SEAMAP Reef Fish Video Survey:
Relative Indices of Abundance of Red Snapper
July 2012

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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 2). 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. hammerhead shark, *Sphyrna lewini*). The survey has been executed from 1992-1997, 2001-2002, and 2004-2011 and historically takes place from May – 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 (minimum count), fish length, habitat type, habitat coverage, and bottom topography. 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 370.6 – 593.1 mm. Age and reproductive data cannot be collected with the camera gear but beginning with the 2012 survey, a vertical line component will be coupled with the video drops to collect hard parts, fin clips, and gonads.

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 (Figures 1 and 2). 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.

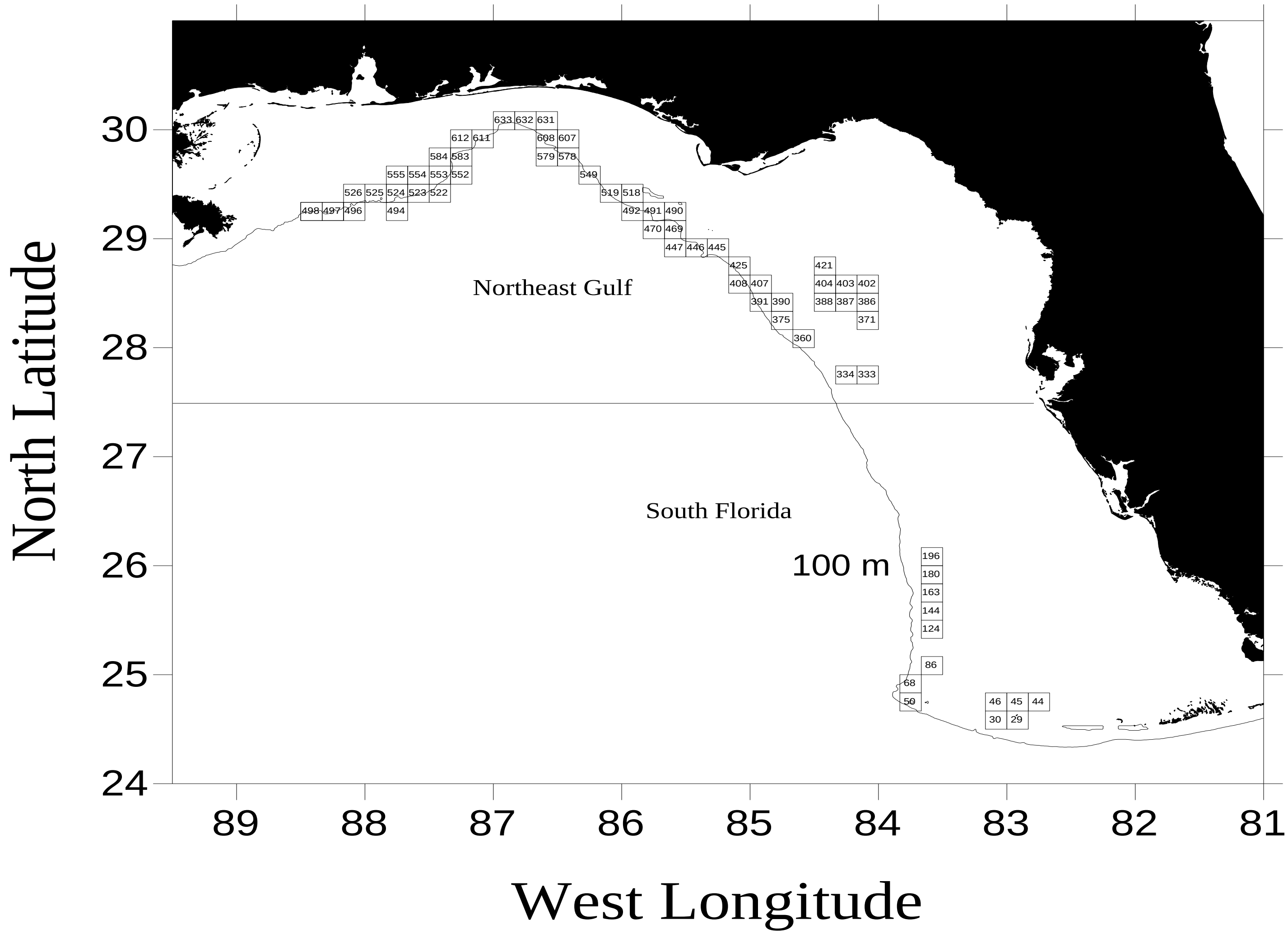

Figure 1. SEAMAP reef fish video survey sample blocks located in the eastern Gulf of Mexico.

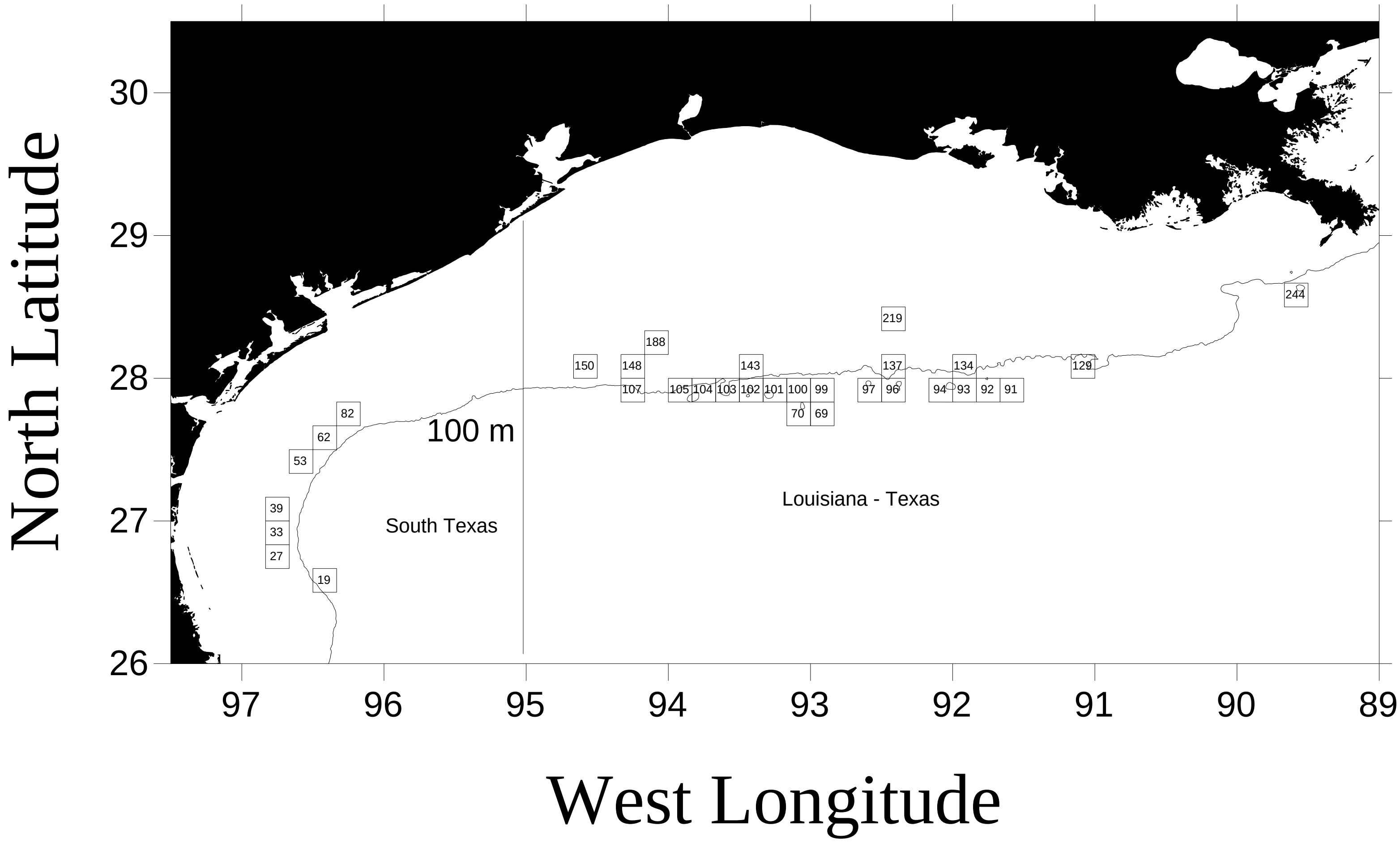

Figure 2. SEAMAP reef fish video survey sample blocks located in the western Gulf of Mexico.

Data reduction

Various limitations either in design, implementation, or performance of gear causes limitations in calculating minimum counts 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). The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western GOM. Because of the spatial imbalance associated with data gathered in 2001, that entire year has been dropped (80 total sites). Stratum 1 (South Florida) and stratum 7 (S. Texas) are blocks that contain very little reef and were not consistently chosen for sampling and were also dropped (184 total sites). 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). By these criteria the data set is reduced 4744 down to 4228 sites analyzed.

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 housing. All of the camcorder housings we have used were 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 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 selected for viewing out of four possible. If all four video cameras face reef fish habitat and are in focus, tape selection is random. 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. The 2008-2011 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 estimator of relative abundance. Minimum count methodology is preferred because it prevents counting the same fish more than once.

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 precluded estimating size frequency distributions. Additionally, the same fish can be measured more than once at a given station. So, the lengths measured provide the range of sizes observed. The stereo cameras used in 2008-2010 allow size estimation from fish images. The Vision Measurement System (Geometrics Inc.) was used to estimate size of red snapper. We estimated a length frequency distribution by weighting station length frequencies by station Minimum Counts (Figure 30, 32).

Model based indices

Delta-lognormal modeling methods were used to estimate relative abundance indices for red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al*. (1992) was estimated as:

(2) $I_y = c_y p_y$,

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

(3) $\ln(c) = X\beta + \varepsilon$

and

(4) $p = \frac{e^{\mathbf{X\beta+\varepsilon}}}{1+e^{\mathbf{X\beta+\varepsilon}}}$,

respectively, where *c* is a vector of the positive catch data, *p* is a vector of the presence/absence data, *X* is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2. Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, SE(c_y) and SE(p_y), respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated as:

$$(5) \qquad V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

where:

$$(6) \qquad \mathrm{Cov}(c, p) \approx \rho_{c,p}\left[\mathrm{SE}(c_y)\mathrm{SE}(p_y)\right],$$

and $\rho_{c,p}$ denotes correlation of *c* and *p* among years.

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Variables that could be included in the submodels were: Year (1987-2011).

Design based indices

A delta-lognormal modeling approach (Lo et al., 1992) was used to develop abundance indices. Independent variables used in the model were year, region and depth. Region is divided into east and west at 89.15 west longitude. The GENMOD procedure in SAS (v.9.2) was used to conduct separate forward stepwise regressions on the binomial and lognormal sub-models to determine which variables to retain for use in fitting the delta lognormal model. Only variables that reduced model deviance by at least 1% with a type 3 analysis level of significance of $\alpha = 0.05$ were retained. The GLIMMIX and MIXED procedures in SAS (v. 9.2) were used to develop the binomial and lognormal sub-models, respectively. A backward selection procedure was used to determine which variables retained from the GENMOD procedure were to be included into each final sub-model based on a type 3 analyses with a level of significance for inclusion of $\alpha = 0.01$. Year was including in all terminal models regardless of significance, while region and depth were retained in both the binomial and lognormal sub-models. The estimates from each model were weighted using the stratum area, and separate covariance structures were developed for each survey year. For the binomial models, a logistic-type mixed model was employed.

Results

Red snapper were observed at banks in both the western and eastern GOM (Figures 3 – 16), and the spatial distributions observed are highly reflective of the reef sampling universe used to select sampling sites (Figures 1 - 2). Gaps in habitat level information exist in central Florida, Mississippi river delta region, and portions of the Texas coast. 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. Reef blocks from coastal Texas are often not selected for sampling due to small spatial coverage of reef, and frequent high winds and rough sea states during the spring/early summer sampling season.

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 0.1 (1993) to 0.41 (2010) with a reported value of 0.35 in 2011 (Table 1, Figure 17), while standardized index of abundance ranged from 0.5 (1995) to 1.88 (2010), and reported a value of 1.84 in 2011 (Table 2, Figure 18). Model based analysis shows GOM wide standardized index trends are similar to the design based runs and ranged from 0.29 (1994) to 2.35 (2011)(Table 12, Figure 43).

Design based analysis retained year, region and depth in the binomial and log-normal east-GOM sub-model. Design based east-GOM red snapper proportion positives ranged from 0.027 (1994) to 0.309 (2011) (Table 1, Figure 17), and the standardized index of abundance ranged from 0.24 (1994) to 2.1 (2011) (Table 2, Figure 18). Model based east-GOM standardized index values trended similarly to design based runs and ranged from 0.04 (1994) to 3.23 (2011) (Table 14, Figure 45). Annual mean fork lengths for east GOM red snapper have ranged from 370.6 to 514.8 mm in the east in 2009 and 2010 respectively (Table 15).

Design based analysis retained year, region and depth in the binomial and log-normal west-GOM sub-model. Design based red snapper proportion positive ranged from 0.15 (1993) to 0.57 (2010) with a reported value of 0.41 in 2011 (Table 1, Figure 17), while standardized index values ranged from 0.59 (1996) to 2.03 (2010) (Table 2, Figure 18). Model based analysis of west GOM standardized index values show similar trends as the design based runs and ranged from 0.53 (1994) to 2.23 (2011) (Table 13, Figure 44). Annual mean fork lengths for west GOM red snapper have ranged from 200 to 917 mm in the east in 2005 and 2004 respectively (Table 15).

Design and model based output for proportion positives, lo-index, and standardized index values from 2010 and 2011 are at historical highs for the survey. Gulf wide and west GOM values for proportion positives, lo-index, and standardized index output show a slight decrease from 2010 to 2011, while east GOM values have continued to increase since 2008. There appears to be some evidence of year classes cycling through as age 3 size fish move onto the reef, for instance 2004 is noted as a strong year class and 2007 we see a spike in min-count in both the east and west data (other strong years classes include 2000 and 2006).

Literature cited

Cochran, W.G. 1977. Sampling Techniques. John Wiley & Sons. New York, NY. 428 p.

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.

Figure 3. Spatial distribution of red snapper observed and associated min-count values during the 1993 reef fish video survey.

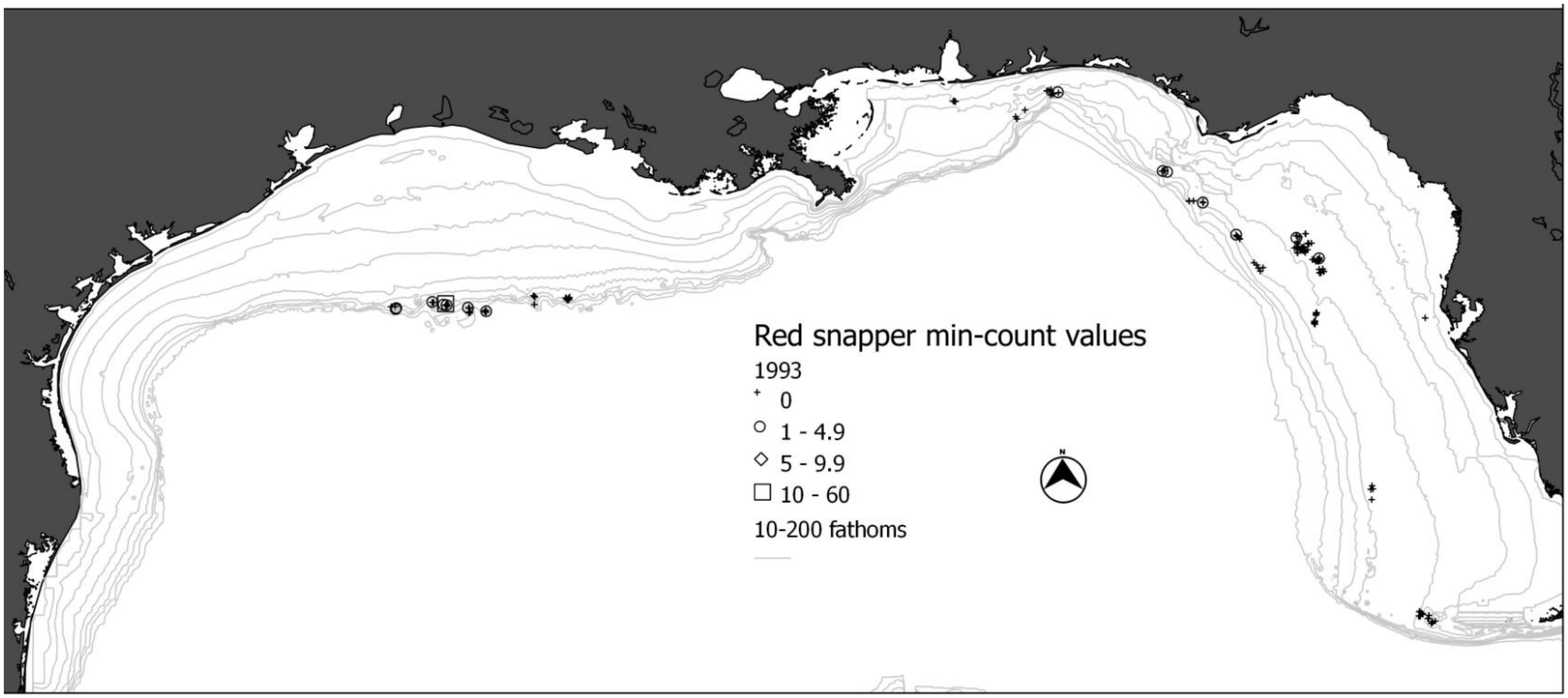

Figure 4. Spatial distribution of red snapper observed and associated min-count values during the 1994 reef fish video survey.

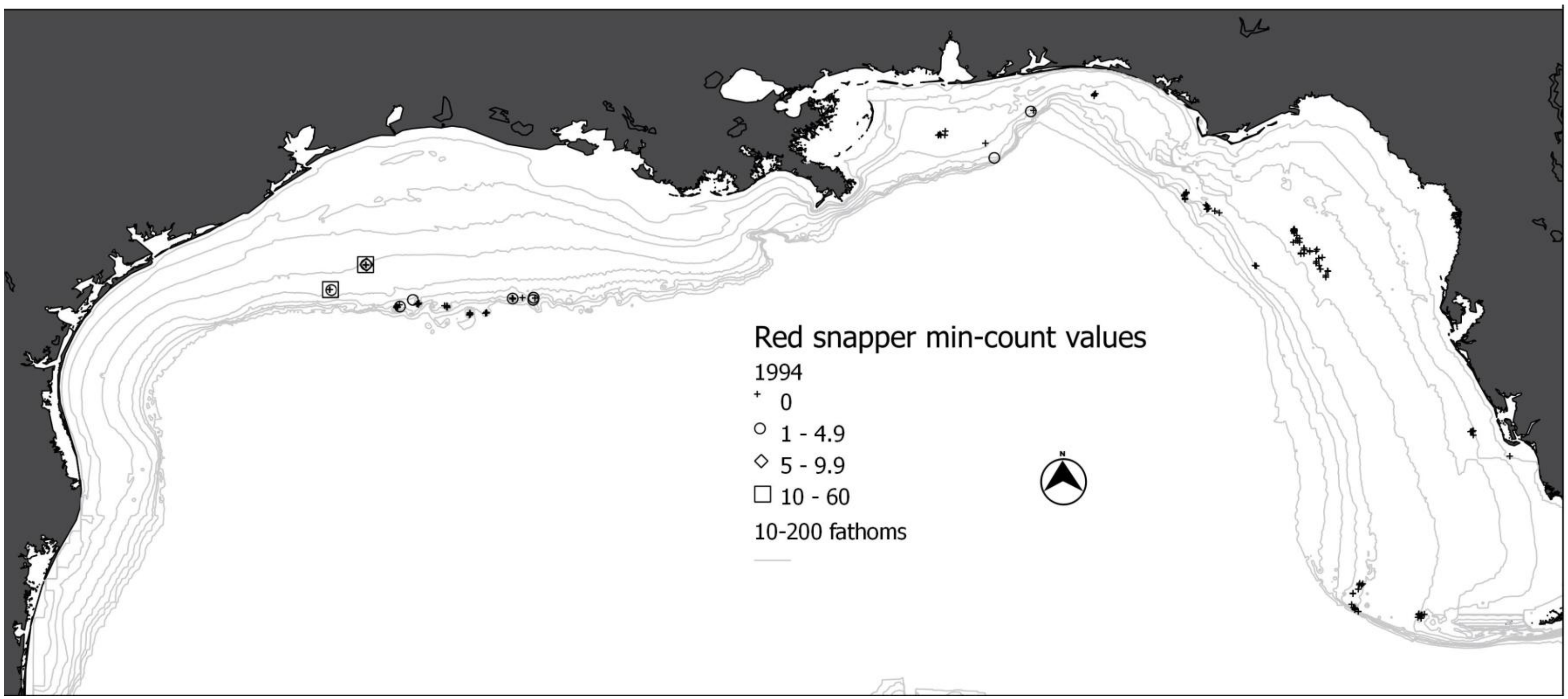

Figure 5. Spatial distribution of red snapper observed and associated min-count values during the 1995 reef fish video survey.

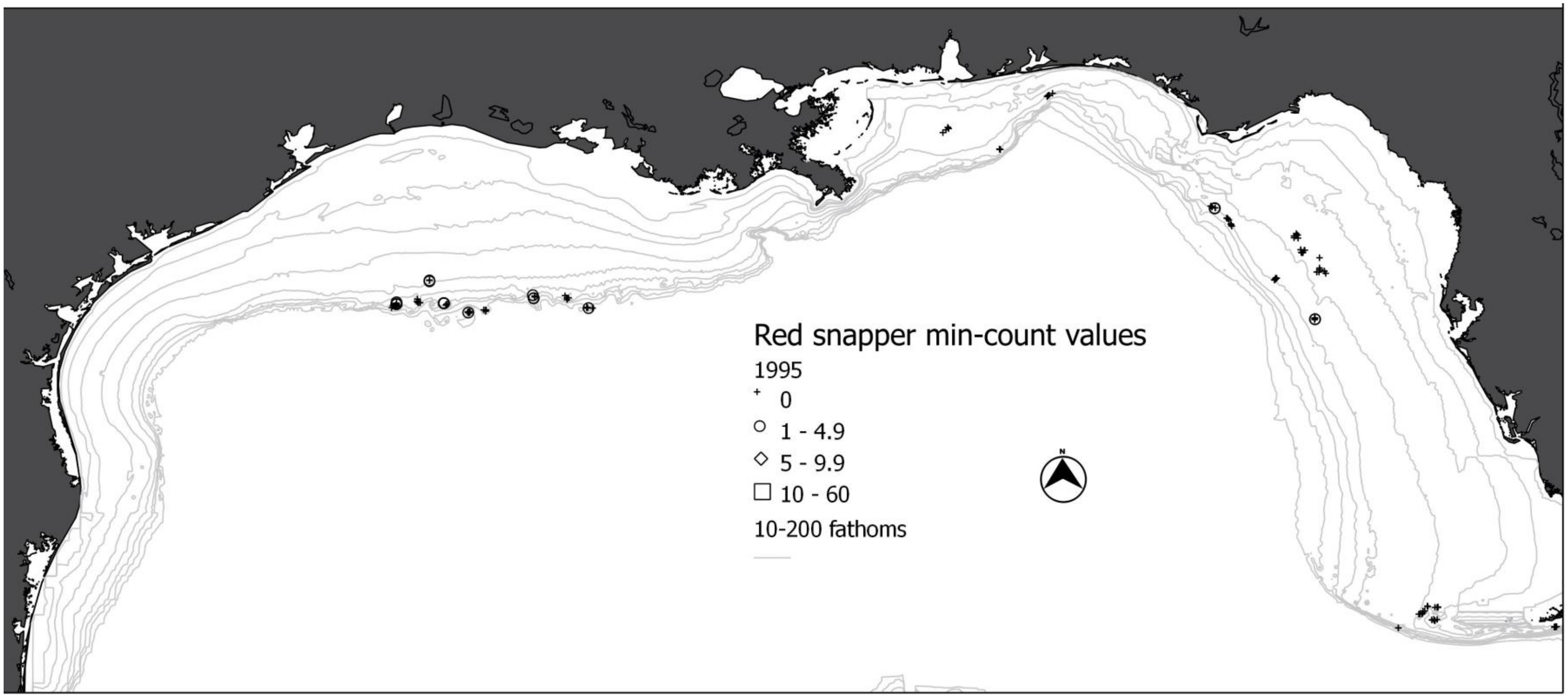

Figure 6. Spatial distribution of red snapper observed and associated min-count values during the 1996 reef fish video survey.

