SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Scamp

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Introduction

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide an index of the relative abundances of fish species associated with topographic features (e.g reefs, banks, and ledges) located on the continental shelf of the Gulf of Mexico (GOM) from Brownsville, TX to the Dry Tortugas, FL (Figures 1, and 11-31). Secondary objectives include quantification of habitat types sampled (video, multi-beam and side-scan), and collection of environmental data throughout the survey. Because the survey is conducted on topographic features the species assemblages targeted are typically classified as reef fish (e.g. red snapper, *Lutjanus campechanus*), but occasionally fish more commonly associated with pelagic environments are observed (e.g. Amberjack, *Seriola dumerili*). The survey has been executed from 1992-1997, 2001-2002, and 2004-present and historically takes place from April - May, however in limited years the survey was conducted through the end of August. The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western Gulf of Mexico. Types of data collected on the survey include diversity, abundance (min-count), fish length, habitat type, habitat coverage, bottom topography and water quality. Fish lengths were historically measured using parallel lasers and eventually changed to stereo-camera methods in 2006 with a validation period from 2006-2008. Age and reproductive data cannot be collected with the camera gear but beginning with the 2012 survey, a vertical line component was coupled with the video drops to collect hard parts, fin clips, and gonads and was included in the life history information provided by the NMFS Panama City Laboratory.

Methods

Sampling design

Total reef area available to select survey sites from is approximately 1771 km², of which 1244 km² is located in the eastern GOM and 527 km² in the western GOM. The large size of the survey area necessitates a two-stage sampling design to minimize travel times between stations. The first-stage uses stratified random sampling to select blocks that are 10 minutes of latitude by 10 minutes of longitude in dimension (Figure 1). The block strata were defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block (blocks $\leq$ 20 km² reef, block > 20 km² reef). There are a total of 7 strata. A 0.1 by 0.1 mile grid is then overlaid onto the reef area contained within a given block and the ultimate sampling sites (second stage units) are randomly selected from that grid.

Gear and deployment

The SEAMAP reef fish survey has employed several camcorders in underwater housings since 1992. Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings were used from 2002 to 2005 and Sony PD170 camcorders during the years 2006 and 2007. In 2008 a stereo video camera system was developed and assembled at the NMFS Mississippi Laboratories - Stennis Space Center Facility and has been used in all subsequent surveys. The stereo video unit consists of a digital stereo still camera head, digital video camera, CPU, and hard drive mounted housed in an aluminum casing. All of the camcorder housings are rated to a maximum depth of 150 meters while the stereo camera housings are rated to 600 meters. Stereo cameras are mounted orthogonally at a height of 50 cm above the bottom of the pod and the array is baited with squid during deployment.

At each sampling site the stereo video unit is deployed for 40 minutes total, however the cameras and CPU delay filming for 5 minutes to allow for descent to the bottom, and settling of suspended sediment following impact. Once turned on, the cameras film for approximately 30 minutes before shutting off and retrieval of the array. During camera deployment the vessel drifts away from the site and a CTD cast is executed, collecting water depth, temperature, conductivity, and transmissivity from the surface to the maximum depth. Seabird units are the standard onboard NOAA vessels however the model employed was vessel/cruise dependent.

Video tape viewing

One video tape from each station is randomly selected for viewing out of all viewable videos. Videos that have issues with visibility, obstructions or camera malfunction cannot be randomly selected and are not viewed. Selected videos are viewed for twenty minutes starting from the time when the view clears from suspended sediment. Viewers identify, and enumerate all species to the lowest taxonomic level during the 20 minute viewable segment. From 1993-2007 the time when each fish entered and left the field of view was recorded a procedure referred to as time in - time out (TITO) and from these data a minimum count was calculated. The minimum count is the maximum number of individuals of a selected taxon in the field of view at one instance. Each 20 minute video is evaluated to determine the highest minimum count observed during a 20 minute recording. From 2008-present the digital video allows the viewer to record a frame number or time stamp of the image when the maximum number of individuals of a species occurred, along with the number of taxon identified in the image, but does not use the TITO method. Both the TITO and current viewing procedure result in the minimum count estimation of abundance (i.e. - mincount). Minimum count methodology is preferred because it prevents counting the same fish multiple times (e.g. if a fish were swimming in circles around the camera).

Fish length measurement

Beginning in 1995 fish lengths were measured from video using lasers attached on the camera system with known geometry. However, the frequency of hitting targets with the laser is low and to increase sample size any measureable fish during the video read was measured (i.e. not just at the mincount), and fish could have potentially been measured twice. The stereo cameras used in 2008-present allow size estimation from fish images. From 2008-2013 Vision Measurement System (VMS, Geometrics Inc.) was used to estimate size of fish and in 2014 we began use of SeaGIS software (SeaGIS Pty. Ltd.). Fish measurement is only performed at the point in the video corresponding to the mincount therefore there is no potential to measure any fish twice.

Data reduction

Various limitations either in design, implementation, or performance of gear causes limitations in calculating mincount and are therefore dropped from the design-based indices development and analysis as follows. In 1992, each fish was counted every time it came into view over the entire record time and the total of all these counts was the maximum count. Maximum count methodologies are not preferred and the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed, so 1992 data is excluded from analyses (unknown number of stations). From 1998 – 2000 and in 2003 the survey was not conducted. In 2001 the survey was spatially restricted to the west and was an abbreviated survey and therefore we removed that year as well. Occasionally tapes are unable to be read (i.e. organisms cannot be identified to species) for the following reasons including: 1) camera views are more than 50% obstructed, 2) sub-optimal lighting conditions, 3) increased backlighting, 4) increased turbidity, 5) cameras out of focus, 6) cameras failed to film.

Explanatory variables and definitions

Year (Y) = The survey is conducted on an annual basis during the spring and the objective is to calculate standardized observation rates by year. Years included 1993-1997, 2001-2002, and 2004-2014.

Region (R) = The survey is conducted throughout the northern Gulf of Mexico, however historically the SEDAR data workshop has requested separate indices for the western and eastern Gulf which is divided at 89° west longitude. This variable is not included in the model itself.

Block (B) = The first stage of the random site selection process is selected from 10' latitude x 10' longitude blocks. Only blocks containing known reef are eligible for selection. Ten sites are randomly selected from within the blocks. Initial models always include a random block factor to test for autocorrelation among sites within a block.

Strata (ST) = Strata are defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block (blocks $\leq$ 20 km² reef, block > 20 km² reef). There are a total of 7 strata.

Depth (D) = Water depth at the lat-lon where the camera was deployed via TDR placed on the array.

Temperature (T) = Water temperature on the bottom (C°) taken during camera deployment via TDR placed on the camera array.

Dissolved oxygen (DO) = Dissolved oxygen (mg/l) taken via CTD cast slightly away from where the camera is deployed.

Salinity (S) = Salinity (ppt) taken via CTD cast slightly away from where the camera is deployed.

Silt sand clay (SSC) = Percent bottom cover of silt, sand, or clay substrates.

Shell gravel (SG) = Percent bottom cover of shell or gravel substrates.

Rock (RK) = Percent bottom cover of rock substrates.

Attached epifauna (AE) = Percent bottom cover of attached epifauna on top of substrate.

Grass (G) = Percent bottom covered by grass.

Sponge (SP) = Percent bottom covered by sponge.

Unknown sessiles (US) = Percent bottom covered by unknown sessile organisms.

Algae (AL) = Percent bottom covered by algae.

Hardcoral (HC) = Percent bottom covered by hard coral.

Softcoral (SC) = Percent bottom covered by soft coral.

Seawhips (SW) = Percent bottom covered by seawhips.

Relief Maximum (RM) = Maximum relief measured from substrate to highest point.

Relief Average (RA) = Average relief measured from substrate to all measurable points.

Reef (RF) = Boolean variable indicating whether or not a station landed on reef or missed reef. It is a composite variable where positive reef stations area identified as having one of the following: > 5% hard coral or >5% rock or >5% soft coral

Index Construction

Video surveys produce count data that often do not conform to assumptions of normality and are frequently modeled using Poisson or negative-binomial error distributions (Guenther et al. 2014). Video data frequently has high numbers of ‘zero-counts’ commonly referred to as ‘zero-inflated’ data distributions, they are common in ecological count data and are a special case of over dispersion that cannot be easily addressed using traditional transformation procedures (Hall 2000). Delta lognormal models have been frequently used to model video count data (Campbell et al. 2012) but recent exploration of models using negative-binomial, poisson (SEDAR 2015), zero-inflated negative-binomial, and zero-inflated poisson models(Guenther et al. 2014) have been accepted for use in assessments in the southeast U.S. Additionally for certain species like Gulf of Mexico red grouper (SEDAR 2015) it has been determined that a combined video index was useful and included data from NMFS-Mississippi Labs, NMFS-

Panama City, and FWRI index. In this analysis we explored model fit using three different error distribution models to construct relative abundance indices including delta-lognormal, poisson and negative binomial.

Because of the identification issues associated with Scamp and Yellowmouth Grouper, we attempted to calculate indices for both species for the Gulf wide and two regional indices for the east and west Gulf. However the eastern Yellowmouth Grouper index would not converge and thus we do not provide any further analysis for that model. In addition we provided data to estimate a combined eastern index that is compiled using NMFS MS Labs, NMFS Panama City, and FWC video survey data (separate document). We provided an east Gulf index here to give insight on the utility of the Yellowmouth Grouper data. Once an error distribution was selected we ran each model with a select set of independent variables including year and reef as fixed effects and depth, average relief, maximum relief. We used the composite variable 'reef' rather than the percent coverage of individual habitat variables because of the strong relationship Scamp have with reef habitat and as a simplifying/aggregating variable to indicate if a camera observed reef habitat. Additionally, in previous SEDAR workshops it was decided that a combination of video indices submitted by NMFS-Mississippi Labs, NMFS-Panama City and FWC was desired. Despite the good coordination between groups the percent habitat cover variables are fairly subjective and may be interpreted different among groups, however groups are consistent in determining if the camera landed on reef habitat (i.e. the 'reef' variable). The GLIMMIX and MIXED procedure in SAS (v. 9.4) were used to develop the binomial and lognormal sub-models in the delta lognormal model (Lo et al. 1992), and GLIMMIX used to develop the poisson and negative binomial models. Best fitting models were determined by evaluating the conditional likelihood, over-dispersion parameter (Pearson chi-square/DF), and visual interpretation of the Q/Q plots. Backwards selection of variables was used to choose the final model and was also based on model fit information and additionally significance of the variable and improvement in AIC values (i.e. exclusion of variables).

Results

Throughout the time frame of the survey Scamp were observed on most if not all of the shelf edge break habitats sampled throughout the northern Gulf in both the east and west regions (Figures 11-31). Scamp spatial distributions covered the entire sampling frames in most years, but they exact locations showed moderate variation year to year with some locations such as Madison-Swanson, Florida Middle Grounds, Mobile Pinnacles and Flower Gardens, having observations every year. In contrast observations of Yellowmouth Grouper were primarily located in the west Gulf and scattered sparsely in both time and space in the east Gulf. Further, in the west Gulf the spatial distributions of Scamp and Yellowmouth Grouper overlap indicating there is no spatial separation between the two species. Thus both species occupy the same habitat simultaneously. Furthermore, the final model selections show that the reef (i.e. binomial variable indicating a set landed on reef) and the average relief variables were significantly, and positively, correlated with increasing Scamp and Yellowmouth abundance. Anecdotal observations of the species further reinforce that the species are primarily observed on the high-relief portions of the sampled universe.

After evaluating model fit information such as over dispersion parameters and QQ Plots of the residuals it was determined that the data best fit a Delta LogNormal (DLN) model and thus all subsequent analysis presented here stems from DLN model runs (Figures 2-3). We evaluated year and reef as fixed effects and depth, average relief, maximum relief as continuous variables. After backwards selection and evaluation of variable significance and AIC information we retained all variables except maximum relief in all model runs (Tables 1-4). Evaluation of standardized index and proportion positive output indicated that the Gulf-wide models derived from the combined and Scamp-only data track each other closely while the Yellowmouth index showed somewhat divergent trends (Tables 5-7 and Figures 5-6). When broken down by region we discovered that the east Yellowmouth Grouper model would not converge (i.e. too few observations) and further that the combined and Scamp-only models were essentially identical (Tables 11-12 and Figures 9-10). Thus in the east, the data are composed almost entirely of Scamp observations and have little if any impact from Yellowmouth Grouper observations. In contrast the west Gulf proportion positives and standardized indices indicate that the combined, Scamp-only and Yellowmouth Grouper models produce very similar if not identical trends (Tables 8-10 and Figures 7-8). Further the west Yellowmouth Grouper trend is similar to the Gulfwide trend and thus the Gulfwide trend is truly reflective of the observations in the west Gulf and should be treated as such. Proportion positives of Yellowmouth Grouper are roughly half of the Scamp observations over time but trends by and large are reflective of the combined and Scamp data. Given that both the proportion positive and standardized indices are so similar we suggest that these are unlikely to be acting as separate populations regardless if the two are distinct species. Two explanations for these trends could be hypothesized: 1) Fishing pressure (i.e. harvest), life-history traits (i.e. year class strength and recruitment), or both processes operate on both species in identical ways and thus the resultant abundance indices are very similar or 2) we are actually observing a single species with one of those being a morphological variant, and we suggest that would most likely be Yellowmouth Grouper.

Mean total length information suggests that Yellowmouth Grouper (465 mm) tended to be larger than Scamp (411 mm) when evaluated Gulfwide. However when broken down by region, specifically the west Gulf where most of the population of Yellowmouth Grouper were observed, Scamp (483 mm), were larger than Yellowmouth Grouper (461 mm). Thus smaller Scamp in the east Gulf (397 mm) were driving the Gulfwide trend that suggested Yellowmouth are larger. Length frequencies by and large overlap each other and the observed differences, especially in the east Gulf data set, could simply be reflective of a lack of data rather than true trend.

In lieu of other evidence to provide sound judgement on the status of these two species we presented indices for the combined, Scamp-only and Yellowmouth only data but suggest that the combined data should be used as the relative abundance index for the assessment of the species. We suggest using the combined data due to the strong correlation between observed standardized index abundance trends as well our belief that fisherman, even those well versed in species identification, are unlikely to be able to differentiate between the species and thus harvest is likely operating on both simultaneously.

Literature cited

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Figure 1. Spatial distribution of known reef from which stations are randomly selected for sampling for the reef fish video survey. Over the history of the survey (1992-2018) new reef tract has been discovered and mapped and therefore this map represents what was available in 2018, and not necessarily what has been available over the entire time series.

