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Yellowedge Grouper Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico

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Abstract: *The National Marine Fisheries Center, Southeast Fisheries Science Center, Mississippi Laboratories (NMFS) has conducted standardized bottom longline surveys in the Gulf of Mexico (GOM), Caribbean, and western North Atlantic Ocean (Atlantic) since 1995. Additionally in 2011, the Congressional Supplemental Sampling Program (CSSP) was conducted, where high levels of standardized bottom longline survey effort were maintained from April through October. Data from the NMFS Bottom Longline Survey and the CSSP Survey were used to produce a relative abundance index for yellowedge grouper (Hyporthodus flavolimbatus) from 2000 to 2021. Two abundance indices were calculated for yellowedge grouper, with one calculated for the western GOM and the second was calculated for the eastern GOM.*

Introduction

The National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories (MSLABS) has conducted standardized bottom longline (BLL) surveys in the Gulf of Mexico (GOM), Caribbean, and western North Atlantic Ocean (Atlantic) since 1995. The objective of these surveys is to provide fisheries independent data for stock assessment purposes for as many species as possible. These surveys are conducted annually in U.S. waters of the GOM and/or the Atlantic, and provide an important source of fisheries independent information on sharks, snappers and groupers. The evolution of these surveys has been the subject of many documents [e.g., Ingram *et al*. 2005 (LCS05/06-DW-27)] and will not be described again in this document.

In 2011, the Congressional Supplemental Sampling Program (CSSP) focused on completing monthly gulfwide bottom longline surveys in the U.S. northern GOM from April through October (for a full review of the CSSP see Campbell et al. 2012). Sampling during the CSSP program was conducted using the same gear as the SEFSC BLL survey, and a similar survey design. The primary differences between the SEFSC BLL and CSSP surveys were in the depth range of coverage and the proportion of samples allocated to each depth strata. The NMFS SEFSC BLL survey samples in depths ranging from 9 to 366 m with 50% of samples in depths of 9 to 55 m, 40% of samples in depths of 55 to 183 m and 10% of samples in depths of 183 to 366 m, with samples allocated to defined longitude/latitude divisions within each depth strata by the proportion of spatial area in each division. In contrast, the CSSP survey sampled depths from 9 to 400m with samples allocated proportionally by the spatial area of 38 strata based on longitude/latitude divisions and 3 depth strata (9 to 55 m, 55 to 183 m and 183 to 400 m). The purpose of this document is to provide abundance indices for yellowedge grouper *(Hyporthodus flavolimbatus)*.

Methodology

Survey Design

Details concerning methodologies and evolution of the NMFS BLL have been covered in previous documents (most recently LCS05/06-DW-27). Basic sample design was a proportional allocation of stations based on continental shelf width within statistical zones and stratified by depth (50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m). When the survey began in 1995, J-hooks were the standard gear. Over time a change was made to 15/0 circle hooks. Henwood *et al.* (2005) examined the difference in catch rates between the two hooks types and found significant difference in catch rates for yellowedge grouper.

Data

Data for the annual BLL survey and the CSSP survey was queried from the SEFSC MSLABS ORACLE database. Data from the CSSP was used to fill in gaps in the annual BLL survey due to vessel breakdowns and weather delays in 2011. Only data from the August survey was used for the Eastern GOM and only data from the September survey was used for the Western and Central GOM in order to not over represent any one area of the GOM. These time frames historically match up with when the annual BLL survey sampled those areas. For this document, the combined dataset will be hereafter referred to as NMFS BLL.

Data Exclusions

We used the time series of data between 2000 and 2021 to develop yellowedge grouper abundance indices (Table 1). Data prior to 2000 were excluded due to low encounters with yellowedge grouper and for the use of J hooks during the survey (Henwood *et al.* 2005). In addition, data from 2020 was excluded because of the low number of samples taken in a relatively small area due to global pandemic. All stations completed at depths less than 70 m were excluded from the analytical dataset due to zero encounters with yellowedge grouper over the course of the time series. After limiting the data, 1,386 stations were used in the analysis.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for yellowedge grouper (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) $$p = \frac{e^{X\beta+\varepsilon}}{1+e^{X\beta+\varepsilon}},$$

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 – Western Gulf of Mexico

Year: 2000 – 2004, 2006 – 2019, 2021
Depth: 70 – 387 m (continuous)
Area: Central GOM (89°W – 93°W), Western GOM (west of 93°W)
Time of Day: Day, Night

Submodel Variables – Eastern Gulf of Mexico

Year: 2000 – 2019, 2021
Depth: 70 – 387 m (continuous)
Area: Eastern GOM (east of 88°W), Central GOM (87°W – 88°W)
Time of Day: Day, Night

Results and Discussion

Size and Distribution

The distribution of yellowedge grouper is presented in Figure 1, with annual abundance and distribution presented in Appendix Figure 1. There were 7 to 107 yellowedge grouper captured per year (Table 2). Of the 619 yellowedge grouper captured, 597 were measured from 2000 – 2021 with an average total length of 715 mm.

Abundance Index

For the NMFS BLL abundance index of yellowedge grouper (western GOM), year was retained in the binomial submodel, while year 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 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 2624.8 and 218.4, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 4. Annual abundance indices are presented in Table 4 and Figure 5.

For the NMFS BLL abundance index of yellowedge grouper (eastern GOM), year, depth, and area were retained in the binomial submodel, while year was retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 2. Table 5 summarizes 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 3933.8 and 295.8, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 6. Annual abundance indices are presented in Table 6 and Figure 7.

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Table 1. Summary of the total number of stations sampled per year used in the analysis.

	Gulf of Mexico		
Year	East	West	Total
2000	52	46	98
2001	54	44	98
2002	20	55	75
2003	61	28	89
2004	55	30	85
2005	38		38
2006	28	27	55
2007	36	26	62
2008	24	8	32
2009	38	32	70
2010	29	24	53
2011	103	81	184
2012	33	21	54
2013	37	20	57
2014	27	14	41
2015	32	20	52
2016	31	21	52
2017	29	24	53
2018	34	23	57
2019	24	14	38
2020			0
2021	28	15	43
Total	*813*	*573*	*1386*

Table 2. Summary of yellowedge grouper length data collected from NMFS Bottom Longline surveys conducted between 2000 and 2021.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Total Length (mm)	Maximum Total Length (mm)	Mean Total Length (mm)	Standard Deviation
2000	98	33	32	505	1050	761	145
2001	98	28	28	490	991	748	151
2002	75	30	29	374	1100	748	161
2003	89	53	52	363	1005	648	158
2004	85	37	34	422	972	679	147
2005	38	12	12	516	932	726	113
2006	55	33	33	481	1228	756	170
2007	62	37	37	423	980	729	133
2008	32	9	9	565	900	714	130
2009	70	38	36	418	1010	703	179
2010	53	28	25	423	990	751	125
2011	184	107	99	441	1030	692	135
2012	54	21	21	440	890	692	136
2013	57	28	28	510	1040	732	136
2014	41	25	24	502	905	699	101
2015	52	21	21	545	960	721	122
2016	52	29	29	452	942	700	133
2017	53	13	13	496	1136	756	209
2018	57	16	15	539	915	733	116
2019	38	7	7	431	891	726	166
2020	0	0					
2021	43	14	13	610	945	775	112

Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured	Overall Mean Total Length (mm)
22	1386	619	597	715

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for western Gulf of Mexico yellowedge grouper index of relative abundance from 2000 to 2021.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 2647.0)*						*Lognormal Submodel Type 3 Tests (AIC 229.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	550	8.14	0.43	0.9852	0.9845	19	110	2.26	0.0045
Depth	1	550	0.10	0.10	0.7544	0.7545	1	110	3.17	0.0775
Area	1	550	3.42	3.42	0.0644	0.0649	1	110	0.05	0.8178
Time of Day	1	550	1.15	1.15	0.2839	0.2843	1	110	8.44	0.0044
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 2635.4)*						*Lognormal Submodel Type 3 Tests (AIC 227.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	551	8.27	0.44	0.9837	0.9829	19	111	2.28	0.0041
Depth				Dropped			1	111	3.27	0.0732
Area	1	551	3.34	3.34	0.0675	0.0680		Dropped		
Time of Day	1	551	1.15	1.15	0.2833	0.2837	1	111	8.51	0.0043
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 2634.0)*						*Lognormal Submodel Type 3 Tests (AIC 218.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	552	8.14	0.43	0.9852	0.9845	19	112	2.13	0.0077
Depth				Dropped				Dropped		
Area	1	552	3.49	3.49	0.0618	0.0623		Dropped		
Time of Day				Dropped			1	112	8.52	0.0042
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 2624.8)*						*Lognormal Submodel Type 3 Tests (AIC 218.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	19	553	8.00	0.42	0.9867	0.9860	19	112	2.13	0.0077
Depth				Dropped				Dropped		
Area				Dropped				Dropped		
Time of Day				Dropped			1	112	8.52	0.0042

