SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Snowy Grouper

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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 5-22). Secondary objectives include quantification of habitat types sampled (optical and acoustic data), 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-present and historically takes place from April - May, however in limited years the survey was conducted through the end of August. The 2001 and 2003 surveys were abbreviated due to ship scheduling which severely limited spatial coverage and total samples in those years and thus are not included in the analysis. Types of data collected on the survey include diversity, abundance (min-count), fish length, habitat type, habitat coverage, bottom-topography and water quality. The size of snowy grouper sampled over the history of the survey showed fork lengths ranging from 85 – 266 mm, and mean annual fork lengths ranging from 105 – 233 mm (Table 4, Figures 24-25). 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 with the life history information provided by NMFS Panama City Laboratory.

Methods

Sampling design

Reef area available to select survey sites from is ~ 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 time. 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 ≤ 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 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 in parallel. However, the frequency of hitting targets with the lasers was low and to increase sample size all measureable fish during the video read were measured (i.e. not just at the mincount), and fish could have potentially been measured twice. The stereo-cameras used since 2008 allow size estimation from fish images and allows for increased sample sizes and for measurements to be taken at the point in the video corresponding to the mincount therefore there is no potential to measure any fish twice. 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.).

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. Unfortunately the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed to obtain mincounts, so 1992 data is excluded from analyses (unknown number of stations). From 1998 – 2000 the survey was not conducted. In 2001 and 2003 the survey was spatially restricted, were abbreviated surveys, and therefore we removed those years 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. In all of these cases the station is flagged as 'XX' in the data set and dropped (190 total sites). Sites that did not receive a stratum assignment are also dropped (62) and all of those occurred early in the survey (1994-1995). Snowy grouper were not observed in the survey until 2005 and were consistently observed in the survey after that point. Through time camera housing technology slowly improved and allowed for deeper deployments. Additionally improvements in camera technology that allow for improved low light capabilities as well as improved deployment strategies (e.g. deep stations at noon on clear days) also allowed for deeper deployments. Many of these improvements took place between 2002 and 2005, therefore we restricted this index to the years 2005-2015.

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 ≤ 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 United States. During development of the provided index, we explored model fit using three different error distributions to construct relative abundance indices including delta-lognormal, poisson and negative binomial.

GOM-wide models were run and independent variables tested in the model included year and reef as fixed effects and depth and maximum relief as continues covariates (mincount = year + reef +depth+maximum relief). Final model runs only retained year, reef and maximum relief (depth increased CV's an order of magnitude with little improvement in the model). We used the composite variable 'reef' rather than the percent coverage of individual habitat variables because of issues associated with using percent coverage of a flat surface rendered from a vertically oriented camera. The 'reef' variable is a presence absence variable (data description above) indicating if a camera observed organisms or structures typically associated with a reef (e.g. coral and rock). Additionally, in past SEDAR data workshops (SEDAR 2015) it was decided that a combination of video indices submitted by NMFS-Mississippi Labs, NMFS-Panama City and FWRI was desired. Despite the good coordination between groups the percent habitat cover variables are fairly subjective and may be interpreted differently among the coordinating laboratories, however each group is 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.

Results

Initial model runs with the delta lognormal model would not converge and produce an index to evaluate regardless of temporal and spatial constraints (i.e. regional models). Evaluation of fit statistics of the error distributions showed similar fit statistics for the negative binomial and poisson model runs (Table 1). Pearson chi-square /DF measures of fit showed the negative binomial models had values close to 1 but had larger AIC values as compared to the poisson model (Table 1). Poisson and negative binomial models both showed a linear relationship when evaluating QQ plots (Figure 5). Poisson and negative binomial models showed fairly similar trajectories when the indices are plotted except for 2015 when they show opposite trajectories. Proportion positives were also reflective of those same trends except in 2015 when the negative binomial model shows a positive trend and the poisson model follows the proportion positive trend (Figure 2). Therefore the poisson model was selected as the best fitting model and all other output and the resultant indices and graphs will be derived from that model.