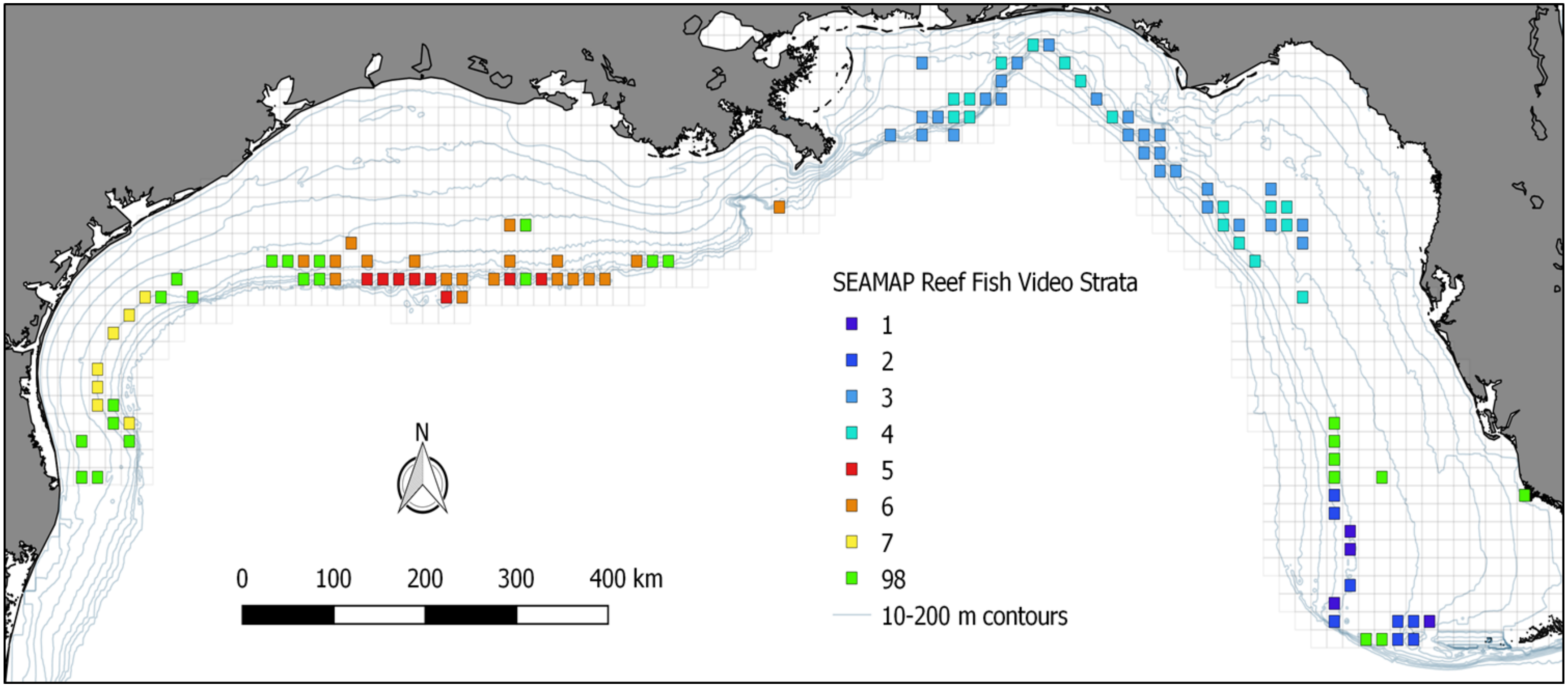

Table 1. Gulf wide proportion positive sub-model test of type III fixed effects. Combined Scamp and Yellowmouth Grouper data.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	20	6404	89.32	4.47	<.0001	<.0001
DEPTH	1	6404	157.29	157.29	<.0001	<.0001

Table 2. Gulf wide positive catch sub-model test of type III fixed effects. Combined Scamp and Yellowmouth Grouper data.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	20	1702	5.56	<.0001
REEF	1	1702	12.12	0.0005
relief_average	1	1702	8.09	0.0045

Table 3. West Gulf proportion positive sub-model run test of type III fixed effects. Combined Scamp and Yellowmouth Grouper data.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	20	2435	57.37	2.87	<.0001	<.0001
DEPTH	1	2435	23.29	23.29	<.0001	<.0001

Table 4. West Gulf positive catch sub-model test of type III fixed effects. Combined Scamp and Yellowmouth Grouper data.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	20	646	1.79	0.0181
REEF	1	646	9.90	0.0017
relief_average	1	646	4.22	0.0403

Figure 2. QQ-Plot of the residuals from the Gulf-wide runs for the combined model.

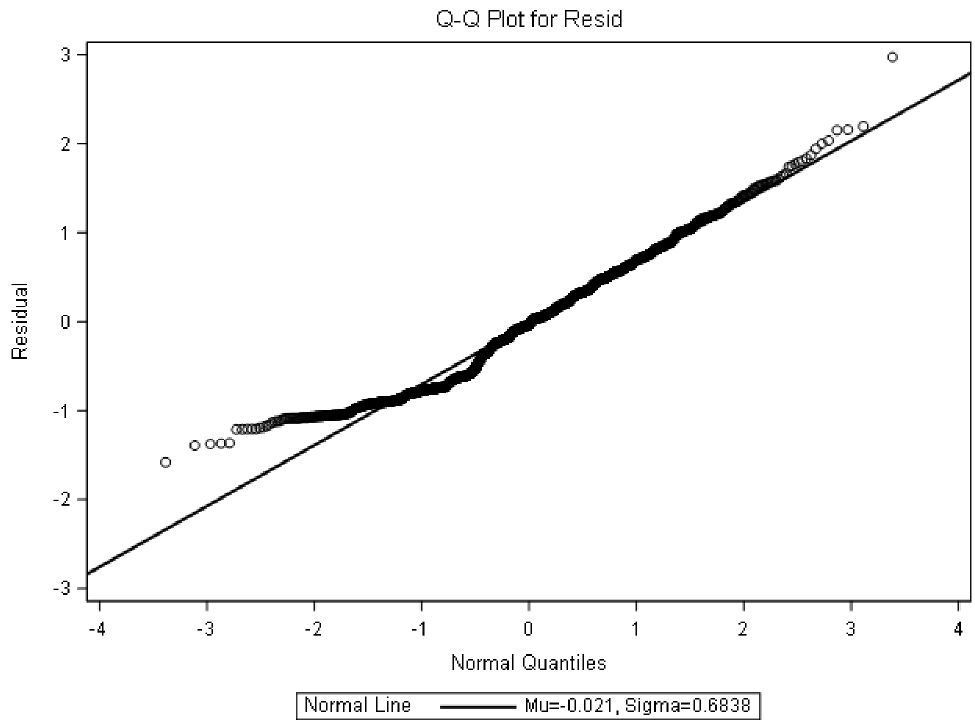

Figure 3. QQ-Plot of the residuals from the West-Gulf runs for the combined model.

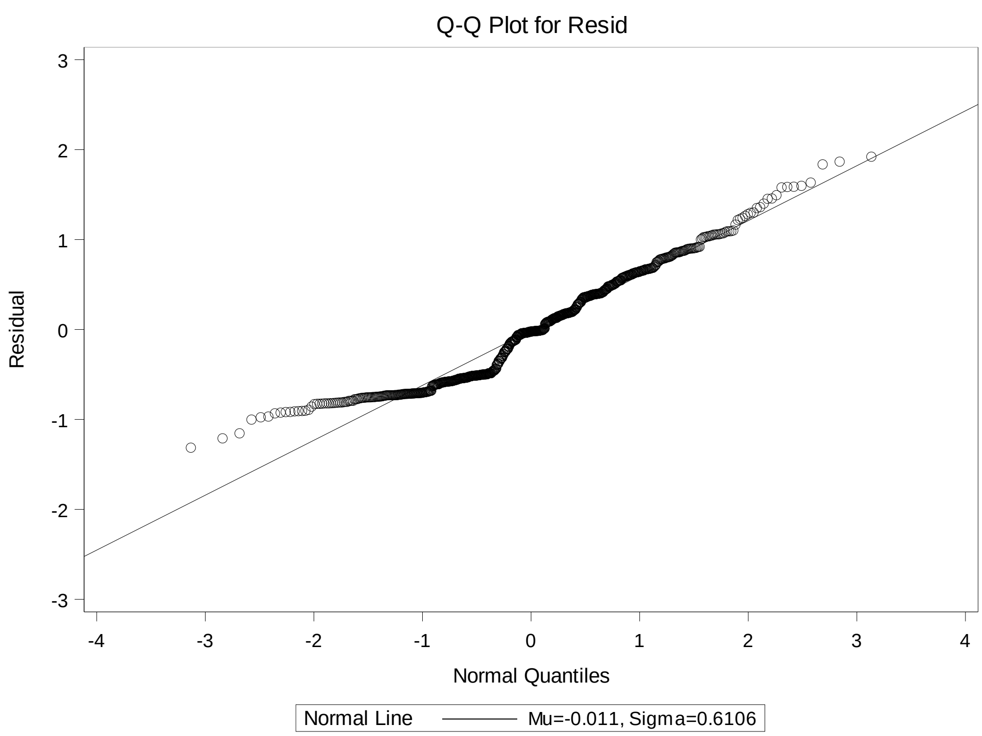

Table 5. Output for the Delta-LogNormal index of relative abundance of combined Scamp and Yellowmouth Grouper data by year, Gulf wide model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.2327	159	0.79374	1.14688	0.14367	0.181	0.80088	1.64236
1994	0.2	120	0.46201	0.66755	0.11552	0.25005	0.40792	1.09243
1995	0.20408	98	0.41738	0.60307	0.11827	0.28337	0.34592	1.05139
1996	0.23103	290	0.48894	0.70646	0.077	0.15749	0.51658	0.96615
1997	0.24911	281	0.48561	0.70165	0.07783	0.16027	0.51026	0.96483
2002	0.43621	243	1.11776	1.61505	0.1272	0.1138	1.28723	2.02636
2004	0.305	200	1.39763	2.01944	0.20488	0.14659	1.50862	2.70322
2005	0.30227	397	0.89211	1.289	0.1021	0.11445	1.02605	1.61935
2006	0.15534	412	0.48725	0.70402	0.07427	0.15244	0.51993	0.9533
2007	0.29375	480	0.72111	1.04193	0.08004	0.111	0.83507	1.30005
2008	0.23676	321	0.53969	0.7798	0.07877	0.14596	0.58327	1.04255
2009	0.2476	416	0.61539	0.88918	0.07304	0.1187	0.70186	1.12649
2010	0.29032	310	1.00064	1.44582	0.12921	0.12913	1.11793	1.86987
2011	0.32471	425	0.87911	1.27022	0.0958	0.10897	1.02213	1.57852
2012	0.23861	461	0.53299	0.77011	0.07361	0.13812	0.585	1.01381
2013	0.27562	283	0.5363	0.7749	0.08652	0.16132	0.56237	1.06776
2014	0.26837	313	0.70852	1.02374	0.09897	0.13968	0.77527	1.35186
2015	0.32065	184	0.69506	1.00429	0.11151	0.16043	0.73013	1.38141
2016	0.34203	345	0.69934	1.01047	0.08803	0.12587	0.78636	1.29846
2017	0.28941	387	0.62632	0.90496	0.08138	0.12994	0.69861	1.17226
2018	0.20541	370	0.437	0.63142	0.06678	0.15281	0.46597	0.85562

Table 6. Output for the Delta-LogNormal index of relative abundance of Scamp only data by year, Gulf wide model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.2327	159	0.78928	1.21671	0.14883	0.18857	0.8372	1.76826
1994	0.18333	120	0.39544	0.60959	0.10847	0.2743	0.3557	1.04468
1995	0.19388	98	0.38007	0.5859	0.11484	0.30215	0.3244	1.05818
1996	0.2	290	0.41654	0.64212	0.07284	0.17488	0.45379	0.90859
1997	0.21708	281	0.41078	0.63324	0.07328	0.17838	0.44447	0.90218
2002	0.39918	243	1.05221	1.62204	0.131	0.1245	1.26573	2.07866
2004	0.3	200	1.34686	2.07625	0.20682	0.15356	1.52995	2.81761
2005	0.29471	397	0.85839	1.32325	0.10349	0.12057	1.04063	1.68263
2006	0.14806	412	0.46252	0.713	0.07451	0.16109	0.51768	0.982
2007	0.27917	480	0.70169	1.08169	0.0834	0.11886	0.85355	1.37081
2008	0.22118	321	0.50977	0.78584	0.08037	0.15767	0.57441	1.07508
2009	0.24519	416	0.59734	0.92083	0.07421	0.12423	0.71893	1.17942
2010	0.28387	310	0.94845	1.46208	0.1291	0.13611	1.11503	1.91714
2011	0.31529	425	0.84247	1.2987	0.0969	0.11502	1.03259	1.63339
2012	0.2321	461	0.4881	0.75243	0.07115	0.14577	0.56301	1.00558
2013	0.25795	283	0.44566	0.68701	0.07761	0.17415	0.48621	0.97072
2014	0.25879	313	0.66032	1.01792	0.09757	0.14777	0.75868	1.36574
2015	0.31522	184	0.66668	1.02771	0.11232	0.16848	0.73546	1.43611
2016	0.32464	345	0.6358	0.98012	0.08576	0.13489	0.74928	1.28209
2017	0.28424	387	0.59429	0.91613	0.0809	0.13612	0.69866	1.20129
2018	0.20541	370	0.42	0.64746	0.06688	0.15924	0.47181	0.8885

Table 7. Output for the Delta-LogNormal index of relative abundance of combined Yellowmouth Grouper data only by year, Gulf wide model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.006289	159	0.006295	0.13875	0.008027	1.27504	0.01945	0.99001
1994	0.033333	120	0.091692	2.02094	0.041746	0.45529	0.84833	4.81439
1995	0.040816	98	0.048512	1.06923	0.026898	0.55446	0.37963	3.01149
1996	0.075862	290	0.084191	1.85561	0.018651	0.22153	1.19775	2.8748
1997	0.081851	281	0.099851	2.20078	0.022983	0.23017	1.3971	3.46675
2002	0.078189	243	0.0669	1.47451	0.017316	0.25883	0.88606	2.45376
2004	0.05	200	0.057969	1.27766	0.017844	0.30783	0.69995	2.33219
2005	0.030227	397	0.03068	0.6762	0.01011	0.32955	0.35578	1.2852
2006	0.021845	412	0.021528	0.47448	0.008037	0.37332	0.2304	0.97716
2007	0.029167	480	0.024906	0.54895	0.007073	0.284	0.3145	0.95818
2008	0.037383	321	0.037406	0.82445	0.010865	0.29047	0.46661	1.45672
2009	0.021635	416	0.016623	0.36638	0.005944	0.3576	0.18307	0.73324
2010	0.03871	310	0.042793	0.94319	0.012074	0.28216	0.54225	1.64058
2011	0.035294	425	0.032227	0.7103	0.009037	0.28041	0.40971	1.23141
2012	0.043384	461	0.043391	0.95636	0.011255	0.25939	0.57409	1.59318
2013	0.067138	283	0.078297	1.7257	0.019601	0.25035	1.05393	2.82566
2014	0.047923	313	0.042627	0.93952	0.013066	0.30651	0.51597	1.71075
2015	0.032609	184	0.023657	0.52142	0.011706	0.49482	0.2045	1.32946
2016	0.06087	345	0.062159	1.37002	0.014117	0.22711	0.87486	2.14544
2017	0.033592	387	0.027234	0.60025	0.009022	0.33127	0.31481	1.14449
2018	0.016216	370	0.013852	0.30531	0.007128	0.51457	0.11582	0.80485

