SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gulf of Mexico - Red 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 11-30). Secondary objectives include quantification of habitat types sampled (e.g. 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. The size of fish sampled with the video gear is species specific however red snapper sampled over the history of the survey had fork lengths ranging from 146 – 917 mm, and mean annual fork lengths ranging from 451 – 640 mm (Table 16, Figure 31-32). 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. Vertical line length composition will be included in this report as reference size composition.

Methods

Sampling design

Total reef area available to select survey sites from is approximately 1771 km^2, of which 1244 km^2 is located in the eastern GOM and 527 km^2 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 km^2 reef, block > 20 km^2 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. In all of these cases the station is flagged as 'XX' in the data set and dropped. Sites that did not receive a stratum assignment are also dropped and all of those occurred early in the survey (1994-1995). We retained a total of 6152 sites out of a total of 6522 sites after dropping all samples from 2001 and 2003 (250 sites) and those that could not be viewed and annotated (231 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 2004-2016. Terms of reference identified 2016 as the terminal year.

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, east gulf, and west gulf models were run and independent variables tested in the model included year, region and depth as fixed effects and block as a random effect (mincount = year + region + depth + block). Region is only used in the Gulf wide model whereas the regional models (i.e. east and west GOM) do not require this 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

Evaluation of the model fit criteria such as the extra dispersion scales, AIC and plots of residuals. Plots of the residuals and extra dispersion scales indicated that while the delta-lognormal model produces some under and over-fitting the model fits were better than those produced by the poisson and negative-binomial models. Because the delta-lognormal model produced the best fits we will only be producing results for those models. We present delta-lognormal models for the Gulf wide, east-GOM, and west-GOM. East and west GOM models are divided at the Mississippi River delta (89 west longitude).

Red snapper were observed in both the eastern and western GOM with increased proportion of positive sites and abundance in the west-GOM (Figures 11-30). Proportion positives and abundance is generally high from the mouth of the Mississippi River delta moving east to Cape San Blas, Florida. Proportion positives and abundance on the west Florida shelf (south and east of Cape San Blas) are generally the lowest observed in the GOM. The spatial distributions observed are highly reflective of the reef sampling universe used to select sampling sites (Figure 1). Gaps in habitat level information exist on the central portion of the west Florida shelf, Mississippi river delta region, and portions of the Texas coast. Since 2012 we have undertaken extensive mapping efforts in these gaps and begun to close these gaps. In most years the survey shows 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.

Design based analysis retained year, region and depth in the binomial and log-normal GOM-wide sub-model. Design based red snapper proportion positives ranged from 0.063 (1993) to 0.43 (2013) with a reported value of 0.41 in 2016 (Table 5, Figure 2), while standardized index of abundance ranged from 0.16 (1993) to 1.94 (2011), and reported a value of 1.53 in 2016 (Table 5, Figure 3). Model fit shows a strong departure from linear for the low quantiles (Figure 4). Poor model performance as indicated by large differences between observed and standardized mincount are always associated with years with low sample size (e.g. 2015).

Design based analysis retained year, region and depth in the binomial and log-normal east-GOM sub-model. Design based red snapper proportion positives ranged from 0.016 (1995) to 0. 3 (2013) with a reported value of 0.15 in 2016 (Table 10, Figure 5), while standardized index of abundance ranged from 0.42 (1993) to 2.29 (2011), and reported a value of 1.23 in 2016 (Table 10, Figure 6). Model fit shows a strong departure from linear for the low quantiles (Figure 7). Poor model performance as indicated by large differences between observed and standardized mincount are always associated with years with low sample size (e.g. 2015).

Design based analysis retained year, region and depth in the binomial and log-normal west-GOM sub-model. Design based red snapper proportion positives ranged from 0.067 (1993) to 0.72 (2016) with a reported value of 0.72 in 2016 (Table 15, Figure 8), while standardized index of abundance ranged from 0.14 (1993) to 2.24 (2013), and reported a value of 1.92 in 2016 (Table 10, Figure 9). Model fit shows a strong departure from linear for the low quantiles (Figure 10). Poor model performance as indicated by large differences between observed and standardized mincount are always associated with years with low sample size (e.g. 2015).

Mean total lengths were similar between regions with slightly larger fish observed in the east GOM (513 mm) than in the west GOM (487 mm)(Table 16, Figures 31-32). In most years larger fish were observed in the east (11) than in the west (7). In general no trends in mean length are observed through time. Comparison of video and vertical line length frequencies show broadly similar lengths were observed/collected in these complimentary gears with slightly fewer of the smallest and largest fish observed on video that were not captured on vertical line.

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 (1992-2016) new reef tract has been discovered and mapped and therefore this map represents what was available in 2016, and not necessarily what has been available over the entire time series.

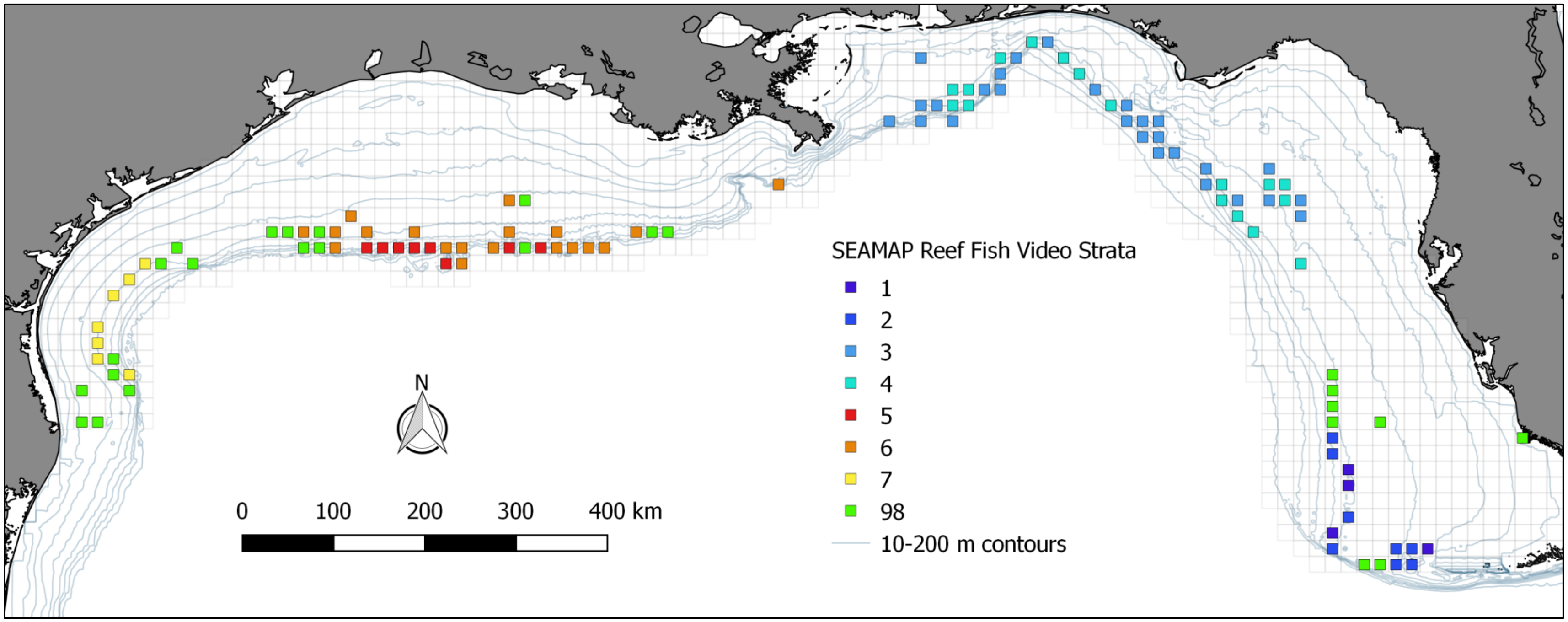

Table 1. Gulf wide delta-lognormal model run test of type III fixed effects binomial submodel.

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	18	1698	200.40	11.06	<.0001	<.0001
region	1	5324	337.94	337.94	<.0001	<.0001

Table 2. Gulf wide delta-lognormal model run fit statistics for the binomial submodel.

Description	*Value*
Deviance	1124.8436
Scaled Deviance	6679.6914
Pearson Chi-Square	1195.1787
Scaled Pearson Chi-Square	7097.3639
Extra-Dispersion Scale	0.1684

Table 3. Gulf wide delta-lognormal model run test of type III fixed effects lognormal submodel.

Type 3 Tests of Fixed Effects				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	18	1441	3.04	<.0001
DEPTH	1	1441	19.15	<.0001

Table 4. Gulf wide delta-lognormal model run fit statistics for the lognormal submodel.

Fit Statistics	
-2 Res Log Likelihood	3851.0
AIC (Smaller is Better)	3853.0
AICC (Smaller is Better)	3853.0
BIC (Smaller is Better)	3858.3

Table 5. Output for the delta-lognormal index of relative abundance of red snapper by year, Gulf wide model run.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.06250	160	0.08823	0.16135	0.04563	0.51718	0.06094	0.42721
1994	0.09220	141	0.12518	0.22894	0.05907	0.47185	0.09339	0.56123
1995	0.10280	107	0.11387	0.20825	0.05436	0.47733	0.08415	0.51536
1996	0.16779	298	0.17741	0.32446	0.04899	0.27611	0.18868	0.55795
1997	0.26190	294	0.40714	0.74457	0.08314	0.20420	0.49699	1.11549
2002	0.23846	260	0.49389	0.90323	0.10177	0.20605	0.60073	1.35804
2004	0.22500	200	0.68902	1.26009	0.14965	0.21719	0.82021	1.93589
2005	0.25854	410	0.66577	1.21756	0.10186	0.15299	0.89819	1.65048
2006	0.12771	415	0.28635	0.52368	0.06866	0.23978	0.32636	0.84029
2007	0.23265	490	0.56552	1.03422	0.08783	0.15531	0.75948	1.40835
2008	0.20772	337	0.46993	0.85940	0.09921	0.21112	0.56600	1.30489
2009	0.23543	429	0.54561	0.99782	0.08850	0.16220	0.72291	1.37727
2010	0.34862	327	0.93683	1.71328	0.13650	0.14570	1.28214	2.28939
2011	0.34545	440	1.06122	1.94077	0.12366	0.11653	1.53851	2.44820
2012	0.29522	481	0.66240	1.21140	0.09671	0.14599	0.90604	1.61967
2013	0.43333	300	0.97054	1.77494	0.14240	0.14672	1.32563	2.37652
2014	0.32945	343	0.76451	1.39813	0.11733	0.15347	1.03043	1.89706
2015	0.29665	209	0.52688	0.96356	0.12469	0.23666	0.60411	1.53689
2016	0.40642	374	0.83900	1.53437	0.13205	0.15739	1.12216	2.09799

Figure 2. Plot of the observed and expected proportion positives for red snapper, Gulf wide model run.

