SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Grey Snapper

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Relative Indices of Abundance of Grey Snapper

August 2015

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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 1-20). Secondary objectives include quantification of habitat types sampled (video 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. The size of fish sampled with the video gear is species specific however grey snapper sampled over the history of the survey had fork lengths ranging from 188 – 734 mm, and mean annual fork lengths ranging from 272 – 464 mm (Table 1, Figures 21-23). 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 ≤ 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. Stereo cameras used in 2008-present allow size estimation from 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. 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). Sites that were less than 0.1 m (6 inches) in maximum relief were deemed to be camera drops that did not land on reef and were eliminated from analysis (2464 sites out of 6131 total available sites).

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 km^2 reef, block > 20 km^2 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 (Walter Ingram). We explored model fit using three different error distribution models to construct relative abundance indices including delta-lognormal, poisson and negative binomial.

Gulf wide, and east gulf models were run and independent variables tested in the model included year, reef, depth, and maximum relief as fixed effects and block as a random effect (mincount = year + reef + depth + maximum relief + block). We used the composite variable 'reef' rather than the percent coverage of individual habitat variables because of the strong relationship grey snapper have with reef habitat and as a simplifying/aggregating variable to indicate if a camera observed reef habitat. Additionally, in data webinars leading up to the workshop 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 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.

Results

In most years grey snapper were only observed in the eastern Gulf of Mexico (e.g. east of the Mississippi River delta) except in 1995, 1996, 1997, 2004, 2012, 2013. In the years they were observed in the west Gulf they were observed in low abundance and normally at only 1-2 sites and those were exclusively at the Flower Gardens, 32 Fathom or Sonnier Bank (west Louisiana). Because of the low abundance and limited spatial range observed in the west, we developed a Gulf-wide and east Gulf set of models. Additionally, because the positive observations were always associated with high-relief features we limited the sites included in the model to those were we observed at least 0.1 m of relief (6 inches) in an effort to exclude drops that did not effectively target reef (i.e. flat bottom). These two exclusions drastically improved model fit as observed in plots of residuals and CV's.

The size of fish sampled with the video gear is species specific however grey snapper sampled over the history of the survey had fork lengths ranging from 188 – 734 mm, and mean annual fork lengths ranging from 272 – 464 mm (Table 1, Figures 21-23). East gulf grey snapper tended to be shorter in length, however 94% of the fish measurements come from the east Gulf (N=524) and there are only measurements for 6 of 15 years from the west Gulf. Furthermore in three of those years we had sample sizes of 2 or less (i.e. no real ability to capture variability). There is some evidence of year classes growing and moving through our sample.

Tests of the Gulf-wide model using only year showed that the delta lognormal model demonstrated best fit as judged by the linearity of the qq plots and evaluation of the residuals as compared to Poisson and negative binomial models. Thus, we only present results for the delta lognormal models for the Gulf-wide and east Gulf data. Proportion positive for the Gulf-wide model ranged from 8-21% (2005 and 1995 respectively), the standardized index ranged from 0.67 – 1.56 (2005 and 2009 respectively), and the CV's ranged from 13.7 - 21.1 (2009 and 1994 respectively)(Table 2-7, Figures 24-29). Evaluation of the residuals shows reasonably good fit in the positive catch models however the qq plot does demonstrate strong tailing for the negative quantiles. Evaluation of the observed versus predicted outcomes closely tracked for both the proportion positive and continuous count plots.

Proportion positive for the east-Gulf model ranged from 10-32% (2007 and 1995 respectively), the standardized index ranged from 0.67 – 1.53 (2008 and 2009 respectively), and the CV's ranged from 14.0 - 20.7 (1997 and 1994 respectively)(Tables 8-13, Figures 30-35). Overall trends between the Gulf-wide and east-Gulf models show that in general they track closely which indicates that the east Gulf data is primarily driving trends. Additionally there was slight improvement in model characteristics with reducing the data to east Gulf only. As in the GOM wide model, evaluation of the residuals shows reasonably good fit in the positive catch models however the qq plot does demonstrate strong tailing for the negative quantiles. Evaluation of the observed versus predicted outcomes closely tracked for both the proportion positive and continuous count plots. Because of the strong influence of the east GOM data, we recommend an east GOM model only. Further if there is no difference between the Mississippi Labs, FWC, and Panama City Lab reef fish video length compositions, we recommend a combined west Florida shelf index. This would allow increased sample in a single index and improved precision and confidence in the video index.

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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.

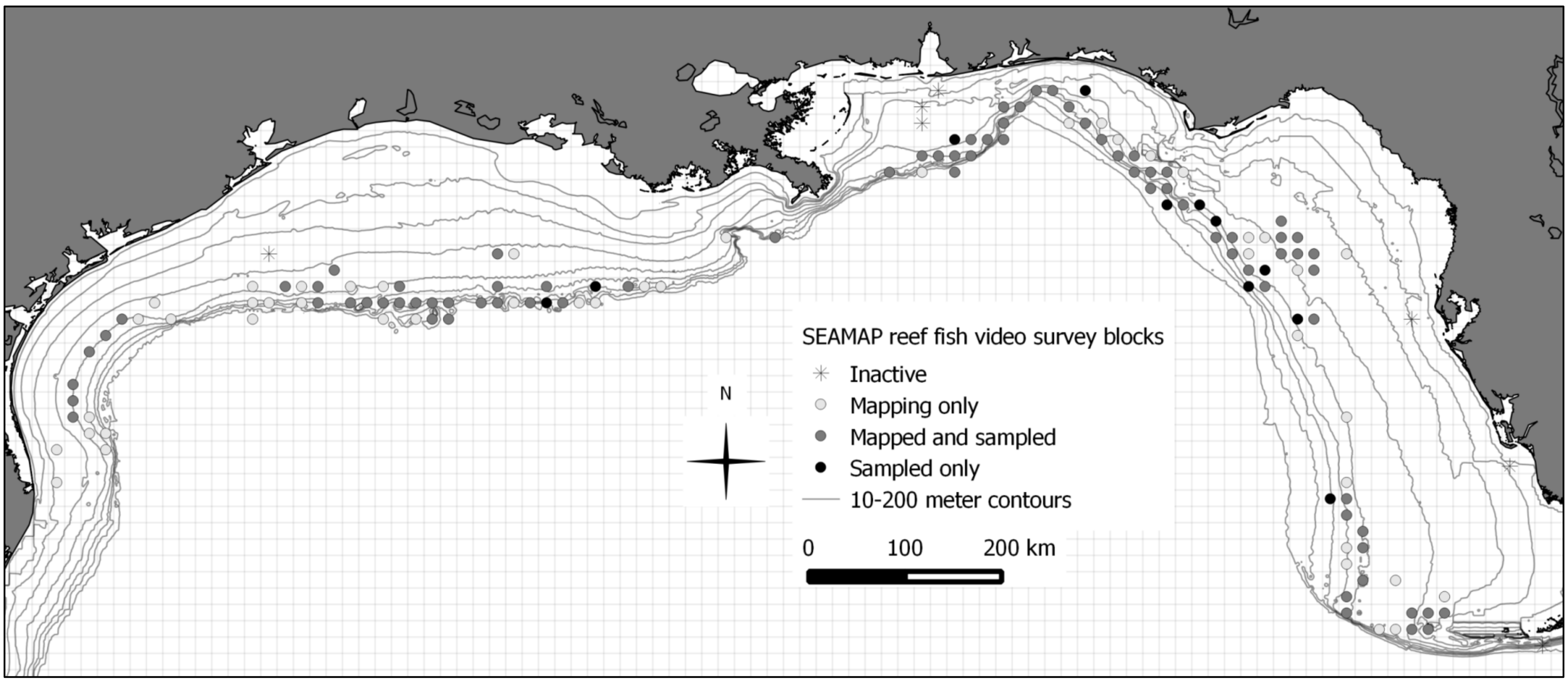

Figure 2. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 1993.

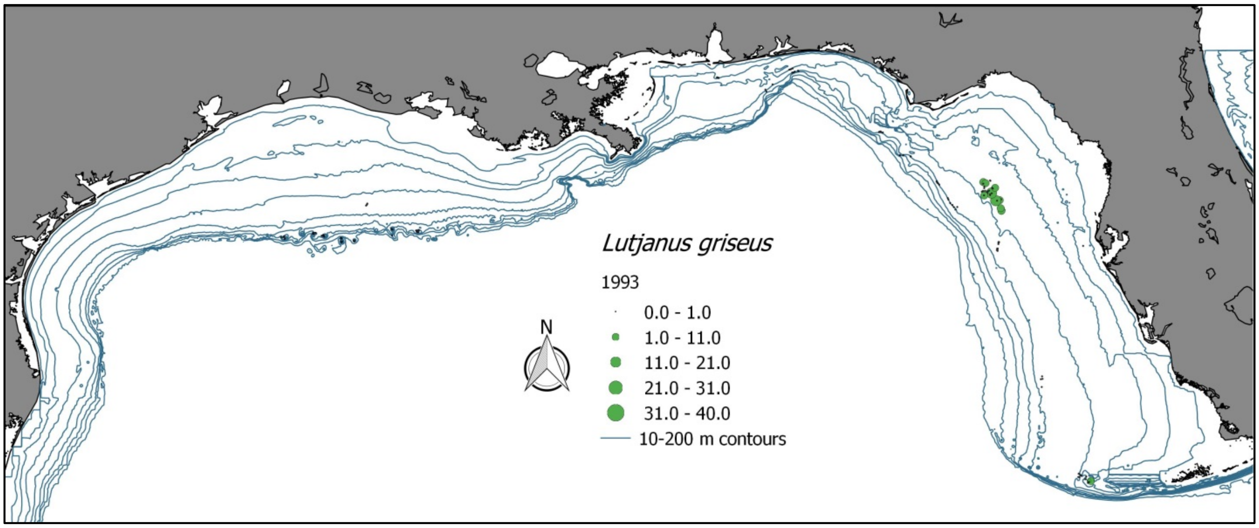

Figure 3. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 1994.

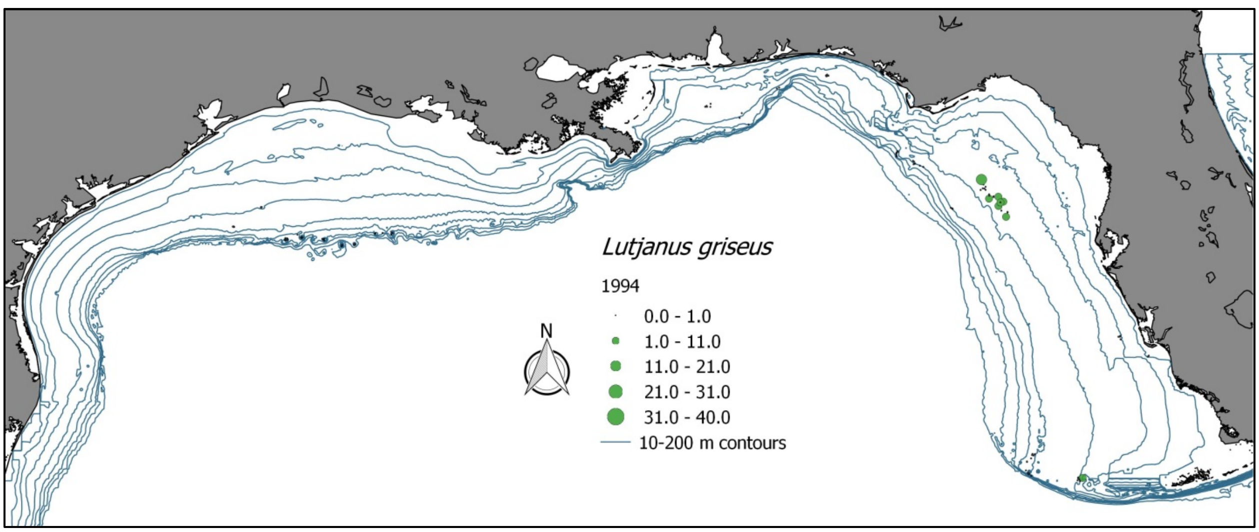

Figure 4. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 1995.