Snowy grouper were observed at very low frequencies and abundances, with one exception were only seen in the northeast GOM, and those are centered around the mobile pinnacles region. In the region in which they are observed the spatial distribution is highly

reflective of the reef sampling universe used to select sampling sites (Figures 1 and 6). Perhaps if the survey could be conducted in deeper depths more observations would be made. Gaps in mapping and habitat information exist on the central portion of the west Florida shelf, Mississippi river delta region, and portions of the Texas coast and those are slowly being investigated and filled. In most years the survey had good coverage in the defined sampling universe, and coverage improved through time as the sampling universe expanded and more sites were added to the survey particularly after 1997. The most recent mapping and sampling efforts in south Texas and in the central portion of the west Florida shelf were accomplished in 2012-14 and are beginning to be incorporated in the sampling frame in 2014.

The model indicated that year was marginally significant but the reef and maximum relief variables were not (Table 2). Including the depth variable in the model increased CV's an order of magnitude and therefore we did not include that variable. The GOM wide index shows a stable index through time (i.e. no consistent increasing or decreasing trends) with significant peaks in the index in 2005, 2007, and 2011 (Figures 2-4). Year to year variations in observed and expected mincounts is low and that is reflected in marginal significance for the year variable in the model. Lowest mincounts were observed in 2006, 2014, and 2015 (Table 3, Figures 2-4). Proportion positives are largely reflective of the abundance trends (Table 3, Figure 2). Given low CVs (Table 3) and marginally significant yearly trends (Table 2), the population in general appears to be stable through time.

Annual mean fork lengths of snowy grouper appear to be steady through time with what might be a slight increasing trend (Table 4, Figure 24) although, due to low observation rates of the species the number of measurements collected is low.

Literature cited

Campbell, M.D., K.R. Rademacher, P. Felts, B. Noble, M. Felts, and J. Salisbury. 2012. SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Snapper, July 2012. SEDAR31-DW08. SEDAR, North Charleston, SC. 61 pp.

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Lo, N. C. H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-1526.

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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 (1992-2015) new reef tract has been discovered and mapped and therefore this map represents what was available in 2015, and not necessarily what has been available over the entire time series.