Table 8. Output for the Delta-LogNormal index of relative abundance of combined Scamp and Yellowmouth Grouper data by year, West Gulf model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.15556	45	0.66001	1.05616	0.24991	0.37864	0.50793	2.19614
1994	0.17778	45	0.36115	0.57792	0.13796	0.382	0.27625	1.20902
1995	0.18182	44	0.38801	0.62089	0.13565	0.34961	0.31482	1.22455
1996	0.20606	165	0.41132	0.6582	0.07231	0.17581	0.46431	0.93305
1997	0.37008	127	0.9868	1.57909	0.1378	0.13964	1.19591	2.08504
2002	0.40217	92	0.77843	1.24565	0.13428	0.1725	0.88442	1.75443
2004	0.2549	51	0.87205	1.39546	0.24069	0.27601	0.81165	2.39923
2005	0.32353	136	0.71917	1.15082	0.1137	0.1581	0.84049	1.57573
2006	0.15827	139	0.32075	0.51326	0.07782	0.24262	0.31813	0.82807
2007	0.30994	171	0.47812	0.76509	0.08065	0.16869	0.54729	1.06957
2008	0.22137	131	0.35602	0.56971	0.08202	0.23038	0.36152	0.89779
2009	0.22754	167	0.40877	0.65412	0.07326	0.17923	0.45836	0.93349
2010	0.22642	106	0.59169	0.94682	0.1438	0.24303	0.58641	1.52875
2011	0.36893	103	0.80095	1.28168	0.12779	0.15955	0.93341	1.75991
2012	0.295	200	0.66049	1.05692	0.09965	0.15087	0.78295	1.42677
2013	0.31618	136	0.84855	1.35785	0.14216	0.16753	0.97352	1.89391
2014	0.30973	113	0.75615	1.21	0.14247	0.18842	0.83283	1.75799
2015	0.375	48	0.74873	1.19812	0.21678	0.28954	0.67929	2.11321
2016	0.3869	168	0.85777	1.37262	0.11686	0.13624	1.04655	1.80027
2017	0.30688	189	0.61389	0.98235	0.09747	0.15877	0.7165	1.34683
2018	0.22165	194	0.50447	0.80725	0.08682	0.1721	0.57361	1.13607

Table 9. Output for the Delta-LogNormal index of relative abundance of Scamp only data by year, West Gulf.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.15556	45	0.65786	1.37205	0.24551	0.3732	0.66638	2.82499
1994	0.15556	45	0.31183	0.65036	0.12928	0.41457	0.29325	1.44234
1995	0.15909	44	0.28117	0.58642	0.10538	0.37479	0.28399	1.2109
1996	0.16364	165	0.2866	0.59774	0.05625	0.19628	0.40517	0.88184
1997	0.29921	127	0.69095	1.44106	0.11322	0.16386	1.04063	1.99557
2002	0.33696	92	0.5255	1.09599	0.10534	0.20046	0.73689	1.63008
2004	0.23529	51	0.71696	1.49529	0.2047	0.28551	0.85424	2.61742
2005	0.30147	136	0.58311	1.21614	0.09689	0.16615	0.87427	1.69168
2006	0.13669	139	0.21665	0.45185	0.05726	0.2643	0.26871	0.75979
2007	0.2807	171	0.38442	0.80174	0.07181	0.1868	0.55357	1.16118
2008	0.19084	131	0.2747	0.57292	0.06993	0.25456	0.34709	0.94568
2009	0.22156	167	0.35085	0.73174	0.06451	0.18387	0.50813	1.05374
2010	0.21698	106	0.46976	0.97974	0.11823	0.25167	0.59684	1.60829
2011	0.33981	103	0.65636	1.36891	0.11044	0.16826	0.98004	1.91209
2012	0.285	200	0.49516	1.0327	0.07646	0.15442	0.75969	1.40383
2013	0.27941	136	0.51345	1.07085	0.09552	0.18603	0.74048	1.54861
2014	0.28319	113	0.52473	1.09438	0.10566	0.20136	0.73452	1.63054
2015	0.35417	48	0.51582	1.0758	0.16044	0.31104	0.58583	1.97554
2016	0.35714	168	0.67763	1.41327	0.09945	0.14676	1.05543	1.89242
2017	0.2963	189	0.49549	1.03339	0.08004	0.16154	0.74965	1.42454
2018	0.22165	194	0.44	0.91767	0.07543	0.17143	0.65293	1.28977

Table 10. Output for the Delta-LogNormal index of relative abundance of Yellowmouth Grouper data only by year, west Gulf model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.02222	45	0.03251	0.20665	0.035679	1.09764	0.03491	1.22337
1994	0.04444	45	0.06196	0.3939	0.043939	0.70915	0.1099	1.41183
1995	0.09091	44	0.12129	0.77106	0.057446	0.47363	0.31357	1.89605
1996	0.10909	165	0.14168	0.9007	0.03246	0.22911	0.57296	1.41592
1997	0.1811	127	0.38144	2.42492	0.070555	0.18497	1.68029	3.49953
2002	0.17391	92	0.28363	1.80309	0.065326	0.23032	1.1443	2.84115
2004	0.13725	51	0.18937	1.20384	0.06663	0.35186	0.60788	2.38407
2005	0.08824	136	0.173	1.09978	0.047562	0.27493	0.64098	1.88699
2006	0.06475	139	0.11557	0.73471	0.03638	0.31479	0.39731	1.35864
2007	0.06433	171	0.09881	0.62817	0.02773	0.28063	0.36218	1.08951
2008	0.0687	131	0.10473	0.66577	0.035955	0.34332	0.3415	1.29796
2009	0.0479	167	0.06775	0.43068	0.023017	0.33975	0.22237	0.83414
2010	0.07547	106	0.14108	0.89687	0.049173	0.34855	0.45563	1.7654
2011	0.09709	103	0.13358	0.84922	0.040721	0.30484	0.46784	1.54149
2012	0.095	200	0.18379	1.16842	0.040668	0.22127	0.75457	1.80925
2013	0.13235	136	0.31344	1.99264	0.067234	0.2145	1.30379	3.04544
2014	0.13274	113	0.22576	1.43521	0.056969	0.25234	0.87319	2.35897
2015	0.10417	48	0.19529	1.24153	0.090657	0.46421	0.51316	3.00371
2016	0.09524	168	0.17946	1.14088	0.042318	0.2358	0.71646	1.81674
2017	0.06878	189	0.10886	0.69204	0.030361	0.2789	0.40032	1.19635
2018	0.03093	194	0.05032	0.31992	0.022229	0.44172	0.13751	0.7443

Table 11. Output for the Delta-LogNormal index of relative abundance of combined Scamp and Yellowmouth Grouper data by year, east Gulf model run.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.26316	114	0.79085	1.12519	0.17194	0.2174	0.7321	1.72937
1994	0.21333	75	0.46846	0.66651	0.14794	0.3158	0.35975	1.23486
1995	0.22222	54	0.4433	0.63071	0.16689	0.37647	0.30451	1.30633
1996	0.264	125	0.53148	0.75617	0.11904	0.22397	0.4858	1.17703
1997	0.14935	154	0.30955	0.44042	0.07979	0.25776	0.2652	0.73141
2002	0.45695	151	1.27395	1.81252	0.1805	0.14168	1.3672	2.4029
2004	0.32215	149	1.51244	2.15183	0.2688	0.17773	1.51229	3.06183
2005	0.29119	261	0.93945	1.33661	0.13926	0.14824	0.99527	1.795
2006	0.15385	273	0.5246	0.74638	0.10037	0.19133	0.51081	1.09058
2007	0.28479	309	0.74875	1.06528	0.10927	0.14593	0.79685	1.42415
2008	0.24737	190	0.59602	0.84799	0.11013	0.18478	0.58781	1.22334
2009	0.26104	249	0.69544	0.98944	0.10485	0.15076	0.73312	1.33538
2010	0.32353	204	1.07752	1.53305	0.17294	0.1605	1.11438	2.10902
2011	0.31056	322	0.88449	1.25842	0.12293	0.13898	0.95429	1.65946
2012	0.1954	261	0.48965	0.69665	0.09559	0.19523	0.47318	1.02567
2013	0.2381	147	0.41858	0.59554	0.09798	0.23408	0.37523	0.94521
2014	0.245	200	0.68851	0.97959	0.12501	0.18156	0.68331	1.40433
2015	0.30147	136	0.65109	0.92635	0.13081	0.20091	0.62228	1.37899
2016	0.29944	177	0.65547	0.93257	0.11648	0.17771	0.65543	1.32689
2017	0.27273	198	0.64732	0.92098	0.11276	0.1742	0.65173	1.30145
2018	0.1875	176	0.41314	0.5878	0.08952	0.21667	0.38299	0.90214

Table 12. Output for the Delta-LogNormal index of relative abundance of Scamp only data by year, east Gulf.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.26316	114	0.7903	1.14661	0.1741	0.2203	0.74187	1.77215
1994	0.2	75	0.4037	0.58571	0.13432	0.33273	0.30636	1.1198
1995	0.22222	54	0.44489	0.64547	0.16938	0.38073	0.30925	1.34726
1996	0.248	125	0.49975	0.72506	0.11716	0.23444	0.45652	1.15157
1997	0.14935	154	0.30826	0.44724	0.08042	0.26089	0.2677	0.74719
2002	0.43709	151	1.2719	1.84535	0.18656	0.14668	1.37833	2.47061
2004	0.32215	149	1.4781	2.14452	0.26607	0.18001	1.50046	3.06505
2005	0.29119	261	0.93301	1.35367	0.14013	0.15019	1.00412	1.82491
2006	0.15385	273	0.52294	0.75871	0.10126	0.19363	0.51693	1.11356
2007	0.27832	309	0.73897	1.07215	0.1104	0.1494	0.79653	1.44313
2008	0.24211	190	0.58115	0.84317	0.11035	0.18988	0.57869	1.22854
2009	0.26104	249	0.68364	0.99186	0.10443	0.15276	0.73203	1.34392
2010	0.31863	204	1.04175	1.51144	0.17061	0.16377	1.09165	2.09266
2011	0.30745	322	0.86677	1.25756	0.12263	0.14148	0.94896	1.66651
2012	0.19157	261	0.48583	0.70487	0.09689	0.19943	0.47486	1.04627
2013	0.2381	147	0.40842	0.59256	0.09687	0.23718	0.37113	0.94608
2014	0.245	200	0.68525	0.9942	0.12601	0.18389	0.69036	1.43178
2015	0.30147	136	0.64649	0.93797	0.13151	0.20343	0.62702	1.40312
2016	0.29379	177	0.62869	0.91214	0.11406	0.18143	0.63642	1.3073
2017	0.27273	198	0.6444	0.93494	0.11369	0.17642	0.65875	1.32694
2018	0.1875	176	0.40996	0.5948	0.08998	0.21948	0.38545	0.91785

Figure 5. Plot of the proportion positives for the Gulf-wide runs for the combined, Scamp only or Yellowmouth grouper only models.

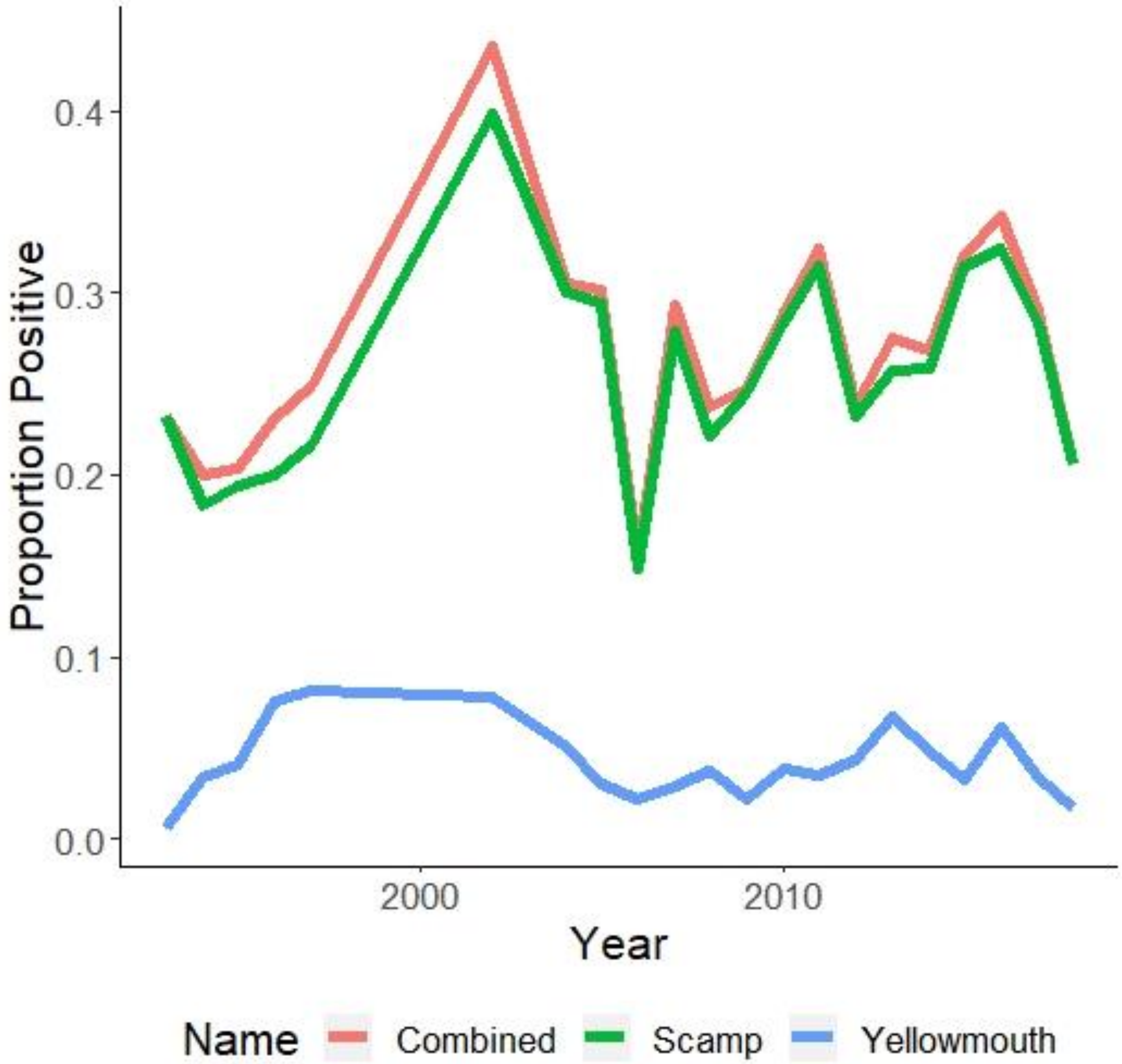

Figure 6. Plot of the standardized indices for the Gulf-wide runs for the combined, Scamp only or Yellowmouth grouper only models.