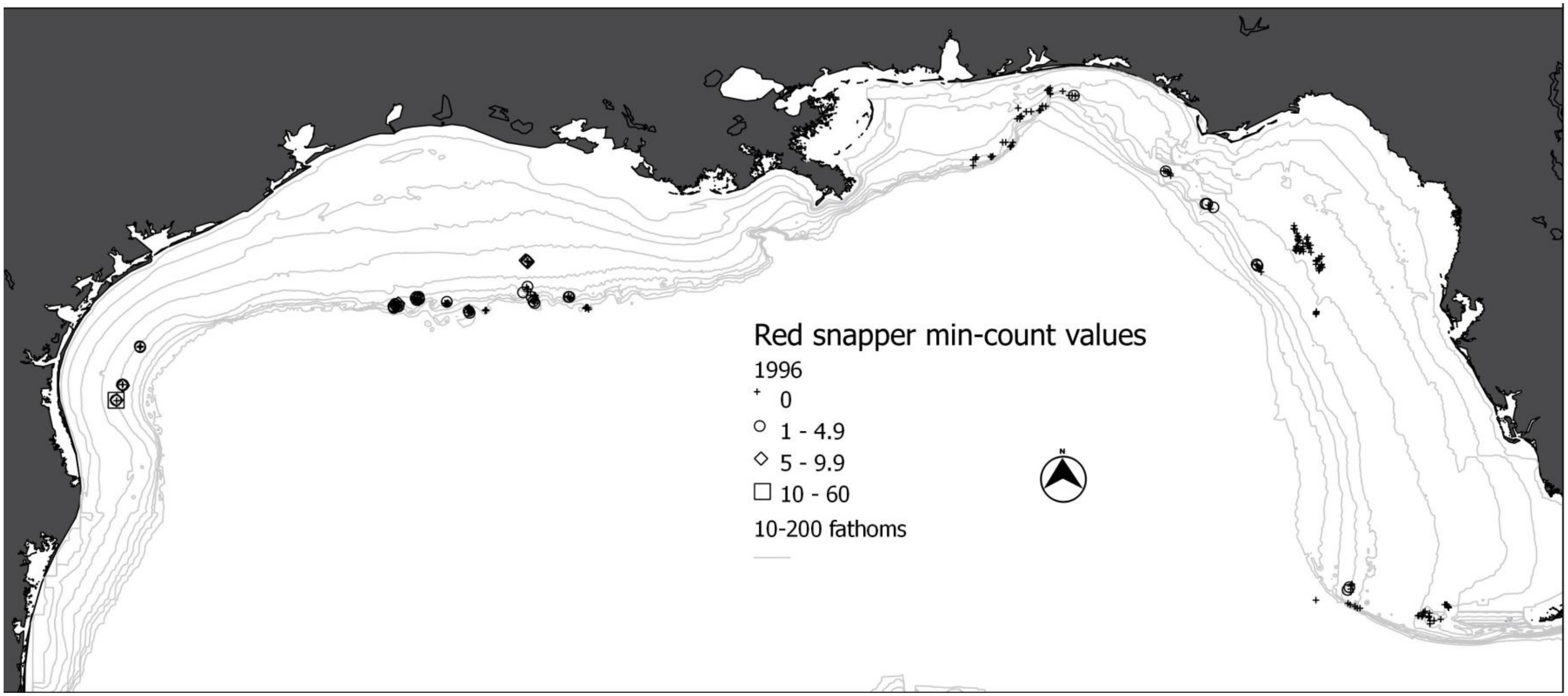

Figure 7. Spatial distribution of red snapper observed and associated min-count values during the 1997 reef fish video survey.

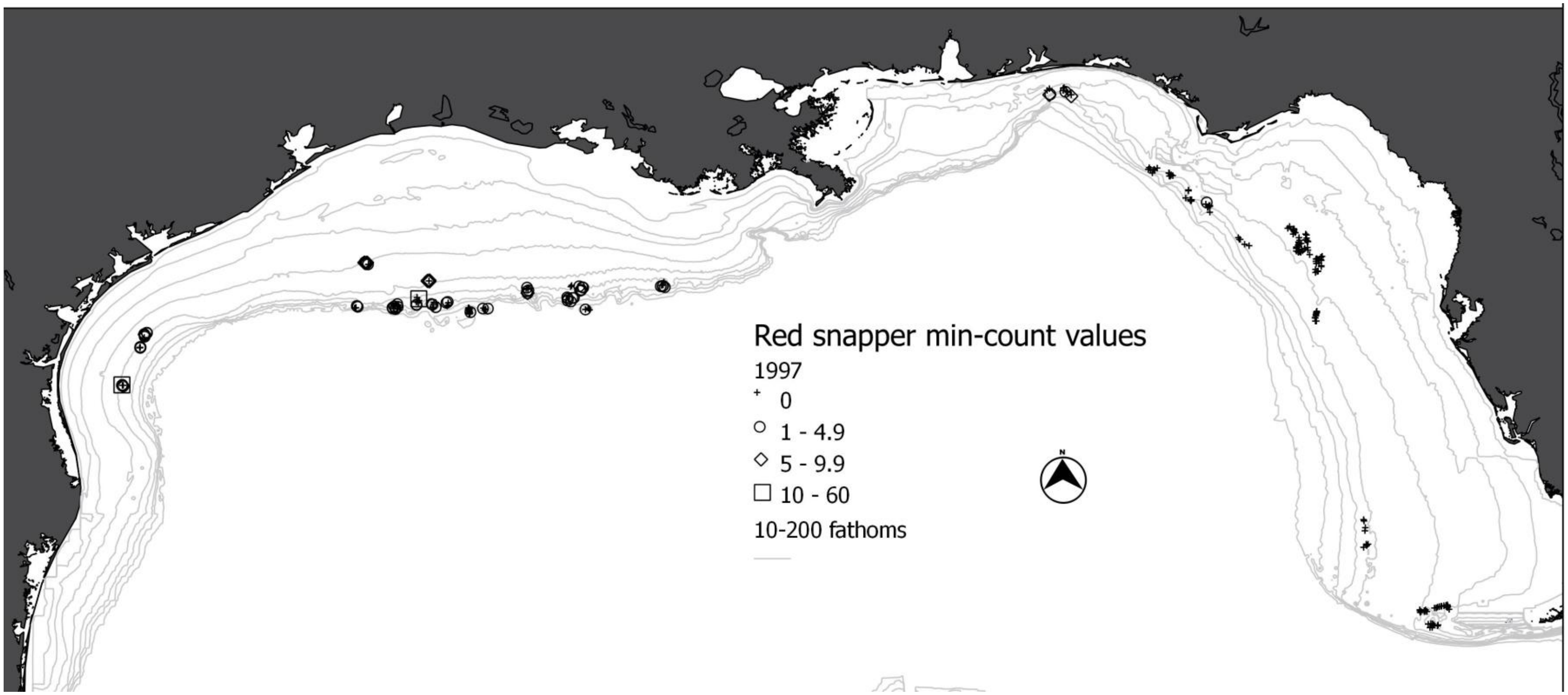

Figure 8. Spatial distribution of red snapper observed and associated min-count values during the 2002 reef fish video survey.

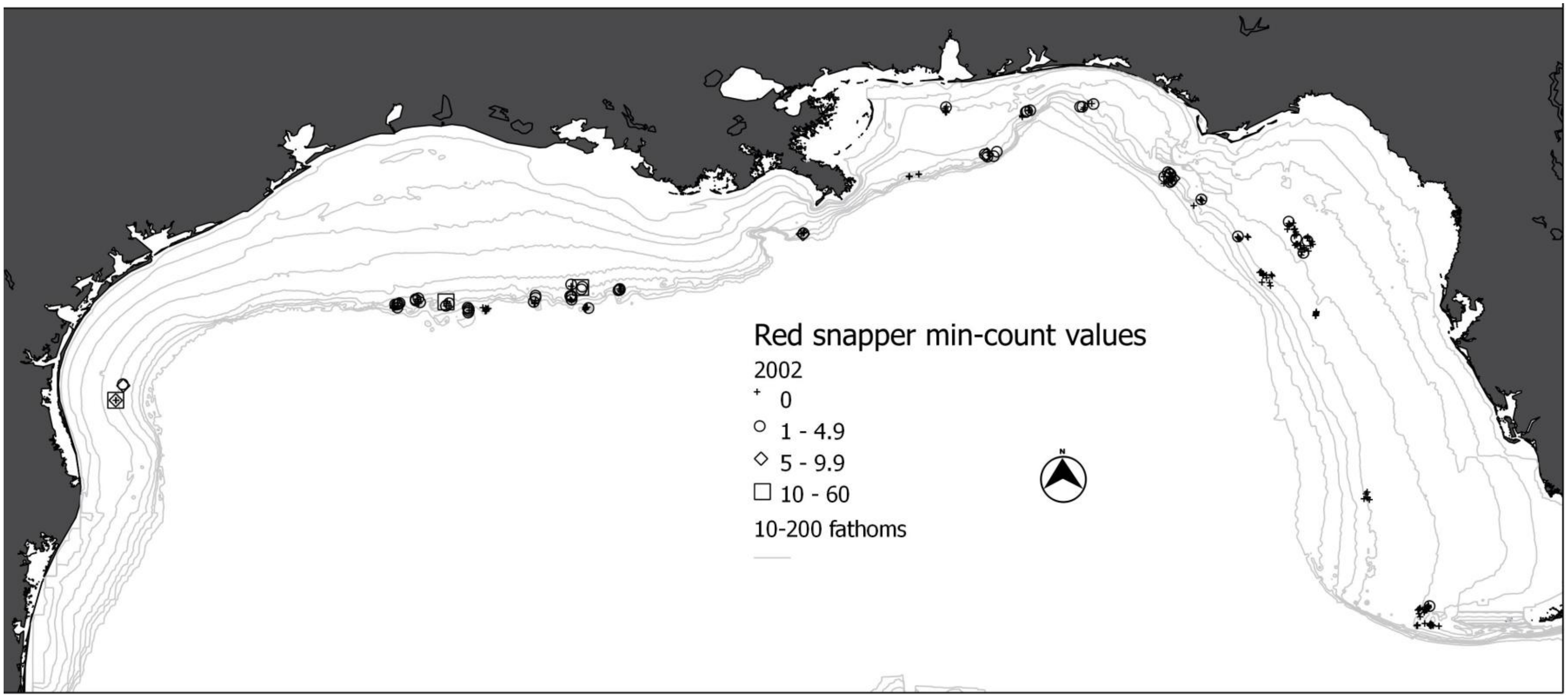

Figure 9. Spatial distribution of red snapper observed and associated min-count values during the 2004 reef fish video survey.

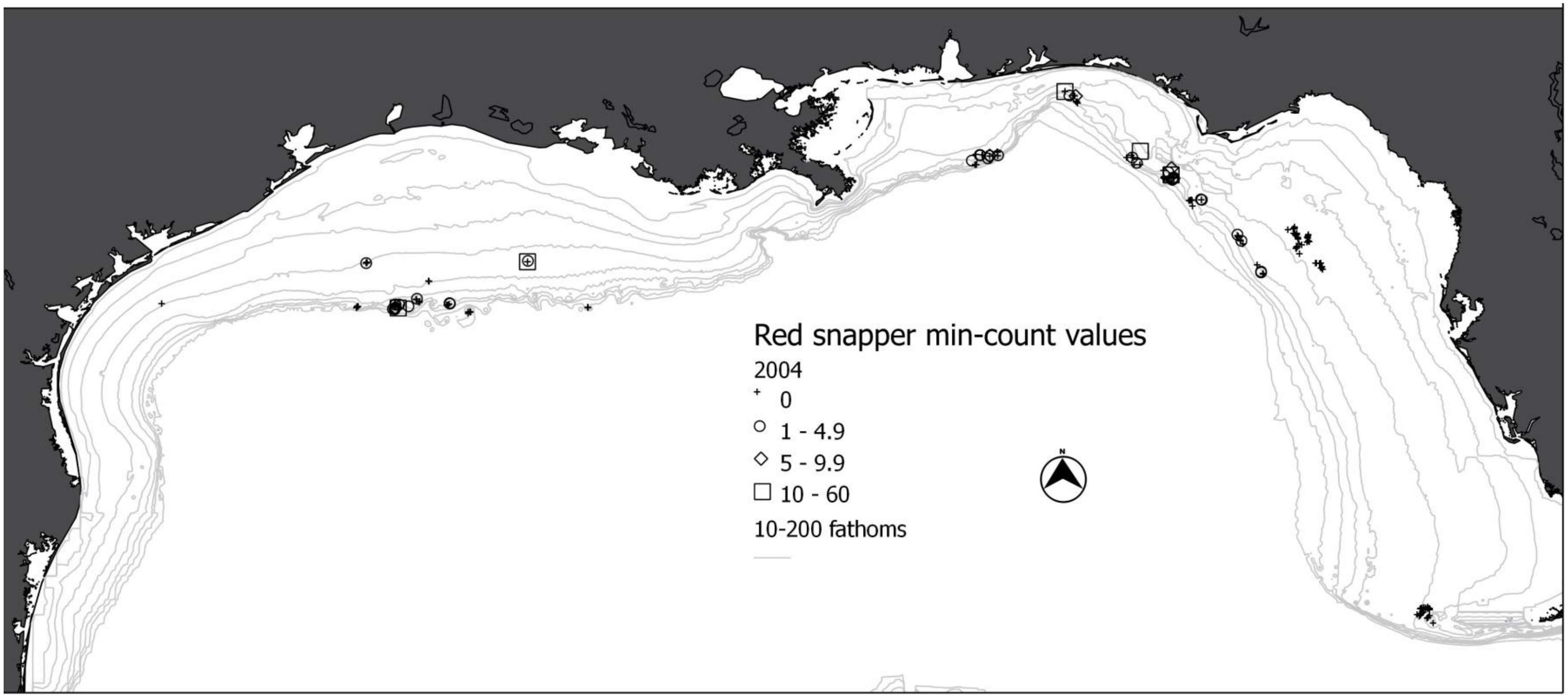

Figure 10. Spatial distribution of red snapper observed and associated min-count values during the 2005 reef fish video survey.

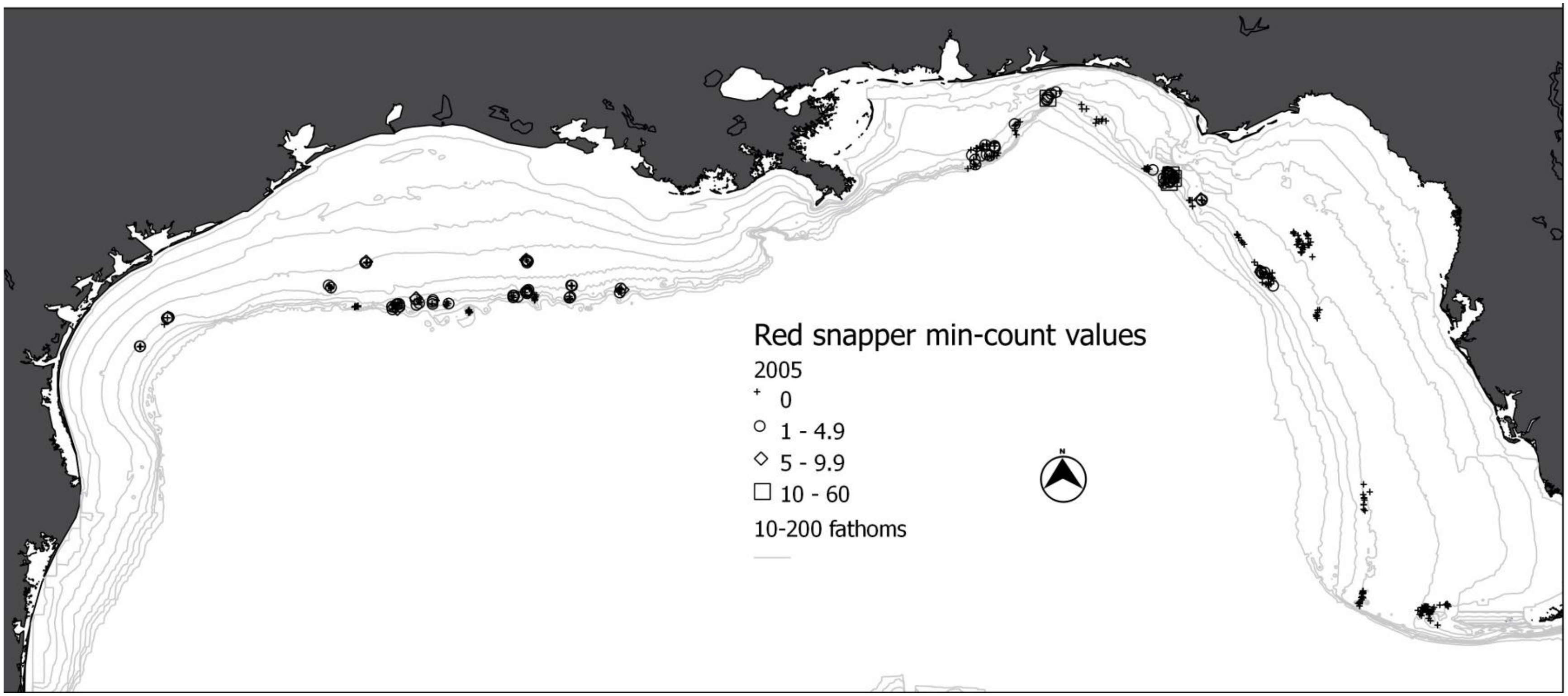

Figure 11. Spatial distribution of red snapper observed and associated min-count values during the 2006 reef fish video survey.

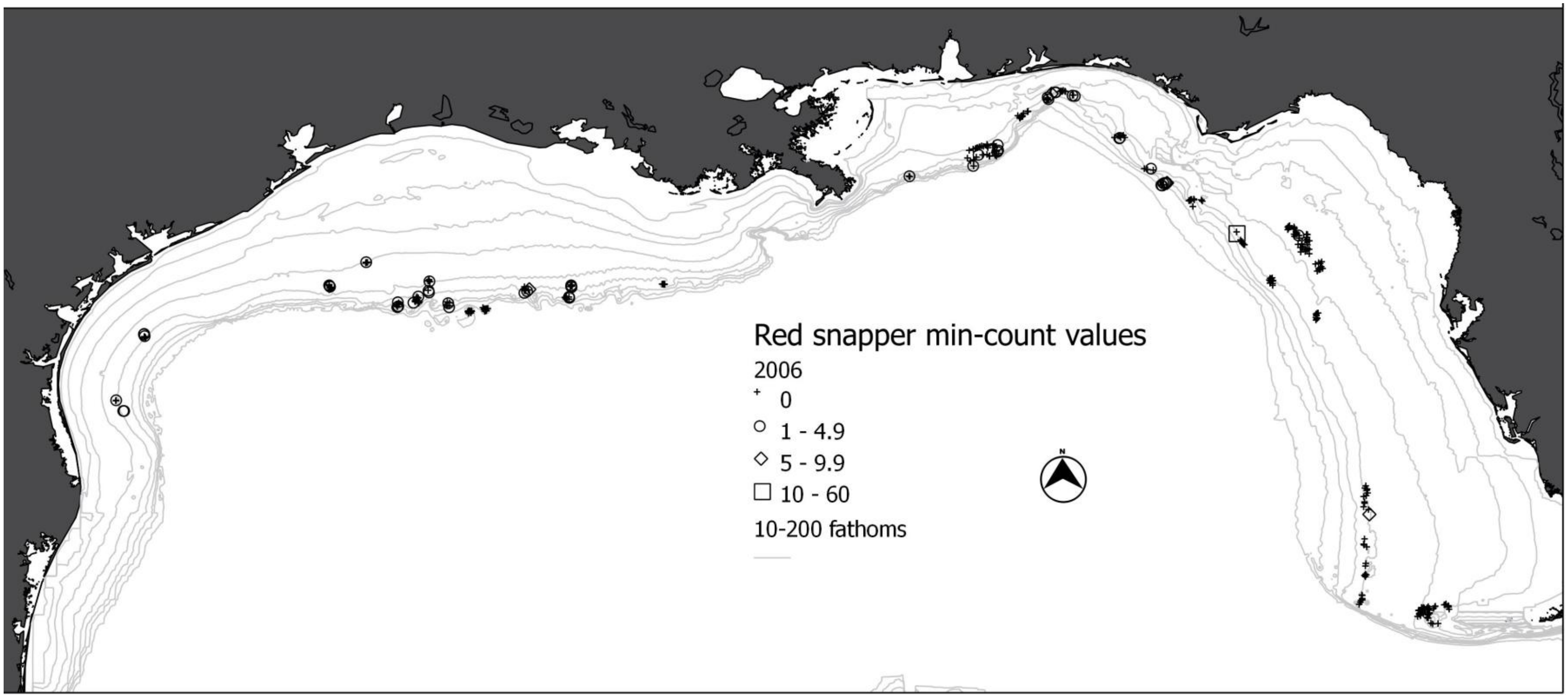

Figure 12. Spatial distribution of red snapper observed and associated min-count values during the 2007 reef fish video survey.