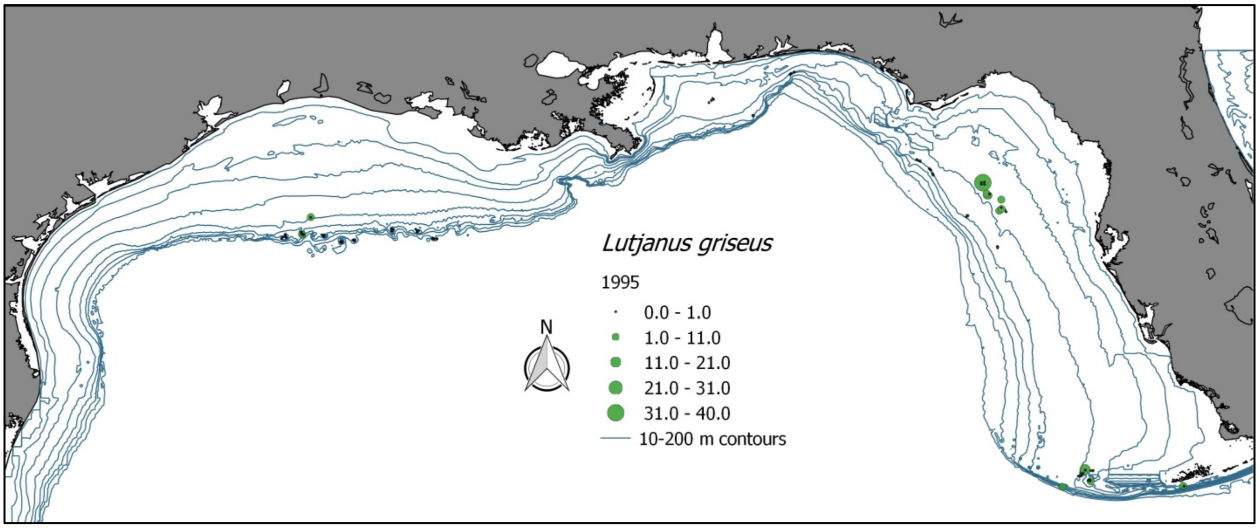

Figure 5. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 1996.

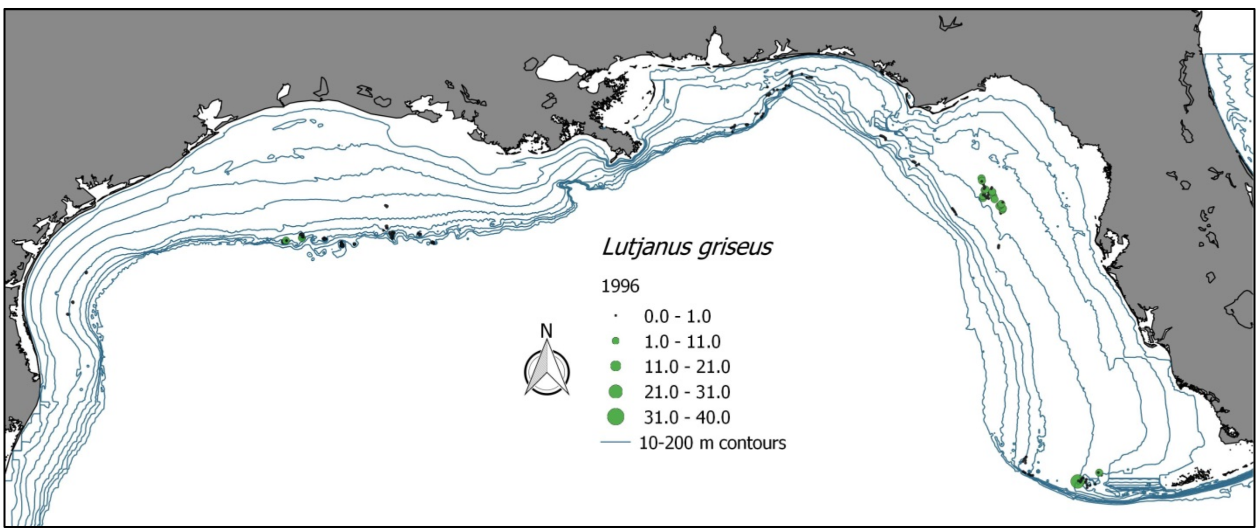

Figure 6. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 1997.

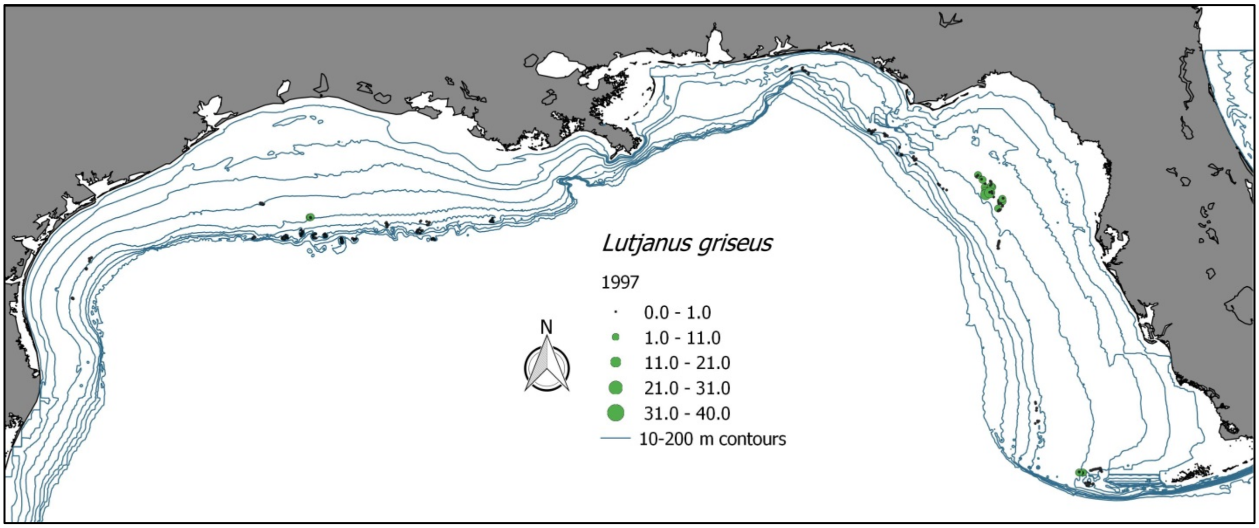

Figure 7. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2001.

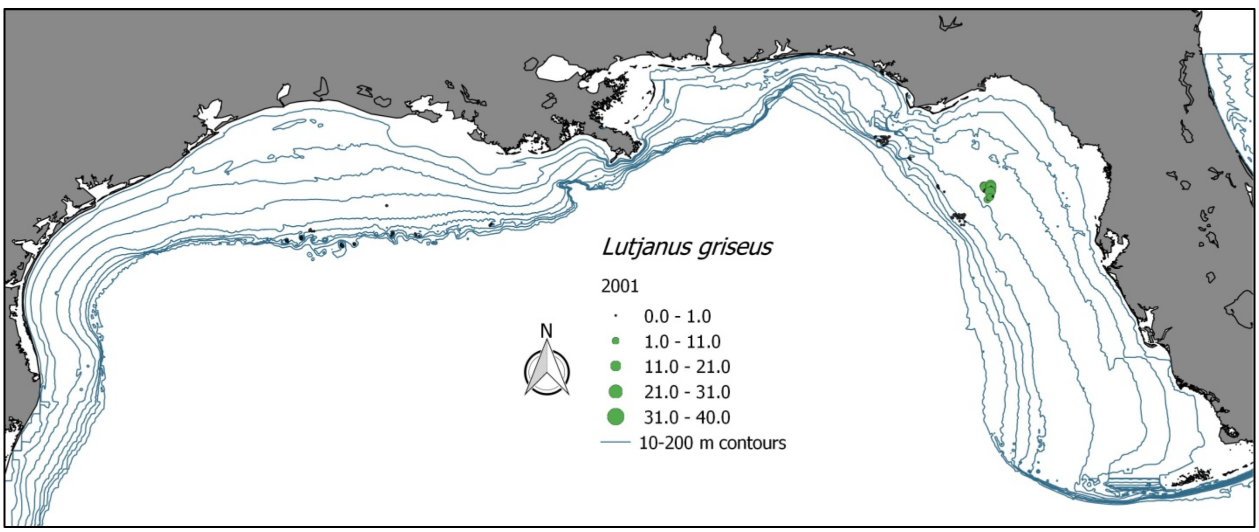

Figure 8. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2002.

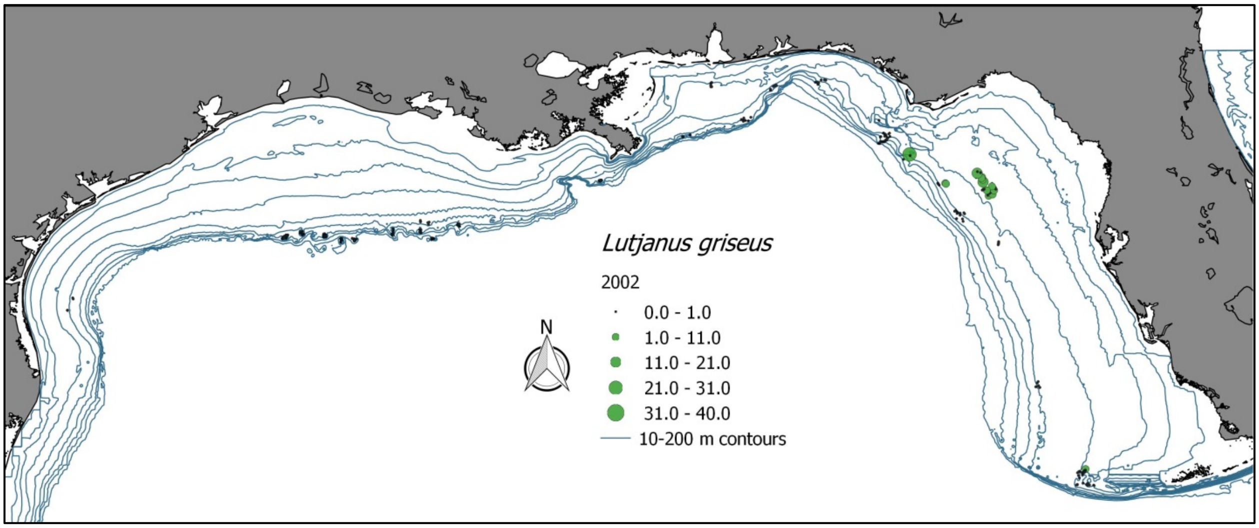

Figure 9. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2004.

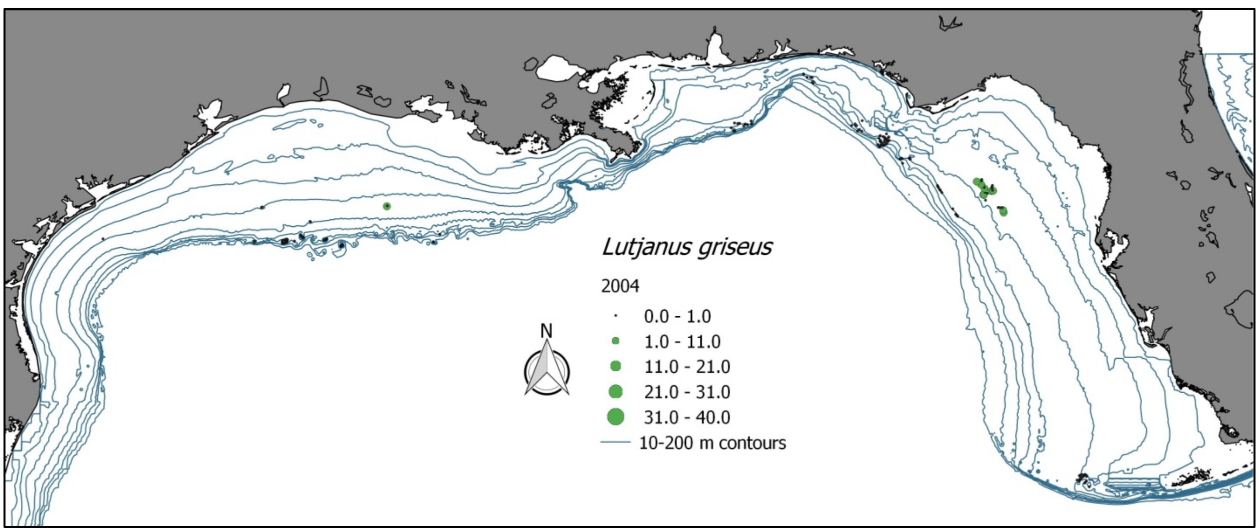

Figure 10. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2005.