Table 4. Indices of western Gulf of Mexico yellowedge grouper abundance developed using the delta-lognormal model for 2000-2021. 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
2000	0.26087	46	0.39952	0.91675	0.29643	0.51307	1.63805
2001	0.27273	44	0.46040	1.05646	0.29470	0.59319	1.88155
2002	0.23636	55	0.38256	0.87784	0.28876	0.49843	1.54605
2003	0.28571	28	0.39942	0.91653	0.35796	0.45766	1.83546
2004	0.23333	30	0.50473	1.15818	0.39283	0.54291	2.47070
2005							
2006	0.29630	27	0.68839	1.57963	0.35672	0.79057	3.15623
2007	0.19231	26	0.31845	0.73074	0.47330	0.29734	1.79586
2008	0.25000	8	0.47503	1.09003	0.72328	0.29786	3.98901
2009	0.21875	32	0.47427	1.08828	0.39522	0.50796	2.33157
2010	0.29167	24	0.83192	1.90897	0.38168	0.91302	3.99136
2011	0.19753	81	0.61664	1.41497	0.26525	0.83995	2.38363
2012	0.28571	21	0.56953	1.30686	0.41511	0.58871	2.90105
2013	0.35000	20	0.64294	1.47534	0.36983	0.72094	3.01913
2014	0.21429	14	0.68248	1.56605	0.60267	0.51442	4.76753
2015	0.25000	20	0.34491	0.79144	0.46044	0.32927	1.90234
2016	0.19048	21	0.26641	0.61132	0.53013	0.22595	1.65399
2017	0.16667	24	0.19272	0.44222	0.53446	0.16227	1.20511
2018	0.13043	23	0.15627	0.35859	0.62672	0.11341	1.13384
2019	0.14286	14	0.17944	0.41175	0.76278	0.10628	1.59529
2020							
2021	0.13333	15	0.12989	0.29806	0.76487	0.07670	1.15824

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for eastern Gulf of Mexico yellowedge grouper index of relative abundance from 2000 to 2021.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 3934.9)*						*Lognormal Submodel Type 3 Tests (AIC 308.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	789	16.99	0.85	0.6536	0.6529	20	132	0.93	0.5554
Depth	1	789	10.24	10.24	0.0014	0.0014	1	132	0.55	0.4594
Area	1	789	9.93	9.93	0.0016	0.0017	1	132	0.00	0.9842
Time of Day	1	789	0.16	0.16	0.6875	0.6876	1	132	1.96	0.1634
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 3933.8)*						*Lognormal Submodel Type 3 Tests (AIC 307.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	790	16.93	0.85	0.6572	0.6565	20	133	0.99	0.4746
Depth	1	790	10.32	10.32	0.0013	0.0014	1	133	0.56	0.4573
Area	1	790	9.90	9.90	0.0017	0.0017		Dropped		
Time of Day				Dropped			1	133	2.00	0.1597
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 3933.8)*						*Lognormal Submodel Type 3 Tests (AIC 296.6)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	790	16.93	0.85	0.6572	0.6565	20	134	0.97	0.4978
Depth	1	790	10.32	10.32	0.0013	0.0014		Dropped		
Area	1	790	9.90	9.90	0.0017	0.0017		Dropped		
Time of Day				Dropped			1	134	1.83	0.1782
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 3933.8)*						*Lognormal Submodel Type 3 Tests (AIC 295.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	790	16.93	0.85	0.6572	0.6565	20	135	1.08	0.3785
Depth	1	790	10.32	10.32	0.0013	0.0014		Dropped		
Area	1	790	9.90	9.90	0.0017	0.0017		Dropped		
Time of Day				Dropped				Dropped		

Table 6. Indices of eastern Gulf of Mexico yellowedge grouper abundance developed using the delta-lognormal model for 2000-2021. 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
2000	0.13462	52	0.25769	1.02179	0.46693	0.42036	2.48373
2001	0.09259	54	0.07150	0.28350	0.56925	0.09826	0.81798
2002	0.25000	20	0.23873	0.94660	0.53524	0.34691	2.58295
2003	0.22951	61	0.37050	1.46908	0.36580	0.72317	2.98437
2004	0.16364	55	0.23924	0.94864	0.43754	0.41074	2.19094
2005	0.18421	38	0.15994	0.63421	0.48767	0.25178	1.59749
2006	0.21429	28	0.36036	1.42890	0.51442	0.54218	3.76586
2007	0.22222	36	0.37096	1.47092	0.45849	0.61402	3.52365
2008	0.08333	24	0.11404	0.45220	0.85729	0.10247	1.99556
2009	0.28947	38	0.47758	1.89371	0.39008	0.89211	4.01984
2010	0.17241	29	0.17364	0.68851	0.55892	0.24268	1.95339
2011	0.22330	103	0.27152	1.07662	0.30749	0.59018	1.96400
2012	0.21212	33	0.20576	0.81587	0.48161	0.32728	2.03386
2013	0.18919	37	0.25741	1.02068	0.47876	0.41144	2.53207
2014	0.18519	27	0.26595	1.05456	0.56582	0.36755	3.02573
2015	0.15625	32	0.21540	0.85410	0.56587	0.29765	2.45081
2016	0.32258	31	0.45750	1.81408	0.40752	0.82831	3.97301
2017	0.13793	29	0.18595	0.73732	0.62309	0.23452	2.31811
2018	0.23529	34	0.24821	0.98420	0.44662	0.41942	2.30946
2019	0.08333	24	0.09013	0.35739	0.86137	0.08055	1.58573
2020							
2021	0.21429	28	0.26408	1.04712	0.51593	0.39630	2.76670

