STANDARDIZED CATCH RATES FOR GAG GROUPER (*Mycteroperca microlepis*) FROM THE MARINE RECREATIONAL FISHERIES STATISTICAL SURVEY (MRFSS).

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SUMMARY

Catch and effort data from the US Marine Recreational Fisheries Statistical Survey of the Atlantic coast and Gulf of Mexico (excluding Texas) were used to update indices of abundance for the gag grouper Gulf of Mexico and Atlantic stocks. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution. The explanatory variables considered for standardization included: geographical area, seasonal trimesters, fishing target species, and mode (a factor that classifies recreational fishing in shore, charter or private/rental boat).

KEY WORDS

Catch/effort, abundance, recreational fisheries, gag, groupers

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Introduction:

Indices of abundance from recreational fisheries have been used to tune stock assessment models (Quinn and Deriso 1999). Data collected and estimated by the Marine Recreational Fisheries Statistical Survey (MRFSS) were used to develop standardized catch per unit effort (CPUE) indices for gag stocks of the Gulf of Mexico and Atlantic. The recreational fisheries survey started in 1979, and its purpose is to establish a reliable database for estimating the impact of marine recreational fishing on marine resources. More detailed information on the methods and protocols of the survey can be found at http://www.st.nmfs.gov/st1/recreational/overview/ overview.html. This Report updates the methods applied to the available US recreational data through 2004, and presents a number of gag standardized indices for Gulf or Mexico (GOM) and Atlantic (ATL) stocks. Standardized catch rates were estimated using the Generalized Linear Mixed Model (GLMM) approach.

Materials and methods:

The MRFSS estimates of catch and effort were based on intercept (i.e. interview at dock) and telephone surveys. Each record report included: the catch in numbers of all caught species and whether it was retained, or released alive or death, number of participating anglers and number of fishing hours, information on gear used, target species, mode (shore, headboat, charter, or private/rental), area (inshore, ocean < 3 miles, 3 < ocean < 10 miles, ocean > 10 miles), county/state, and date. Headboat mode trip/interviews were not included in any of the present analyses. Frequency and sampling design of interview and telephone surveys were based on demographic and seasonal (wave) considerations by county from Maine through Louisiana on the Atlantic and US Gulf of Mexico coast. This Report does not include MRFSS estimates from the US Caribbean region.

The MRFSS data included estimates of catch and effort from 1981 through 2004 from Louisiana through Maine. Because of the reduced number of records for some states, regional areas were defined and used as a spatial factor: Central Gulf (LA, AL, MS), Western Gulf (FLW), Florida east coast (FLE), NC-GE (GE, SC, NC), Mid Atlantic (VA, MD, DE, NJ, NY), and New England (CT, RI, MA, NH, ME). Trimesters were used to account for seasonal fishery distribution through the year (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec). Interviews also collected information on the intended target species for each trip; based on the ecological and habitat groups, target species were classified into "guilds" in the MRFSS data base: inshore species, reef species, non-reef species, pelagic species, and sharks. When no primary or secondary target was specified, the record was assigned as an unclassified guild. Fishing effort (angler hours) was estimated as the number of anglers times the number of hours fishing, and nominal catch rates were defined as the total catch kept and released (AB1B2, in number of fish) per thousand angler hours.

Figure 1 shows a summary of the reported recreational catch of gag, other grouper species (red grouper, black grouper), and unclassified groupers in general from the MRFSS data. Recreational catch of groupers was primarily composed of red grouper and gag; the total number of fish caught increased, particularly since the early 1990's, with a peak catch above 30,000 fish in 2004. For gag alone, ninety percent of the recreational catch was caught in the Gulf of Mexico (Figure 2). Since 1981 recreational fishing effort has increased. By 2004 the total fishing hours were about 0.5 million or 4 time the effort in 1984; the increase was due to the number of people participating (contributors, Fig 3). The proportional distribution of groupers recreational catch also changed. During the 1980s, the gag catch was about 30% of groupers, with 40% red grouper, and 20% black grouper and other groupers; since 1993, the gag catch increased to 40-50%, along with a reduction of black grouper catches (Fig 4). The increase in gag catch was not simply an effect of increased recreational fishing activity. A scatter plot of gag catch per year versus number of trips/interview shows a non-linear relationship, with a change in the slope about 1992-1993 when the gag catch proportion shifted (Fig 5).

One potential problem with indices derived from the recreational MRFSS database is the selection of trips/interviews that have relevance to the species in analysis, in this case gag. MRFSS covers all recreational fisheries from shore anglers or small bays up to large charter vessels fishing offshore. The task is then to identify the trips that potentially had a positive probability of catching gag. Within the interview, anglers are asked for targeted species of each trip, and in general the catch composition reflects the species found in the habitat associated with the intended species. As mentioned before, the MRFSS database classified the trips into "guilds" based on

habitat related species: sharks, pelagic species, inshore species, reef species, and non reef species; additional guild was created if the target species of the trip was gag. Nevertheless, about 50% of the trips do not have a target species definition (Fig 6). There is a difference in the proportion of target 'guilds' between the Atlantic and GOM recreational trips: reef and inshore species have higher proportion of trips in the GOM. Reviewing the reported catch of gag based on this guild classification shows that gag is caught in almost all types of trips, except for trips targeting sharks (Fig 7). In the GOM and Atlantic reef and gag trips caught the largest proportion of gag, however a significant number of catches of gag were from trips without specified target definition. Looking in more detail at the trips that caught gag and other species also reported in the same trip, it is possible to create a matrix of co-occurring species and possibly use this composition matrix as a subsetting condition. From 1981 to 2004, 25,812 trip/interviews reported catches of gag in the MRFSS database; among these trips, gag was the only species caught on only 13% (3311). The rest (22,501) of the trips reported from 2 to 19 other species being caught in addition to gag (Fig 8). In most cases, two to five species plus gag was the typical catch of a trip catching gag. The most common co-occurring species was red grouper (27%), followed by red snapper and white grunt (Fig 9). In general, the reef-associated species were the main co-occurring species (73%); however, pelagic, nonreef, and inshore species were also present (Fig 9B).

Stephens and MacCall (2004) developed a multispecies approach to subsetting trips of catch and effort data based on the species composition of each trip. Using a logistic regression, they predict a probability that the species of concern, in this case gag, would be present in a given trip. Then, a minimum probability threshold is defined, which is used to select a given subset of trips/records. The initial step is to define the species used for the logistic regression of the objective species. In the case of gag, the MRFSS database has reported at least 860 species (or species groups); a plot of the cumulative catch versus number of species shows that 96 species account for 94% of the total recreational catch (95% of charter and private/rental modes catch) (Fig 10). The logistic regression of gag on these 96 species was restricted to the Charter and private/rental modes of fishing from the MRFSS database due to size limits of the input matrix. The estimate of the logistic regression is then a probability value that a given trip would catch gag based on the presence-absence of the other species; the coefficients of the model quantify the predictive impact of each species on the likelihood of catching the species of concern. A critical value (threshold) is then selected so that the number of incorrect predictions (false negatives, false positives) is at minimum. This threshold represents the minimum probability for a trip to be selected (Stephens and MacCall 2004). Figure 11 shows the logistic coefficient estimates for the main explanatory species on positive catch of gag per trip for the Gulf of Mexico MRFSS data. Not surprisingly, they are basically the same species identified as co-occurrent with gag catches. For the Atlantic gag catch, the logistic regression did fail to converge to a solution using the 96 species matrix.

In summary, there were three alternatives for selecting trips/interview records from the MRFSS database for standardizing catch rates of gag: a) using all records in the geographic areas where gag have been caught at least once; [n.b. this eliminated the New England region (north of North Carolina) where no gag were ever reported]; b) using records with guild definition and within the guild categories: reef, pelagic, non-reef and inshore; and c) using all trips/interviews selected by the Stephens & MacCall logistic regression model. Standardization analyses were done with all records in geographic areas where gag had been caught (option a); relative indices for options b and c were also generated to evaluate the effect(s) of subsetting the data set. The final model (factors and interactions) of option (a) was applied to the other cases.

Another potential problem with gag catch rates is due to the mis-identification of gag with black grouper (*M. bonaci*) (Schirripa and Goodyear 1994). Overall reported recreational catches of black grouper (7620 fish) are between 2-8% of the gag annual catches since 1991 (Fig 12). However, in the 1985-1989 period catches of black grouper were greater than the catches of gag. Looking at catches by state and county, in the Gulf region, west Monroe County (FL) had overall the highest proportion of black grouper (72%) compared to gag, but other counties and states in the Gulf also reported black grouper catches (Fig 13). In the Atlantic Ocean, black grouper recreational catches were more common in all states and counties, with Dade County (FL) having the highest percent (56%) of combined gag and black grouper catches (Fig 14). In prior evaluations, the mis-identification of gag-black grouper was "corrected" by adding black grouper and gag together for all areas, and applying a proportion based on MRFSS data by county (Schirripa and Goodyear 1994). In this evaluation, only gag catches were evaluated, and it was assumed that the identification of species was correct for all states and counties, including the Gulf and Atlantic units.