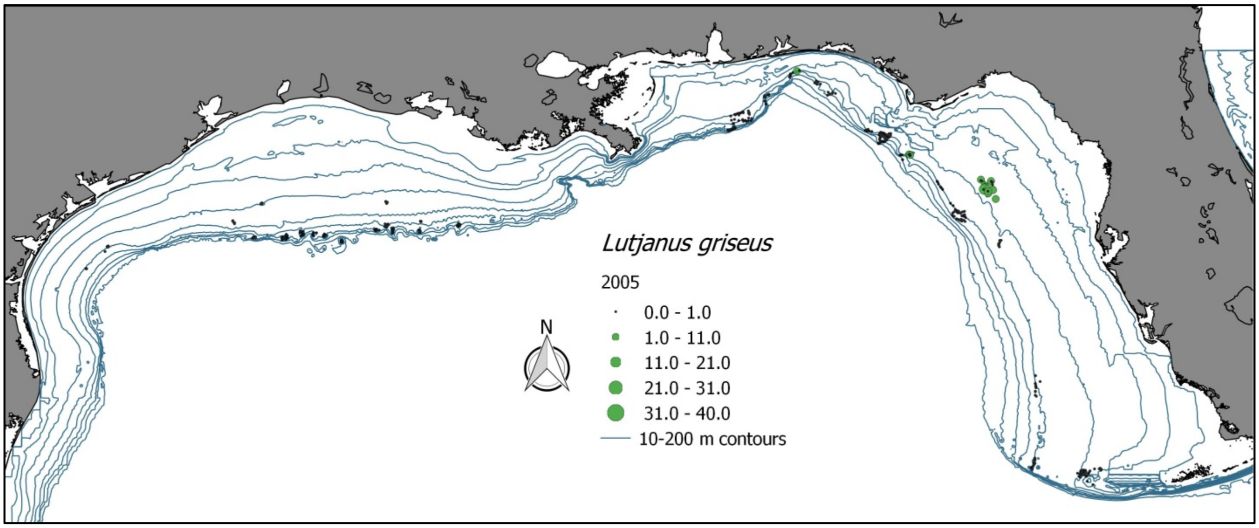

Figure 11. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2006.

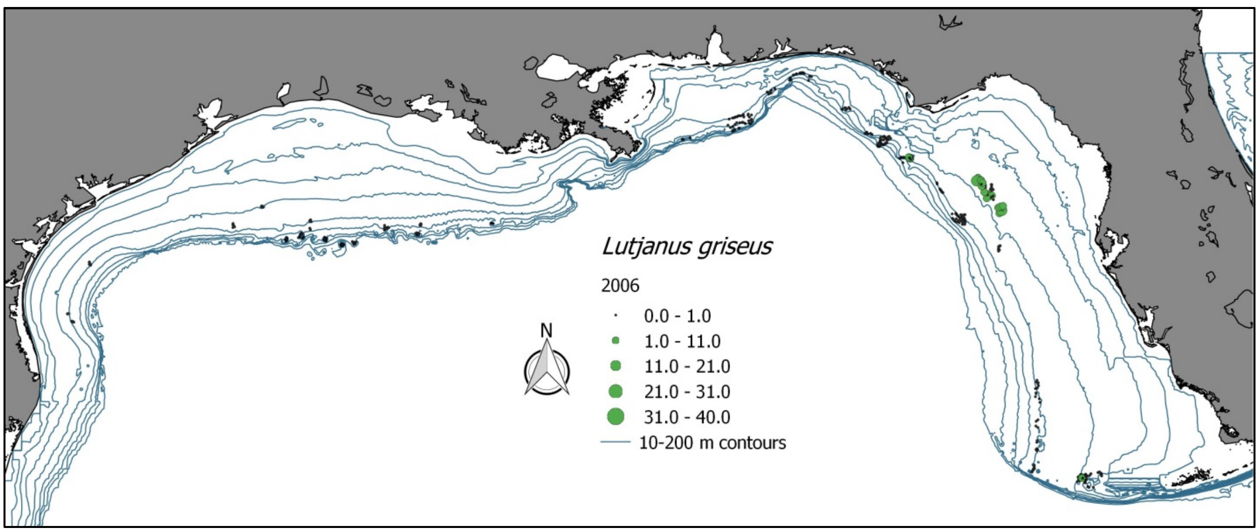

Figure 12. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2007.

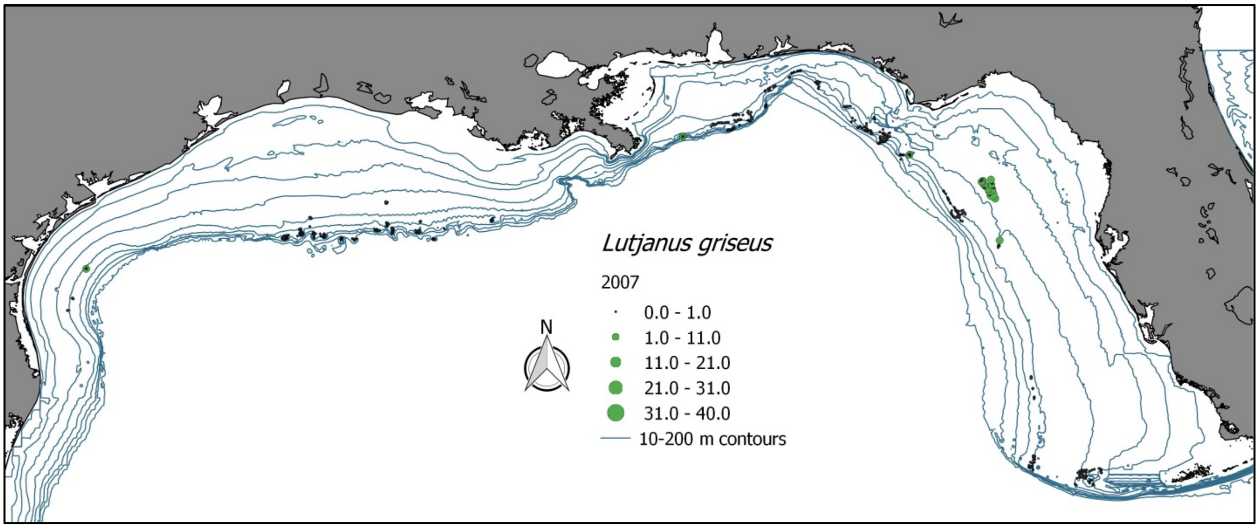

Figure 13. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2008.

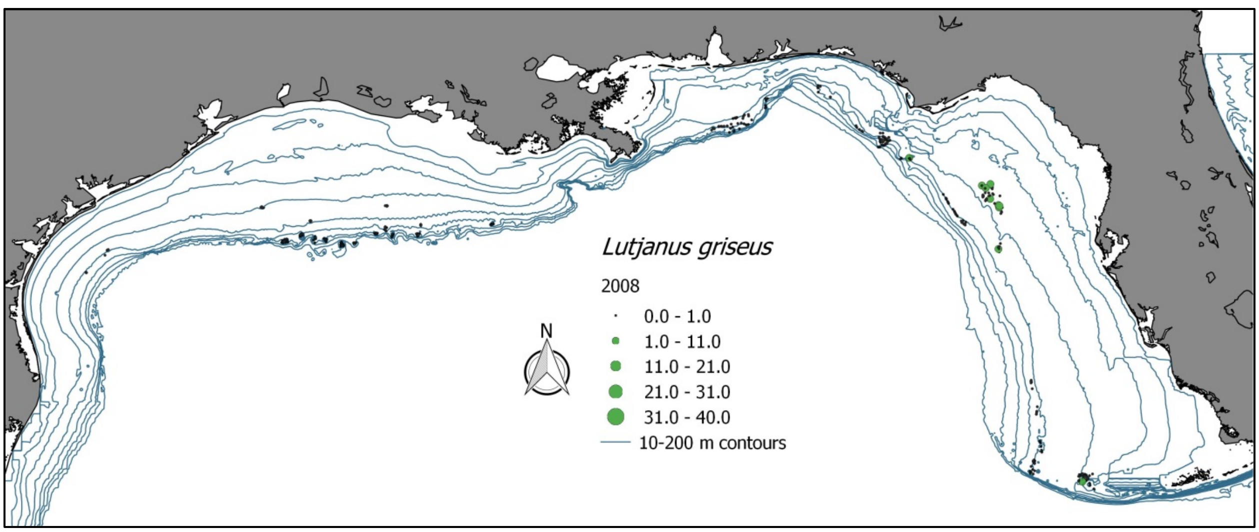

Figure 14. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2009.

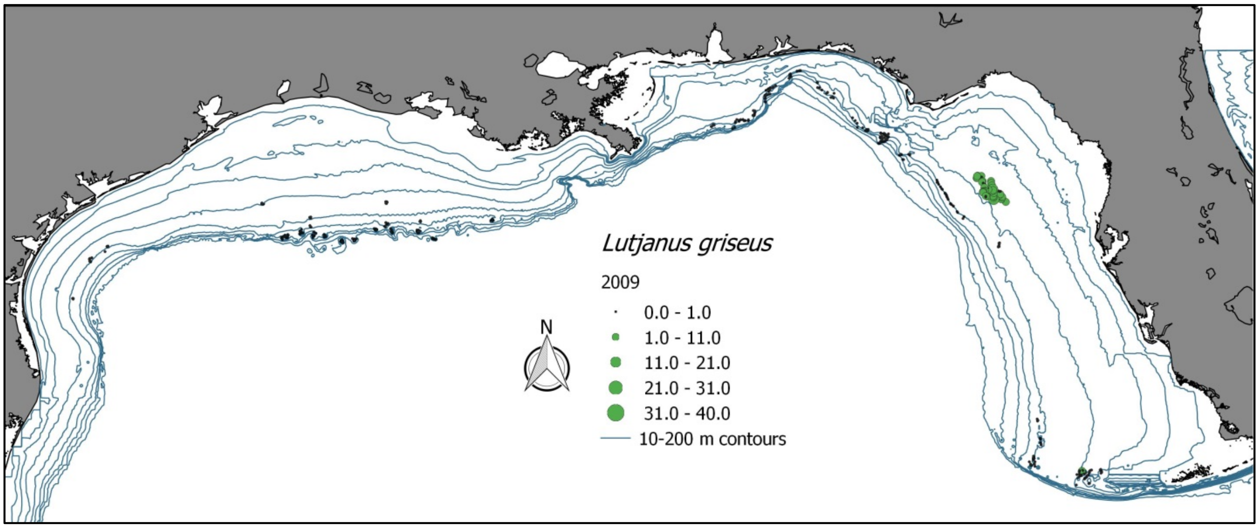

Figure 15. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2010.