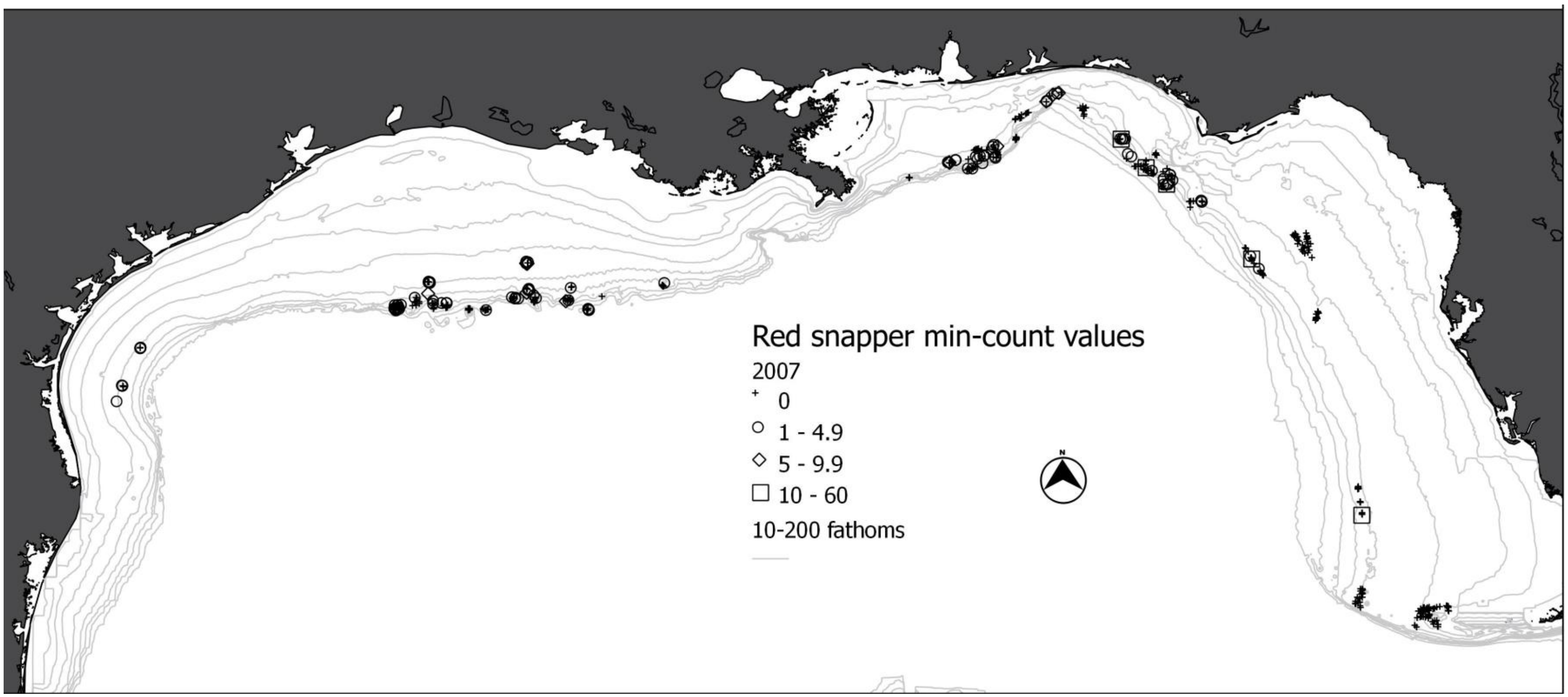

Figure 13. Spatial distribution of red snapper observed and associated min-count values during the 2008 reef fish video survey.

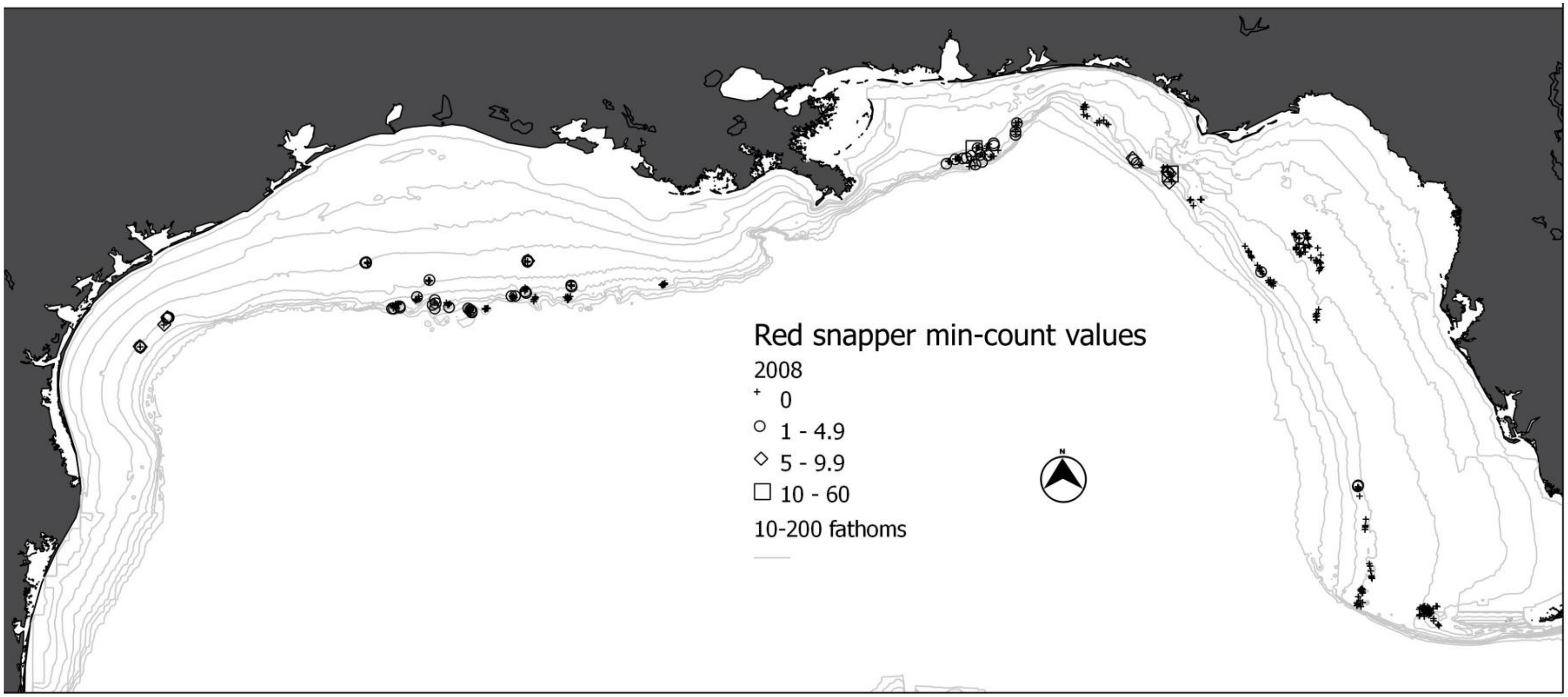

Figure 14. Spatial distribution of red snapper observed and associated min-count values during the 2009 reef fish video survey.

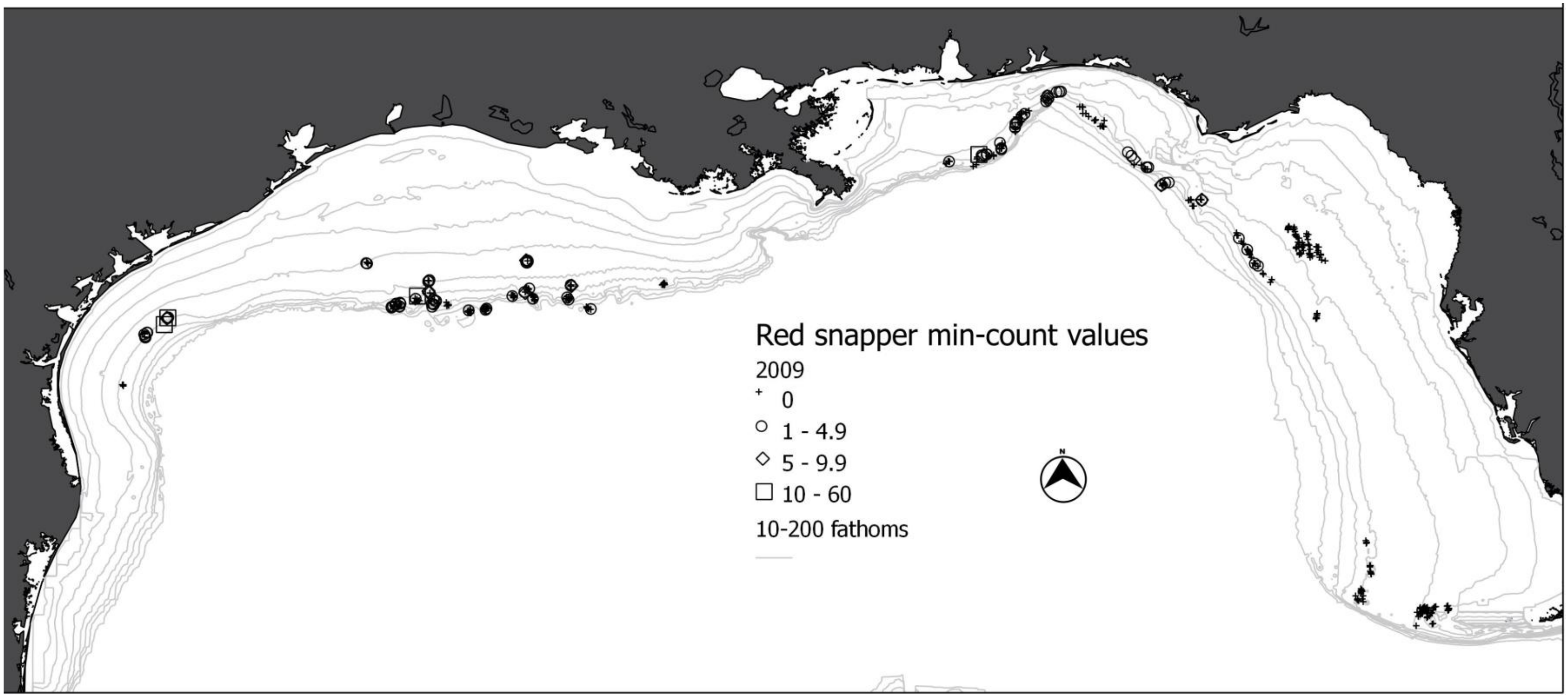

Figure 15. Spatial distribution of red snapper observed and associated min-count values during the 2010 reef fish video survey.

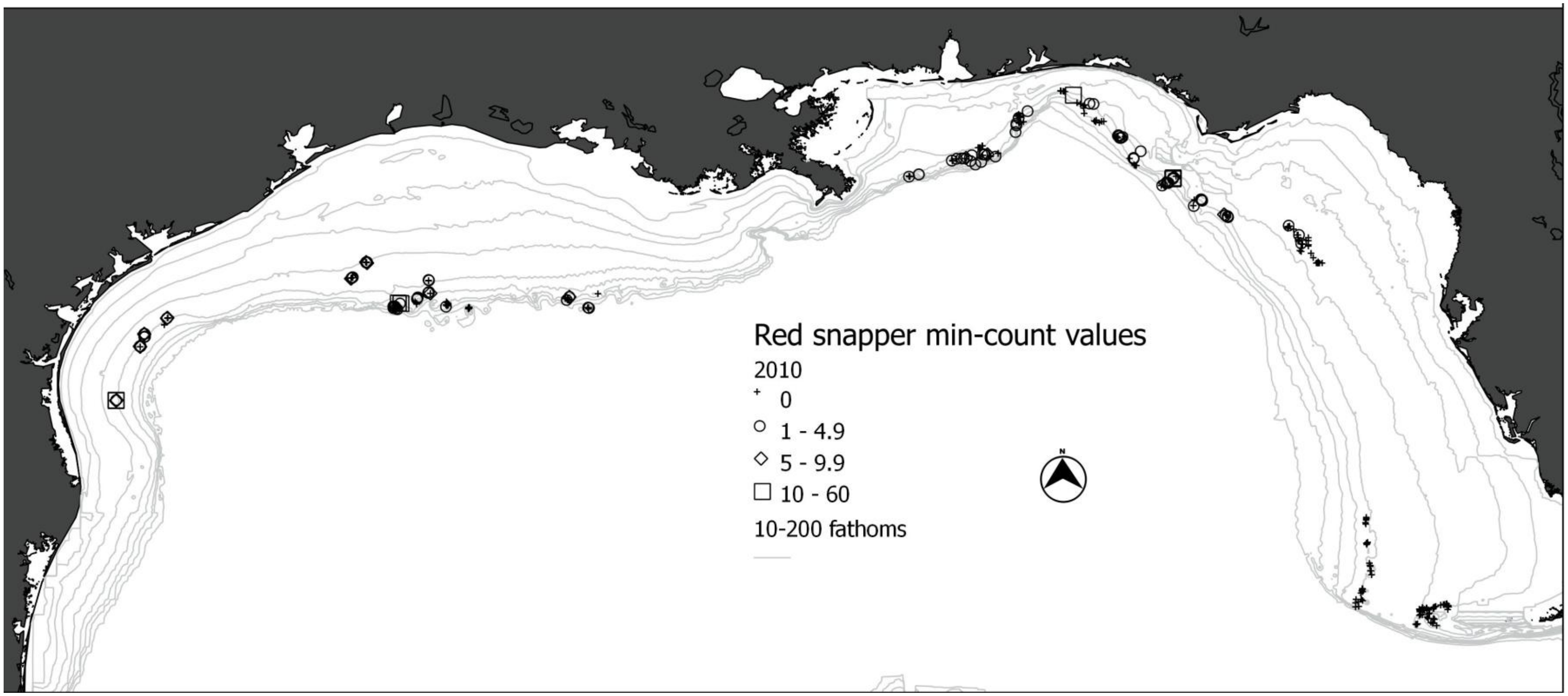

Figure 16. Spatial distribution of red snapper observed and associated min-count values during the 2011 reef fish video survey.

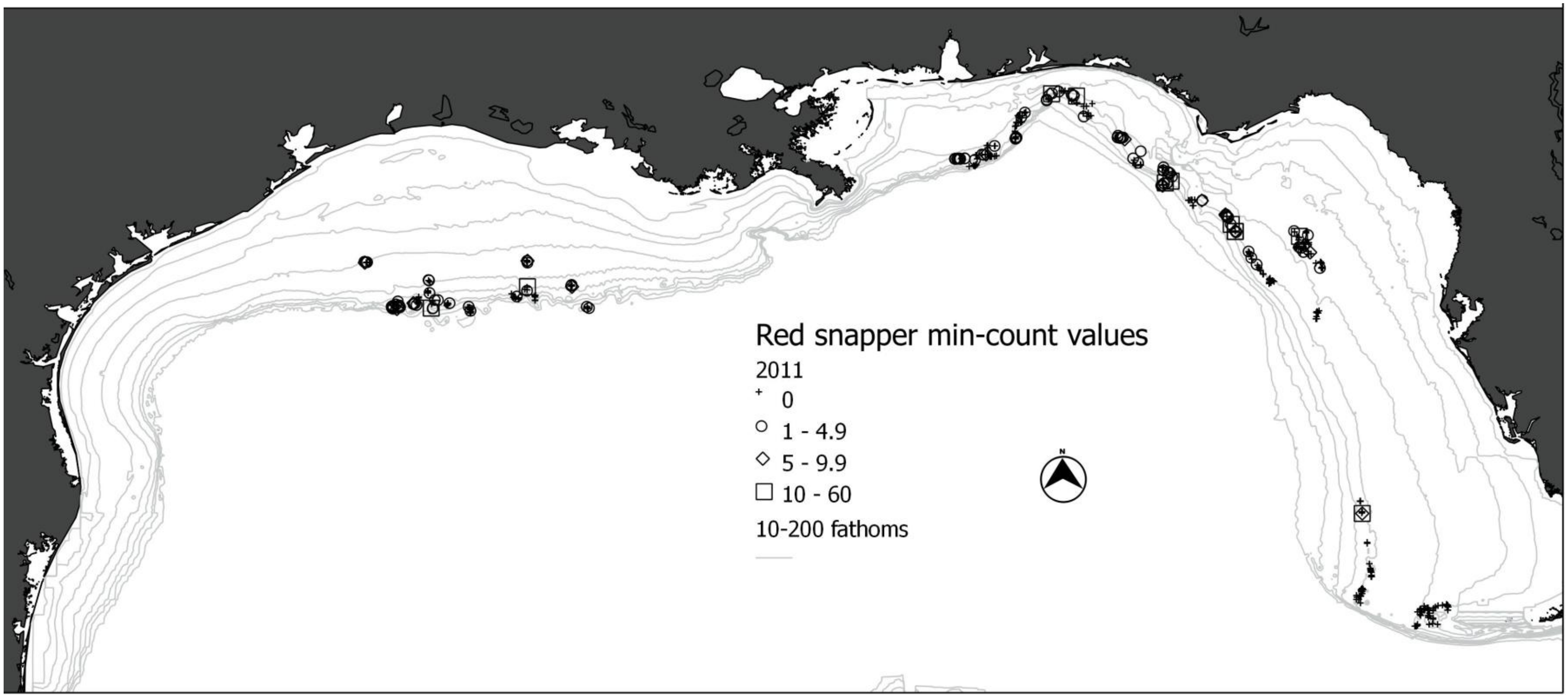

Table 1. Proportion of stations capturing red snapper (proportion positive) by region and year for the design based model.

Year	GOM wide	East GOM	West GOM
1993	0.1040936	0.0526316	0.1555556
1994	0.1284742	0.0266667	0.2325581
1995	0.1467432	0.0529801	0.2405063
1996	0.1500716	0.0583942	0.2339181
1997	0.2859206	0.0337838	0.5413534
2002	0.2683614	0.1552795	0.3814433
2004	0.2537324	0.2013423	0.3061224
2005	0.2908075	0.2125984	0.3823529
2006	0.1472674	0.0932836	0.2058824
2007	0.2747524	0.1677419	0.3924051
2008	0.2011923	0.0994152	0.3114754
2009	0.2575986	0.1585366	0.3674699
2010	0.4155844	0.3045685	0.5714286
2011	0.3512597	0.3096774	0.4150943

Figure 17. Comparison of the east, west, and GOM-wide proportion of positive red snapper catch sites for the design based model.

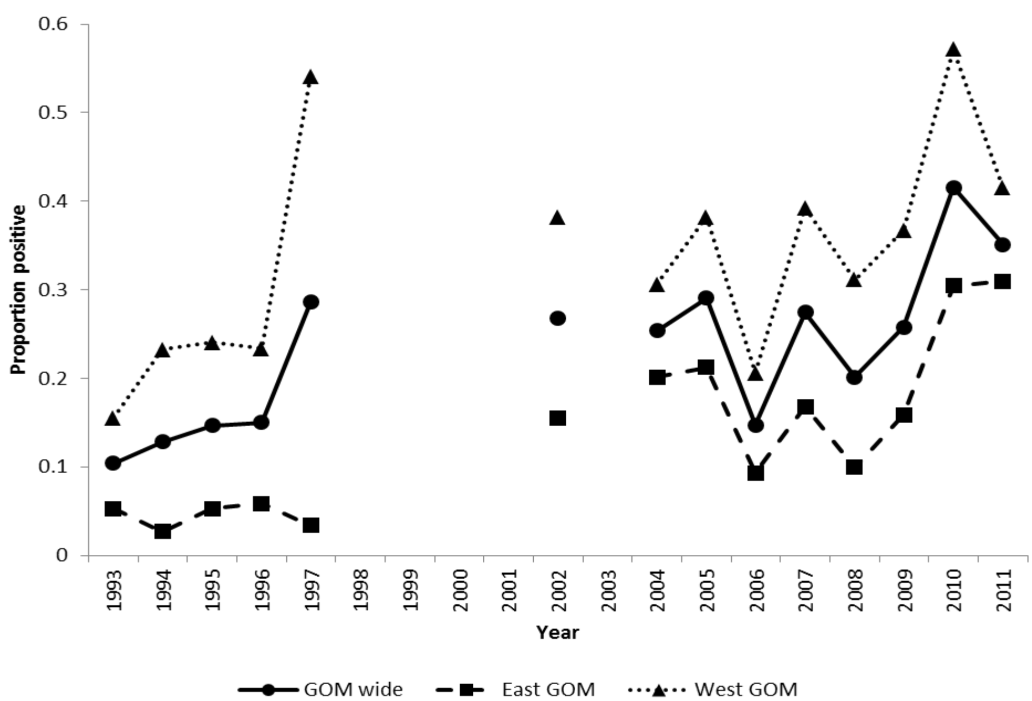

Table 2. Lo and standardized index values by region and year for the design based model.

	Lo index			Standardized index		
	GOM wide	East GOM	West GOM	GOM wide	East GOM	West GOM
1993	0.20967	0.11488	0.40422	0.51427	0.4397	0.61146
1994	0.23845	0.06248	0.53307	0.58487	0.23916	0.80638
1995	0.20462	0.09399	0.39582	0.5019	0.35977	0.59876
1996	0.24199	0.11507	0.39036	0.59355	0.44043	0.5905
1997	0.52027	0.16181	1.0229	1.27611	0.61932	1.54734
2002	0.51478	0.39263	0.70069	1.26265	1.50278	1.05993
2004	0.54023	0.41162	0.60728	1.32506	1.57546	0.91864
2005	0.50115	0.36563	0.7256	1.22921	1.39945	1.09762
2006	0.22005	0.1762	0.28464	0.53973	0.67442	0.43057
2007	0.41428	0.26069	0.79635	1.01614	0.99781	1.20463
2008	0.23233	0.1815	0.40457	0.56985	0.69469	0.612
2009	0.3526	0.23474	0.6521	0.86485	0.89847	0.98643
2010	0.76841	0.53619	1.34125	1.88474	2.05228	2.02892
2011	0.74897	0.5503	0.99611	1.83707	2.10627	1.50682

Figure 18. Comparison of the east, west, and GOM-wide standardized indices of red snapper abundance.

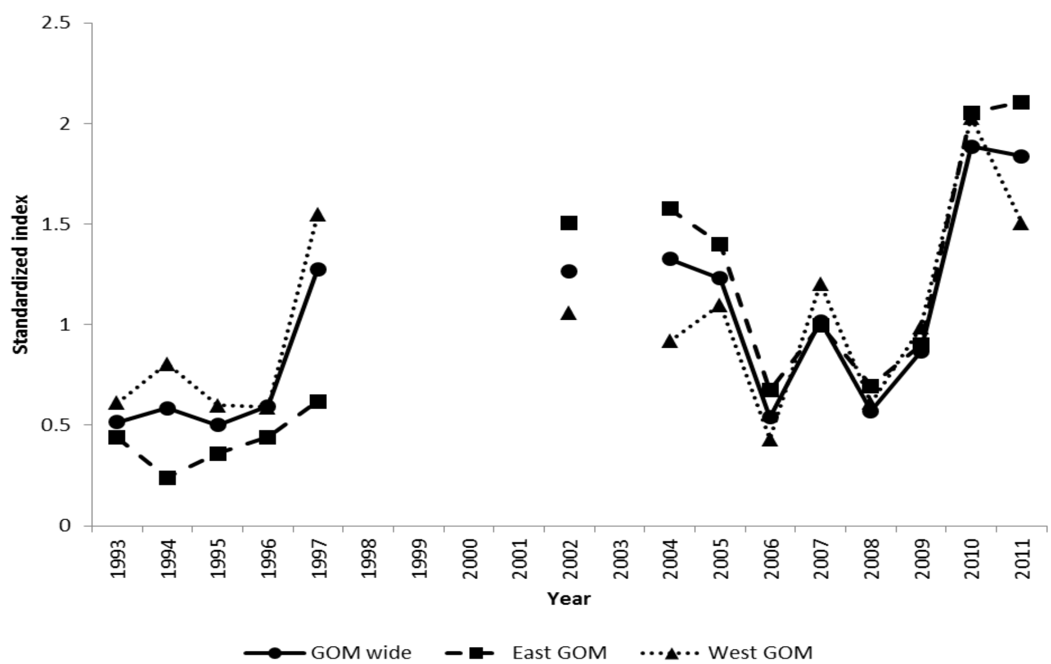

Table 3. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics of the GLIMMIX binomial on proportion positives for the GOM-wide model.

a

Iteration History

Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	21956.42410392	0.00000000

b

Fit Statistics

-2 Res Log Likelihood	21956.4
AIC (smaller is better)	21984.4
AICC (smaller is better)	21984.5
BIC (smaller is better)	22073.9

c

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	13	1466	128.02	9.80	<.0001	<.0001
zone	1	4178	70.94	70.94	<.0001	<.0001
depth	1	3411	120.16	120.16	<.0001	<.0001

d

Description	*Value*
Deviance	741.5532
Scaled Deviance	3572.6273
Pearson Chi-Square	788.0838
Scaled Pearson Chi-Square	3796.8002
Extra-Dispersion Scale	0.2076

Figure 19. GOM-wide observed versus proportion positive for design based simulation.

