Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

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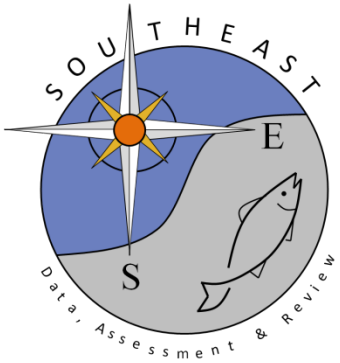

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Abstract

The National Marine Fisheries Service, Southeast Fisheries Science Center, Trawl and Plankton Branch 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 were brought under the same survey design within the Southeast Area Monitoring and Assessment Program (SEAMAP). These fisheries independent data were used to develop abundance indices for red grouper (Epinephelus morio). Since red grouper had only been observed in the eastern Gulf of Mexico, the time series had to be limited to 2009 – 2022, as no sampling previously was conducted in the eastern Gulf of Mexico.

Introduction

The National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC), Trawl and Plankton Branch and state partners have conducted standardized trawl surveys in the Gulf of Mexico (GOM) under the auspices of the Southeast Area Monitoring and Assessment Program (SEAMAP) since 1982. The program 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 the trawl surveys is to collect data on the abundance and distribution of demersal organisms in the northern GOM. Surveys are conducted semi-annually during the summer and fall, and collect information on numerous commercially and recreationally important species throughout the region. The SEAMAP summer survey was initiated in 1982, while the SEAMAP fall survey was initiated in1985. Fall trawl surveys prior to 1986 were conducted independently by NMFS and date back to 1972. This document outlines the development of an index of abundance for red grouper (*Epinephelus morio*) from NMFS and SEAMAP trawl survey data.

Methodology

Survey Design and Expansion

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 (between 88° and 97° W longitude, statistical zones 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 shrimp statistical zone with a weighting by spatial 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. In 2013, a depth stratification of 5 - 20 fathoms and 20 – 60 fathoms was added to the survey design.

The trawl survey area has been expanded throughout the course of the fall time series. Prior to 1985, 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. 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 and in Pollack and Ingram (2010).

Data

Trawl data was obtained from the Trawl and Plankton Branch 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. Age data was obtained from the SEFSC Panama City Laboratory and FWRI. Details concerning the aging methodologies of red grouper can be found in Lombardi-Carlson (2014).

Trawl data was initially limited to only tows without problems (i.e. net torn, doors crossed, etc.), tows taken between 9 and 110 meters and tows sampled with 40 ft shrimp trawls (Texas uses a 20 foot shrimp trawl and data are not used). A final total of 23,808 stations from 1972- 2022 were available for analysis with 10,593 and 13,215 stations sampled during the summer and fall surveys, respectively (Tables 1 and 2).

Preliminary mapping indicated that red grouper were taken only within shrimp statistical zones 2 - 8 (east of 86° W) coinciding with the eastward expansion of the trawl surveys in the fall of 2008 (Figure 1). Sampling coverage was also limited over the West Florida Shelf in 2008. Therefore, only 1,611 (summer) and 1,236 (fall) stations taken between 2009 and 2022 from statistical zones 2 -8 were retained for further analysis. Further examination of the spatial distribution of the SEAMAP Fall Groundfish Survey (Appendix Figure 1) determined that a relative abundance index could not be produced because of the gaps in the survey coverage. The gaps that were of particular concern were those occurring south of Tampa Bay and in waters less than 50 m, where most of the red grouper were captured during other surveys. This follows the

recommendations that were made during the previous SEDARs for red grouper (Pollack and Walter 2014, Pollack *et al.* 2018). Based on the distribution of red grouper in trawls and the lack of consistent spatial coverage by the fall trawl survey, indices of red group abundance are developed utilizing only stations within shrimp statistical zones 2 – 8 from 2009 to 2022 summer trawl data. Note that no survey was conducted during the summer of 2020 because of the COVID-19 global pandemic.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for red grouper (Lo *et al*. 1992). 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 (Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al*. (1992) 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 as:

(4) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

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 considered for inclusion in the submodels were:

Submodel Variables (SEAMAP Summer Groundfish)

Year: 2009 – 2022
Depth: 9 – 110 meters (continuous)
Sponge: 0 kg, < 50 kg, > 50 kg
Shrimp Statistical Zone: Zones 2 - 8
Time of Day: Day, Night

Results and Discussion

Size and Age

The distribution of red grouper is presented in Figure 1, with seasonal/annual abundance and distribution presented in the Appendix Figures 1 and 2. The total number of red grouper captured during the SEAMAP Summer Groundfish Survey ranged from 28 to 171 (Table 3). Of the 1,136 red grouper captured during the summer survey, 1,133 were measured with an average fork length of 298 mm (± 115 mm standard deviation). The length frequency distribution of red grouper captured is shown in Figure 2. Analysis of otoliths collected from red grouper collected during the summer survey, indicated that most (84%) are five years old or younger (Figure 3A and 3C). Length frequency distribution and age information for red grouper collected during the fall survey is presented in Figure 2 and Figure 3B and 3D for comparison even though no index was produced.

Index of Abundance

The final delta-lognormal index of red grouper abundance retained year, depth, sponge and shrimp statistical zone in the binomial submodel, while year, depth and shrimp statistical zone were retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 4 summarizes the backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 9182.2 and 915.4, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 4, and indicate the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 5 and Figure 5.

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Table 1. Number of stations sampled by shrimp statistical zone during the SEAMAP Summer Groundfish Survey from 1982-2022.

	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
1982										14	36	24	26	8	1	11	30	10	3	23	***186***
1983								5	19	8	26		6	16	19	25	24	21	5	17	***191***
1984										13	36	10	16	16	22	17	15	23	28	14	***210***
1985										10	48	11	27	12	10	7	7	12	11	10	***165***
1986										17	49	4	20	14	8	11	8	11	14	6	***162***
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	21	37	39	47	50	33	29	23	***535***
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	30	35	19	16	16	13	16	7	14	18	25	30	27	20	20	15	***405***
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	32	24	22	15	5	15	8	9	14	3	12	13	20	27	22	16	20	12	***300***

	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
2020																					
2021		9	24	22	19	3		9	7	6	6	4	9	8	17	22	20	14	14	11	***224***
2022		6	23	21	21	24	2	11	9	6	11	5	9	8	15	20	21	15	15	9	***251***
Total	***1***	***109***	***347***	***344***	***314***	***308***	***156***	***196***	***159***	***272***	***1433***	***431***	***859***	***749***	***810***	***874***	***746***	***846***	***899***	***740***	***10593***

Table 2. Number of stations sampled by shrimp statistical zone during the SEAMAP Fall Groundfish Survey from 1972-2022.