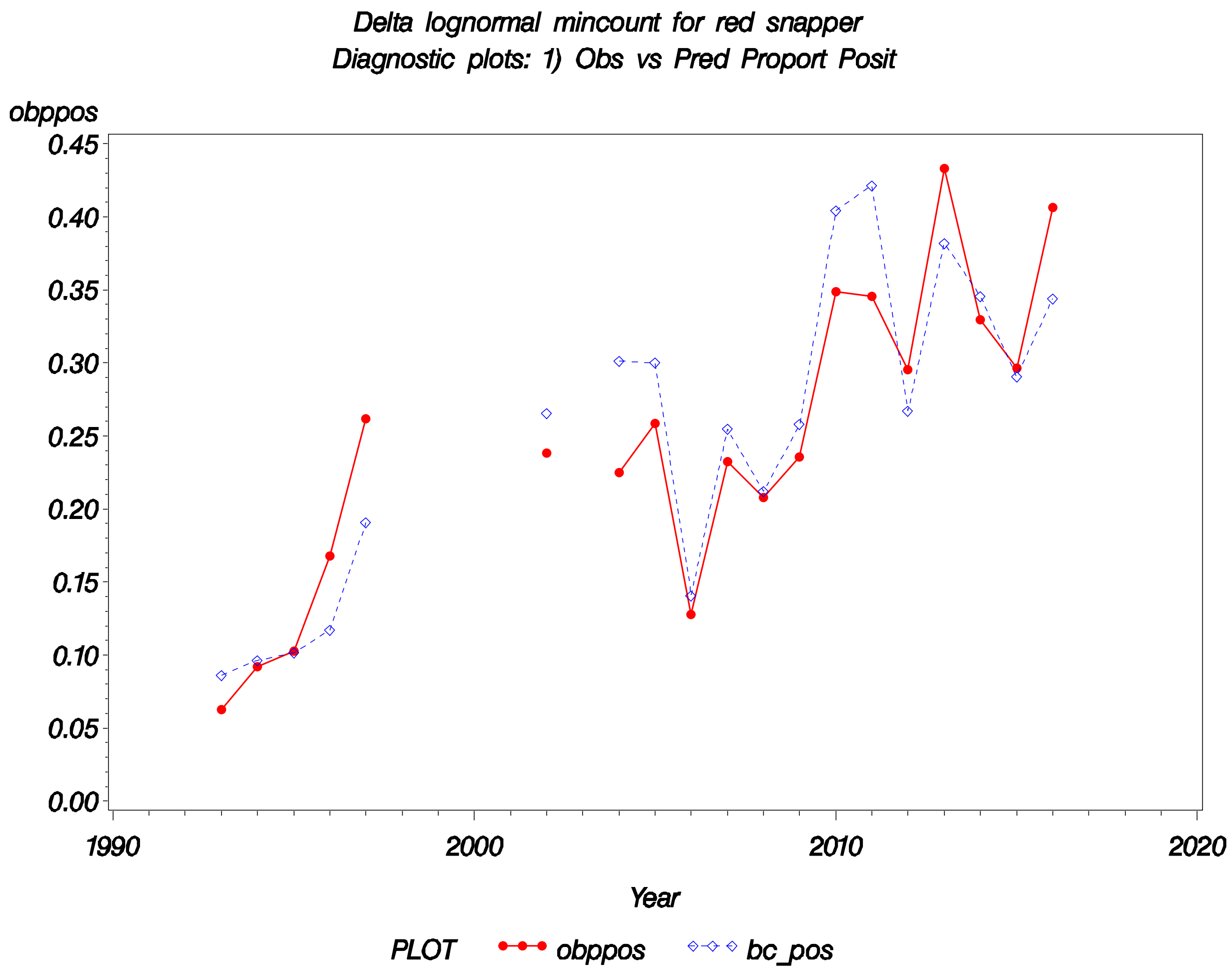

Figure 3. Mean red snapper counts for the observed (mincount) and standardized mincounts from the Gulf wide delta-lognormal model run.

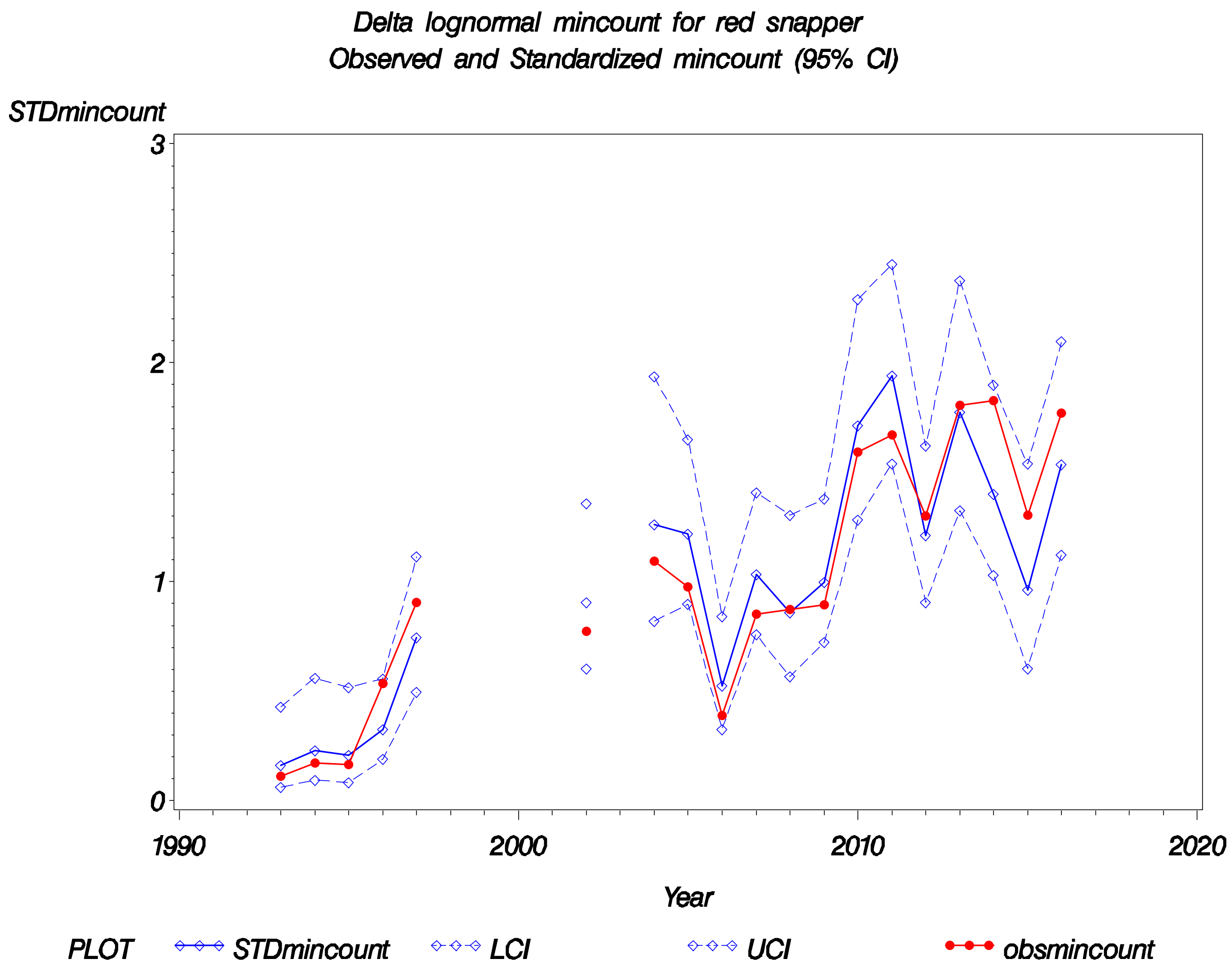

Figure 4. QQ plot of conditional residuals for the Gulf wide delta-lognormal model run.

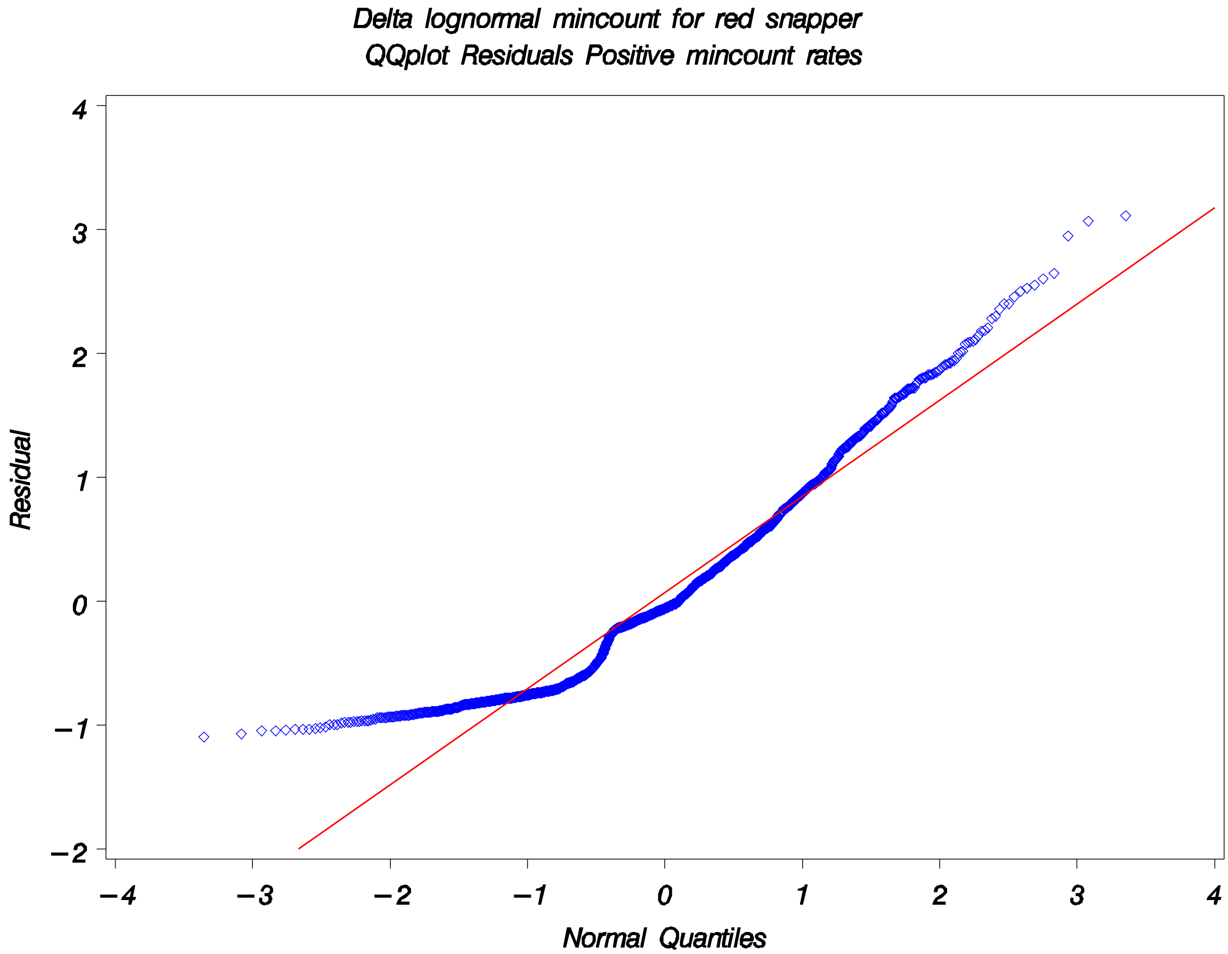

Table 6. East-GOM delta-lognormal model run test of type III fixed effects binomial submodel.

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	18	1057	113.13	6.22	<.0001	<.0001

Table 7. East-GOM delta-lognormal model run fit statistics for the binomial submodel.

Description	*Value*
Deviance	1112.8531
Scaled Deviance	3484.7767
Pearson Chi-Square	1291.7577
Scaled Pearson Chi-Square	4044.9967
Extra-Dispersion Scale	0.3193

Table 8. East-GOM delta-lognormal model run test of type III fixed effects lognormal submodel.

Type 3 Tests of Fixed Effects				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	18	578	1.70	0.0356
DEPTH	1	578	14.97	0.0001

Table 9. East-GOM delta-lognormal model run fit statistics for the lognormal submodel.

Fit Statistics	
-2 Res Log Likelihood	1451.9
AIC (Smaller is Better)	1453.9
AICC (Smaller is Better)	1453.9
BIC (Smaller is Better)	1458.2

Table 10. Output for the delta-lognormal index of relative abundance of red snapper by year, East-GOM model run.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.06087	115	0.05520	0.16014	0.03081	0.55811	0.05652	0.45374
1994	0.03333	90	0.05997	0.17399	0.05304	0.88442	0.03804	0.79578
1995	0.01639	61	0.01453	0.04216	0.01874	1.28942	0.00583	0.30511
1996	0.07519	133	0.09049	0.26252	0.04342	0.47984	0.10563	0.65246
1997	0.03086	162	0.10569	0.30663	0.06379	0.60354	0.10058	0.93475
2002	0.15789	152	0.32100	0.93129	0.09439	0.29406	0.52353	1.65664
2004	0.20134	149	0.53888	1.56341	0.13903	0.25799	0.94099	2.59753
2005	0.19708	274	0.50365	1.46120	0.09926	0.19708	0.98890	2.15907
2006	0.08696	276	0.21956	0.63701	0.06602	0.30069	0.35368	1.14733
2007	0.15047	319	0.36805	1.06781	0.07696	0.20909	0.70603	1.61499
2008	0.14563	206	0.42265	1.22623	0.11634	0.27525	0.71423	2.10524
2009	0.14885	262	0.40072	1.16259	0.08667	0.21628	0.75808	1.78296
2010	0.25792	221	0.66188	1.92029	0.12203	0.18437	1.33217	2.76805
2011	0.30267	337	0.79275	2.29996	0.11498	0.14505	1.72342	3.06937
2012	0.14947	281	0.36942	1.07177	0.08752	0.23691	0.67163	1.71030
2013	0.21951	164	0.47413	1.37557	0.12416	0.26188	0.82183	2.30242
2014	0.17391	230	0.41805	1.21285	0.09343	0.22350	0.77990	1.88615
2015	0.16447	152	0.30759	0.89239	0.09295	0.30218	0.49408	1.61181
2016	0.15049	206	0.42471	1.23218	0.11009	0.25920	0.73992	2.05194

Figure 5. Plot of the observed and expected proportion positives for red snapper, East-GOM model run.