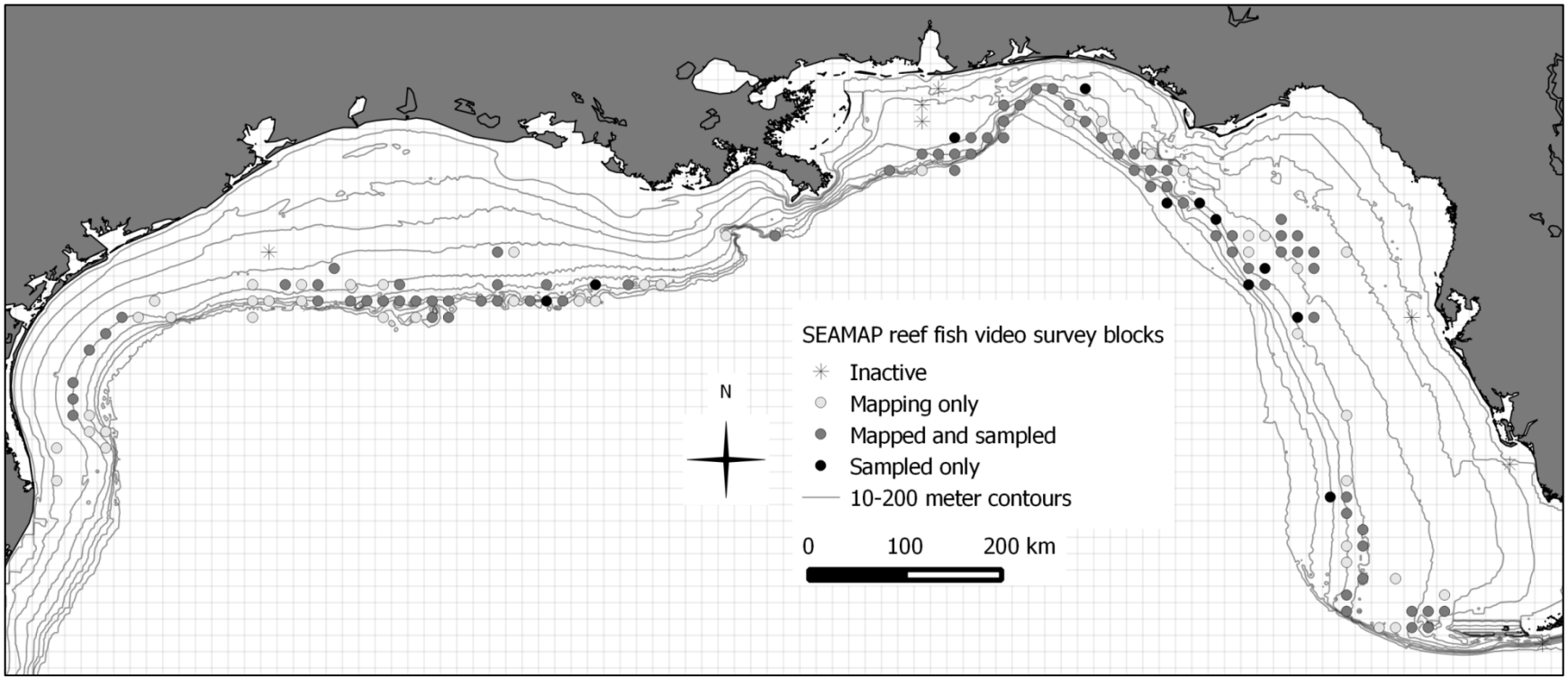

Table 1. Fit statistics (AIC and log likelihood) for model runs that only include year, reef, and maximum relief for the negative binomial, and poisson error distributions using only east GOM data.

	Poisson	NB
-2 Log Likelihood	**379.55**	391.15
AIC (smaller is better)	**405.55**	419.15
AICC (smaller is better)	**405.66**	419.27
BIC (smaller is better)	**484.96**	504.66
CAIC (smaller is better)	**497.96**	518.66
HQIC (smaller is better)	**433.96**	449.75
Pearson Chi-Square	**4820.59**	3409.31
Pearson Chi-Square / DF	**1.45**	1.03

Table 2. Test of type III fixed effects for the east GOM poisson model run.

Effect	**Num DF**	**Den DF**	**F Value**	**Pr>F**
year	10	3309	1.8	0.0562
RM	1	3309	0.01	0.9364
REEF	1	3309	0.33	0.5648

Table 3. Output for the relative abundance index of snowy grouper by year, east GOM poisson model run.

year	N	Proportion positive	mincount	predM	predM cv
2005	348	0.0086	0.0230	0.0230	14.2812
2006	388	0.0026	0.0026	0.0026	14.1035
2007	434	0.0184	0.0184	0.0184	14.4628
2008	263	0.0038	0.0038	0.0038	13.8892
2009	305	0.0033	0.0033	0.0033	14.0894
2010	236	0.0085	0.0085	0.0085	14.0131
2011	322	0.0186	0.0280	0.0280	14.2707
2012	333	0.0060	0.0090	0.0090	14.5256
2013	227	0.0044	0.0044	0.0044	14.4479
2014	330	0.0030	0.0030	0.0030	14.2241
2015	136	0.0000	0.0000	0.0000	13.7867

Figure 2. East GOM relative indices of mincounts and proportion positive for snowy grouper produced by the poisson, and negative binomial (base model, I = year*reef*maximum relief).

