SEAMAP Reef Fish Video Survey:
Relative Indices of Abundance of Greater Amberjack

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SEDAR33-DW16

9 May 2013

Please cite as:

Campbell, M.D., K.R. Rademacher, P. Felts, B. Noble, M. Felts, and J. Salisbury. 2013. SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Greater Amberjack. SEDAR33-DW16. SEDAR, North Charleston, SC. 50 pp.

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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 2004-2012 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 greater amberjack sampled over the history of the survey had fork lengths ranging from 101.0 – 2065.0 mm, and mean annual fork lengths ranging from 571.8 – 759.9 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.

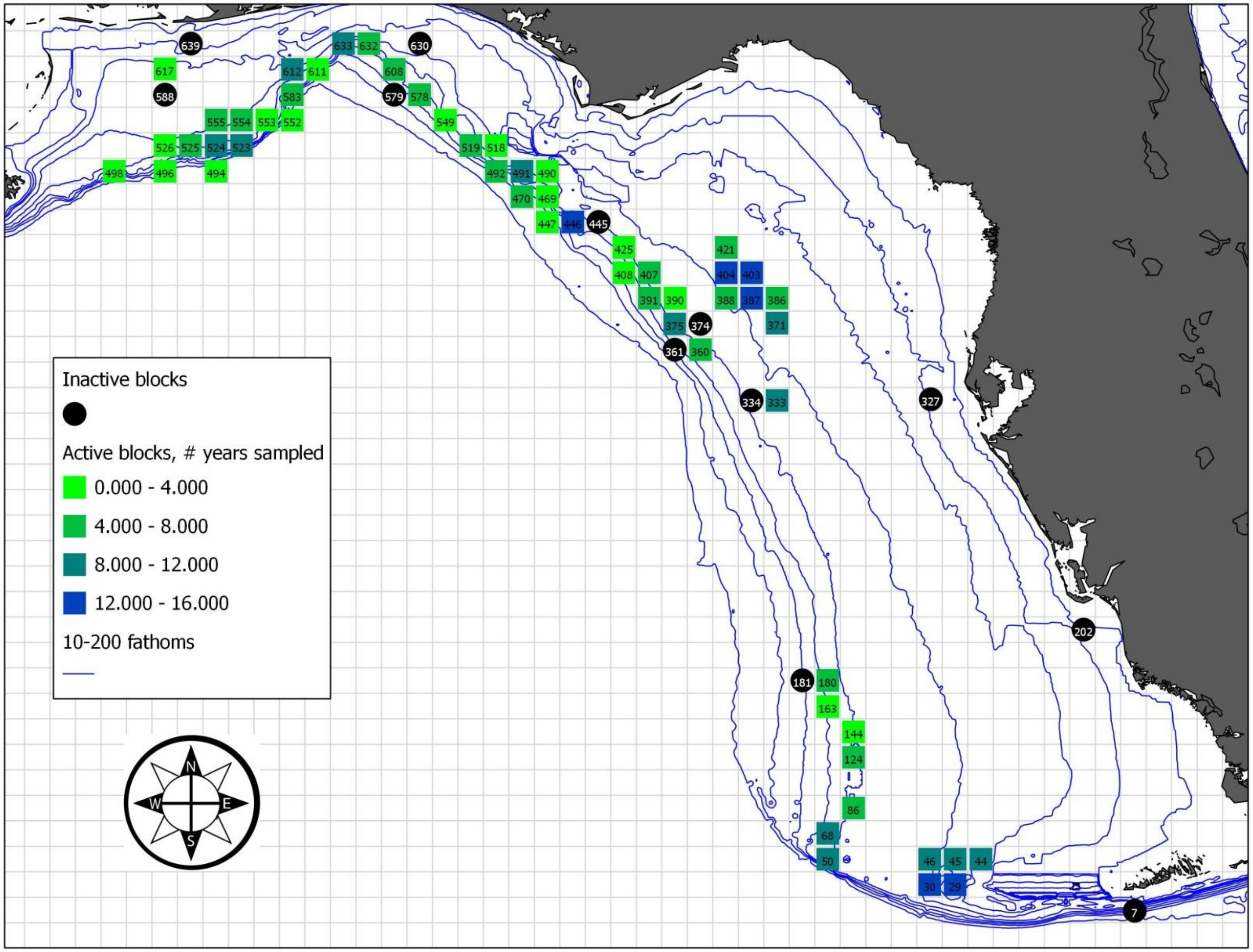

Figure 1. SEAMAP reef fish video survey sample blocks located in the eastern Gulf of Mexico.

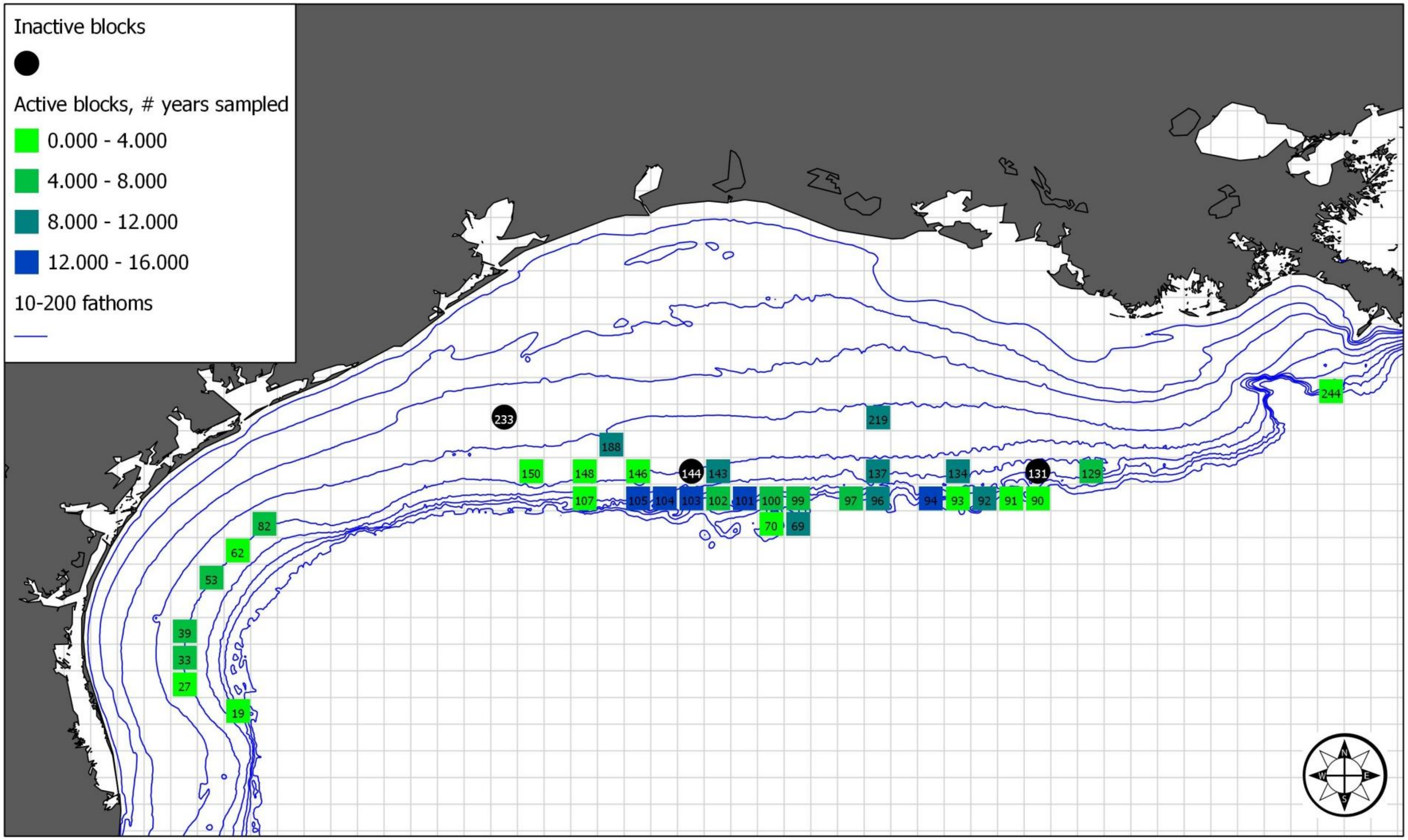

Figure 2. SEAMAP reef fish video survey sample blocks located in the western Gulf of Mexico.

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 1993-2008 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 and represents the conservative maximum number of fish that were at a location at one point in time.

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 greater amberjack. 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 greater amberjack (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) $$V(I_y) \approx V(c_y) p_y^2 + c_y^2 V(p_y) + 2 c_y p_y \mathrm{Cov}(c, p),$$

where:

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

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

Greater amberjack were observed at banks in both the western and eastern GOM (Figures 3 – 17), 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, depth, and maxrelief in the binomial and log-normal GOM-wide sub-model. Design based greater amberjack proportion positives ranged from 0.15 (1997) to 0.34 (2002) with a reported value of 0.26 in 2012 (Figure 18), while standardized index of abundance ranged from 0.61 (1997) to 1.84 (2002), and reported a value of 0.94 in 2012 (Table 2, Figure 20). Coefficient of variation ranged from 10% (2012) to 19% (1993), with the lowest values having been reported in the most recent survey year.

Design based analysis retained year, depth, and maxrelief in the binomial and log-normal east-GOM sub-model. Design based east-GOM greater amberjack proportion positives ranged from 0.08 (1997) to 0.30 (2002) (Figure 26), and the standardized index of abundance ranged from 0.53 (1997) to 2.21 (2002) (Table 5, Figure 28). Coefficient of variation ranged from 18.3% (2012) to 43% (1995) with the lowest values having been reported in the most recent survey year.

Design based analysis retained year, region and depth in the binomial and log-normal west-GOM sub-model. Design based greater amberjack proportion positive ranged from 0.12 (2004) to 0.47 (1995) with a reported value of 0.29 in 2012 (Figure 34), while standardized index values ranged from 0.36 (1996) to 1.66 (1995) (Table 8, Figure 36). Coefficient of variation ranged from 14.7% (2012) to 44.7% (2004), with the lowest values having been reported in the most recent survey year.

Proportion positives, lo-index, and standardized index values from in 2012 are average relative to all other sample years in the survey. Gulf wide and east GOM values for proportion positives, lo-index, and standardized index output suggest that gulf wide population trends appear to be in large part driven by eastern populations. Western indices appear to be slightly out of sync with several peak years not match the trends than observed in the eastern GOM. Median lengths 'notched' boxplots suggest that greater amberjack sampled in 2012 are significantly larger than any other year sampled, although the range of lengths appears to be within normal bounds observed over the history of the survey.

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 greater amberjack observed and associated min-count values during the 1993 reef fish video survey.