	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
1972										10	55	27	41	34	17						***184***
1973									11	17	98	34	71	39	2						***272***
1974										12	92	35	73	31							***243***
1975											93	33	80	35	32	7					***280***
1976											108	42	79	56	22						***307***
1977											97	31	76	38							***242***
1978										36	101	32	67	58	25						***319***
1979											109	35	72	55	2						***273***
1980										24	85	22	70	32							***233***
1981										21	85	33	66	49	25						***279***
1982										21	102	41	72	37							***273***
1983										17	82	35	63	25							***222***
1984											82	32	64	47	1						***226***
1985										30	63	23	37	53	32	10	20	20	19	19	***326***
1986								20	10	25	34	13	27	14	27	35	26	23	22	21	***297***
1987										13	23	30	29	30	17	15	15	15	18	3	***208***
1988										8	28	10	31	24	18	26	19	21	31	20	***236***
1989											45	18	31	23	22	20	17	22	25	26	***249***
1990											52	20	24	27	22	19	18	22	19	27	***250***
1991											46	16	32	18	20	25	24	19	25	22	***247***
1992											34	15	33	14	25	18	17	27	30	18	***231***
1993											73	14	35	21	26	18	16	25	28	18	***274***
1994											50	19	24	27	25	20	21	23	24	20	***253***
1995											40	14	29	26	24	19	14	26	30	19	***241***
1996											45	11	36	23	17	28	13	25	29	24	***251***
1997											44	18	31	22	26	19	18	23	22	24	***247***
1998											44	30	50	14	34	11	15	24	29	22	***273***
1999											42	10	40	18	29	18	12	28	29	22	***248***
2000											43	10	29	28	20	26	12	30	25	21	***244***
2001											45	14	31	23	26	20	14	27	28	23	***251***
2002										1	51	16	27	26	22	23	14	26	30	21	***257***
2003										1	76	20	20	21	24	22	20	23	25	23	***275***
2004											43	6	23	24	17	27	14	24	30	21	***229***
2005											45	21	32	18	33	18	14	23	24	27	***255***
2006										1	46	7	22	14	18	28	13	23	32	19	***223***
2007											33	15	29	26	18	28	17	20	18	26	***230***
2008					15	14	4	4	3	4	35	18	28	34	42	46	44	19	36	20	***366***
2009				20	21	25	11	21	13	12	50	12	23	23	30	49	47	31	36	22	***446***

	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
2010				10	25	27	17	16	11	14	15	7	15	18	26	30	29	18	19	14	***311***
2011								9	11	7	15	6	15	16	27	31	28	21	18	15	***219***
2012			2	3	6	6	17	10	7	5	12	5	11	13	19	23	22	13	15	11	***200***
2013		4	14	12	10	11	10	10	6	5	10	5	11	12	4	12	16	12	14	9	***187***
2014	1	8	31	25	22	23	13	12	7	7	16	5	14	15	21	27	22	15	17	12	***313***
2015	1	10	29	25	25	21	15	12	9	11	16	6	13	13	19	27	21	16	17	12	***318***
2016	1	5	4	8	11	9	6	13	5	4	8	4	12	12	18	22	17	13	13	8	***193***
2017		9	19	27	19	18	8	12	7	7	15	6	9	12	22	25	22	15	18	14	***284***
2018		9	29	21	14	10	7	13	8	7	13	5	12	15	21	25	22	13	15	14	***273***
2019		11	17	17	19	24	9	11	9	10	12	4	9	13	20	25	22	16	16	12	***276***
2020		9	15	17	20	8	4	8	7	9	12	4	9	10	18	22	18	15	14	11	***230***
2021		6	23	17	17	14	2	12	5	6	12	4	11	12	19	25	22	16	16	12	***251***
2022		6	22	20	14	16	9	10	7	6	10	2	10		2	11	11	16	16	12	***200***
Total	***3***	***77***	***205***	***222***	***238***	***226***	***132***	***193***	***136***	***351***	***2485***	***895***	***1798***	***1288***	***976***	***900***	***746***	***788***	***872***	***684***	***13215***

Table 3. Summary of the red grouper length data collected during summer SEAMAP Summer Groundfish Surveys conducted between 2009 and 2022. (Note that prior to 2008, no red grouper were caught and 2008 was excluded from the index because of survey coverage.)

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	121	171	171	74	578	284	75
2010	126	113	111	137	718	282	98
2011	123	114	114	46	805	308	126
2012	184	142	140	37	838	316	142
2013	126	65	65	73	754	347	146
2014	160	109	109	174	670	347	118
2015	162	92	92	121	613	275	120
2016	143	76	75	131	609	308	109
2017	128	52	52	136	539	277	78
2018	141	31	31	143	638	314	127
2019	124	28	28	75	475	280	107
2020	0						
2021	86	55	55	36	501	280	102
2022	108	88	88	22	573	243	90

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Fork Length (mm)
13	1732	1136	1131	298