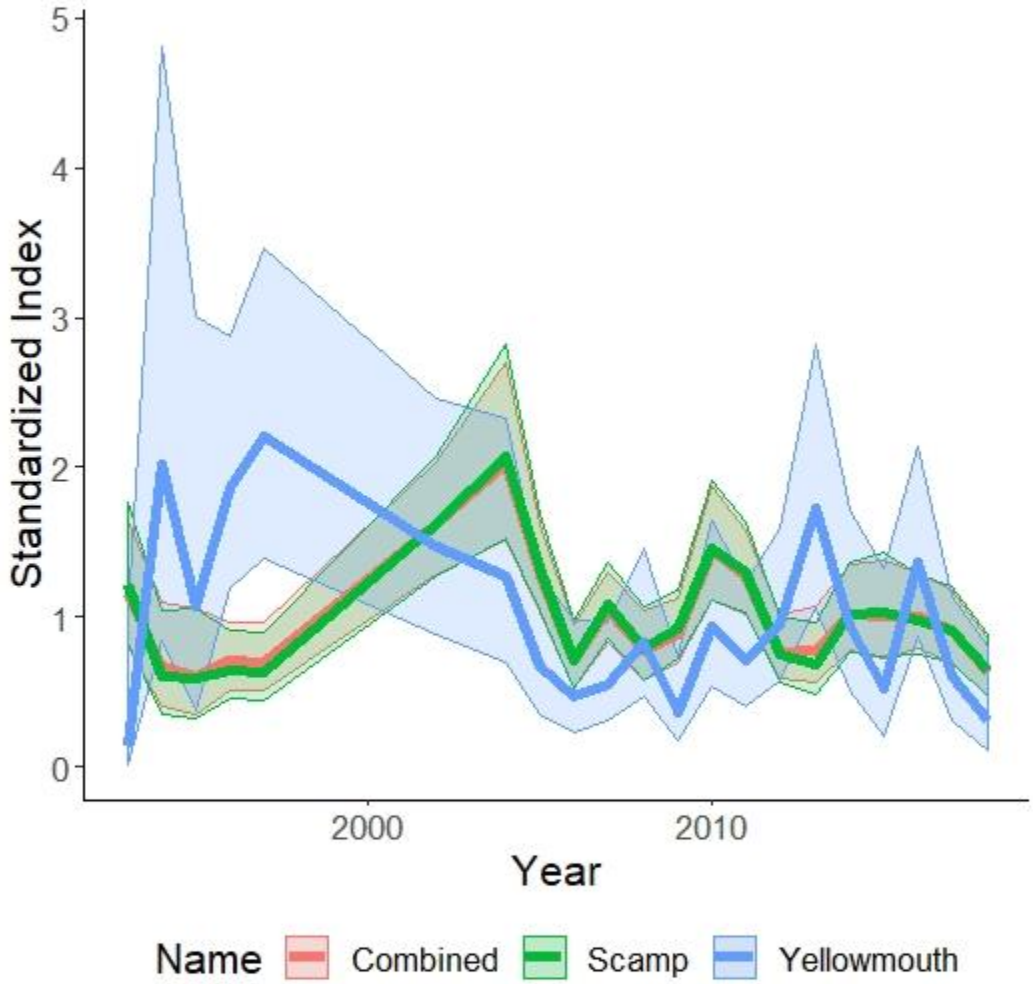

Figure 7. Plot of the proportion positives for the west Gulf runs for the combined, Scamp only or Yellowmouth grouper only models.

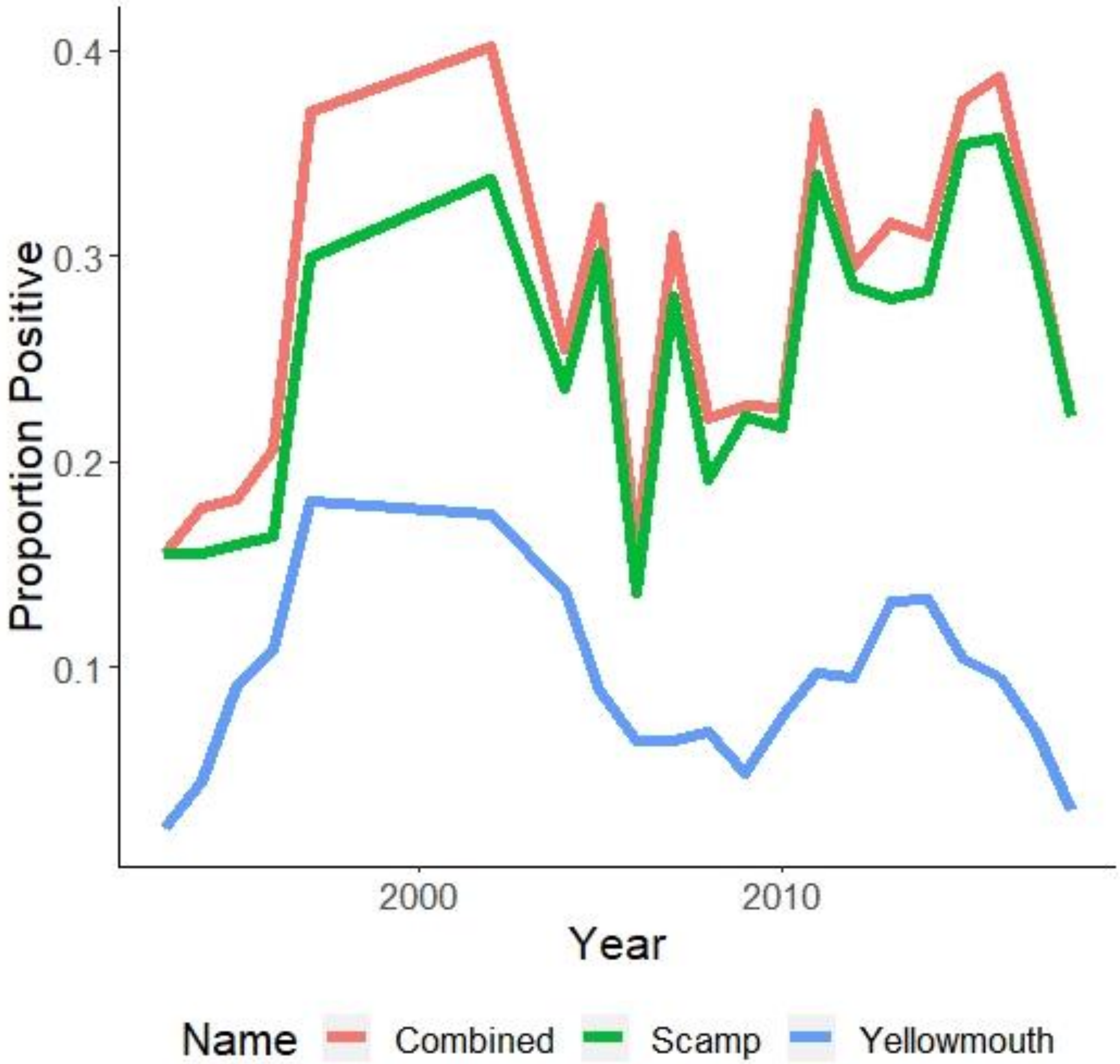

Figure 8. Plot of the standardized indices for the west Gulf runs for the combined, Scamp only or Yellowmouth grouper only models.

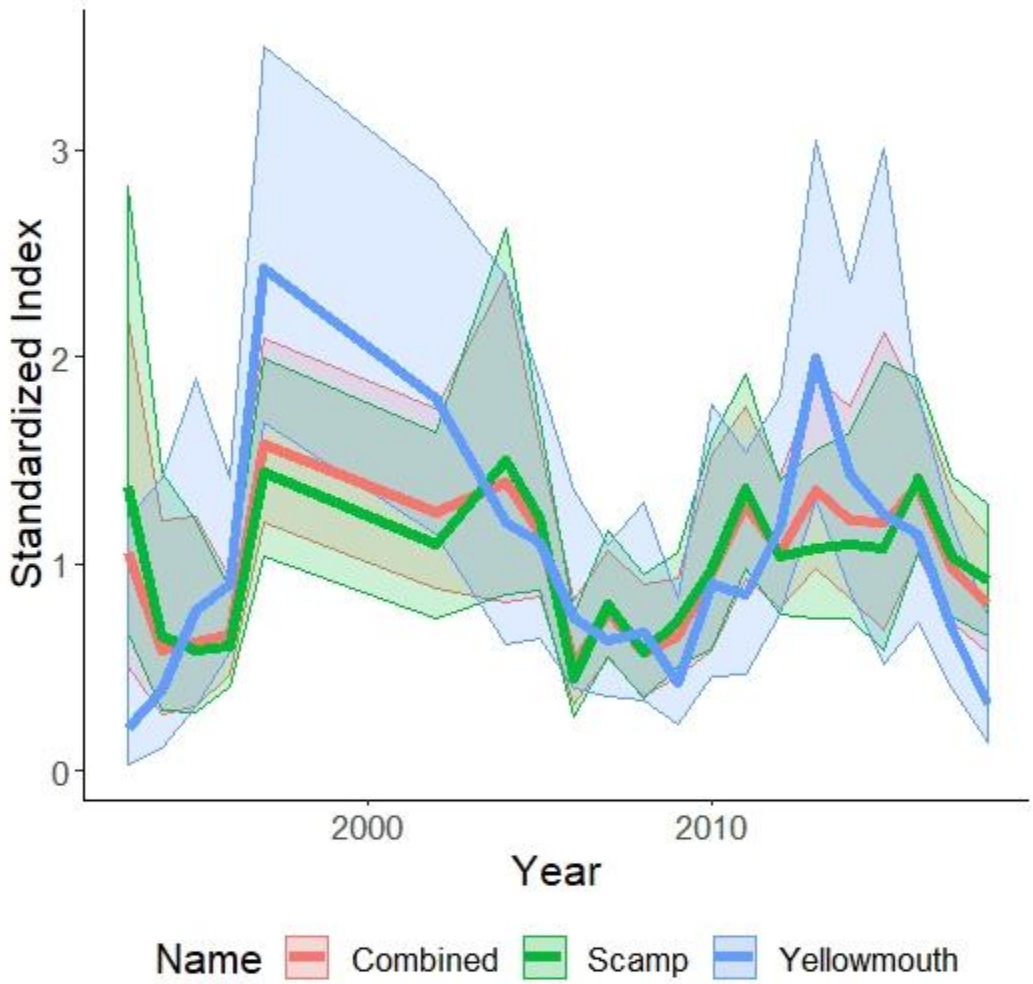

Figure 9. Plot of the proportion positives for the east Gulf runs for the combined, Scamp only models. Models using Yellowmouth grouper data only would not converge.

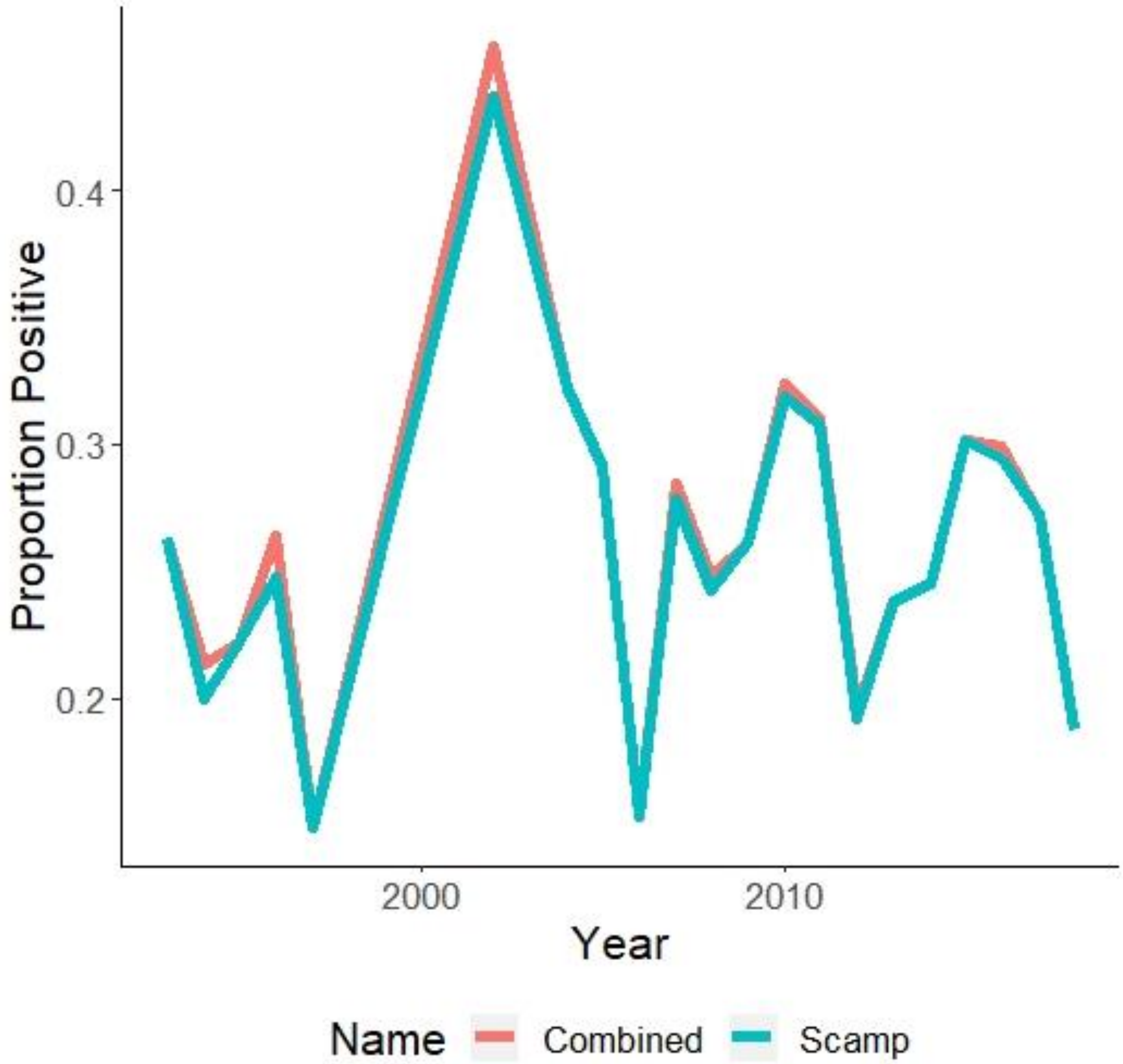

Figure 10. Plot of the standardized indices for the east Gulf runs for the combined, Scamp only model runs. Models using only Yellowmouth Grouper data would not converge.

