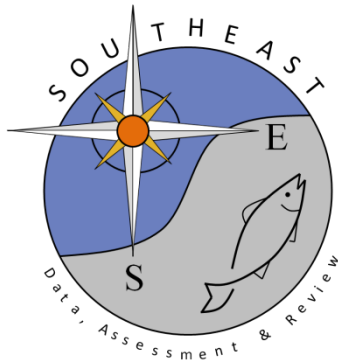# SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Lane Snapper

Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, John Moser, Ryan Caillouet

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**Relative Indices of Abundance of Lane Snapper**

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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 lane snapper 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).  Mapping of reef areas results in establishment of polygons of reef tracts for which habitat types contained in the polygon may still be unknown or which have not been ground truthed.  Furthermore habitat classification of acoustic data still provides only coarse levels of description.  This can result in camera drops that end up viewing non-reef areas.  Therefore, sites that showed less than 0.15 m of maximum relief were considered non-reef sites and were excluded (i.e. flat featureless bottom).

*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 (mincount = year + reef). 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 spatial constraints (i.e. regional models) or habitat constraints (i.e. maximum relief > than 0.15). Evaluation of fit statistics of the error distributions showed improved fit statistics for the negative binomial as compared to the poisson (Table 1). Pearson chi-square /DF measures of fit showed the negative binomial models had values close to 1 and had smaller 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 were plotted and proportion positives were also reflective of those same trends (Figure 2). Therefore the negative binomial model was selected as the best fitting model and all other output and the resultant indices and graphs will be derived from that model.

Lane snapper were observed throughout the eastern and western Gulf of Mexico in most years and the spatial distributions observed are highly reflective of the reef sampling universe used to select sampling sites (Figures 1 and 6-23). Increasing proportion positives later in the survey (2005+) could be the result of improved camera housings that allowed for deeper deployments. It is unlikely that low proportion positives early in the survey were the result of an identification issues. 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 beginning in 2014 are being incorporated in the sampling frame.

The model indicated that year was significant but the reef variable was not (Table 2). The GOM wide index shows a general increasing trend through time with significant peaks in the index in 2007, 2009 and 2012 (Figures 2-4). Low or zero observations early in the survey (1990's) could be the result of improvements to camera housings that allowed for deeper deployments, but fish were fairly consistently observed over the course of the time series but at fairly low rates. Highest mincounts were observed in 2007, 2009, and 2012 while the lowest was observed in 1993, 1995, and 2002 (Table 3, Figures 2-4). Proportion positives are largely reflective of the abundance trends (Table 3, Figure 2).

Annual mean fork lengths of lane snapper appear to be steady through time (Table 4, Figure 24) although, due to low observation rates of the species the number of measurements collected is low. Length frequency graphs show that East GOM lane snapper were smaller (mean = 256.11) than west GOM fish (mean = 304.09, Figure 25). West and east GOM lane snapper showed some overlapping in length distributions with the west distribution skewed to the right (Figure 25).

**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.

Guenther, C.B., T.S. Switzer, S.F. Keenan, and R.H. McMichael, Jr. 2014. Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf. SEDAR42-DW-08. SEDAR, North Charleston, SC. 21 pp.

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.

SEDAR, 2015. Southeast Data, Assessment, and Review, Gulf of Mexico Red Grouper - Data Workshop Report. SEDAR-42-DW-report. SEDAR, North Charleston, SC. 286 pp.

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.
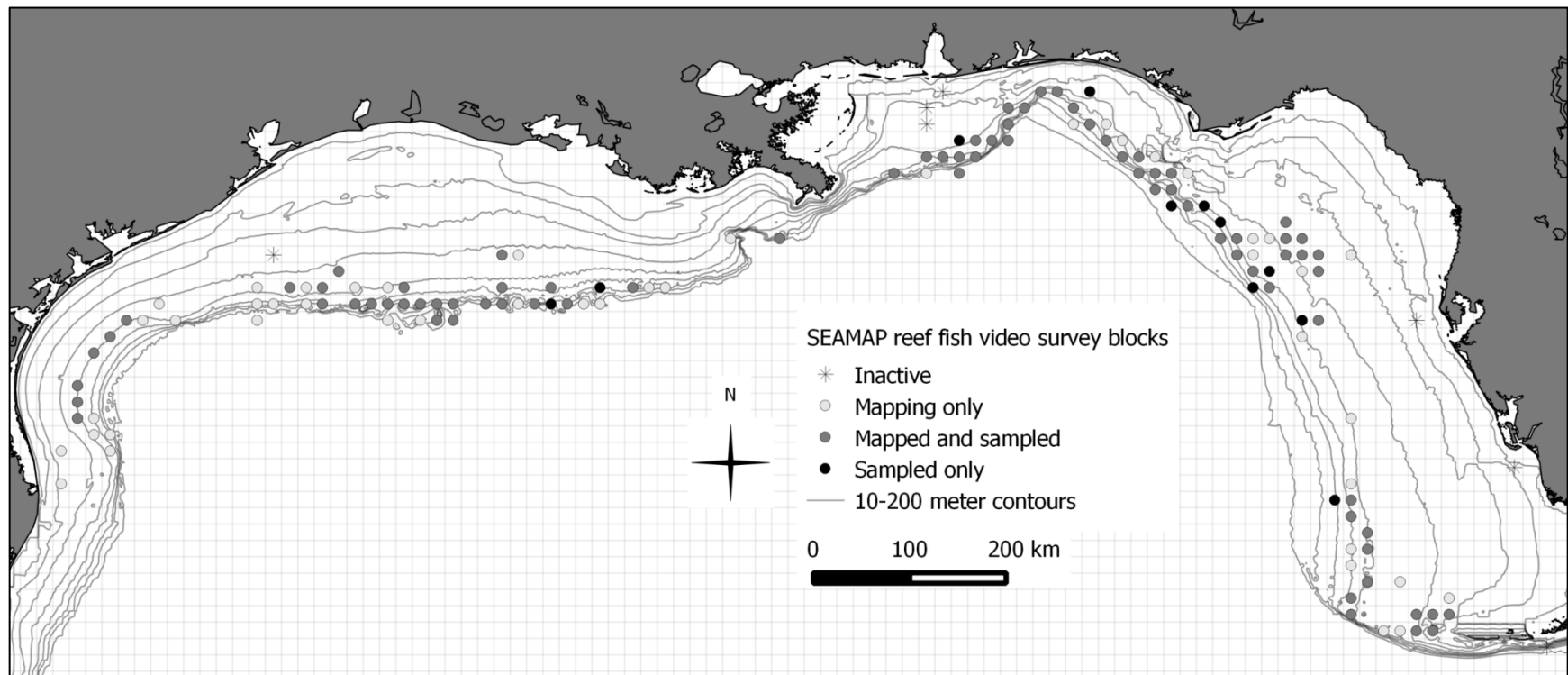
Table 1.  Fit statistics (AIC and log likelihood) for model runs that only include year as a variable but used the negative binomial and poisson error distributions.

|  | Poisson | **Negative binomial** |
|---|---|---|
| -2 Log Likelihood | 1627.06 | **1027.16** |
| AIC  (smaller is better) | 1665.06 | **1067.16** |
| AICC (smaller is better) | 1665.26 | **1067.38** |
| BIC  (smaller is better) | 1627.06 | **1027.16** |
| CAIC (smaller is better) | 1646.06 | **1047.16** |
| HQIC (smaller is better) | 1627.06 | **1027.16** |
| Pearson Chi-Square | 11707.66 | **3487.3** |
| Pearson Chi-Square / DF | 3.07 | **0.91** |

Table 2.  Test of type III fixed effects for the negative binomial model.