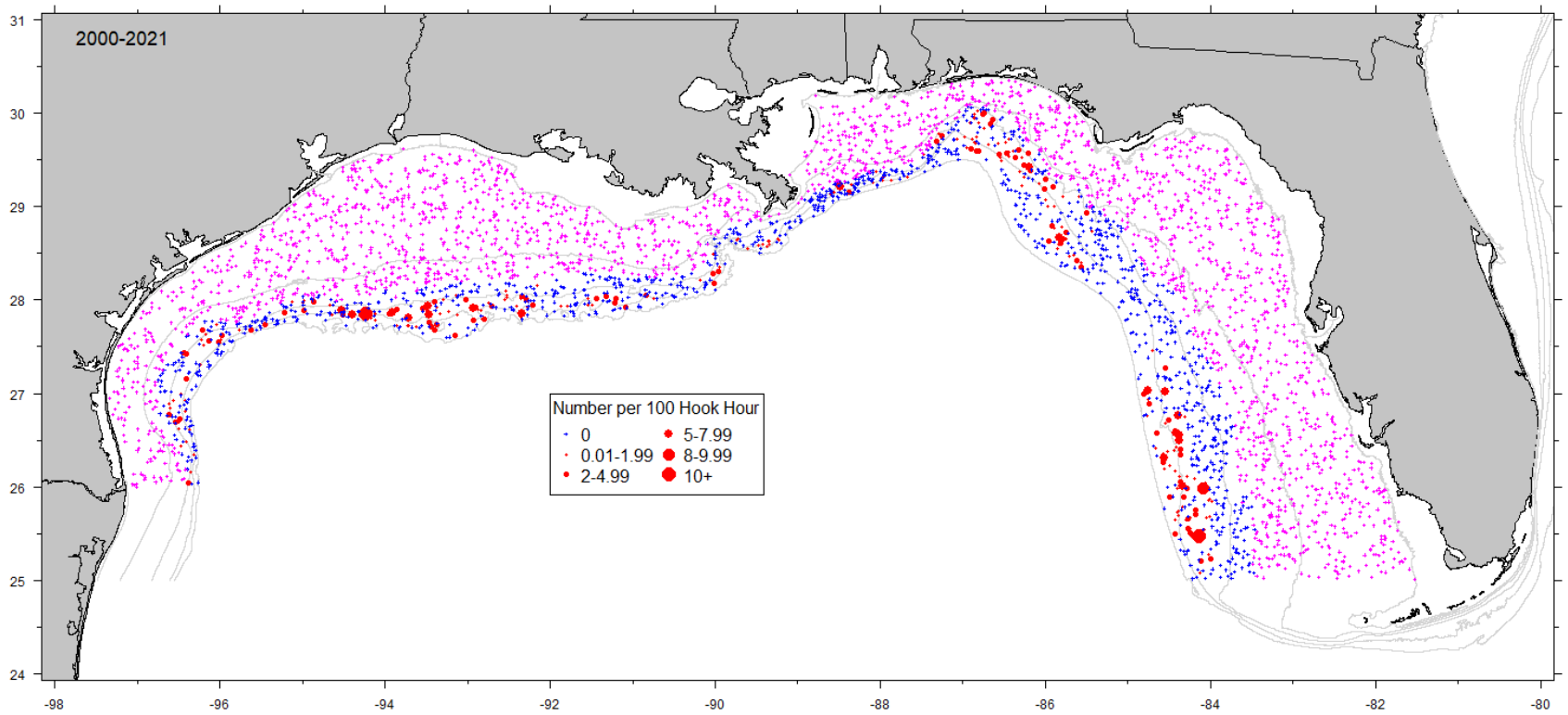


Figure 1. Stations sampled from 2000 to 2021 during the NMFS Bottom Longline Survey with the CPUE for yellowedge grouper. Note that stations in pink were in depth ranges excluded from analysis due to zero encounters with yellowedge grouper over the time series.

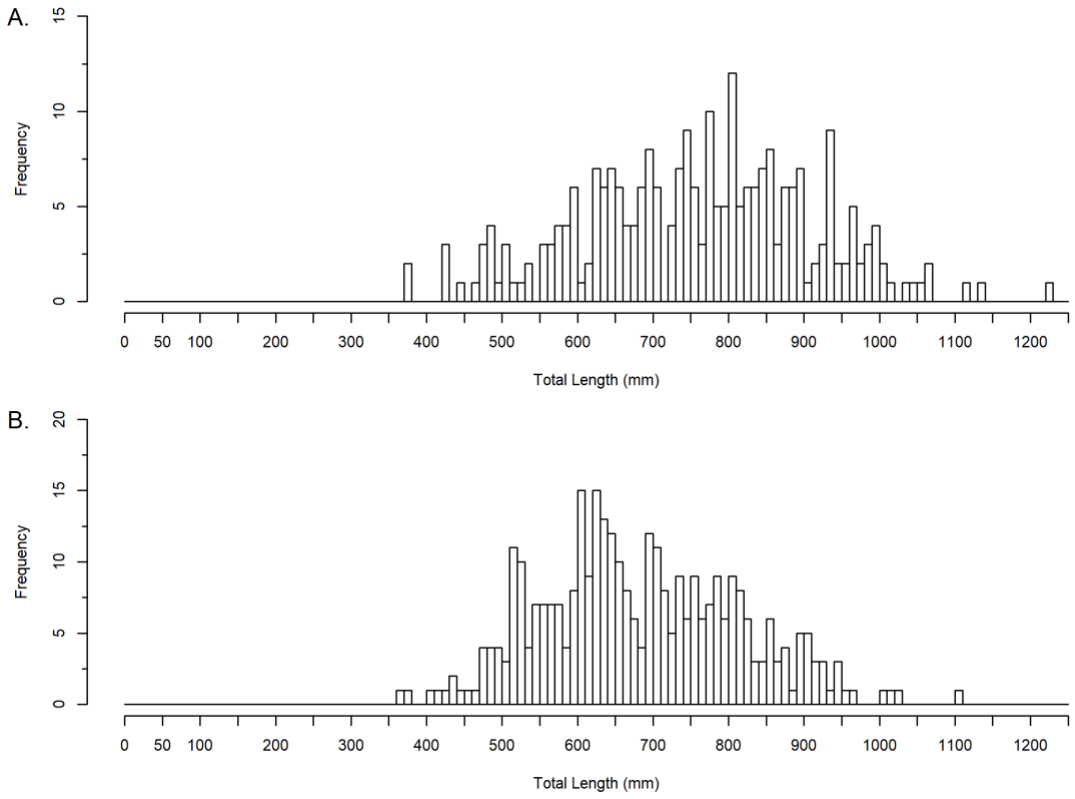


Figure 2. Length frequency histogram for yellowedge grouper captured during the NMFS Bottom Longline Survey from 2000-2021 in the **A.** western Gulf of Mexico and **B.** eastern Gulf of Mexico.

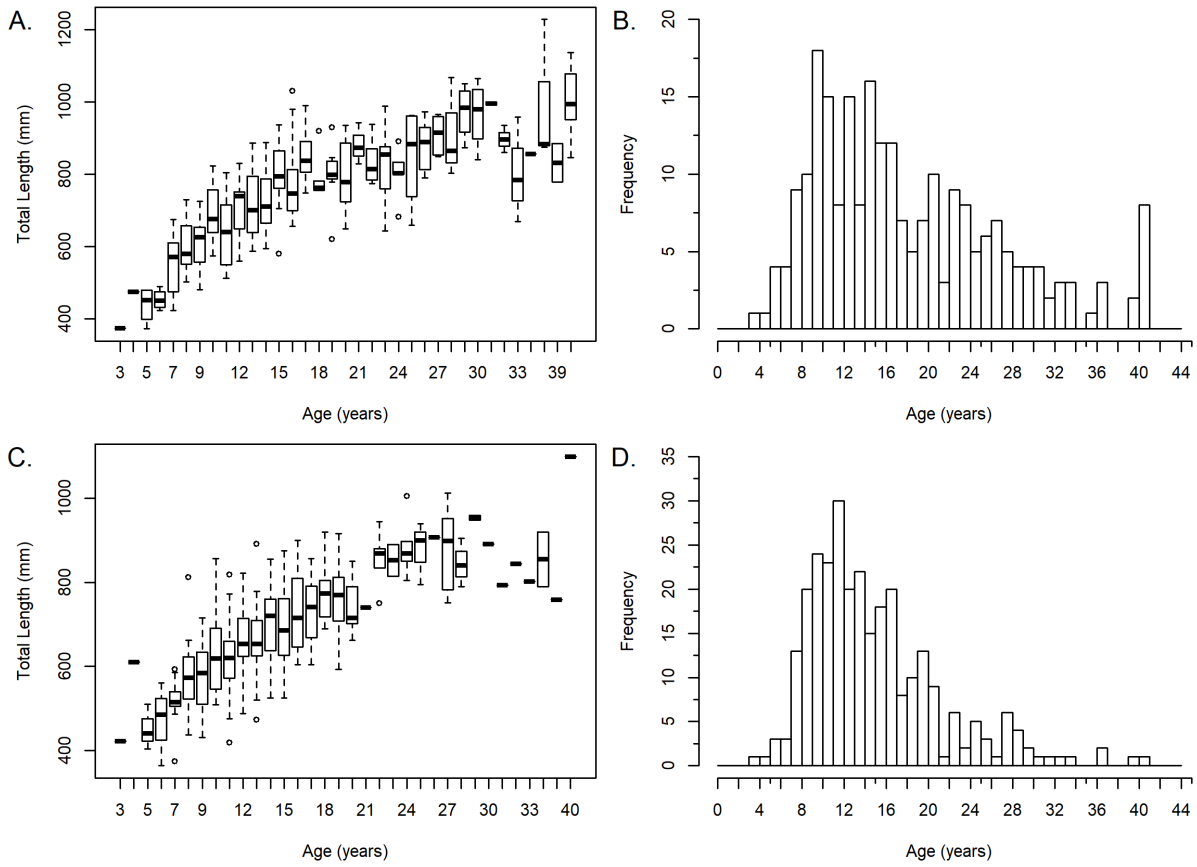


Figure 3. Breakdown of yellowedge grouper ages for fish caught during the NMFS Bottom Longline Survey from 2000-2021 in the **A.** western Gulf of Mexico and **B.** eastern Gulf of Mexico.