Table 4. Summary of backward selection procedure for building delta-lognormal submodels for red grouper SEAMAP Summer Groundfish Survey index of relative abundance from 2009 to 2022.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 9181.4)*						*Lognormal Submodel Type 3 Tests (AIC 919.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	12	1709	29.07	2.42	0.0038	0.0041	12	397	2.52	0.0033
Depth	1	1709	120.86	120.86	<.0001	<.0001	1	397	20.90	<.0001
Sponge	2	1709	89.34	44.67	<.0001	<.0001	2	397	1.72	0.1812
Statistical Zone	6	1709	89.31	14.89	<.0001	<.0001	6	397	5.75	<.0001
Time of Day	1	1709	0.02	0.02	0.8769	0.8769	1	397	2.40	0.1221
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 9182.2)*						*Lognormal Submodel Type 3 Tests (AIC 916.6)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	12	1710	29.06	2.42	0.0039	0.0041	12	399	2.40	0.0052
Depth	1	1710	120.85	120.85	<.0001	<.0001	1	399	22.05	<.0001
Sponge	2	1710	89.64	44.82	<.0001	<.0001		Dropped		
Statistical Zone	6	1710	89.20	14.87	<.0001	<.0001	6	399	6.21	<.0001
Time of Day				Dropped			1	399	2.36	0.1251
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 9182.2)*						*Lognormal Submodel Type 3 Tests (AIC 915.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	12	1710	29.06	2.42	0.0039	0.0041	12	400	2.34	0.0067
Depth	1	1710	120.85	120.85	<.0001	<.0001	1	400	23.70	<.0001
Sponge	2	1710	89.64	44.82	<.0001	<.0001		Dropped		
Statistical Zone	6	1710	89.20	14.87	<.0001	<.0001	6	400	6.34	<.0001
Time of Day				Dropped				Dropped		

Table 5. Indices of red grouper abundance developed using the delta-lognormal (DL) model for SEAMAP Summer Groundfish Survey from 2009-2022. 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	0.34711	121	1.47508	2.11830	0.23081	1.34308	3.34098
2010	0.31746	126	0.88667	1.27332	0.24500	0.78564	2.06373
2011	0.24390	123	0.80516	1.15626	0.27204	0.67760	1.97307
2012	0.30435	184	0.99308	1.42613	0.20346	0.95329	2.13349
2013	0.25397	126	0.57057	0.81937	0.26003	0.49125	1.36666
2014	0.23750	160	0.71440	1.02592	0.23673	0.64311	1.63660
2015	0.17284	162	0.55213	0.79289	0.27189	0.46479	1.35262
2016	0.25175	143	0.69611	0.99966	0.24267	0.61956	1.61296
2017	0.16406	128	0.48808	0.70092	0.30911	0.38307	1.28248
2018	0.12766	141	0.25121	0.36076	0.32873	0.19010	0.68462
2019	0.16129	124	0.22864	0.32834	0.32529	0.17412	0.61914
2020							
2021	0.30233	86	0.68965	0.99038	0.28353	0.56791	1.72713
2022	0.30556	108	0.70174	1.00774	0.26437	0.59922	1.69478

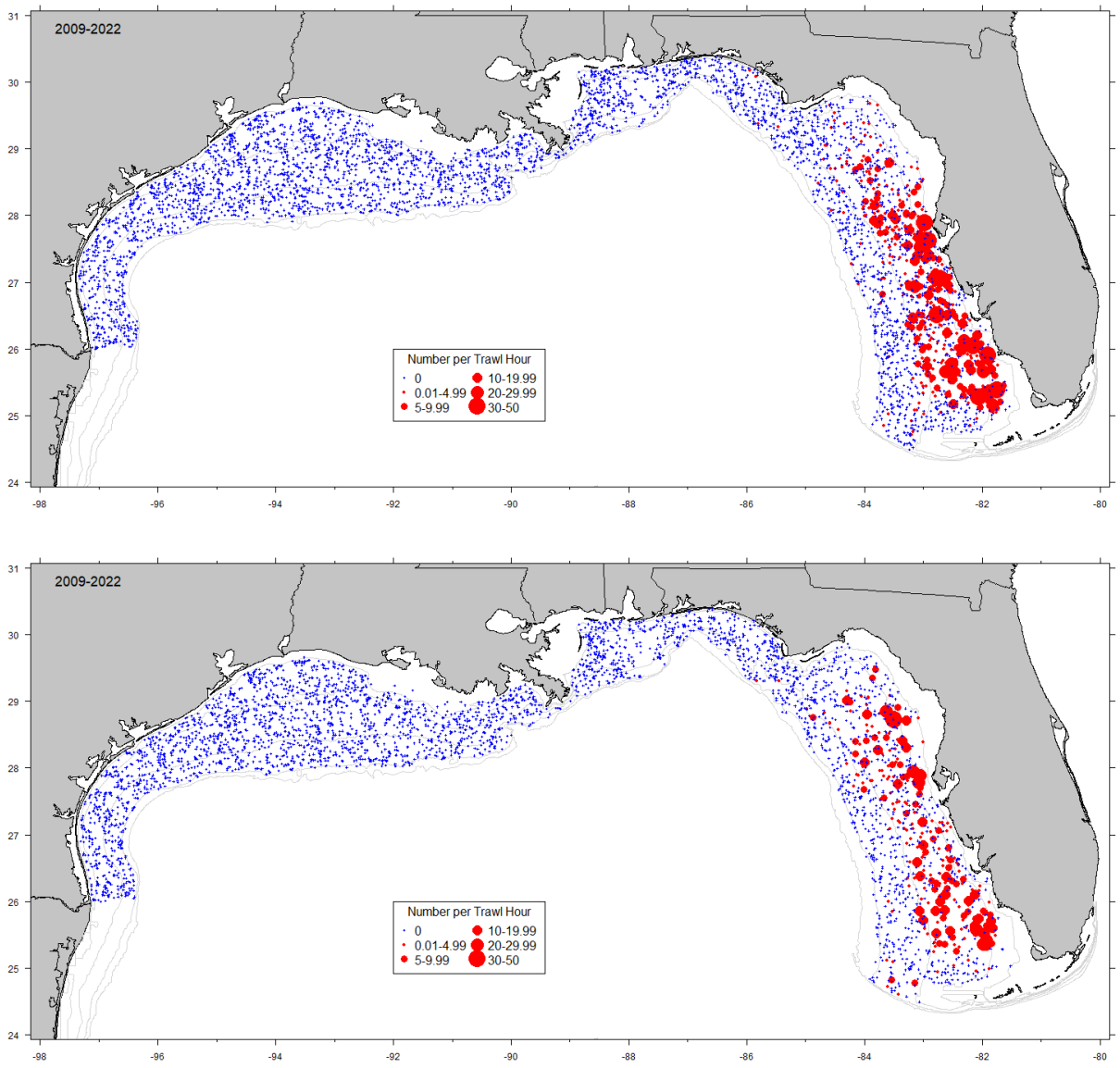


Figure 1. Stations sampled from 2009 to 2022 during the SEAMAP Summer (top) and Fall (Bottom) Groundfish Surveys with the CPUE for red grouper. Note that all stations west of 86° W were excluded from the abundance index.