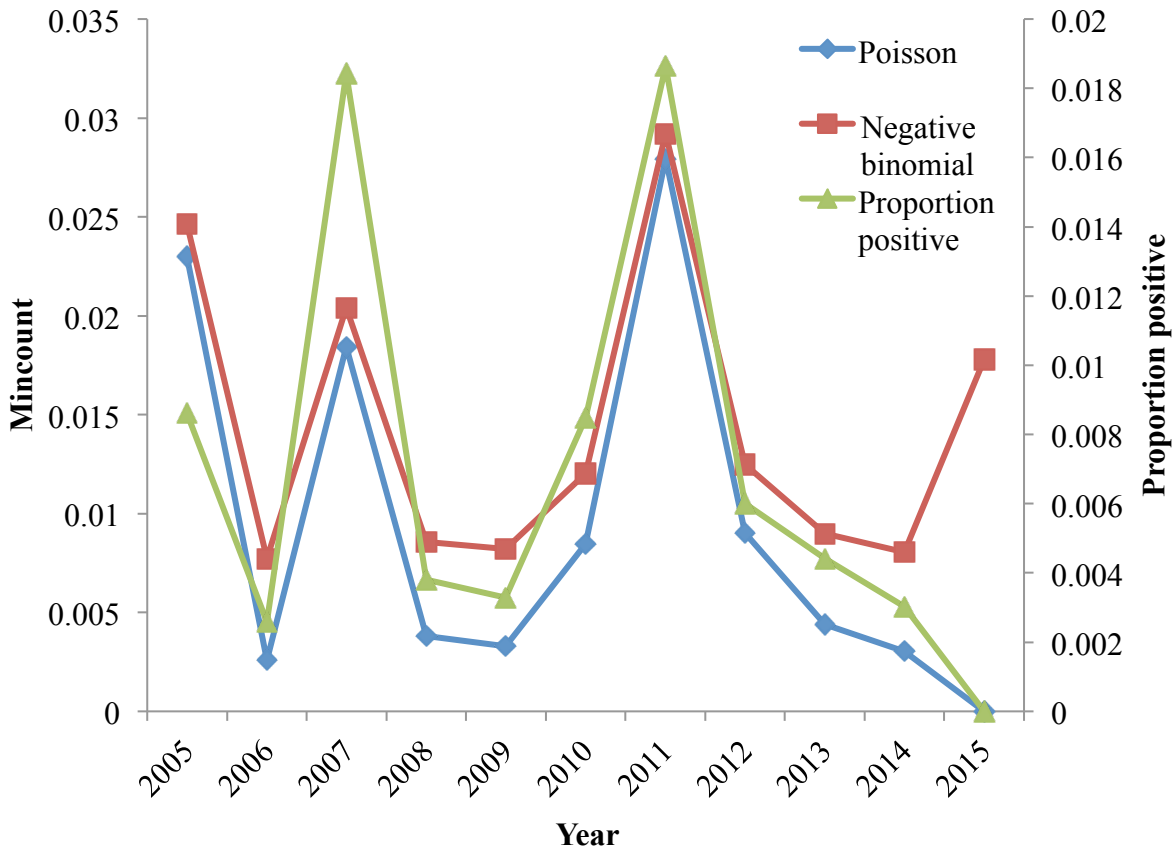

Figure 3. LS Means with 95% CI of snowy grouper mincounts, east GOM poisson model run.