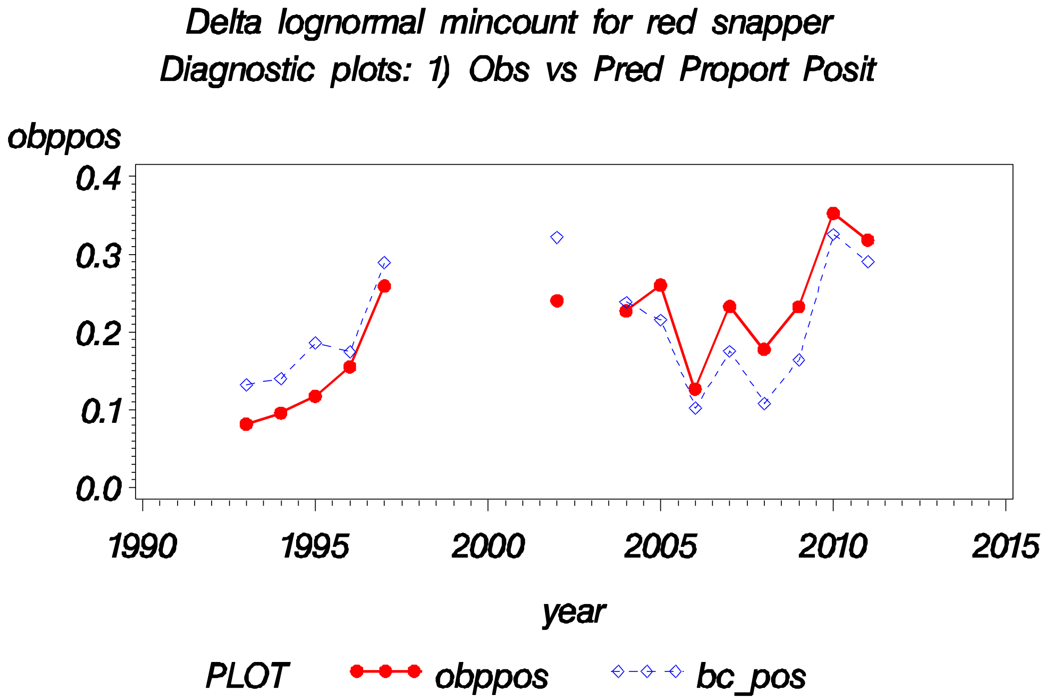

Figure 20. GOM-wide chi-square residuals of proportion positive design based model.

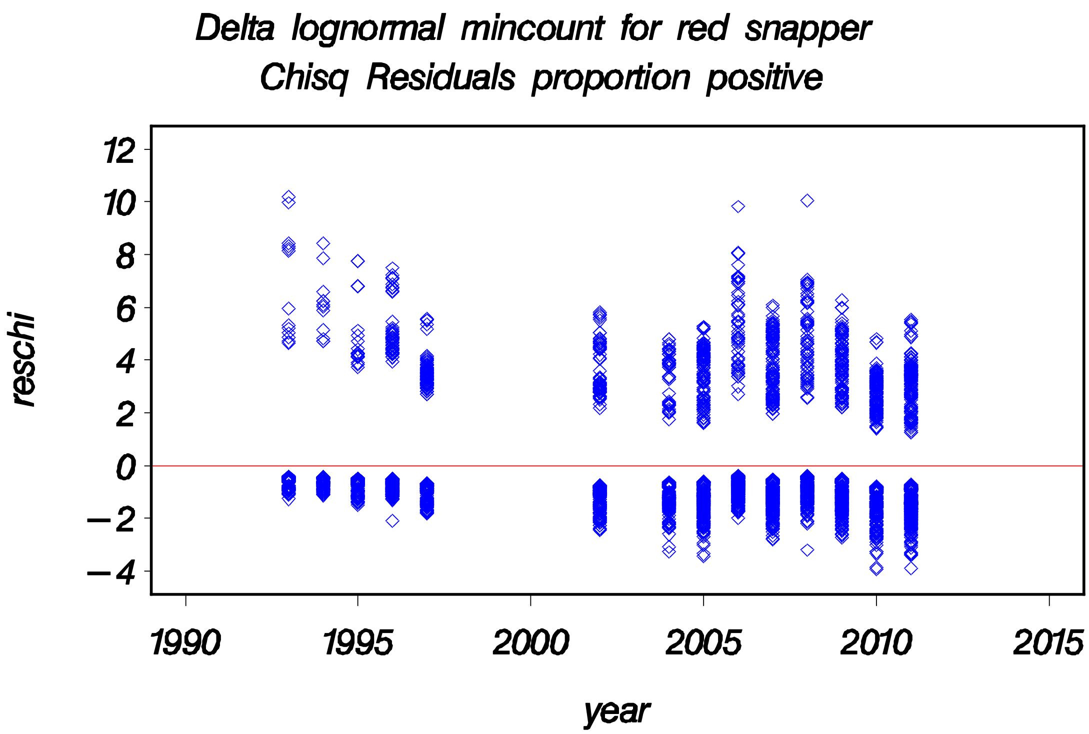

Table 4. GOM-wide red snapper lo and standardized index of abundance values by year design based model.

Year	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	159	0.20967	0.51427	0.079286	0.37815	0.24754	1.0684
1994	125	0.23845	0.58487	0.092332	0.38722	0.27695	1.23514
1995	230	0.20462	0.5019	0.051326	0.25083	0.30624	0.82257
1996	322	0.24199	0.59355	0.051993	0.21485	0.3881	0.90777
1997	297	0.52027	1.27611	0.084398	0.16222	0.92449	1.76148
2002	258	0.51478	1.26265	0.080064	0.15553	0.92682	1.72016
2004	198	0.54023	1.32506	0.095156	0.17614	0.93413	1.87959
2005	407	0.50115	1.22921	0.066427	0.13255	0.94405	1.6005
2006	418	0.22005	0.53973	0.045024	0.20461	0.35997	0.80924
2007	489	0.41428	1.01614	0.056484	0.13634	0.77459	1.33302
2008	309	0.23233	0.56985	0.05134	0.22098	0.36821	0.88189
2009	430	0.3526	0.86485	0.05222	0.1481	0.64417	1.16114
2010	329	0.76841	1.88474	0.091725	0.11937	1.48571	2.39094
2011	440	0.74897	1.83707	0.08251	0.11016	1.47478	2.28836

Table 5. Fit statistics (a), and type III tests (b) of the GLM on positive catches for the GOM-wide design based model.

a

Fit Statistics	
-2 Res Log Likelihood	2507.8
AIC (smaller is better)	2509.8
AICC (smaller is better)	2509.8
BIC (smaller is better)	2514.6

b

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	13	954	3.05	0.0002
zone	1	954	0.03	0.8563
depth	1	954	12.06	0.0005

Figure 21. GOM-wide observed versus standardized mincount for design based model.

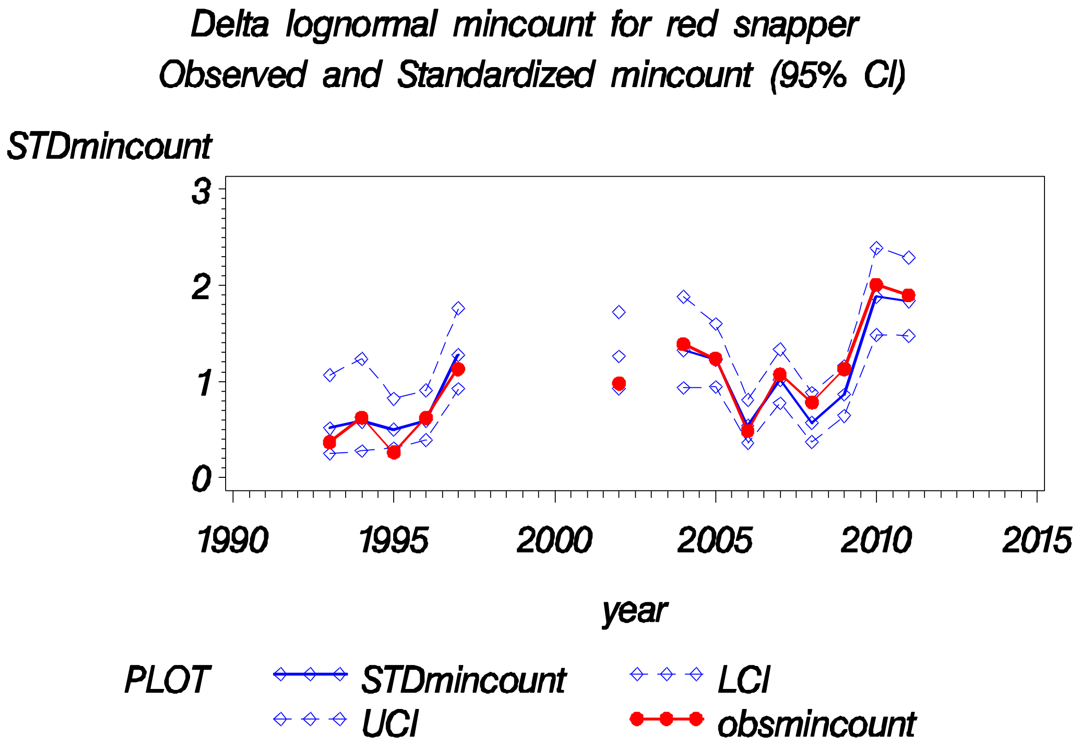

Figure 22. GOM-wide observed versus predicted mincount of positive data for design based model.

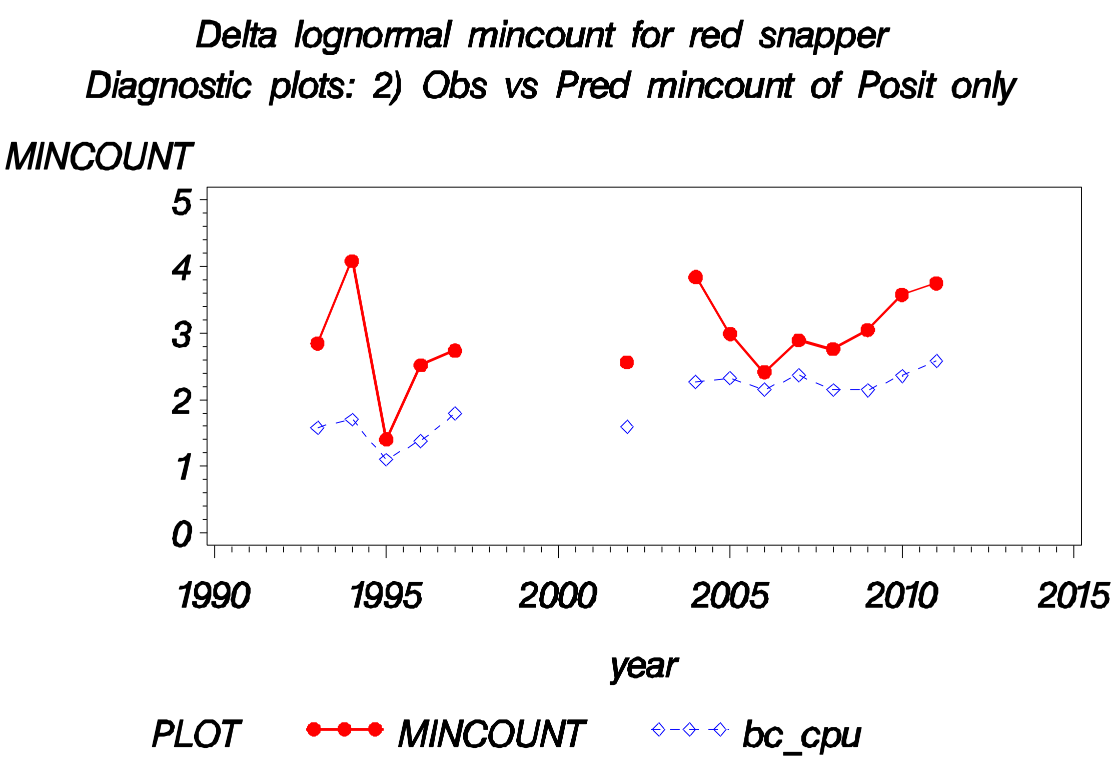

Figure 23. GOM-wide observed versus predicted mincount for design based model.

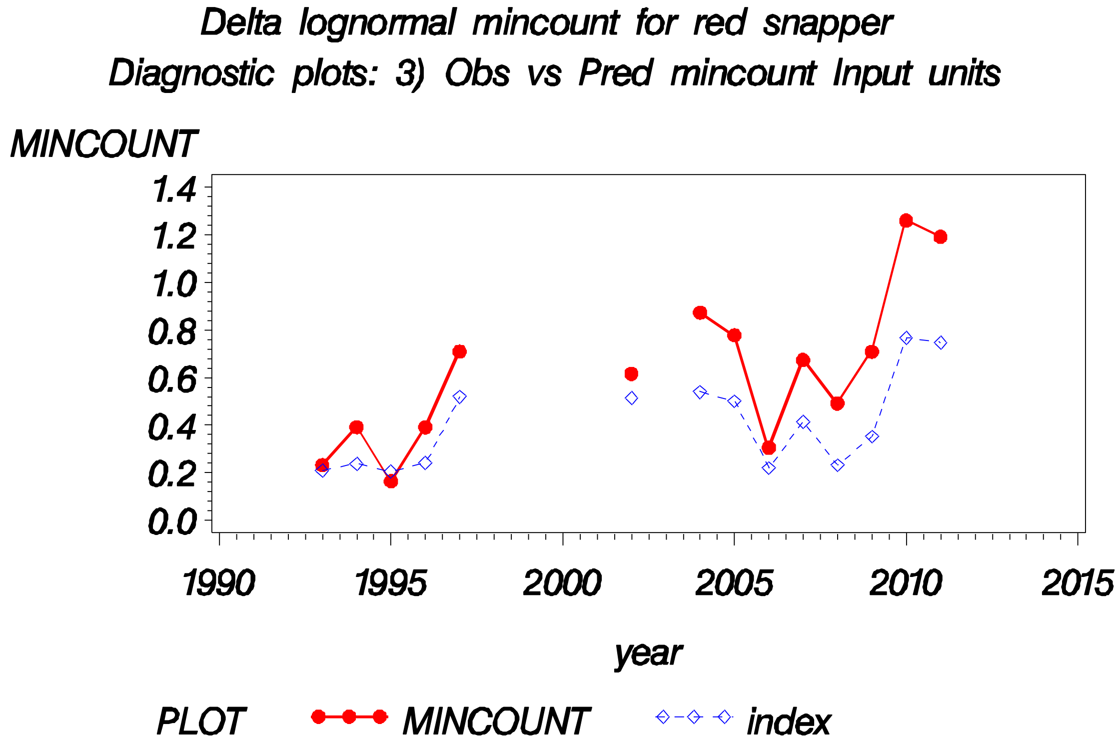

Figure 24. GOM wide residuals of positive mincounts by year for design based model.

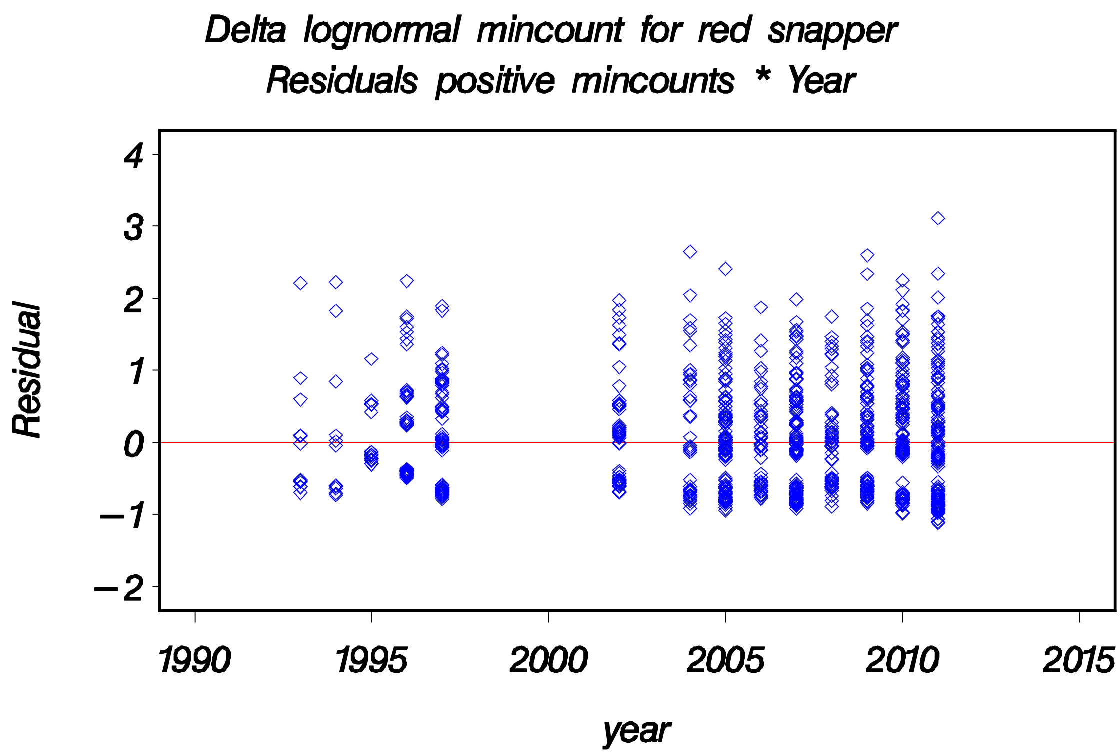

Figure 25 GOM-wide residuals distribution from positive mincount design based model.

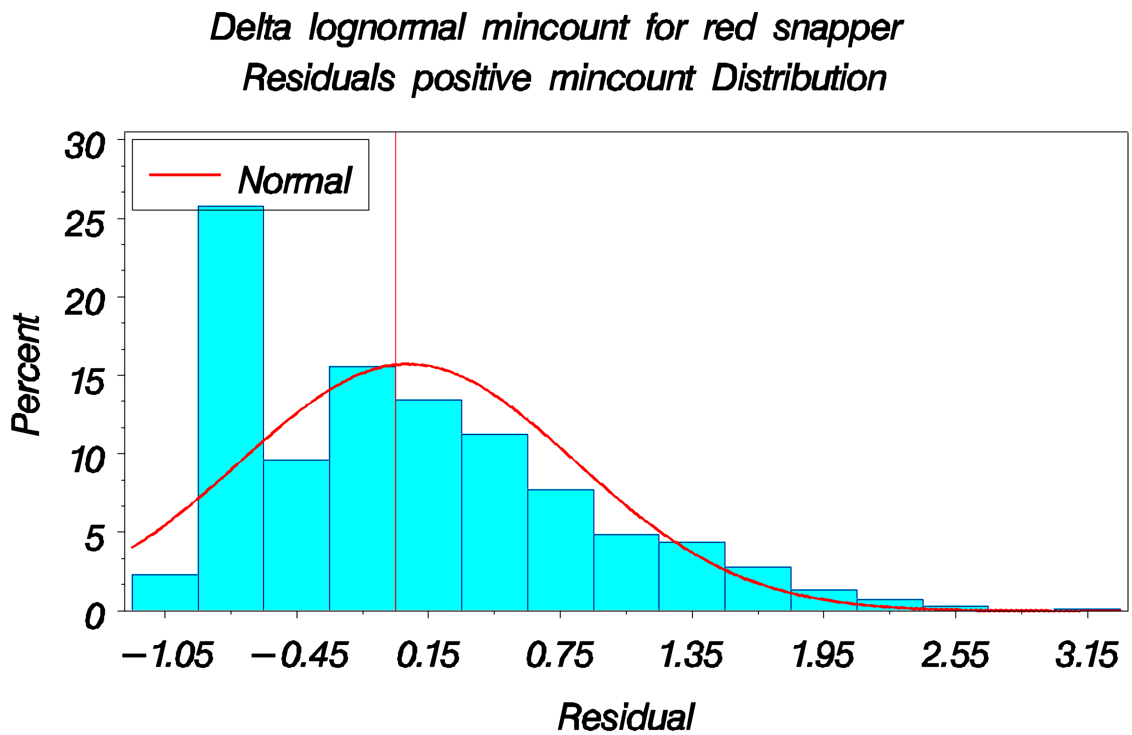

Figure 26 GOM-wide qqplot of residuals of positive mincounts from design based model.

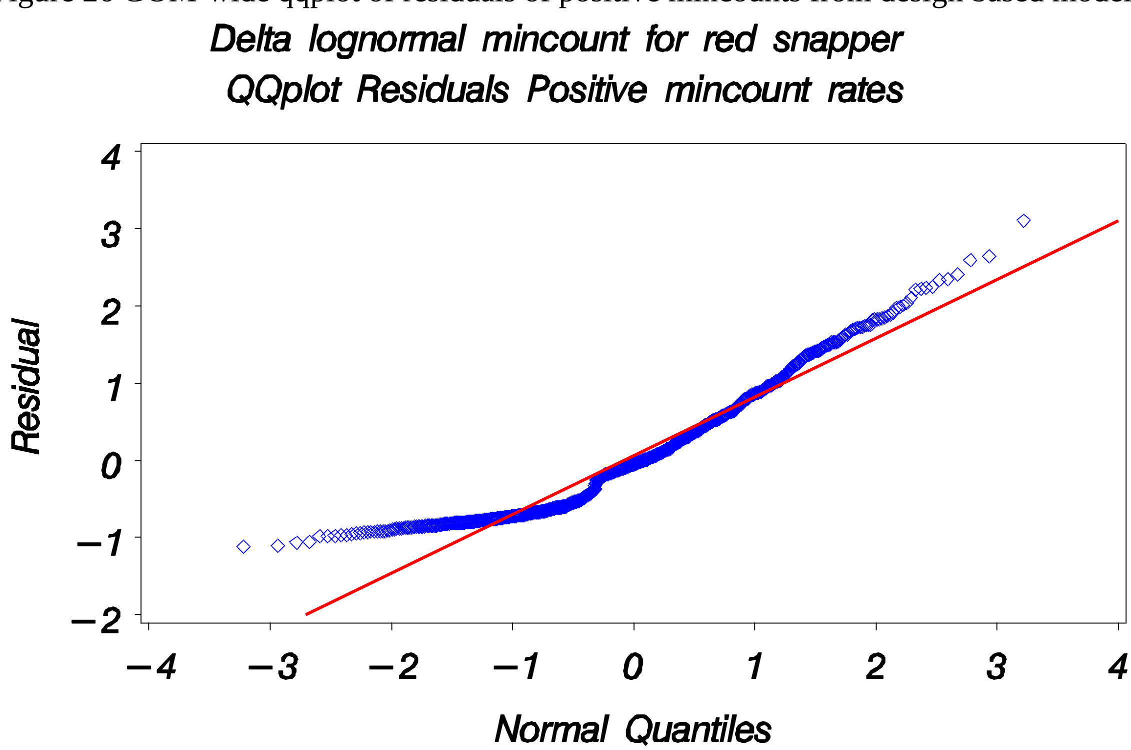

Table 6. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics of the GLIMMIX binomial on proportion positives for the east GOM model.

a

Iteration History

Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	13797.30604244	0.00000000

b

Fit Statistics

-2 Res Log Likelihood	13797.3
AIC (smaller is better)	13825.3
AICC (smaller is better)	13825.5
BIC (smaller is better)	13907.9

c

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	13	875	80.77	6.16	<.0001	<.0001
depth	1	1930	113.95	113.95	<.0001	<.0001

d

Description	*Value*
Deviance	684.1846
Scaled Deviance	1990.4576
Pearson Chi-Square	807.0360
Scaled Pearson Chi-Square	2347.8620
Extra-Dispersion Scale	0.3437

Figure 27. Observed versus predicted proportion positive from east GOM design based model.