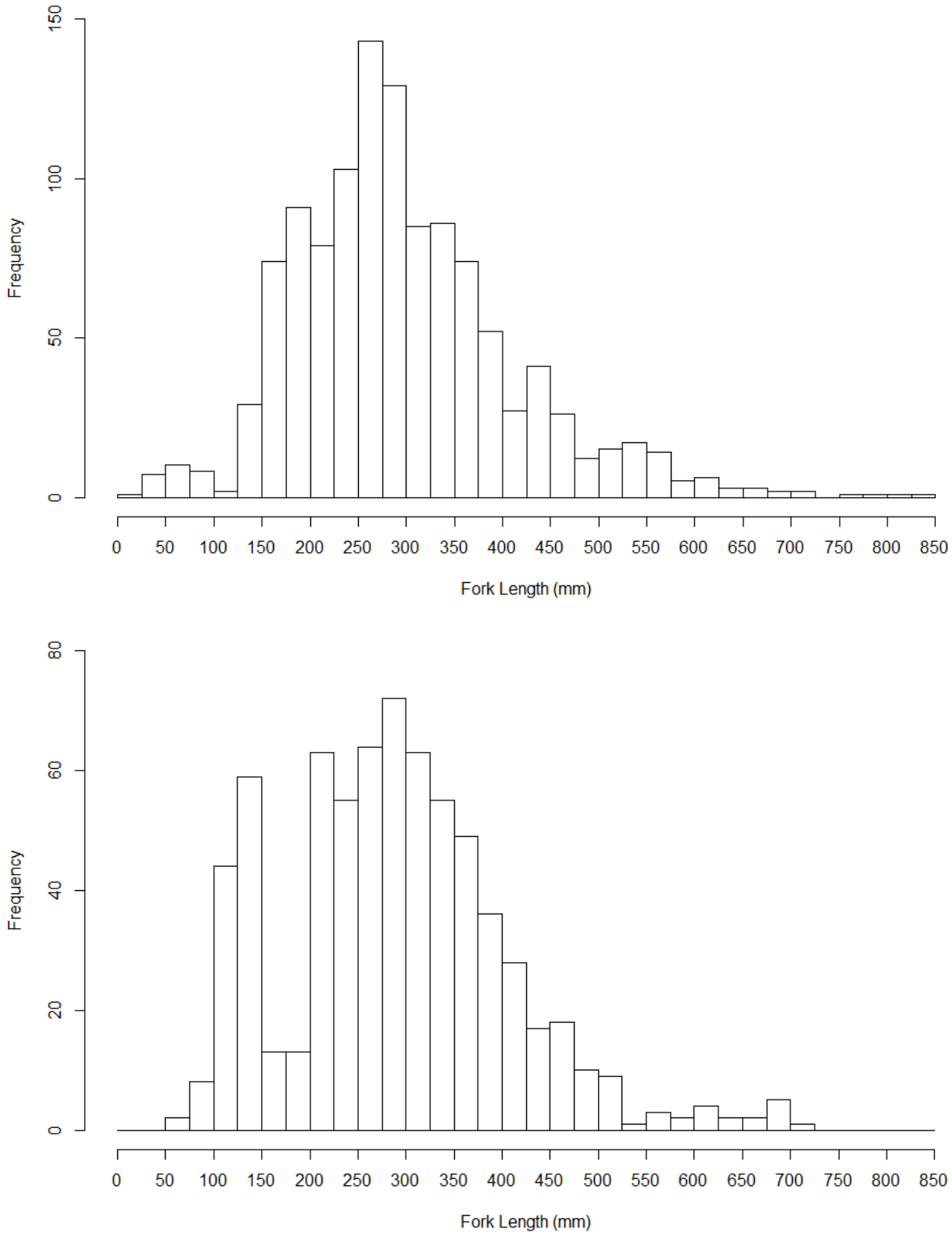


Figure 2. Length frequency histograms for red grouper captured Summer (top) and Fall (bottom) SEAMAP Groundfish surveys from 2009 - 2022.