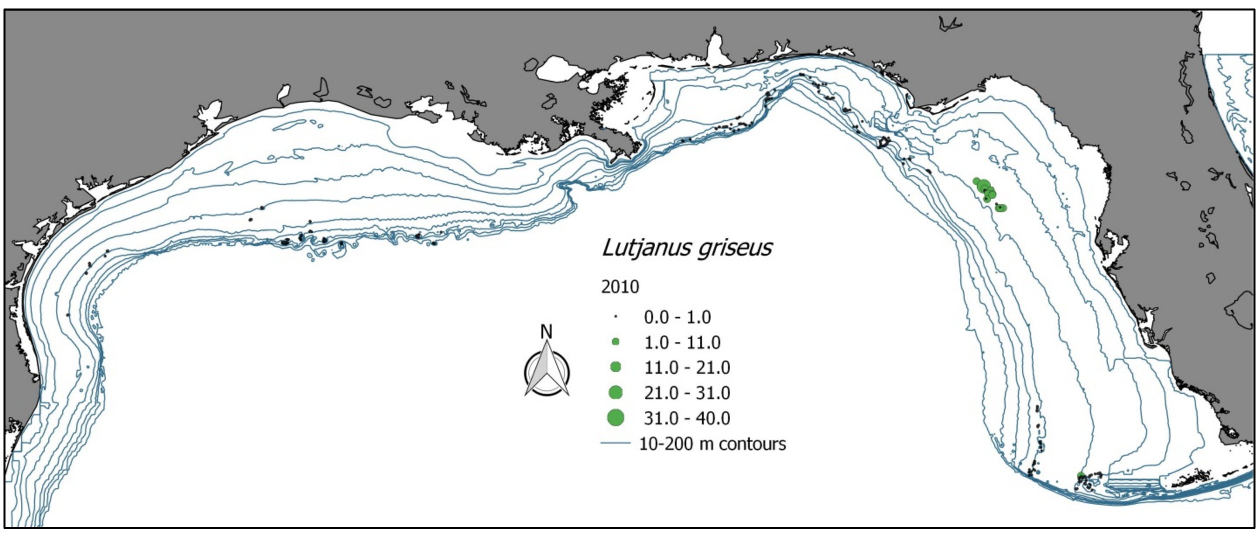

Figure 16. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2011.

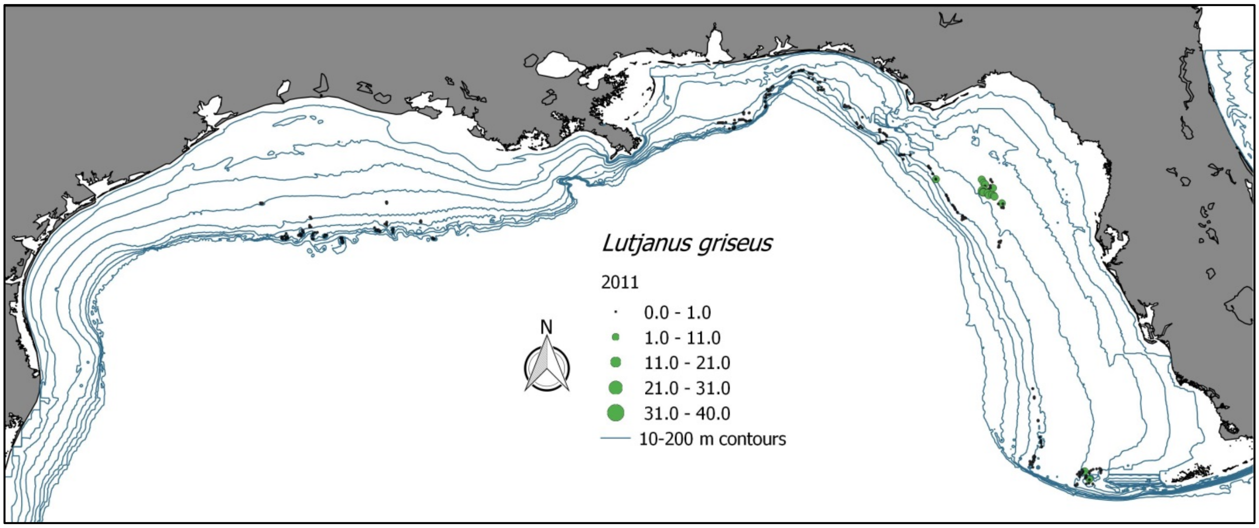

Figure 17. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2012.

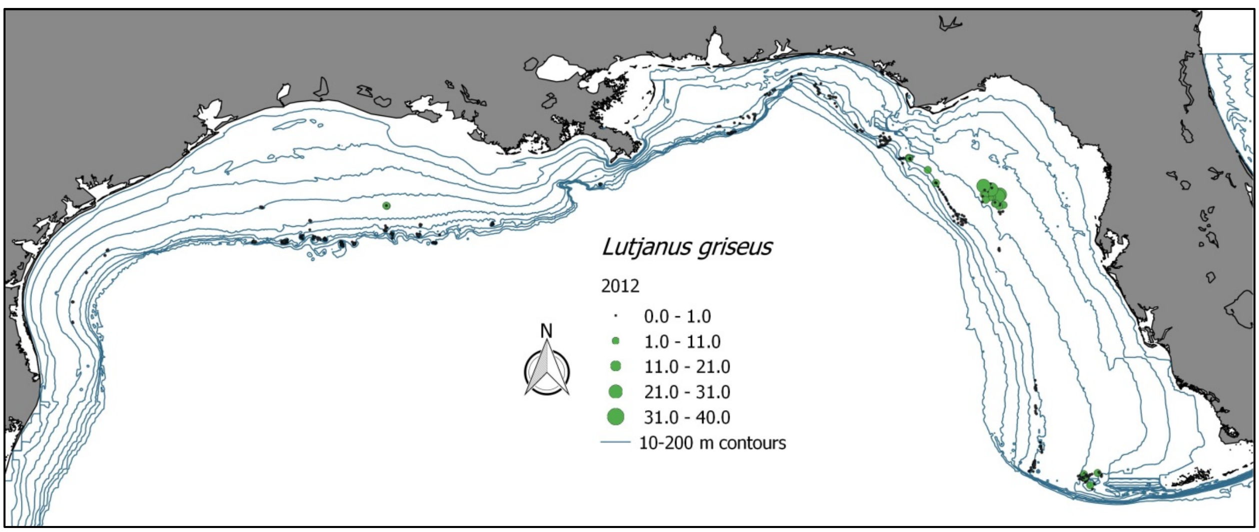

Figure 18. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2013.

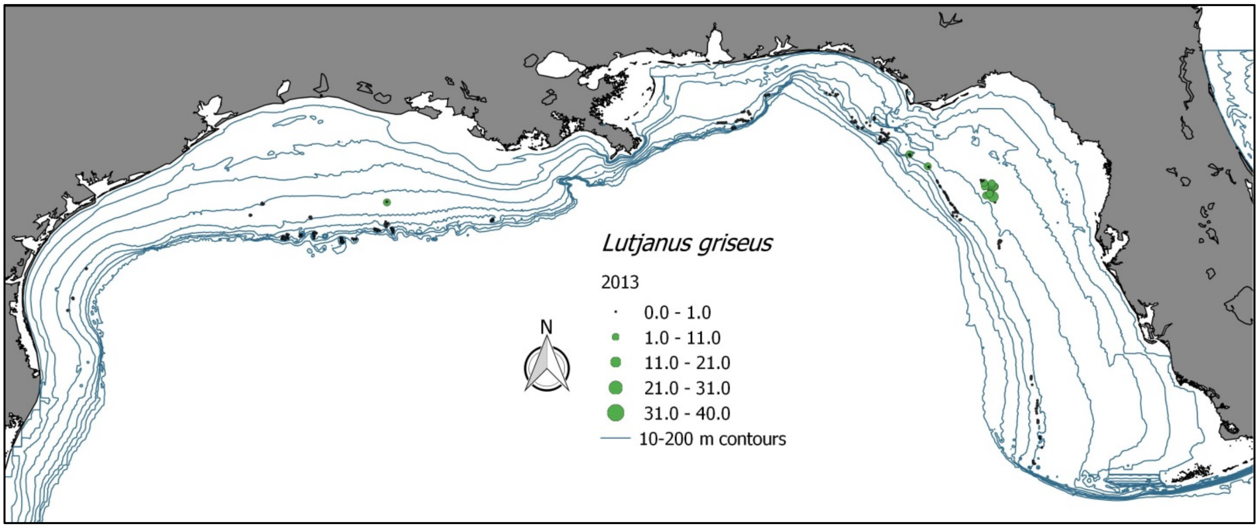

Figure 19. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2014.

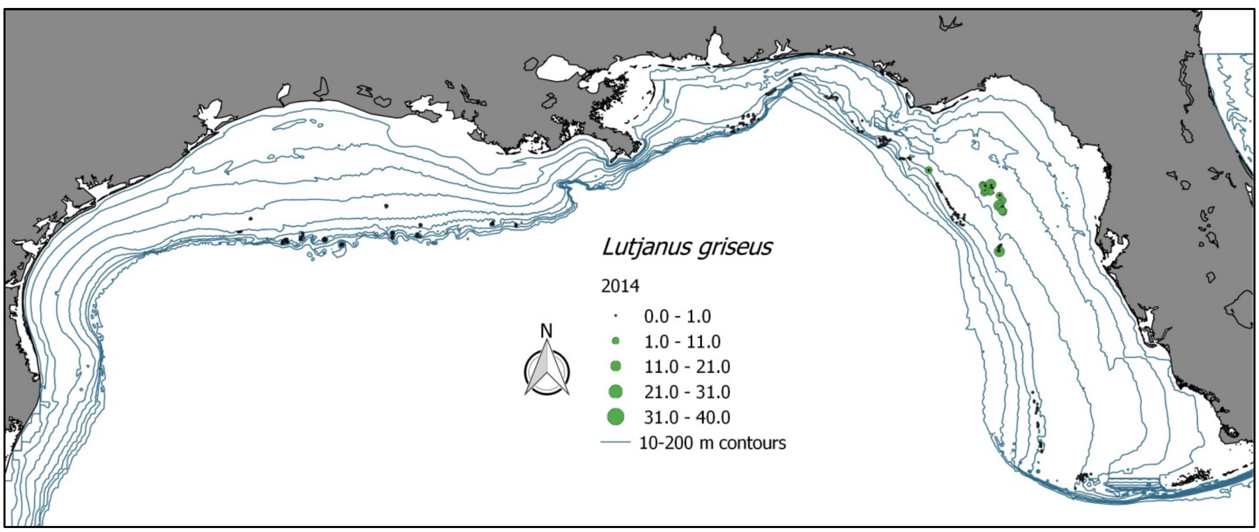

Figure 20. Map of grey snapper mincounts during the SEAMAP reef fish video cruise in 2015.

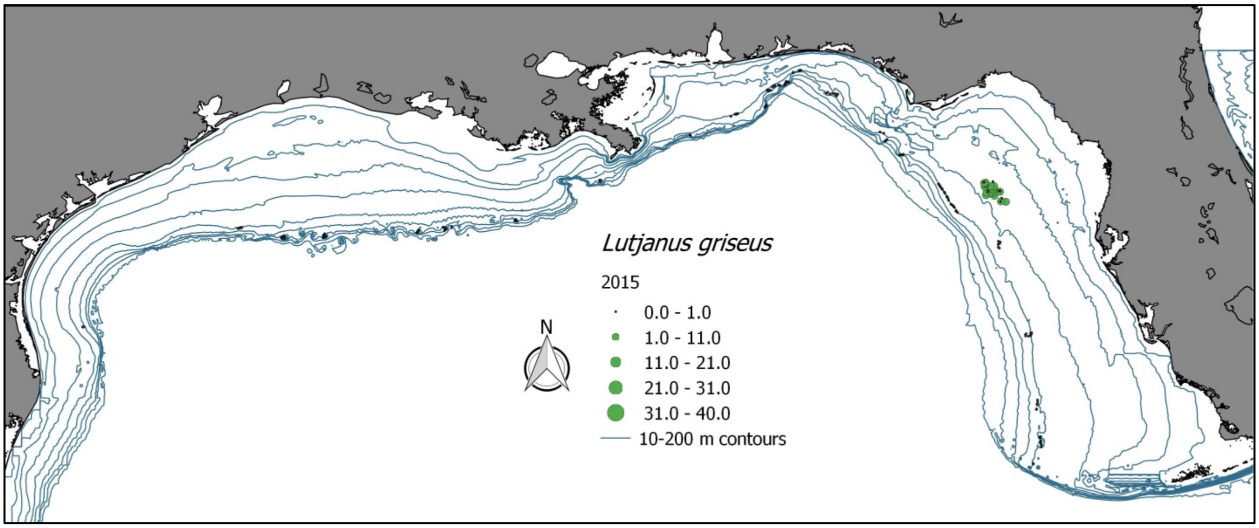

Table 1. Mean (± sd) grey snapper lengths (FL) from the SEAMAP reef fish video cruise from 1993 – 2013. Includes estimates by region and Gulf wide.