| Effect | Num DF | Den DF | F Value | Pr > F |
|---|---|---|---|---|
| year | 15 | 3797 | 2.31 | 0.0029 |
| REEF | 1 | 3797 | 0.4 | 0.5253 |

Table 3.  Output for the delta lognormal index of relative abundance of lane snapper by year, GOM wide negative binomail model run.

| year | N | Proportion positive | mincount | predM | predM cv |
|------|-----|----------|----------|-------------|-------------|
| 1993 | 148 | 0 | 0 | 1.49211E-10 | 14.84036394 |
| 1994 | 104 | 0.019231 | 0.019231 | 0.031288915 | 14.93097468 |
| 1995 | 81 | 0 | 0 | 6.90894E-08 | 14.66711461 |
| 1996 | 243 | 0.004115 | 0.024691 | 0.027432787 | 13.54273177 |
| 1997 | 248 | 0.016129 | 0.032258 | 0.031575744 | 14.12518792 |
| 2002 | 234 | 0 | 0 | 1.06924E-13 | 12.94500515 |
| 2004 | 177 | 0.00565 | 0.00565 | 0.004865765 | 14.05570889 |
| 2005 | 338 | 0.029586 | 0.04142 | 0.042300839 | 13.61307598 |
| 2006 | 344 | 0.040698 | 0.072674 | 0.070558516 | 13.99139952 |
| 2007 | 388 | 0.030928 | 0.07732 | 0.083954723 | 13.76105804 |
| 2008 | 247 | 0.024291 | 0.024291 | 0.024364571 | 13.05355583 |
| 2009 | 296 | 0.040541 | 0.189189 | 0.181578186 | 13.34784968 |
| 2010 | 232 | 0.056034 | 0.060345 | 0.071003959 | 13.64837918 |
| 2011 | 274 | 0.010949 | 0.010949 | 0.012797148 | 14.15329432 |
| 2012 | 335 | 0.050746 | 0.116418 | 0.113368702 | 14.83177088 |
| 2013 | 220 | 0.022727 | 0.022727 | 0.023005125 | 14.89180589 |
| 2014 | 220 | 0.022727 | 0.022727 | 0.02300109 | 14.80499682 |
| 2015 | 185 | 0.016216 | 0.027027 | 0.005946938 | 12.80357911 |