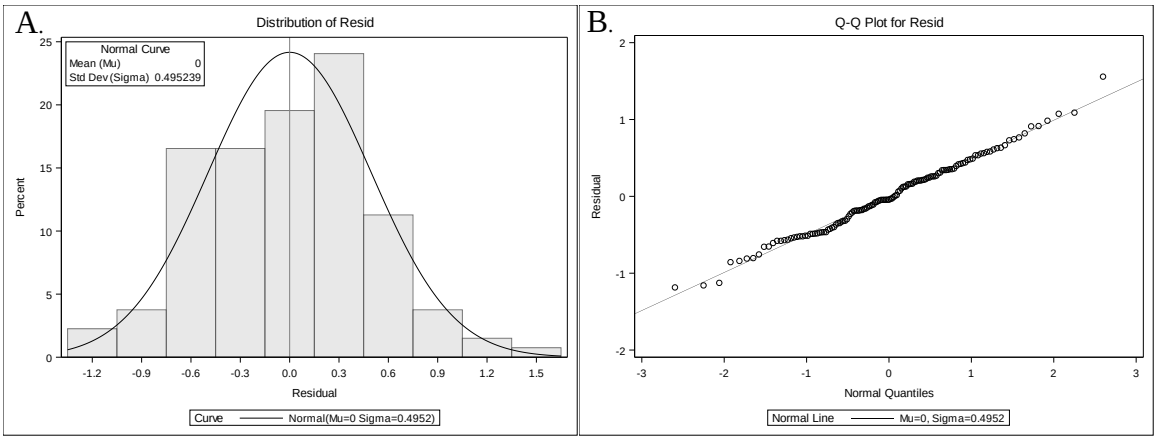


Figure 4. Diagnostic plots for lognormal component of the western Gulf of Mexico yellowedge grouper NMFS Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

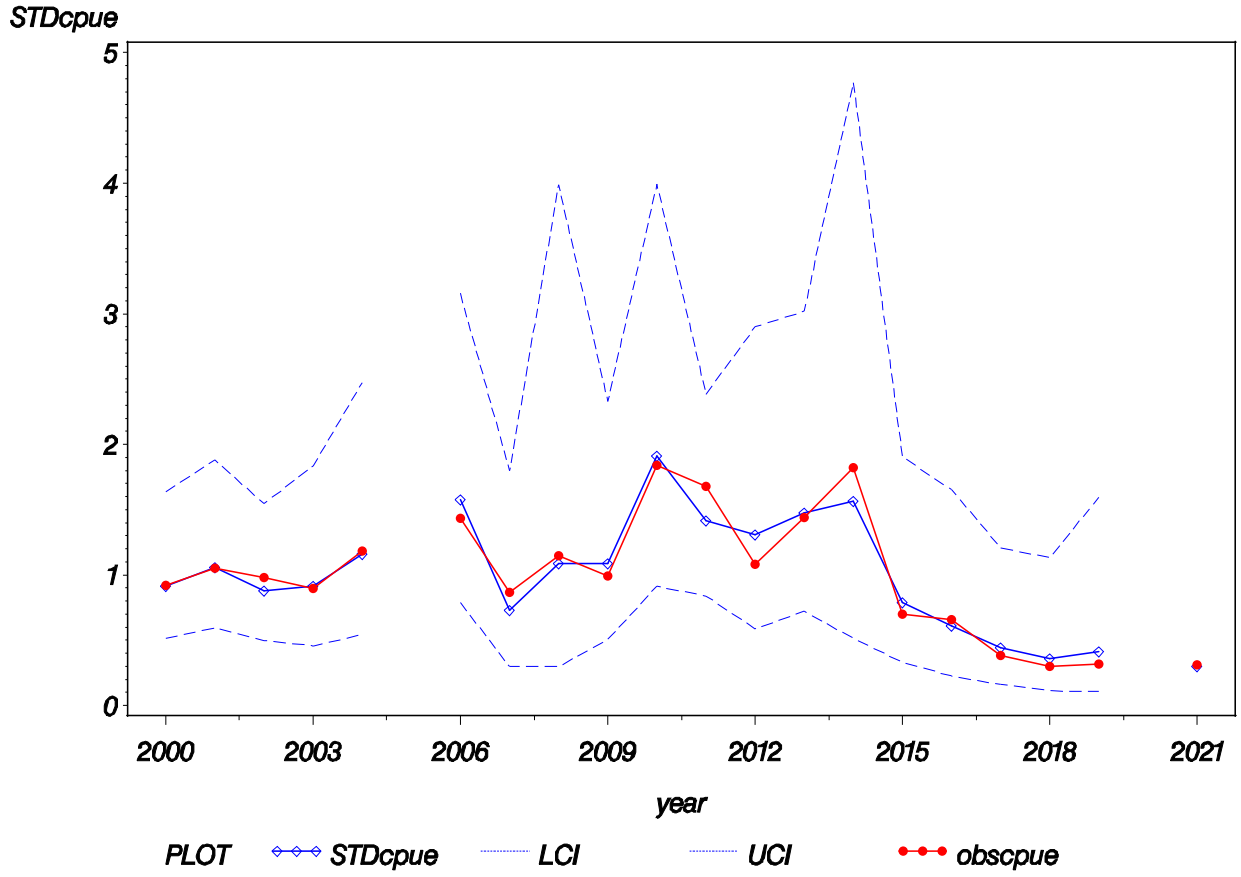


Figure 5. Annual index of abundance for western Gulf of Mexico yellowedge grouper from the NMFS Bottom Longline Surveys from 2000 – 2021.

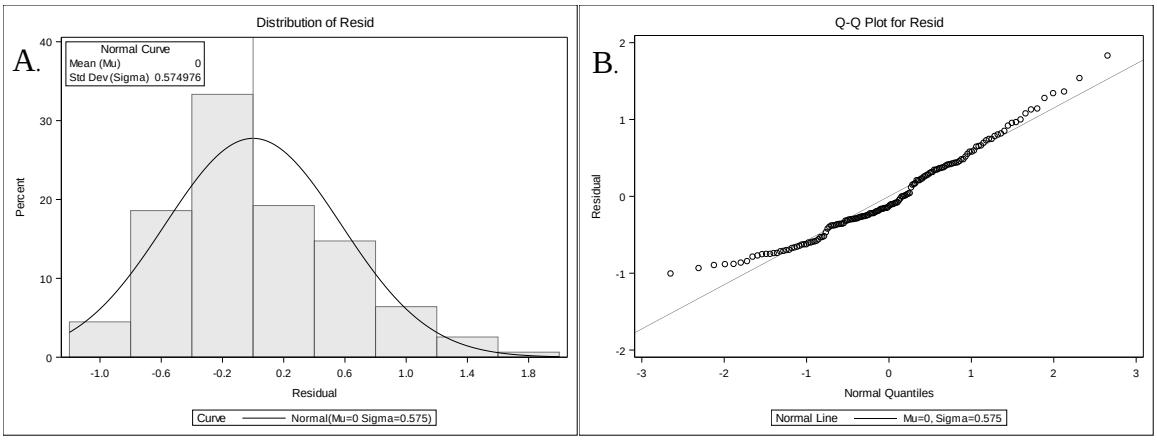


Figure 6. Diagnostic plots for lognormal component of the eastern Gulf of Mexico yellowedge grouper NMFS Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