Standardized indices of abundance were estimated for gag Gulf of Mexico and gag Atlantic unit stocks; catches off the Florida Keys (Monroe County) were assigned to the Gulf of Mexico stock. Gag relative indices of abundance were estimated by the Generalized Linear Modeling approach assuming a delta lognormal model distribution. The standardization protocols assumed a delta model with a binomial error distribution for modeling the proportion of positive sets, and a lognormal error distribution for modeling the mean catch rate of successful (i.e. positive gag catch) trip/interviews. The nominal log transformed gag catch rate distributions of all positive trip/interview records from the MRFSS data are shown in Figure 15. Parameterization of the models used the GLM structure; for the proportion of successful observations per stratum was assumed to follow a binomial distribution where the estimated probability was a linear function of fixed factors and interactions. The logit function was used as a link between the linear factor component and the binomial error. For successful trip/interviews, estimated CPUE rates assumed a lognormal distribution of a linear function of fixed and random effect interactions when the *year* term was within the interaction.

A step-wise regression procedure was used to determine the set of systematic factors and interactions that significantly explained the observed variability. As the difference in deviance between two consecutive nested models follows a chi-square (χ^2) distribution, this statistic was used to test for the significance of an additional factor(s) in the model. Deviance tables are presented for each analysis. Each table includes the deviance for the proportion of positive observations, and the deviance for the positive catch rates. Final selection of the explanatory factors was conditional on: a) the relative percent of deviance explained by adding the factor in consideration (normally factors that explained more than 5% were included in the final model), b) the χ^2 test significance, and c) a type III test significance within the final specified model. Once a set of fixed factors was specified, possible first level interactions were evaluated and in particular interactions between the *year* effect and other factors which were assumed to be random. The significance of random interactions was evaluated between nested models by using the likelihood ratio test (Pinheiro and Bates 2000), the Akaike information criteria (AIC), and the Bayesian information criteria (BIC) (Littell et al 1996), where lower values indicated better model fitting. Analyses were done using GLIMMIX and MIXED procedures from the SAS® statistical computer software (SAS Institute Inc. 1997)

Relative indices were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal components. LSmeans estimates were weighted proportional to observed marginal sums in the positive observations data, and for the lognormal estimates, a log-back transformed bias corrections was applied (Lo et al. 1992).

Results and Discussion

The deviance analyses tables for all records of the Atlantic gag CPUE standardization from the MRFSS data are shown in Table 1. Table 3 shows the deviance table for all records of the Gulf of Mexico gag from the MRFSS data. The step wise analyses of deviance indicated that guild, area, mode, and region were the main explanatory factors for the proportion of positive trips model in both the Atlantic and Gulf stocks. While for the positive catch trips model, the main explanatory factors were area, mode and guild in the Atlantic stock; the main explanatory factors were guild, mode, region and season for the Gulf stock. Of the interactions evaluated, the year*region, and year*area were also important explanatory factors primarily for the proportion positive model for the Atlantic stock while year*season, year*region and year*mode were significant interactions in the positive catch rate models. In contrast, for the Gulf stock year*guild and year*mode were important explanatory interactions in the proportion of positive trips, and year*region, year*mode and year*mode in the positive catch model. Tables 2 and 4 present the evaluation of these interactions as random components in the mixed models.

Tables 5 and 6, and Figure 16 show the nominal and standardized CPUE for Atlantic gag and Gulf Mexico gag from the MRFSS all records data, respectively. Reviewing index trends for Atlantic gag they showed a trend of catch rates below the overall mean for the early years (1981-1989) and above the mean for the period of 1990-92, 1994-95, and last three years (2002-04). However, estimated 95% confidence intervals are quite broad, with a CV (coefficient of variation) averaging 60% for the Atlantic index. In the Gulf, the relative index showed an increasing trend, with values below the overall mean prior to 1993, and over the mean thereafter. Estimated 95% confidence intervals were narrower compared to the Atlantic stock, and averaged 40% overall.

Relative indices for Atlantic and Gulf gag were also developed for subsets of the MRFSS data. Filtering was done either by selecting only trip/interviews in which the angler specified the targeted species and this species belonged to the reef, nonreef, pelagic or inshore guilds (b, Filter guilds), or by using the Stephens & MacCall (2004) logistic multispecies approach (c, Multispp). In all cases, the standardization model was the same as the model used with all records (including fix factors and interactions). Figure 17 shows the trend of the estimated relative index (scaled to the overall mean) for the Atlantic and Gulf gag stocks. In the case of Atlantic gag, the logistic multispecies regression failed to converge to a solution with the input matrix of 86 species, therefore no index was estimated. In general, the data subsets provided similar trends of relative catch rates for Atlantic gag and Gulf gag. Moreover, if the estimated 95% confidence intervals are plotted, there was no difference between the indices generated (Fig 18). Figure 19 shows the number of records, trip/interviews used in each model by year. The filtering of trips by guilds on average eliminated 50% of the records, while the multispecies logistic regression eliminated more than 98% of the records (in the case of Gulf of Mexico gag).

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Table 1. Deviance analysis table of explanatory variables in the delta lognormal model for Atlantic gag catch rates (number of fish per thousand angler-hours) from the MRFSS data. Percent of total deviance refers to the deviance explained by the full model; *p* value refers to the Chi-square probability between consecutive models (alpha = 0.05).

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	p
1	1	2433.09			
Year	23	2362.36	70.7	10.8%	< 0.001
Year Area	2	2112.47	249.9	38.1%	< 0.001
Year Area Season	3	2091.88	20.6	3.1%	< 0.001
Year Area Season Mode	2	1912.64	179.2	27.3%	< 0.001
Year Area Season Mode Region	1	1912.57	0.1	0.0%	0.792
Year Area Season Mode Region Guild	5	1875.83	36.7	5.6%	< 0.001
Year Area Season Mode Region Guild Season*Mode	6	1873.44	2.4	0.4%	0.880
Year Area Season Mode Region Guild Area*Mode	3	1868.81	7.0	1.1%	0.071
Year Area Season Mode Region Guild Area*Season	6	1868.10	7.7	1.2%	0.258
Year Area Season Mode Region Guild Season*Guild	15	1865.35	10.5	1.6%	0.788
Year Area Season Mode Region Guild Region*Guild	5	1862.77	13.1	2.0%	0.023
Year Area Season Mode Region Guild Mode*Region	2	1860.37	15.5	2.4%	< 0.001
Year Area Season Mode Region Guild Area*Region	2	1856.90	18.9	2.9%	< 0.001
Year Area Season Mode Region Guild Area*Guild	10	1855.97	19.9	3.0%	0.031
Year Area Season Mode Region Guild Mode*Guild	10	1852.53	23.3	3.6%	0.010
Year Area Season Mode Region Guild Year*Area	44	1817.02	58.8	9.0%	0.067
Year Area Season Mode Region Guild Year*Mode	39	1816.59	59.2	9.0%	0.020
Year Area Season Mode Region Guild Year*Region	23	1808.58	67.3	10.3%	< 0.001
Year Area Season Mode Region Guild Year*Season	64	1788.75	87.1	13.3%	0.029
Year Area Season Mode Region Guild Year*Guild	99	1777.08	98.8	15.1%	0.488

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	p
1	1	9418.11935			
Year	23	9075.88085	342.2	6.5%	< 0.001
Year Area	2	7499.17002	1576.7	29.7%	< 0.001
Year Area Season	3	7379.75247	119.4	2.3%	< 0.001
Year Area Season Mode	2	6755.48305	624.3	11.8%	< 0.001
Year Area Season Mode Region	1	6312.58226	442.9	8.4%	< 0.001
Year Area Season Mode Region Guild	5	4437.46398	1875.1	35.4%	< 0.001
Year Area Season Mode Region Guild Area*Season	6	4404.8279	32.6	0.6%	< 0.001
Year Area Season Mode Region Guild Area*Mode	3	4339.8562	97.6	1.8%	< 0.001
Year Area Season Mode Region Guild Year*Season	68	4284.46985	153.0	2.9%	< 0.001
Year Area Season Mode Region Guild Area*Guild	10	4274.42223	163.0	3.1%	< 0.001
Year Area Season Mode Region Guild Year*Mode	46	4252.24769	185.2	3.5%	< 0.001
Year Area Season Mode Region Guild Year*Region	23	4173.12728	264.3	5.0%	< 0.001
Year Area Season Mode Region Guild Year*Area	46	4154.90265	282.6	5.3%	< 0.001
Year Area Season Mode Region Guild Year*Guild	111	4117.12565	320.3	6.0%	< 0.001