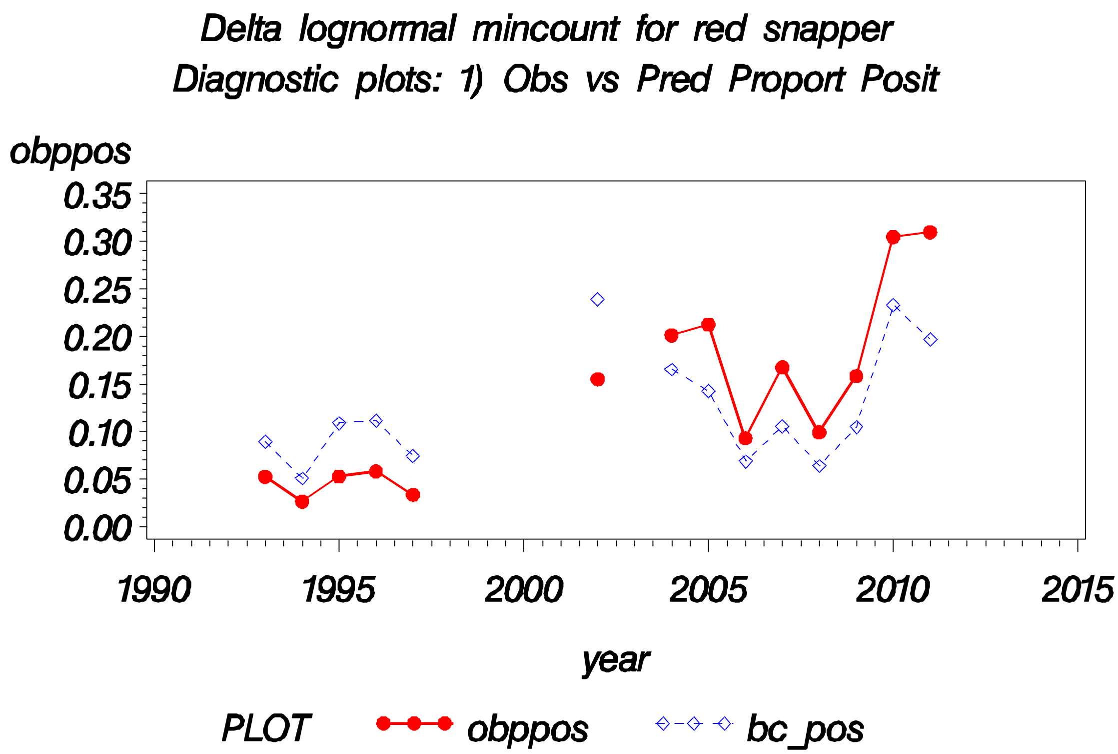

Figure 28. Chi-square residuals of proportion positives from east GOM design based model.

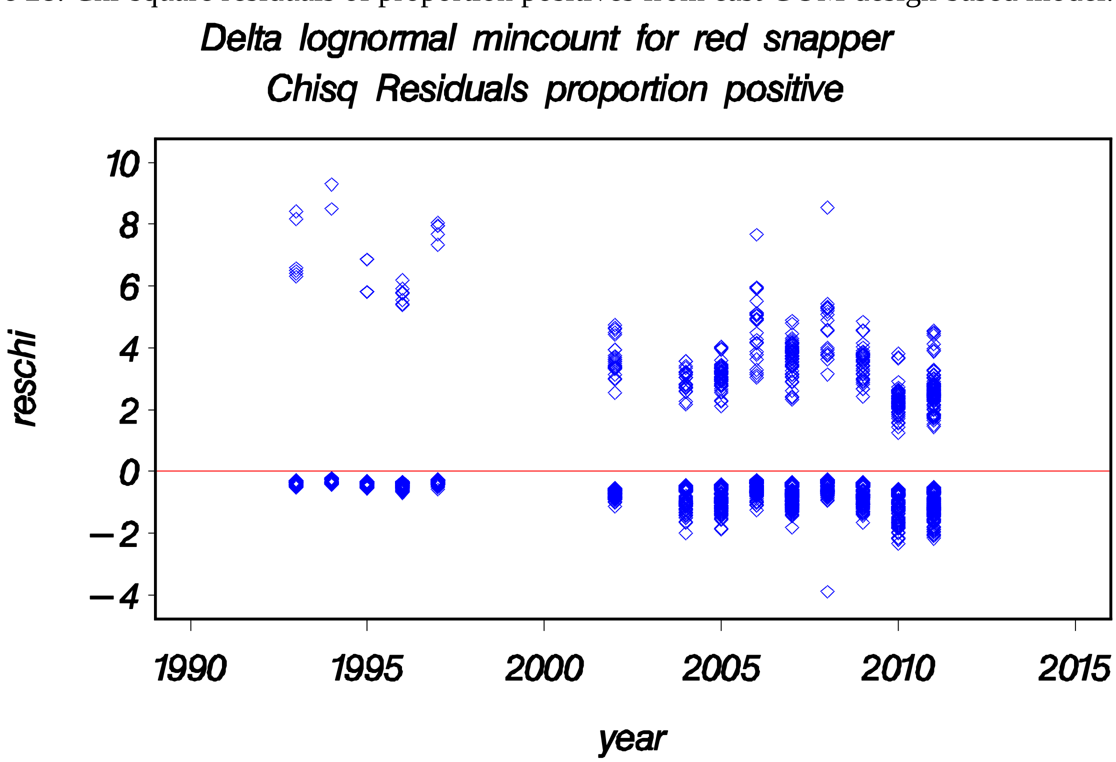

Table 7. East GOM red snapper lo and standardized index of abundance by year for design based model.

Year	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	114	0.11488	0.4397	0.064842	0.56443	0.15359	1.25874
1994	75	0.06248	0.23916	0.058254	0.9323	0.04917	1.16316
1995	151	0.09399	0.35977	0.041984	0.44667	0.1533	0.84428
1996	137	0.11507	0.44043	0.04905	0.42627	0.19452	0.9972
1997	148	0.16181	0.61932	0.087341	0.53978	0.22527	1.70268
2002	161	0.39263	1.50278	0.095485	0.24319	0.93044	2.42719
2004	149	0.41162	1.57546	0.090826	0.22066	1.01864	2.43665
2005	254	0.36563	1.39945	0.065864	0.18014	0.9789	2.00067
2006	268	0.1762	0.67442	0.045942	0.26073	0.40381	1.12638
2007	310	0.26069	0.99781	0.050659	0.19432	0.67892	1.46647
2008	171	0.1815	0.69469	0.061778	0.34038	0.35827	1.34702
2009	246	0.23474	0.89847	0.050221	0.21394	0.58851	1.37169
2010	197	0.53619	2.05228	0.088657	0.16535	1.4777	2.85027
2011	310	0.5503	2.10627	0.080644	0.14654	1.57363	2.8192

Table 8. Fit statistics (a), and type III tests (b) of the GLM on positive catches for the east GOM design based model.

a

Fit Statistics	
-2 Res Log Likelihood	1033.2
AIC (smaller is better)	1035.2
AICC (smaller is better)	1035.2
BIC (smaller is better)	1039.2

b

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	13	412	2.11	0.0128
depth	1	412	4.59	0.0327

Figure 29. Observed and standardized mincounts from east GOM design based model.

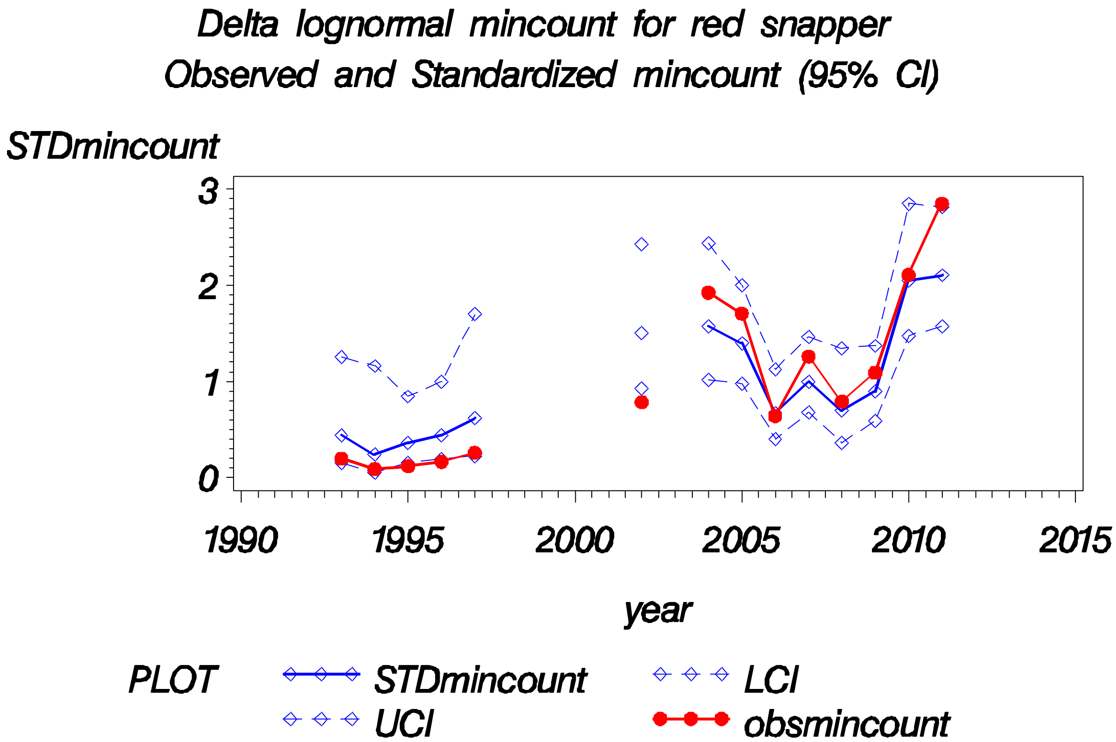

Figure 30. Observed versus predicted mincounts from east GOM design based model.

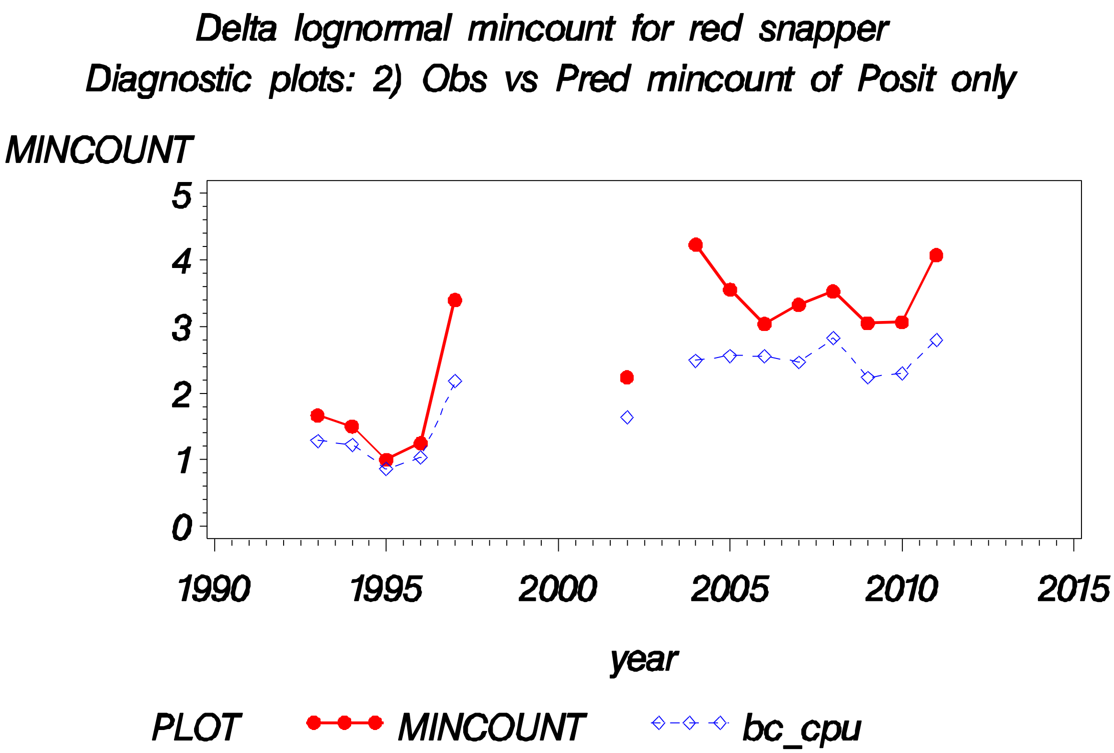

Figure 31. Observed versus predicted mincounts from east GOM design based models

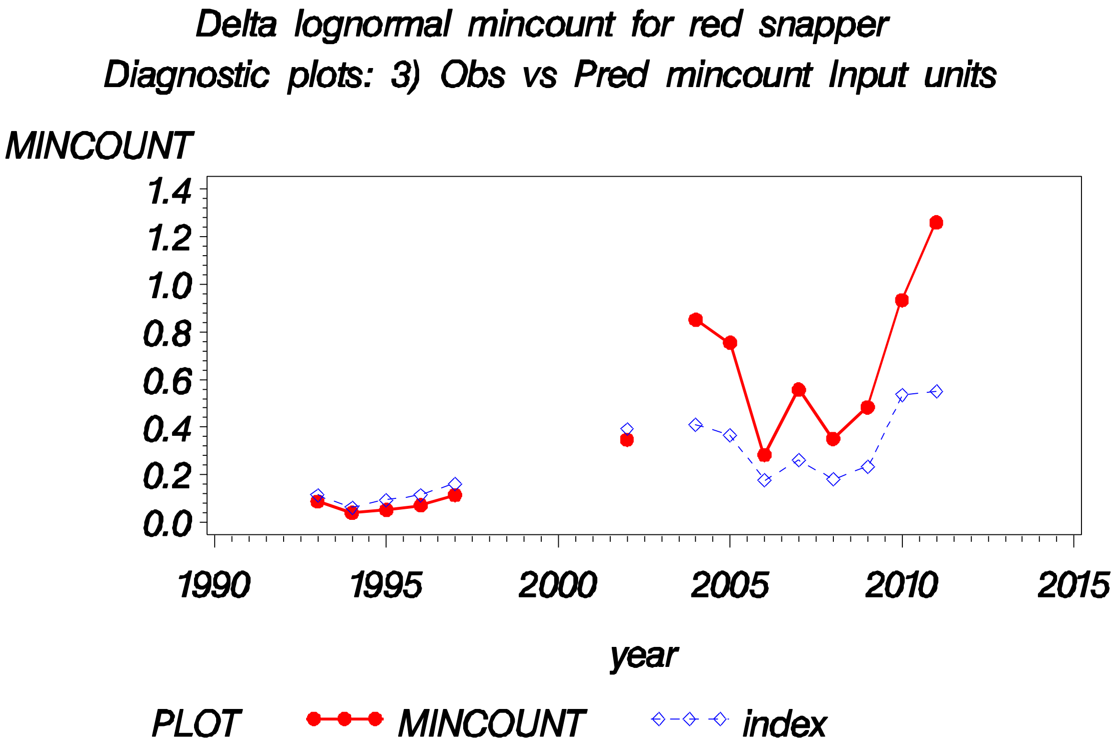

Figure 32 Residuals of positive mincounts for east GOM design based model.

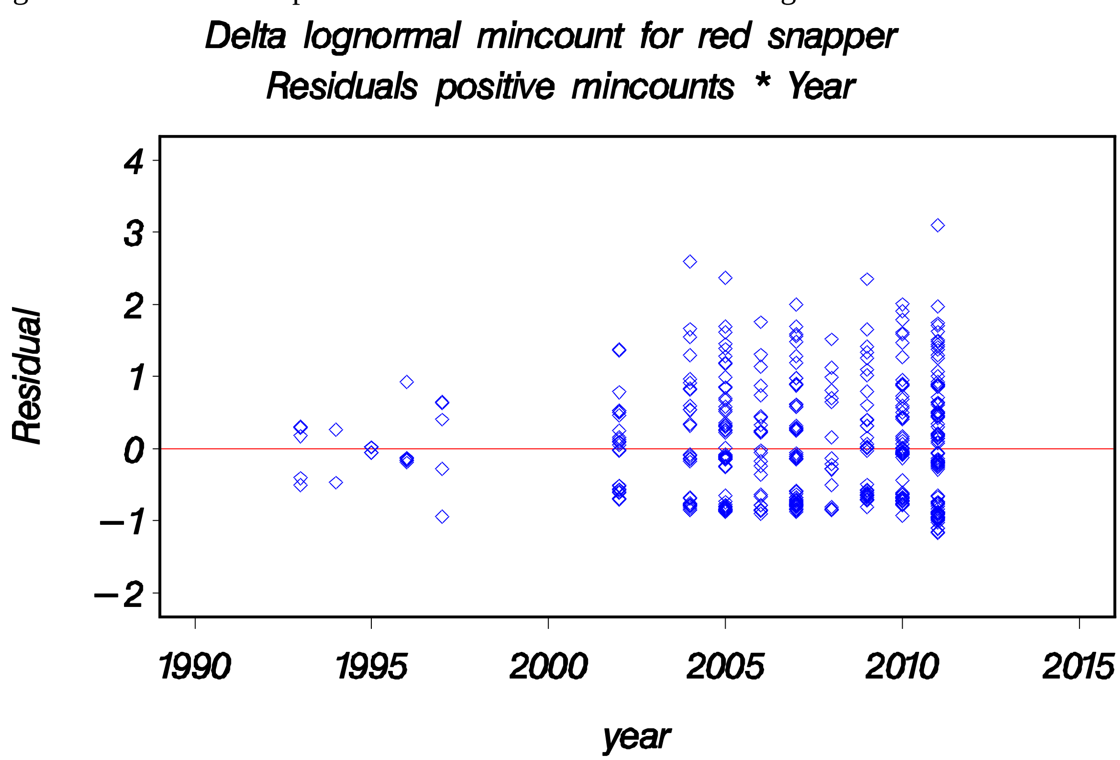

Figure 33. Positive mincount distribution from east GOM design based model.

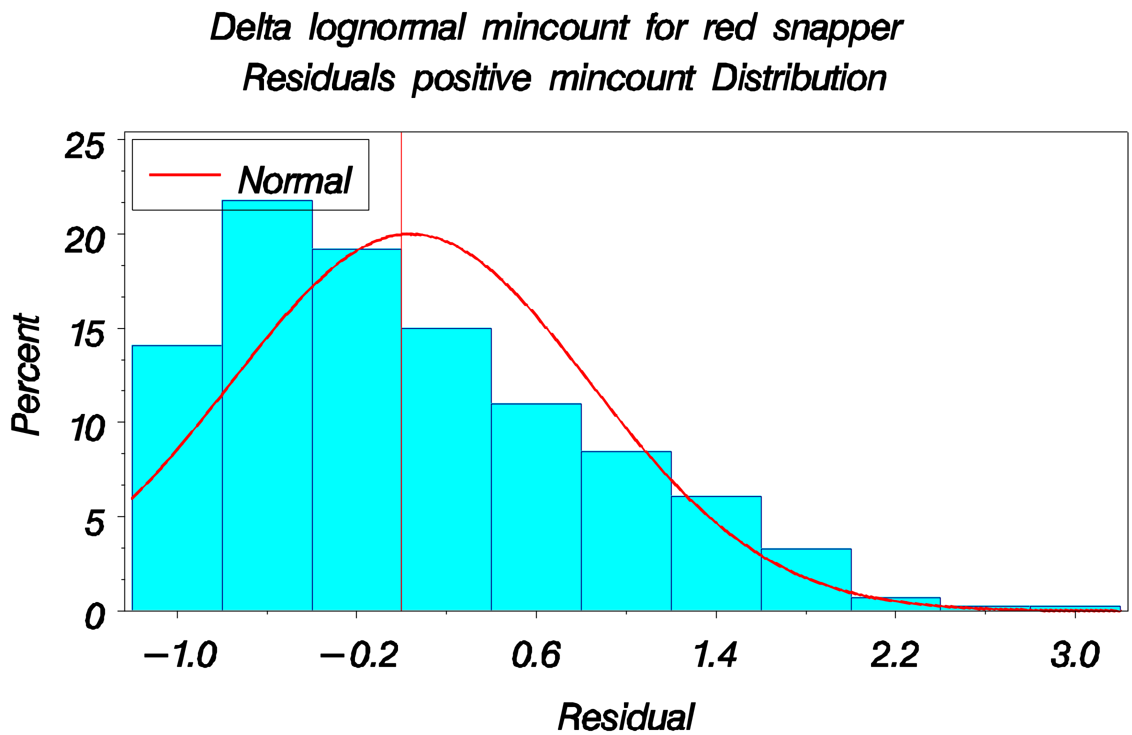

Figure 34. QQ plot of positive mincounts from east GOM design based model.

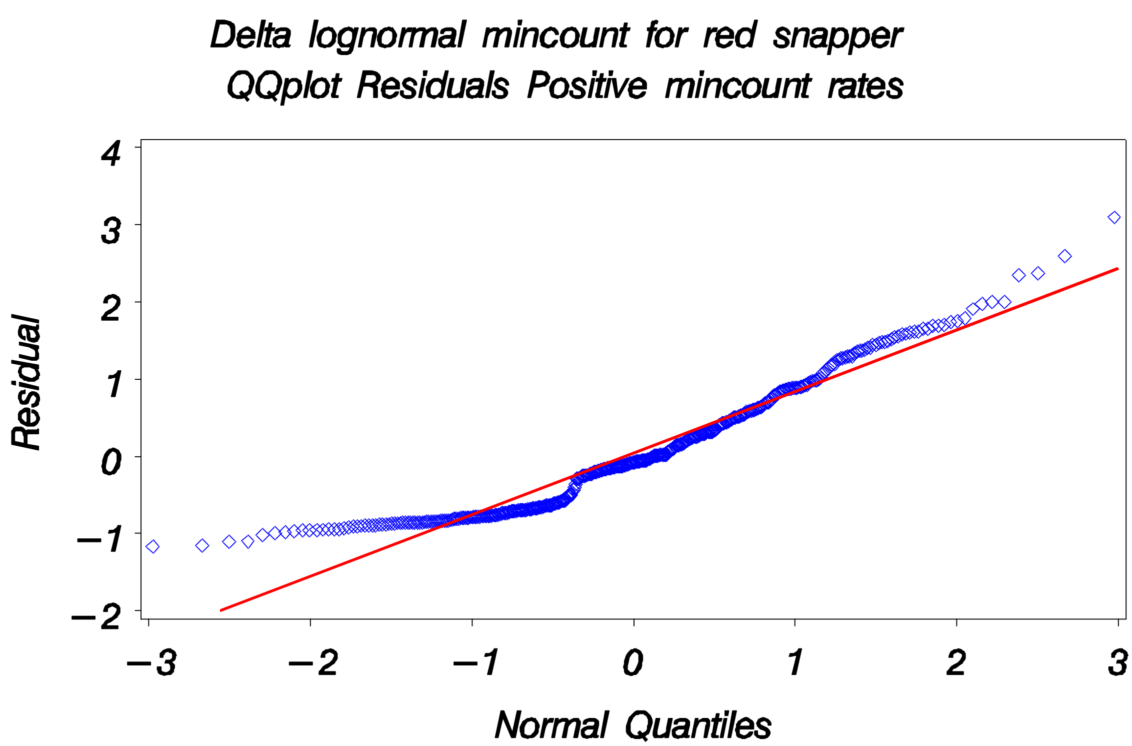

Table 9. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics of the GLIMMIX binomial on proportion positives for the west GOM model.

a

Iteration History			
Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	7112.76125721	0.00000000

b

Fit Statistics	
-2 Res Log Likelihood	7112.8
AIC (smaller is better)	7140.8
AICC (smaller is better)	7141.0
BIC (smaller is better)	7215.5

c

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	13	463	71.29	5.39	<.0001	<.0001
depth	1	1191	5.72	5.72	0.0167	0.0169

d

Description	*Value*
Deviance	819.0246
Scaled Deviance	1751.3653
Pearson Chi-Square	684.1130
Scaled Pearson Chi-Square	1462.8763
Extra-Dispersion Scale	0.4676

Figure 35. Observed versus predicted proportion positive from west GOM design based model.