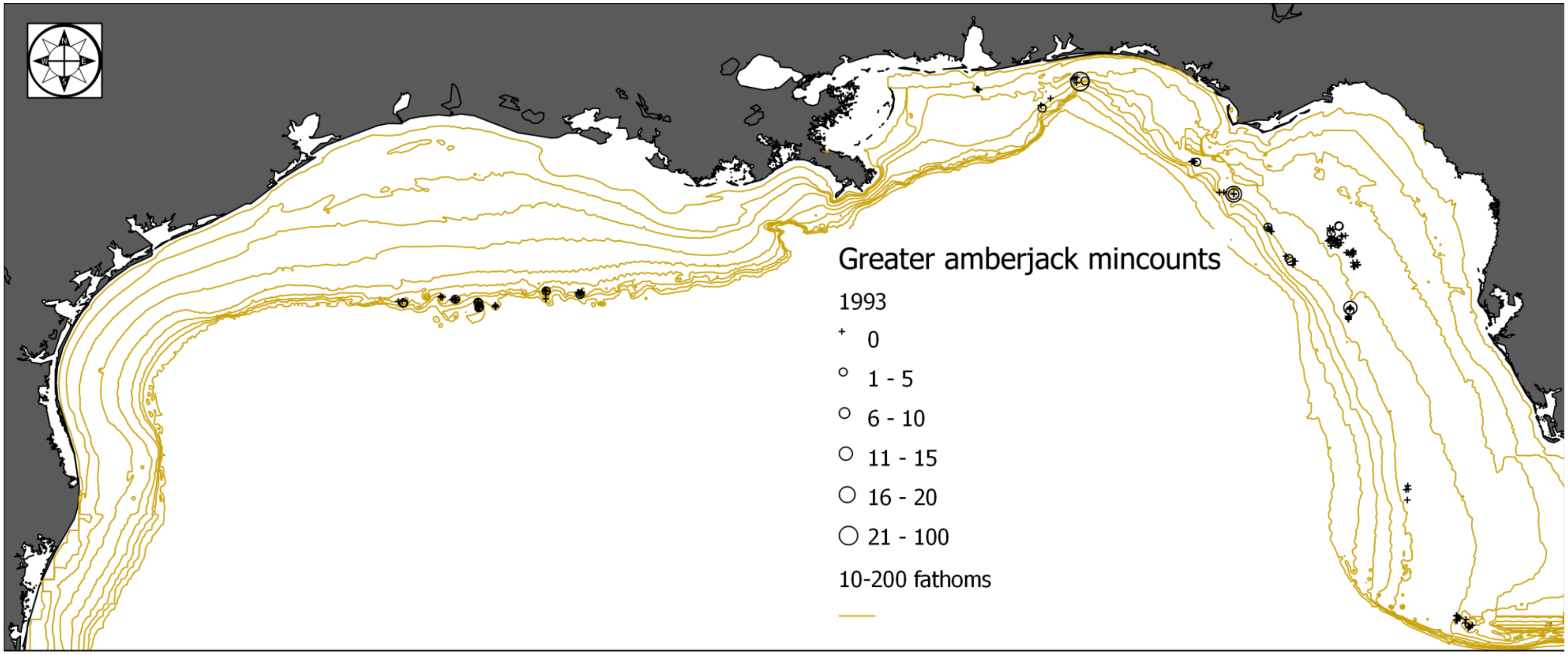

Figure 4. Spatial distribution of greater amberjack observed and associated min-count values during the 1994 reef fish video survey.

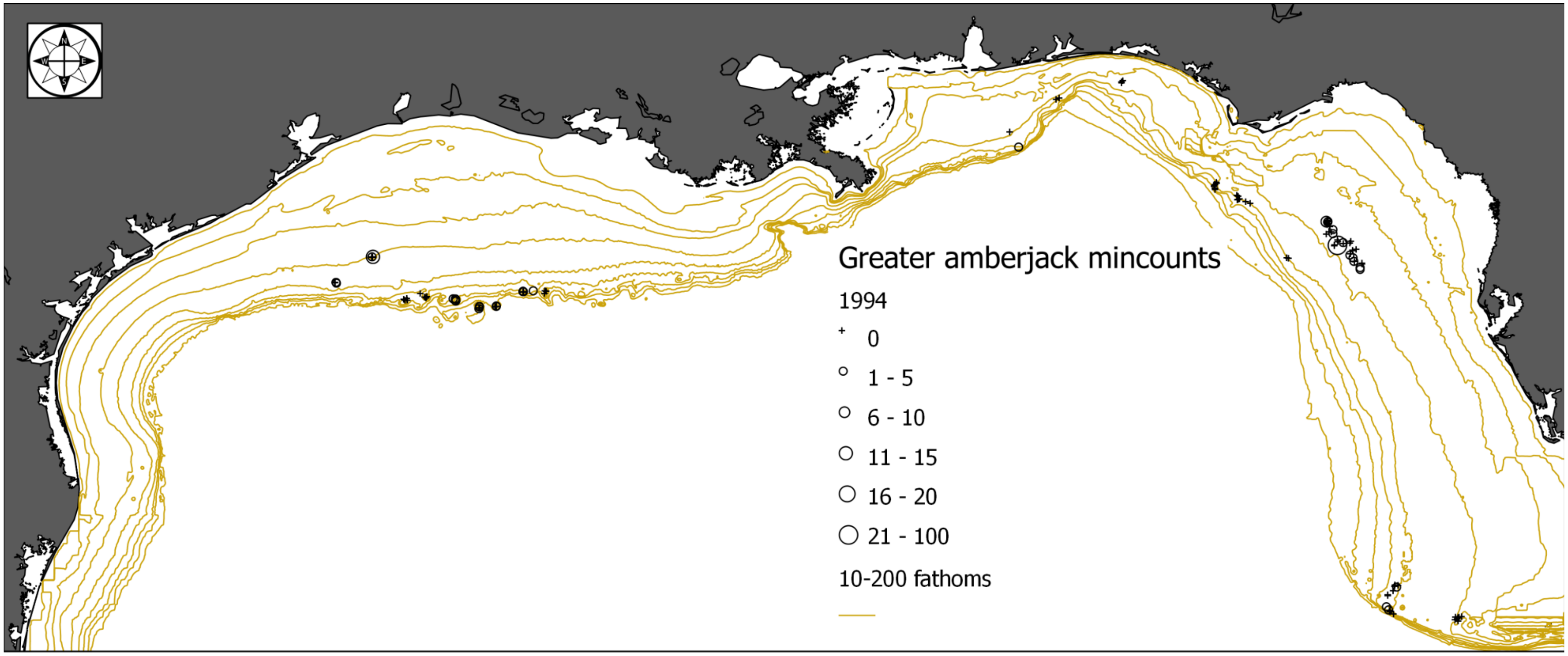

Figure 5. Spatial distribution of greater amberjack observed and associated min-count values during the 1995 reef fish video survey.

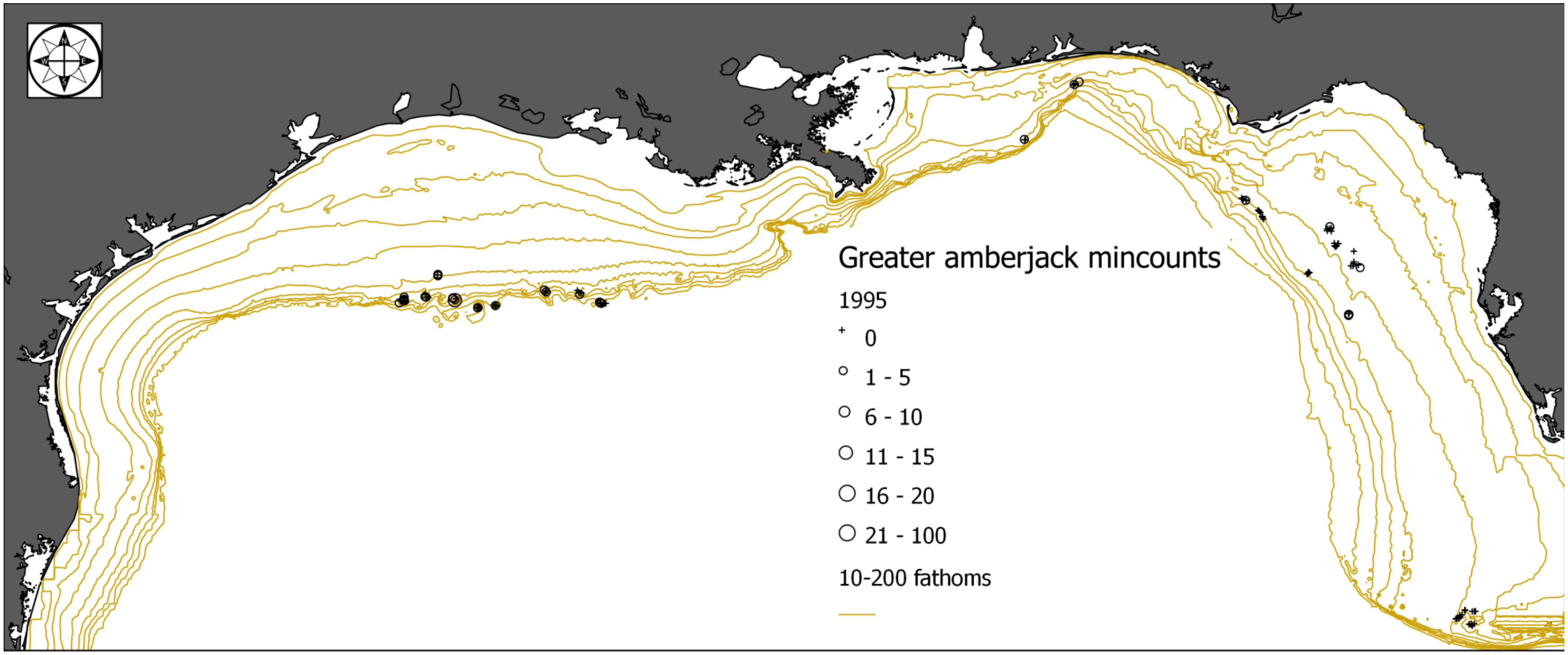

Figure 6. Spatial distribution of greater amberjack observed and associated min-count values during the 1996 reef fish video survey.