	GOM-wide			East GOM			West GOM		
Year	**Mean FL**	**SD FL**	**N**	**Mean FL**	**SD FL**	**N**	**Mean FL**	**SD FL**	**N**
1996	464.6667	87.36895	3	513	35.35534	2	368	-	1
1997	272.5	31.81981	2	272.5	31.81981	2			0
2002	399.4415	102.1212	34	378.7364	56.96055	11	409.3439	117.6923	23
2004	418.6111	58.64664	18	403.375	60.74194	16			0
2005	404.335	63.26839	14	418.6111	58.64664	18			0
2006	344.355	72.85144	94	404.335	63.26839	14			0
2007	462.1515	92.57366	33	344.355	72.85144	94	529.3333	68.78184	18
2008	401.0619	66.98121	25	381.5333	32.81956	15	522.6973	-	1
2009	380.0972	67.13675	76	395.9938	63.33622	24			0
2010	434.2182	21.66151	2	380.0972	67.13675	76	434.2182	21.66151	2
2011	368.034	67.57241	56	368.034	67.57241	56			0
2012	389.5482	81.01102	73	389.5482	81.01102	73			0
2013	395.4788	60.92814	31	394.1741	55.17275	27	404.2858	103.0632	4
2014	306.3298	65.82334	48	306.3298	65.82334	48			0
2015	356.2585	60.77469	48	356.2585	60.77469	48			0
Total	376.4109	80.59314	557	369.0158	73.06448	524	455.4936	110.6972	49

Figure 21. Mean lengths (± sd) of grey snapper observed GOM-wide during the SEAMAP reef fish video cruise from 1993 - 2015.

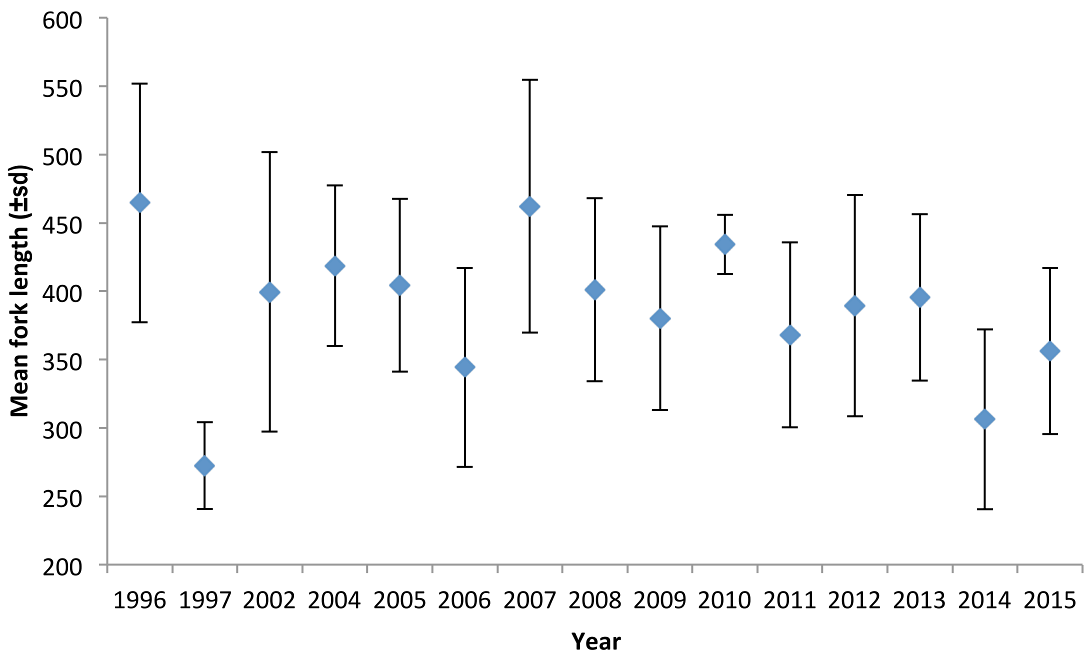

Figure 22. Mean lengths (± sd) of grey snapper observed GOM-wide during the SEAMAP reef fish video cruise from 1993 - 2015.

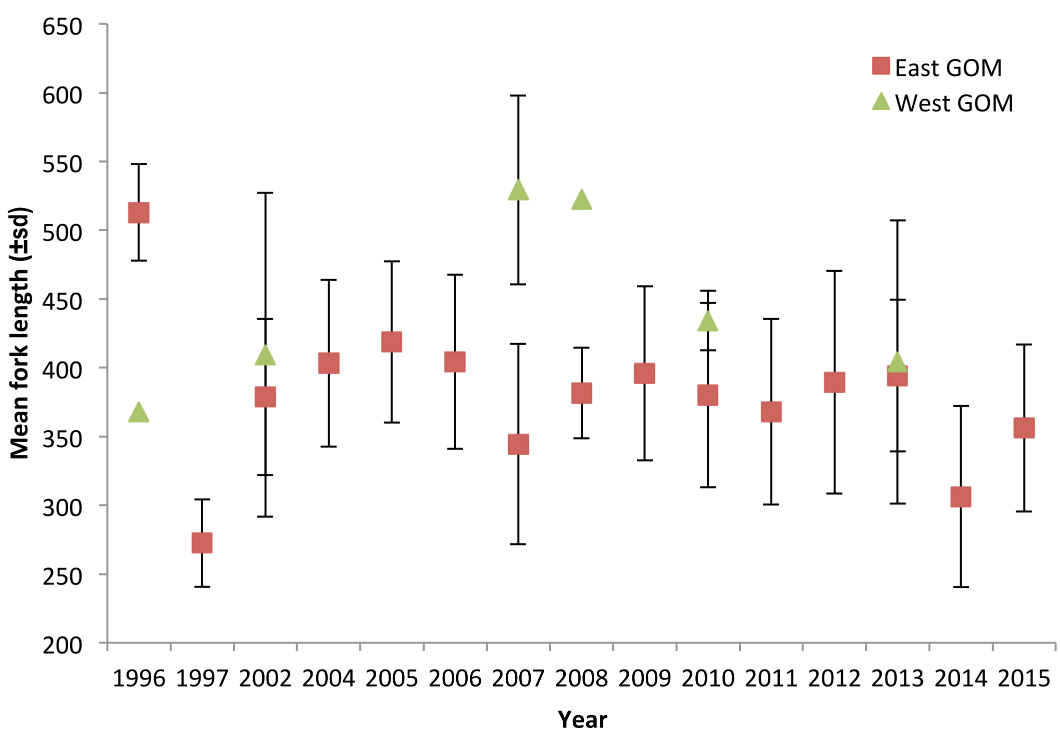

Figure 23. Length frequency histogram (25 mm bins) of grey snapper observed GOM-wide during the SEAMAP reef fish video cruise from 1993 - 2015.

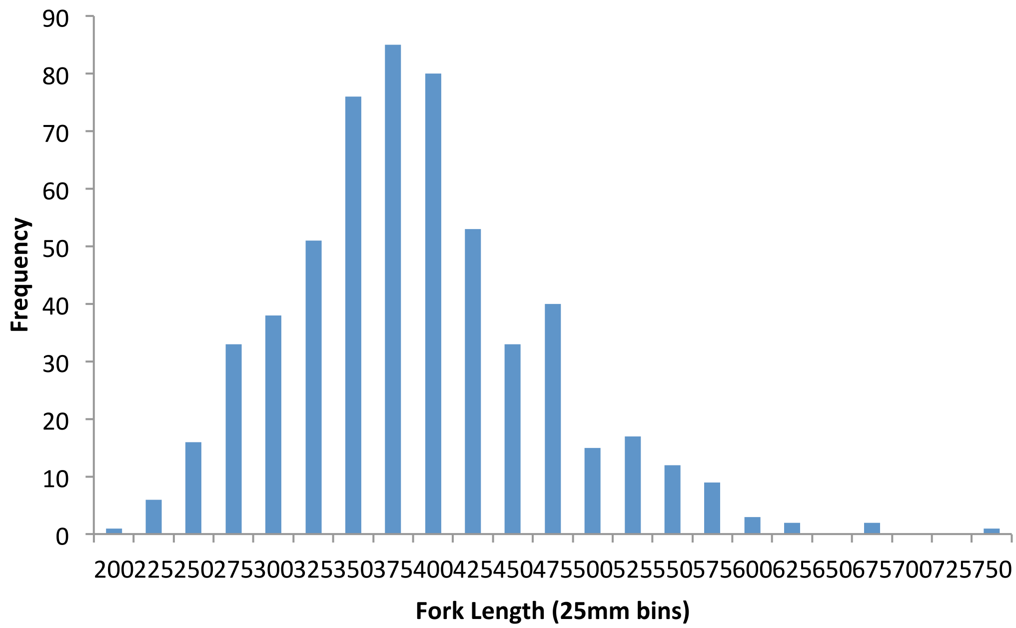

Table 2. Gulf wide delta lognormal type III fixed effects of the binomial submodel.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	3285	30.08	1.77	0.0258	0.0263

Table 3. Gulf wide delta lognormal fit statistics of the binomial submodel.

Fit Statistics	
-2 Res Log Likelihood	16339.7
AIC (Smaller is Better)	16341.7
AICC (Smaller is Better)	16341.7
BIC (Smaller is Better)	16347.8

Table 4. Gulf wide delta lognormal model statistics of the binomial submodel.

Description	*Value*
Deviance	635.0618
Scaled Deviance	3041.6674
Pearson Chi-Square	685.8666
Scaled Pearson Chi-Square	3285.0000
Extra-Dispersion Scale	0.2088

Figure 24. Gulf wide delta lognormal chi-square residuals of the binomial submodel.