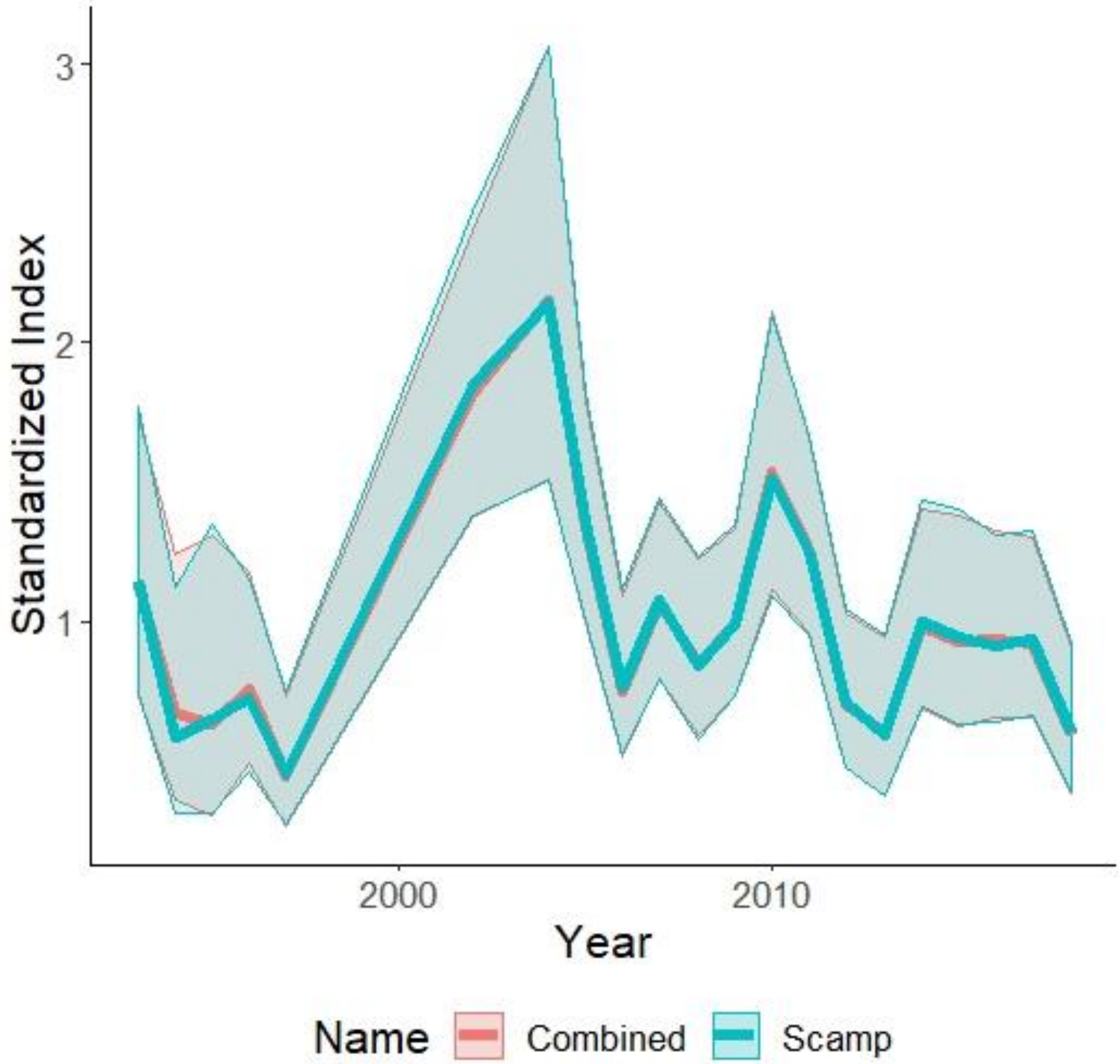

Figure 11. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 1993.

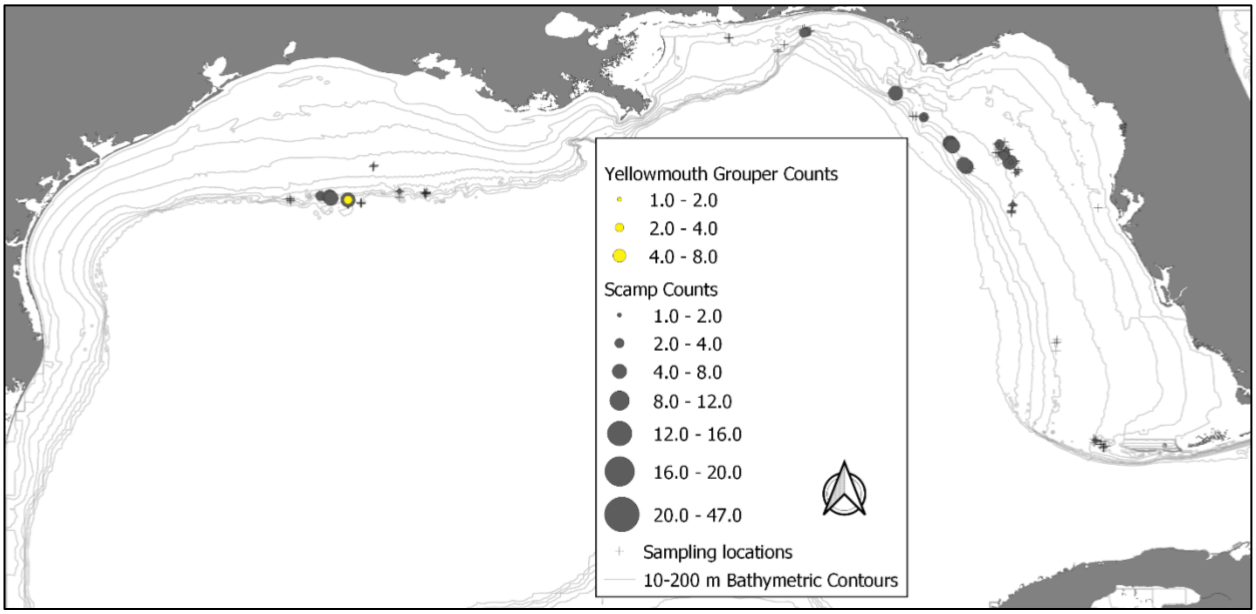

Figure 12. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 1994.

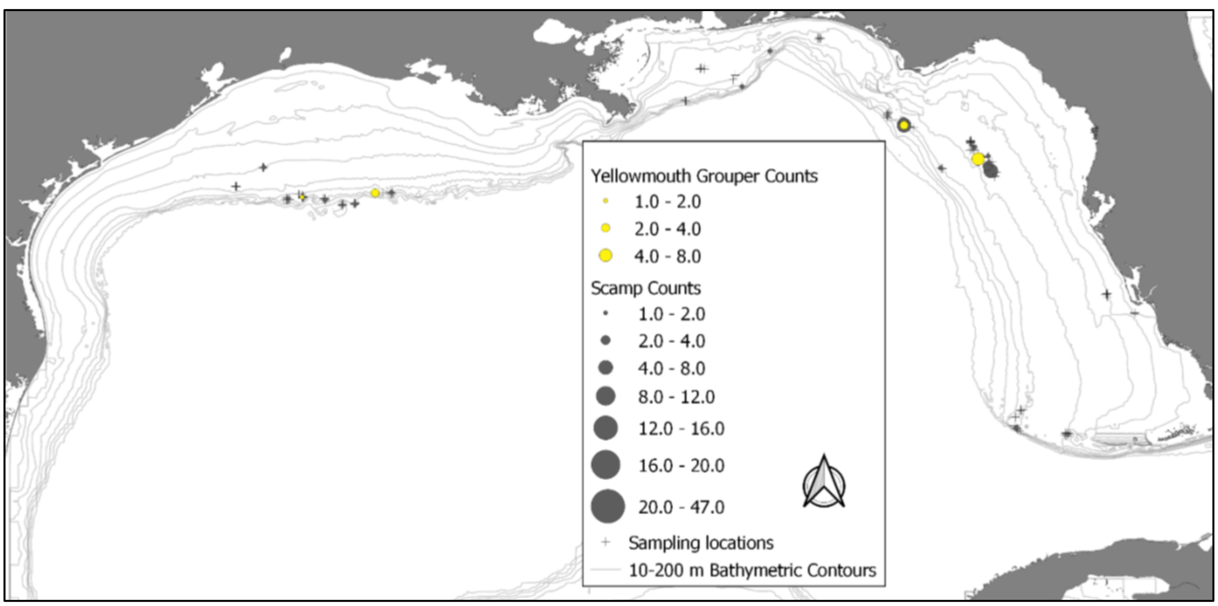

Figure 13. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 1995.

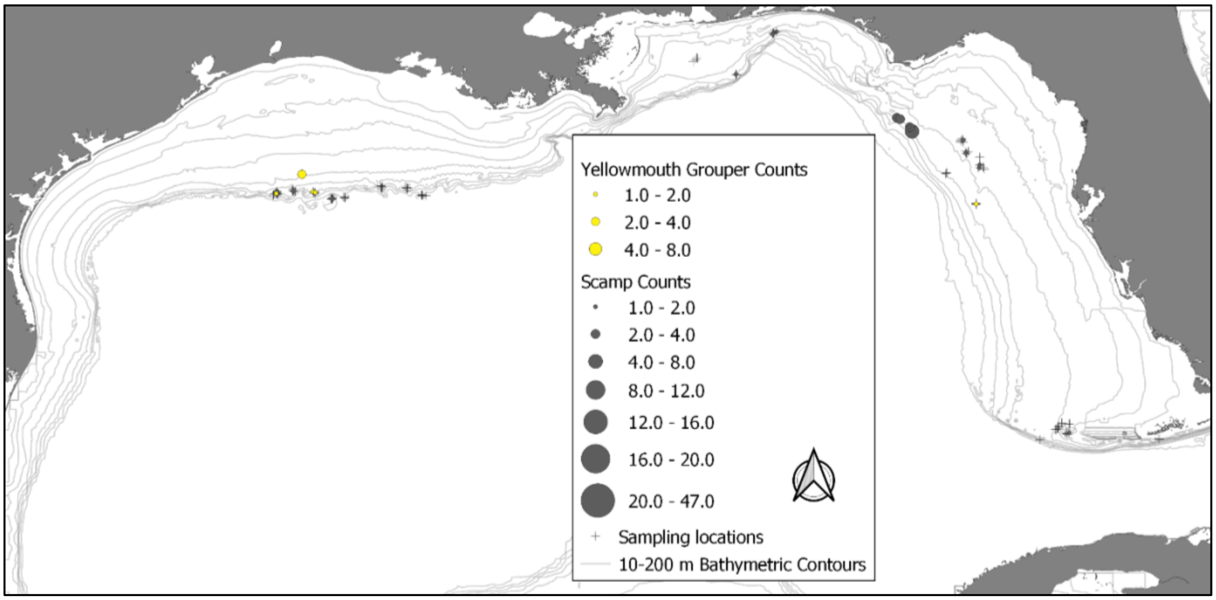

Figure 14. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 1996.

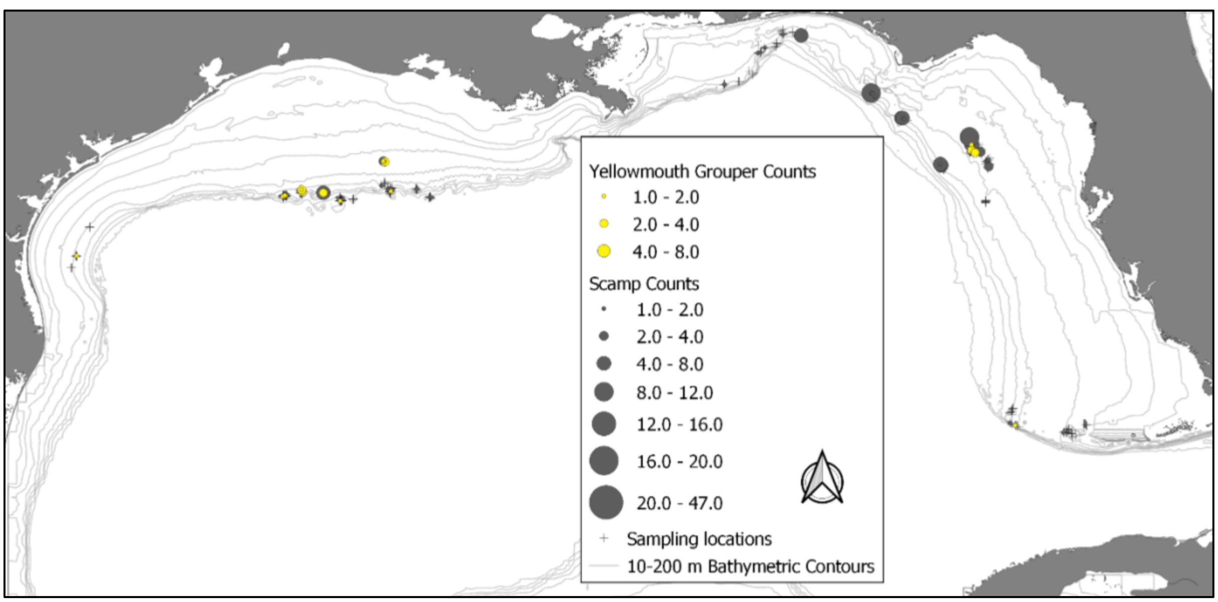

Figure 15. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 1997.

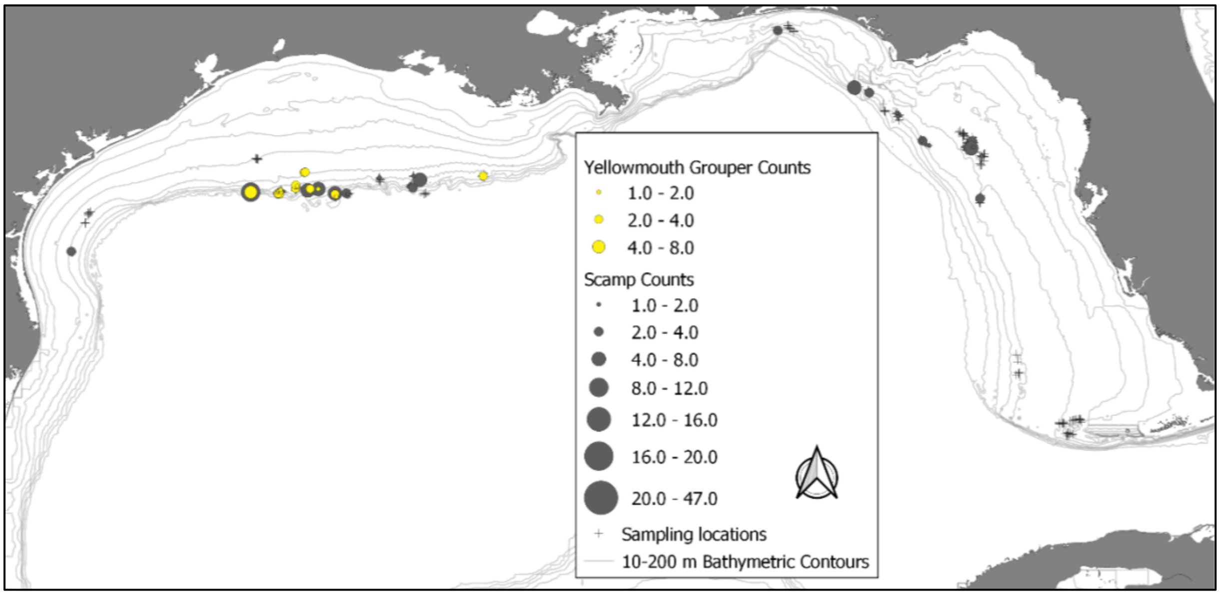

Figure 16. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2002.