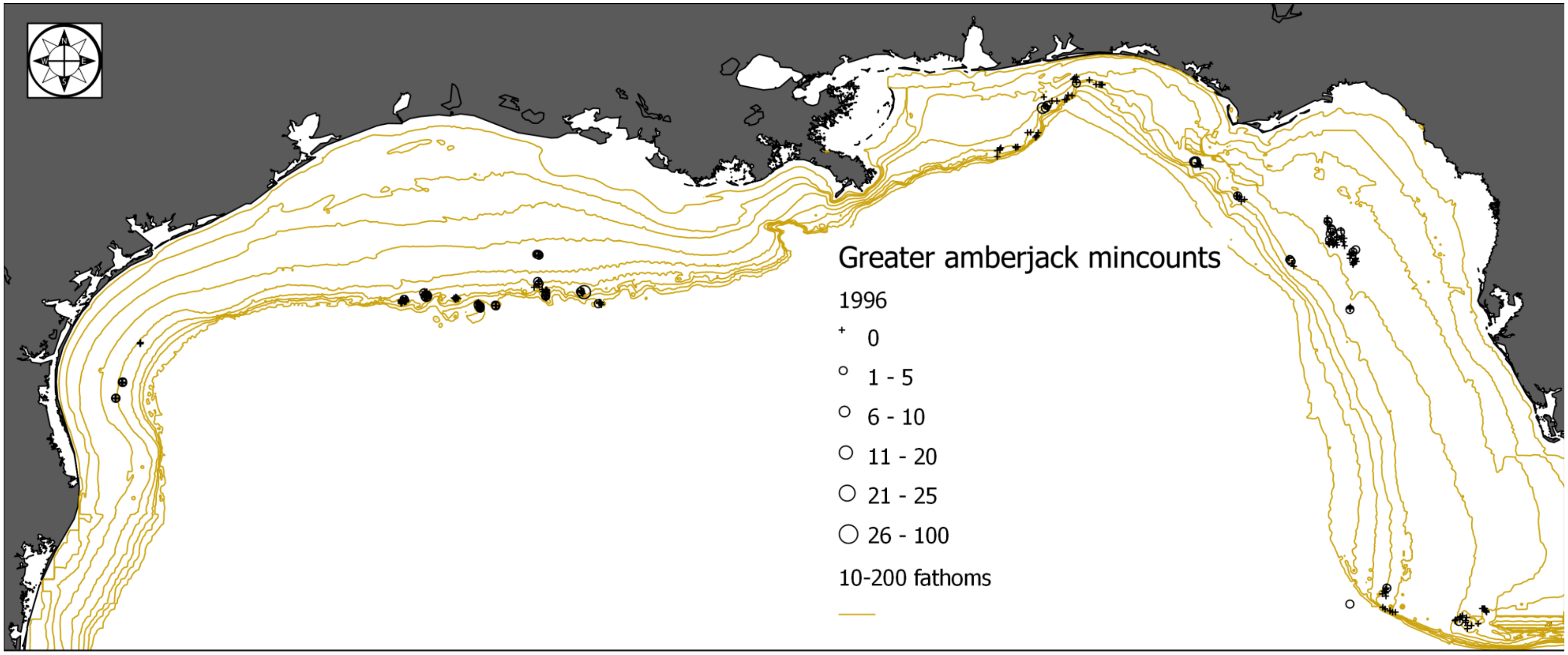

Figure 7. Spatial distribution of greater amberjack observed and associated min-count values during the 1997 reef fish video survey.

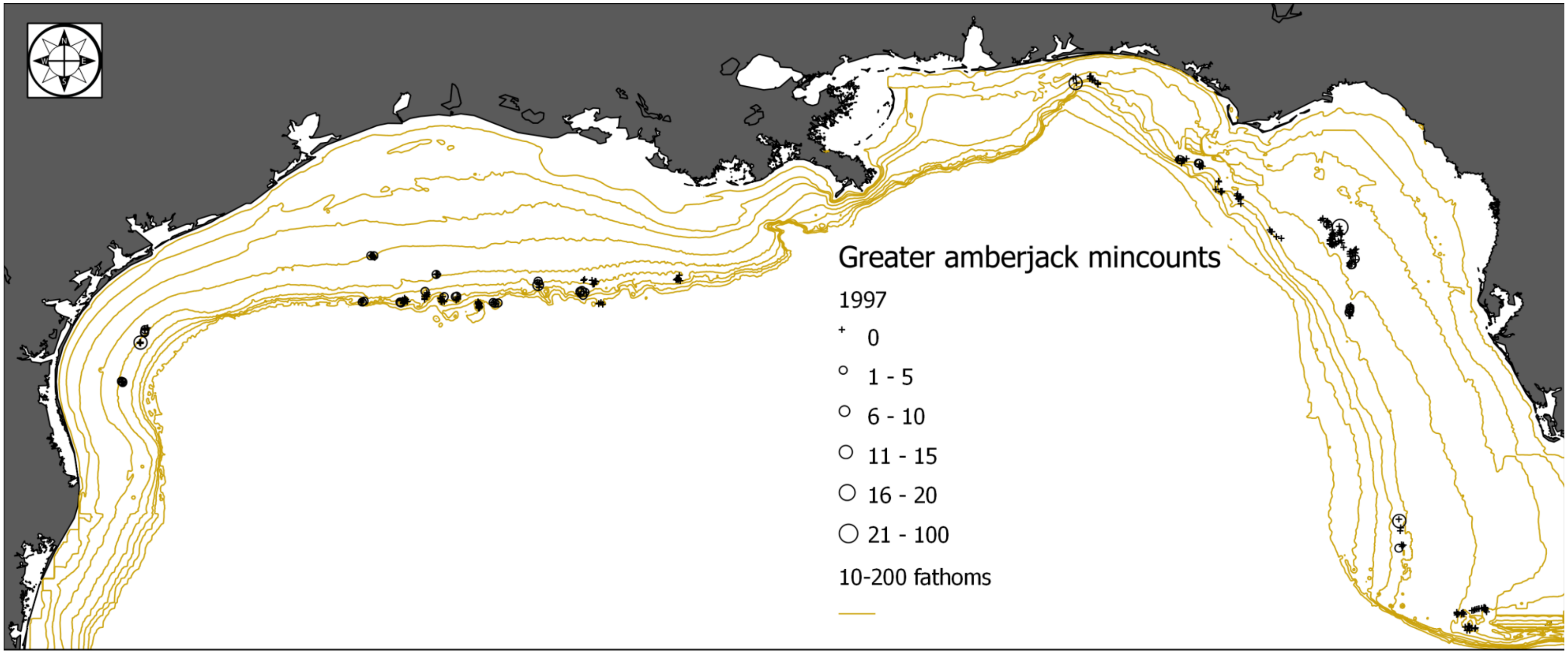

Figure 8. Spatial distribution of greater amberjack observed and associated min-count values during the 2002 reef fish video survey.

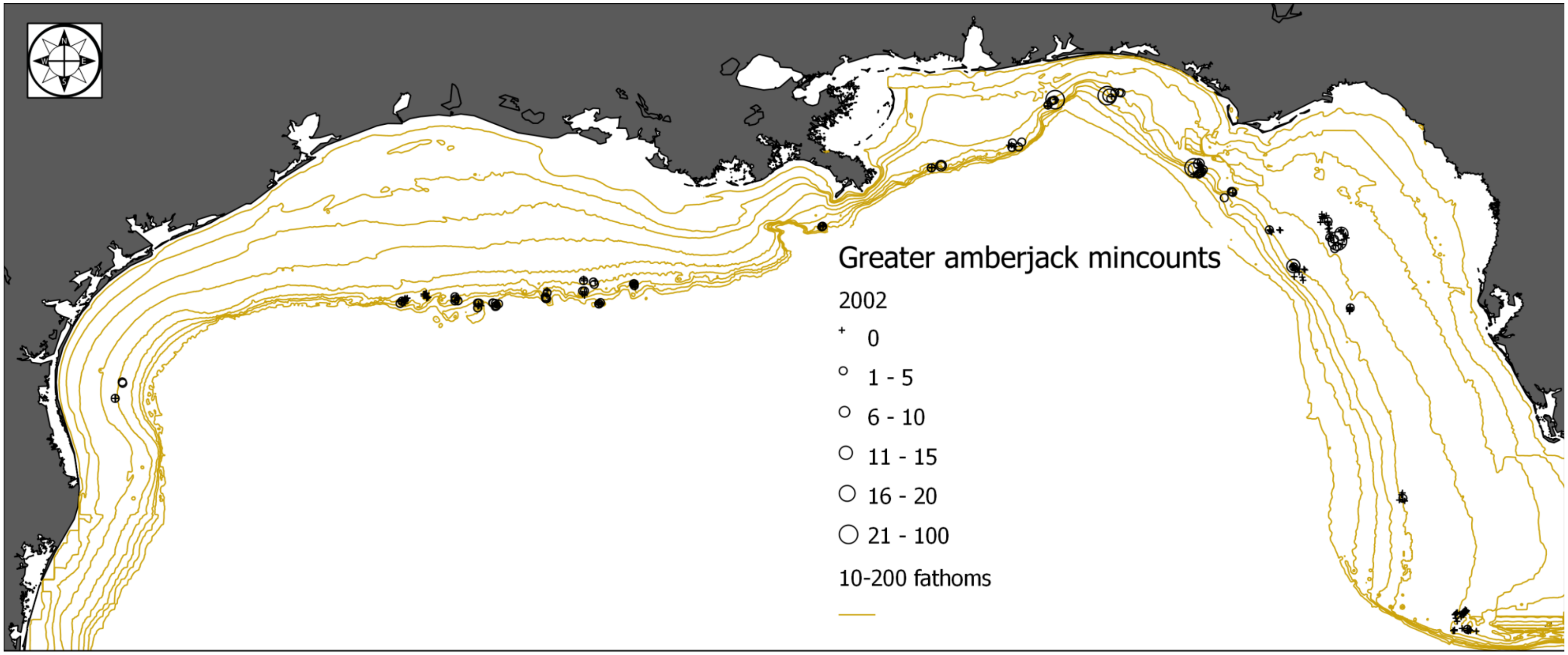

Figure 9. Spatial distribution of greater amberjack observed and associated min-count values during the 2004 reef fish video survey.

