21429	3.0570
Shrimp Statistical Zone	11	196	4	0.02041	0.2857
Time of Day	Day	968	275	0.28409	13.1073
Time of Day	Night	671	197	0.29359	6.7705
Year	2009	224	52	0.23214	9.6390
Year	2010	171	43	0.25146	7.9196
Year	2011	158	44	0.27848	14.6305
Year	2012	223	72	0.32287	20.3464
Year	2013	154	47	0.30519	11.9481
Year	2014	185	45	0.24324	6.1233
Year	2015	191	61	0.31937	8.7073
Year	2016	173	59	0.34104	8.1641
Year	2017	160	49	0.30625	5.1268

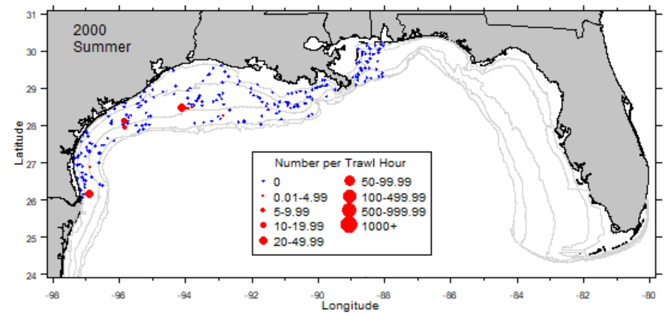
Appendix Figure 1. Annual survey effort and catch of vermilion snapper from the SEAMAP Summer Groundfish Survey.

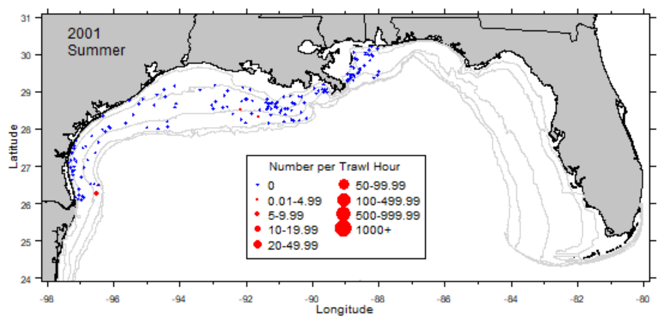



1997
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000+
Latitude
Longitude


1998
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+
Latitude
Longitude


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+
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+
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
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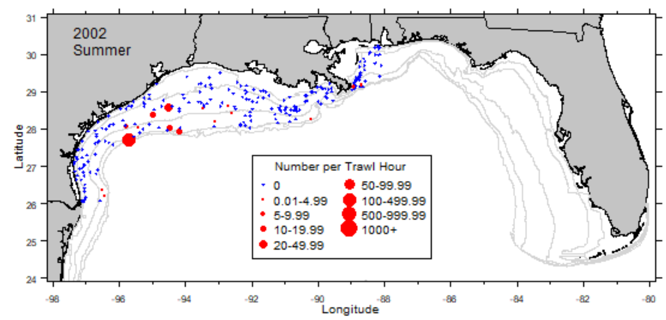
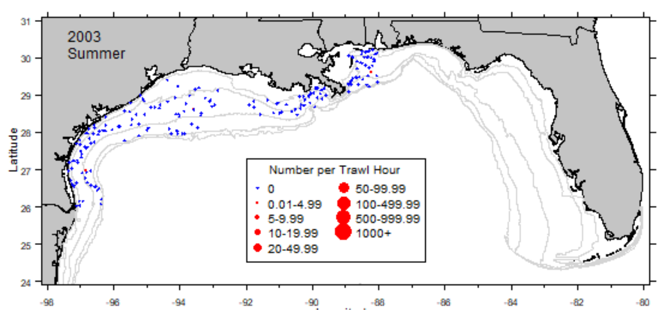
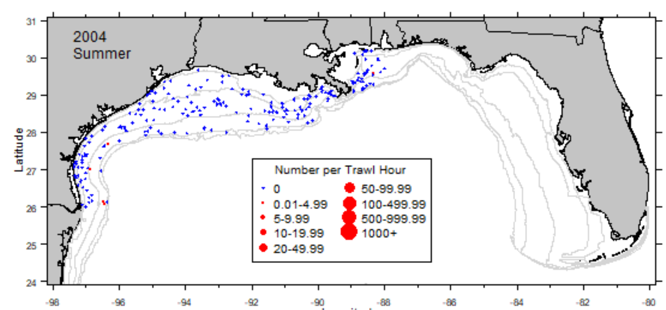
1000+
Latitude
Longitude


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+
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+
Latitude
Longitude