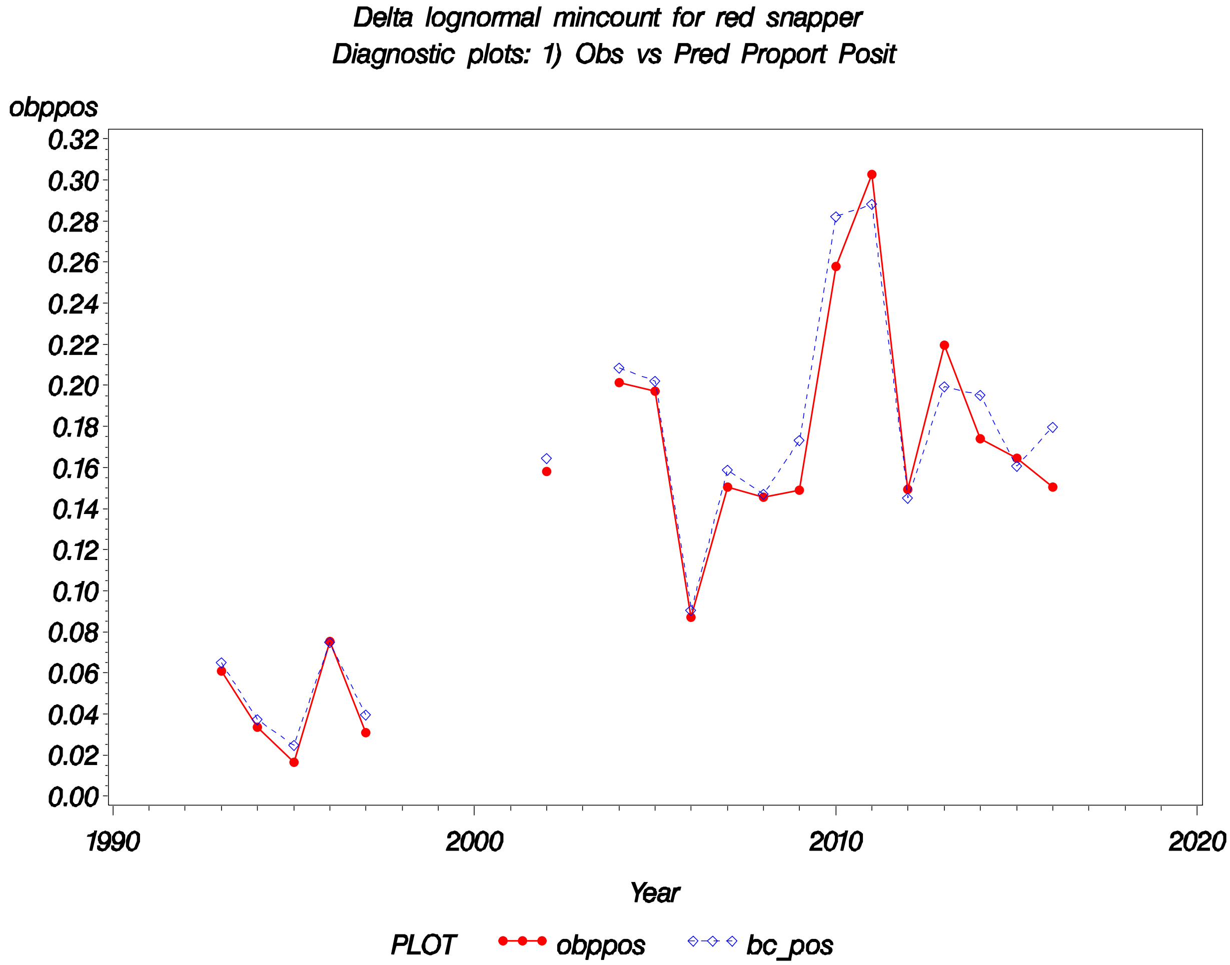

Figure 6. Mean red snapper counts for the observed (mincount) and standardized mincounts from the East-GOM delta-lognormal model run.

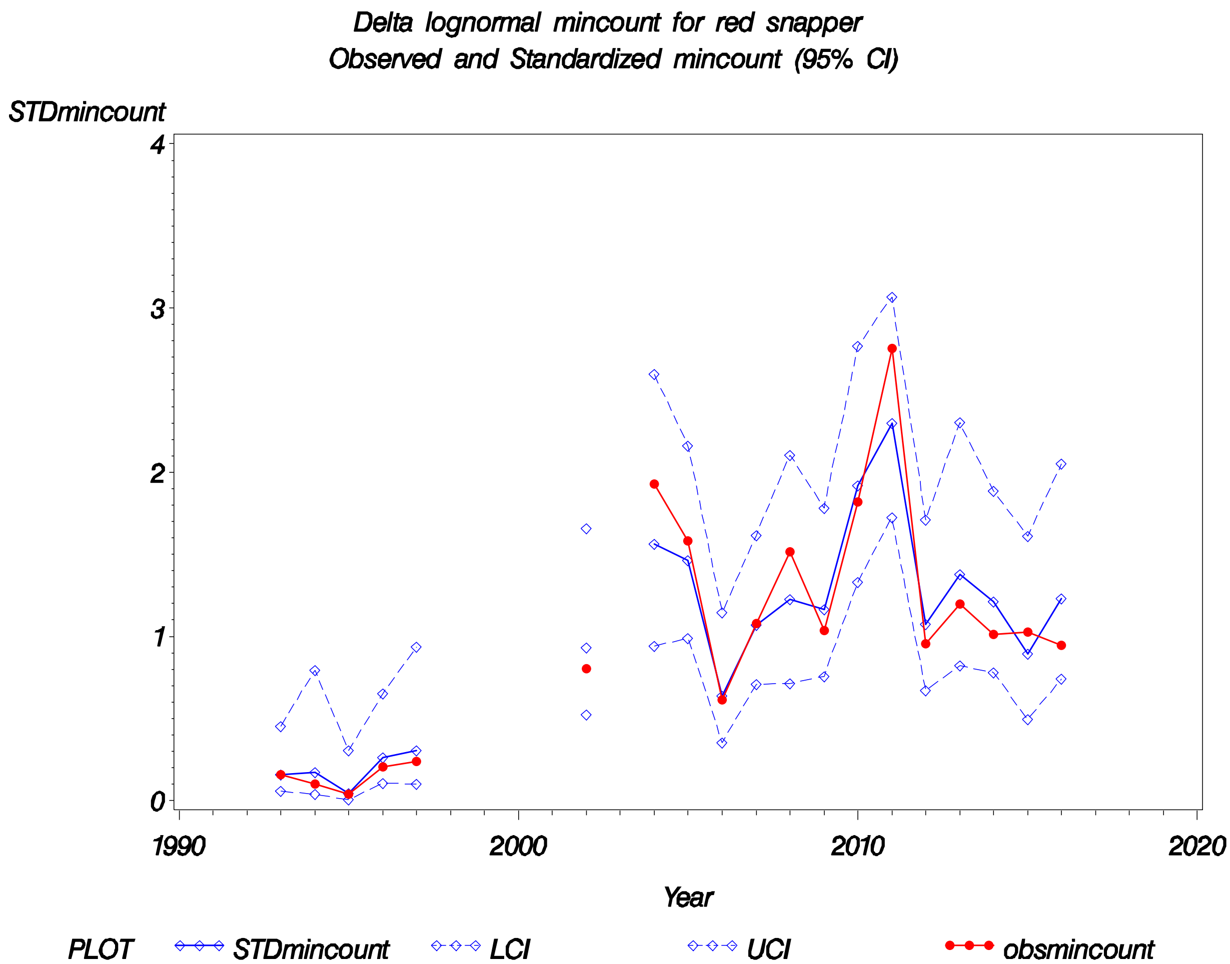

Figure 7. QQ plot of conditional residuals for the East-GOM delta-lognormal model run.

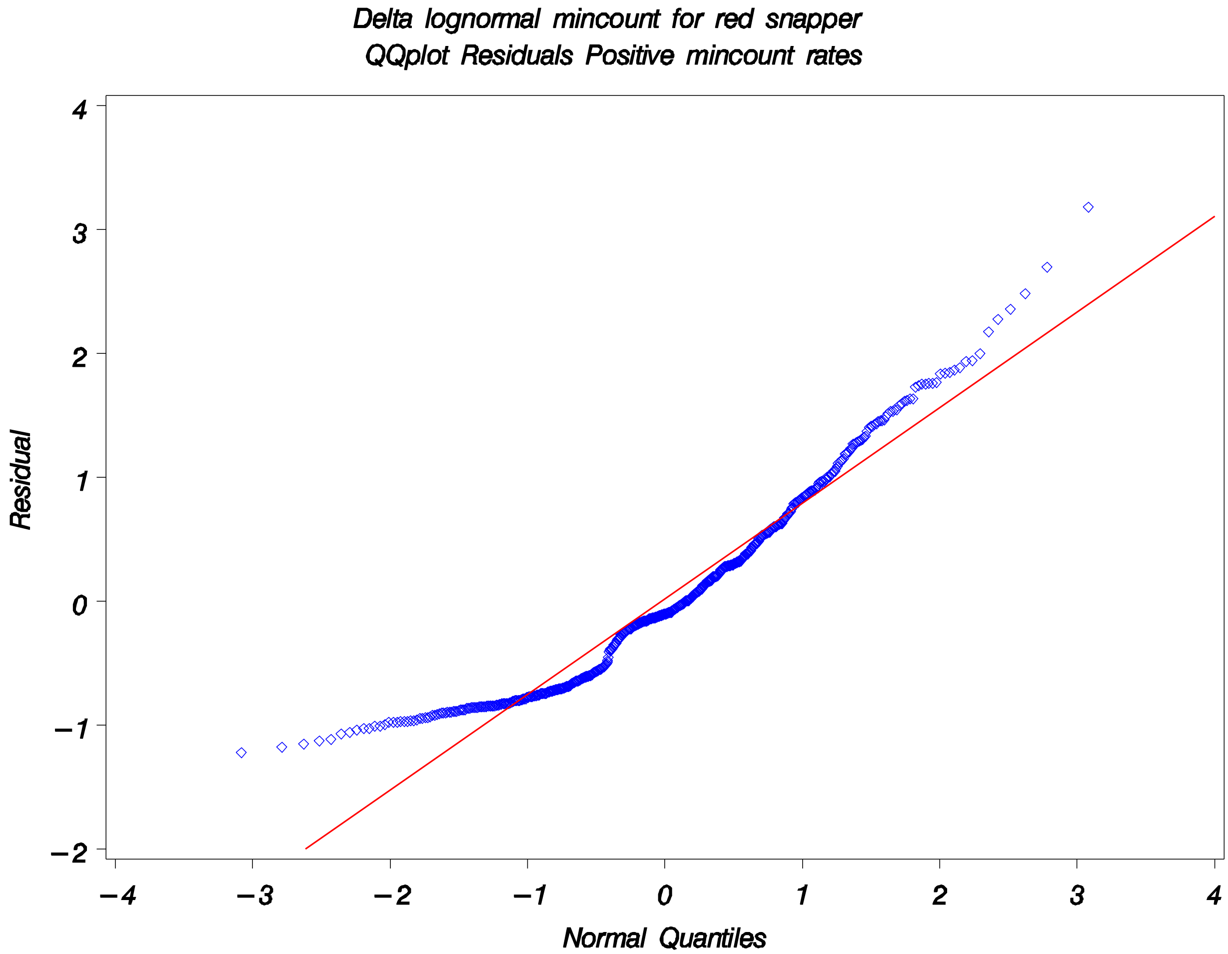

Table 11. West GOM delta-lognormal model run test of type III fixed effects binomial submodel.

Type 3 Tests of Fixed Effects						
Effect	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
year	18	520	164.81	8.96	<.0001	<.0001

Table 12. West GOM delta-lognormal model run fit statistics for the binomial submodel.

Description	Value
Deviance	1105.7133
Scaled Deviance	2778.3194
Pearson Chi-Square	895.9830
Scaled Pearson Chi-Square	2251.3313
Extra-Dispersion Scale	0.3980

Table 13. West GOM delta-lognormal model run test of type III fixed effects lognormal submodel.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
year	18	843	3.63	<.0001
DEPTH	1	843	2.50	0.1143

Table 14. West GOM delta-lognormal model run fit statistics for the lognormal submodel.