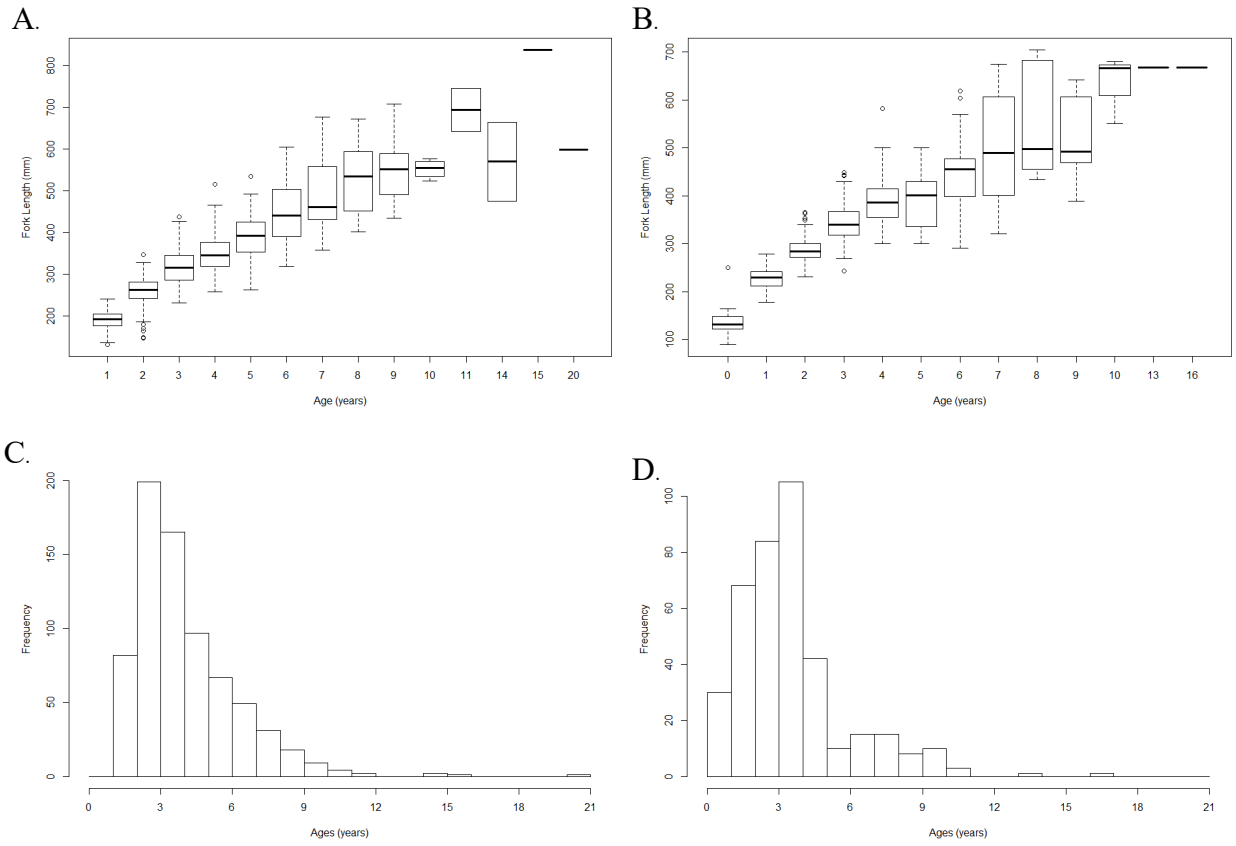


Figure 3. Age distribution of red grouper (n = 1119) captured during **A.** SEAMAP Summer Groundfish Surveys (n = 727) and **B.** SEAMAP Fall Groundfish Surveys (n = 392), and length at age information for **C.** Summer and **D.** Fall.

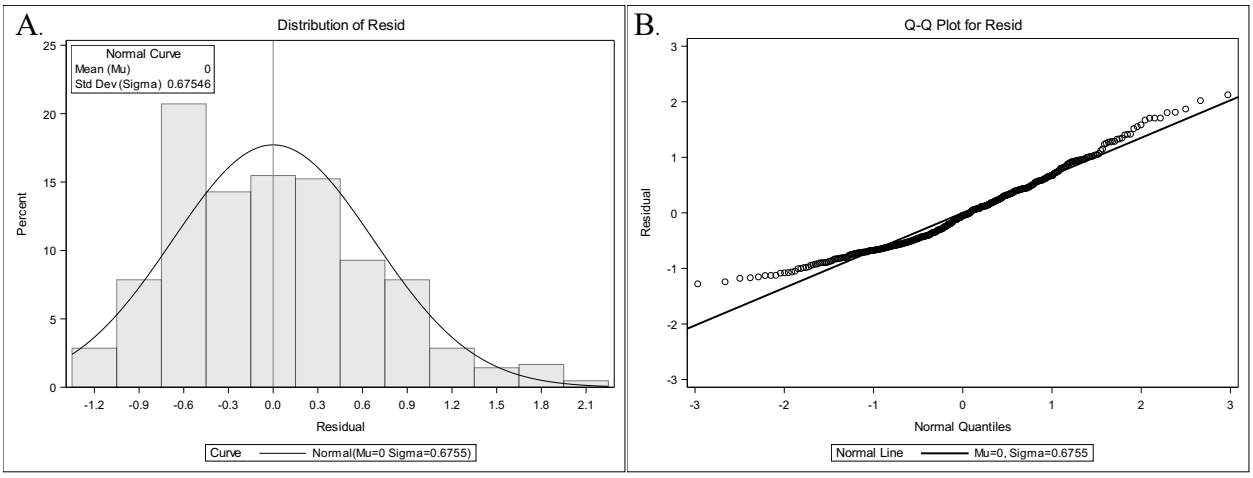


Figure 4. Diagnostic plots for lognormal component of the red grouper SEAMAP Summer Groundfish Survey model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