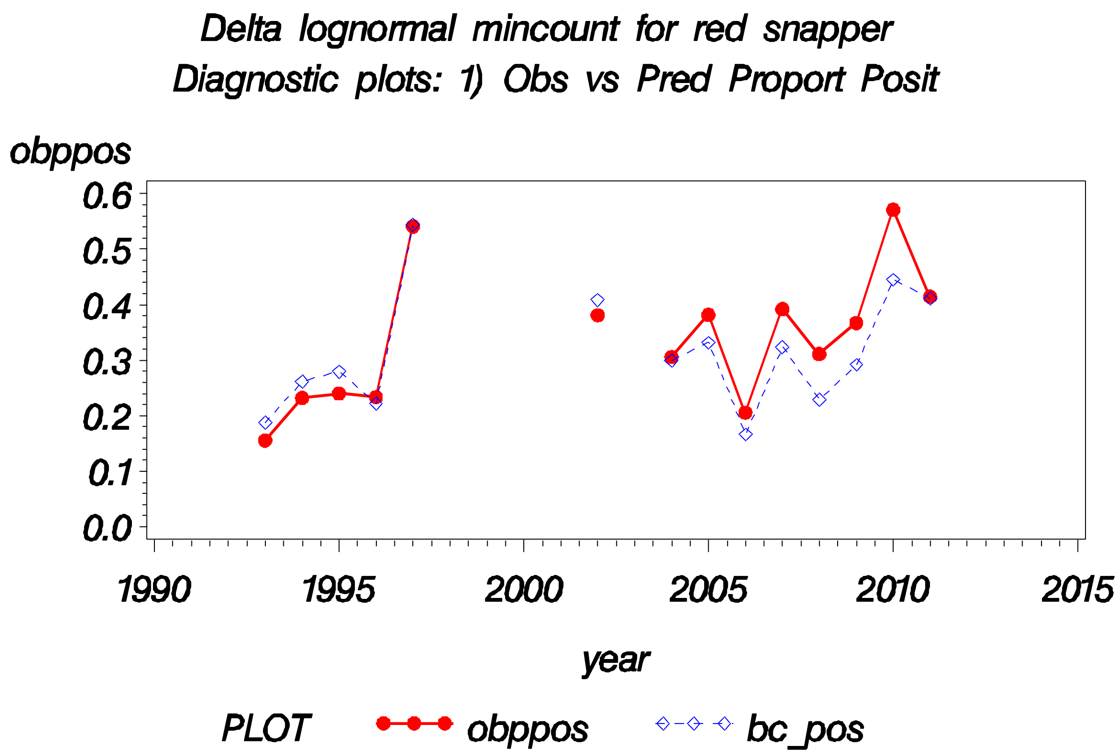

Figure 36. Chi-square residuals of proportion postives of west GOM design based model.

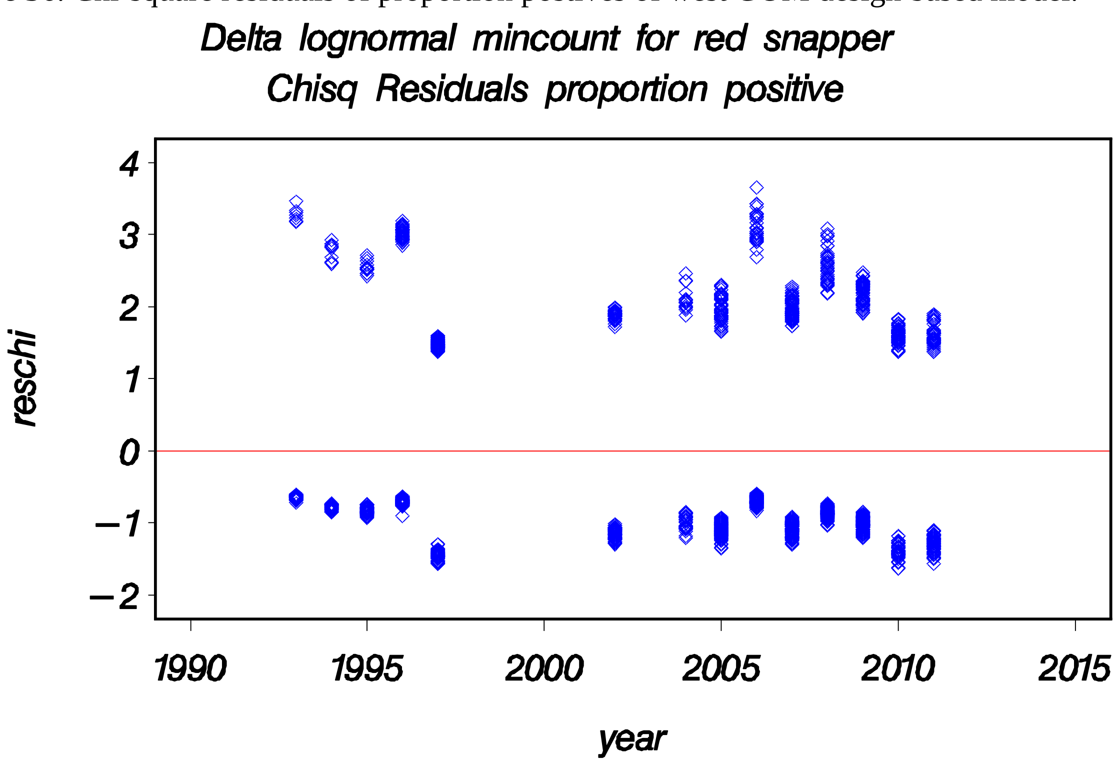

Table 10. West GOM red snapper Lo and standardized index of abundance by year for design based model.

Year	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	45	0.40422	0.61146	0.18653	0.46146	0.25394	1.47233
1994	43	0.53307	0.80638	0.20841	0.39096	0.37928	1.71443
1995	79	0.39582	0.59876	0.11036	0.2788	0.34643	1.03491
1996	171	0.39036	0.5905	0.09221	0.23621	0.37053	0.94105
1997	133	1.0229	1.54734	0.14198	0.13881	1.1738	2.03974
2002	97	0.70069	1.05993	0.13077	0.18663	0.73208	1.53461
2004	49	0.60728	0.91864	0.17917	0.29504	0.51547	1.63714
2005	136	0.7256	1.09762	0.12643	0.17424	0.77668	1.55118
2006	136	0.28464	0.43057	0.08142	0.28605	0.24573	0.75446
2007	158	0.79635	1.20463	0.13151	0.16514	0.86773	1.67235
2008	122	0.40457	0.612	0.09745	0.24087	0.38061	0.98407
2009	166	0.6521	0.98643	0.11332	0.17378	0.69863	1.39279
2010	98	1.34125	2.02892	0.2309	0.17215	1.44154	2.85564
2011	106	0.99611	1.50682	0.16627	0.16692	1.08162	2.09918

Table 11. Fit statistics (a), and type III tests (b) of the GLM on positive catches for the west GOM design based model.

a

Fit Statistics	
-2 Res Log Likelihood	1360.0
AIC (smaller is better)	1362.0
AICC (smaller is better)	1362.0
BIC (smaller is better)	1366.2

b

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	13	524	2.28	0.0064
depth	1	524	5.76	0.0168

Figure 37. Observed and standardized mincounts from west GOM design based model.

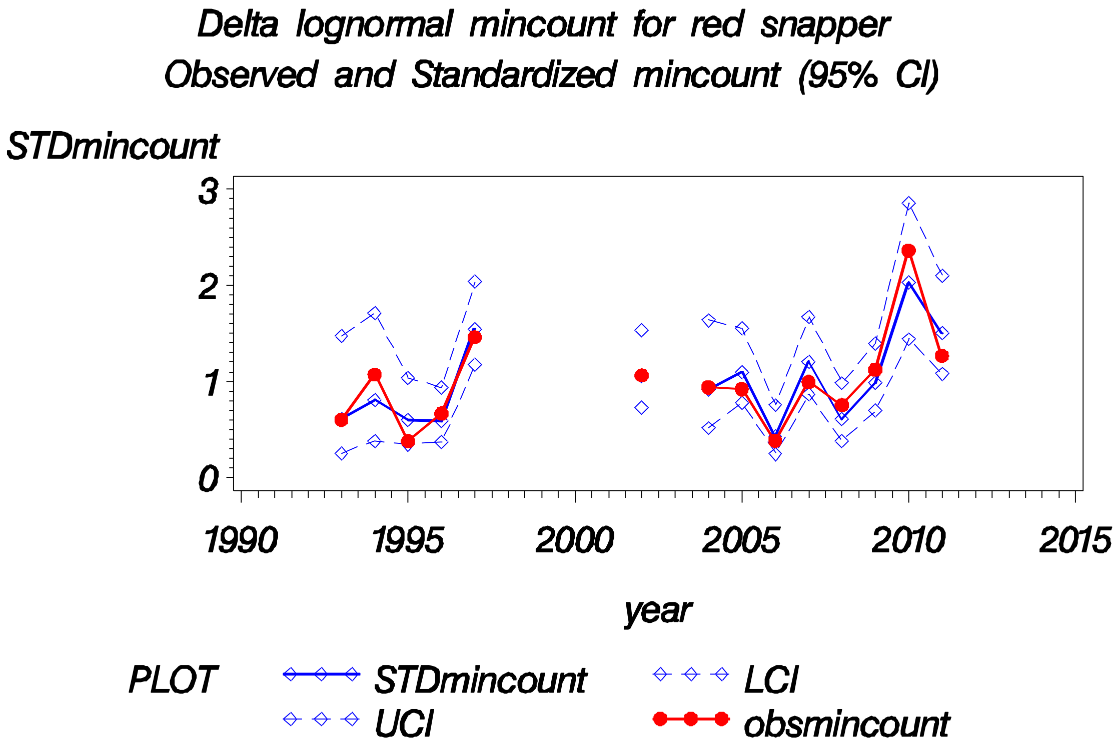

Figure 38. Observed versus predicted mincounts of positive data from west GOM design based model.

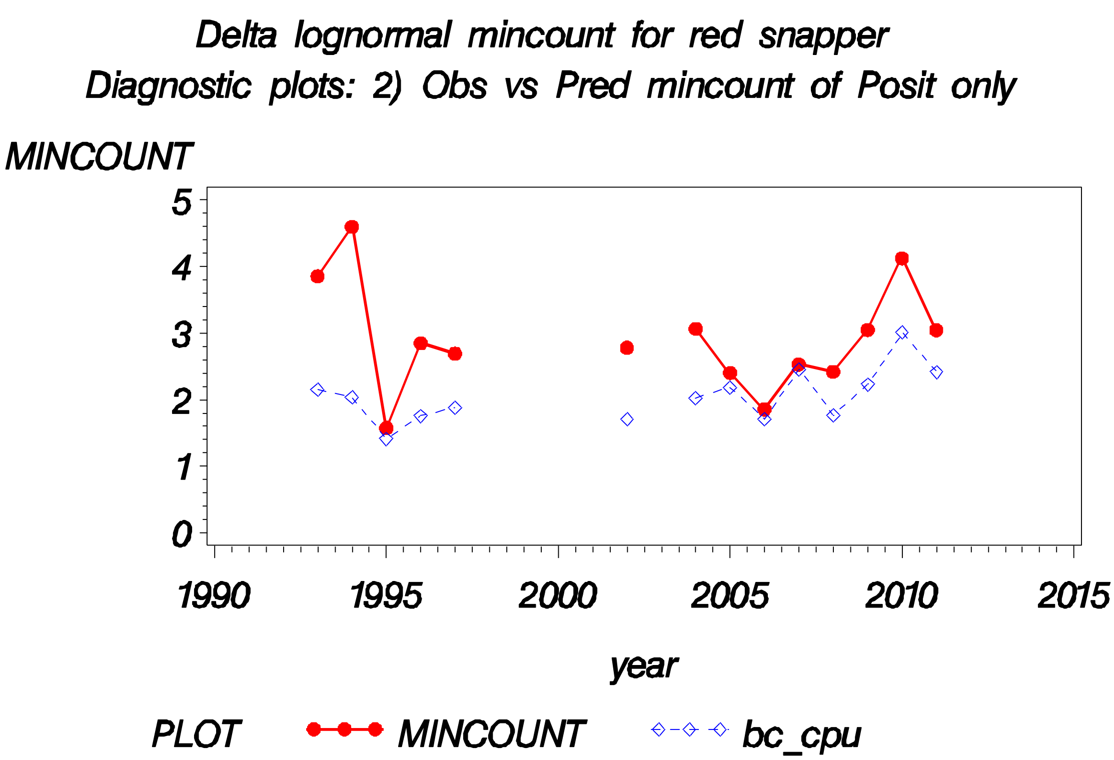

Figure 39. Observed versus predicted mincounts of west GOM design based model.

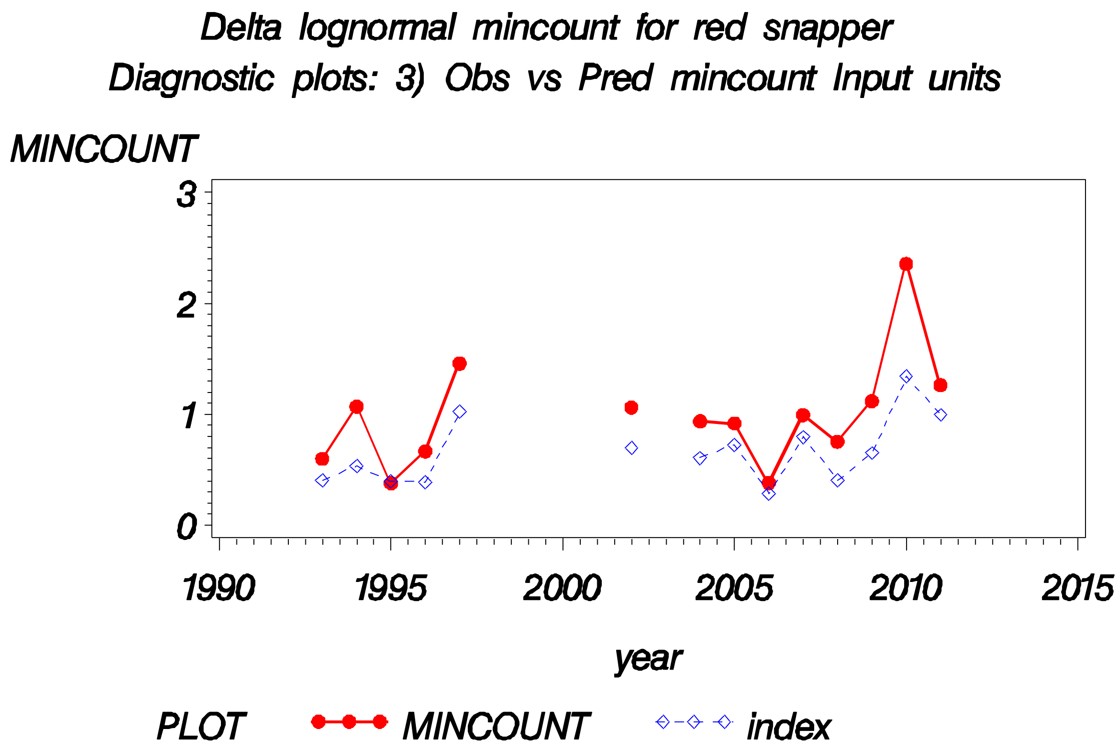

Figure 40. Residuals of positive mincounts for west GOM design based model.

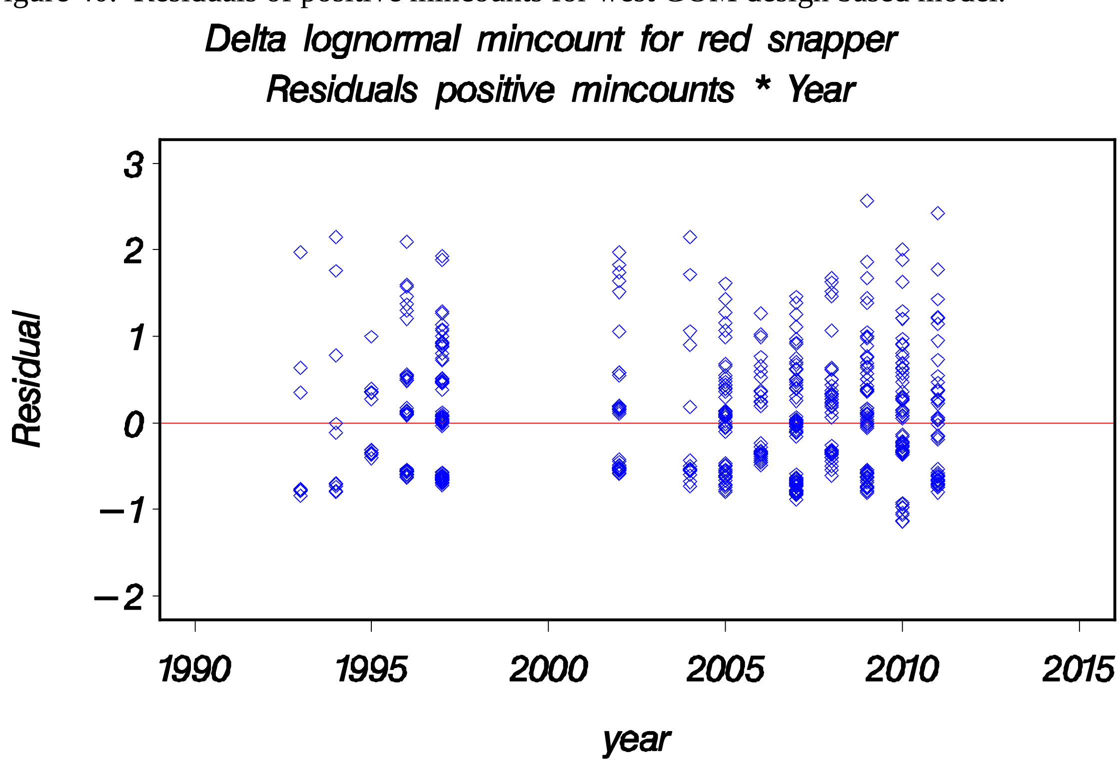

Figure 41. Positive mincount distribution of residuals for west GOM design based model.

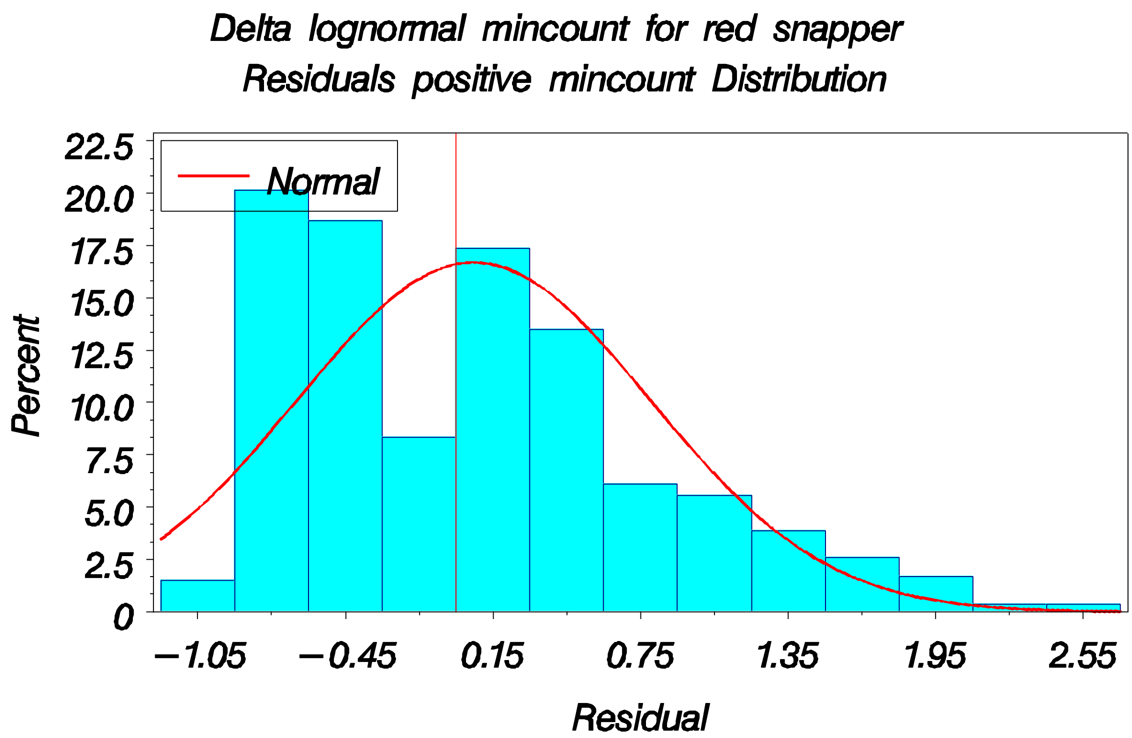

Figure 42. QQ plot of positive mincounts for west GOM design based model.

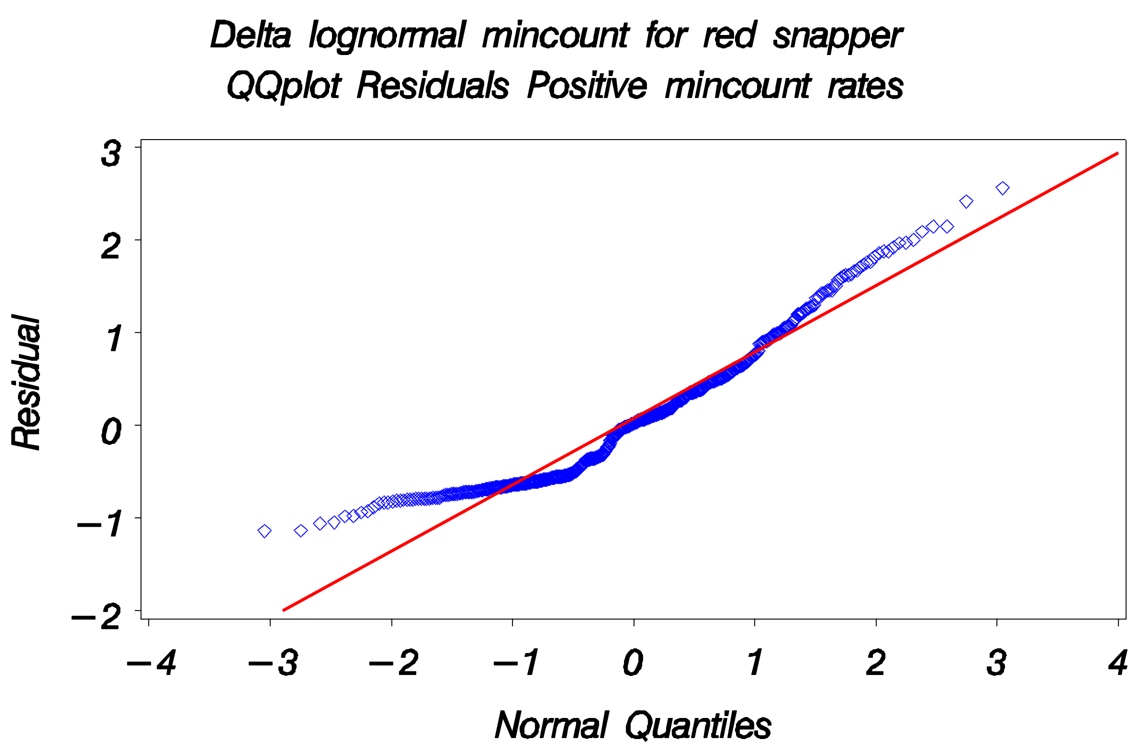

Table 12. GOM wide red snapper Lo and standardized index of abundance by year for model based runs.