Fit Statistics	
-2 Res Log Likelihood	2244.9
AIC (Smaller is Better)	2246.9
AICC (Smaller is Better)	2246.9
BIC (Smaller is Better)	2251.6

Table 15. Output for the delta-lognormal index of relative abundance of red snapper by year, west GOM model run.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.06667	45	0.11663	0.13556	0.09852	0.84468	0.03124	0.58823
1994	0.19608	51	0.28000	0.32544	0.12916	0.46129	0.13520	0.78339
1995	0.21739	46	0.31637	0.36772	0.13680	0.43240	0.16066	0.84162
1996	0.24242	165	0.36615	0.42557	0.09499	0.25942	0.25545	0.70900
1997	0.54545	132	1.04770	1.21774	0.17273	0.16487	0.87763	1.68964
2002	0.35185	108	0.73910	0.85905	0.16679	0.22567	0.55009	1.34153
2004	0.29412	51	0.60493	0.70311	0.20766	0.34328	0.36068	1.37065
2005	0.38235	136	0.75855	0.88166	0.14852	0.19580	0.59817	1.29949
2006	0.20863	139	0.29994	0.34862	0.08948	0.29833	0.19441	0.62514
2007	0.38596	171	0.83765	0.97359	0.15354	0.18330	0.67683	1.40047
2008	0.30534	131	0.44362	0.51561	0.11125	0.25077	0.31464	0.84495
2009	0.37126	167	0.70123	0.81503	0.13407	0.19119	0.55795	1.19055
2010	0.53774	106	1.34501	1.56329	0.28576	0.21246	1.02691	2.37982
2011	0.48544	103	1.15818	1.34614	0.20979	0.18114	0.93978	1.92822
2012	0.50000	200	1.23834	1.43931	0.17636	0.14242	1.08411	1.91089
2013	0.69118	136	1.93077	2.24411	0.25458	0.13186	1.72588	2.91796
2014	0.64602	113	1.51789	1.76422	0.25342	0.16696	1.26628	2.45797
2015	0.64912	57	0.98954	1.15013	0.31387	0.31719	0.61918	2.13637
2016	0.72024	168	1.65544	1.92410	0.24939	0.15065	1.42598	2.59624

Figure 8. Plot of the observed and expected proportion positives for red snapper, west GOM model run.

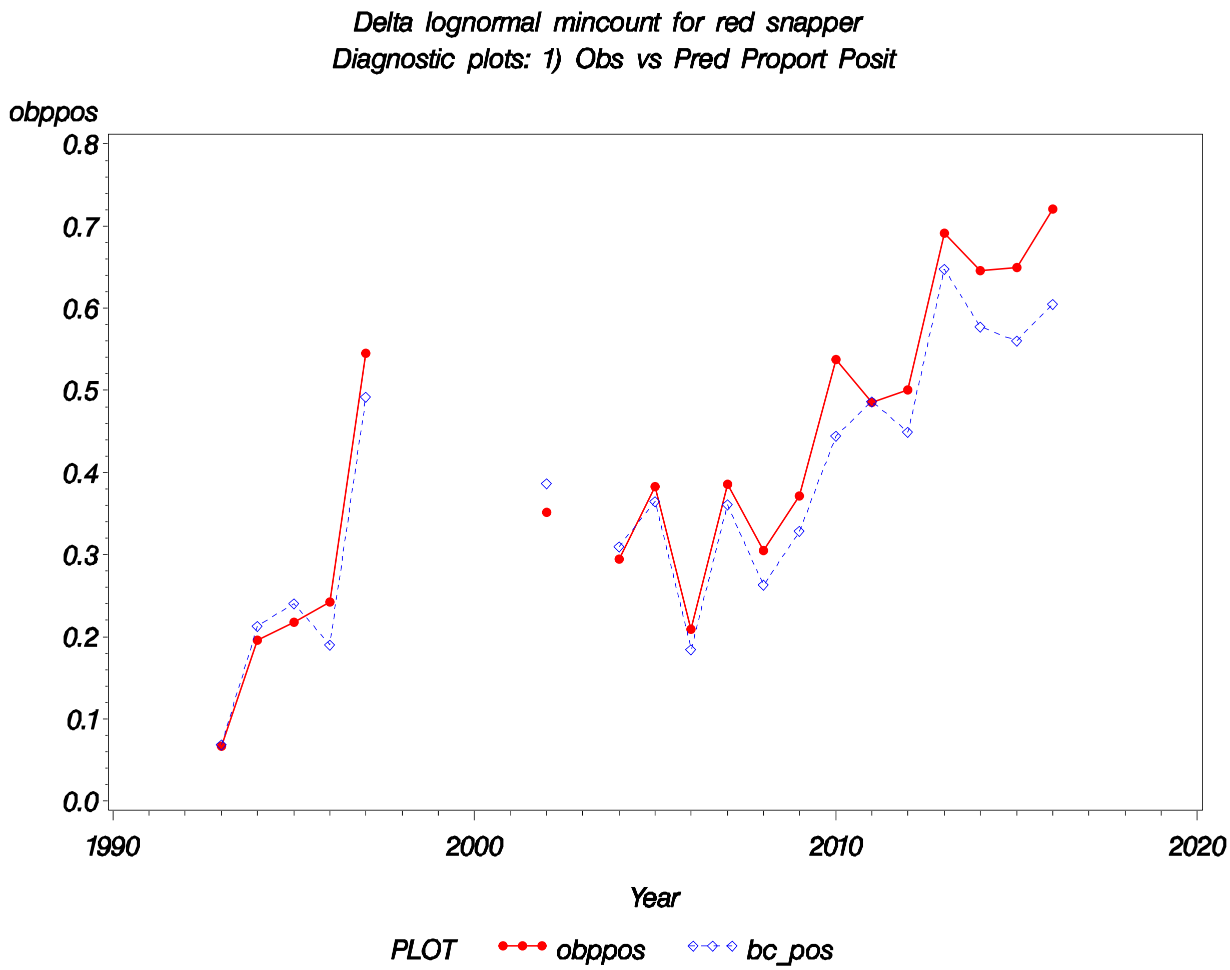

Figure 9. Mean red snapper counts for the observed (mincount) and standardized mincounts from the west GOM delta-lognormal model run.

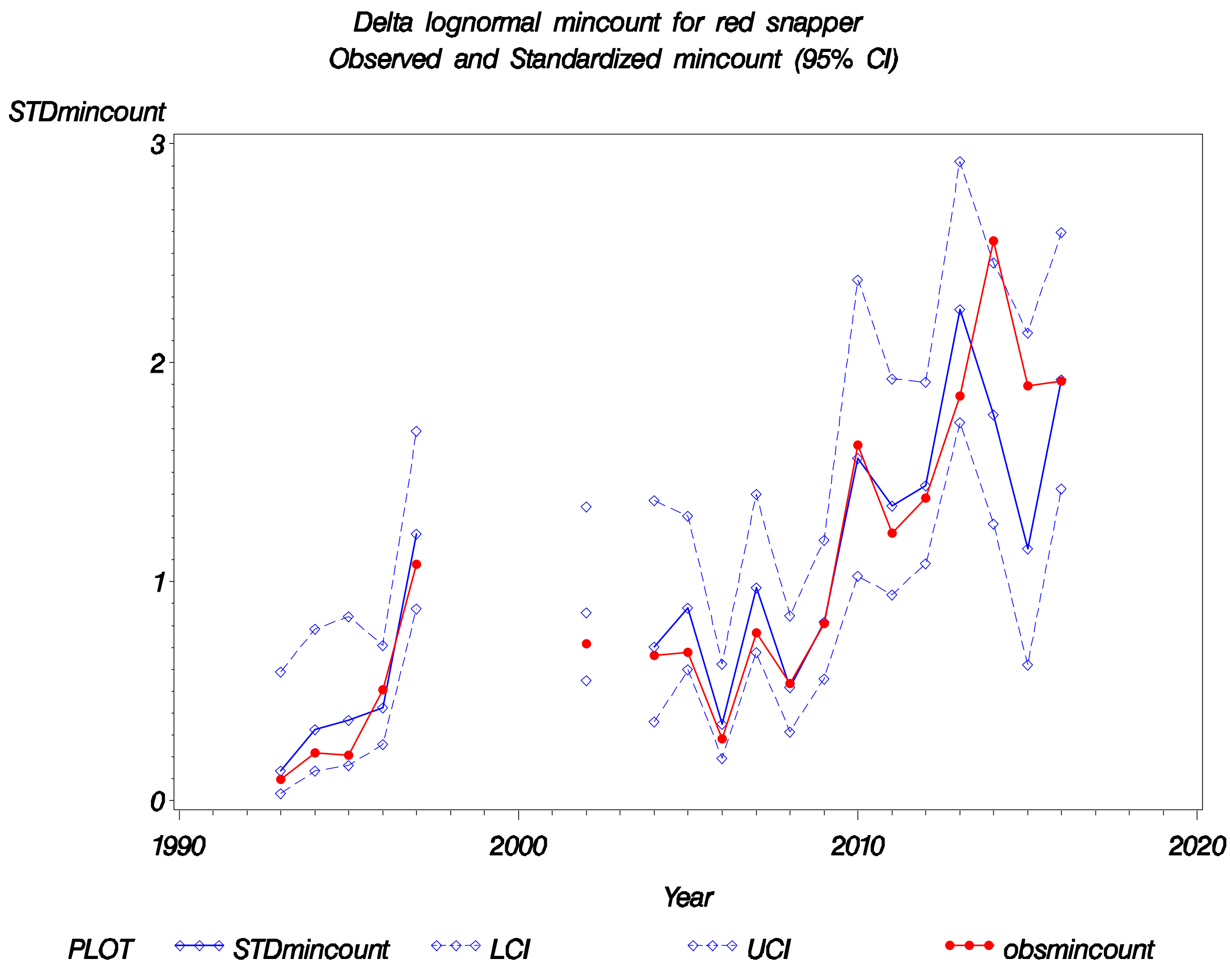

Figure 10. QQ plot of conditional residuals for the west GOM delta-lognormal model run.

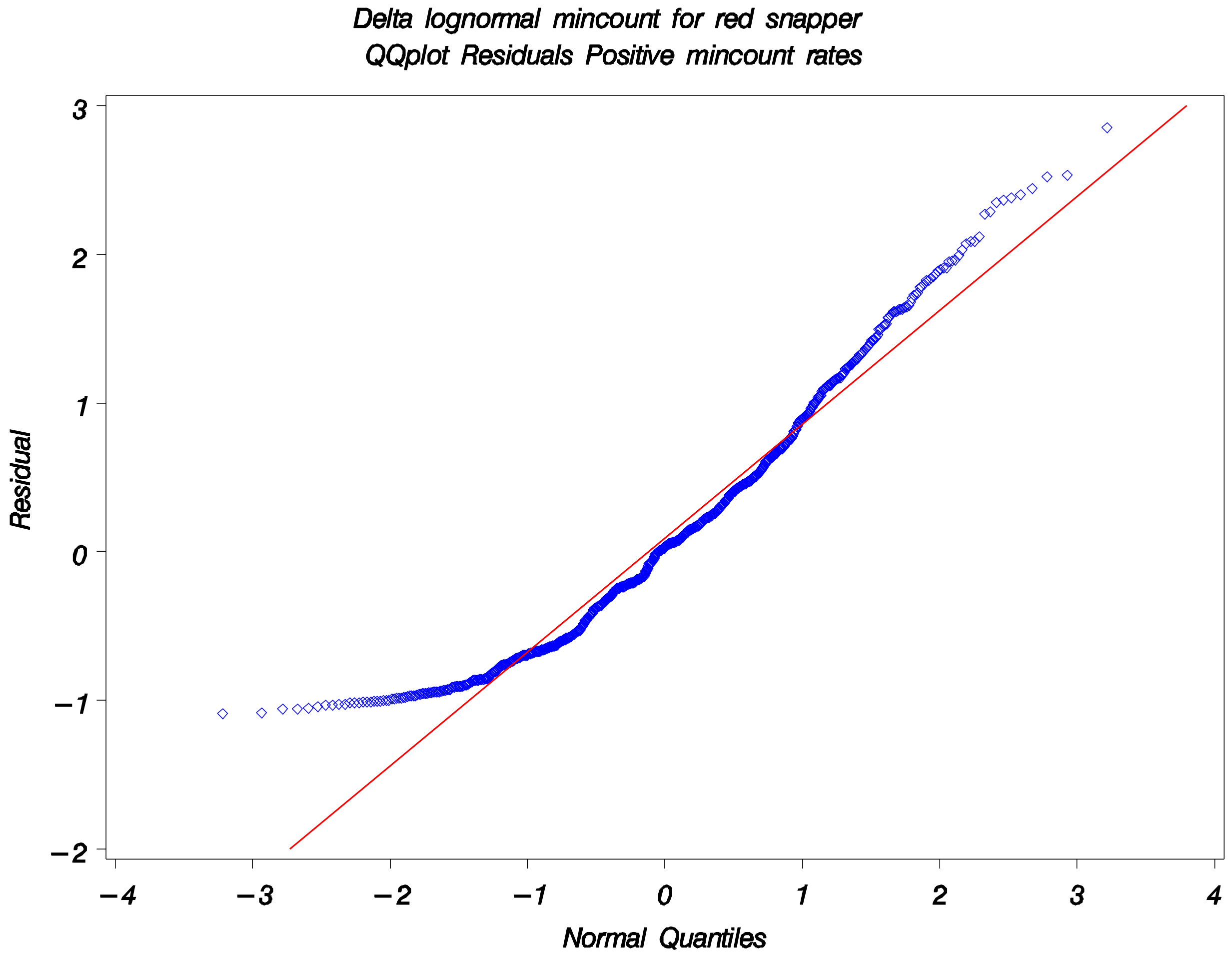

Figure 11. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 1993.