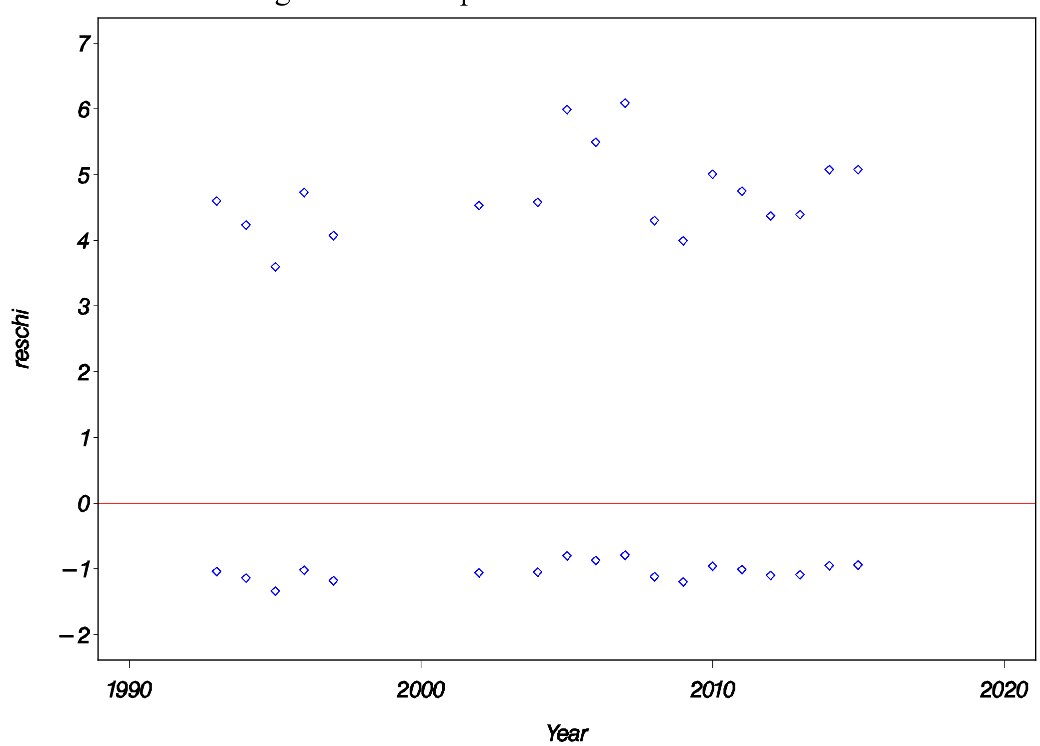

Table 5. Gulf wide delta lognormal type III fixed effects of the lognormal submodel.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
year	17	436	1.81	0.0247

Table 6. Gulf wide delta lognormal fit statistics of the lognormal submodel.

Fit Statistics	
-2 Res Log Likelihood	1183.1
AIC (Smaller is Better)	1185.1
AICC (Smaller is Better)	1185.1
BIC (Smaller is Better)	1189.2

Figure 25. Gulf wide delta lognormal residuals of the positive catch submodel.

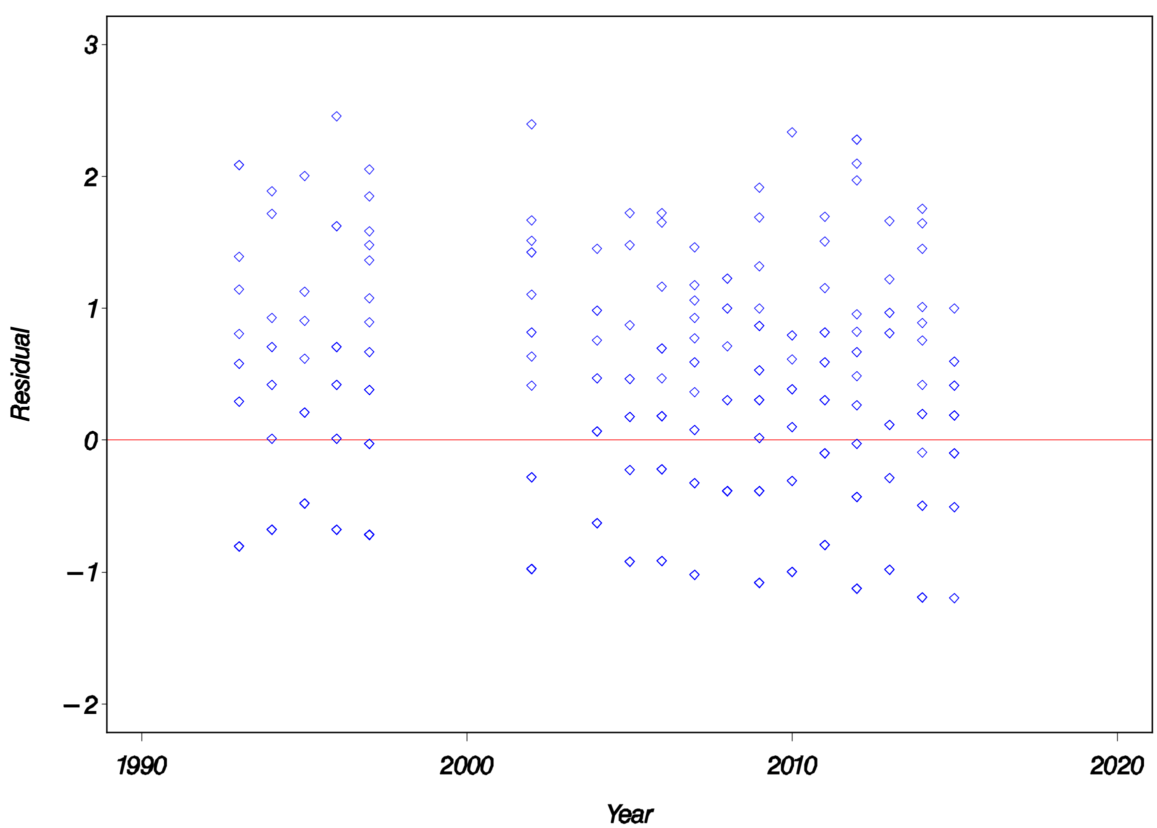

Figure 26. Gulf wide delta lognormal distribution of residuals of the positive catch submodel.

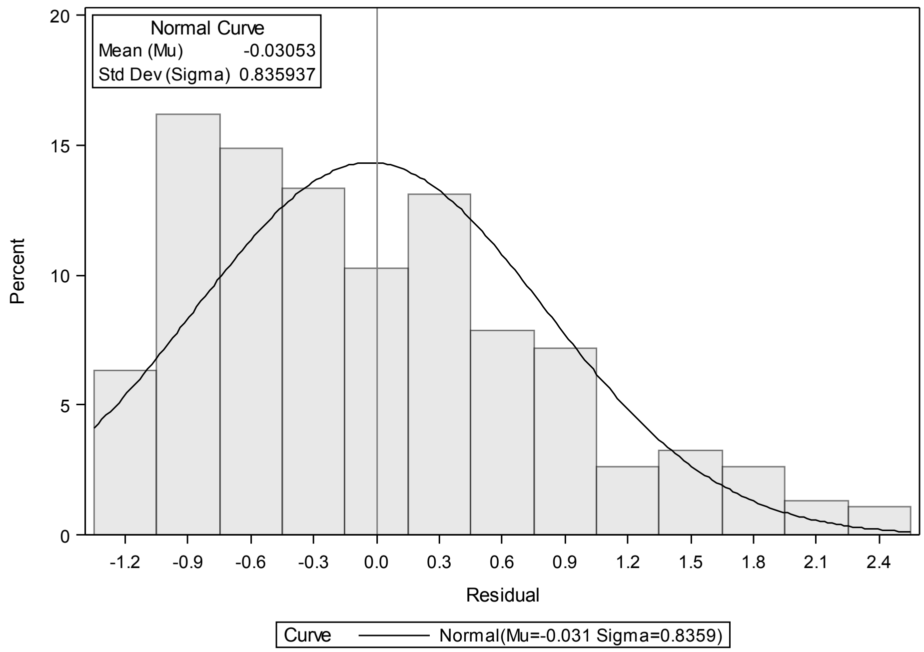

Figure 27. Gulf wide delta lognormal qq plot of residuals of the positive catch submodel.

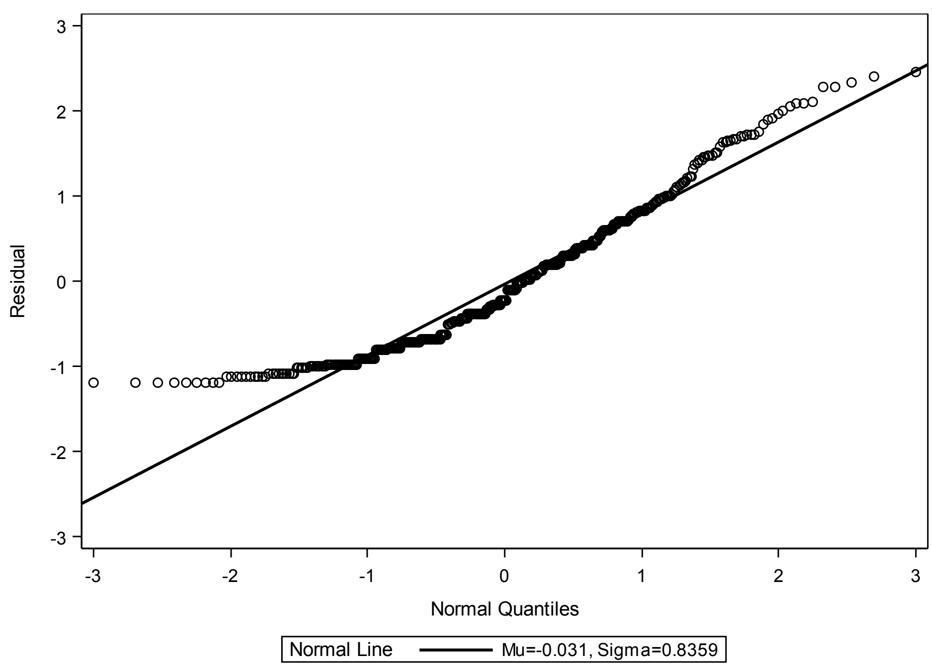

Figure 28. Gulf wide delta lognormal observed versus predicted proportion positive.

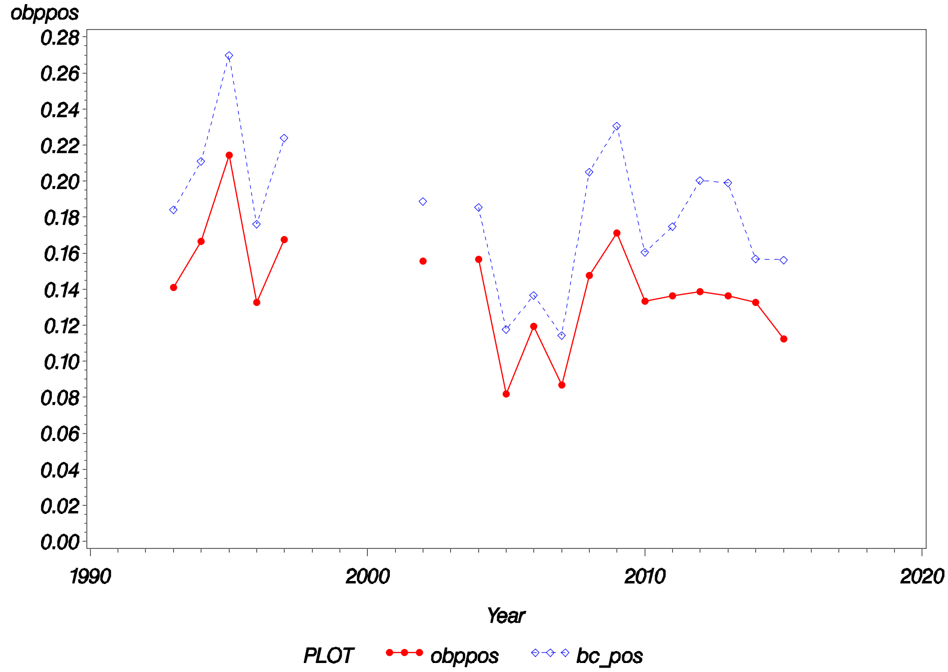

Figure 29. Gulf wide delta lognormal observed versus standardized mincount.