Table 2. Analysis of mixed model formulations for Atlantic gag catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Gag grouper Atlantic	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year Area Mode Region Guild	40431.4	40433.4	40440		
Year Area Mode Region Guild Year*Guild	40431.4	40433.4	40436.3	0	1.0000
Year Area Mode Region Guild Year*Guild Year*area	40068.2	40072.2	40078.1	363.2	0.0000
Year Area Mode Region Guild Year*Guild Year*area Year*Region	39378.4	39386.4	39398.1	689.8	0.0000
Positive Catch					
Year Area Season Mode Region Guild	6135.9	6137.9	6143.6		
Year Area Season Mode Region Guild Year*Guild	6135.5	6139.5	6145.2	0.4	0.5271
Year Area Season Mode Region Guild Year*Guild Year*Season	6129.6	6135.6	6144.2	5.9	0.0151
Year Area Season Mode Region Guild Year*Guild Year*Season Year*Region	6102.2	6110.2	6121.6	27.4	0.0000
Year Area Season Mode Region Guild Year*Guild Year*Season Year*Region Year*Mode	6098.3	6108.3	6122.6	3.9	0.0483
Year Area Season Mode Region Guild Year*Guild Year*Season Year*Region Year*Mode Year*Area	6097.1	6109	6126.2	1.2	0.2733

Table 3. Deviance analysis table of explanatory variables in the delta lognormal model for Gulf Mexico gag catch rates (number of fish per thousand angler hours) from the MRFFS data. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (alpha = 0.05)

Gulf of Mexico Gag MRFSS

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	p
1	1	25664.46			
Year	23	25072.92	591.5	20.6%	< 0.001
Year Area	2	25034.37	38.5	1.3%	< 0.001
Year Area Season	3	24625.99	408.4	14.2%	< 0.001
Year Area Season Mode	2	24172.63	453.4	15.8%	< 0.001
Year Area Season Mode Region	1	23553.99	618.6	21.6%	< 0.001
Year Area Season Mode Region Guild	6	23036.02	518.0	18.1%	< 0.001
Year Area Season Mode Region Guild Mode*Region	2	23032.65	3.4	0.1%	0.185
Year Area Season Mode Region Guild Area*Region	2	23025.98	10.0	0.4%	0.007
Year Area Season Mode Region Guild Area*Mode	3	23024.06	12.0	0.4%	0.008
Year Area Season Mode Region Guild Area*Guild	12	23013.68	22.3	0.8%	0.034
Year Area Season Mode Region Guild Season*Guild	17	22968.66	67.4	2.3%	< 0.001
Year Area Season Mode Region Guild Region*Guild	6	22964.85	71.2	2.5%	< 0.001
Year Area Season Mode Region Guild Mode*Guild	12	22945.17	90.9	3.2%	< 0.001
Year Area Season Mode Region Guild Area*Season	6	22916.62	119.4	4.2%	< 0.001
Year Area Season Mode Region Guild Year*Area	42	22901.12	134.9	4.7%	< 0.001
Year Area Season Mode Region Guild Year*Region	20	22878.33	157.7	5.5%	< 0.001
Year Area Season Mode Region Guild Season*Mode	6	22871.23	164.8	5.7%	< 0.001
Year Area Season Mode Region Guild Year*Mode	42	22829.85	206.2	7.2%	< 0.001
Year Area Season Mode Region Guild Year*Season	67	22815.63	220.4	7.7%	< 0.001
Year Area Season Mode Region Guild Year*Guild	118	22797.70	238.3	8.3%	< 0.001

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	p
1	1	62268.0209			
Year	23	52843.9651	9424.1	18.7%	< 0.001
Year Area	2	36999.4936	15844.5	31.5%	< 0.001
Year Area Season	3	35424.3074	1575.2	3.1%	< 0.001
Year Area Season Mode	2	32385.6386	3038.7	6.0%	< 0.001
Year Area Season Mode Region	1	26453.9384	5931.7	11.8%	< 0.001
Year Area Season Mode Region Guild	6	12678.533	13775.4	27.4%	< 0.001
Year Area Season Mode Region Guild Area*Season	6	12521.4307	157.1	0.3%	< 0.001
Year Area Season Mode Region Guild Year*Area	46	12251.0252	427.5	0.8%	< 0.001
Year Area Season Mode Region Guild Area*Mode	3	12210.9223	467.6	0.9%	< 0.001
Year Area Season Mode Region Guild Year*Season	68	12080.4772	598.1	1.2%	< 0.001
Year Area Season Mode Region Guild Area*Guild	12	12067.4523	611.1	1.2%	< 0.001
Year Area Season Mode Region Guild Year*Region	23	12064.3576	614.2	1.2%	< 0.001
Year Area Season Mode Region Guild Year*Mode	46	12014.3578	664.2	1.3%	< 0.001
Year Area Season Mode Region Guild Year*Guild	136	11917.3515	761.2	1.5%	< 0.001

Table 4. Analyses of mixed model formulations for Gulf Mexico gag catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Gulf of Mexico gag grouper	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year Area Mode Region Guild	39018.8	39020.8	39027.7		
Year Area Mode Region Guild *Year*Guild*	38469.8	38473.8	38480	549	0.0000
Year Area Mode Region Guild *Year*Guild Year*Mode*	38104.3	38110.3	38119.7	365.5	0.0000
Year Area Mode Region Guild *Year*Guild Year*Mode Year*Region*	38698.5	38706.5	38718.9	-594.2	#NUM!
Positive Catch					
Year Area Season Mode Region Guild	64742.6	64744.6	64752.7		
Year Area Season Mode Region Guild *Year*Guild*	64704.8	64708.8	64714.8	37.8	0.0000
Year Area Season Mode Region Guild *Year*Guild Year*Mode*	64628.2	64634.2	64643.2	76.6	0.0000
Year Area Season Mode Region Guild *Year*Guild Year*Mode Year*Season*	64557.2	64565.2	64577.2	71	0.0000
Year Area Season Mode Region Guild *Year*Guild Year*Mode Year*Season Season*Mode*	64425.6	64435.6	64450.6	131.6	0.0000
Year Area Season Mode Region Guild *Year*Guild Year*Mode Year*Season Season*Mode Year*Region*	64323.6	64335.6	64353.6	102	0.0000

Table 5.   Nominal and standardized Atlantic gag CPUE series (fish/ thousand angler-hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	3382	0.542	0.523	104.7%	0.537	0.096	2.999
1982	7501	0.356	0.323	120.1%	0.331	0.050	2.191
1983	6684	0.137	0.168	133.9%	0.172	0.023	1.306
1984	7846	0.480	0.852	67.9%	0.873	0.255	2.994
1985	10095	0.894	1.023	64.2%	1.049	0.324	3.395
1986	11711	0.892	0.701	60.1%	0.718	0.237	2.180
1987	18101	1.246	0.970	56.6%	0.995	0.346	2.856
1988	18881	0.785	0.630	60.0%	0.646	0.213	1.958
1989	20460	1.512	1.571	52.1%	1.611	0.604	4.294
1990	18249	1.031	1.158	55.4%	1.188	0.422	3.345
1991	23729	0.978	1.229	53.4%	1.260	0.463	3.431
1992	28868	1.185	1.163	52.5%	1.192	0.444	3.200
1993	30249	0.789	0.906	54.7%	0.929	0.334	2.585
1994	37306	1.234	1.392	51.6%	1.427	0.540	3.773
1995	37293	1.294	1.767	50.6%	1.812	0.697	4.711
1996	40421	0.716	0.918	52.7%	0.941	0.350	2.534
1997	39653	0.653	0.690	55.2%	0.708	0.252	1.985
1998	39319	0.497	0.420	59.4%	0.430	0.143	1.292
1999	39325	1.152	1.082	52.1%	1.110	0.416	2.960
2000	39028	1.851	1.414	50.9%	1.450	0.555	3.790
2001	44656	0.864	0.709	53.3%	0.727	0.268	1.978
2002	43284	1.937	1.008	52.3%	1.034	0.387	2.761
2003	38709	2.267	1.321	51.3%	1.355	0.515	3.565
2004	35495	2.066	1.467	49.9%	1.505	0.586	3.864