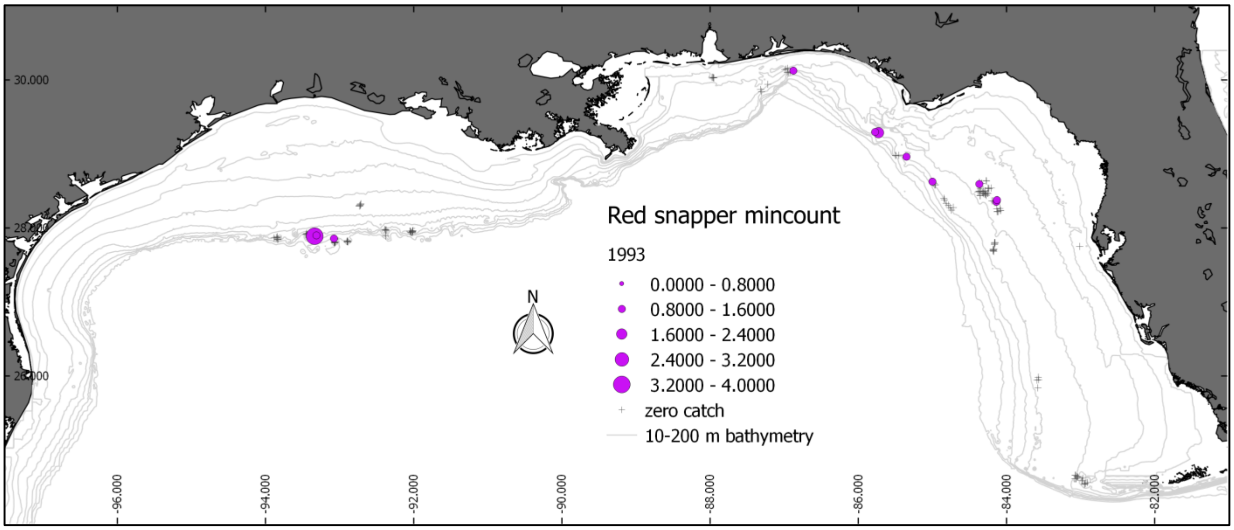

Figure 12. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 1994.

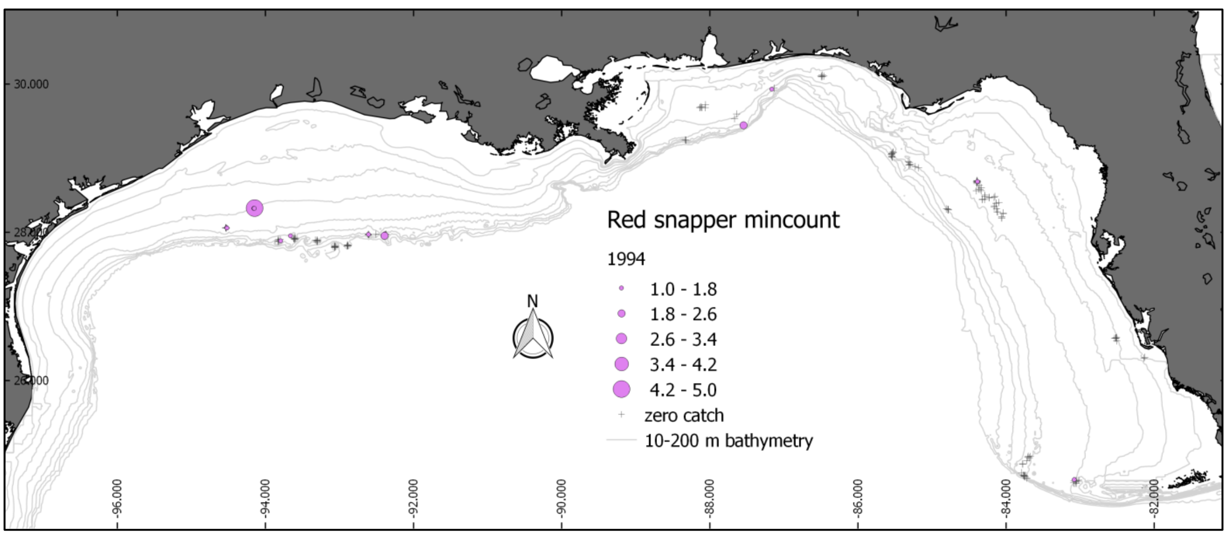

Figure 13. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 1995.

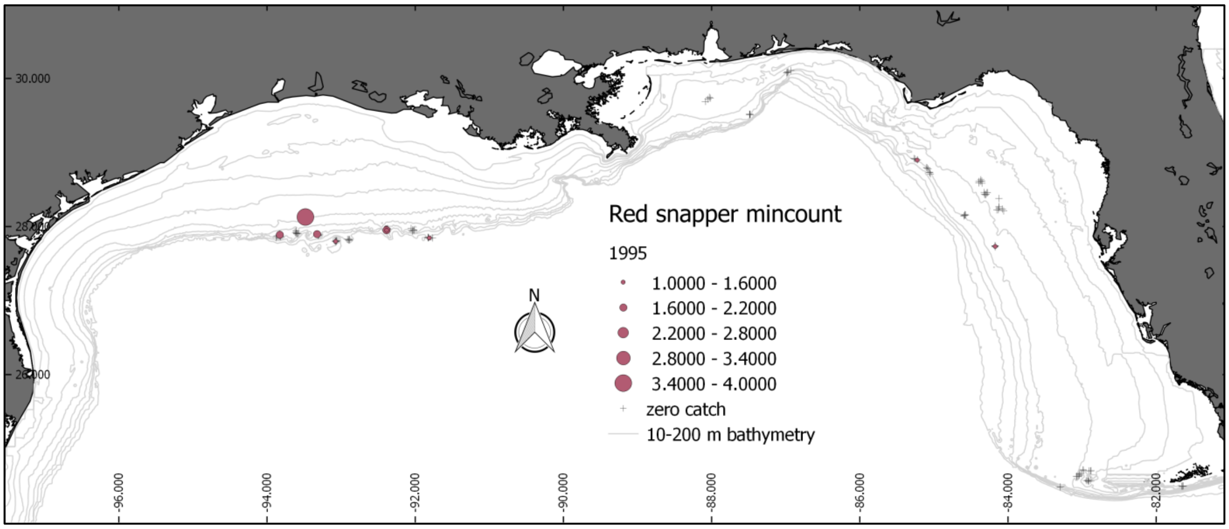

Figure 14. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 1996.

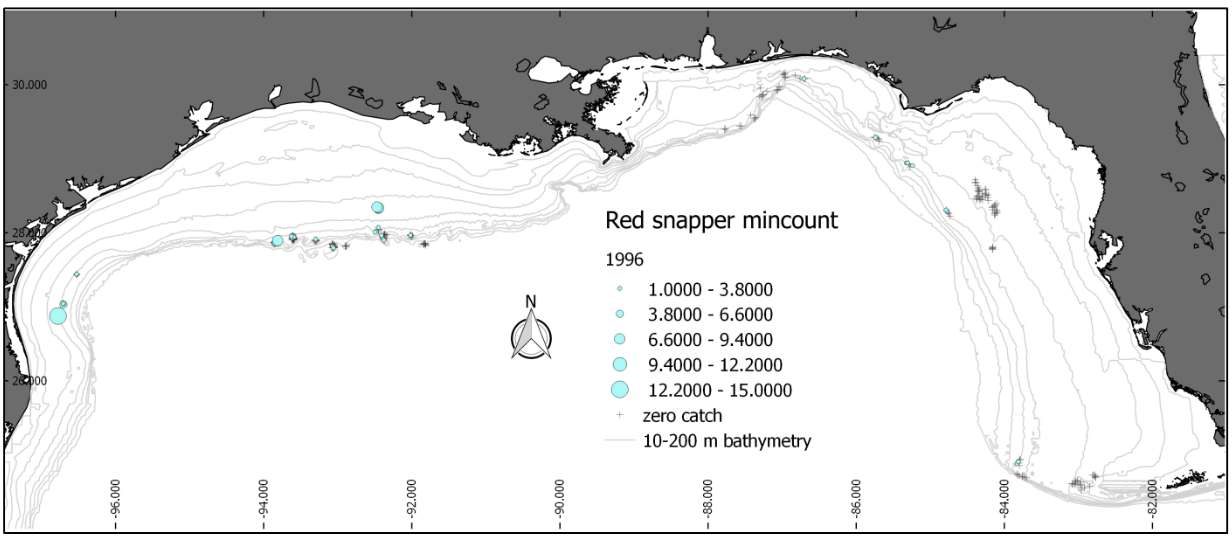

Figure 15. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 1997.

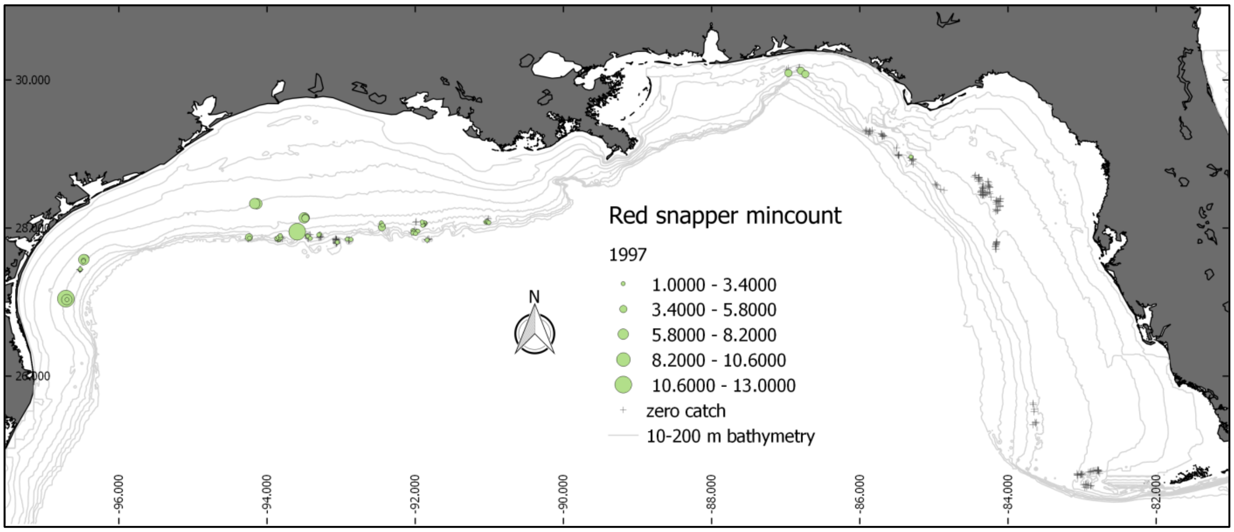

Figure 16. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2001.

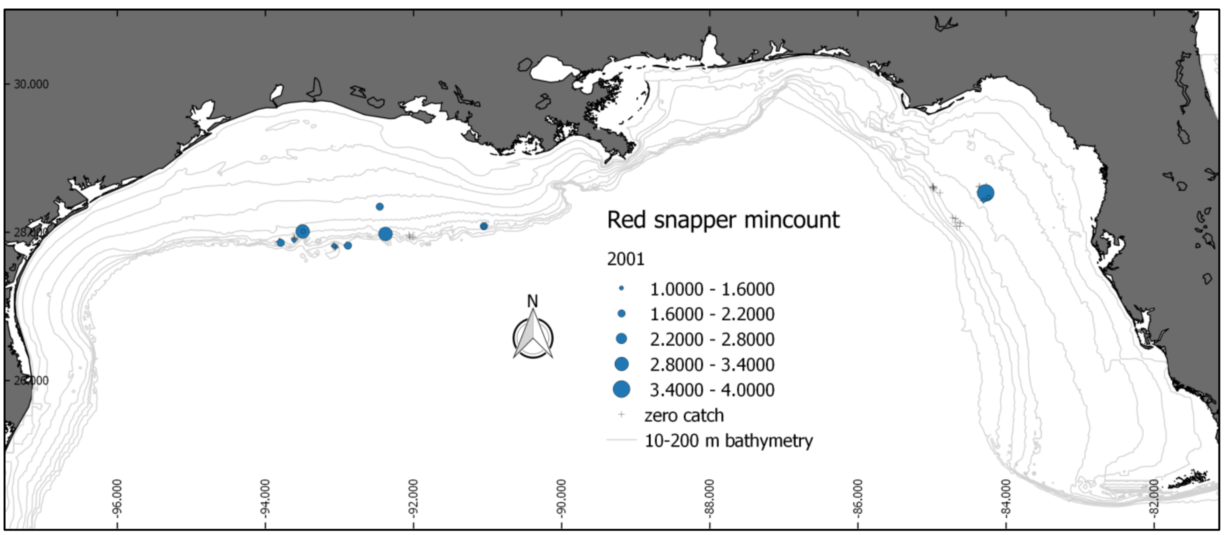

Figure 17. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2002.