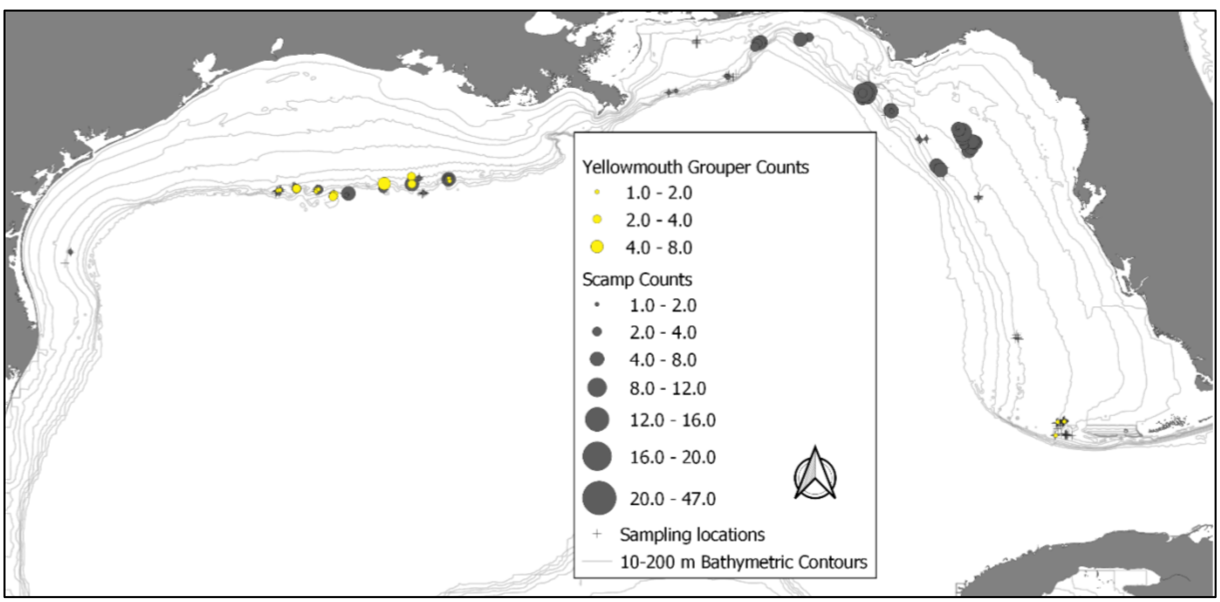

Figure 17. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2004.

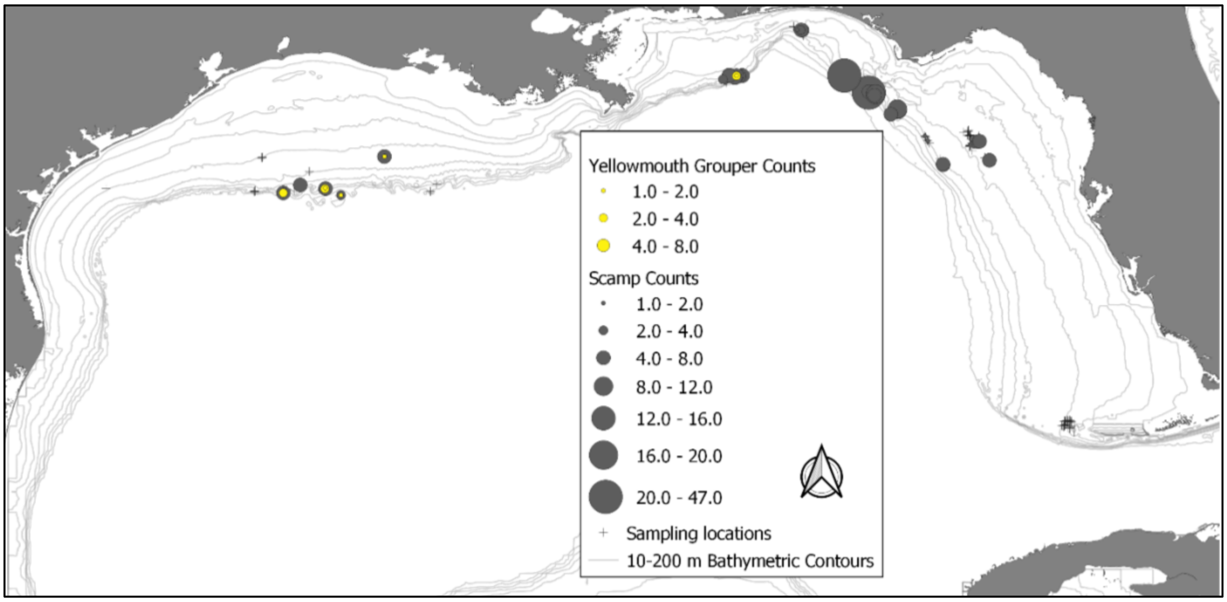

Figure 18. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2005.

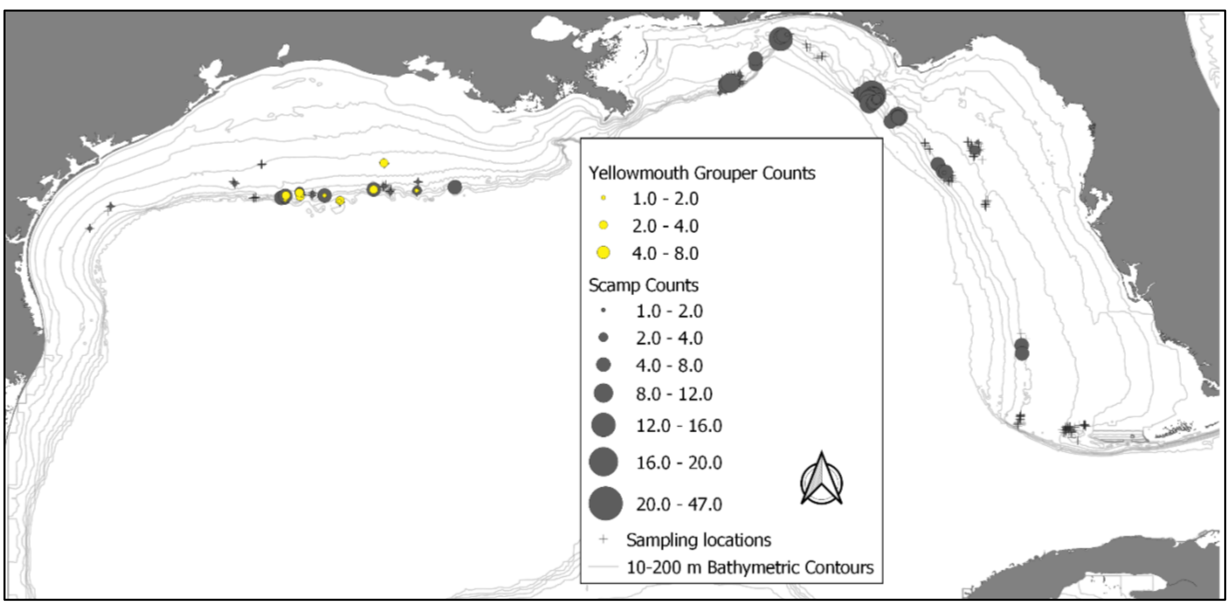

Figure 19. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2006.

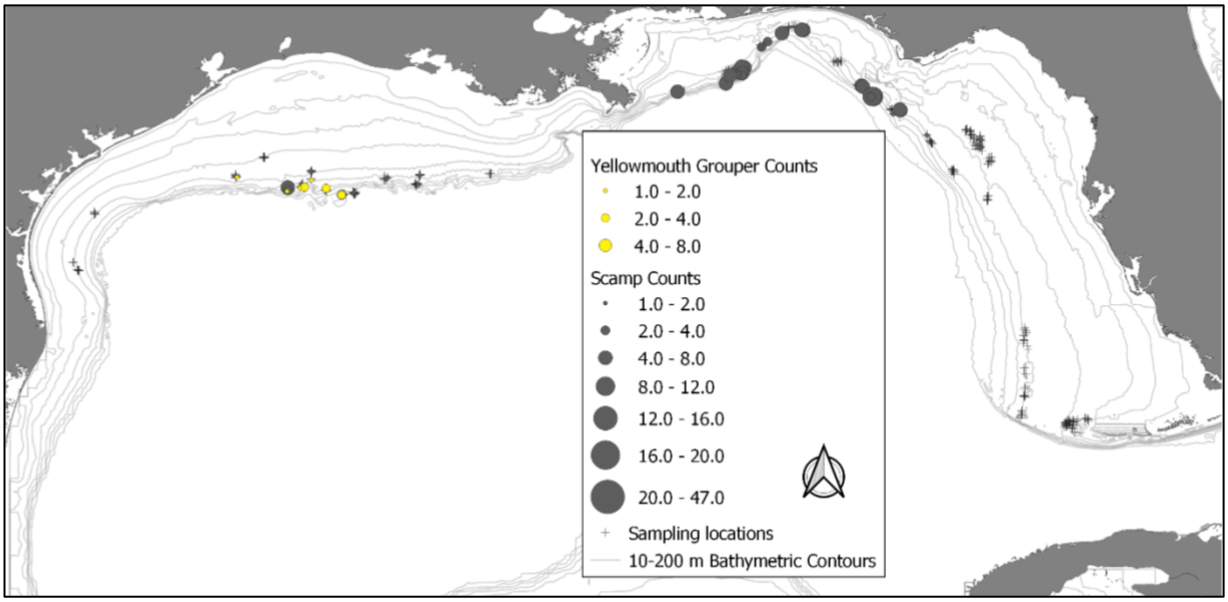

Figure 20. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2007.

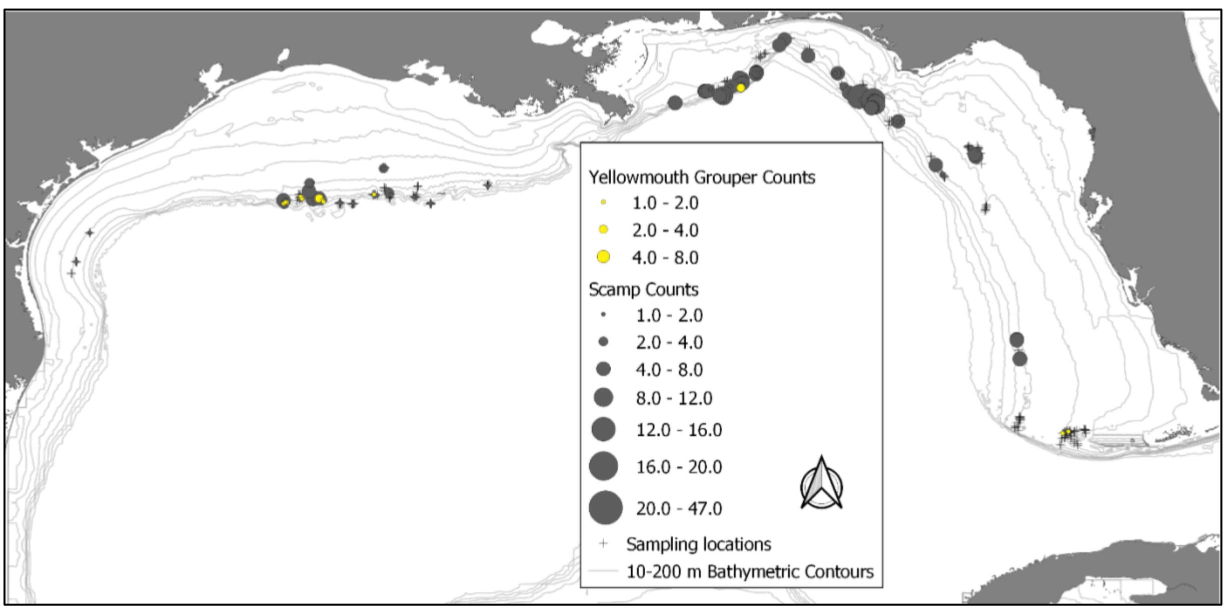

Figure 21. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2008.

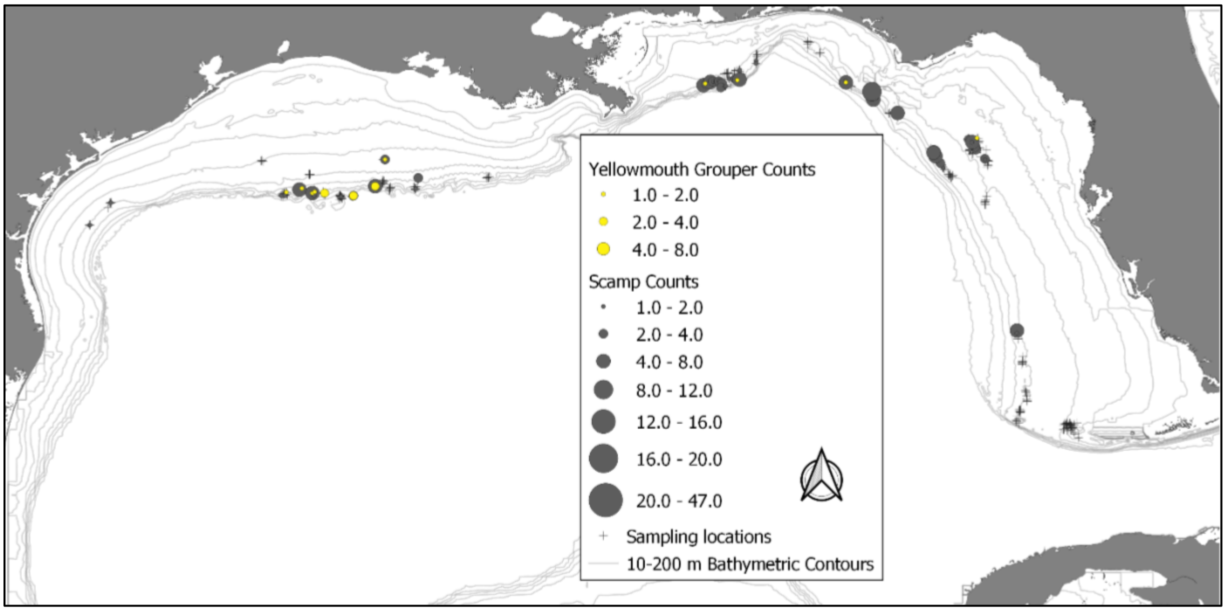

Figure 22. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2009.

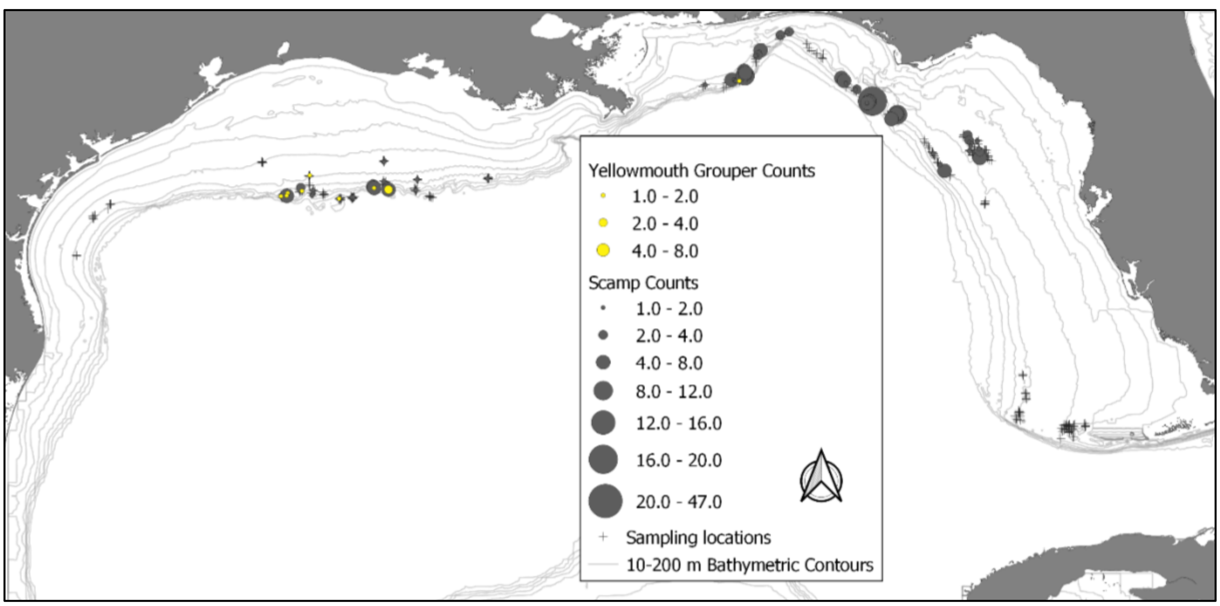

Figure 23. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2010.