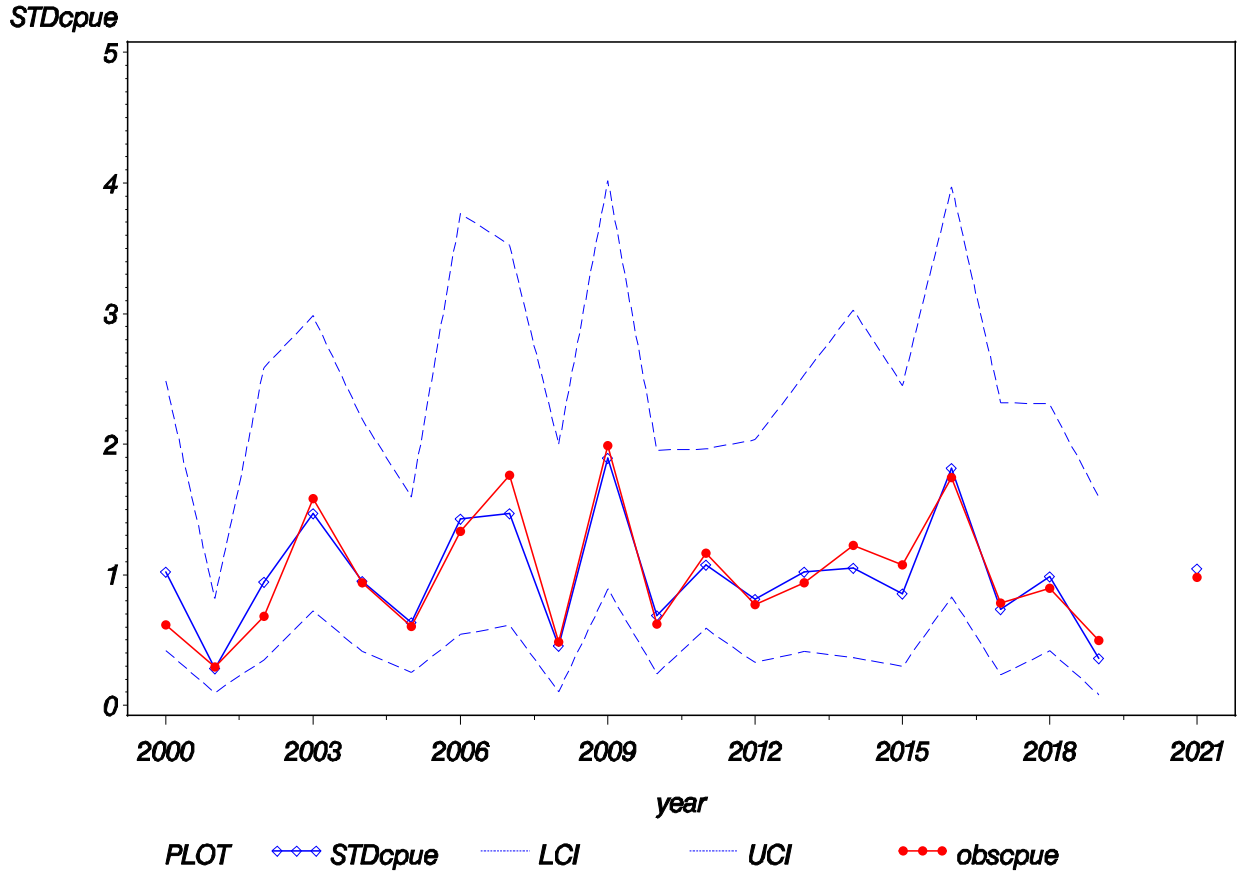


Figure 7. Annual index of abundance for eastern Gulf of Mexico yellowedge grouper from the NMFS Bottom Longline Surveys from 2000 – 2021.

Appendix

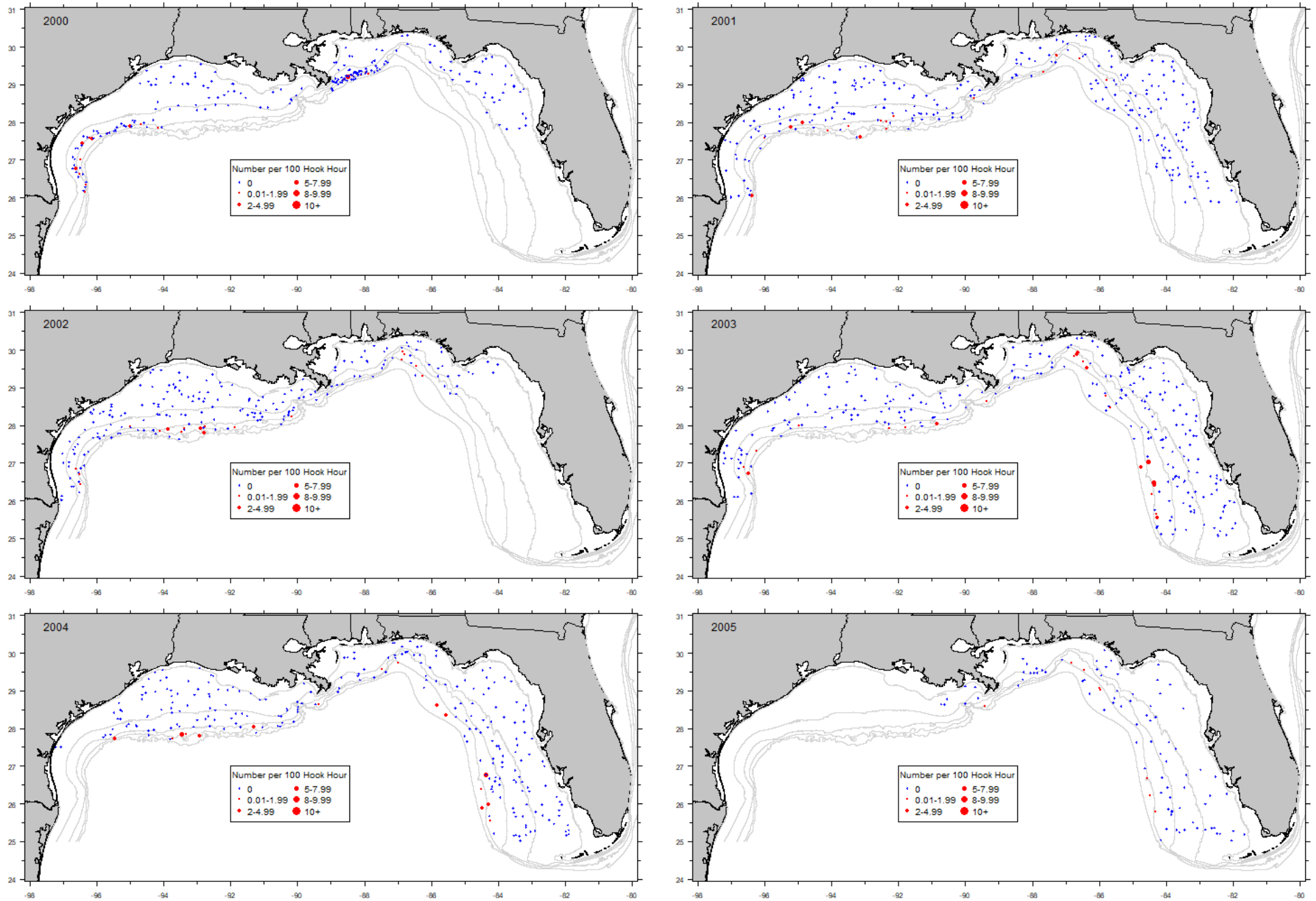
Appendix Table 1. Summary of the factors used in constructing the western Gulf of Mexico yellowedge grouper abundance index from the NMFS Bottom Longline Survey data.

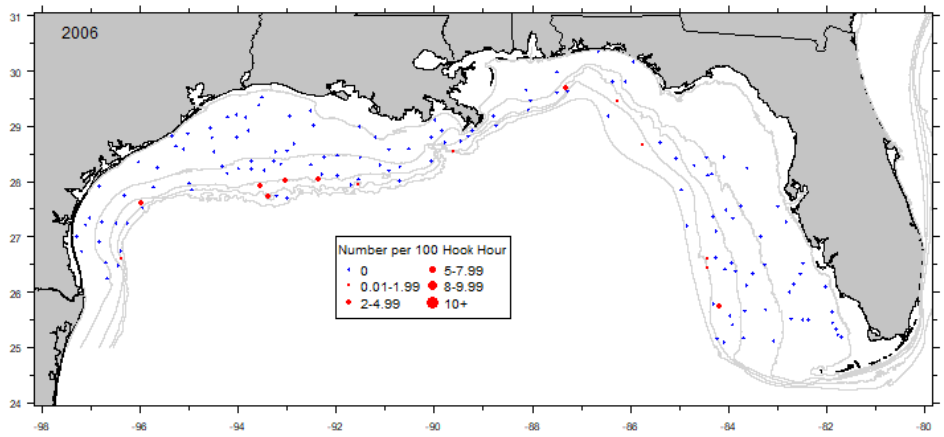
Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2000	46	12	0.26087	0.40254
Year	2001	44	12	0.27273	0.46029
Year	2002	55	13	0.23636	0.42762
Year	2003	28	8	0.28571	0.39251
Year	2004	30	7	0.23333	0.51667
Year	2005				
Year	2006	27	8	0.29630	0.62684
Year	2007	26	5	0.19231	0.37983
Year	2008	8	2	0.25000	0.50232
Year	2009	32	7	0.21875	0.43273
Year	2010	24	7	0.29167	0.80445
Year	2011	81	16	0.19753	0.73353
Year	2012	21	6	0.28571	0.47257
Year	2013	20	7	0.35000	0.63063
Year	2014	14	3	0.21429	0.79782
Year	2015	20	5	0.25000	0.30600
Year	2016	21	4	0.19048	0.28658
Year	2017	24	4	0.16667	0.16813
Year	2018	23	3	0.13043	0.13127
Year	2019	14	2	0.14286	0.14012
Year	2020				
Year	2021	15	2	0.13333	0.13676
Area	West Gulf	317	83	0.26183	0.54022
Area	Central Gulf	256	50	0.19531	0.38215
Time of Day	Day	316	79	0.25000	0.56828
Time of Day	Night	257	54	0.21012	0.34827