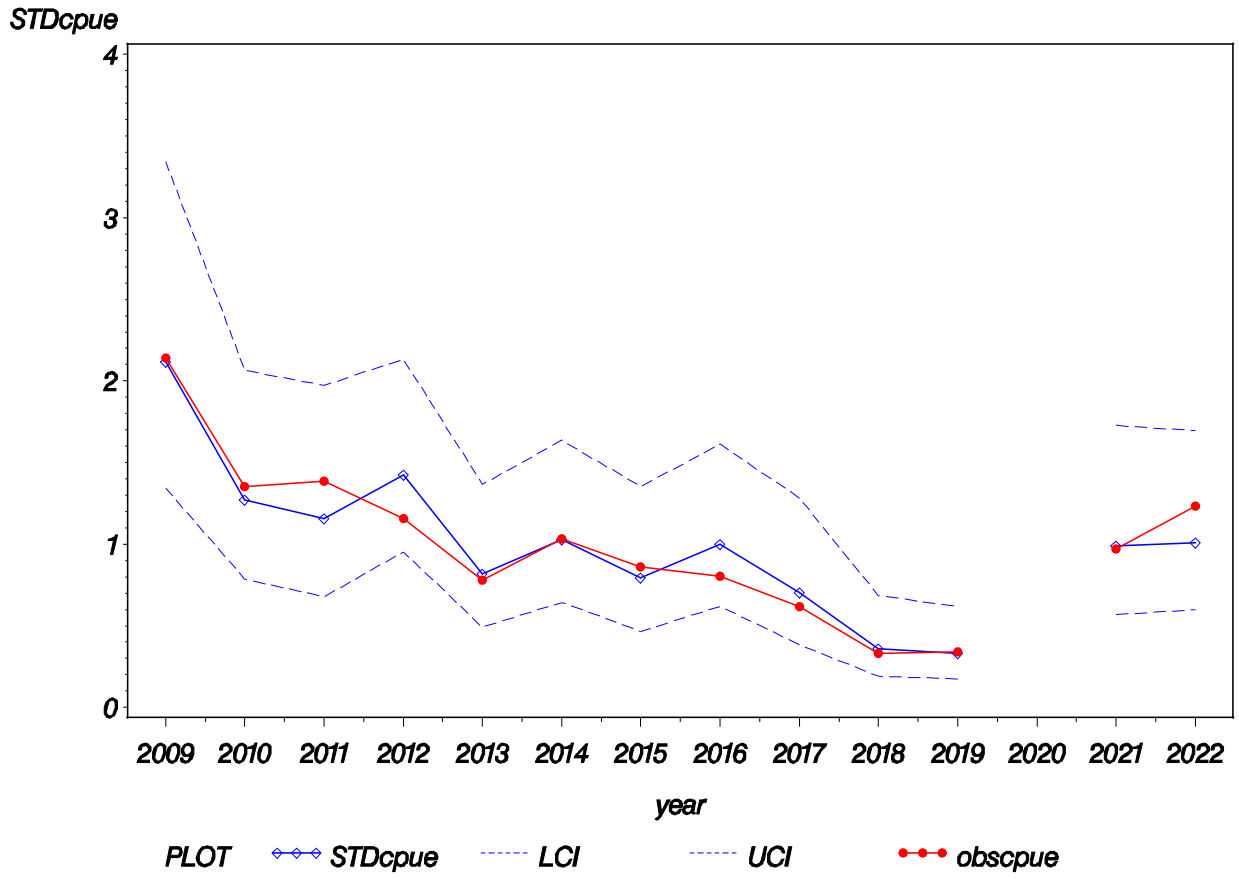


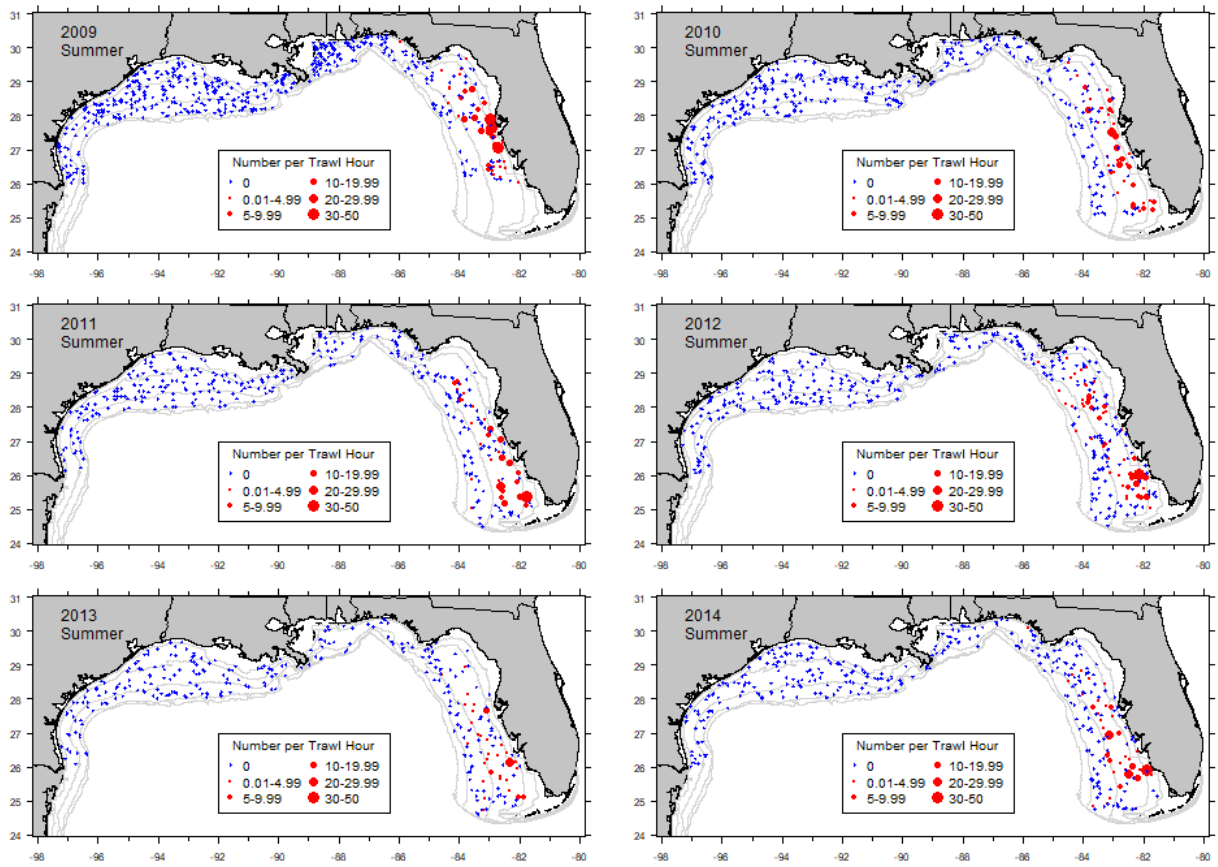
Figure 5. Annual index of abundance for red grouper from the SEAMAP Summer Groundfish Survey from 2009 – 2022.

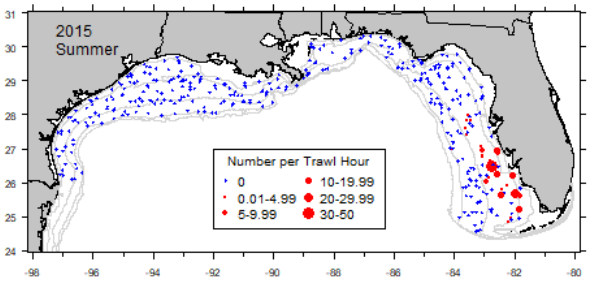
Appendix

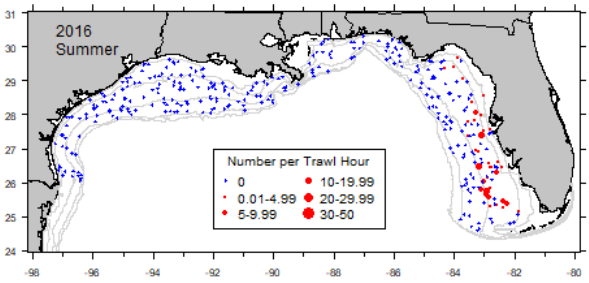
Appendix Table 1. Summary of the factors used in constructing the red grouper abundance index from the SEAMAP Summer Groundfish Survey data.