Figure 2. GOM wide Relative indices of mincounts and proportion positive for lane snapper produced by the poisson, and negative binomial.
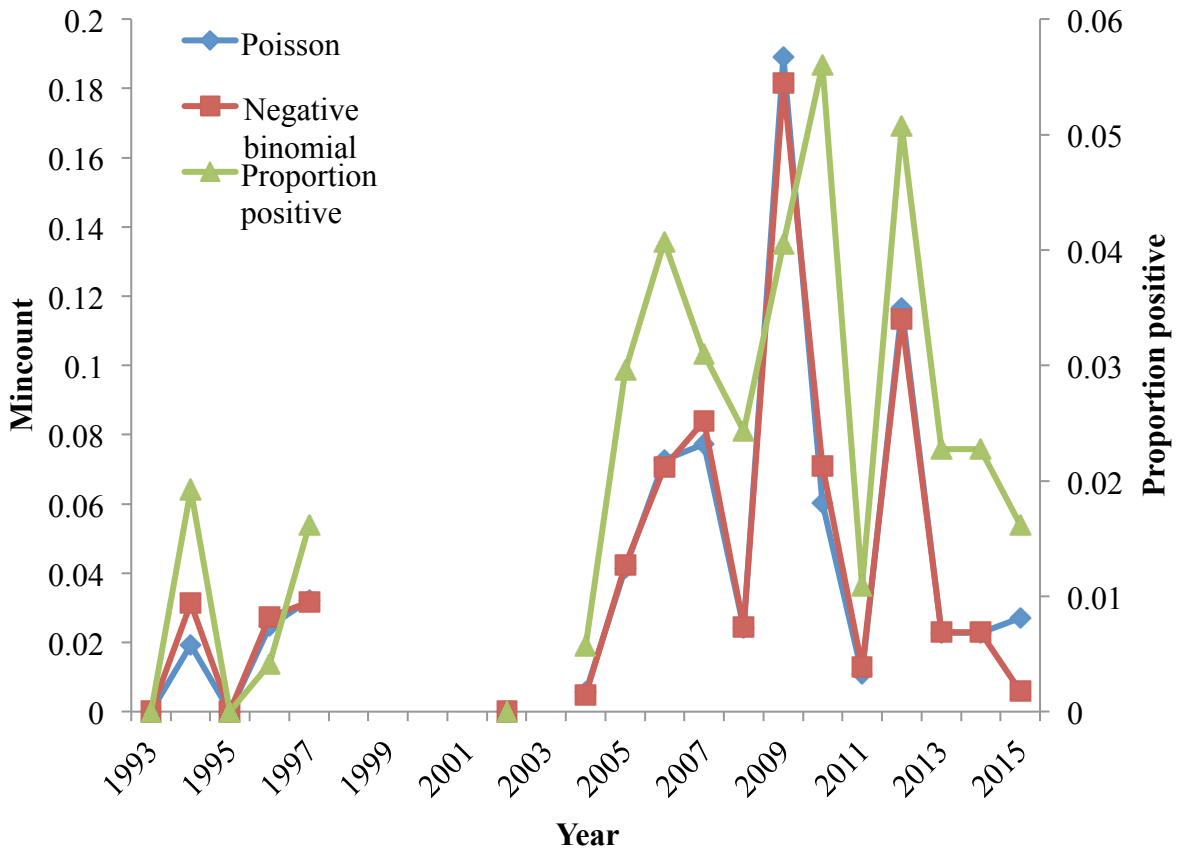
Figure 3. LS Means with 95% CI of lane snapper mincounts, GOM wide negative binomial model run.
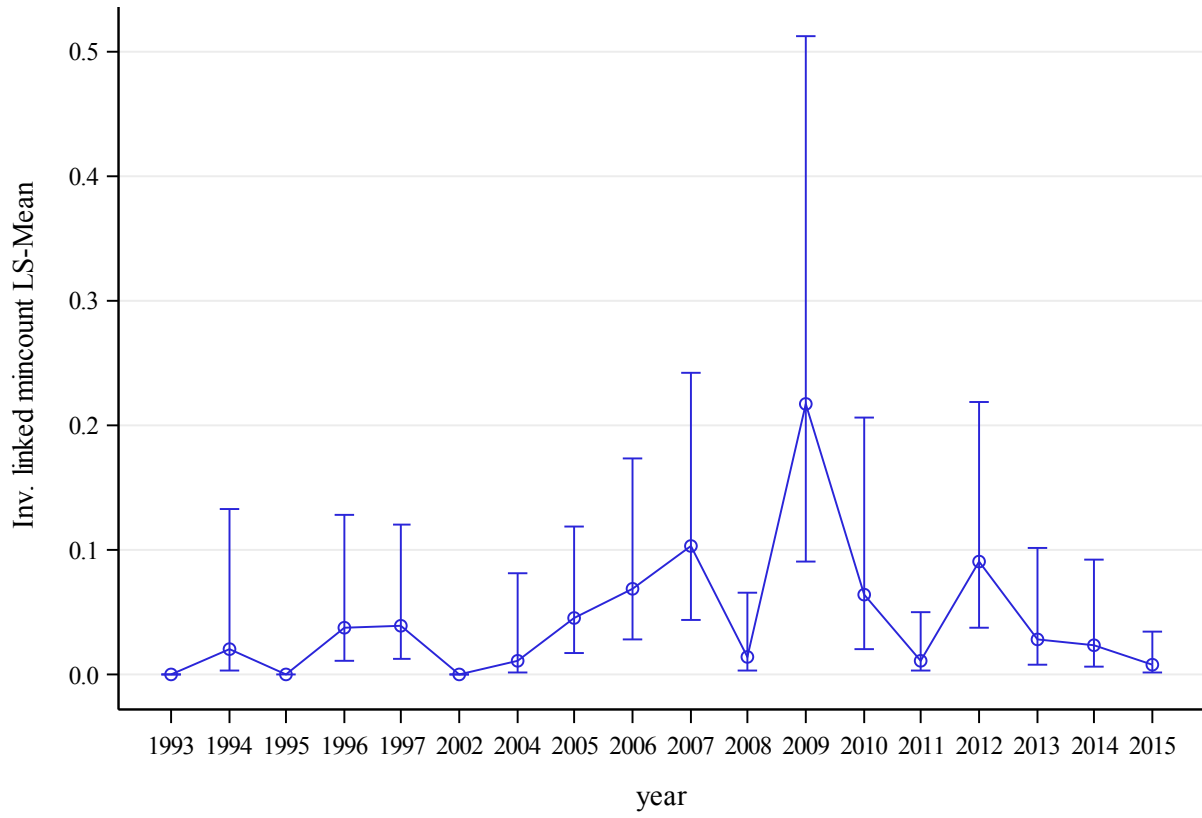
Figure 4. Observed (mincount) and predicted mincounts (mu noblups) mincounts of lane snapper from the GOM wide negative binomial model run.
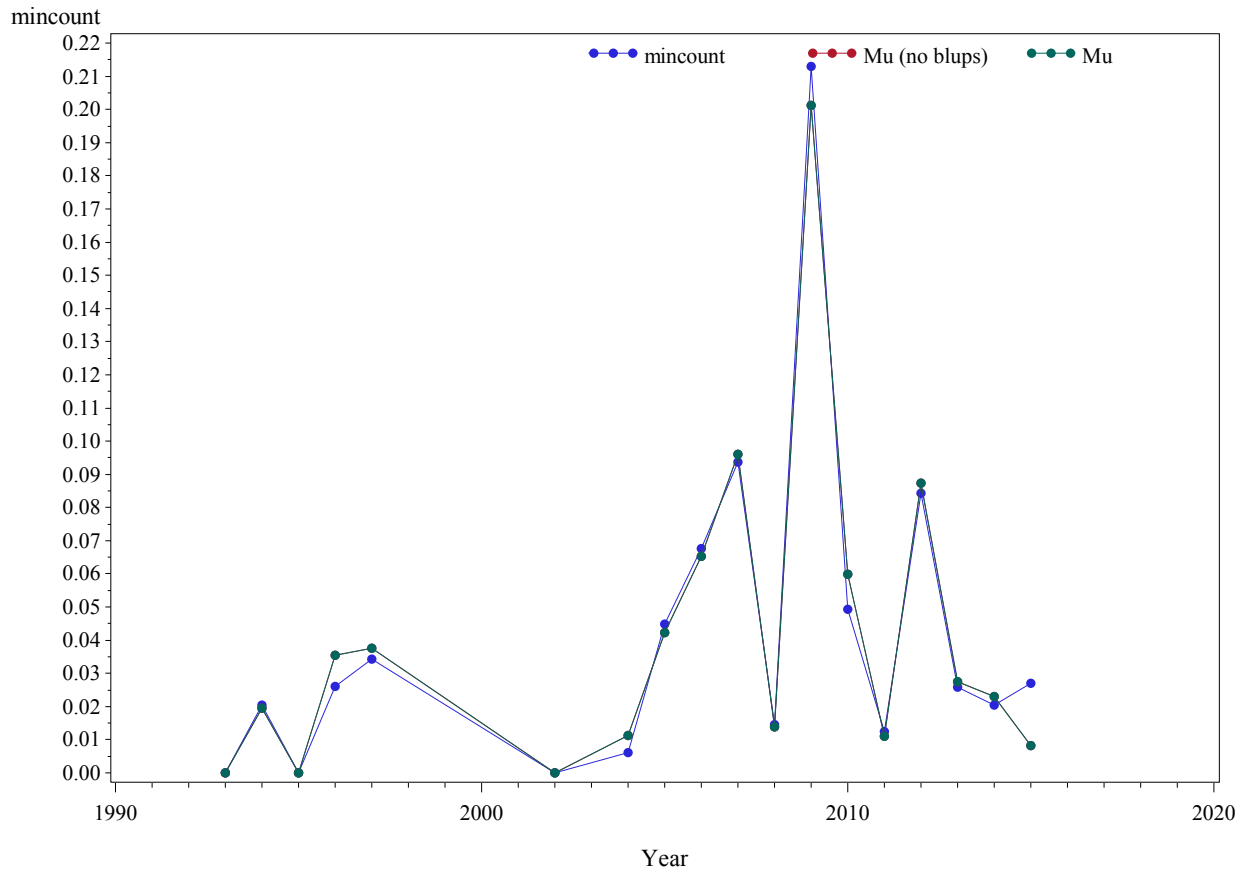
Figure 5.  QQ plot of conditional residuals for the GOM wide negative binomial model run.
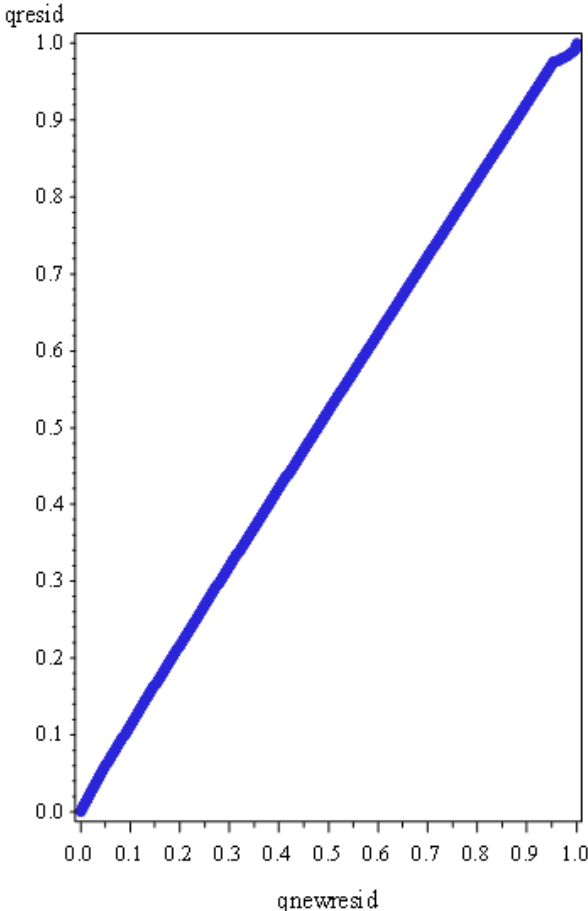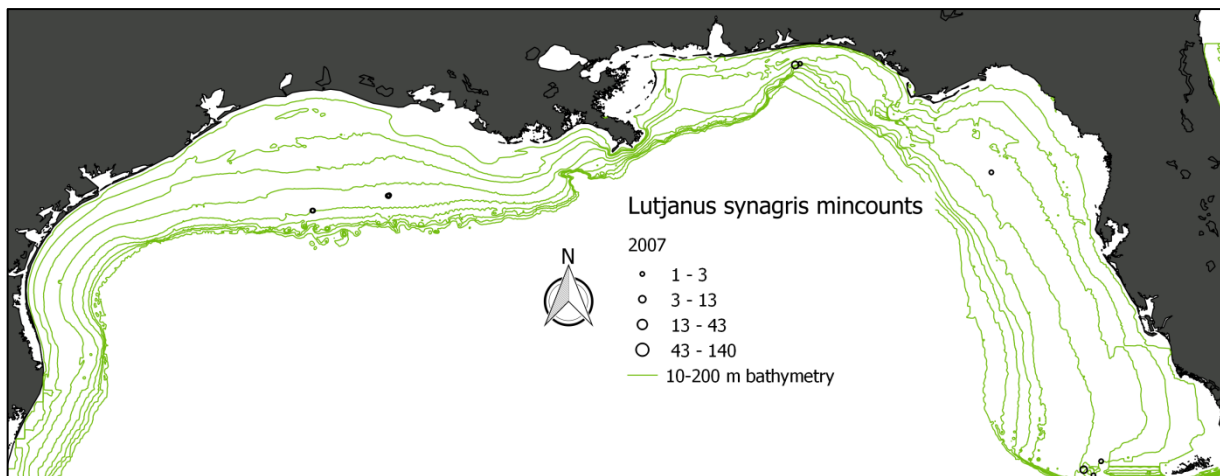
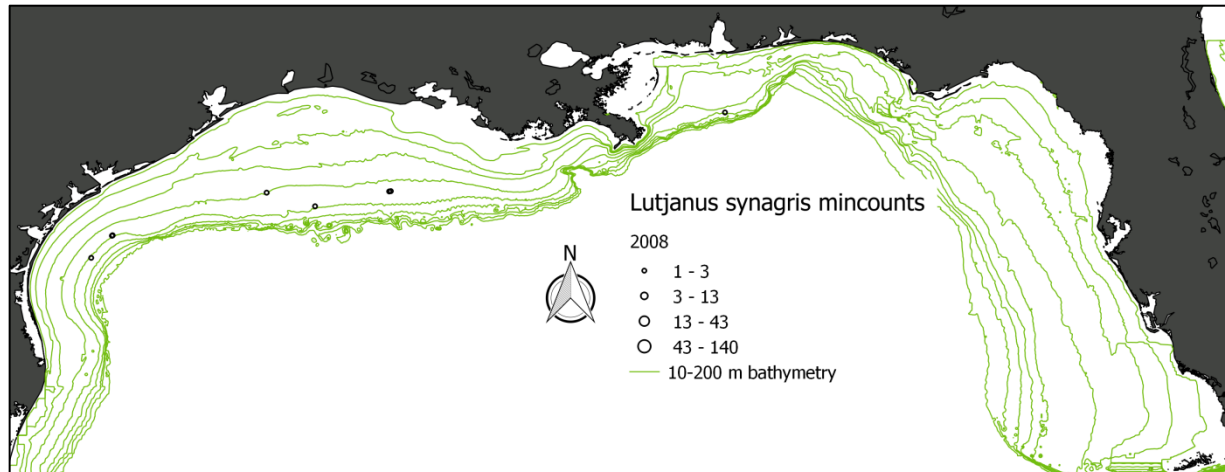Figure 6. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 1993.
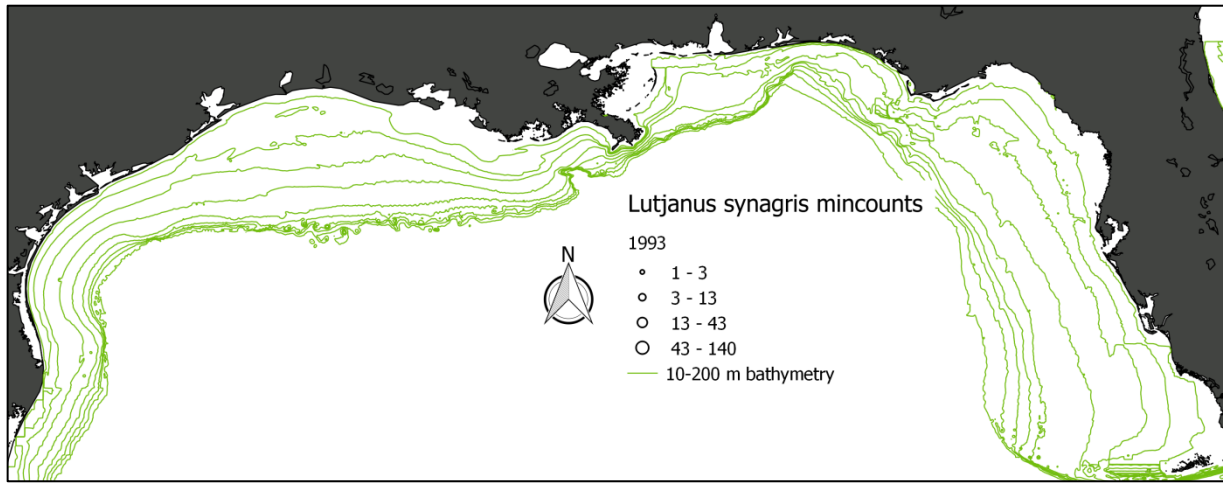