Table 6.   Nominal and standardized Gulf Mexico gag CPUE series (fish/ thousand angler-hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	4295	6.493	4.213	47.6%	0.575	0.233	1.419
1982	7693	3.259	2.264	51.2%	0.309	0.118	0.810
1983	5111	5.151	3.532	53.6%	0.482	0.176	1.315
1984	6106	1.829	1.462	62.3%	0.199	0.063	0.627
1985	6859	1.262	0.983	68.5%	0.134	0.039	0.463
1986	13900	5.093	1.789	43.4%	0.244	0.106	0.559
1987	13314	3.493	1.400	44.2%	0.191	0.082	0.445
1988	14640	2.561	0.953	46.7%	0.130	0.054	0.316
1989	10662	5.439	2.705	41.1%	0.369	0.167	0.813
1990	9055	15.312	6.089	41.8%	0.830	0.372	1.854
1991	10940	11.547	3.333	40.4%	0.455	0.209	0.989
1992	23531	10.762	3.553	37.3%	0.484	0.236	0.997
1993	20464	18.921	8.128	35.4%	1.108	0.558	2.202
1994	23276	22.498	11.293	34.9%	1.540	0.782	3.033
1995	21138	28.387	13.095	34.3%	1.786	0.917	3.478
1996	21870	21.016	12.364	34.7%	1.686	0.859	3.309
1997	22964	25.793	9.229	34.6%	1.259	0.643	2.465
1998	28996	42.665	16.694	33.4%	2.277	1.187	4.366
1999	40041	38.647	13.715	33.4%	1.870	0.977	3.582
2000	37500	19.940	7.986	34.1%	1.089	0.561	2.115
2001	37313	24.339	7.450	34.3%	1.016	0.522	1.978
2002	38812	36.329	14.250	33.1%	1.943	1.019	3.707
2003	39357	51.214	14.346	33.2%	1.956	1.025	3.736
2004	40865	65.819	15.160	33.2%	2.067	1.083	3.946

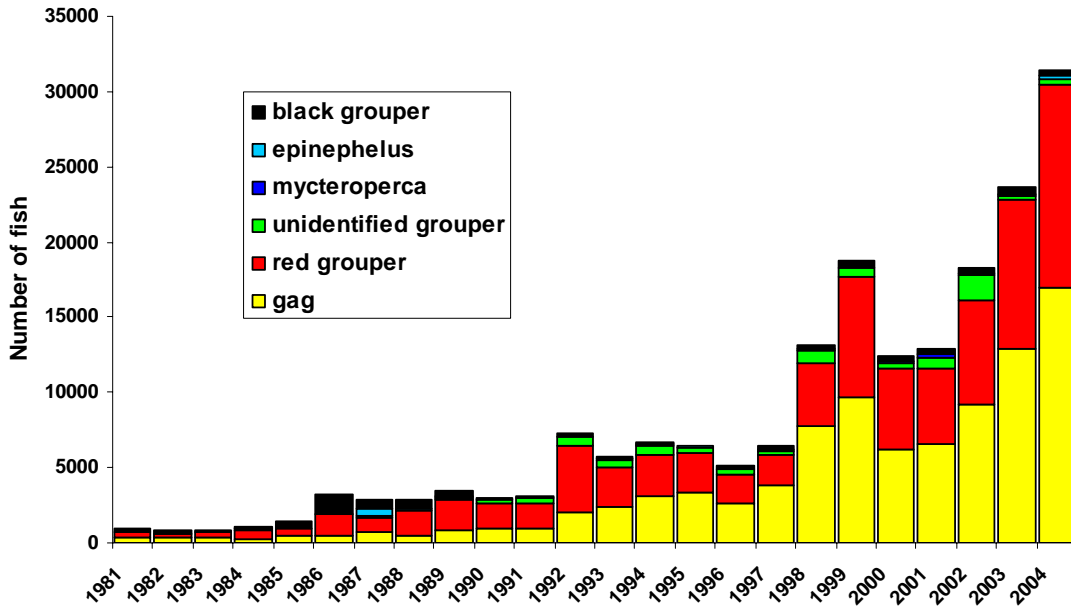## Total catch (AB1B2) reported by MRFSS 1981-2004

Figure 1. Recreational catch of gag and related grouper categories recorded in MRFSS interviews for all states, Gulf of Mexico (excluding Texas) and Atlantic coast 1981-2004.

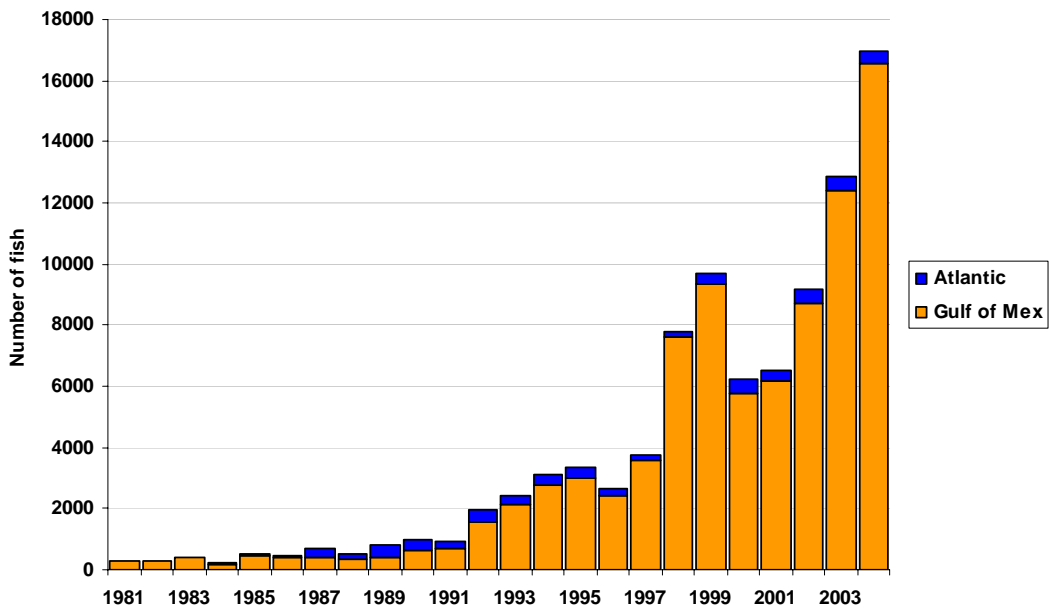## Total catch (AB1B2) of gag reported by MRFSS by stock unit 1981-2004

Figure 2. Distribution of gag recreational catch (AB1B2) between Gulf of Mexico (Louisiana, Alabama, Mississippi, and Florida west coast) and Atlantic coast (Florida east coast, Georgia, South Carolina, and North Carolina) as recorded in MRFSS interviews.

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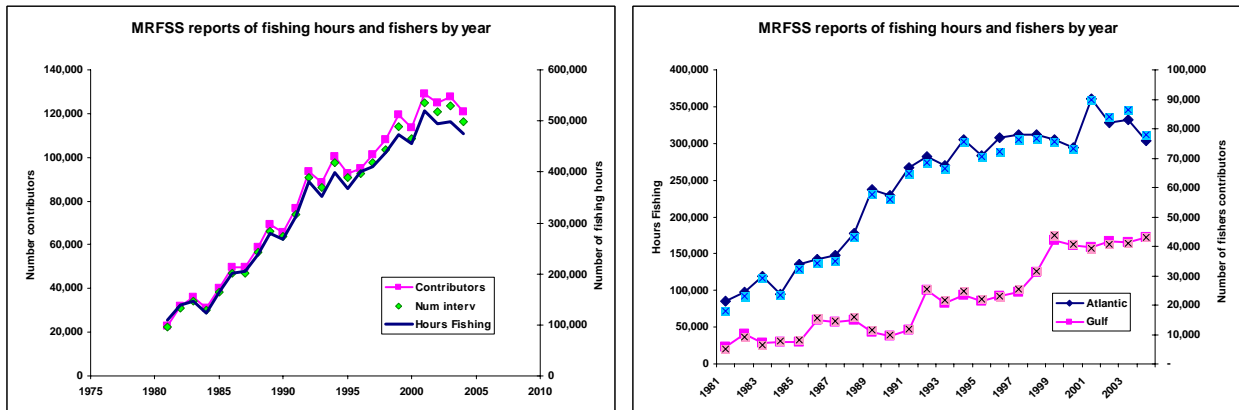
Figure 3. Trends of fishing effort (number of fishing hours), number of angles (contributors) and number of interviews from the MRFSS sampling in 1981-2004. Left plot all states, right trends for the Gulf of Mexico states and Atlantic coast states, lines with solid marker represent number of hours fishing, single x markers represent number of anglers (fishers contributors).