Appendix Table 2. Summary of the factors used in constructing the eastern Gulf of Mexico yellowedge grouper abundance index from the NMFS Bottom Longline Survey data.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2000	52	7	0.13462	0.26138
Year	2001	54	5	0.09259	0.12370
Year	2002	20	5	0.25000	0.28927
Year	2003	61	14	0.22951	0.66852
Year	2004	55	9	0.16364	0.39757
Year	2005	38	7	0.18421	0.25505
Year	2006	28	6	0.21429	0.56234
Year	2007	36	8	0.22222	0.74466
Year	2008	24	2	0.08333	0.20600
Year	2009	38	11	0.28947	0.83980
Year	2010	29	5	0.17241	0.26294
Year	2011	103	23	0.22330	0.49366
Year	2012	33	7	0.21212	0.32710
Year	2013	37	7	0.18919	0.39763
Year	2014	27	5	0.18519	0.51880
Year	2015	32	5	0.15625	0.45495
Year	2016	31	10	0.32258	0.73725
Year	2017	29	4	0.13793	0.33124
Year	2018	34	8	0.23529	0.37939
Year	2019	24	2	0.08333	0.21116
Year	2020				
Year	2021	28	6	0.21429	0.41481
Area	Central Gulf	103	8	0.07767	0.15881
Area	East Gulf	710	148	0.20845	0.47329
Time of Day	Day	439	87	0.19818	0.48371
Time of Day	Night	374	69	0.18449	0.37445

Appendix Figure 1. Annual survey effort and catch of yellowedge grouper from the NMFS bottom longline survey (2000-2021).

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Number per 100 Hook Hour
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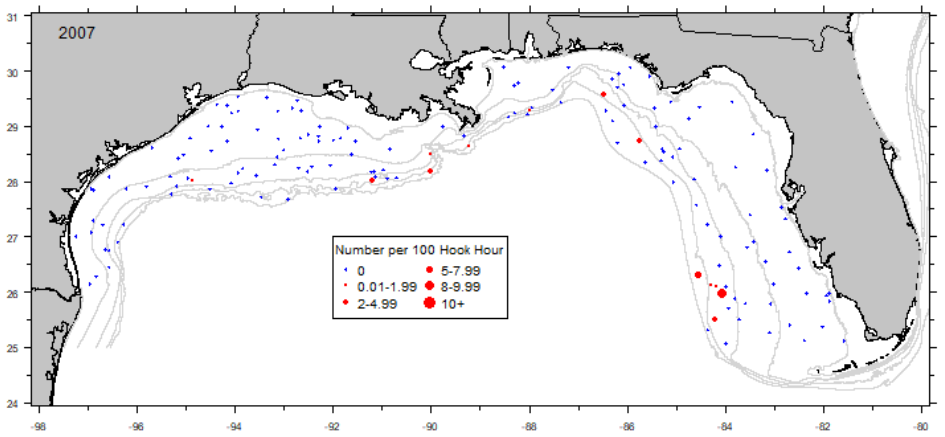
2-4.99
5-7.99
8-9.99
10+


2007
Number per 100 Hook Hour
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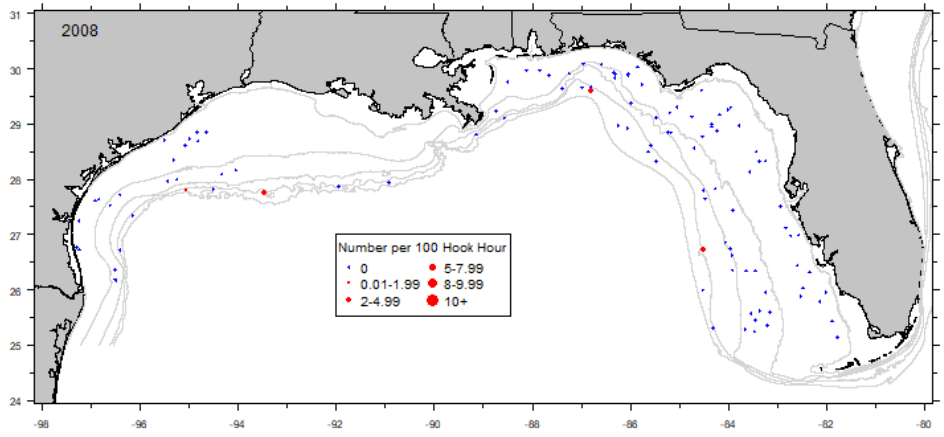
5-7.99
8-9.99
10+


2008
Number per 100 Hook Hour
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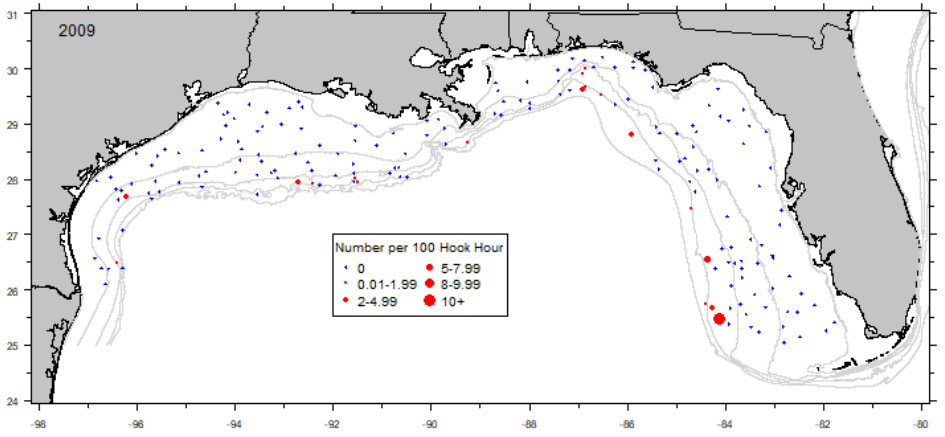
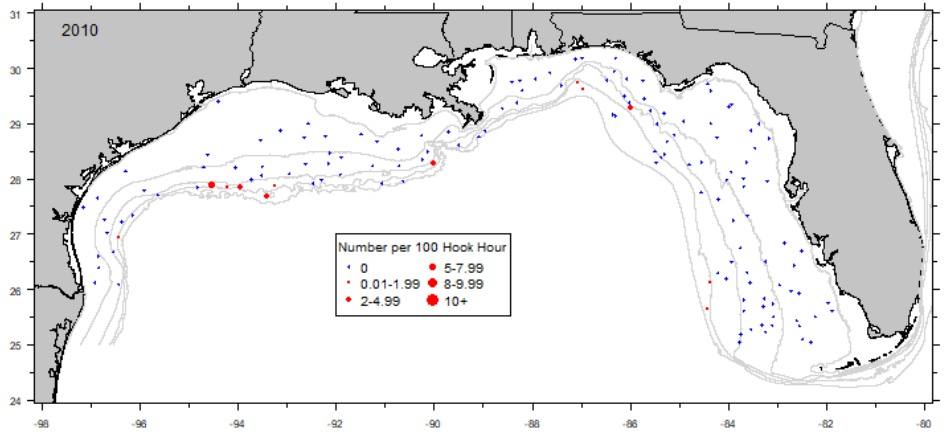
2-4.99
5-7.99
8-9.99
10+