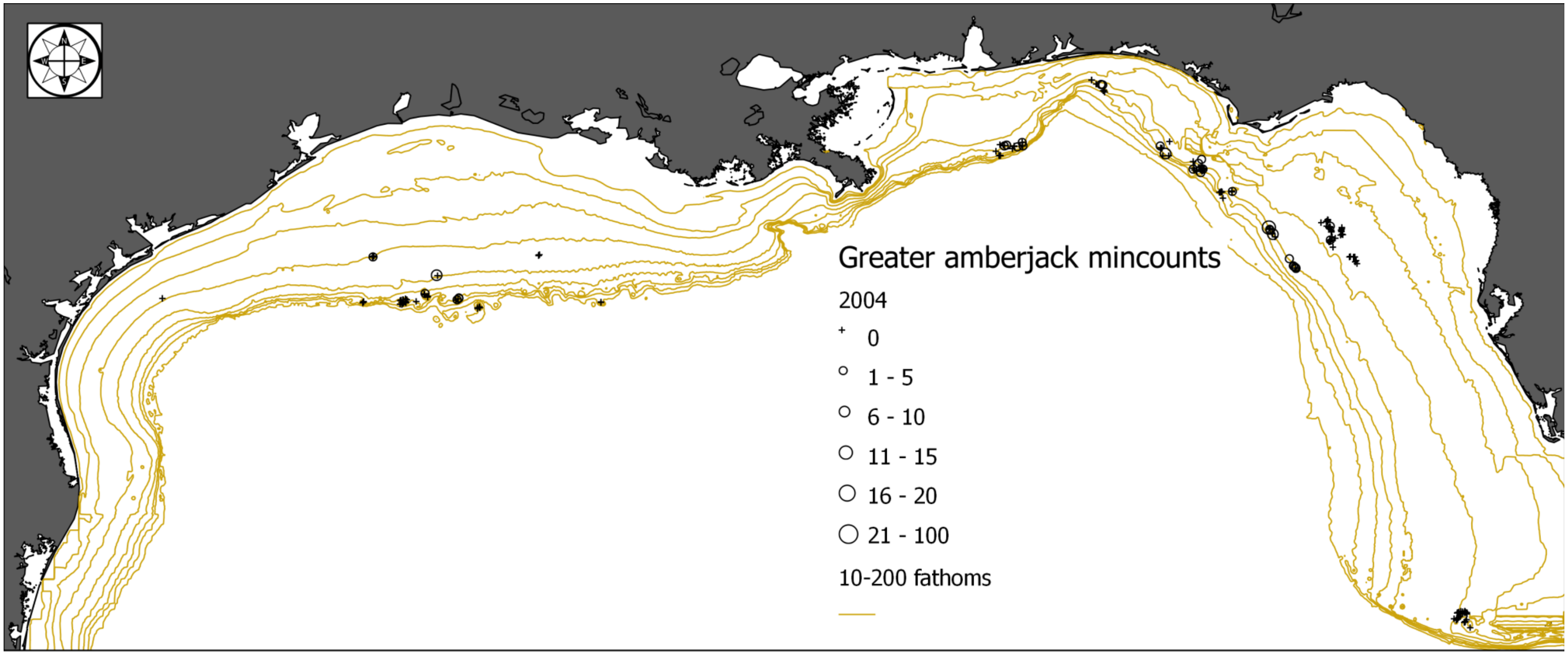

Figure 10. Spatial distribution of greater amberjack observed and associated min-count values during the 2005 reef fish video survey.

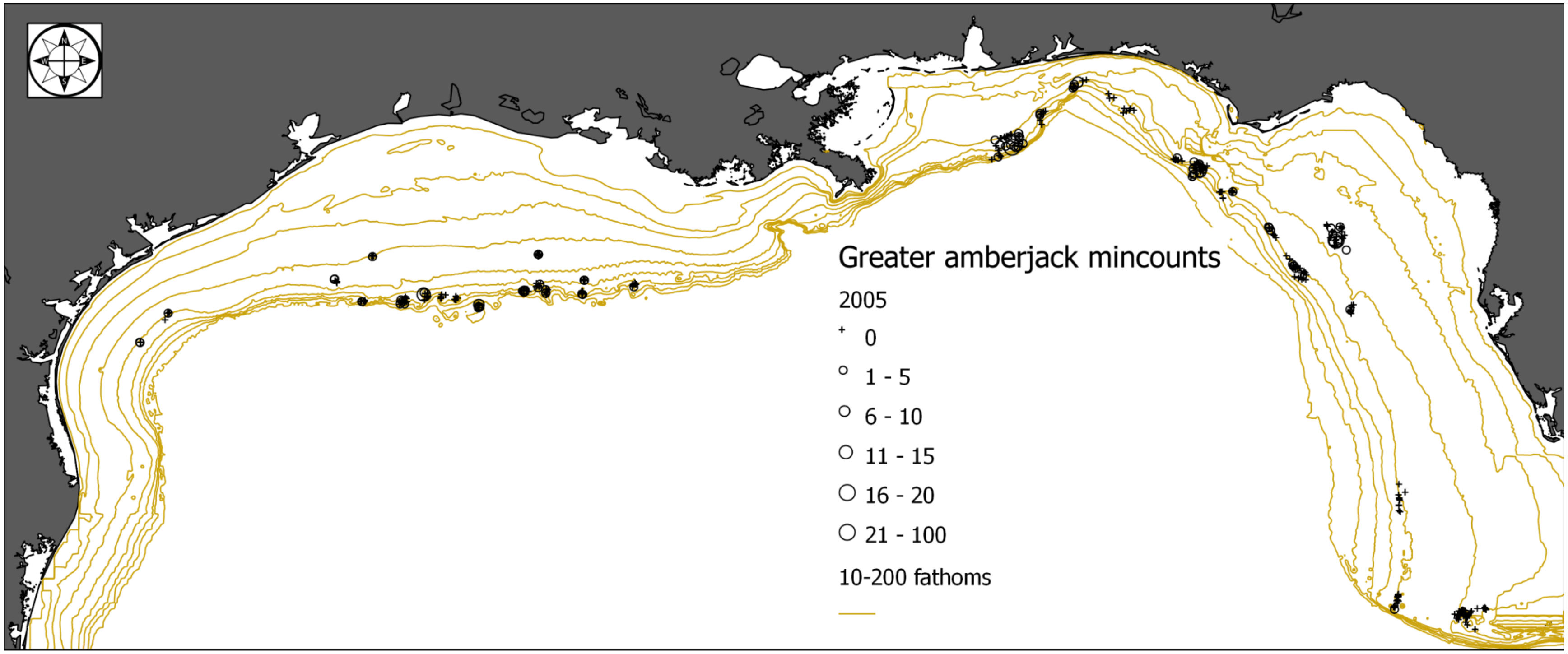

Figure 11. Spatial distribution of greater amberjack observed and associated min-count values during the 2006 reef fish video survey.

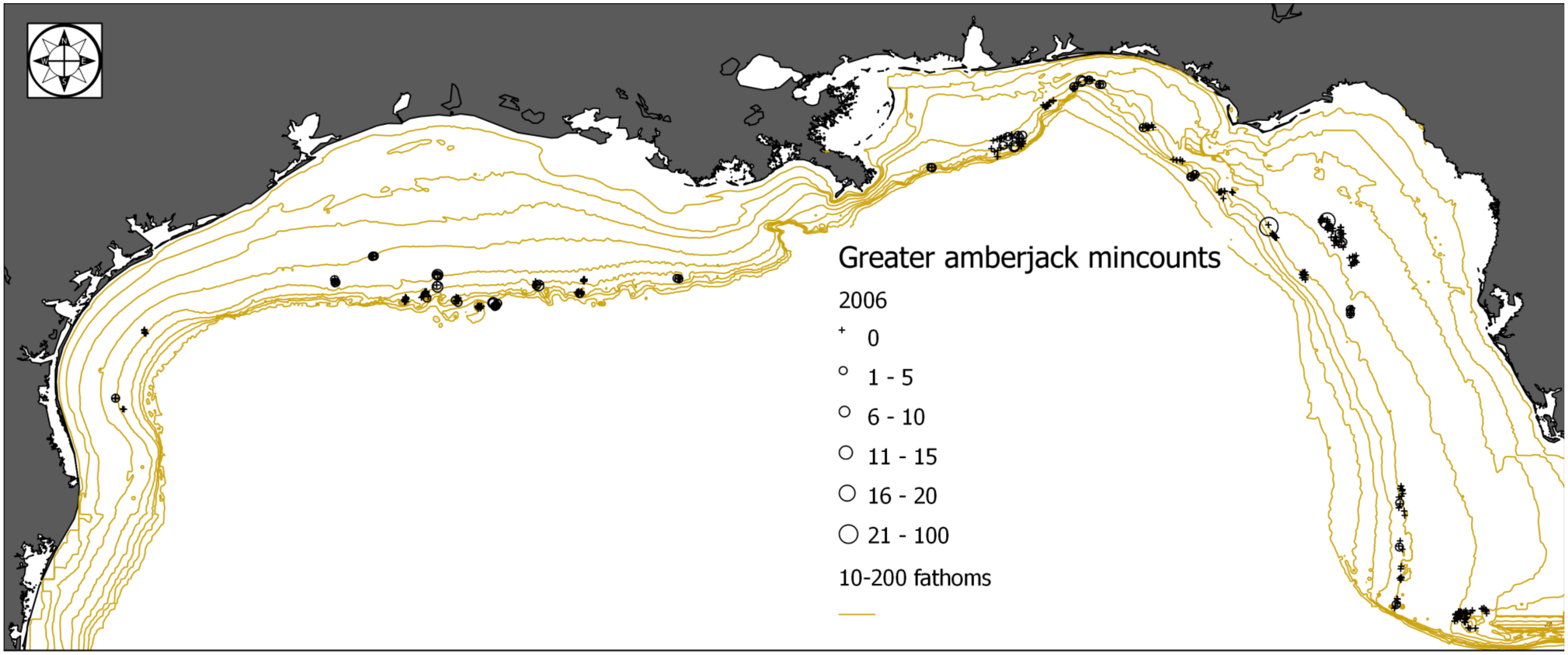

Figure 12. Spatial distribution of greater amberjack observed and associated min-count values during the 2007 reef fish video survey.

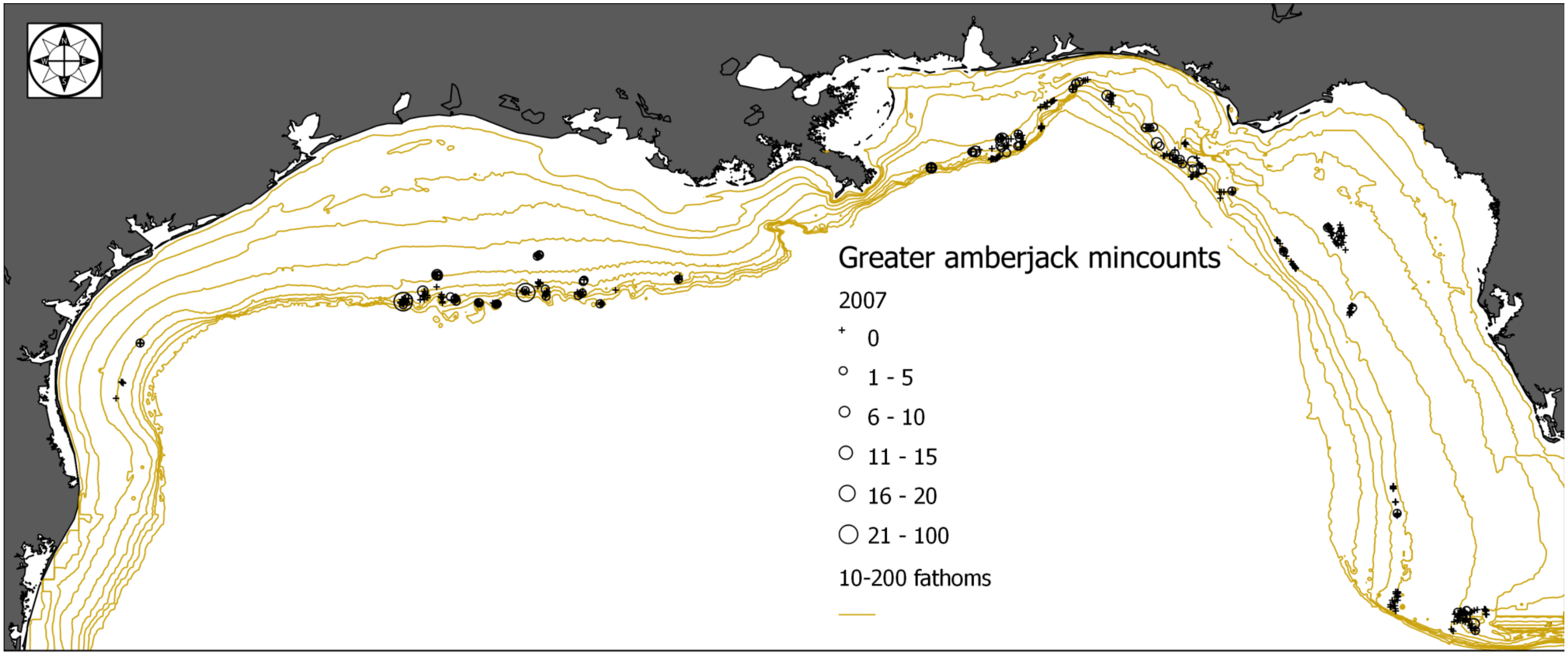

Figure 13. Spatial distribution of greater amberjack observed and associated min-count values during the 2008 reef fish video survey.