Figure 4. Proportional distribution of recreational catch between gag and other main groupers by year from the MRFSS interviews 1981-2004

MRFSS catch of GAG (AB1B2) per year and correspondent number of interviews/trips
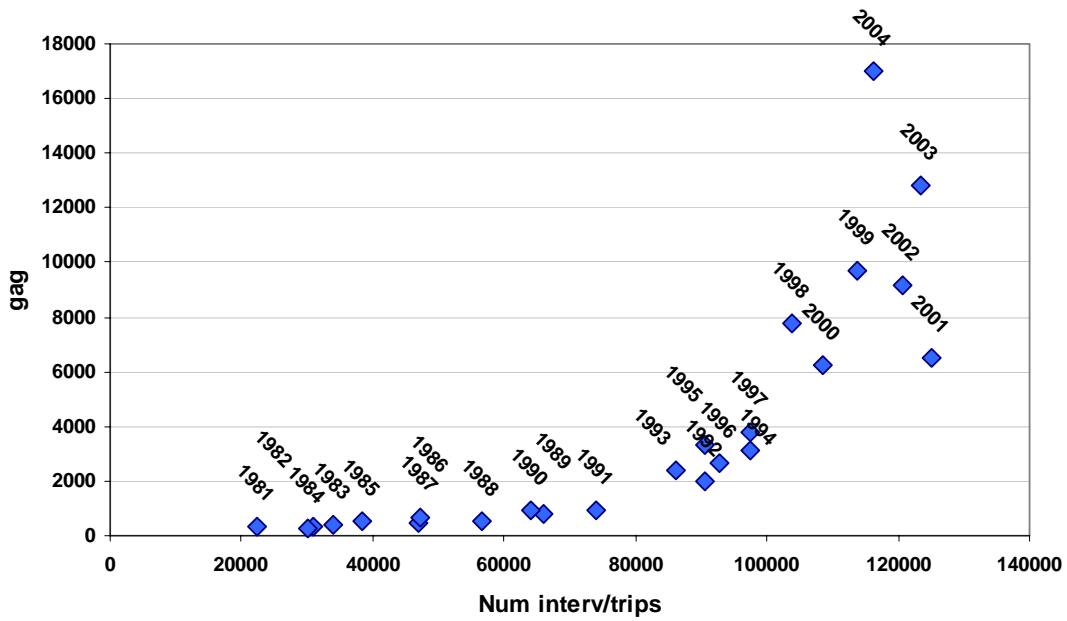
Figure 5. Scatter plot of the number of trip/interviews and the total reported catch of gag by year from the MRFSS sampling in 1981-2004 for the Gulf of Mexico and Atlantic coast combined.

Atlantic distribution of trip/interv MRFSS by target spp Guild

Gulf of Mexico distribution of trip/interv MRFSS by target spp Guild
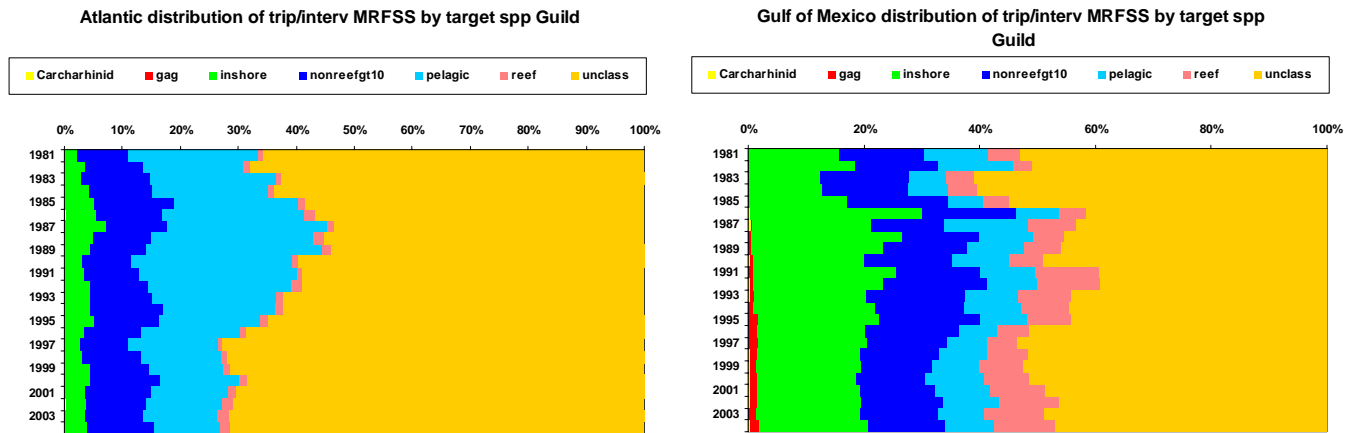
Figure 6.   Percent distribution of trip/interviews according to the guilds classification based on the targeted species reported by angler(s), unclassified group represent records when the interviewed angler did not report a primary or secondary target species.   Left plot, Atlantic coast trip/interviews, and right plot Gulf of Mexico trip/interviews.

Catch of gag Atlantic by trip/interv MRFSS by target spp Guild

Catch of gag GOM by trip/interv MRFSS by target spp Guild
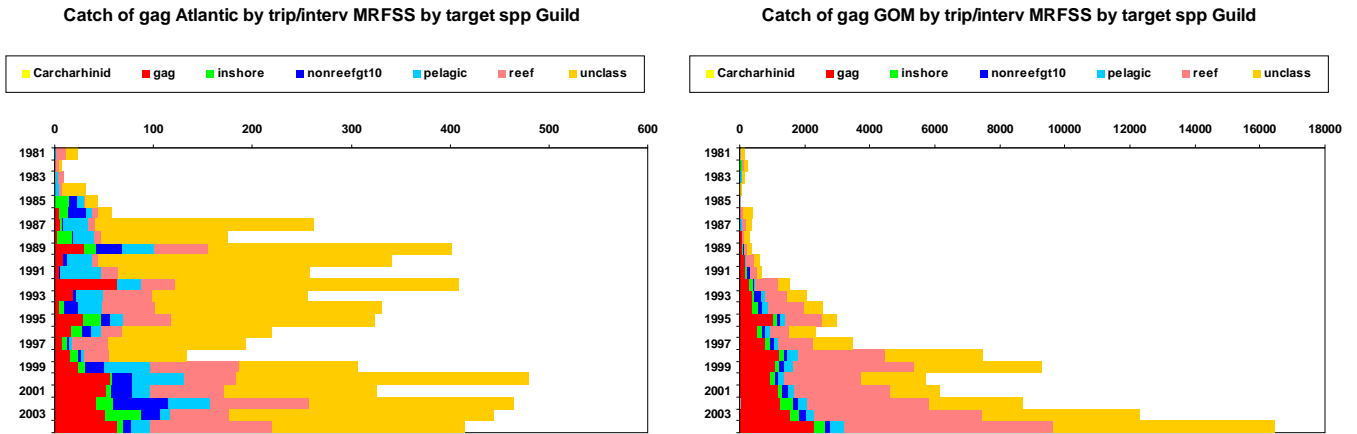
Figure 7. Distribution of reported recreational gag catch by guilds for the Atlantic (left plot) and Gulf of Mexico (right plot) from the MRFSS intervierws in 1981-2004.

Number of species reported per interview when GAG was caught MRFSS
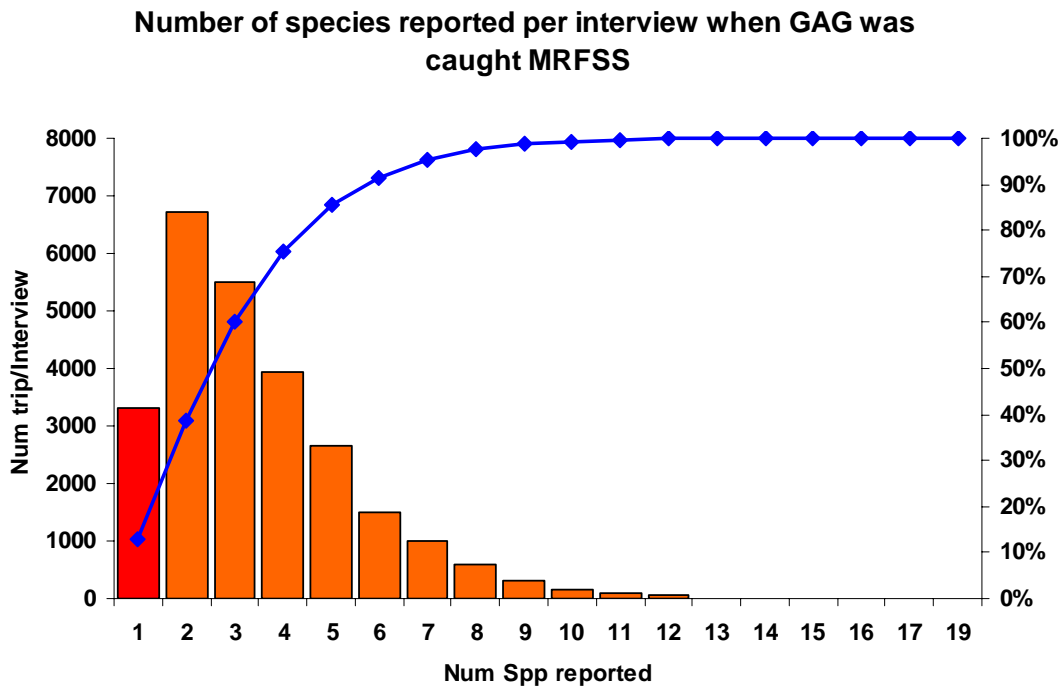
Figure 8. Number of species reported and cumulative percent of trip/interviews that caught gag from the MRFSS 1981 – 2004 data. Bin 1 represents trip/interviews were gag was the only species caught and reported.