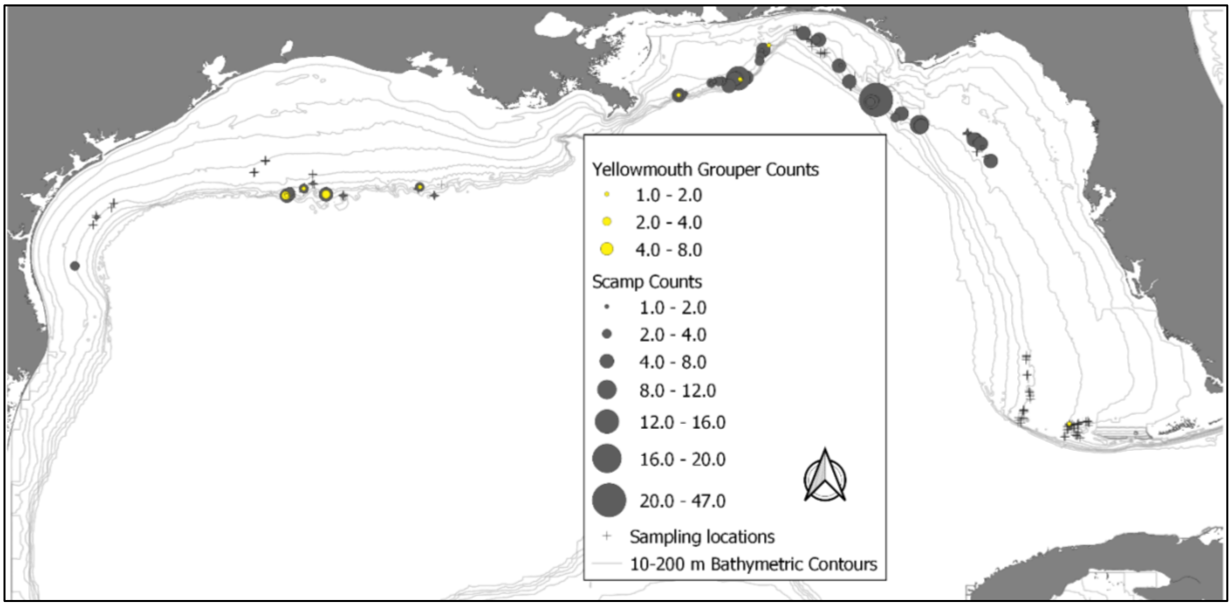

Figure 24. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2011.

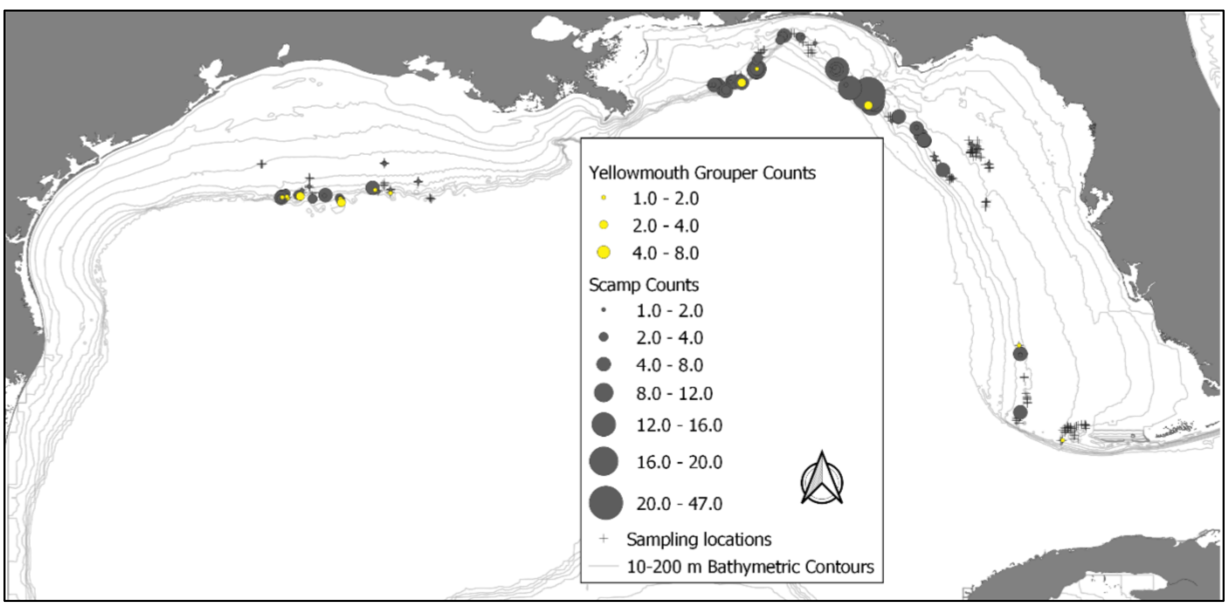

Figure 25. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2012.

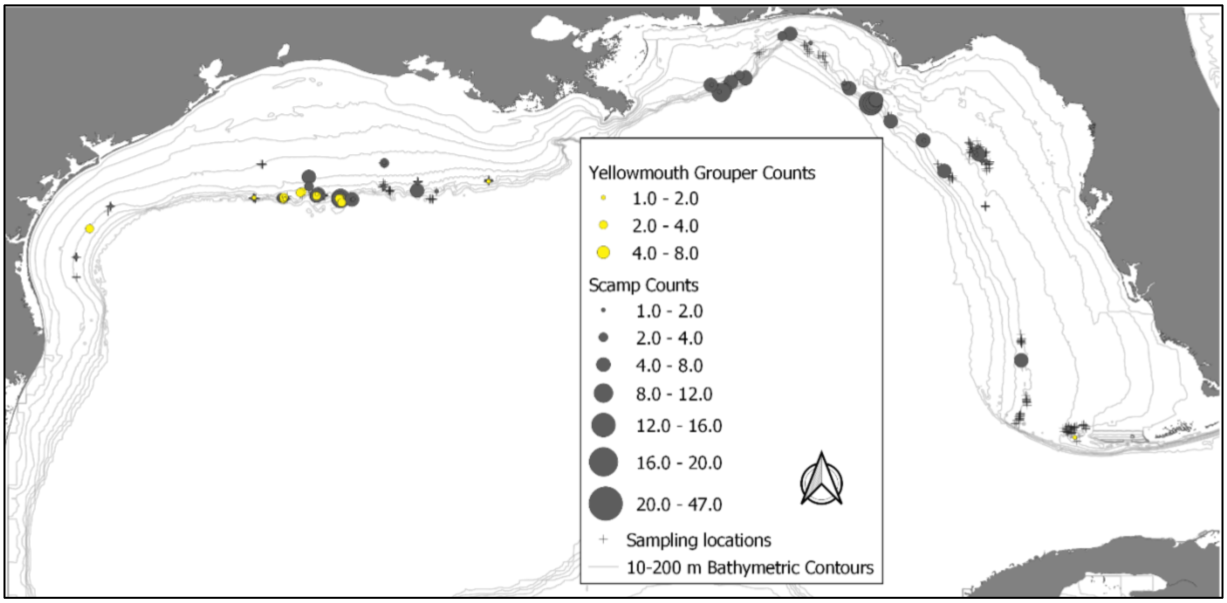

Figure 26. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2013.

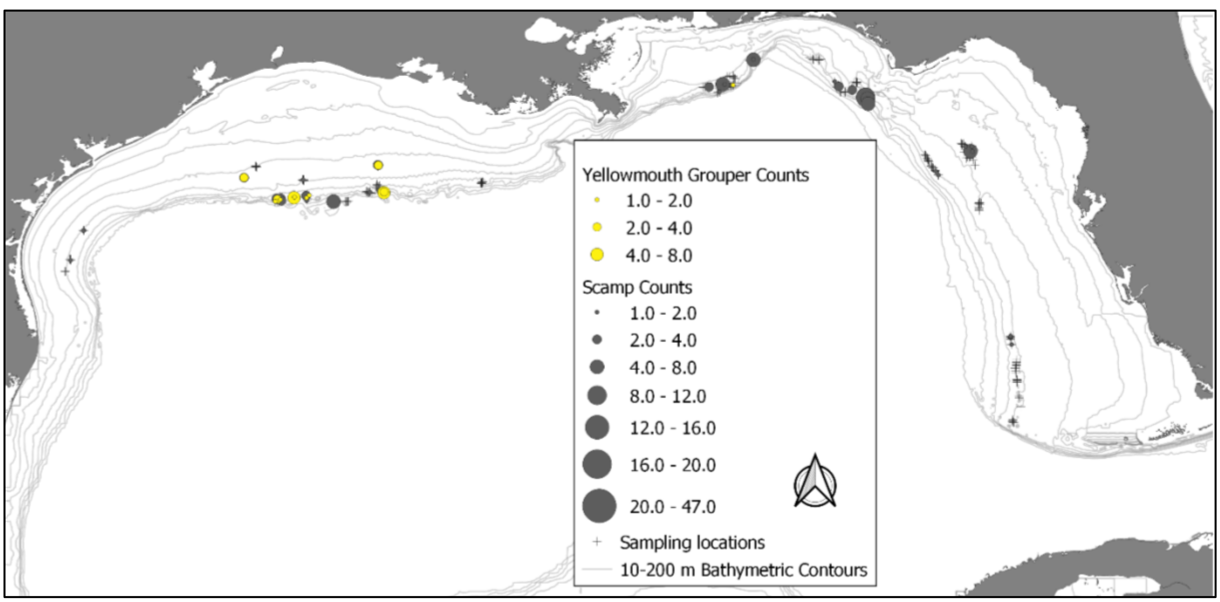

Figure 27. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2014.

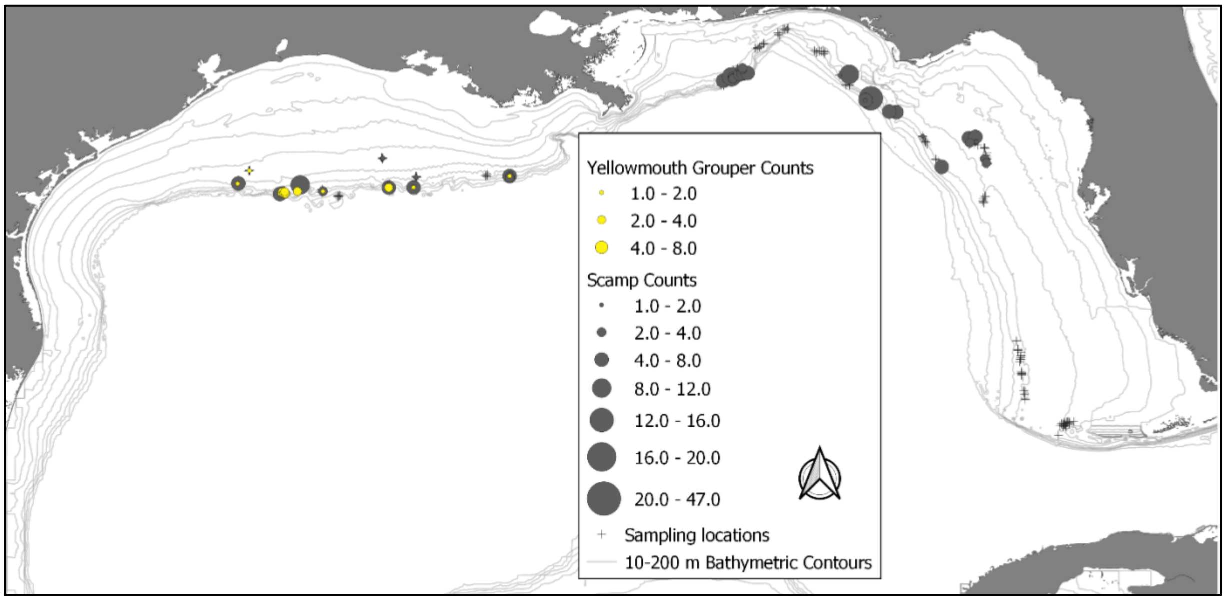

Figure 28. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2015.

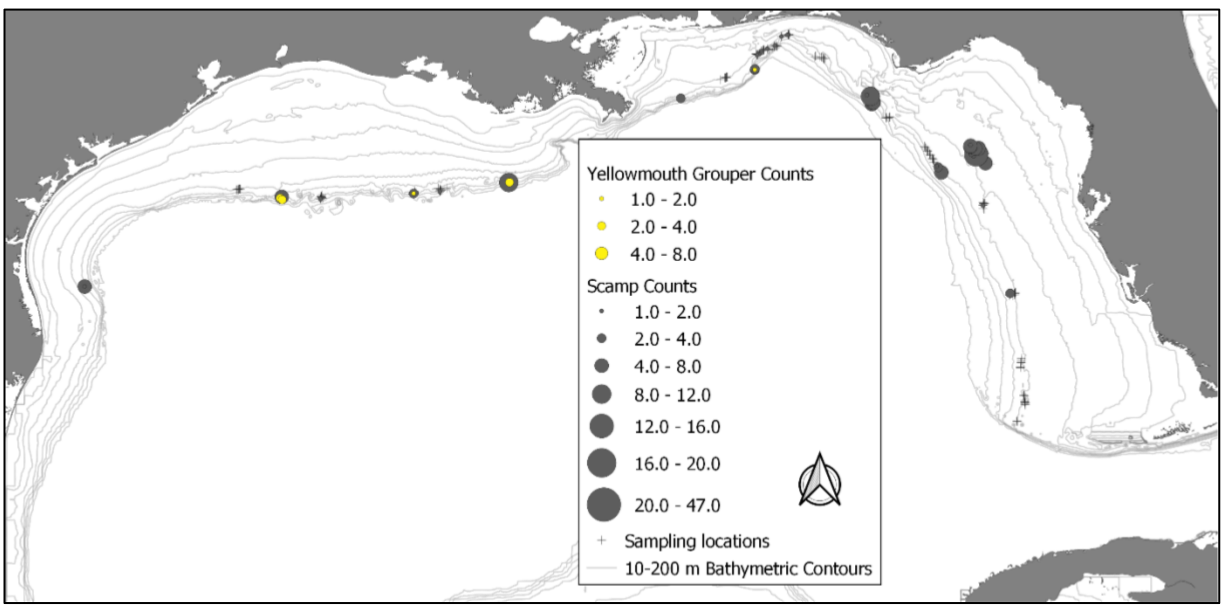

Figure 29. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2016.