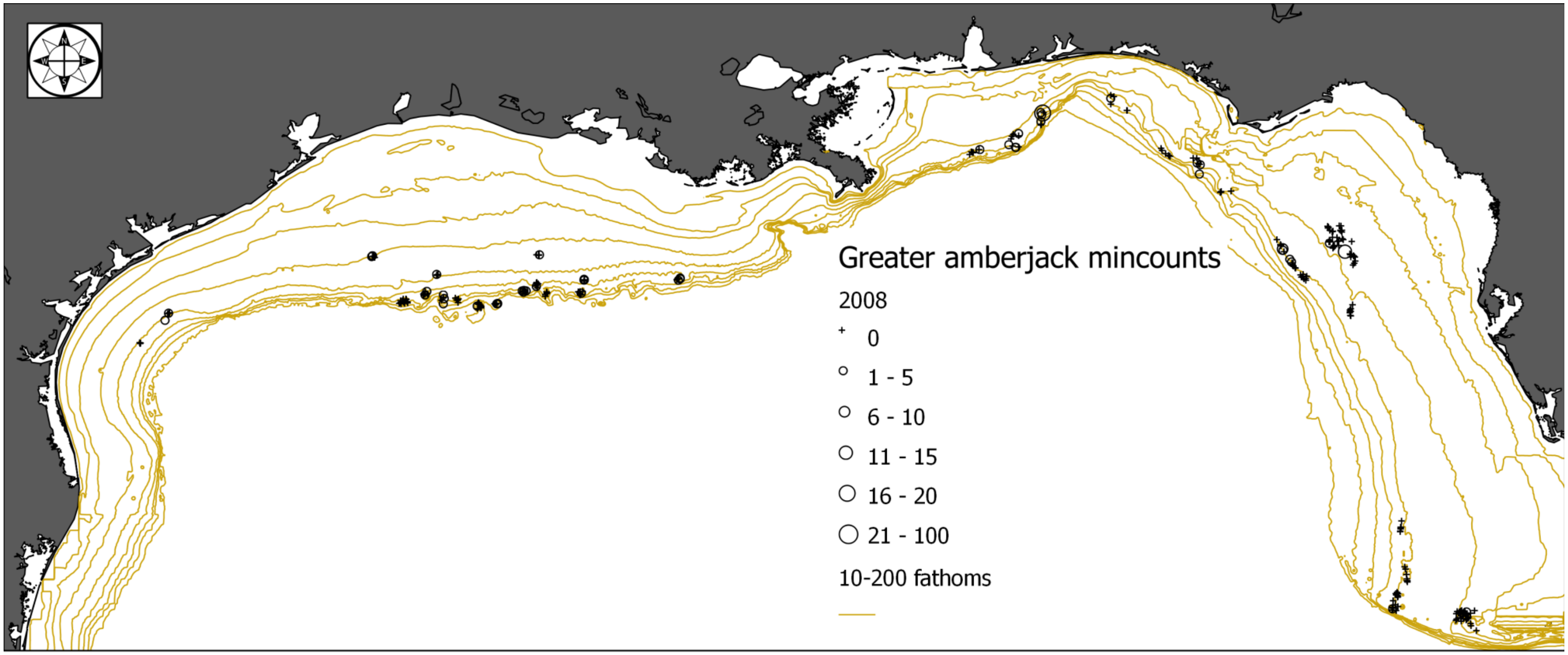

Figure 14. Spatial distribution of greater amberjack observed and associated min-count values during the 2009 reef fish video survey.

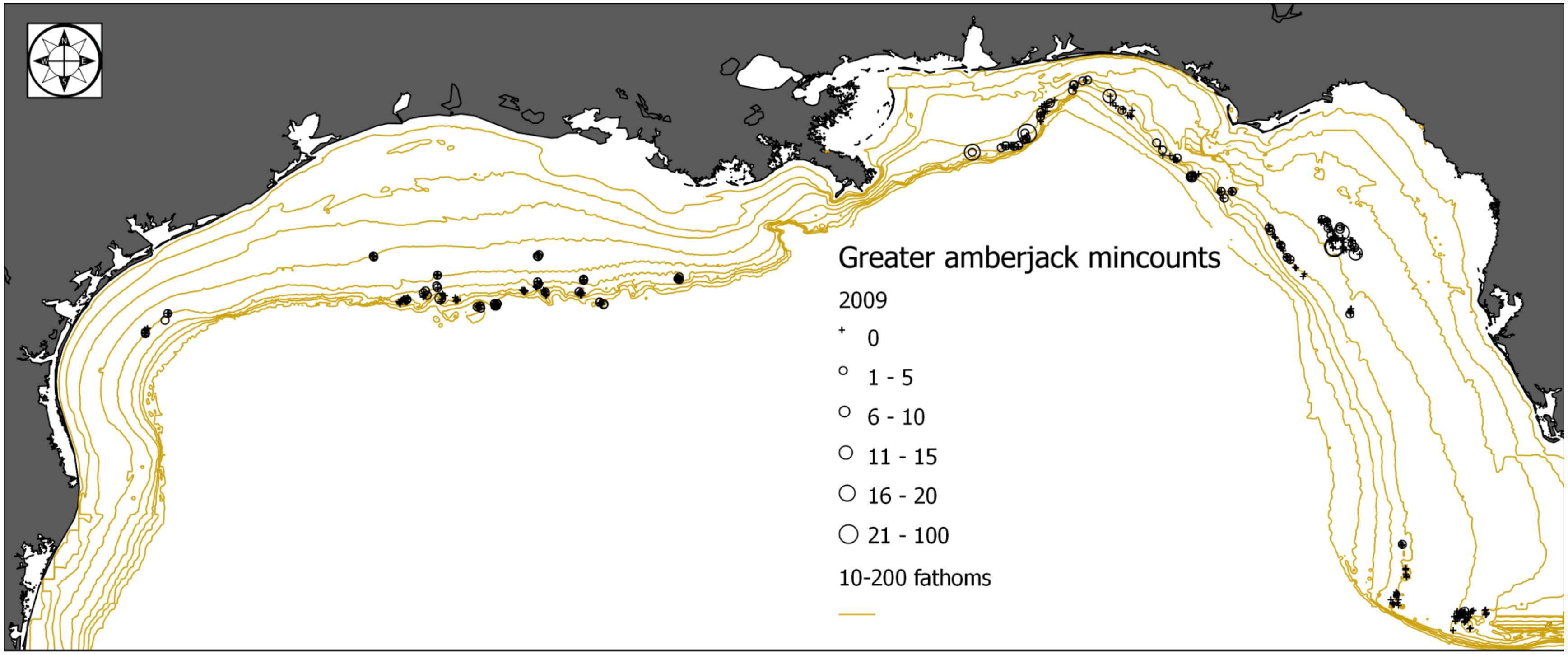

Figure 15. Spatial distribution of greater amberjack observed and associated min-count values during the 2010 reef fish video survey.

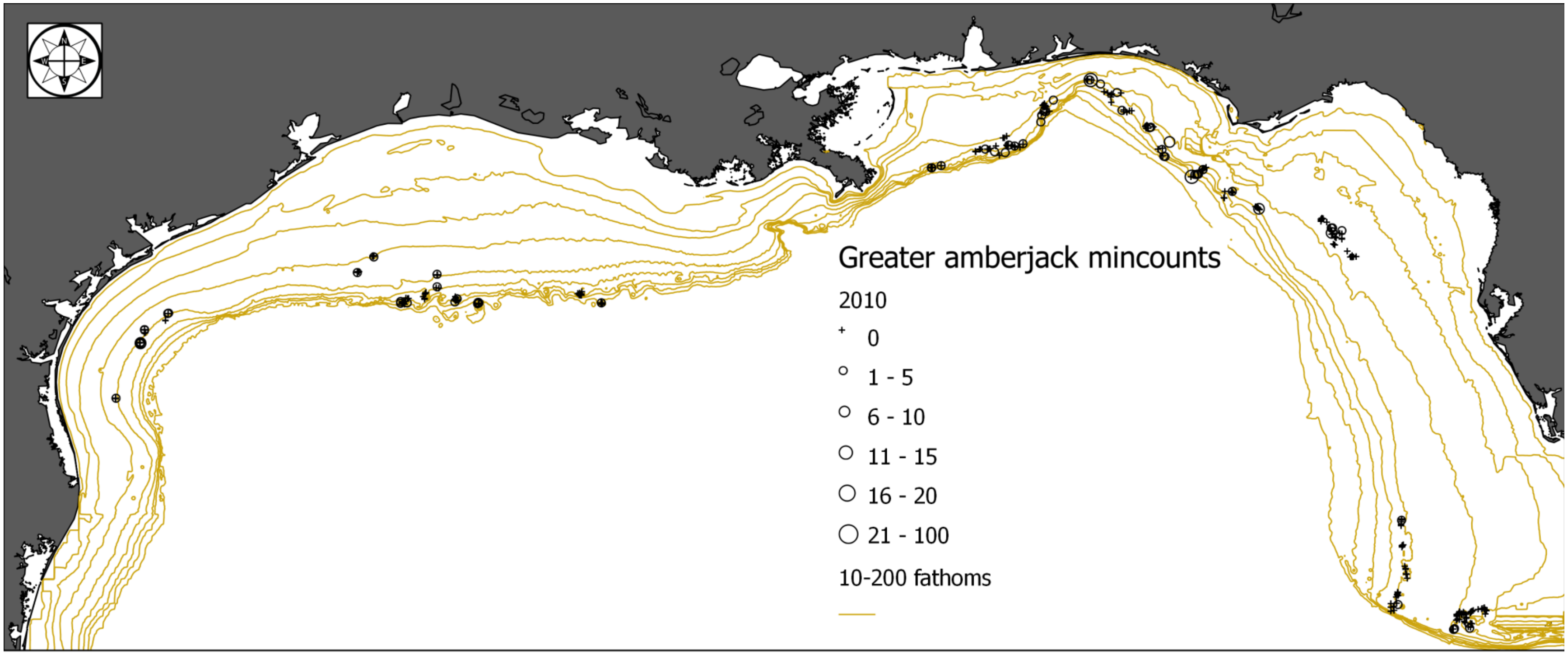

Figure 16. Spatial distribution of greater amberjack observed and associated min-count values during the 2011 reef fish video survey.