Figure 7. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 1994.
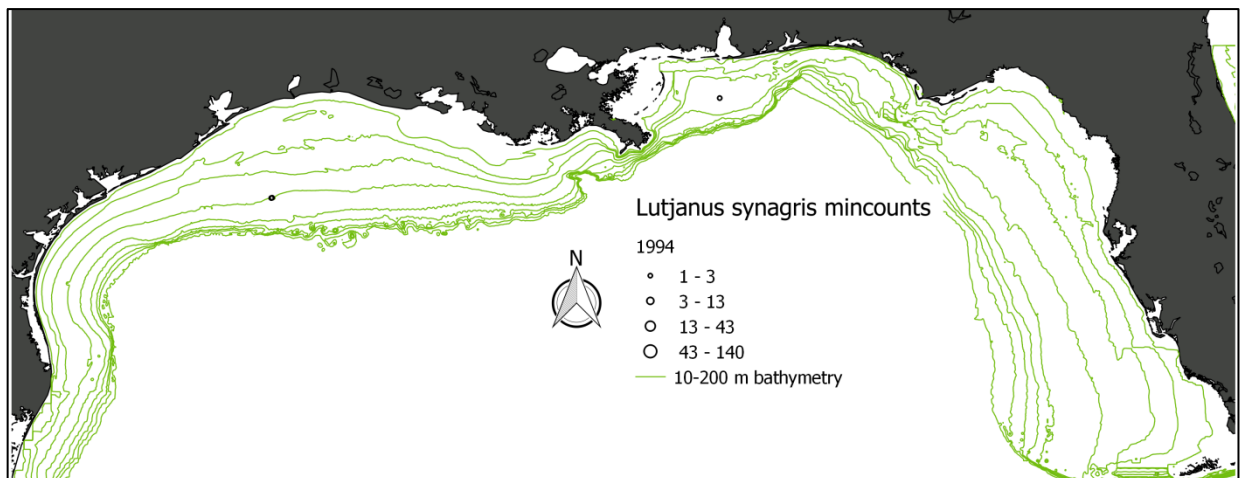
Figure 8. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 1995.
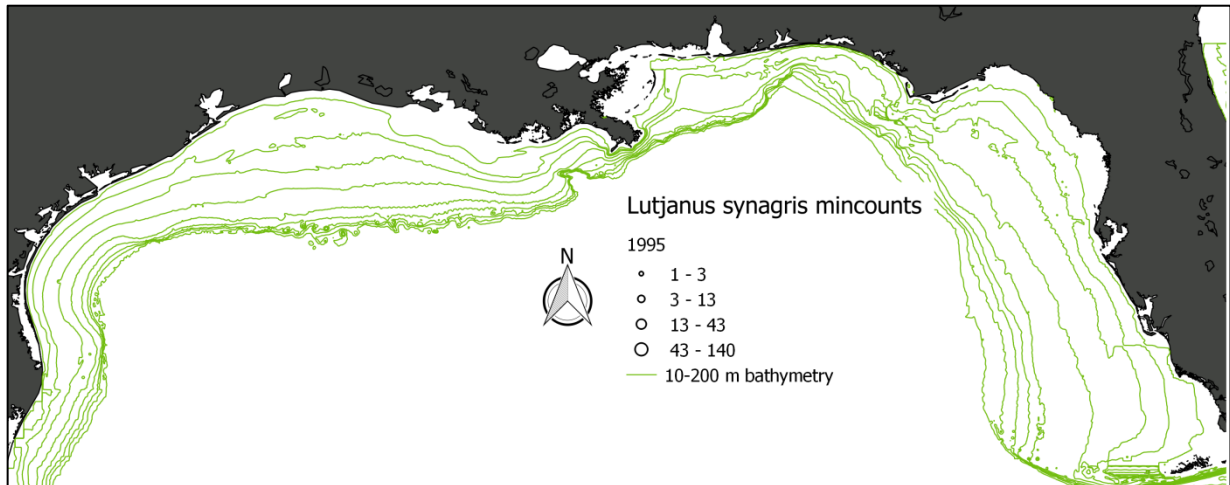