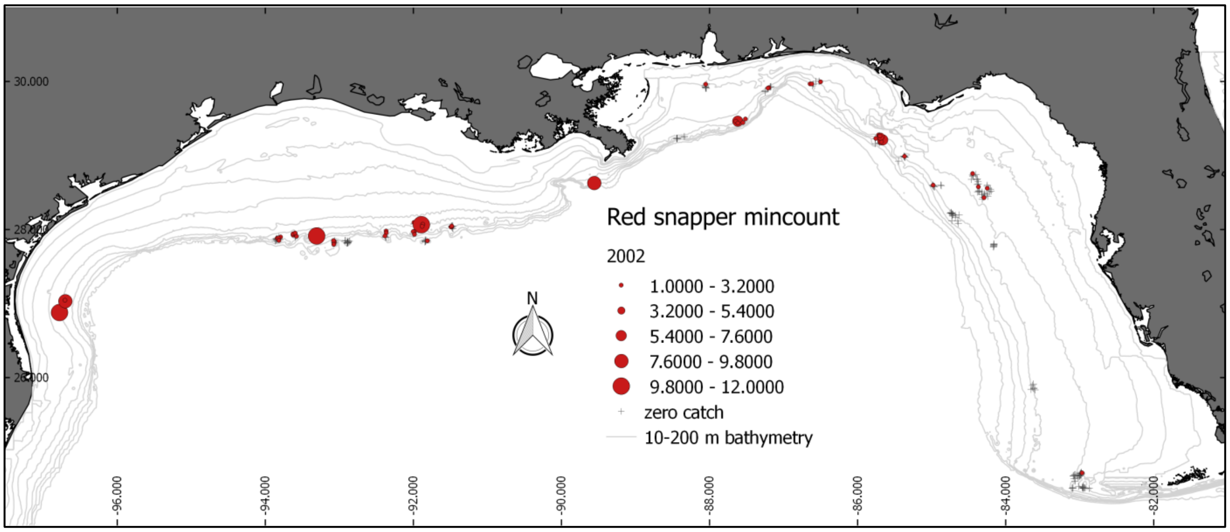

Figure 18. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2004.

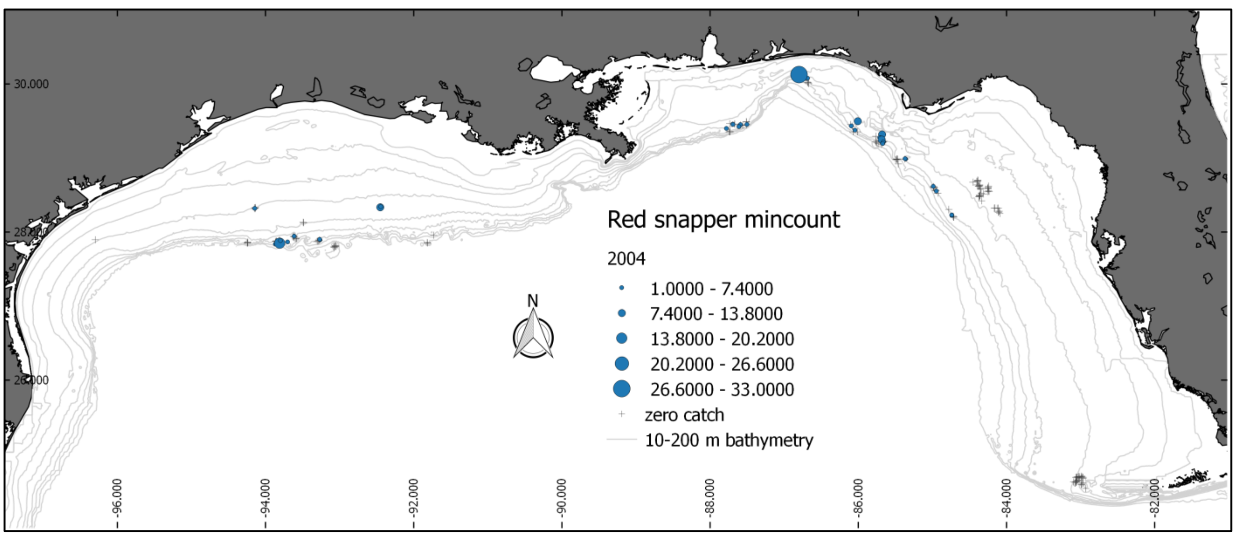

Figure 19. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2005.

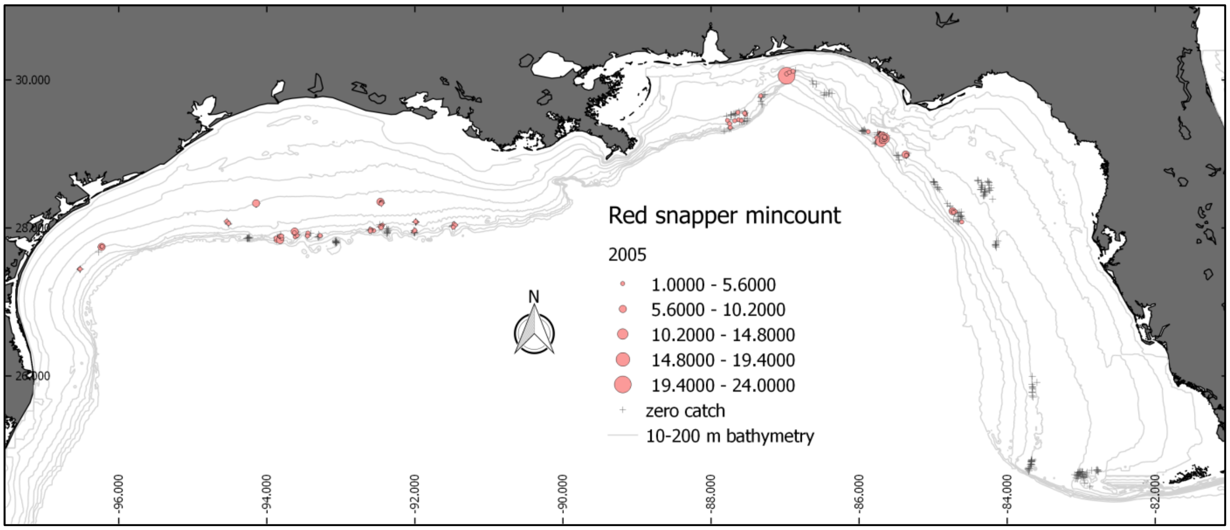

Figure 20. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2006.

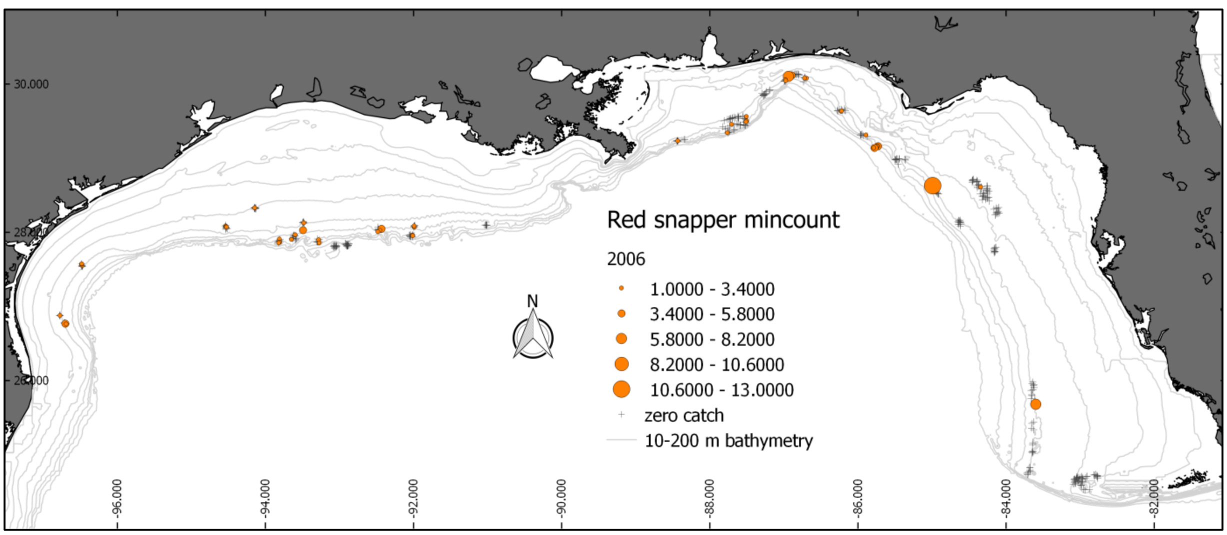

Figure 21. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2007.

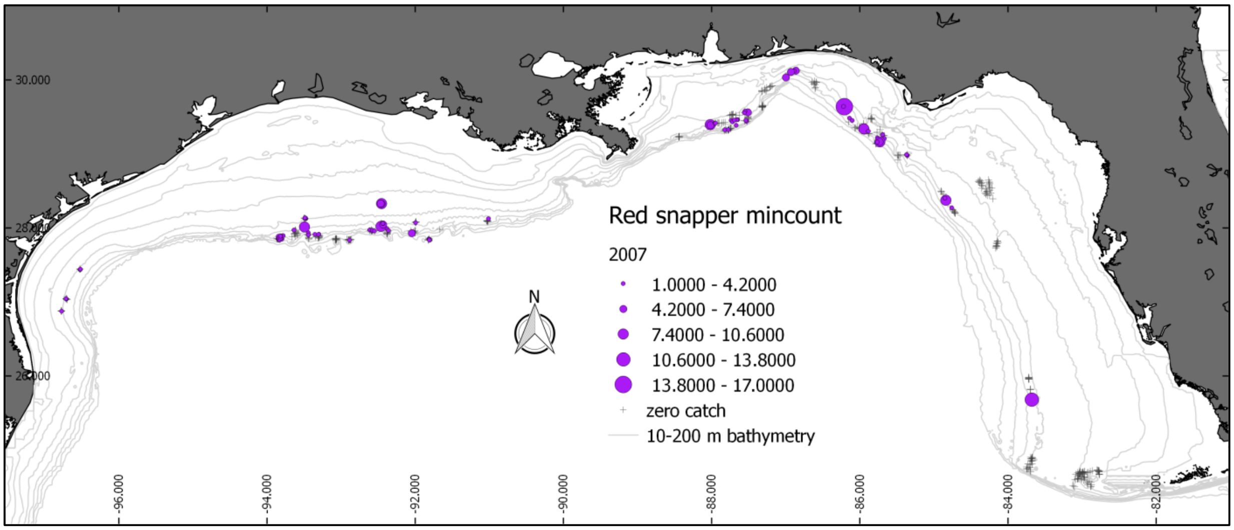

Figure 22. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2008.

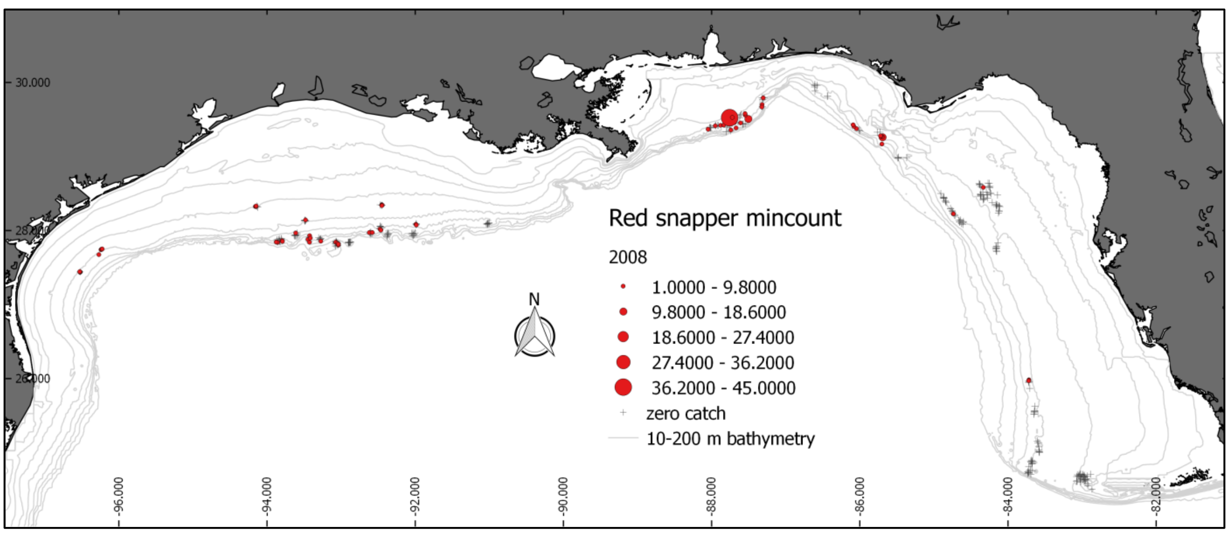

Figure 23. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2009.