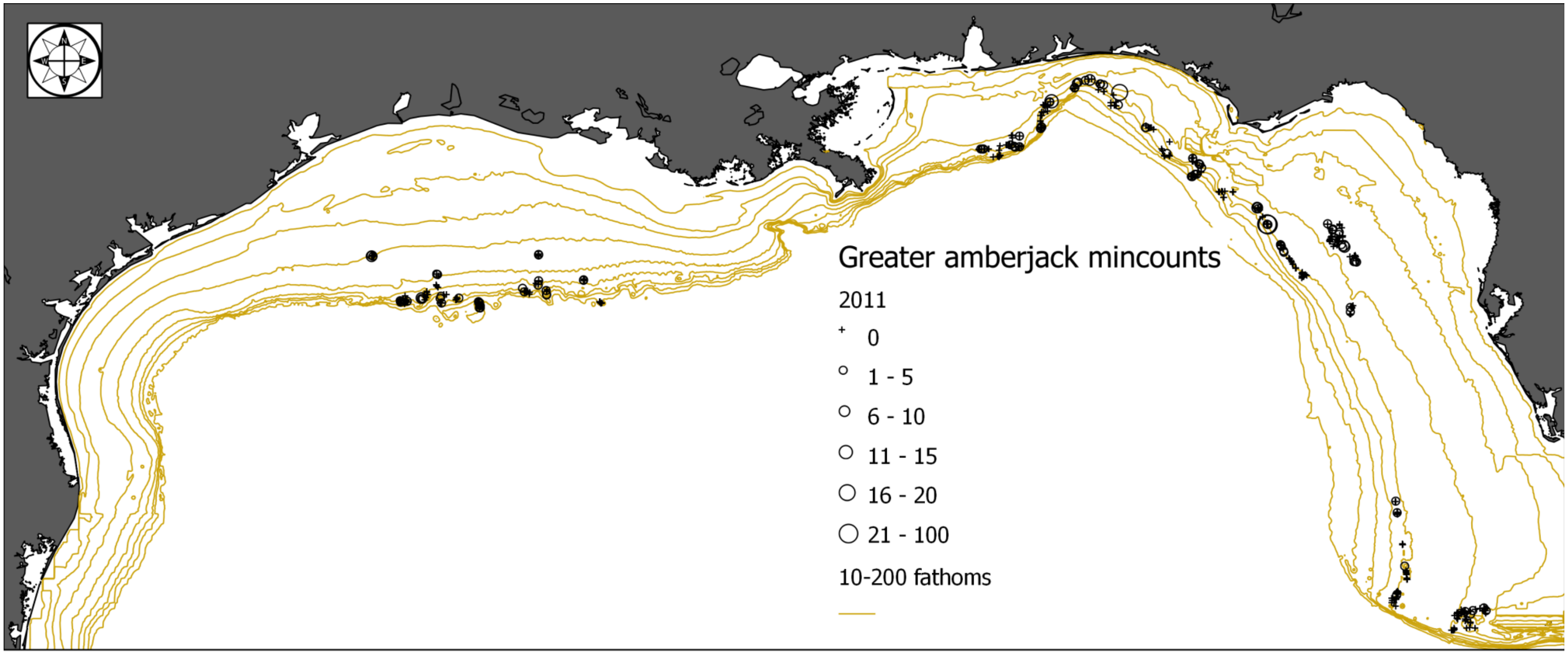

Figure 17. Spatial distribution of greater amberjack observed and associated min-count values during the 2012 reef fish video survey.

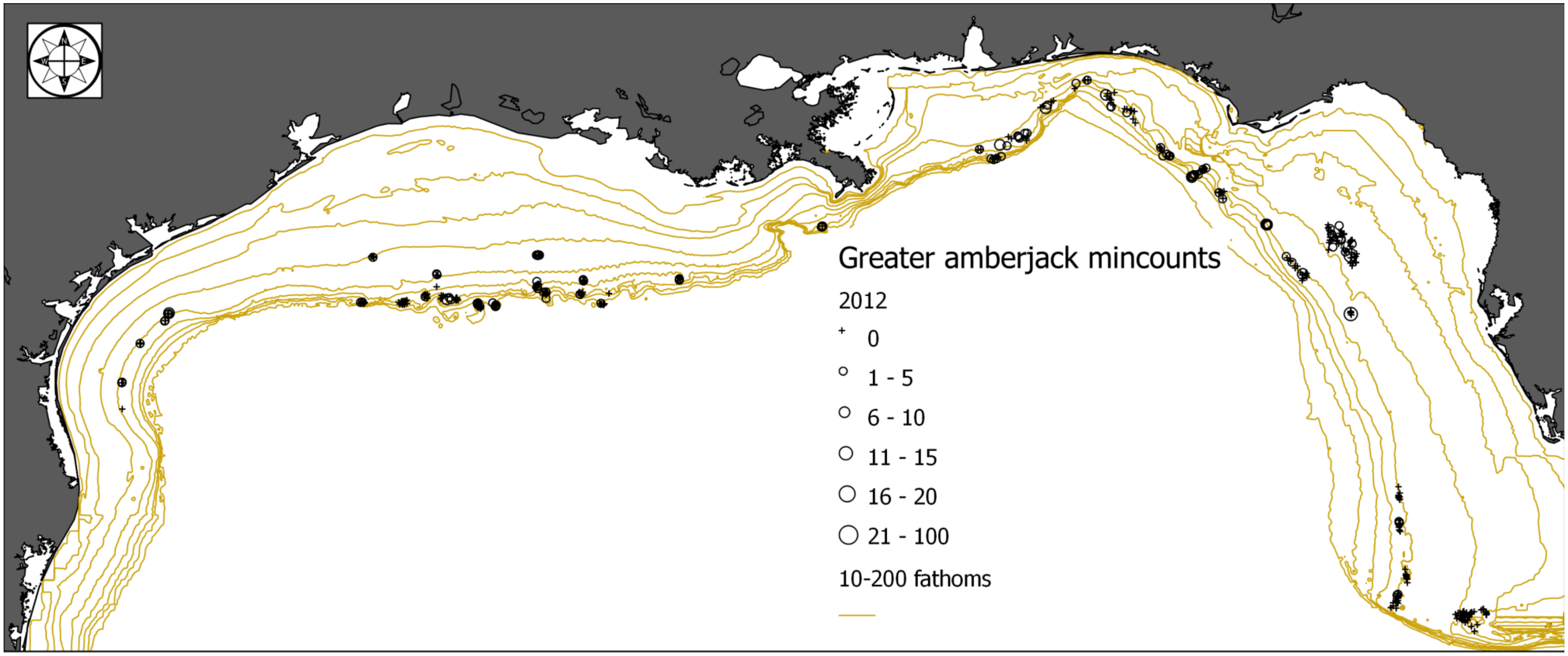

Table 1. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics (d) of the GLIMMIX binomial on proportion positives for the GOM-wide model.

a

Iteration History			
Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	21641.97029372	0.00000000

b

Fit Statistics	
-2 Res Log Likelihood	21642.0
AIC (smaller is better)	21672.0
AICC (smaller is better)	21672.1
BIC (smaller is better)	21768.4

c

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	14	1409	75.18	5.34	<.0001	<.0001
depth	1	3713	46.82	46.82	<.0001	<.0001
MAXRELIEF	1	3233	28.36	28.36	<.0001	<.0001

d

Description	*Value*
Deviance	849.4589
Scaled Deviance	4859.3083
Pearson Chi-Square	864.0730
Scaled Pearson Chi-Square	4942.9082
Extra-Dispersion Scale	0.1748

Figure 18. GOM-wide observed versus proportion positive for design based simulation.

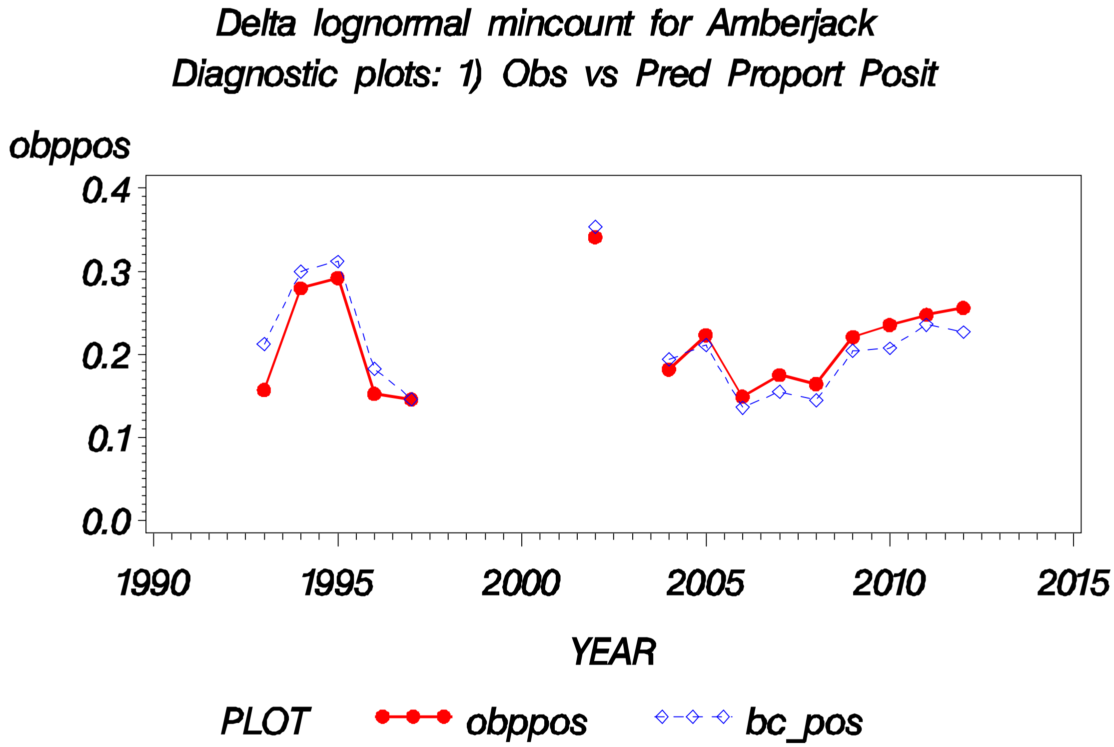

Figure 19. GOM-wide chi-square residuals of proportion positive design based model.