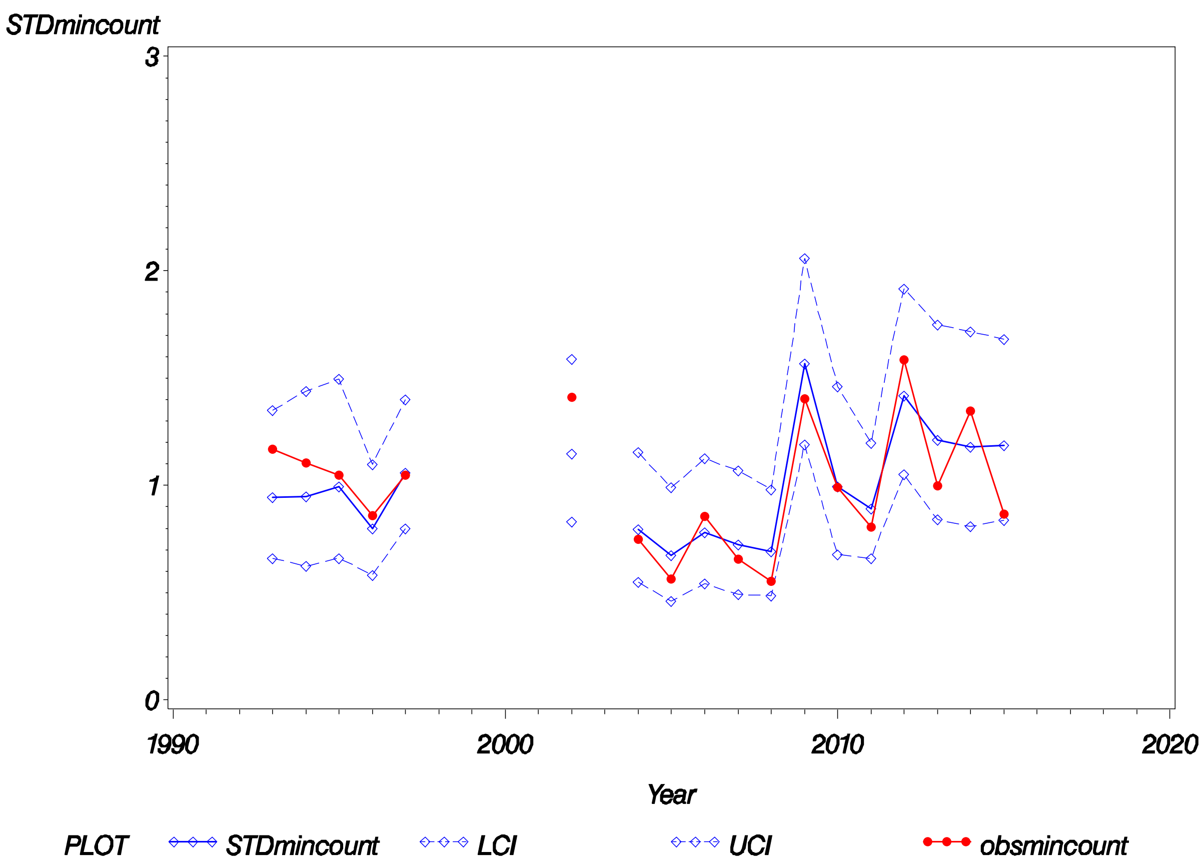

Table 7. Output for the delta lognormal index of relative abundance of grey snapper by year, Gulf wide model run.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.14094	149	0.44636	0.94363	0.08033	0.17997	0.66028	1.34857
1994	0.16667	102	0.44807	0.94724	0.09497	0.21194	0.62286	1.44057
1995	0.21429	84	0.47018	0.99399	0.09687	0.20603	0.66112	1.49444
1996	0.13248	234	0.37798	0.79907	0.06036	0.15970	0.58176	1.09756
1997	0.16738	233	0.50017	1.05738	0.07041	0.14078	0.79901	1.39930
2002	0.15544	193	0.54328	1.14852	0.08861	0.16310	0.83061	1.58809
2004	0.15672	134	0.37614	0.79518	0.07038	0.18712	0.54870	1.15240
2005	0.08190	232	0.31881	0.67397	0.06194	0.19428	0.45862	0.99044
2006	0.11927	218	0.36966	0.78147	0.06784	0.18352	0.54303	1.12461
2007	0.08696	253	0.34272	0.72451	0.06731	0.19641	0.49097	1.06914
2008	0.14744	156	0.32687	0.69102	0.05776	0.17670	0.48662	0.98129
2009	0.17130	216	0.74075	1.56597	0.10194	0.13762	1.19073	2.05947
2010	0.13333	180	0.47055	0.99476	0.09139	0.19422	0.67699	1.46169
2011	0.13636	242	0.42059	0.88915	0.06303	0.14986	0.65998	1.19790
2012	0.13866	238	0.67072	1.41792	0.10153	0.15138	1.04933	1.91598
2013	0.13636	154	0.57331	1.21201	0.10595	0.18480	0.84010	1.74855
2014	0.13253	166	0.55698	1.17747	0.10577	0.18990	0.80810	1.71568
2015	0.11230	187	0.56136	1.18673	0.09861	0.17566	0.83741	1.68178

Table 8. East Gulf delta lognormal type III fixed effects of the binomial submodel.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	2080	34.71	2.04	0.0068	0.0071

Table 9. East gulf delta lognormal fit statistics of the binomial submodel.

Fit Statistics	
-2 Res Log Likelihood	9802.4
AIC (Smaller is Better)	9804.4
AICC (Smaller is Better)	9804.4
BIC (Smaller is Better)	9810.0

Table 10. East gulf delta lognormal model statistics of the binomial submodel.

Description	*Value*
Deviance	783.8318
Scaled Deviance	2175.1137
Pearson Chi-Square	749.5563
Scaled Pearson Chi-Square	2080.0000
Extra-Dispersion Scale	0.3604

Figure 30. East gulf delta lognormal chi-square residuals of the binomial submodel.

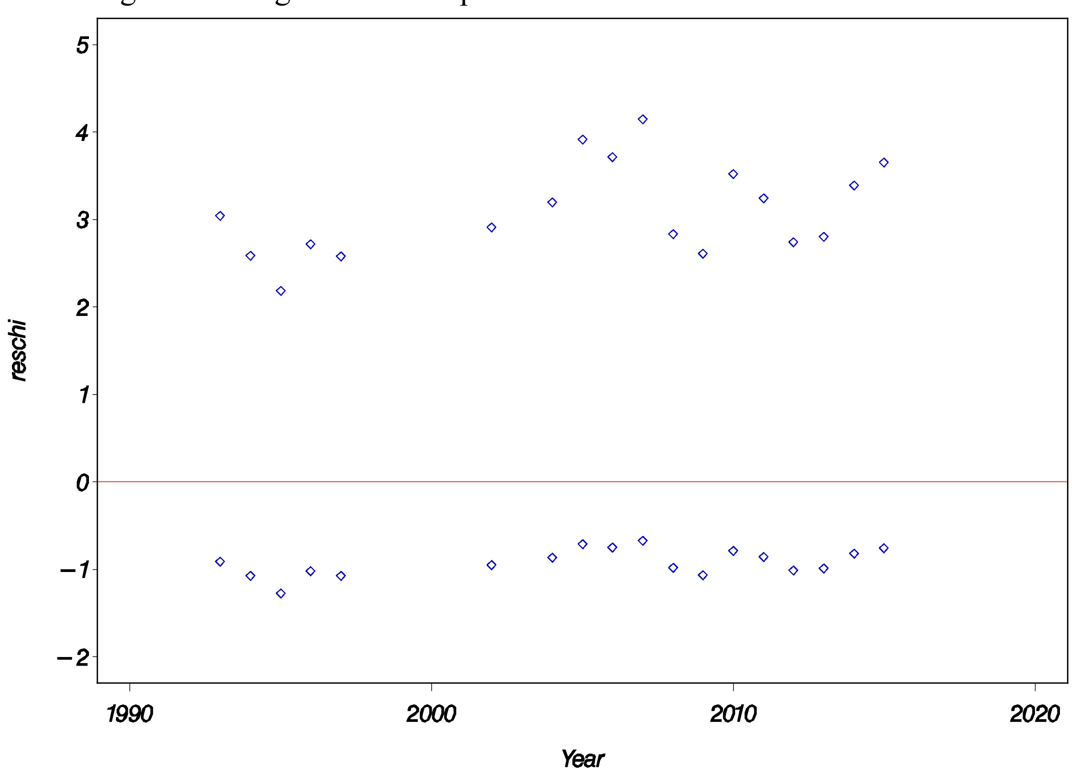

Table 11. East gulf delta lognormal type III fixed effects of the lognormal submodel.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
year	17	408	1.85	0.0209

Table 12. East gulf delta lognormal fit statistics of the lognormal submodel.

Fit Statistics	
-2 Res Log Likelihood	1095.9
AIC (Smaller is Better)	1097.9
AICC (Smaller is Better)	1097.9
BIC (Smaller is Better)	1101.9

Figure 31. East gulf delta lognormal residuals of the positive catch submodel.

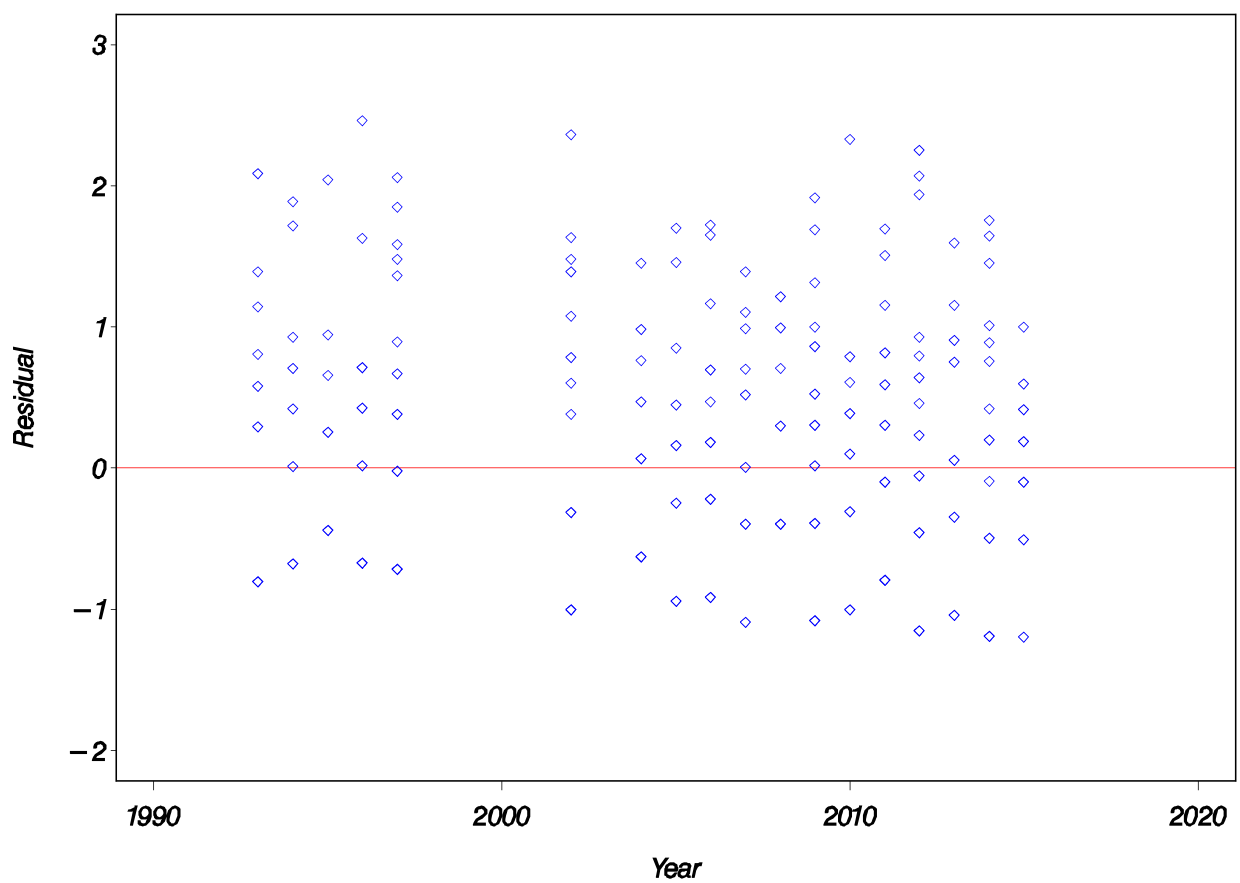

Figure 32. East gulf delta lognormal distribution of residuals of the positive catch submodel.