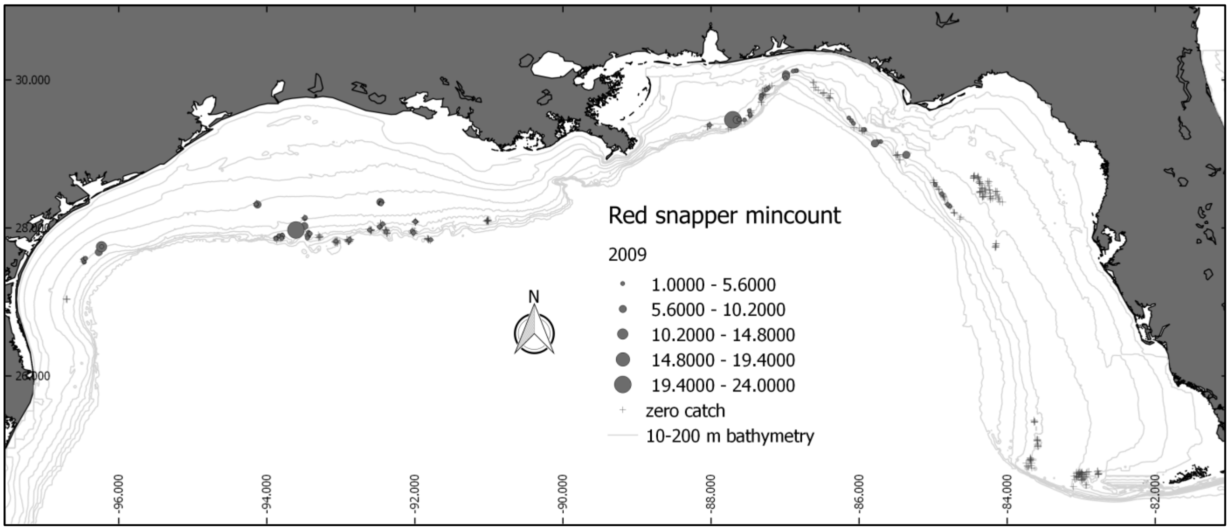

Figure 24. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2010.

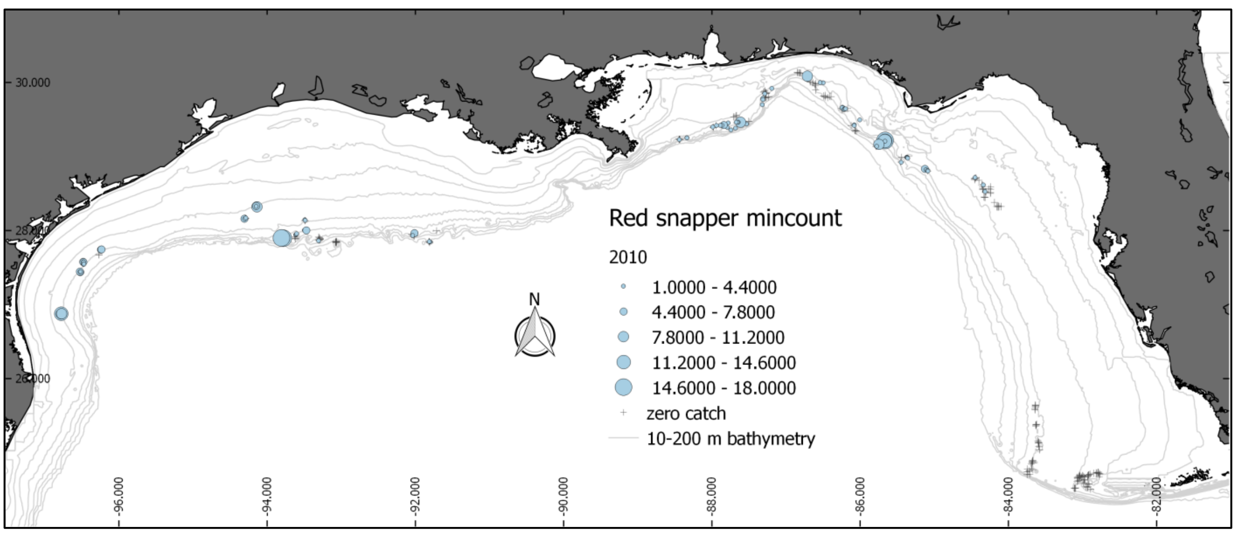

Figure 25. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2011.

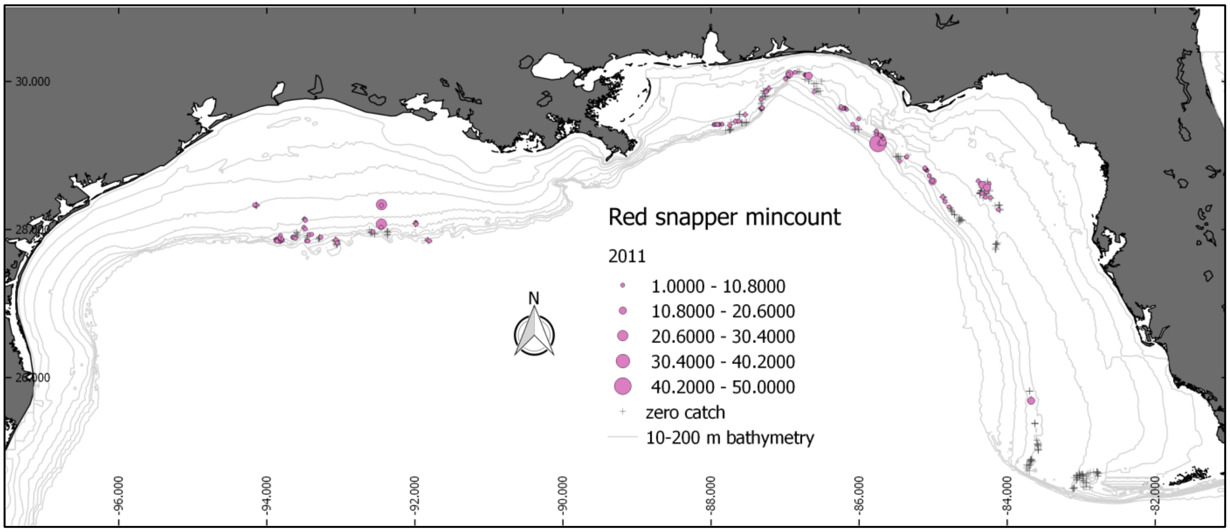

Figure 26. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2012.

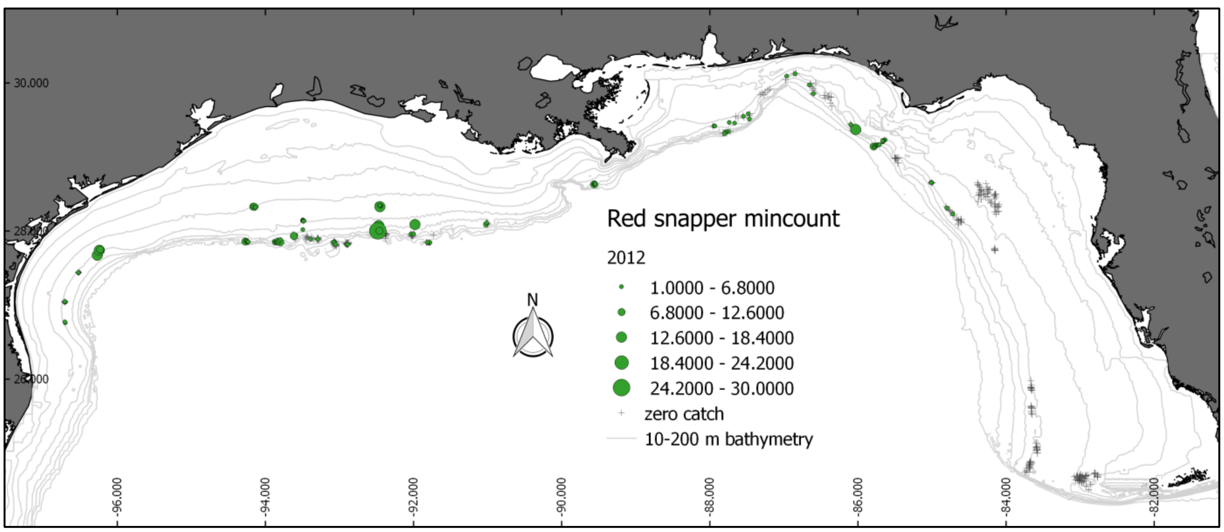

Figure 27. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2013.

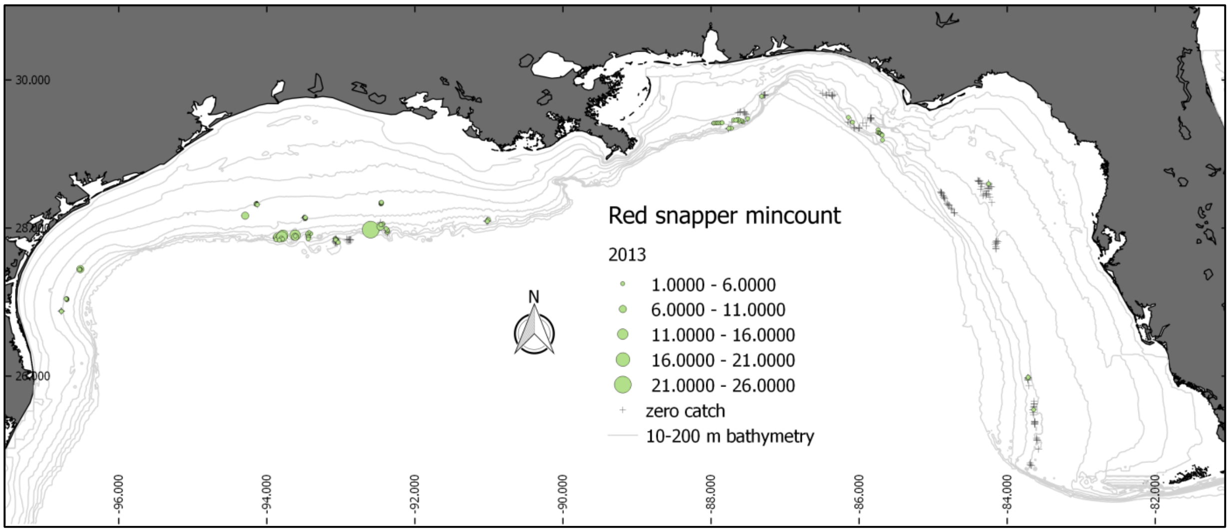

Figure 28. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2014.

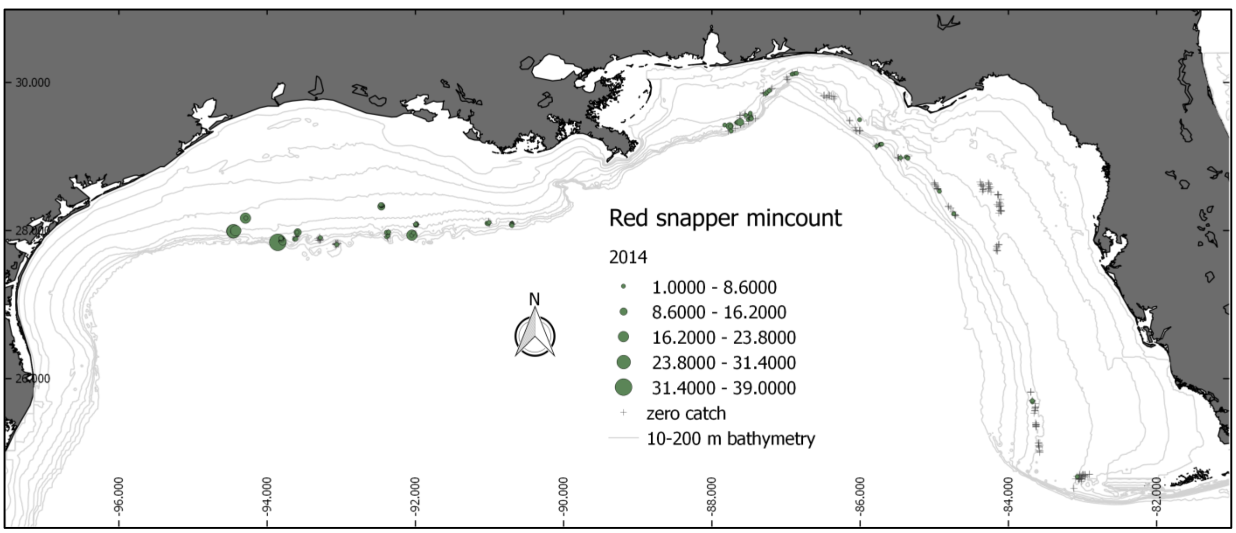

Figure 29. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2015.