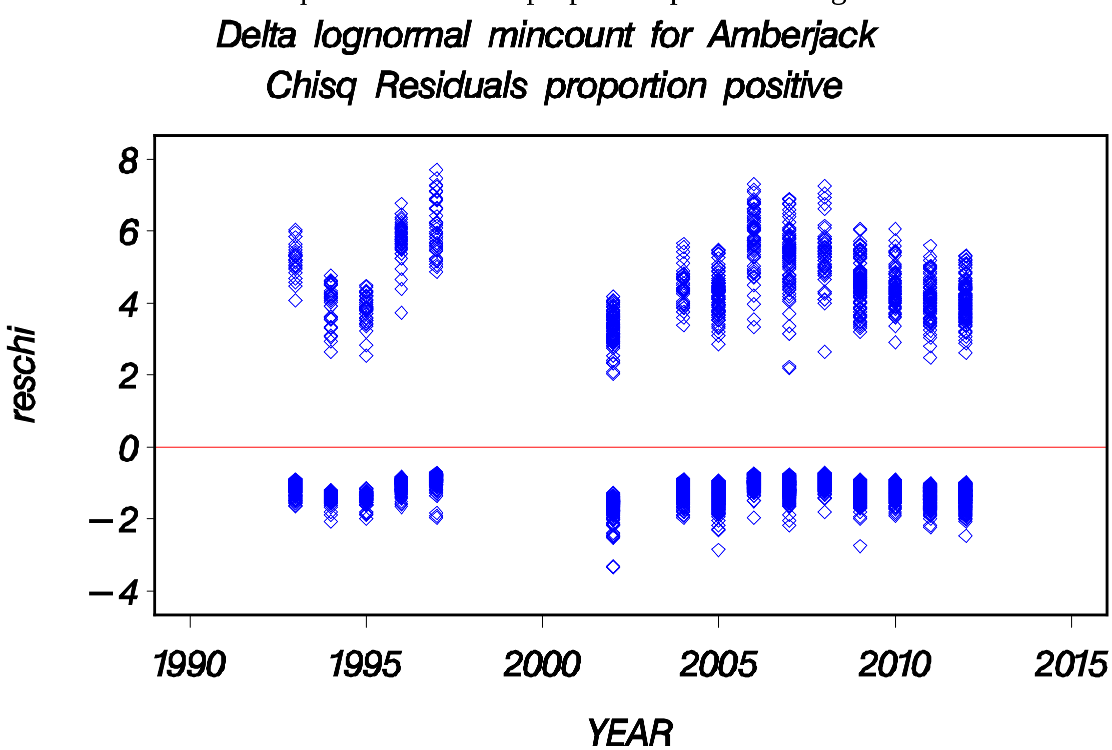

Table 2. GOM-wide greater amberjack lo and standardized index of abundance values by year design based model.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.15723	159	0.47200	1.14831	0.090376	0.19147	0.78568	1.67833
1994	0.27966	118	0.49831	1.21231	0.089951	0.18051	0.84738	1.73441
1995	0.29204	113	0.45749	1.11299	0.081160	0.17740	0.78270	1.58268
1996	0.15260	308	0.28655	0.69713	0.045083	0.15733	0.50991	0.95310
1997	0.14591	281	0.25085	0.61028	0.046058	0.18361	0.42401	0.87840
2002	0.34109	258	0.75454	1.83568	0.082089	0.10879	1.47768	2.28043
2004	0.18182	198	0.39662	0.96491	0.061284	0.15452	0.70969	1.31192
2005	0.22308	390	0.41865	1.01852	0.044949	0.10736	0.82221	1.26171
2006	0.14925	402	0.30351	0.73839	0.041943	0.13819	0.56081	0.97219
2007	0.17521	468	0.36762	0.89436	0.043879	0.11936	0.70503	1.13454
2008	0.16438	292	0.30484	0.74163	0.047110	0.15454	0.54544	1.00839
2009	0.22087	412	0.44078	1.07234	0.048554	0.11016	0.86088	1.33575
2010	0.23549	293	0.34333	0.83526	0.044116	0.12850	0.64665	1.07888
2011	0.24769	432	0.48580	1.18189	0.055936	0.11514	0.93950	1.48682
2012	0.25607	453	0.38472	0.93597	0.038541	0.10018	0.76642	1.14304

Table 3. 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	2523.4
AIC (smaller is better)	2525.4
AICC (smaller is better)	2525.4
BIC (smaller is better)	2530.2

b

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
year	14	918	1.63	0.0664
depth	1	918	8.14	0.0044
MAXRELIEF	1	918	0.01	0.9255

Figure 20. GOM-wide observed versus standardized mincount for design based model.

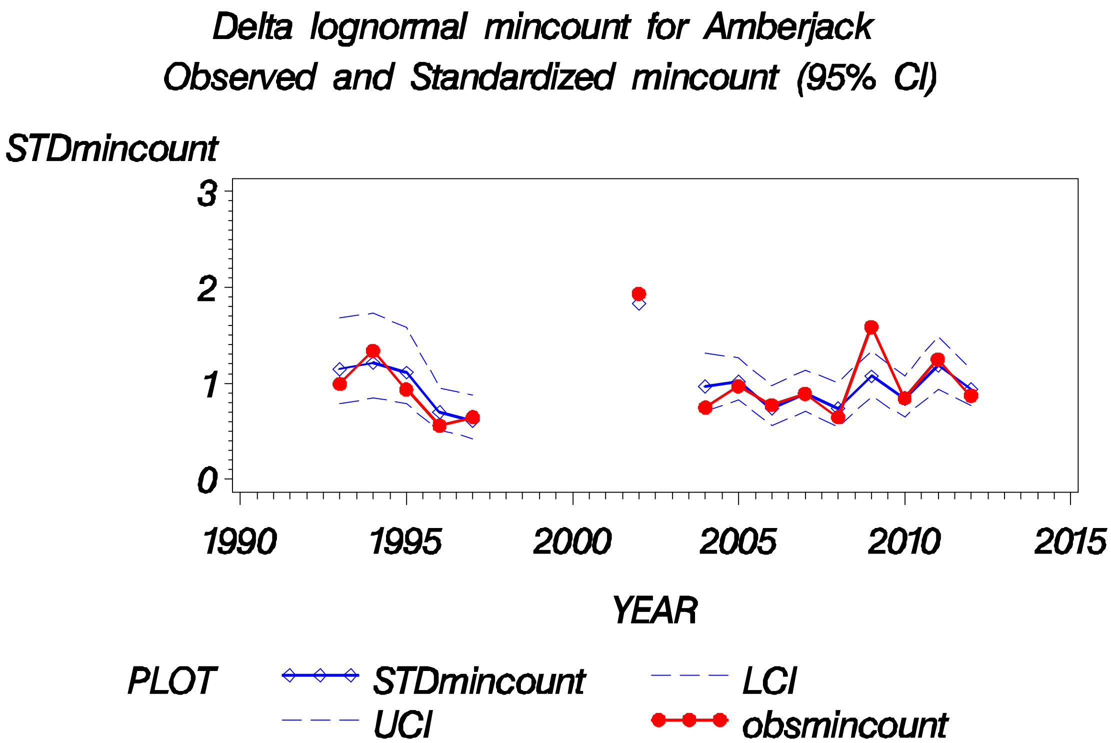

Figure 21. GOM-wide observed versus predicted mincount of positive data for design based model.

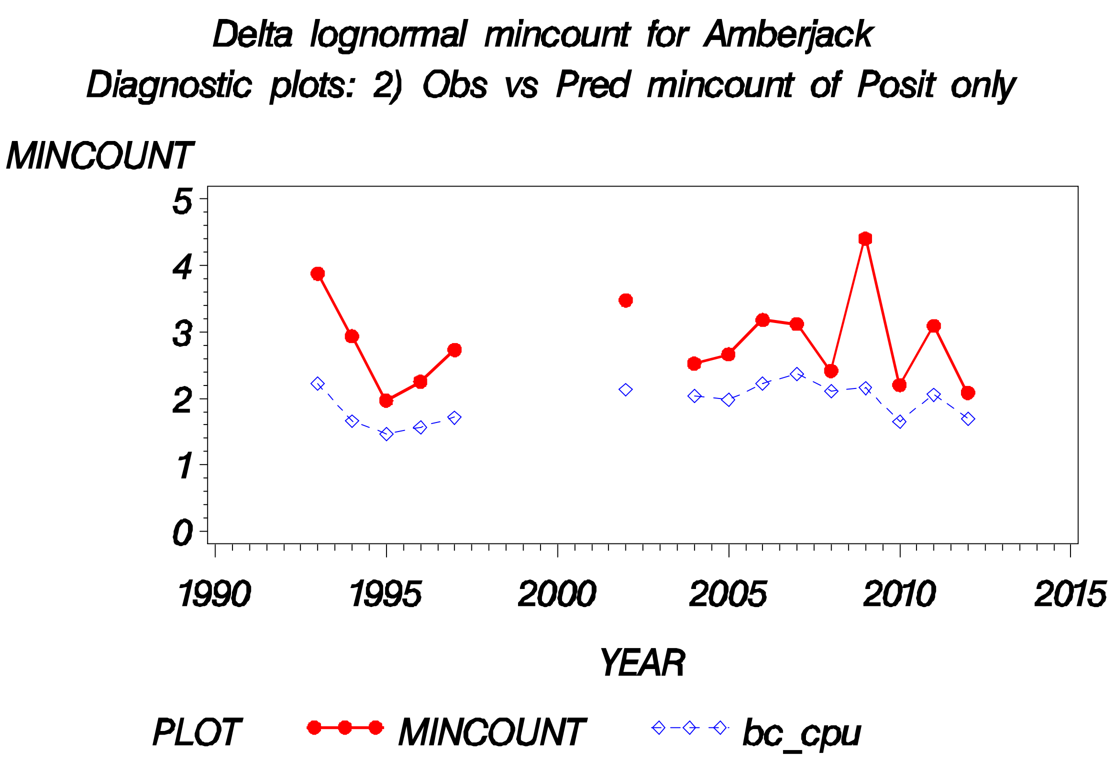

Figure 22. GOM-wide observed versus predicted mincount for design based model.