Figure 9. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 1996.
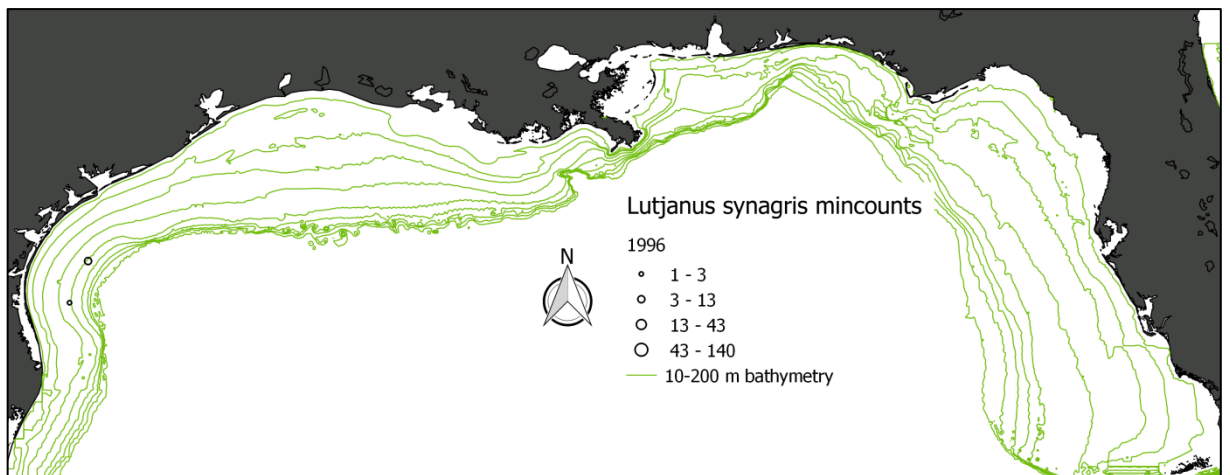
Figure 10. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 1997.
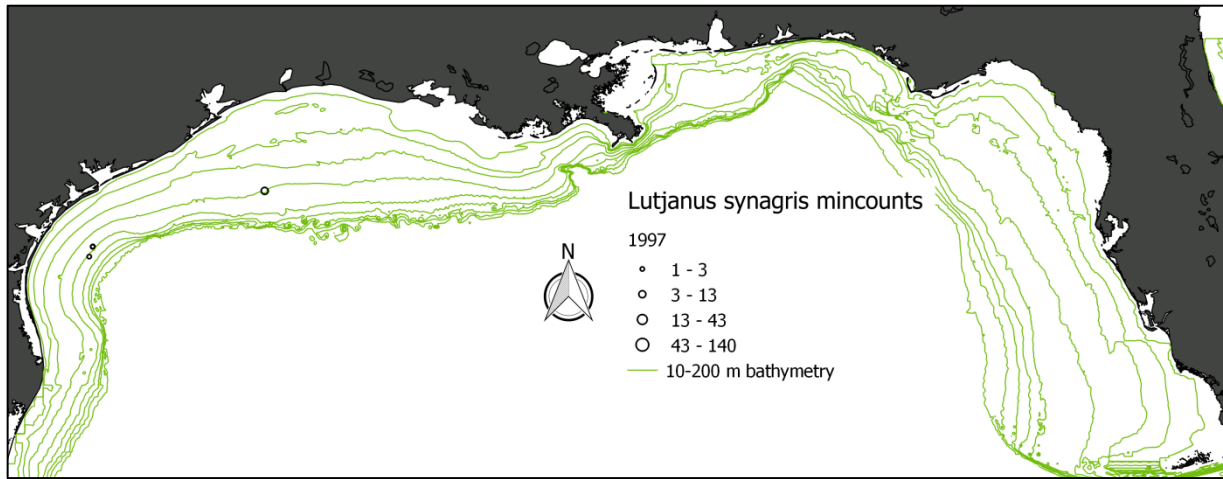