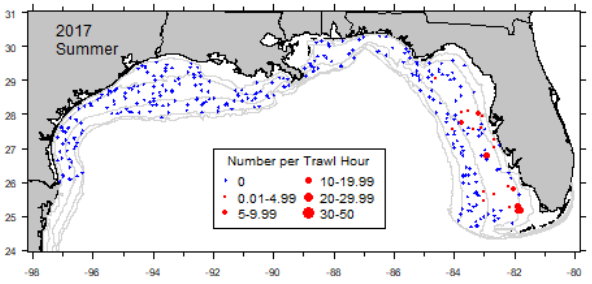
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
YEAR	2009	121	42	0.34711	2.82627
YEAR	2010	126	40	0.31746	1.78966
YEAR	2011	123	30	0.24390	1.82901
YEAR	2012	184	56	0.30435	1.52785
YEAR	2013	126	32	0.25397	1.02877
YEAR	2014	160	38	0.23750	1.36207
YEAR	2015	162	28	0.17284	1.13580
YEAR	2016	143	36	0.25175	1.06362
YEAR	2017	128	21	0.16406	0.81244
YEAR	2018	141	18	0.12766	0.43972
YEAR	2019	124	20	0.16129	0.45130
YEAR	2020	0			
YEAR	2021	86	26	0.30233	1.27907
YEAR	2022	108	33	0.30556	1.62914
SPONGE	0 kg	620	61	0.09839	0.53604
SPONGE	< 50 kg	845	217	0.25680	1.25317
SPONGE	> 50 kg	267	142	0.53184	3.27285
STATZONE	2	109	6	0.05505	0.12837
STATZONE	3	347	112	0.32277	2.08084
STATZONE	4	343	112	0.32653	1.82940
STATZONE	5	306	92	0.30065	1.85157
STATZONE	6	297	78	0.26263	0.98028
STATZONE	7	150	16	0.10667	0.23916
STATZONE	8	180	4	0.02222	0.04443
TOD	Day	1005	246	0.24478	1.21996
TOD	Night	727	174	0.23934	1.42925

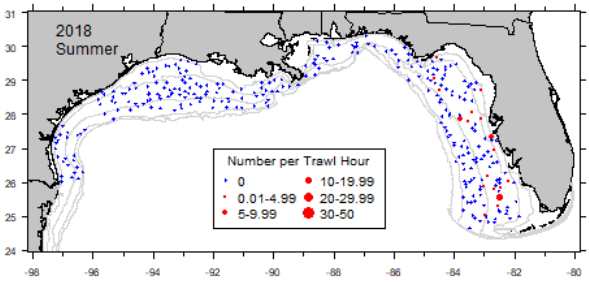
Appendix Figure 1. Annual survey effort and catch of red grouper from the SEAMAP Summer Groundfish Surveys. Note that only data from 2009 forward is shown due to the lack of catch of red grouper until sampling expanded onto the West Florida Shelf.