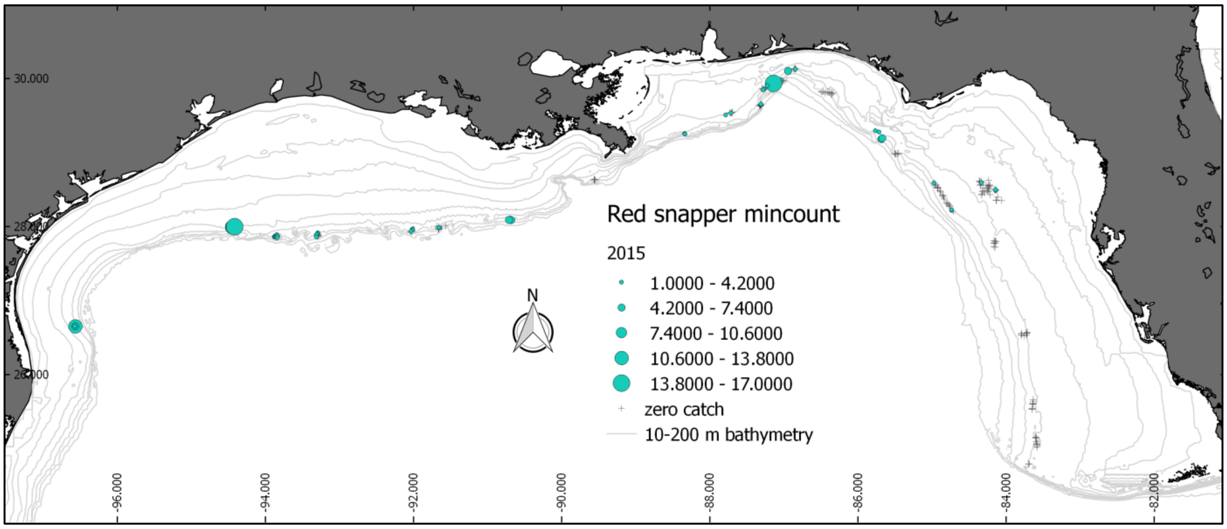

Figure 30. Map of red snapper mincounts during the SEAMAP reef fish video cruise in 2016.

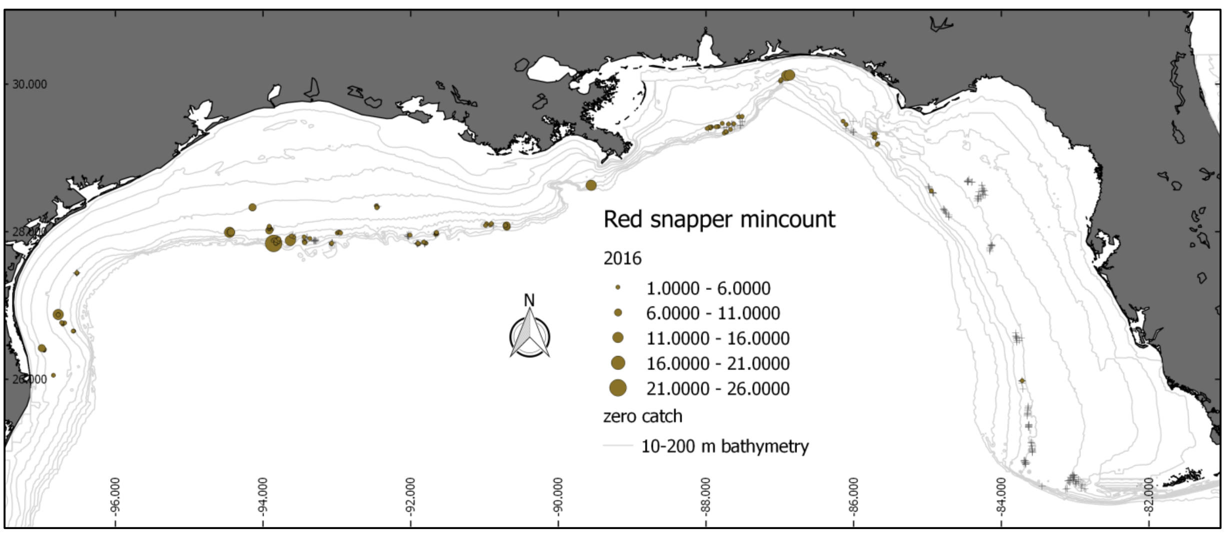

Table 16. Red snapper lengths (TL) from the SEAMAP reef fish video cruise from 1993 – 2016. Includes estimates by region and Gulf wide.

Total Length	East			West			GOM		
Year	Mean	STD	n	Mean	STD	n	Mean	STD	n
1995				628.40	122.63	9	628.40	122.63	9
1996	432.49	21.77	4	469.45	106.68	89	467.86	104.68	93
1997	307.37	25.71	7	472.86	114.35	48	451.80	120.63	55
2001				640.01	105.18	13	640.01	105.18	13
2002	500.33	84.82	176	551.70	136.63	113	520.42	110.73	289
2003	495.23	101.08	169				495.23	101.08	169
2004	493.15	116.51	238	415.51	139.08	81	473.44	127.00	319
2005	527.12	116.04	522	491.68	113.85	174	518.26	116.43	696
2006	478.12	126.26	274	470.59	115.69	63	476.71	124.22	337
2007	462.41	118.33	453	453.37	141.97	327	458.62	128.76	780
2008	497.07	145.02	24	503.73	133.81	24	500.40	138.08	48
2009	512.69	112.93	69	518.93	204.66	23	514.25	140.23	92
2010	575.40	131.97	50	469.72	111.16	84	509.15	129.46	134
2011	540.68	114.26	144	487.41	134.72	57	525.58	122.46	201
2012	630.02	100.50	139	555.93	115.59	62	607.17	110.55	201
2013	580.22	114.91	66	512.25	128.07	96	539.94	127.01	162
2014	612.76	138.28	80	479.42	130.40	117	533.57	148.60	197
2015	540.14	175.07	22	449.17	107.17	38	482.52	141.66	60
2016	536.13	192.27	36	523.91	131.58	128	526.59	146.47	164
Survey	513.00	125.77	2473	487.09	134.48	1546	503.03	129.79	4019

Figure 31. Mean total lengths of red snapper observed during the SEAMAP reef fish video cruise from 1993 - 2016.

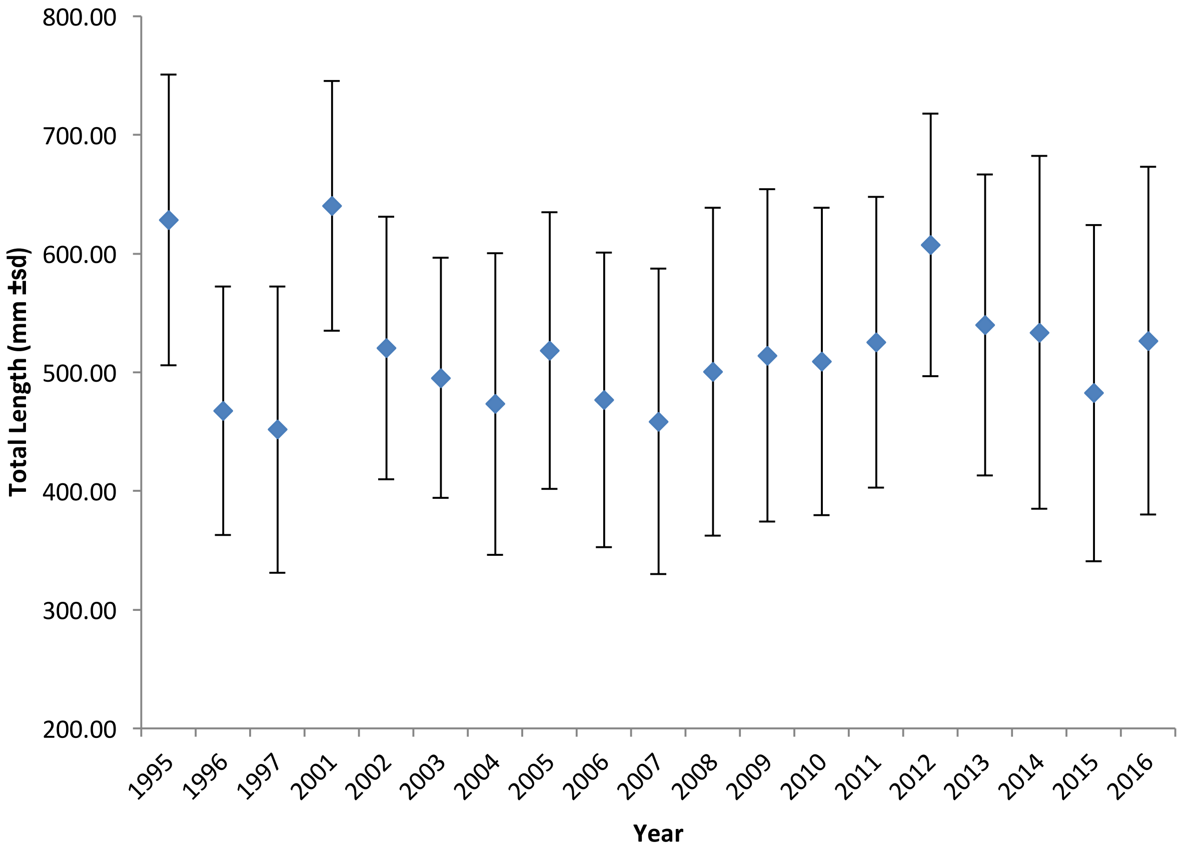

Figure 32. Length frequency histograms (TL, 25 mm bins) of red snapper observed during the SEAMAP reef fish video cruise from 1993 - 2016.

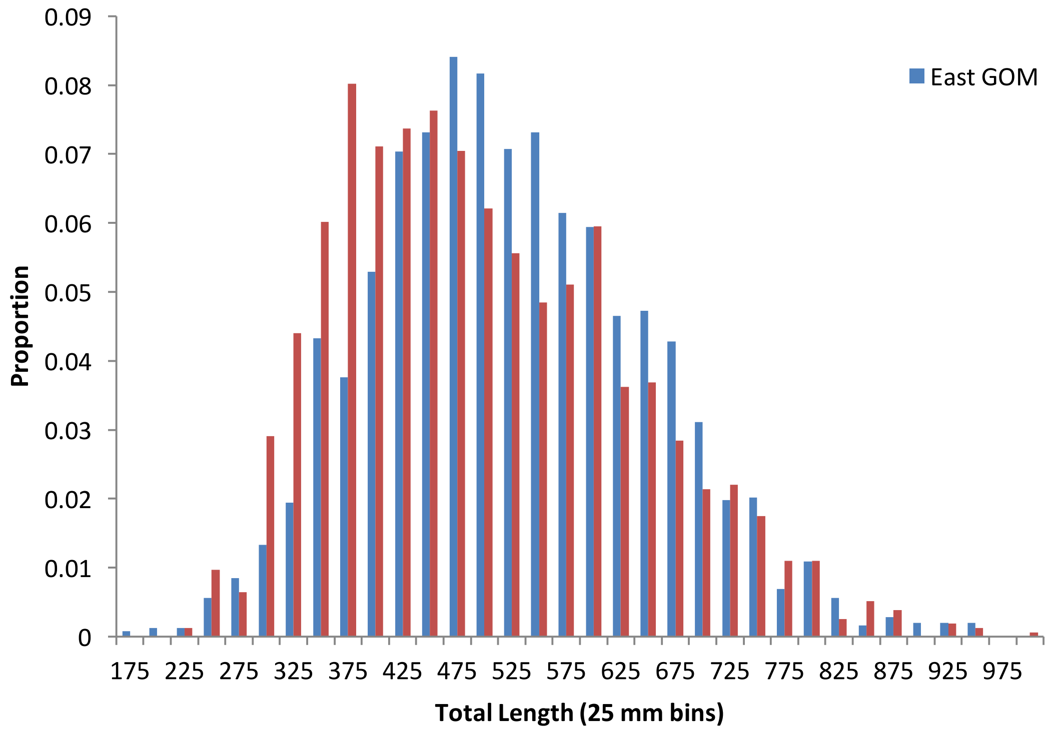

Figure 33. Length frequency histograms (TL, 25 mm bins) of red snapper observed during the SEAMAP reef fish video cruise from 1993 - 2016.