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Percent co-ocurrence of species caugth with GAG MRFSS at least 2% (N 25812)
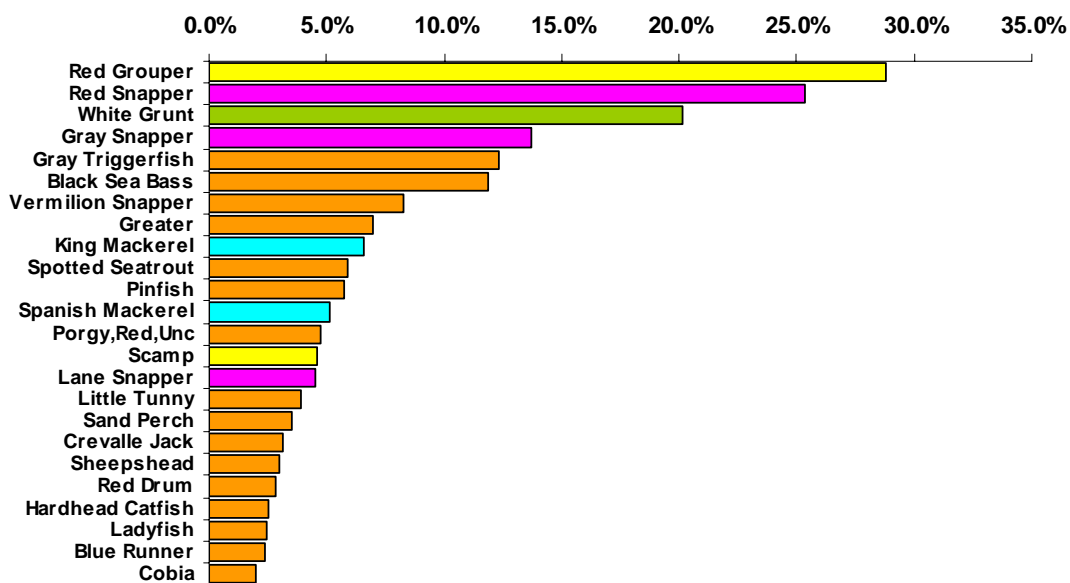
Figure 9.   Species co-occurring with gag, bar represents the percent of trips reporting the co-occurring species of the total trip/interviews that reported gag catches. Plot shows only those species that occurred in at least 2% of the gag caught trips.

Percent co-ocurrence of spp caught with GAG
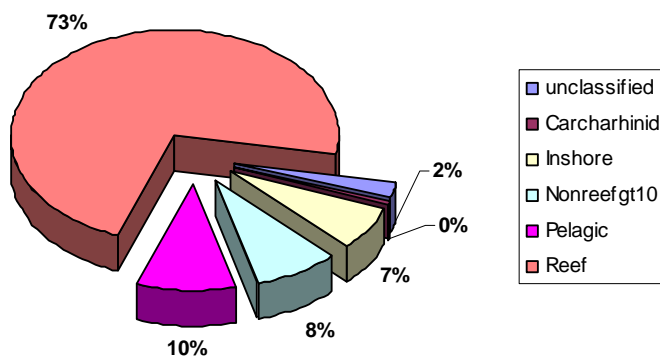
Figure 9B. Percent distribution of guilds of co-occurring species in trip/interviews that reported gag catch.

MRFSS catch Charter & Private-rental modes
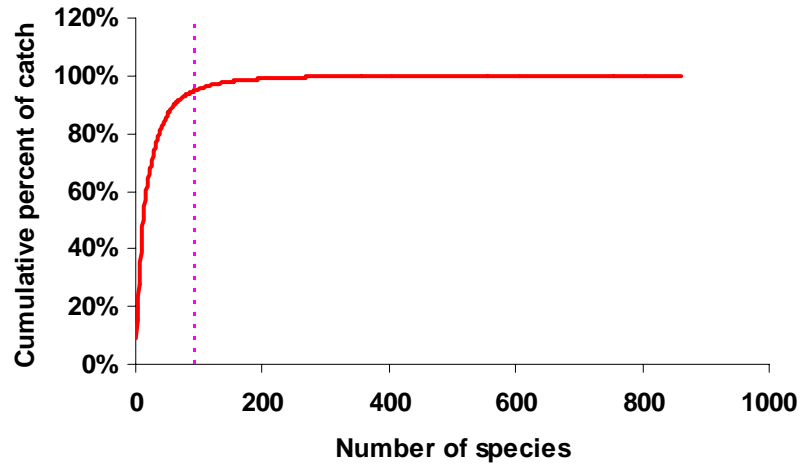
Figure 10. Cumulative percent of catch versus number of species in the MRFSS data. The vertical line indicates the contributions of the species used in the analyses.
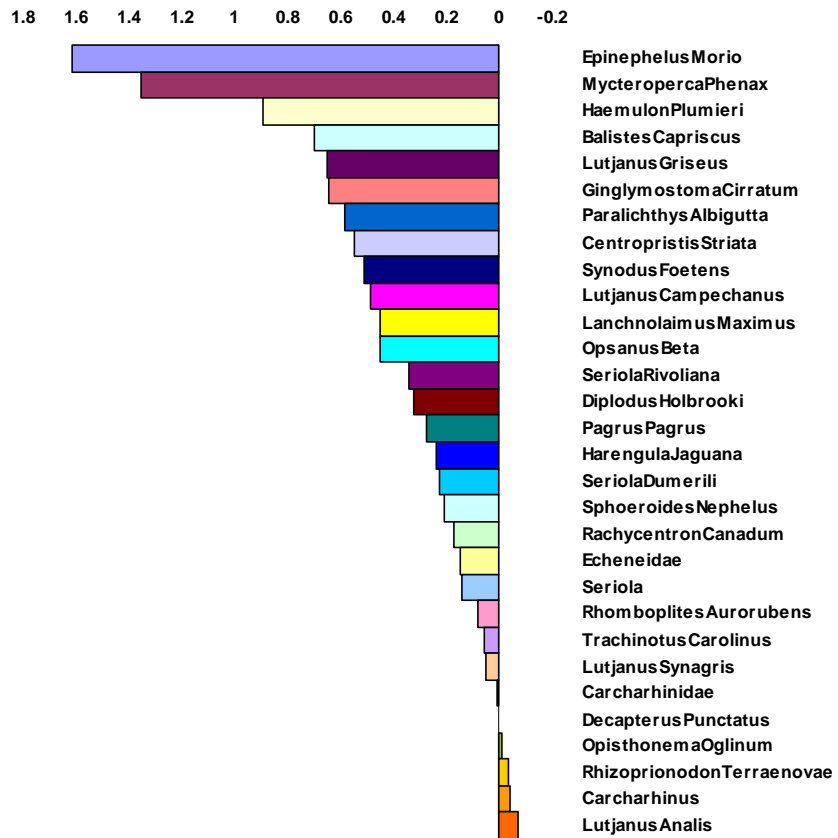
Figure 11. Estimates of species-specific regression coefficients based on the MRFSS Gulf of Mexico data (only charter and private/rental modes) for gag positive trip/interviews.