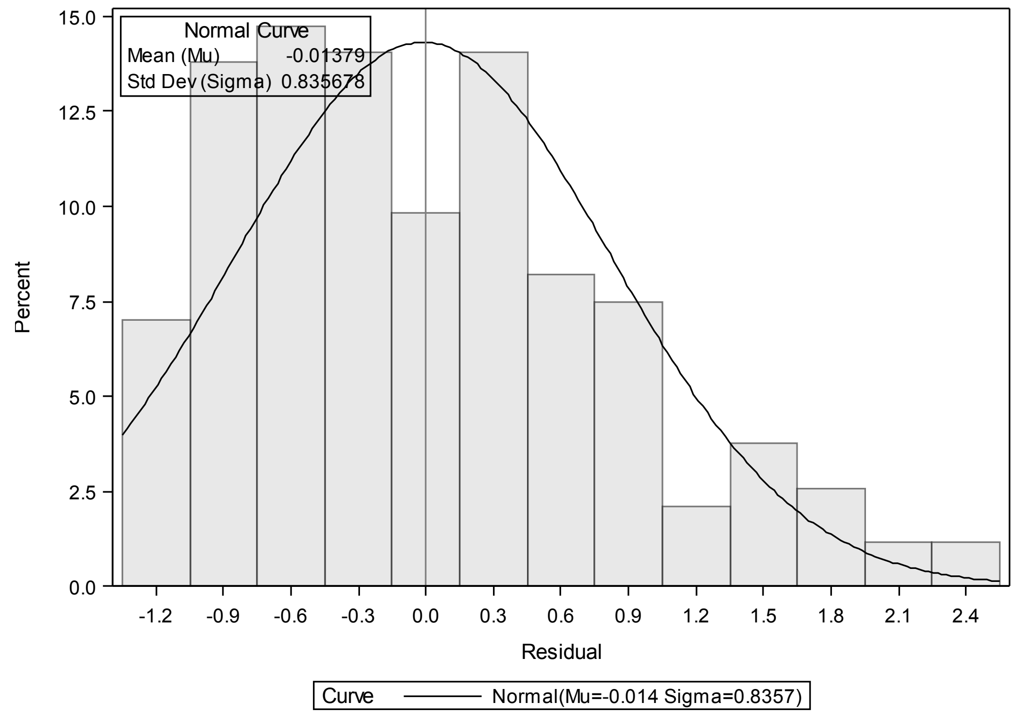

Figure 33. East gulf delta lognormal qq plot of residuals of the positive catch submodel.

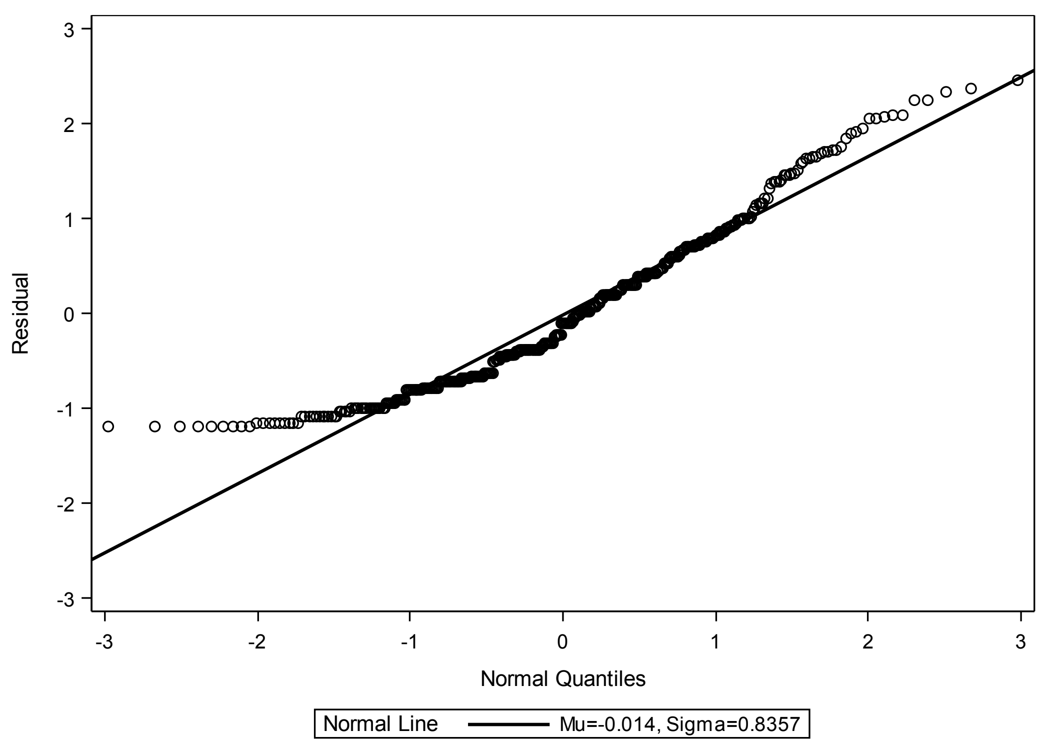

Figure 34. East gulf delta lognormal observed versus predicted proportion positive.

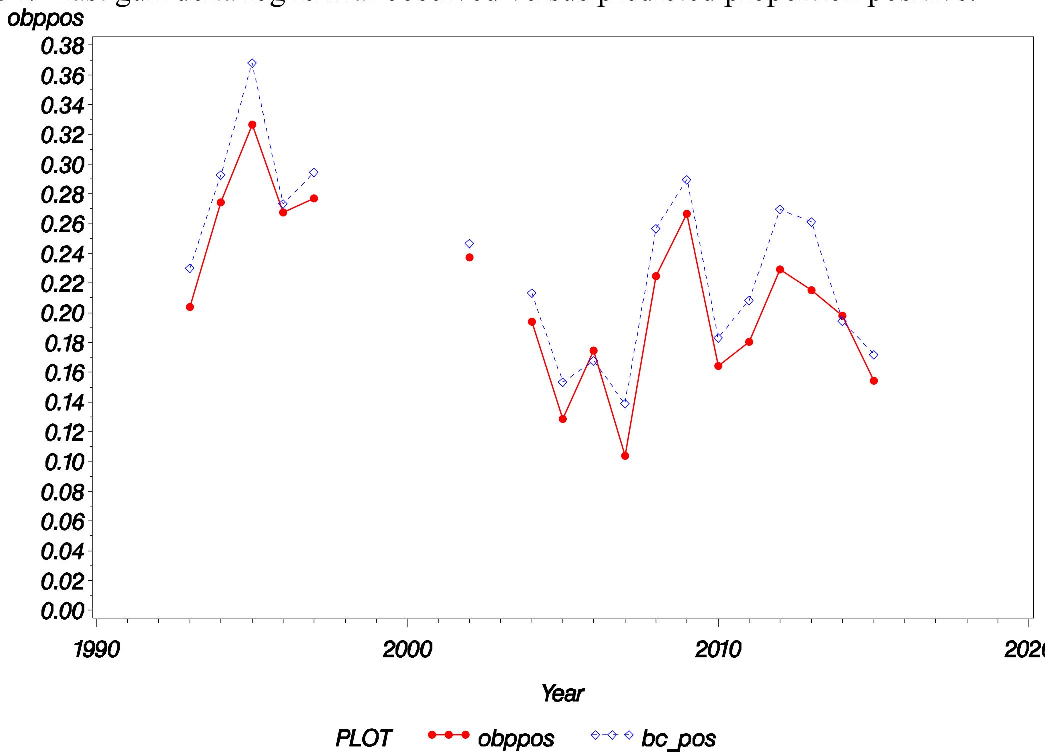

Figure 35. East gulf delta lognormal observed versus standardized mincount.

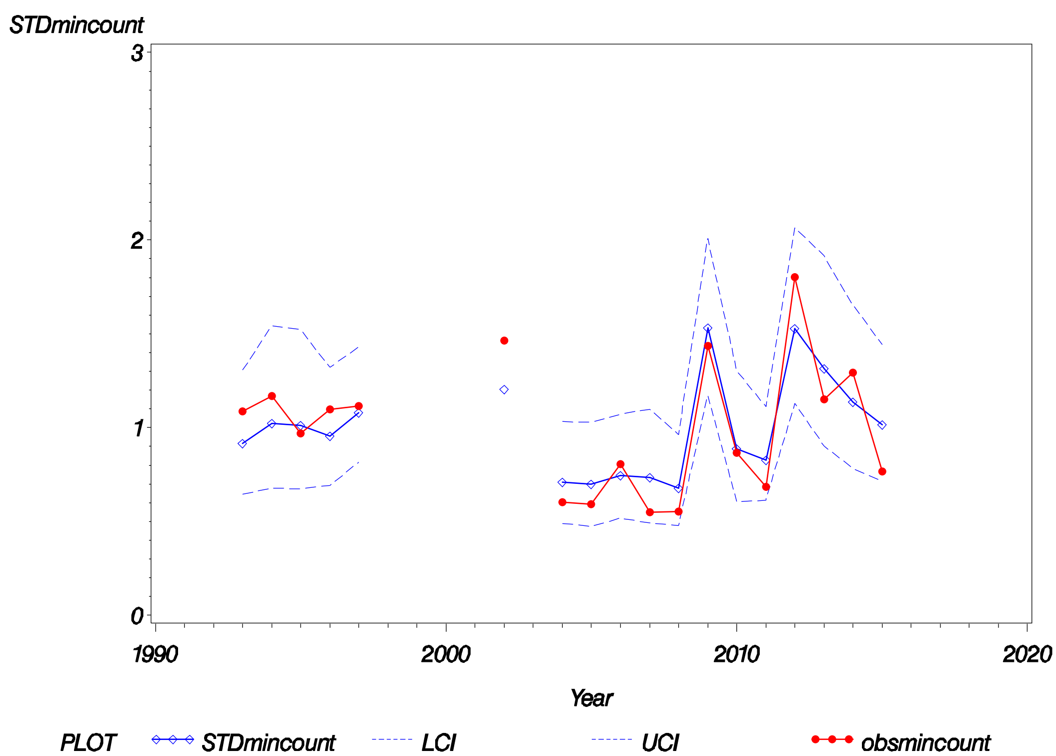

Table 13. Output for the delta lognormal index of relative abundance of grey snapper by year, east Gulf model run.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.20388	103	0.58314	0.91734	0.10395	0.17825	0.64404	1.30662
1994	0.27419	62	0.65018	1.02280	0.13475	0.20725	0.67868	1.54140
1995	0.32653	49	0.64309	1.01164	0.13275	0.20643	0.67234	1.52217
1996	0.26733	101	0.60808	0.95656	0.09884	0.16254	0.69255	1.32123
1997	0.27692	130	0.68705	1.08080	0.09687	0.14099	0.81636	1.43089
2002	0.23729	118	0.76535	1.20396	0.12513	0.16349	0.87004	1.66604
2004	0.19417	103	0.45194	0.71095	0.08512	0.18834	0.48941	1.03278
2005	0.12857	140	0.44371	0.69799	0.08686	0.19575	0.47361	1.02868
2006	0.17450	149	0.47402	0.74568	0.08677	0.18305	0.51864	1.07211
2007	0.10390	154	0.46666	0.73410	0.09493	0.20342	0.49075	1.09813
2008	0.22449	98	0.43133	0.67853	0.07599	0.17616	0.47832	0.96253
2009	0.26667	135	0.97462	1.53317	0.13208	0.13552	1.17061	2.00802
2010	0.16406	128	0.56313	0.88586	0.10940	0.19427	0.60282	1.30181
2011	0.18033	183	0.52518	0.82616	0.07830	0.14909	0.61416	1.11134
2012	0.22901	131	0.97038	1.52649	0.14735	0.15185	1.12862	2.06463
2013	0.21519	79	0.83614	1.31532	0.15871	0.18981	0.90286	1.91621
2014	0.19820	111	0.72210	1.13592	0.13636	0.18883	0.78120	1.65171
2015	0.15441	136	0.64632	1.01672	0.11369	0.17590	0.71710	1.44152