Survey Year	Frequency	N	Lo Index	Scaled Index	CV	LCL	UCL
1993	0.08929	168	0.07873	0.36992	0.70235	0.10425	1.31259
1994	0.08451	142	0.07169	0.33683	0.84613	0.07747	1.46442
1995	0.10266	263	0.06264	0.29435	0.67252	0.08675	0.99872
1996	0.15528	322	0.07598	0.35701	0.57243	0.12310	1.03537
1997	0.25926	297	0.19372	0.91024	0.41834	0.40770	2.03222
2001	0.23750	80	0.24015	1.12841	0.48343	0.45124	2.82180
2002	0.23596	267	0.22808	1.07168	0.38202	0.51225	2.24207
2004	0.22500	200	0.22032	1.03523	0.40298	0.47654	2.24893
2005	0.25791	411	0.26298	1.23565	0.34377	0.63328	2.41100
2006	0.12679	418	0.11511	0.54089	0.47013	0.22129	1.32206
2007	0.23313	489	0.24803	1.16544	0.34914	0.59144	2.29651
2008	0.16587	416	0.16659	0.78275	0.41933	0.34998	1.75064
2009	0.21535	469	0.25851	1.21468	0.35083	0.61452	2.40097
2010	0.33623	345	0.46882	2.20285	0.30357	1.21646	3.98906
2011	0.30769	455	0.50100	2.35407	0.28695	1.34119	4.13189

Figure 43. Model based GOM-wide standardized versus observed mincounts.

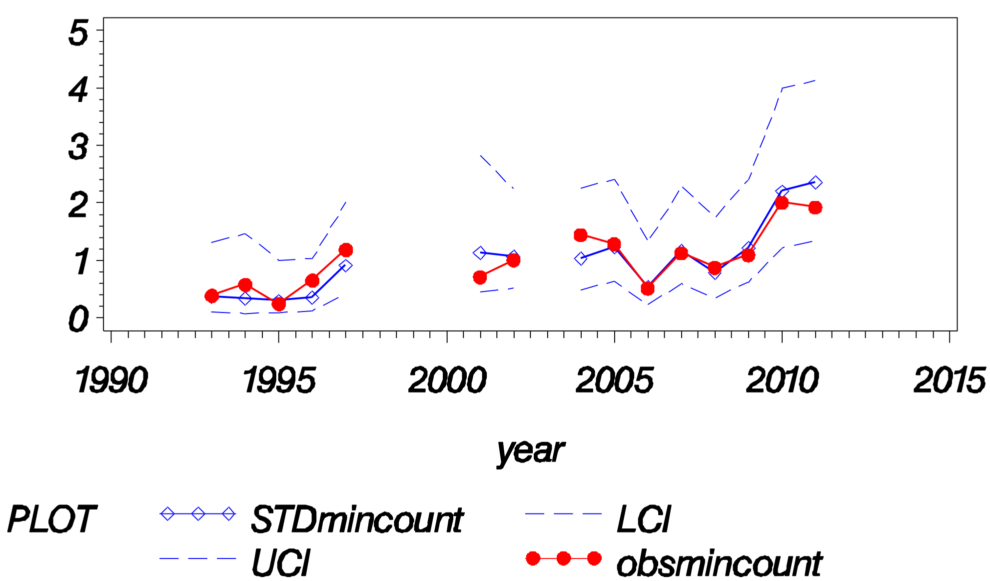

Table 13. West GOM red snapper Lo and standardized index of abundance by year for model based runs.

Survey Year	Frequency	N	Lo Index	Scaled Index	CV	LCL	UCL
1993	0.17021	47	0.32502	0.55434	0.46715	0.22797	1.34800
1994	0.22222	45	0.40985	0.69902	0.41710	0.31378	1.55724
1995	0.22892	83	0.31509	0.53741	0.29894	0.29936	0.96476
1996	0.23392	171	0.32834	0.55999	0.24919	0.34276	0.91490
1997	0.54135	133	0.88256	1.50526	0.15520	1.10561	2.04936
2001	0.28889	45	0.41267	0.70384	0.35269	0.35486	1.39599
2002	0.38144	97	0.54674	0.93250	0.22054	0.60306	1.44191
2004	0.30000	50	0.55731	0.95052	0.29913	0.52927	1.70702
2005	0.38235	136	0.66606	1.13601	0.17575	0.80148	1.61017
2006	0.20588	136	0.27406	0.46743	0.29992	0.25990	0.84069
2007	0.39241	158	0.76710	1.30833	0.16188	0.94846	1.80474
2008	0.28467	137	0.40156	0.68489	0.23416	0.43146	1.08718
2009	0.35028	177	0.64564	1.10117	0.17019	0.78538	1.54394
2010	0.53333	105	1.30970	2.23376	0.18087	1.56025	3.19800
2011	0.40367	109	0.95308	1.62553	0.16231	1.17741	2.24421

Figure 44. Model based west GOM standardized versus observed mincounts.

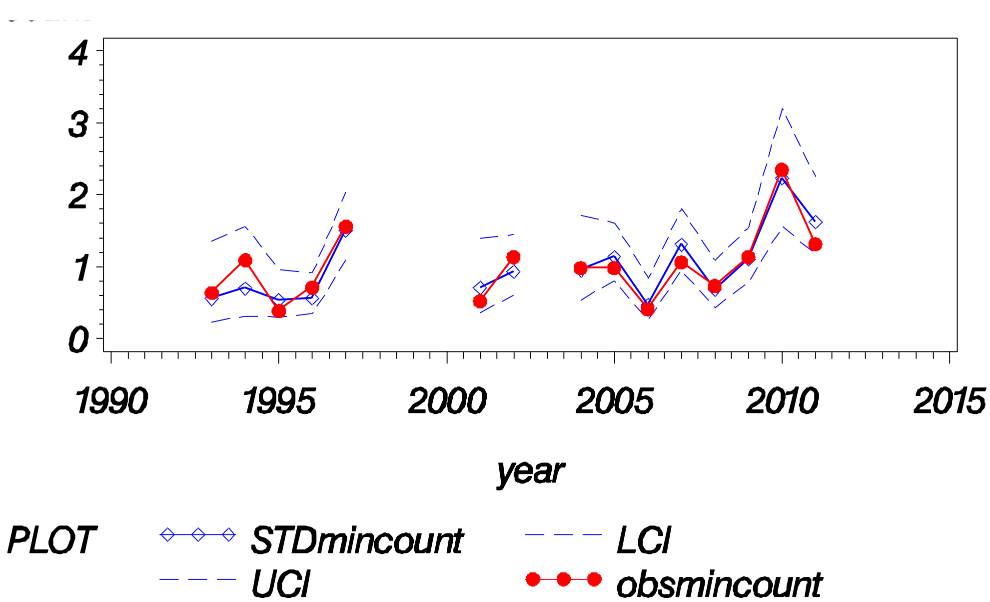

Table 14. East GOM red snapper Lo and standardized index of abundance by year for model based runs.

Survey Year	Frequency	N	Lo Index	Scaled Index	CV	LCL	UCL
1993	0.05785	121	0.01032	0.14507	2.28759	0.00970	2.17045
1994	0.02062	97	0.00288	0.04046	6.26370	0.00087	1.89067
1995	0.04444	180	0.00302	0.04240	4.16360	0.00140	1.28472
1996	0.06623	151	0.00720	0.10113	2.56188	0.00588	1.73942
1997	0.03049	164	0.00861	0.12102	2.71622	0.00655	2.23463
2002	0.15294	170	0.07411	1.04138	0.80026	0.25499	4.25291
2004	0.20000	150	0.07826	1.09977	0.77984	0.27708	4.36508
2005	0.19636	275	0.10491	1.47423	0.67608	0.43216	5.02901
2006	0.08865	282	0.04482	0.62979	0.92859	0.13010	3.04874
2007	0.15710	331	0.07977	1.12090	0.72005	0.30775	4.08259
2008	0.10753	279	0.07523	1.05708	0.80929	0.25563	4.37123
2009	0.13356	292	0.10527	1.47920	0.69914	0.41887	5.22366
2010	0.25000	240	0.17141	2.40863	0.61045	0.78150	7.42349
2011	0.27746	346	0.23050	3.23892	0.56357	1.13300	9.25916

Figure 45. Model based east GOM standardized versus observed mincounts.

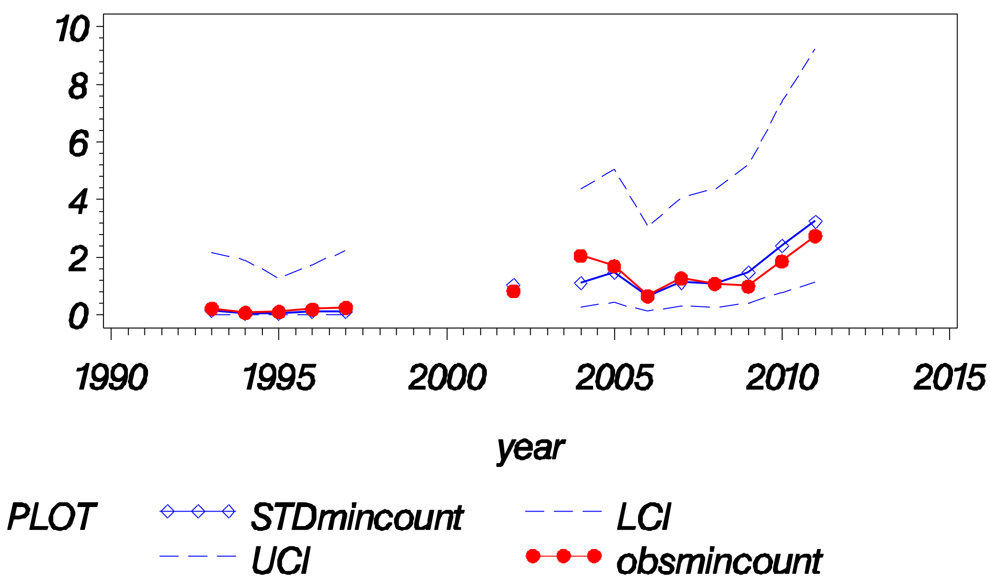

Figure 46. Red snapper length frequency of fish measured from video with lasers in 1995.

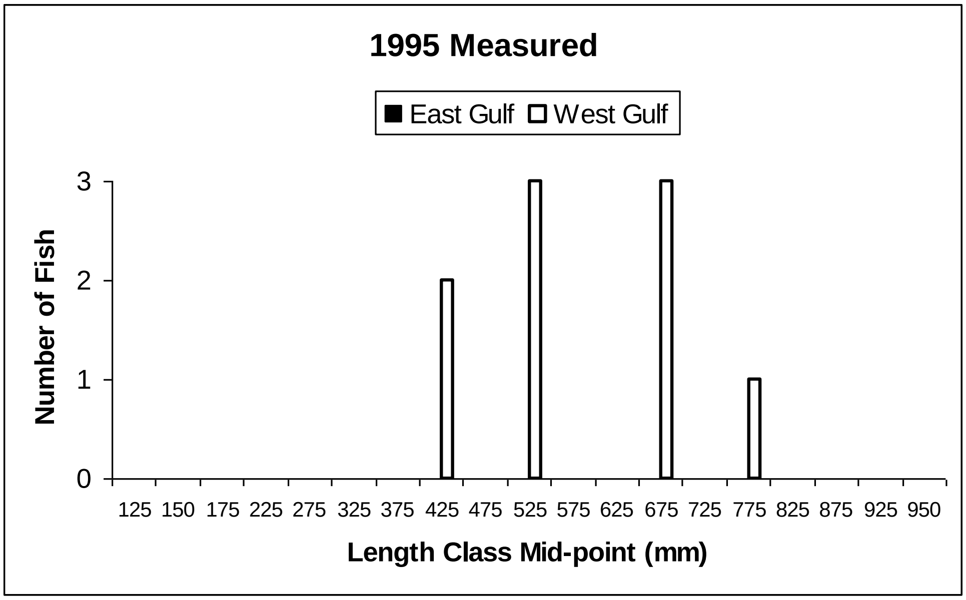

Figure 47. Red snapper length frequency of fish measured from video with lasers in 1996.

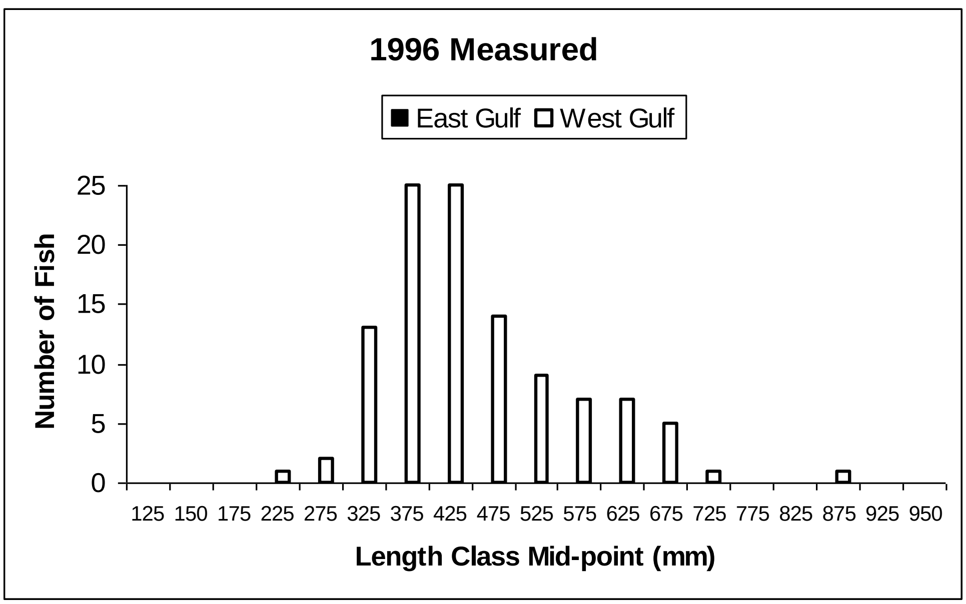

Figure 48. Red snapper length frequency of fish measured from video with lasers in 1997.

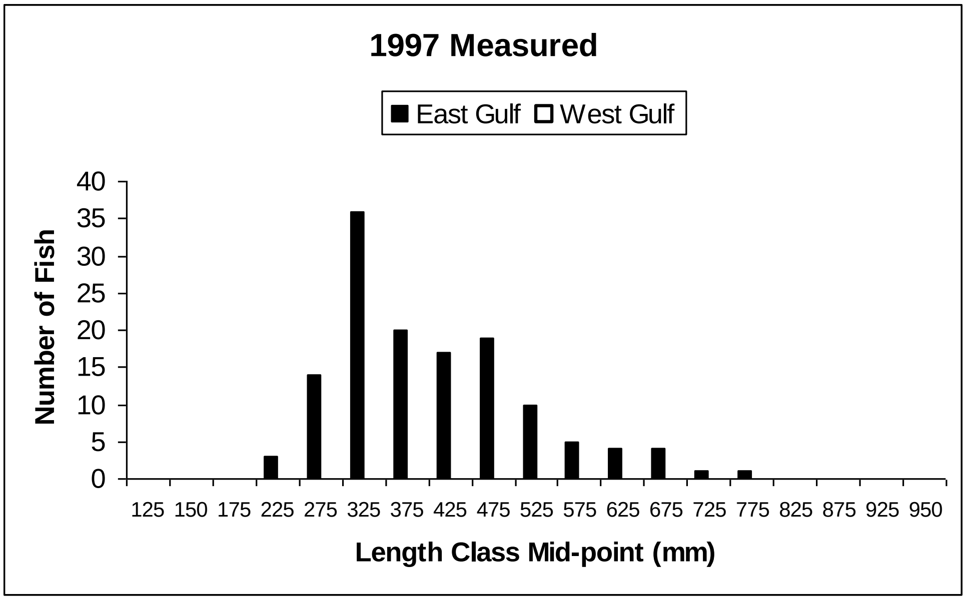

Figure 49. Red snapper length frequency of fish measured from video with lasers in 2001.

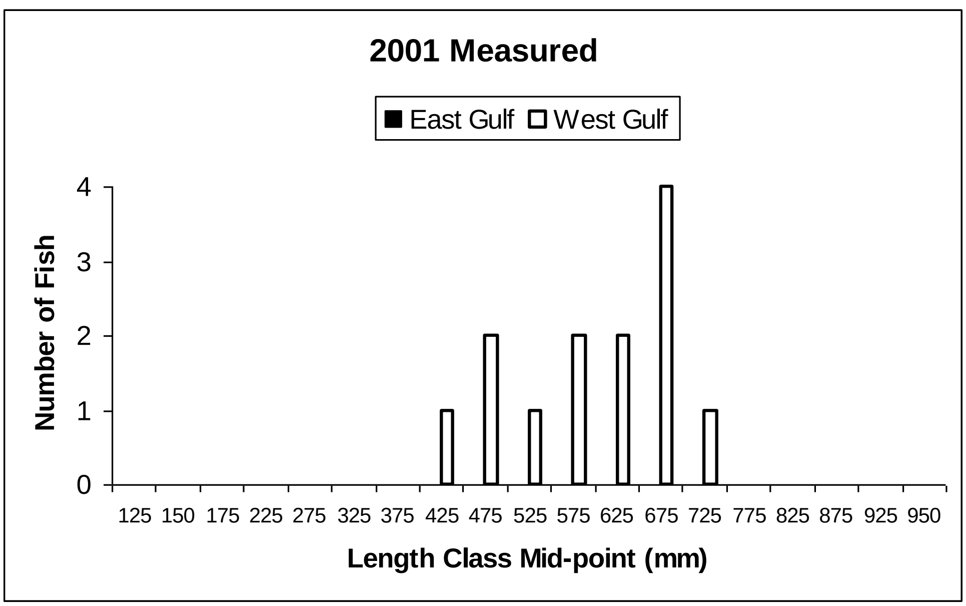

Figure 50. Red snapper length frequency of fish measured from video with lasers in 2002.

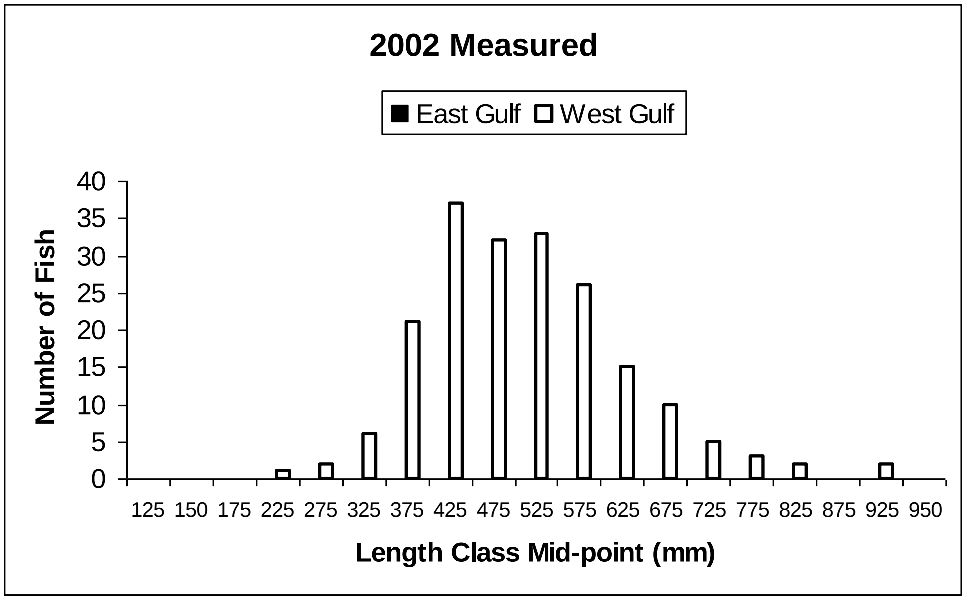

Figure 51. Red snapper length frequency of fish measured from video with lasers in 2004.

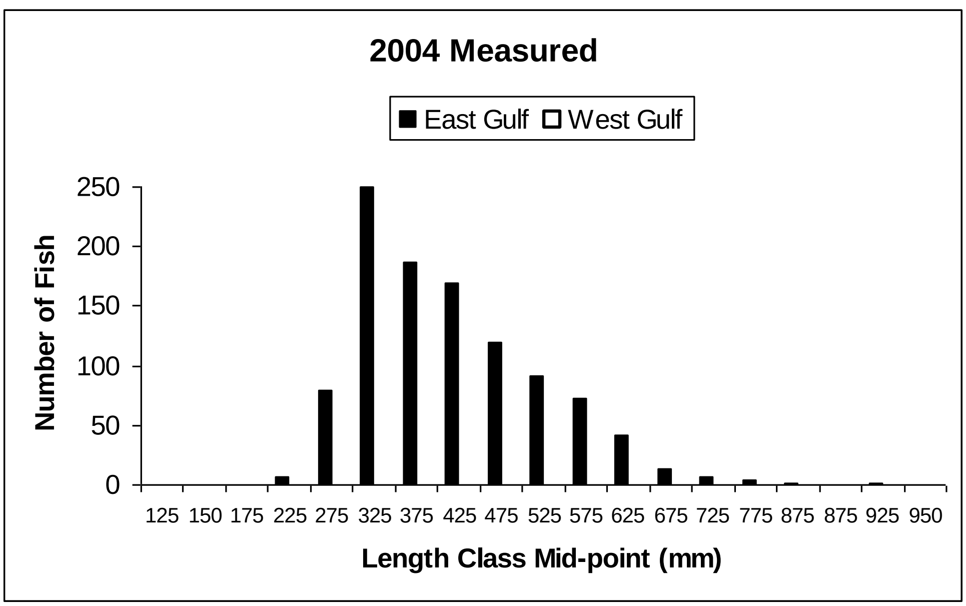

Figure 52. Red snapper length frequency of fish measured from video with lasers in 2005.