Recreational Catch AB1B2 of Gag & Black grouper MRFSS
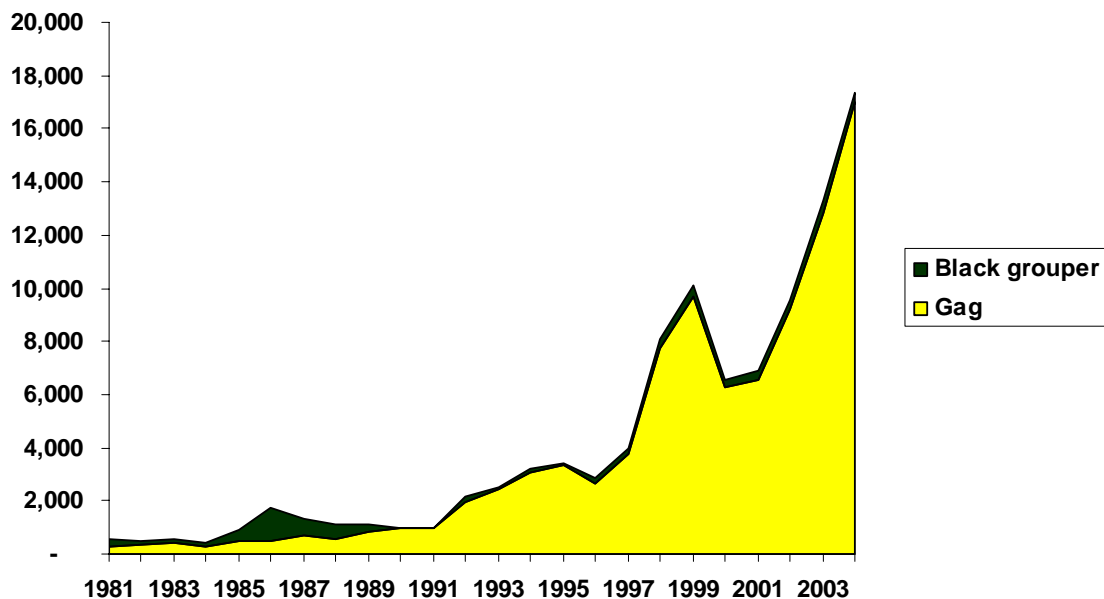
Figure 12. Reported recreational catch of black grouper and gag from the MRFSS interviews in 1981-2004.
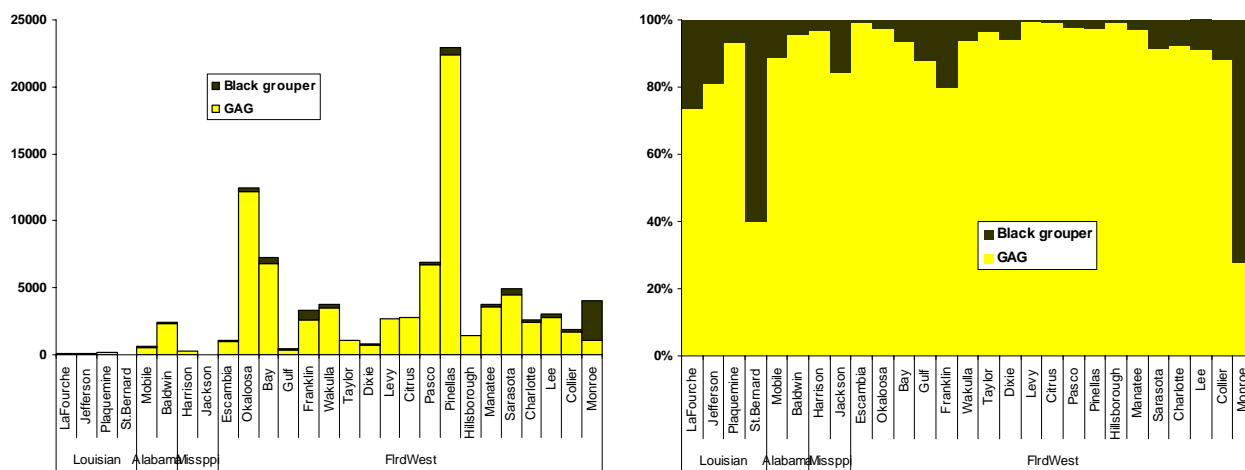
Figure 13. Catches (left plot) and percent distribution of black grouper and gag by county and state for the Gulf of Mexico from the cumulative MRFSS interviews in 1981-2004.

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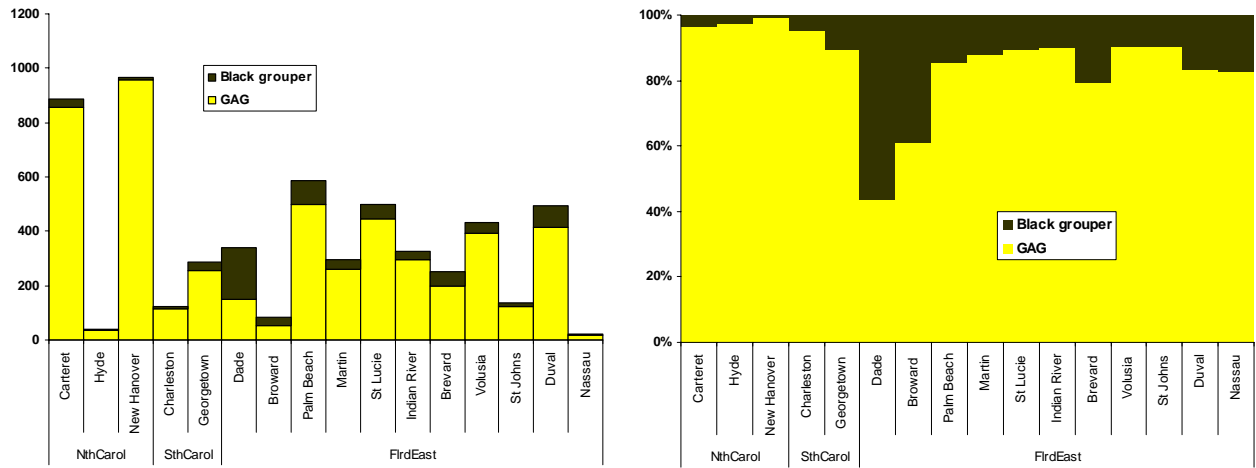
Figure 14. Catches (left plot) and percent distribution of black grouper and gag by county and state for the Atlantic from the cumulative MRFSS interviews in 1981-2004.
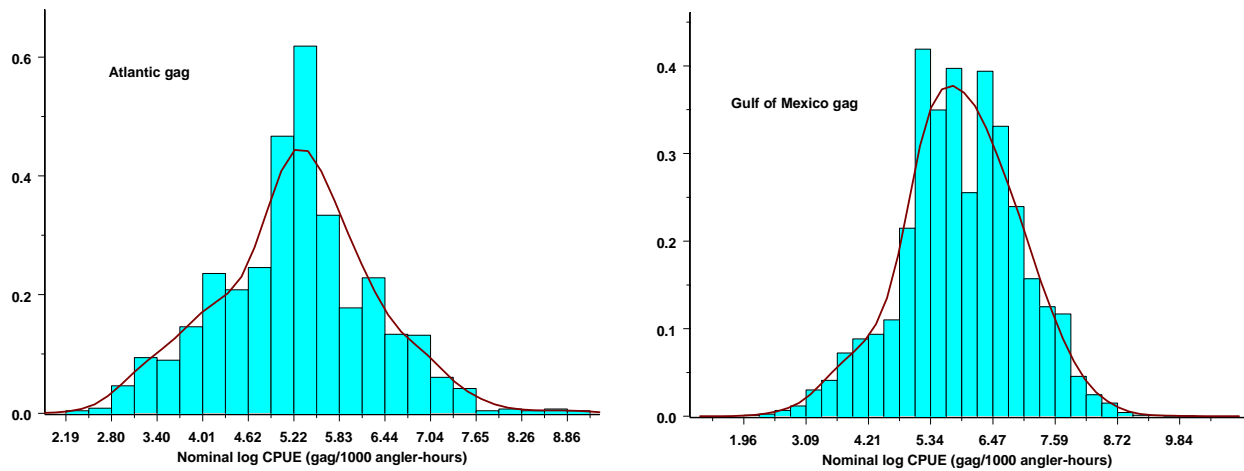
Figure 15. Log-transformed nominal catch rates (gag per thousand angler-hours) of gag Atlantic and Gulf of Mexico stock units for positive trip/interviews from MRFSS all records 1981-2004 data set.