Figure 11. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2002.
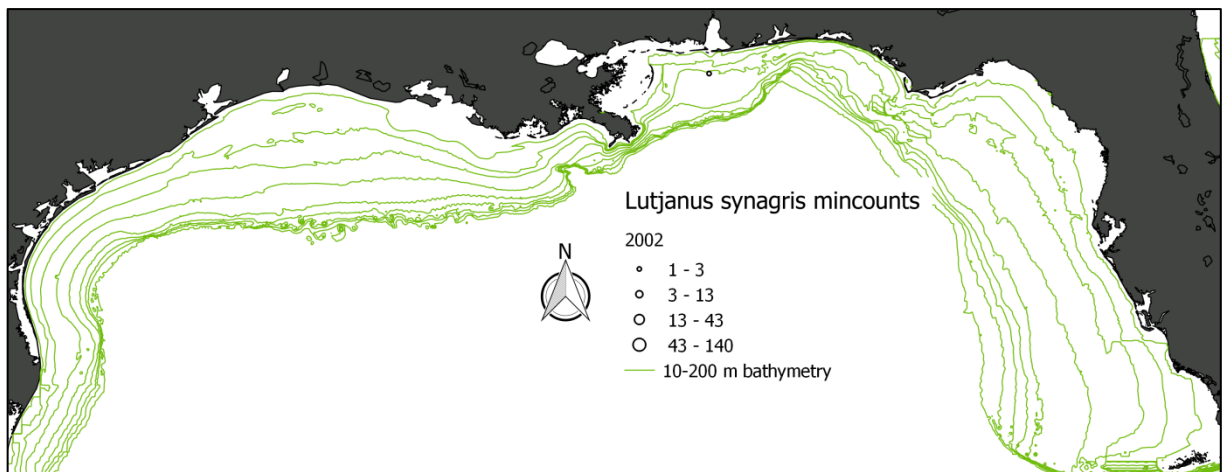
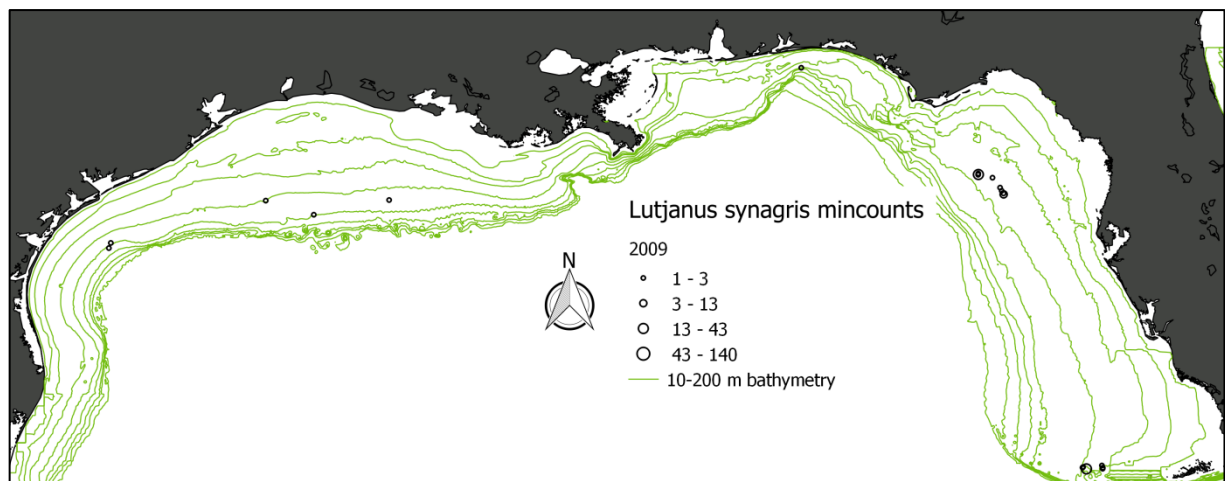Figure 12. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2004.
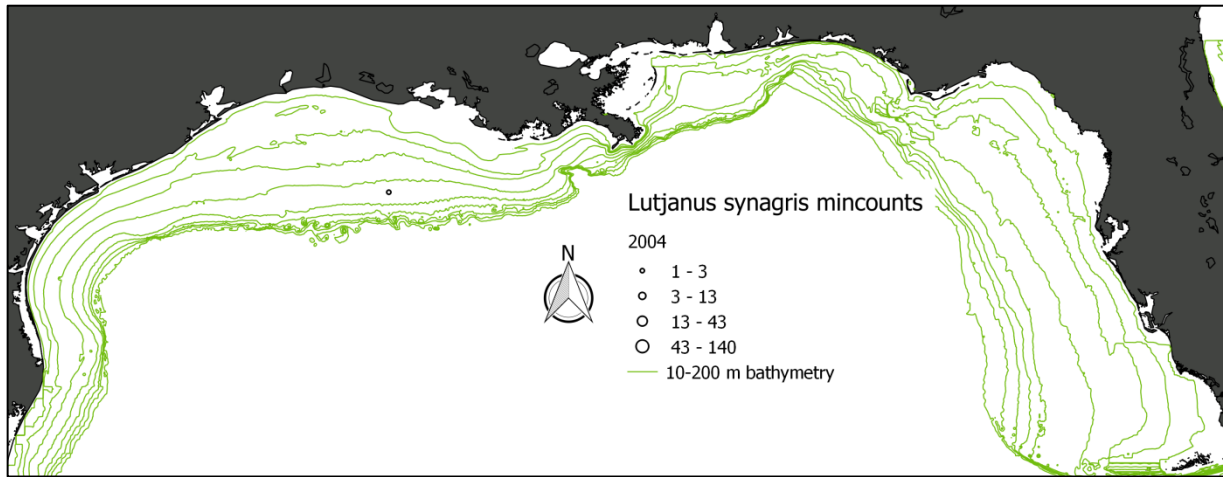


Figure 13. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2005.
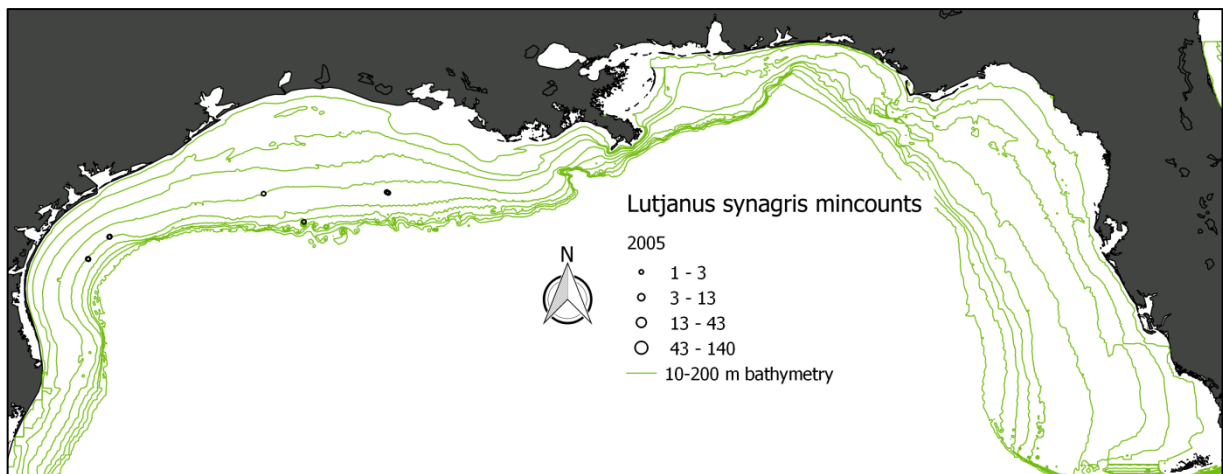
Figure 14. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2006.
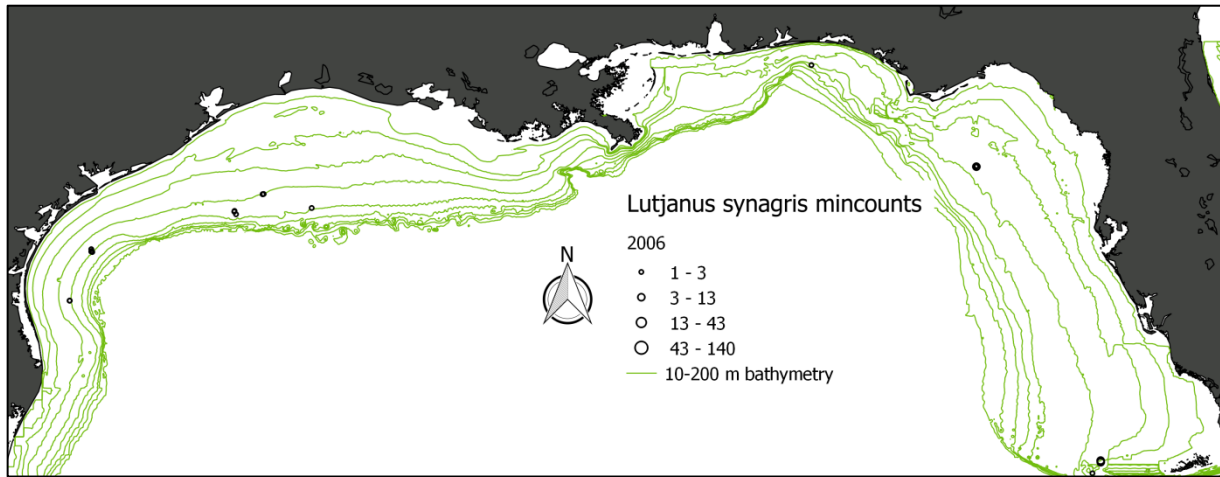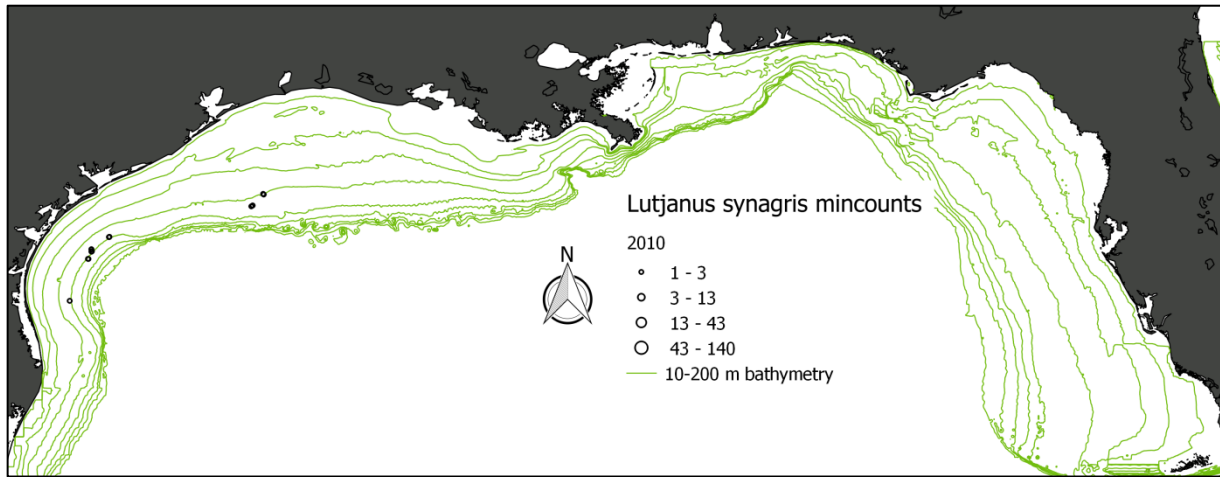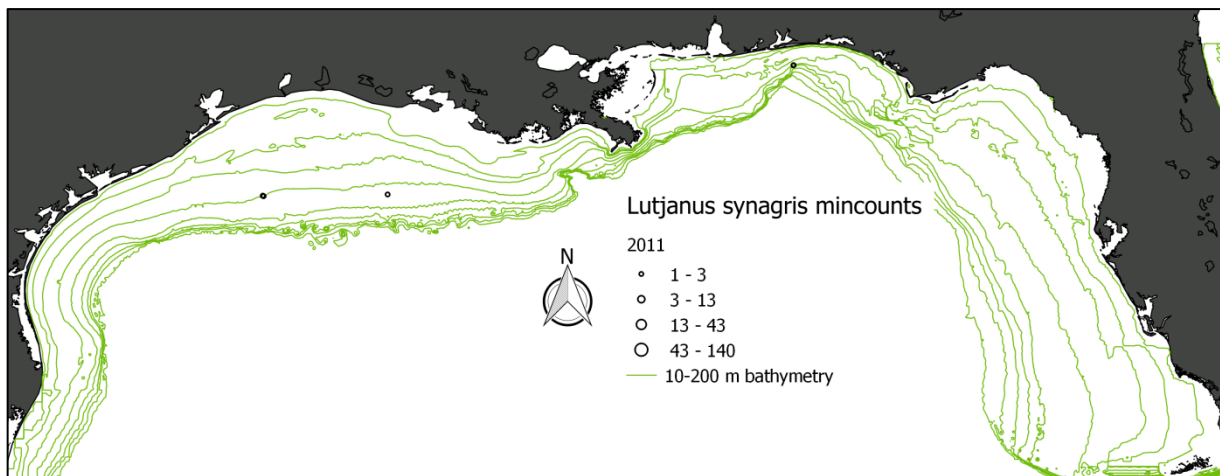