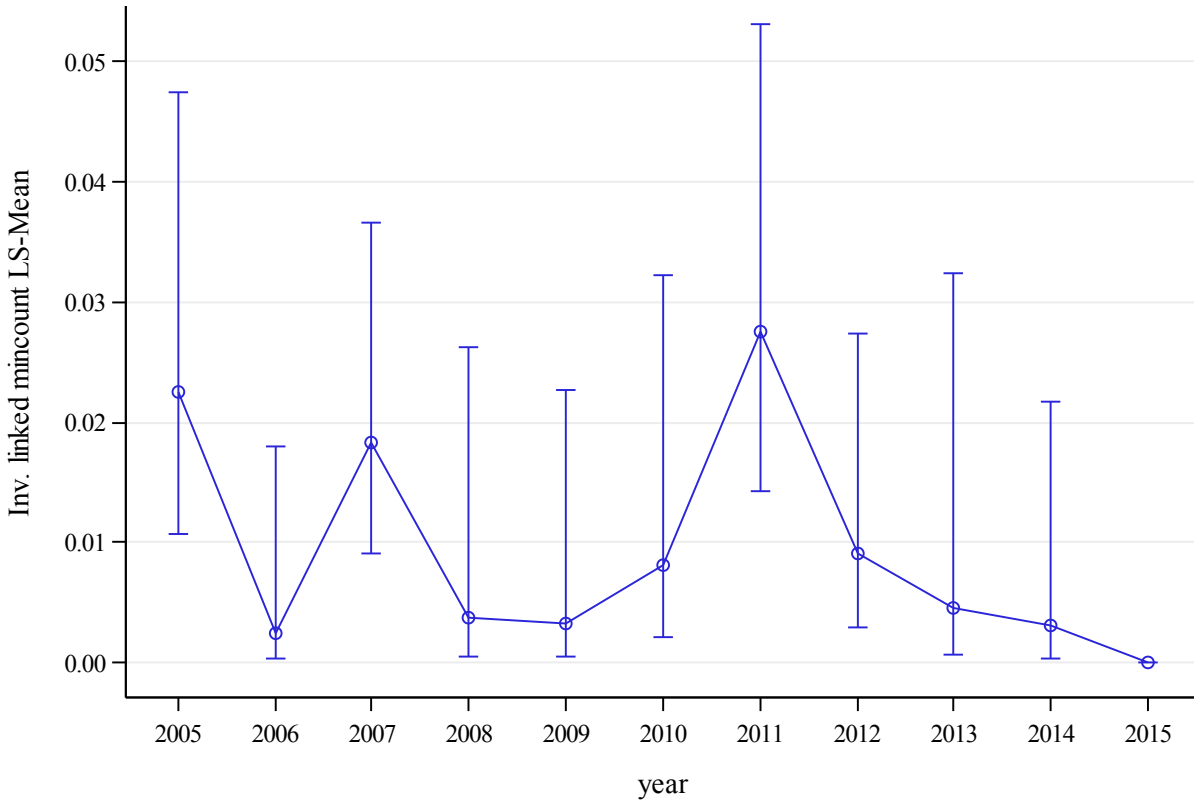

Figure 4. Observed (mincount) and predicted mincounts (mu noblups) mincounts of snowy grouper from the east GOM poisson model run.