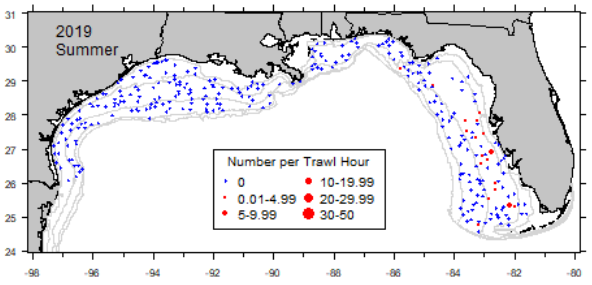


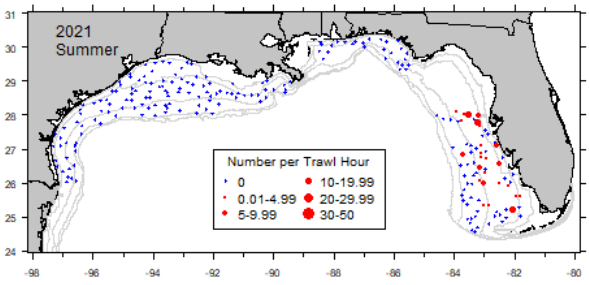

2015
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50

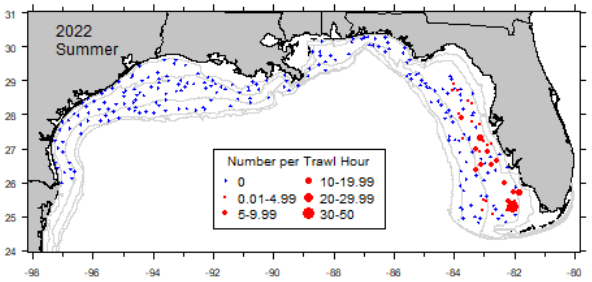

2016
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50


2017
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50

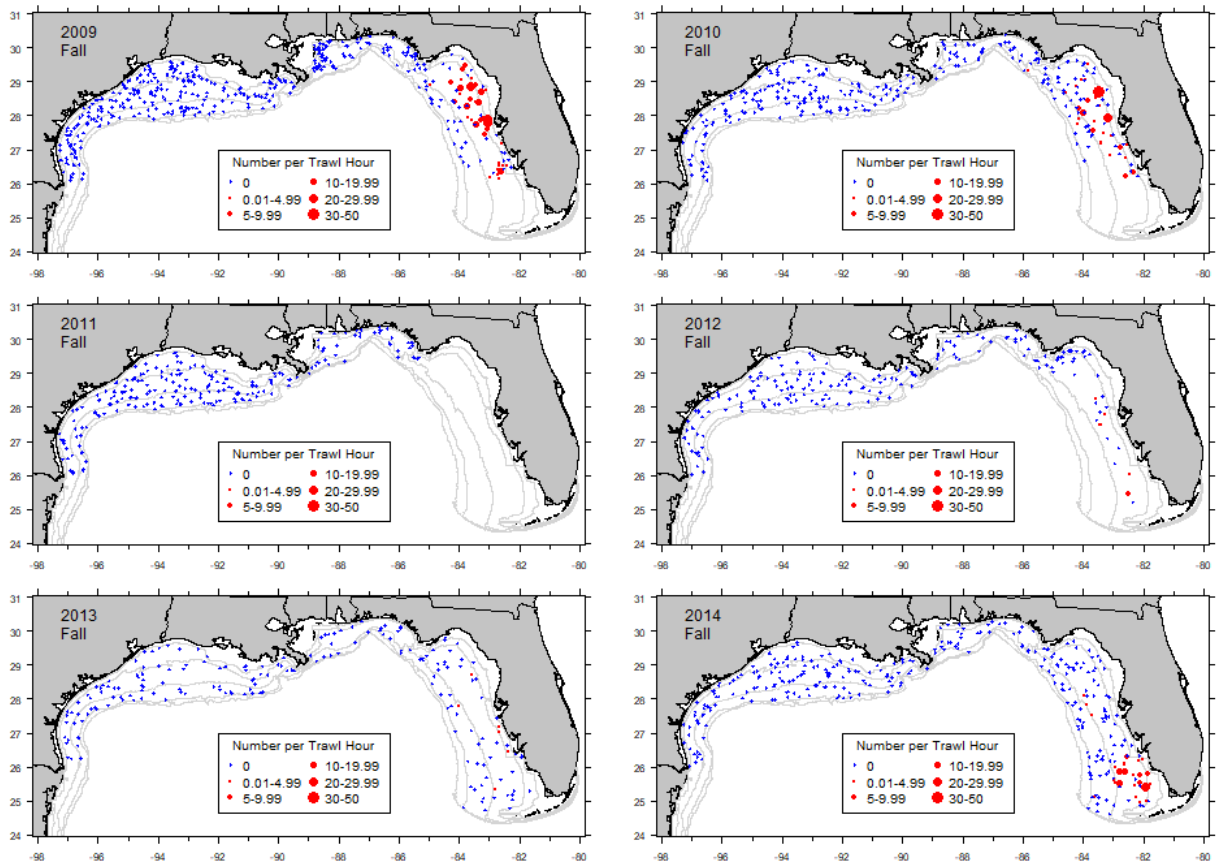

2018
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50

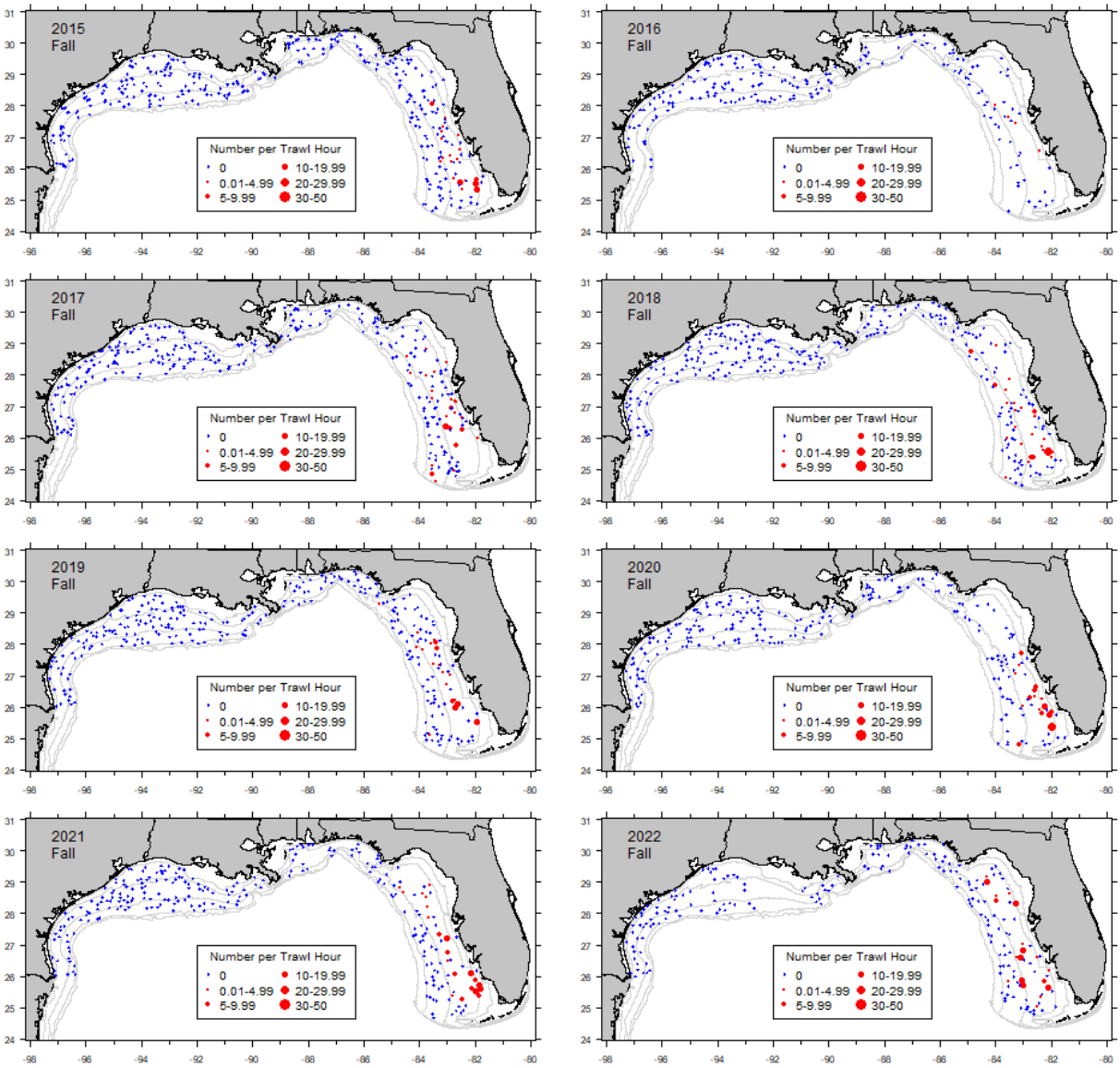

2019
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50


2021
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50


2022
Summer
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50

Appendix Figure 2. Annual survey effort and catch of red grouper from the SEAMAP Summer Groundfish Surveys. Note that only data from 2009 forward is shown due to the lack of catch of red grouper until sampling expanded onto the West Florida Shelf.




2015
Fall
2016
Fall
2017
Fall
2018
Fall
2019
Fall
2020
Fall
2021
Fall
2022
Fall
Number per Trawl Hour
0
0.01-4.99
5-9.99
10-19.99
20-29.99
30-50