Figure 15. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2007.

Figure 16. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2008.



Figure 17. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2009.

Figure 18. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2010.



Figure 19. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2011.

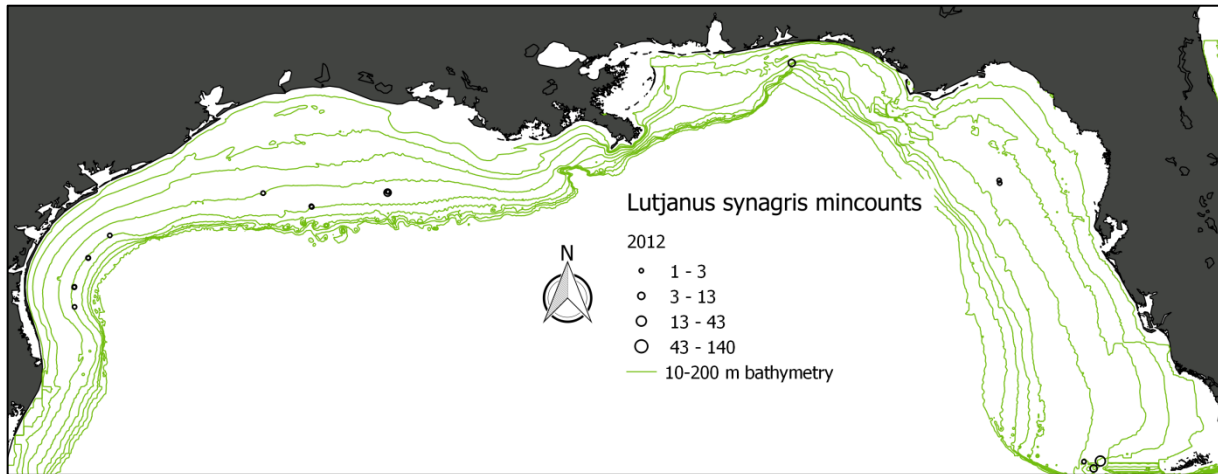Figure 20. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2012.



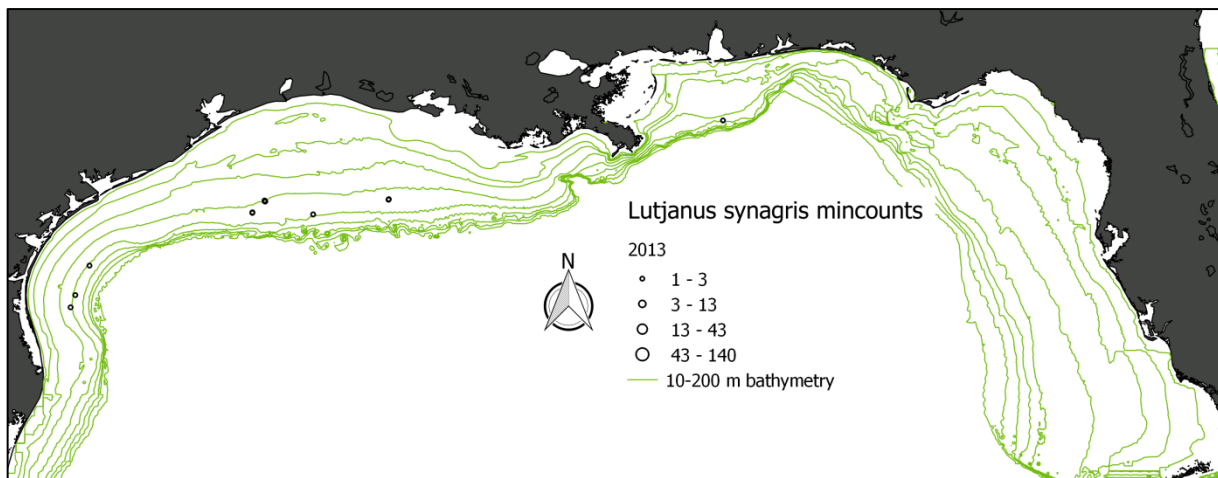Figure 21. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2013.