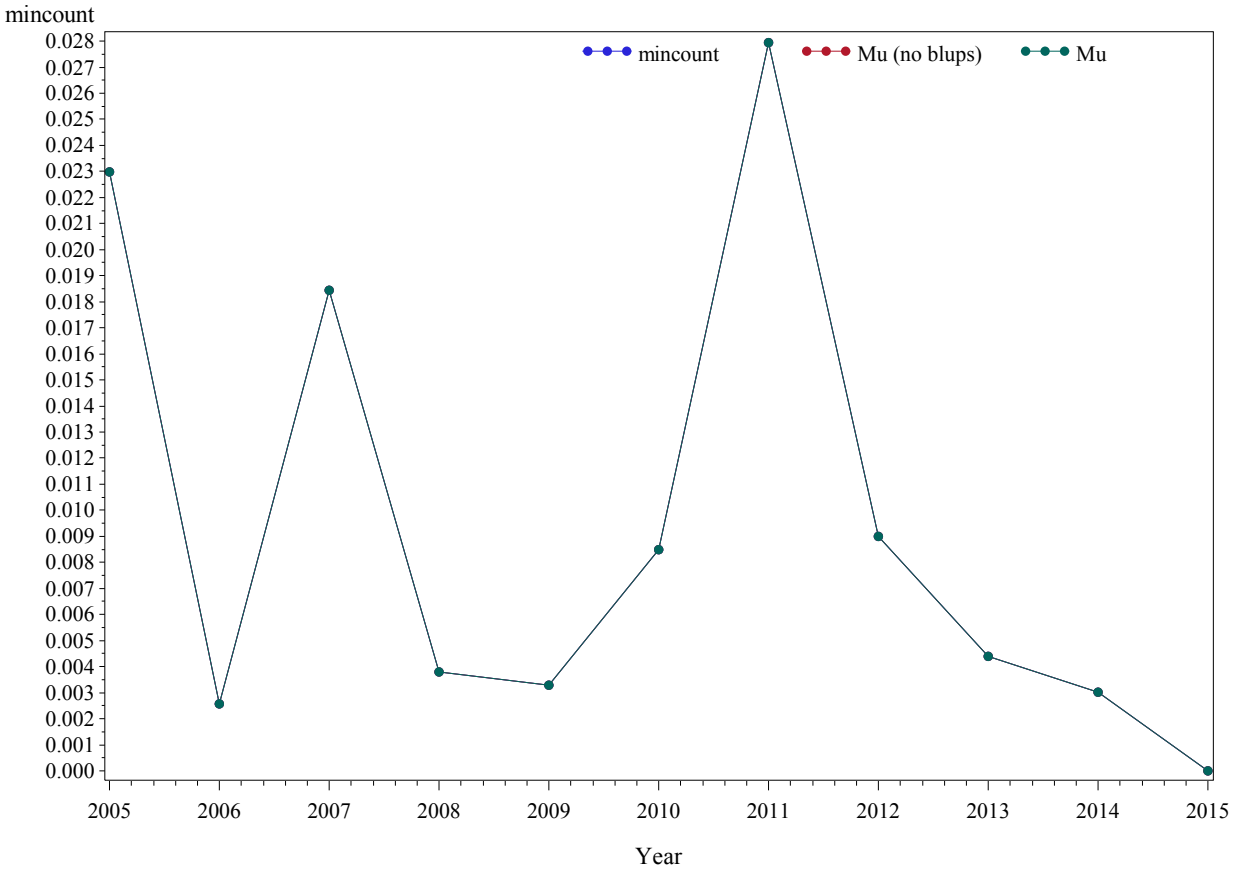

Figure 5. QQ plot of conditional residuals for the east GOM poisson model run.

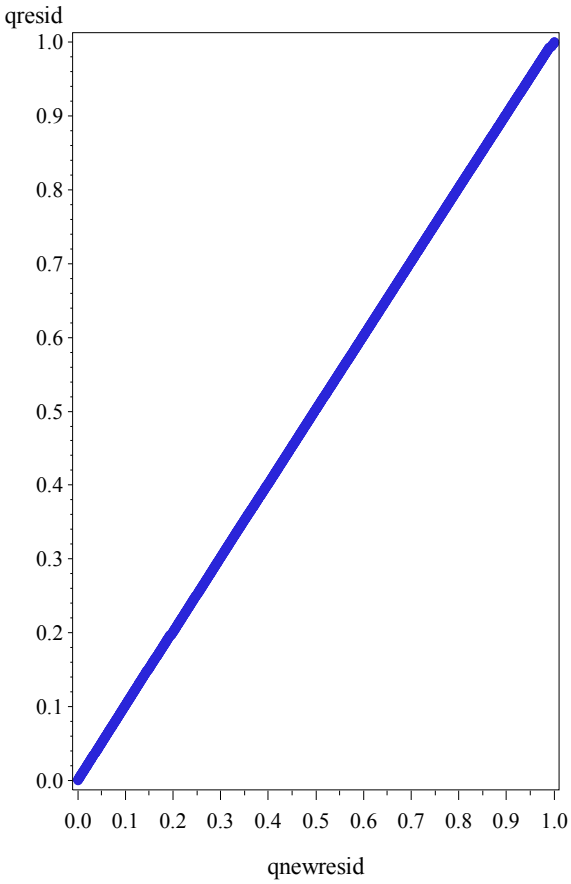

Figure 6. Map of snowy grouper mincounts of the SEAMAP reef fish video survey 1992-2015.