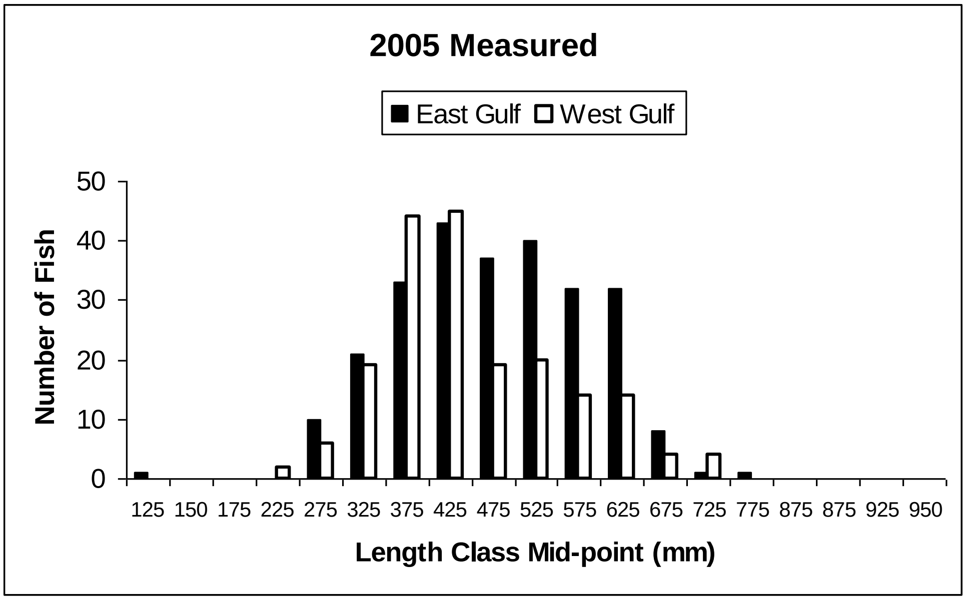

Figure 53. Red snapper length frequency of fish measured from video with lasers in 2006.

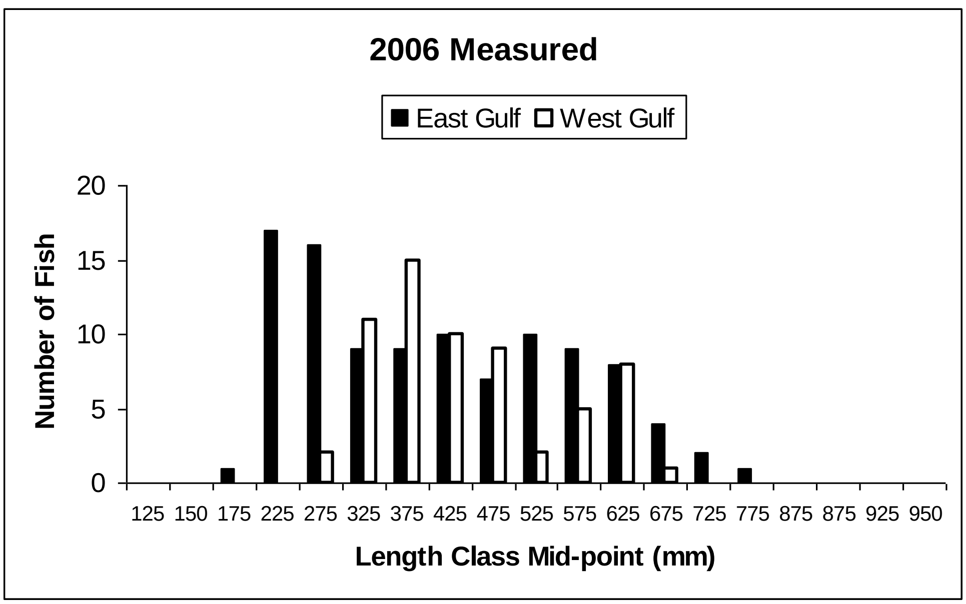

Figure 54. Red snapper length frequency of fish measured from video with lasers in 2007.

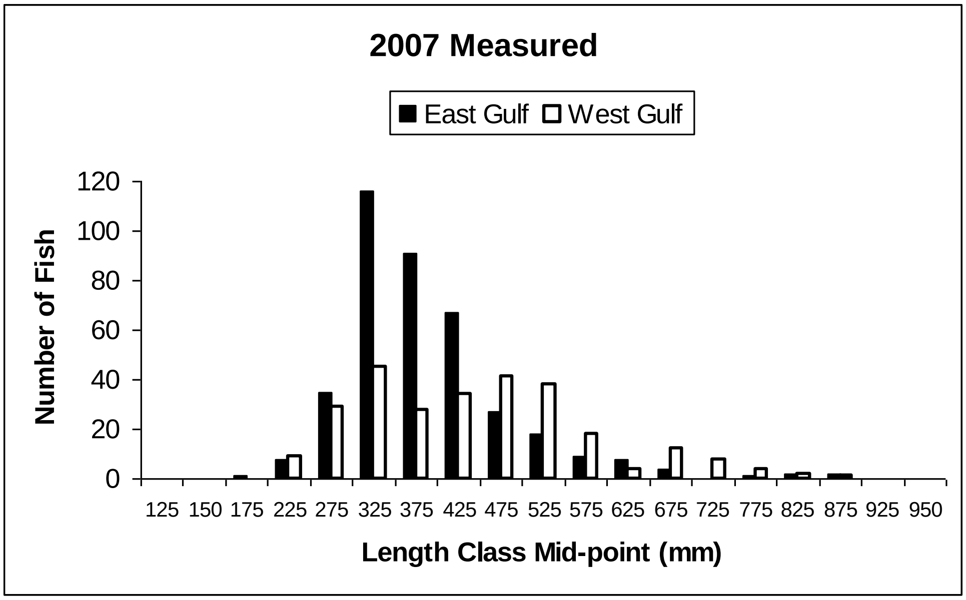

Figure 55. Red snapper length frequency of fish measured with stereo cameras in 2008.

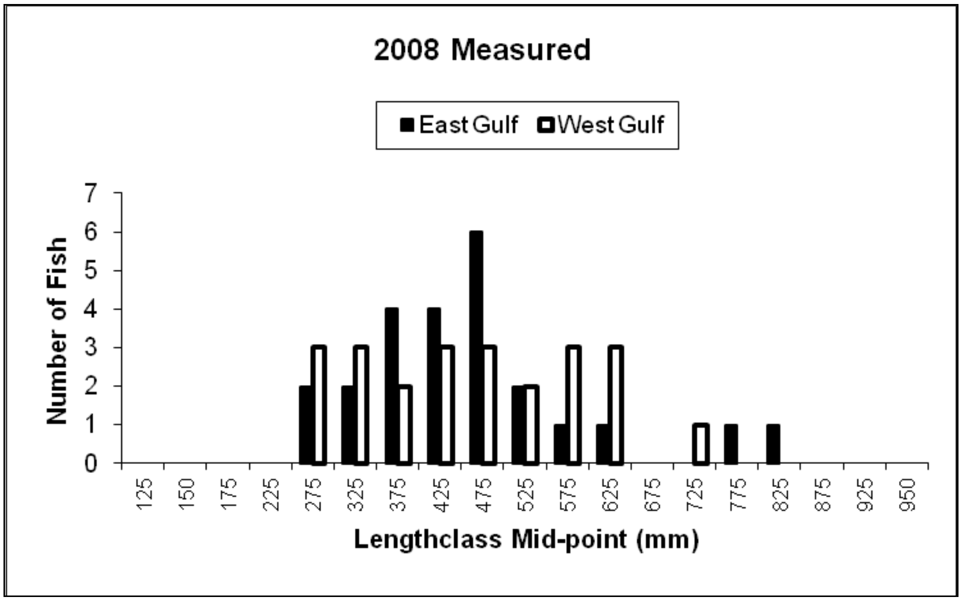

Figure 56. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2008.

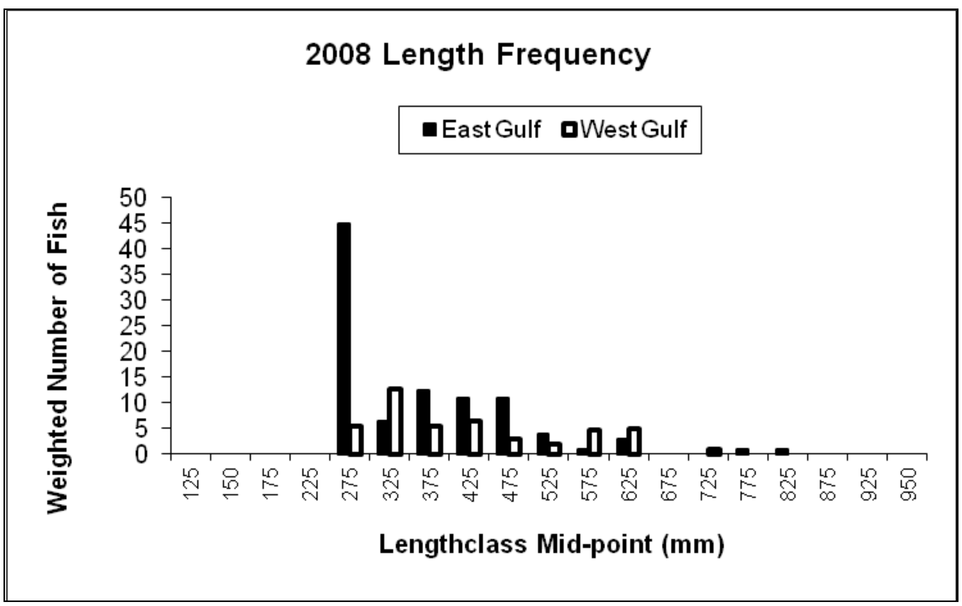

Figure 57. Red snapper length frequency of fish measured with stereo cameras in 2009.

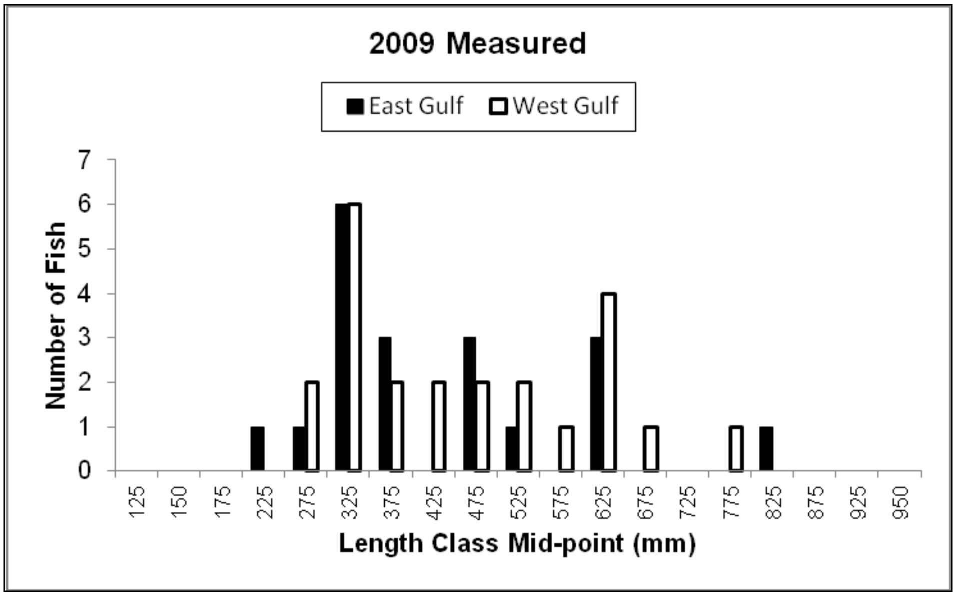

Figure 58. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2009.

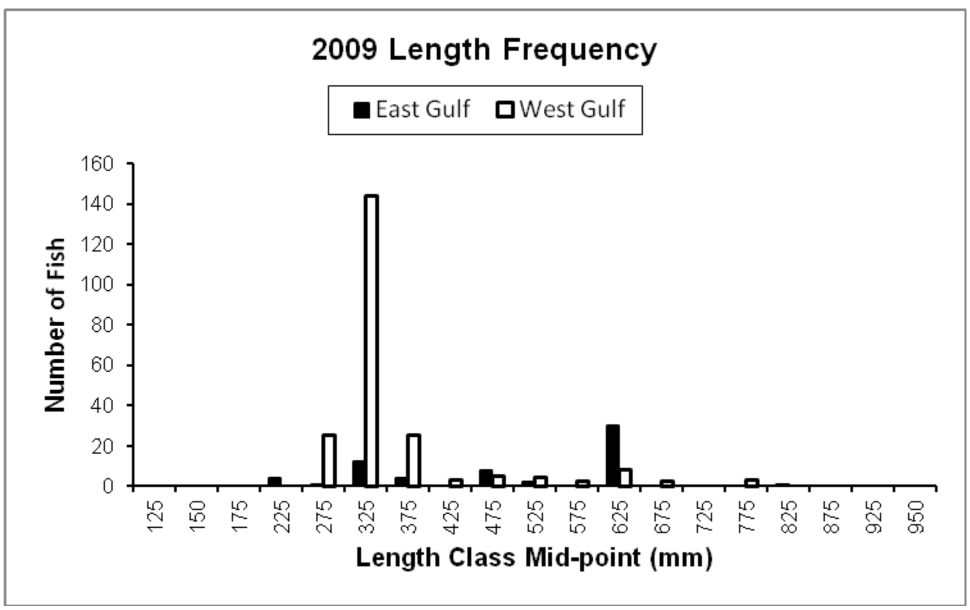

Figure 59. Red snapper length frequency of fish measured with stereo cameras in 2010.

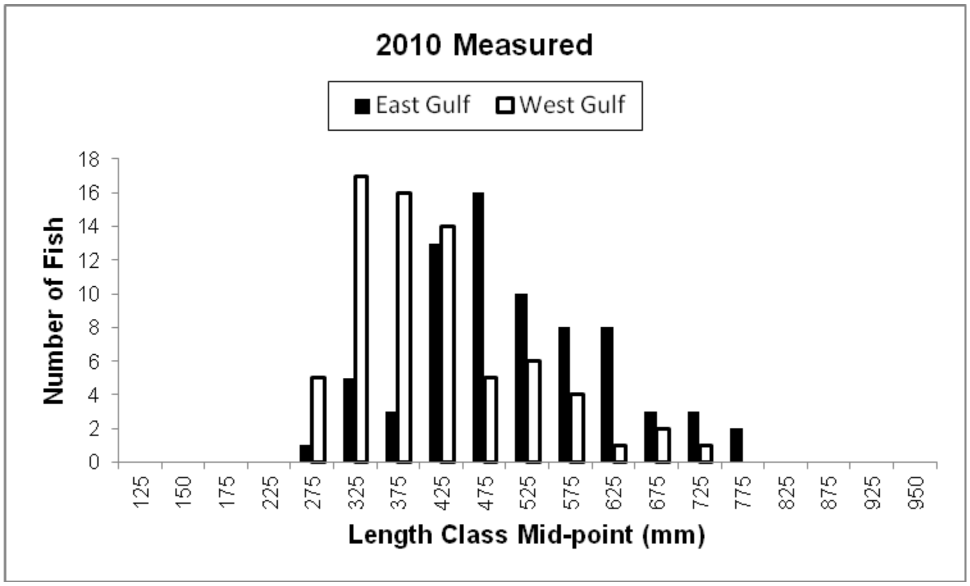

Figure 60. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2010.

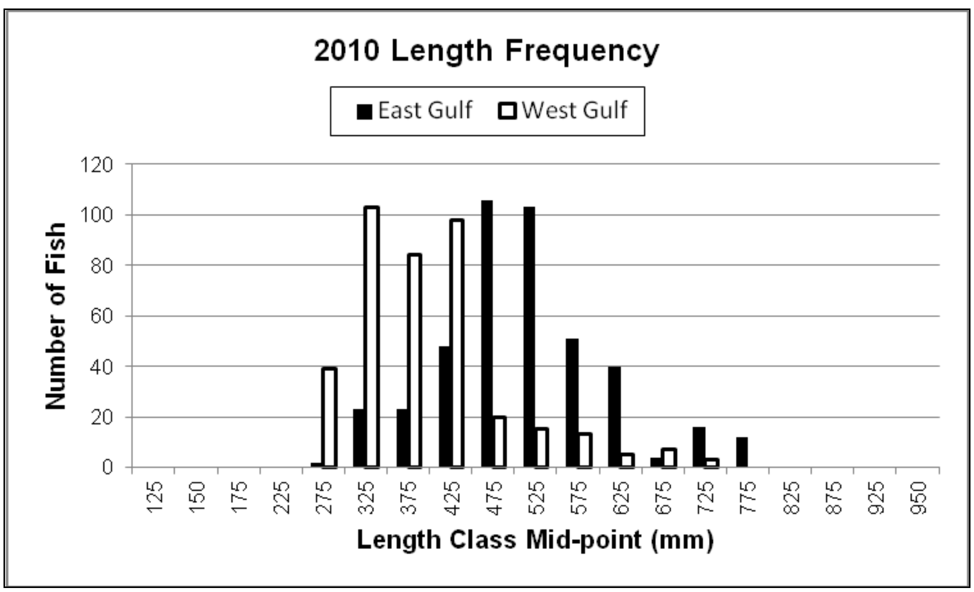

Figure 61. Red snapper length frequency of fish measured with stereo cameras in 2011.

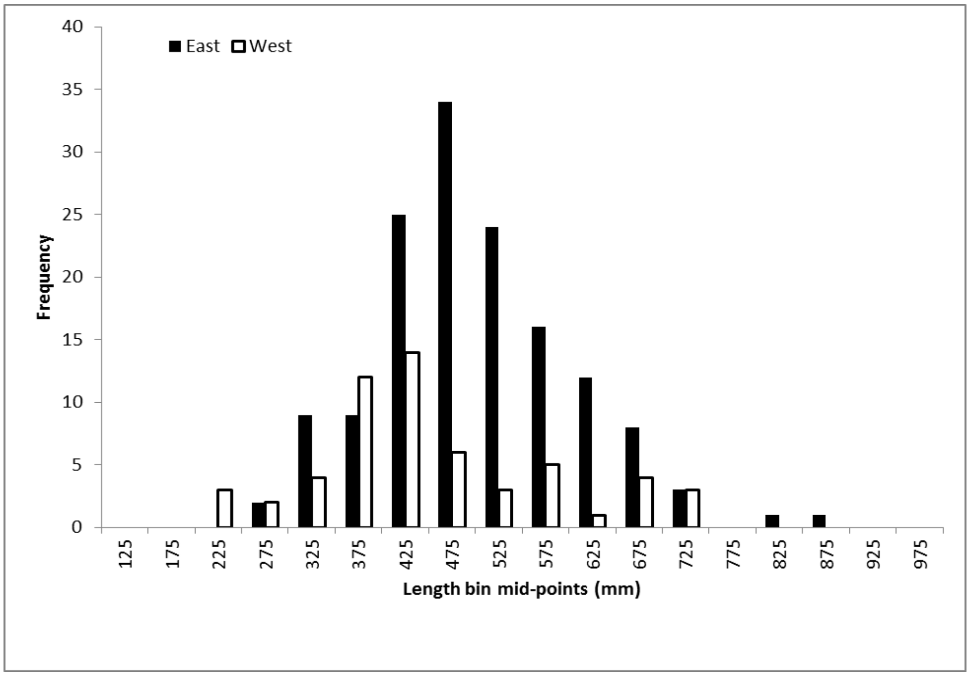

Figure 62. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2011.

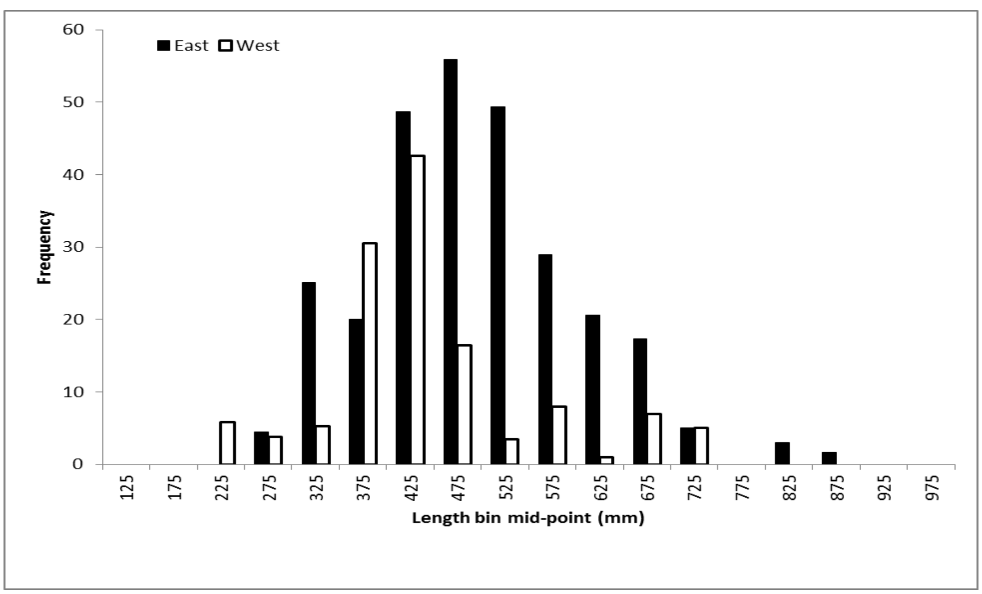

Table 15. Red snapper lengths (fork lengths in mm) measured by laser from video tapes (1995-2007) and by stereo still cameras (2008-2010).

	East Gulf					West Gulf				
Year	N	Minimum	Maximum	Mean	SE	N	Minimum	Maximum	Mean	SE
1995	0	-	-	-	-	9	430.0	766.0	582.33	38.09
1996	0	-	-	-	-	110	214.0	860.0	449.62	10.64
1997	134	236.0	758.0	406.52	9.56	0	-	-	-	-
2001	0	-	-	-	-	13	400.0	725.0	593.15	27.19
2002	0	-	-	-	-	195	245.0	917.0	506.83	8.16
2004	1044	207.0	915.0	417.97	3.25	0	-	-	-	-
2005	259	146.0	790.0	476.37	6.69	191	200.0	733.0	446.62	7.59
2006	103	183.0	752.0	412.33	14.90	63	276.0	668.0	442.63	13.16
2007	389	190.0	874.0	386.77	5.06	273	213.0	868.0	443.60	8.13
2008	24	284.2	834.0	459.93	27.59	23	287.7	721.9	470.06	26.34
2009	27	275.0	583.0	370.63	13.48	120	253.0	545.0	375.46	6.34
2010	72	290.6	798.6	514.81	13.03	71	271.4	742.5	415.60	11.91
2011	122	294.69	865.55	512.07	9.64	45	205.69	735.59	468.08	31.34

Appendix I - List of Tables and Figures

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Figure 4. Spatial distribution of red snapper observed and associated min-count values during the 1994 reef fish video survey.

Figure 5. Spatial distribution of red snapper observed and associated min-count values during the 1995 reef fish video survey.

Figure 6. Spatial distribution of red snapper observed and associated min-count values during the 1996 reef fish video survey.

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Figure 10. Spatial distribution of red snapper observed and associated min-count values during the 2005 reef fish video survey.

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Figure 13. Spatial distribution of red snapper observed and associated min-count values during the 2008 reef fish video survey.

Figure 14. Spatial distribution of red snapper observed and associated min-count values during the 2009 reef fish video survey.

Figure 15. Spatial distribution of red snapper observed and associated min-count values during the 2010 reef fish video survey.

Figure 16. Spatial distribution of red snapper observed and associated min-count values during the 2011 reef fish video survey.

Figure 60. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2010.

Figure 61. Red snapper length frequency of fish measured with stereo cameras in 2011.

Figure 62. Red snapper length frequency distribution (weighted by minimum counts at each site) from fish measured with stereo cameras in 2011.