ATLANTIC GAG GROUPER STANDARDIZED MRFSS CPUE DELTA-LOGNORMAL MODEL
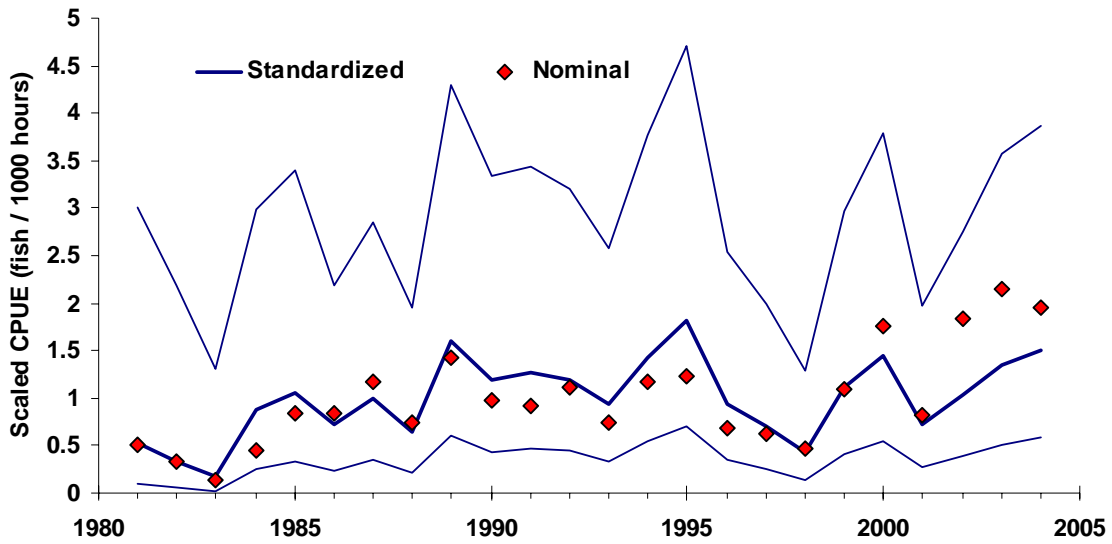
GULF OF MEXICO GAG STANDARDIZED MRFSS CPUE DELTA-LOGNORMAL MODEL
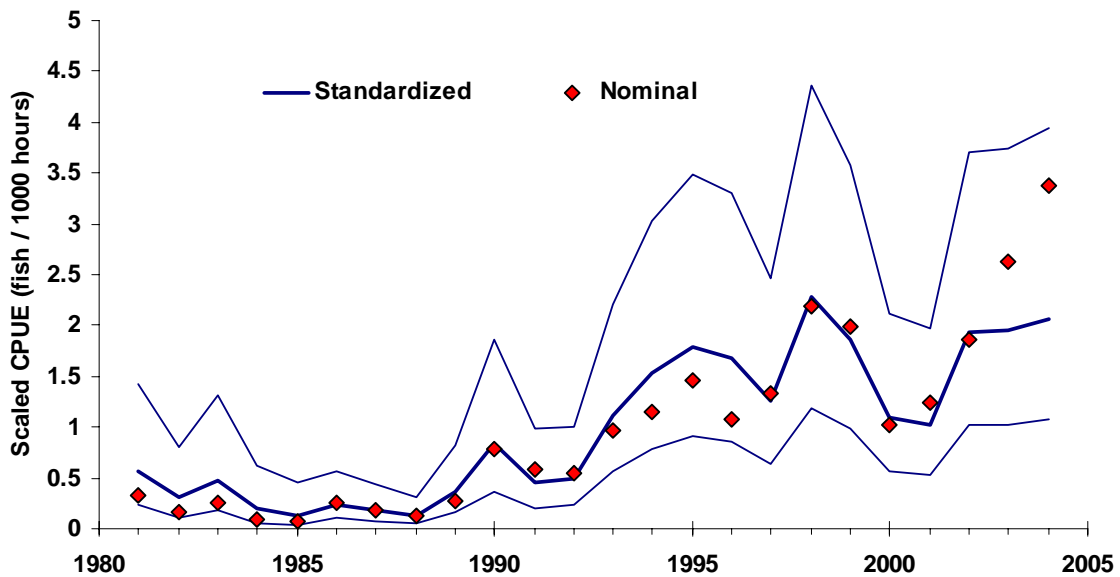
Figure 16. Standardized relative indices of abundance and nominal catch rates for gag Atlantic (top) and Gulf of Mexico stock units from the MRFSS data set. Outer lines indicate the estimated 95% confidence intervals for standardized values.
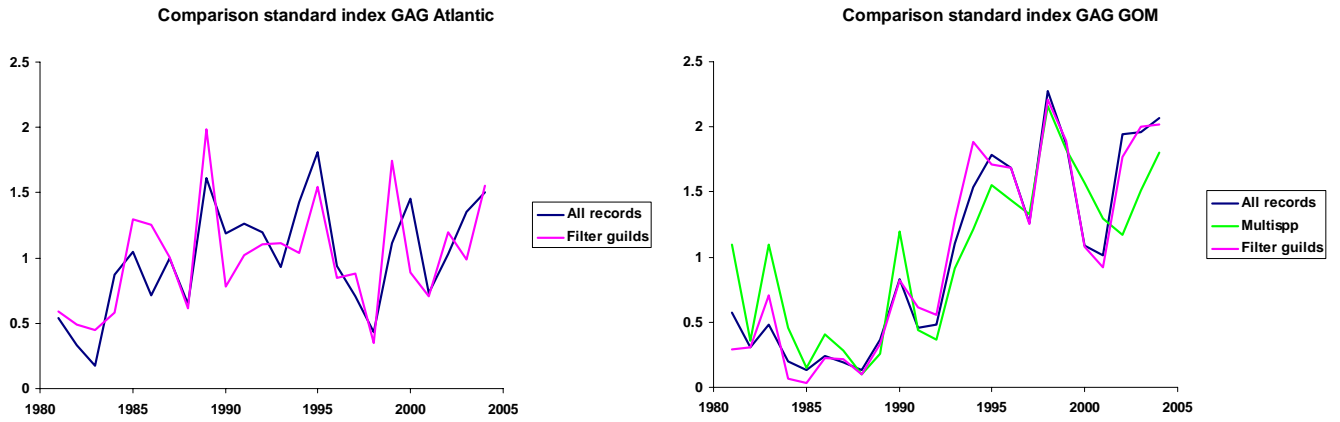
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Figure 17. Scaled time series of standardized gag CPUE from analyses of all and subset records of MRFSS data set. Filter guilds represent records where angler specified targeted species and the captured species belong to the reef, nonreef, pelagic and inshore guilds. Multispp represents records selected by the multispecies logistic regression approach of Stephens and MacCall (2004).
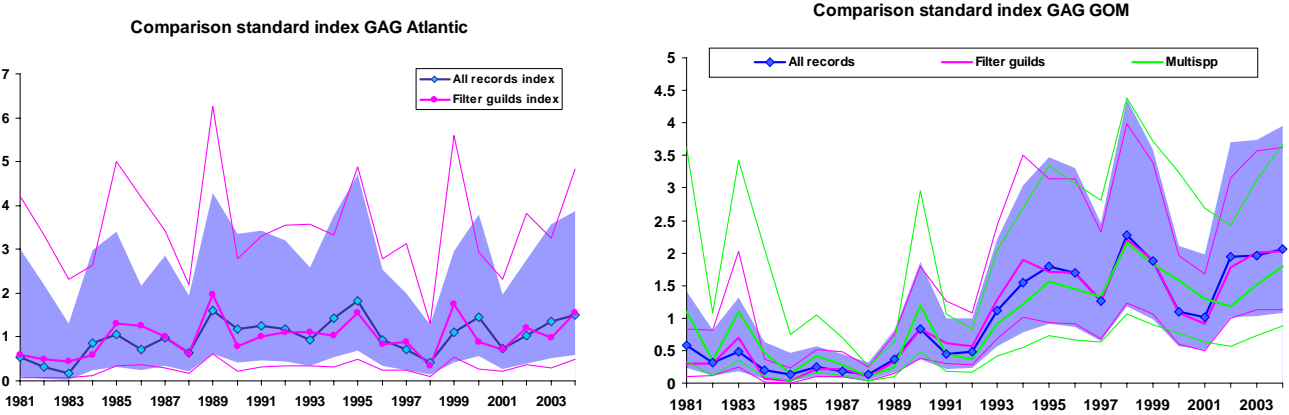

Figure 18. Scaled gag CPUE and 95% estimated confidence bounds for all and subset records of MRFSS data set. See text for subset definitions.
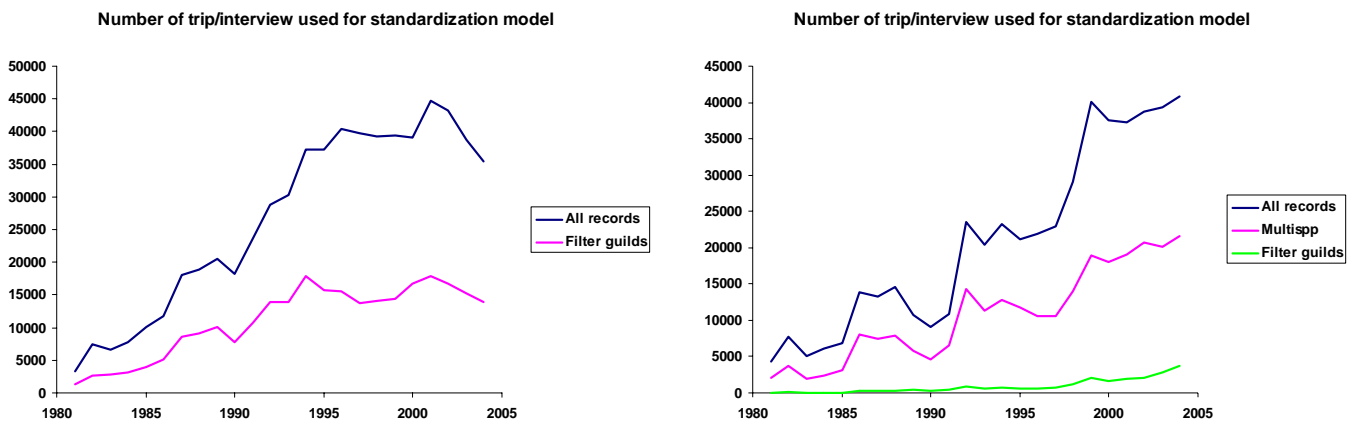

Figure 19. Number of records (trip/interviews) used in each of the CPUE standardization models for gag from the MRFSS data set.