2009
Number per 100 Hook Hour
0
0.01-1.99
2-4.99
5-7.99
8-9.99
10+


2010
Number per 100 Hook Hour
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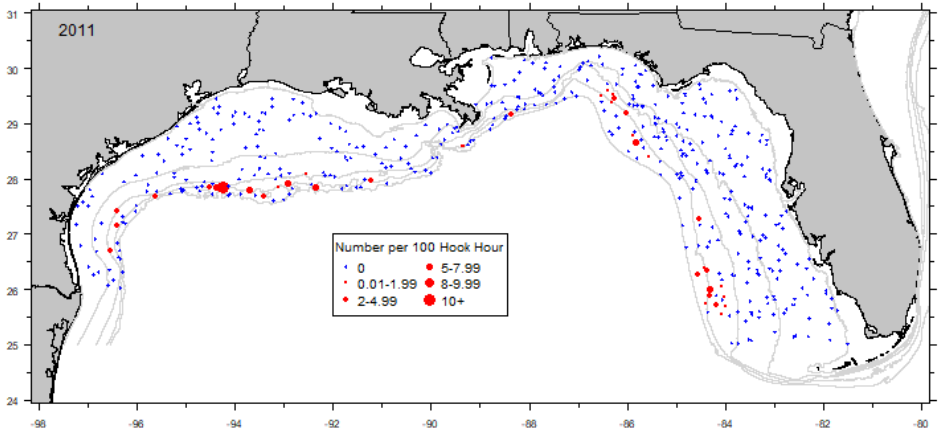
5-7.99
8-9.99
10+


2011
Number per 100 Hook Hour
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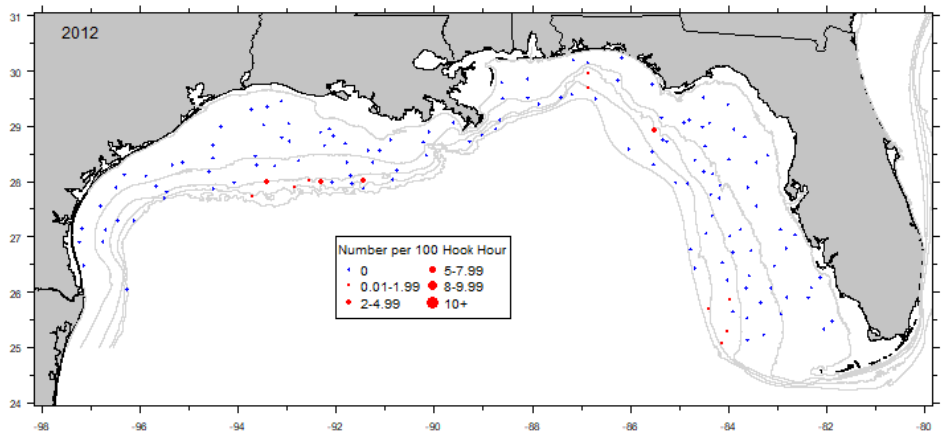
2-4.99
5-7.99
8-9.99
10+


2012
Number per 100 Hook Hour
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0.01-1.99
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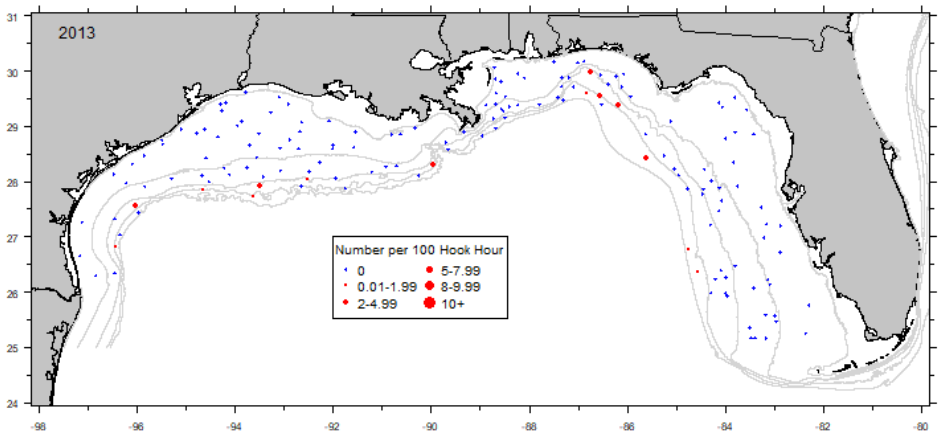
5-7.99
8-9.99
10+


2013
Number per 100 Hook Hour
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0.01-1.99
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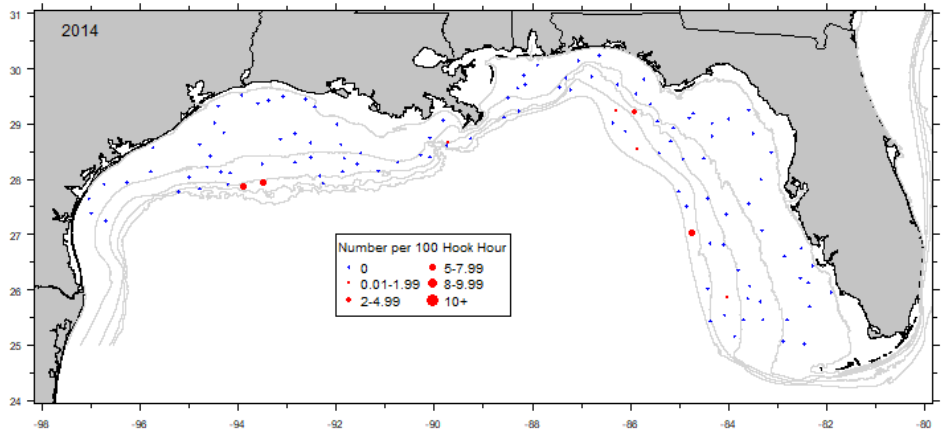
5-7.99
8-9.99
10+


2014
Number per 100 Hook Hour
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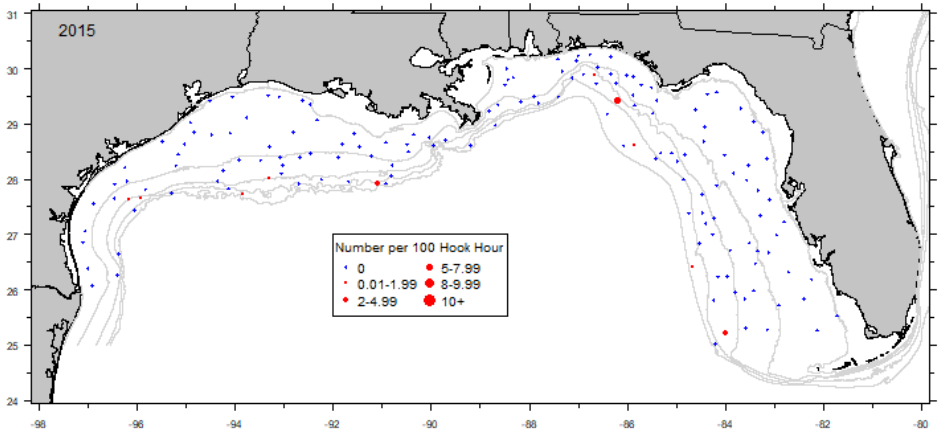
0.01-1.99
2-4.99
5-7.99
8-9.99
10+