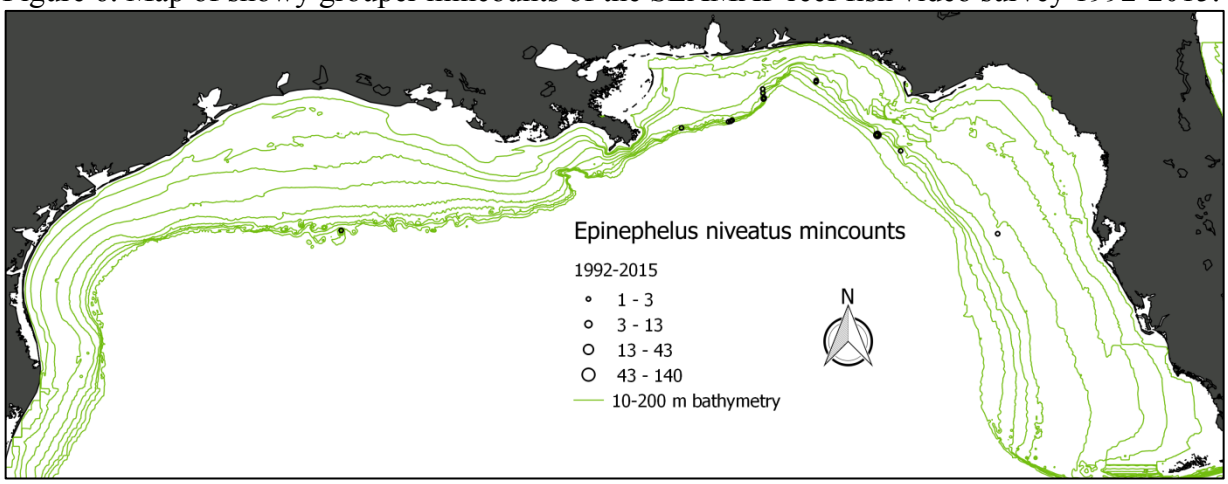

Table 4. Mean and standard deviation of snowy grouper lengths (FL) from the SEAMAP reef fish video cruise from 2002 – 2015. No observations were obtained prior to 2002.

Year	Mean	STD	N
2002	485.5	26.16295	2
2005	609.75	203.2673	4
2009	542.1592		1
2011	597.1062		1
2012	568.6532	57.56938	2
2014	758.884		1

Figure 7. Mean lengths and standard deviation of snowy grouper observed during the SEAMAP reef fish video cruise from 2002 – 2015. No observations were obtained prior to 2002.

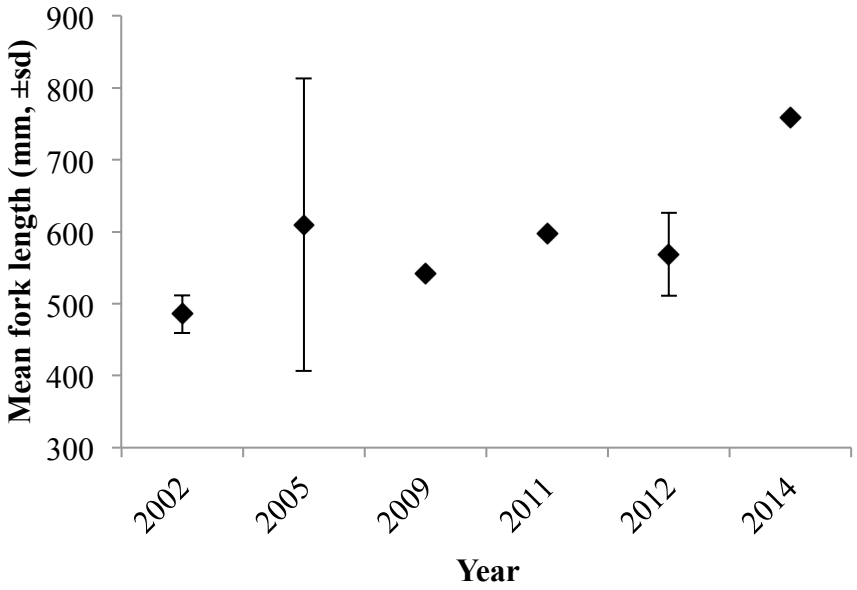

Figure 8. Length frequency histograms of snowy grouper observed during the SEAMAP reef fish video cruise from 2002 - 2015. No measurements were obtained prior to 2002.