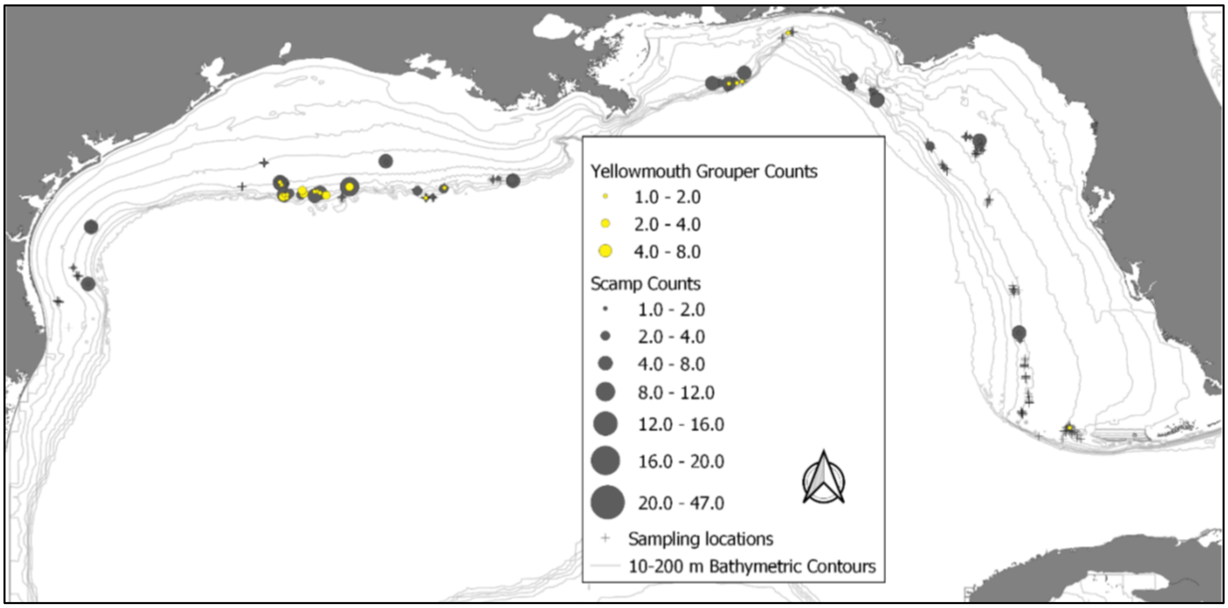

Figure 30. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2017.

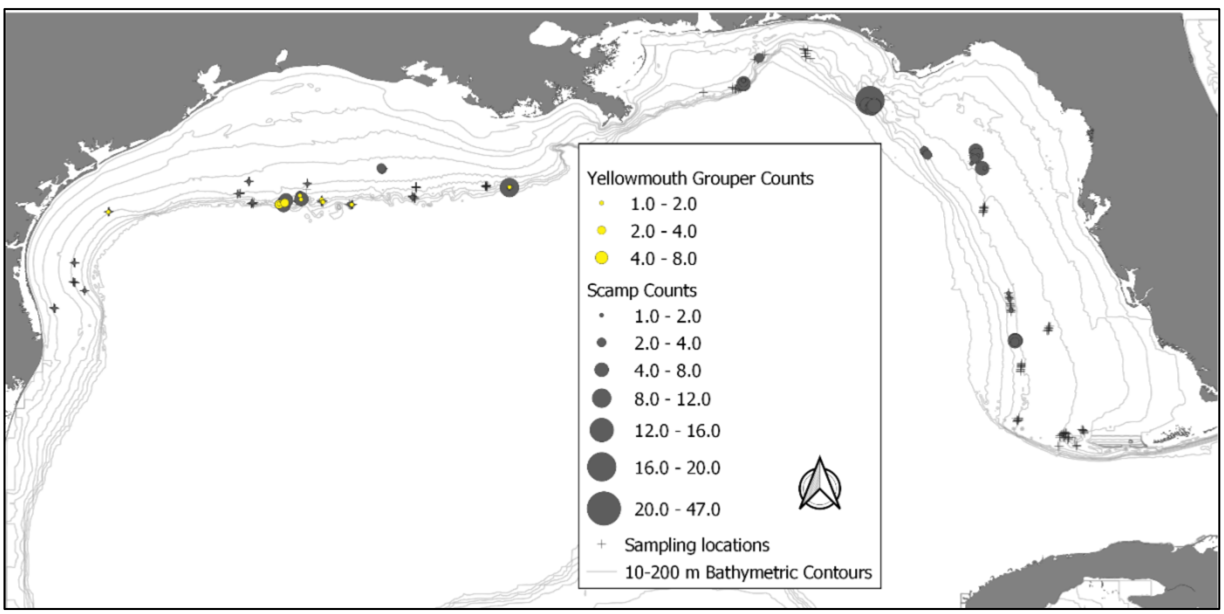

Figure 31. Map of Scamp and Yellowmouth Grouper mincounts during the SEAMAP reef fish video cruise in 2018.

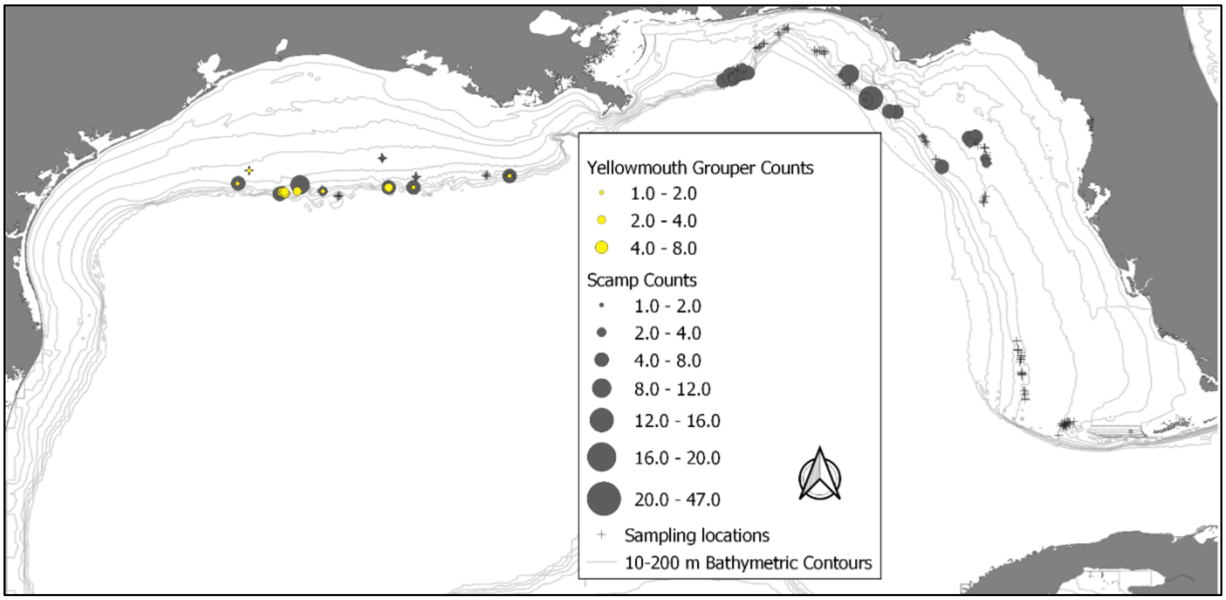

Table 13. Scamp and Yellowmouth Grouper mean and standard deviation of total lengths (TL) from the SEAMAP reef fish video cruise from 1993 – 2018. * Indicates year with single observation.

	MYCTEROPERCA INTERSTITIALIS						***MYCTEROPERCA PHENAX***					
	Gulfwide		***East***		***West***		***Gulfwide***		**East**		**West**	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1995	521.00	*	*	*	521.00	*	408.00	32.53	*	*	408.00	32.53
1996	476.00	*	*	*	476.00	*	445.53	112.86	405.38	90.27	532.50	109.73
1997	443.67	24.85	*	*	443.67	24.85	469.44	133.79	373.92	67.84	517.21	133.78
2001	586.67	68.25	*	*	586.67	68.25	400.27	106.45	345.90	66.73	504.05	90.04
2002	396.00	36.77	*	*	396.00	36.77	411.25	104.50	392.57	83.98	498.66	141.60
2003	*	*	*	*	*	*	382.97	71.78	382.97	71.78	*	*
2004	535.75	109.46	567.00	*	525.33	131.61	398.95	78.09	392.37	69.63	470.44	119.60
2005	433.00	200.13	*	*	433.00	200.13	388.46	79.04	382.10	71.88	518.95	103.87
2006	*	*	*	*	*	*	360.33	76.09	353.91	66.60	465.73	130.16
2007	319.00	38.18	346.00	*	292.00	*	419.49	86.21	408.82	80.18	465.76	95.96
2008	591.93	142.10	594.80	144.17	590.97	155.26	407.63	107.48	391.15	79.49	434.10	138.71
2009	631.44	134.31	*	*	631.44	134.31	403.50	93.52	392.60	80.70	476.78	134.99
2010	438.54	121.88	586.13	54.06	364.75	44.74	444.84	95.47	444.24	96.01	447.10	95.65
2011	474.58	116.68	467.25	102.32	476.68	128.01	433.64	100.27	420.65	92.84	505.46	110.46
2012	494.57	70.63	*	*	494.57	70.63	446.29	94.02	439.16	85.77	492.87	128.72
2013	363.12	95.47	356.04	113.10	364.70	98.89	438.66	110.07	431.55	91.71	461.22	154.19
2014	414.44	106.02	*	*	414.44	106.02	453.46	140.85	444.88	145.16	485.28	119.48
2015	418.70	120.23	432.44	*	415.95	134.21	434.71	89.24	412.66	73.34	485.11	102.48
2016	444.07	132.57	367.61	81.50	461.07	139.11	464.26	110.52	433.89	102.73	501.60	109.27
2017	510.18	53.73	*	*	510.18	53.73	447.74	125.55	408.15	96.36	508.12	141.23
2018	537.01	39.83	*	*	*	*	474.31	95.21	408.15	96.36	508.12	141.23
Pooled	465.42	126.06	468.39	124.11	461.20	129.08	411.34	96.23	397.19	84.94	483.73	119.39

Figure 32. Mean lengths of Scamp observed during the SEAMAP reef fish video cruise from 1993 - 2018.

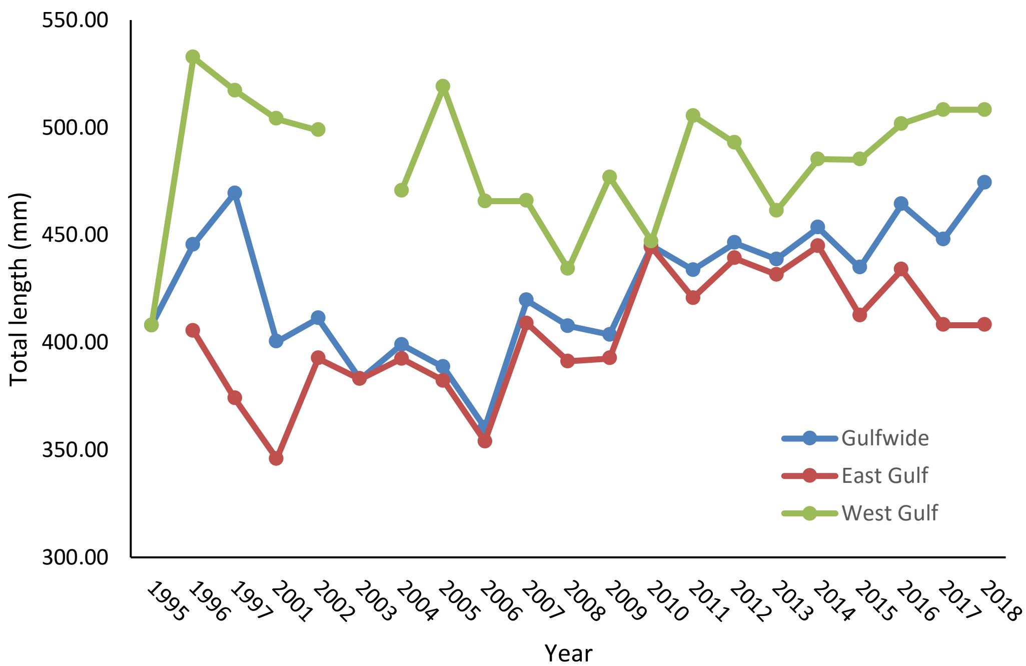

Figure 33. Mean lengths of Yellowmouth Grouper observed during the SEAMAP reef fish video cruise from 1993 - 2018.

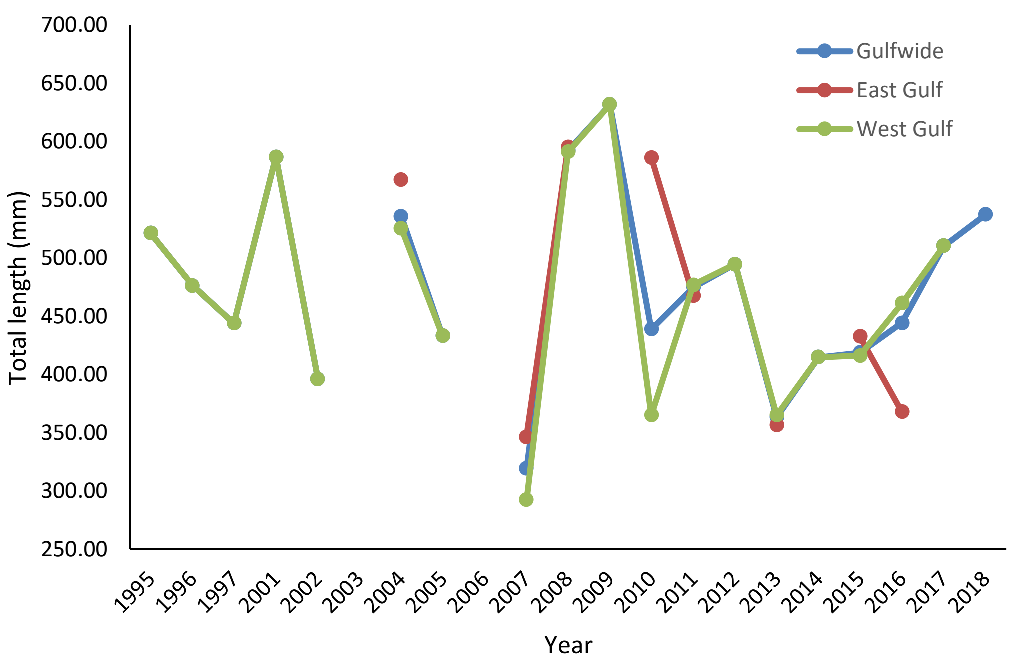

Figure 34. Length frequency histograms of Scamp and Yellowmouth Grouper observed during the SEAMAP reef fish video cruise from 1993 – 2013 (pooled over years).