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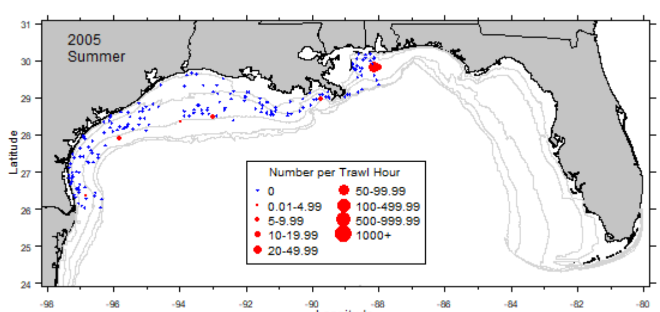
0.01-4.99
5-9.99
10-19.99
20-49.99
50-99.99
100-499.99
500-999.99
1000+
Latitude
Longitude


2005
Summer
Number per Trawl Hour
0
0.01-4.99
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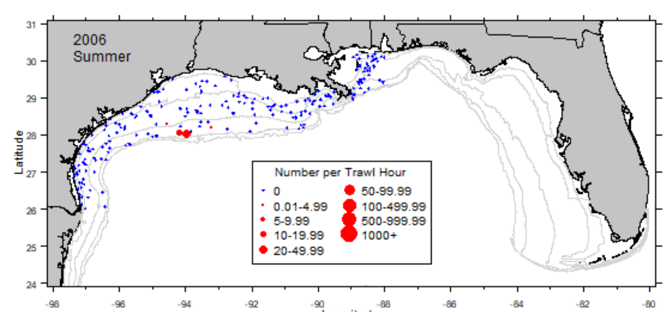
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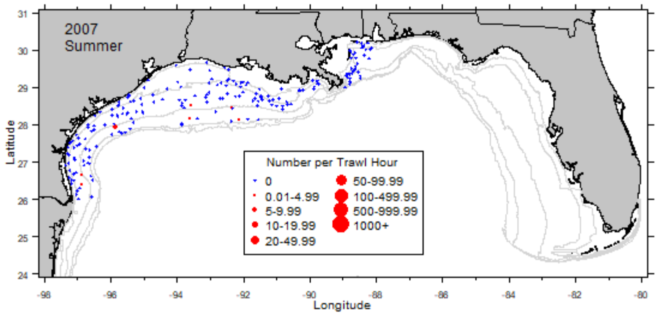
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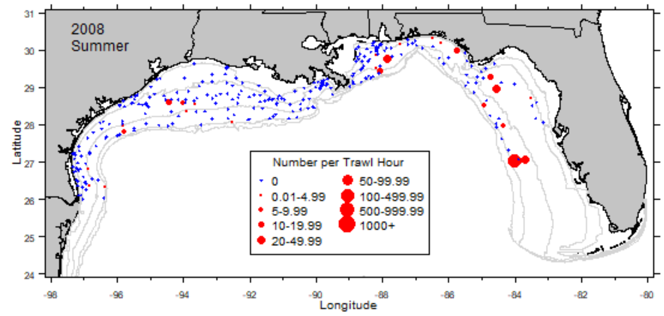
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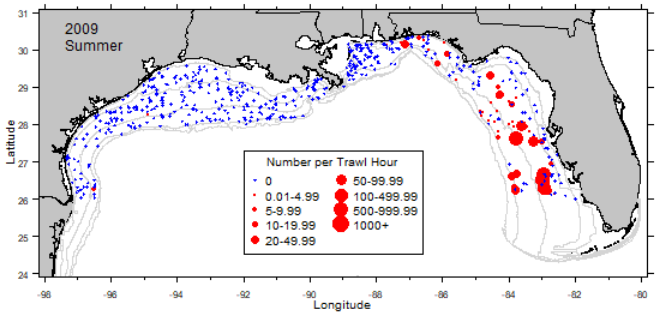
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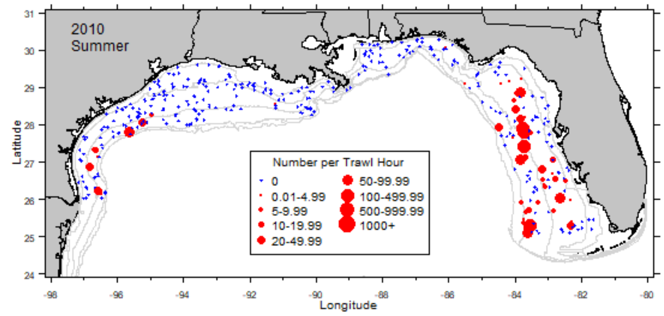
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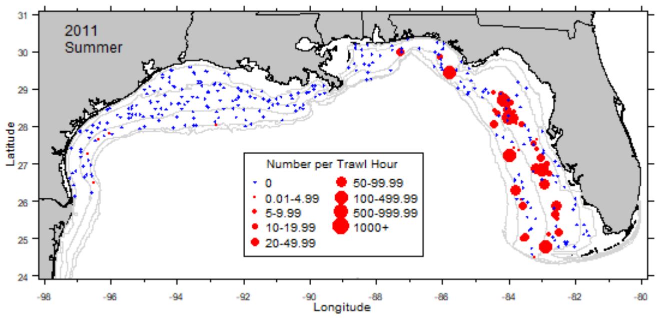
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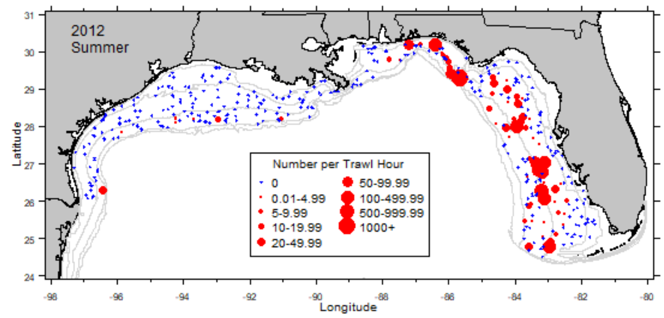