Figure 22. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2014.
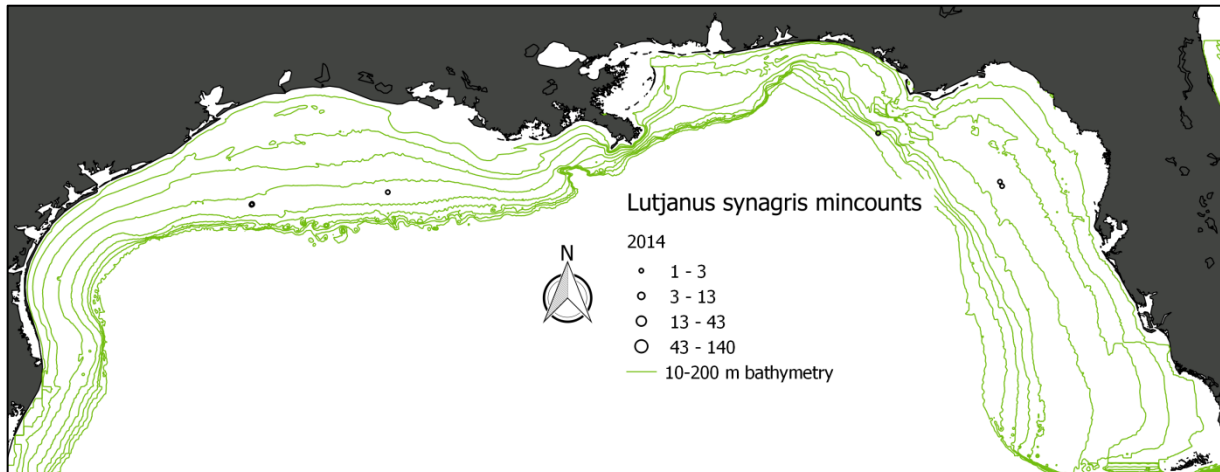


Figure 23. Map of lane snapper mincounts during the SEAMAP reef fish video cruise in 2015.
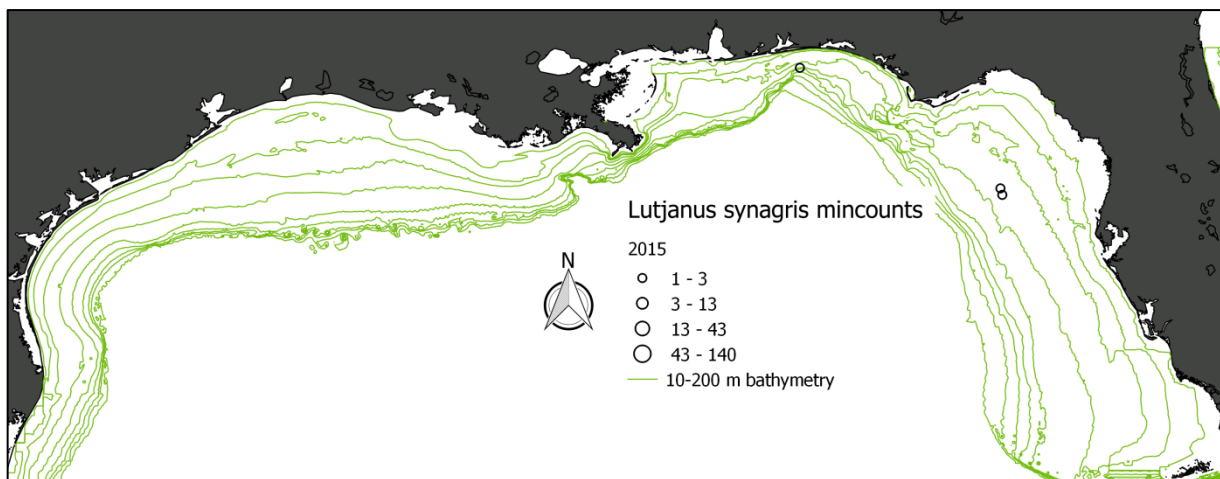
Table 4.  Mean and standard deviation of lane snapper lengths (FL) from the SEAMAP reef fish video cruise from 1995 – 2015.  No measurements of lane snapper were obtained prior to 2005.

| Year | Mean | STD | N |
|------|------|------|------|
| 2005 | 303.00 | 15.64 | 4 |
| 2006 | 288.50 | 53.24 | 22 |
| 2007 | 181.67 | 13.20 | 3 |
| 2008 | 335.48 | 99.22 | 4 |
| 2009 | 282.89 | 63.03 | 27 |
| 2010 | 300.29 | 37.73 | 10 |
| 2011 | 315.42 | 32.86 | 3 |
| 2012 | 233.02 | 49.29 | 34 |
| 2013 | 291.81 | 44.11 | 11 |
| 2014 | 327.55 | 43.97 | 5 |
| 2015 | 208.44 | 8.27 | 3 |

Figure 24. Mean lengths and standard deviation of lane snapper  observed during the SEAMAP reef fish video cruise from 1995 – 2015.  No measurements of lane snapper were obtained prior to 2005.
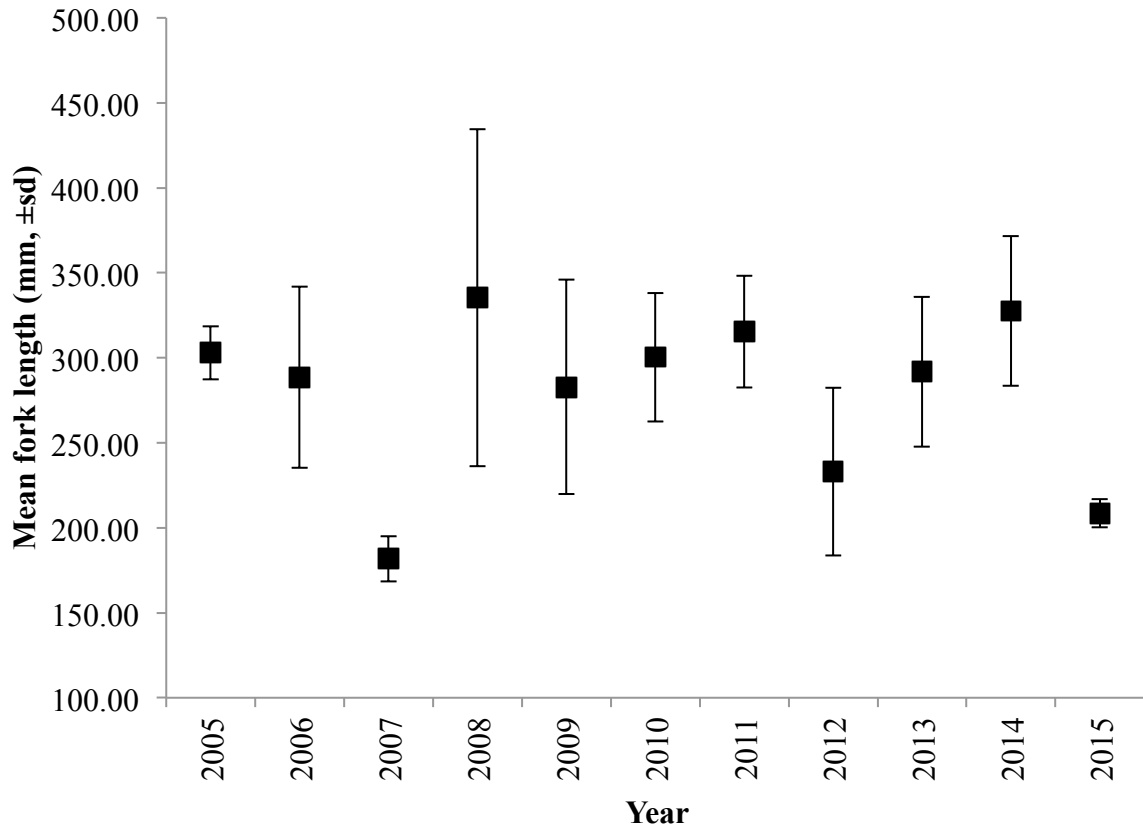
Figure 25. Length frequency histograms of lane snapper observed during the SEAMAP reef fish video cruise from 1995 - 2015. No measurements of lane snapper were obtained prior to 2005.



East
Mean - 256.11
STD - 62.51

West
Mean - 304.09
STD - 44.56

GOM wide
Mean - 273.24
STD - 61.09