2015
Number per 100 Hook Hour
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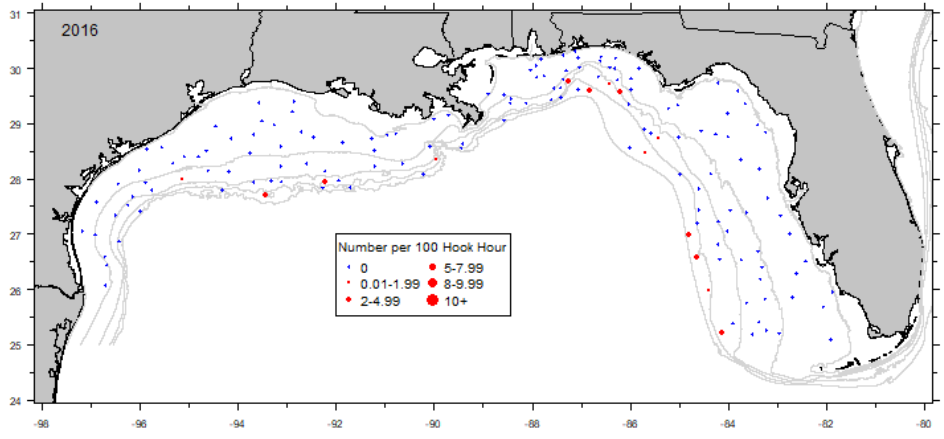
0.01-1.99
2-4.99
5-7.99
8-9.99
10+


2016
Number per 100 Hook Hour
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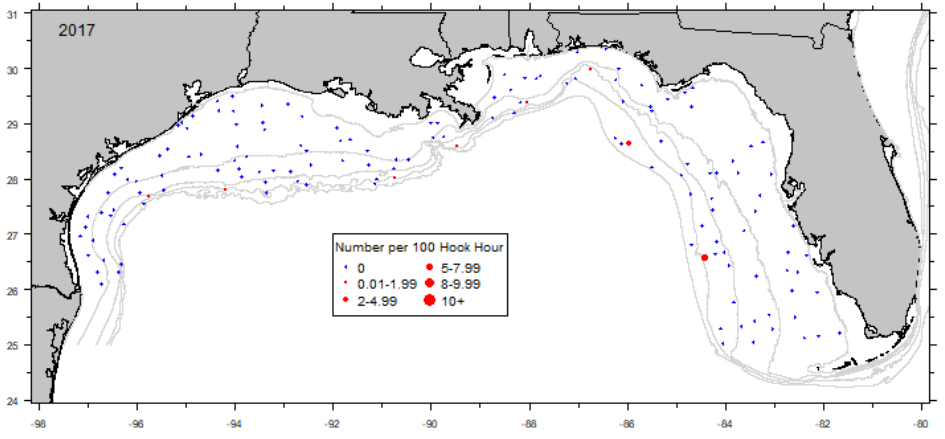
0.01-1.99
2-4.99
5-7.99
8-9.99
10+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Number per 100 Hook Hour
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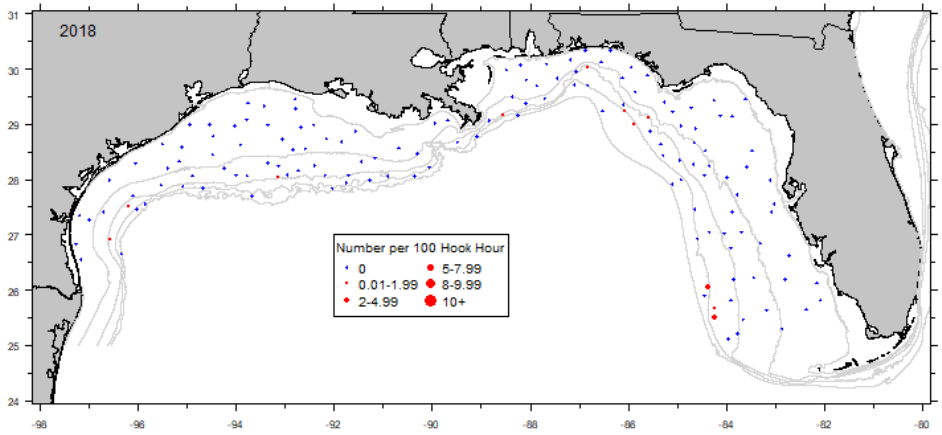
0.01-1.99
2-4.99
5-7.99
8-9.99
10+


2018
Number per 100 Hook Hour
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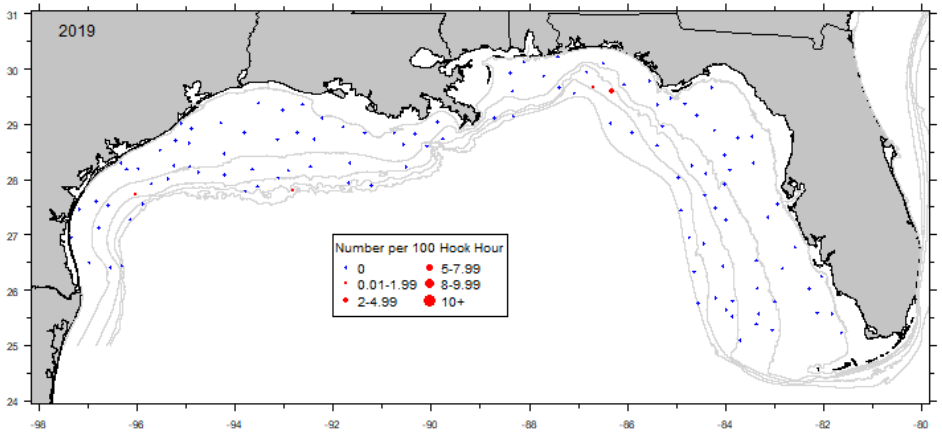
0.01-1.99
2-4.99
5-7.99
8-9.99
10+


2019
Number per 100 Hook Hour
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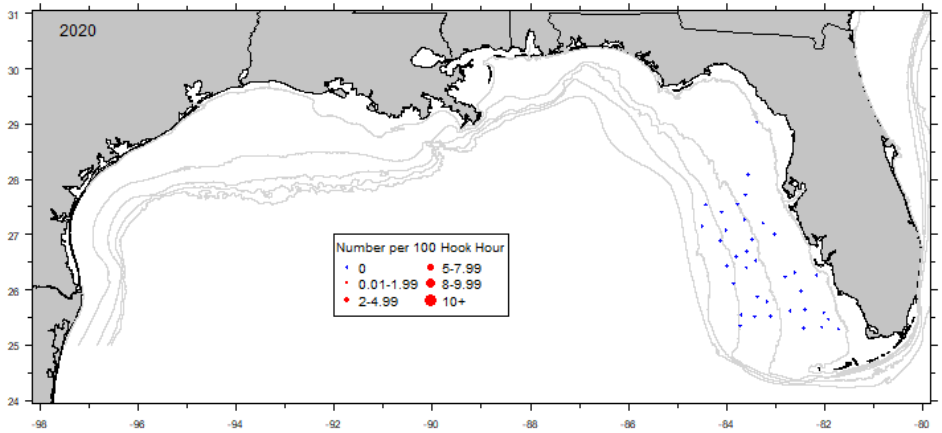
0.01-1.99
2-4.99
5-7.99
8-9.99
10+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Number per 100 Hook Hour
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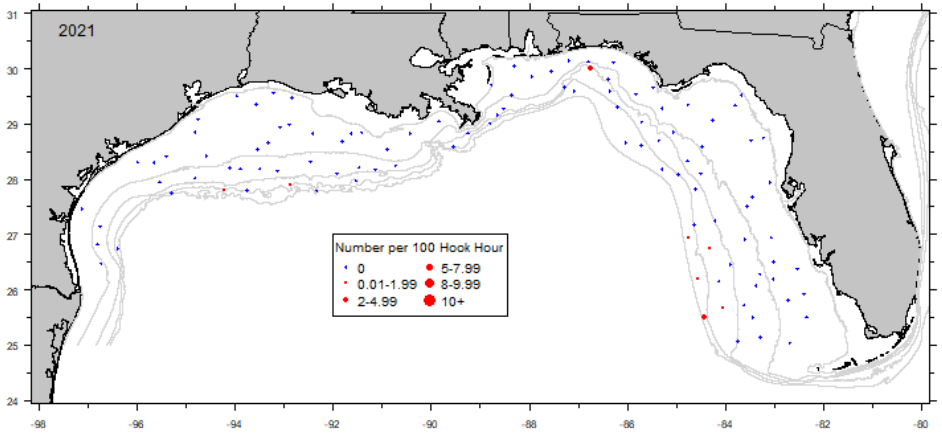
2-4.99
5-7.99
8-9.99
10+


2021
Number per 100 Hook Hour
0
0.01-1.99
2-4.99
5-7.99
8-9.99
10+