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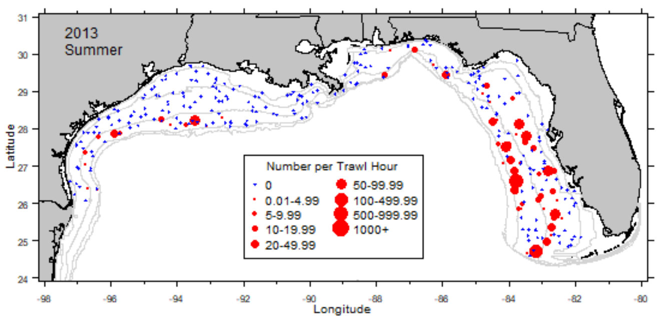
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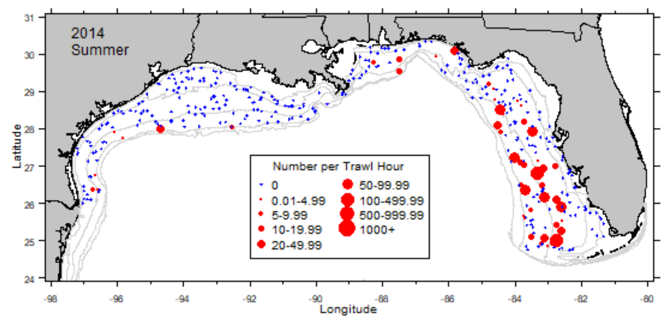
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Summer
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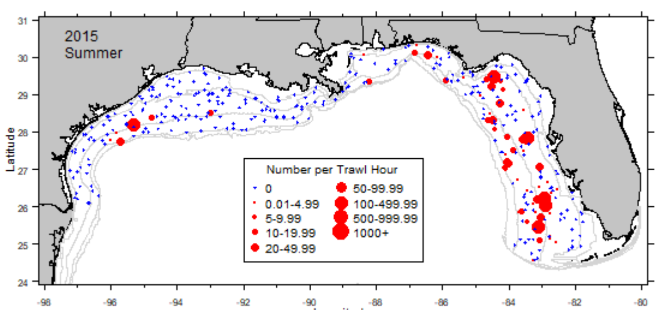
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Summer
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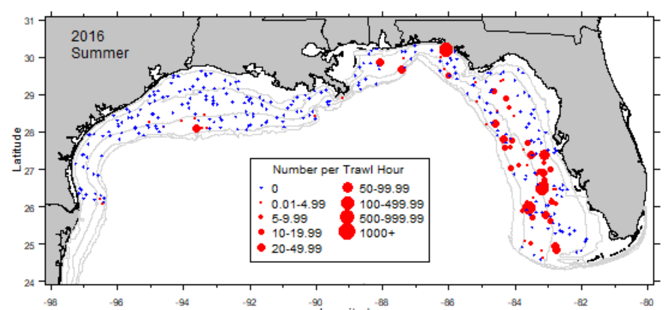
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Summer
Number per Trawl Hour
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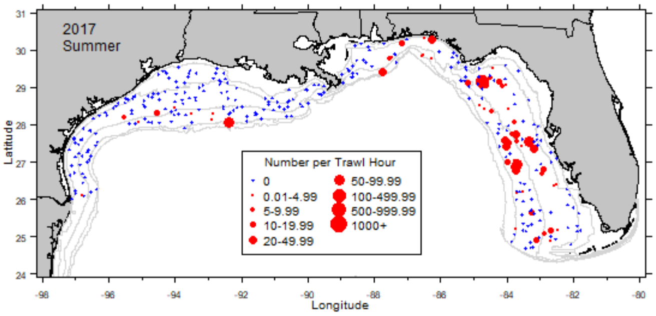
2017
Summer
Number per Trawl Hour
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500-999.99
1000+
Latitude
Longitude
31
30
29
28
27
26
25
24
-98
-96
-94
-92
-90
-88
-86
-84
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