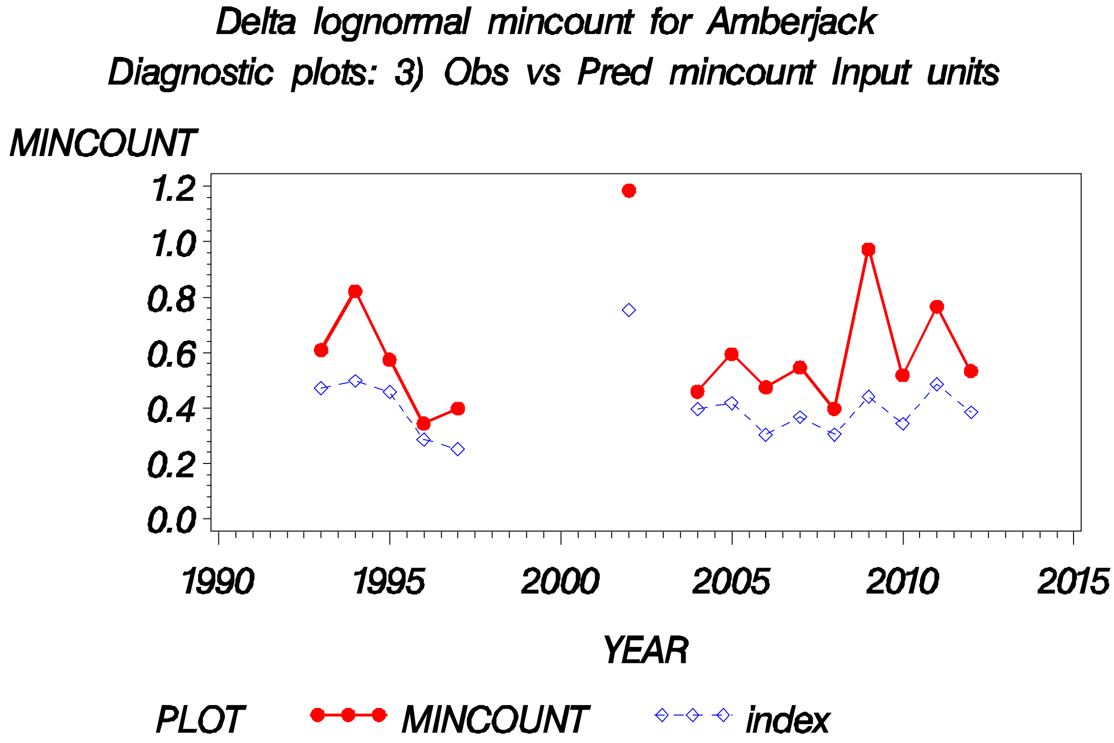

Figure 23. GOM wide residuals of positive mincounts by year for design based model.

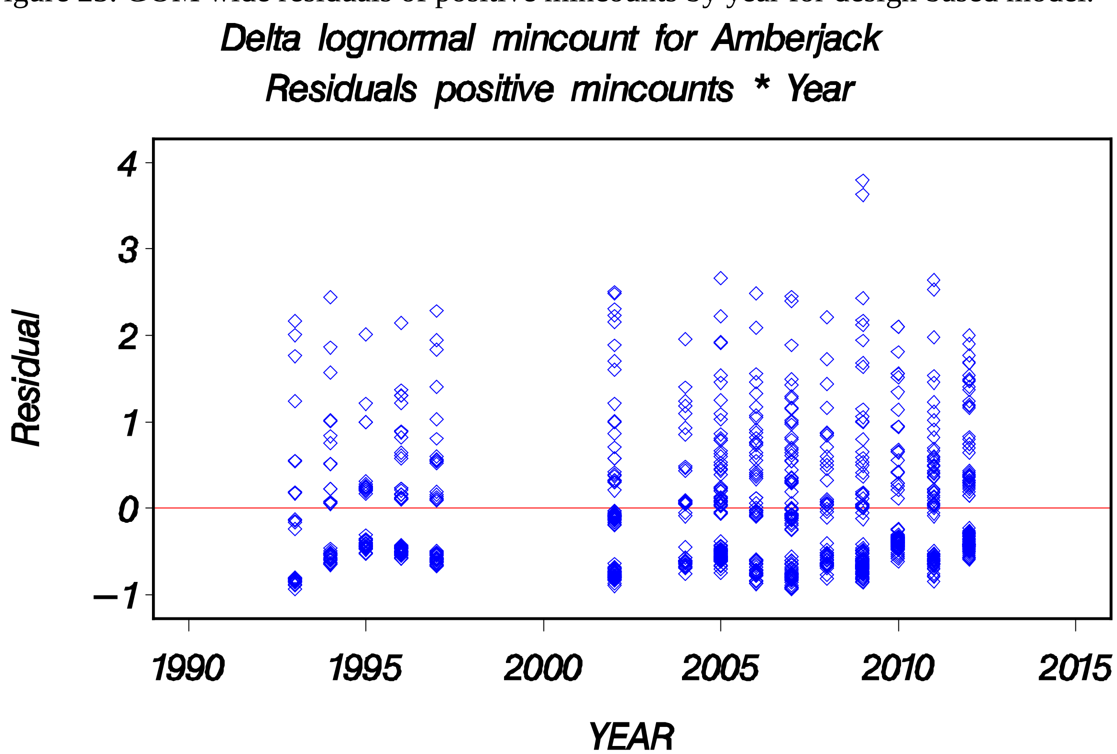

Figure 24 GOM-wide residuals distribution from positive mincount design based model.

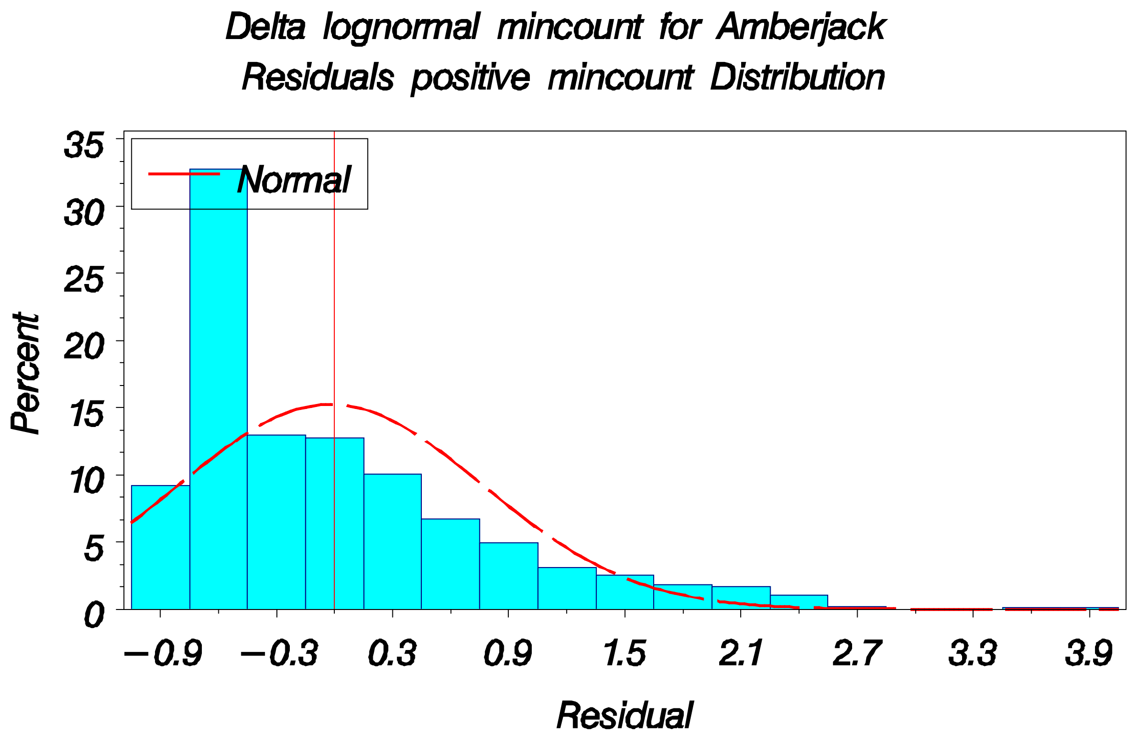

Figure 25 GOM-wide qqplot of residuals of positive mincounts from design based model.

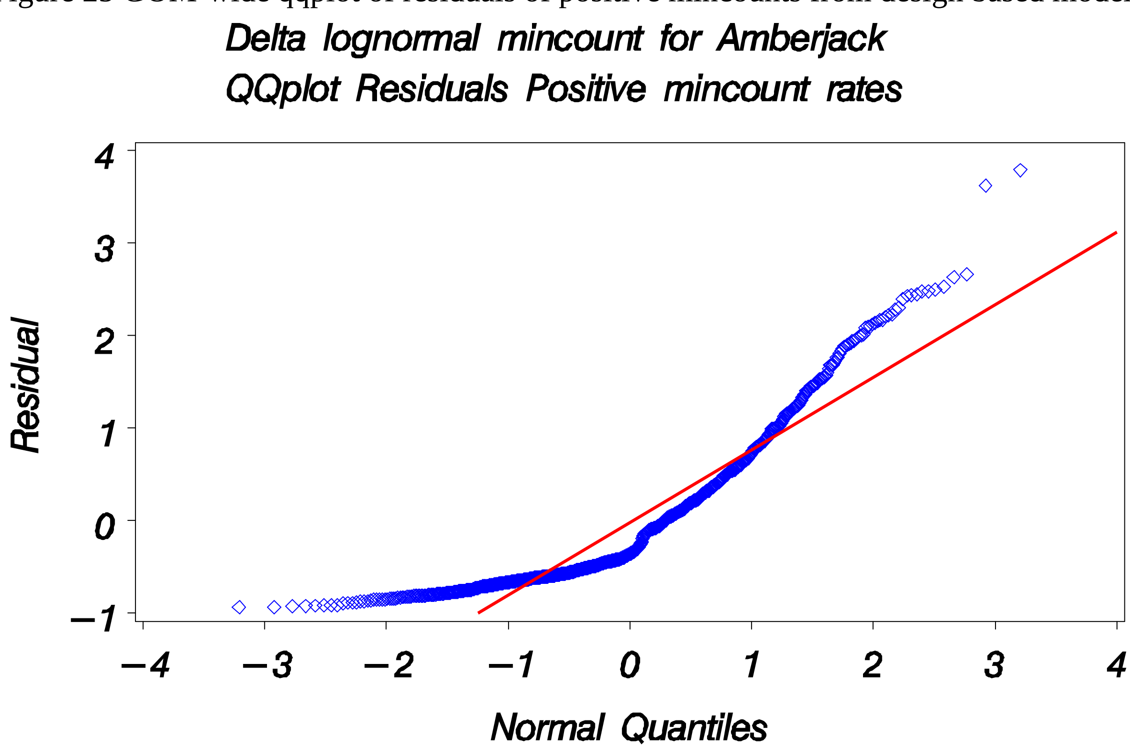

Table 4. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics (d) of the GLIMMIX binomial on proportion positives for the east GOM model.

a

Iteration History			
Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	13406.28031850	0.00000000

b

Fit Statistics	
-2 Res Log Likelihood	13406.3
AIC (smaller is better)	13436.3
AICC (smaller is better)	13436.5
BIC (smaller is better)	13525.6

c

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	14	857	45.95	3.25	<.0001	<.0001
depth	1	2183	54.50	54.50	<.0001	<.0001
MAXRELIEF	1	1951	39.53	39.53	<.0001	<.0001

d

Description	*Value*
Deviance	846.8134
Scaled Deviance	2884.3447
Pearson Chi-Square	911.3169
Scaled Pearson Chi-Square	3104.0509
Extra-Dispersion Scale	0.2936

Figure 26. Observed versus predicted proportion positive from east GOM design based model.

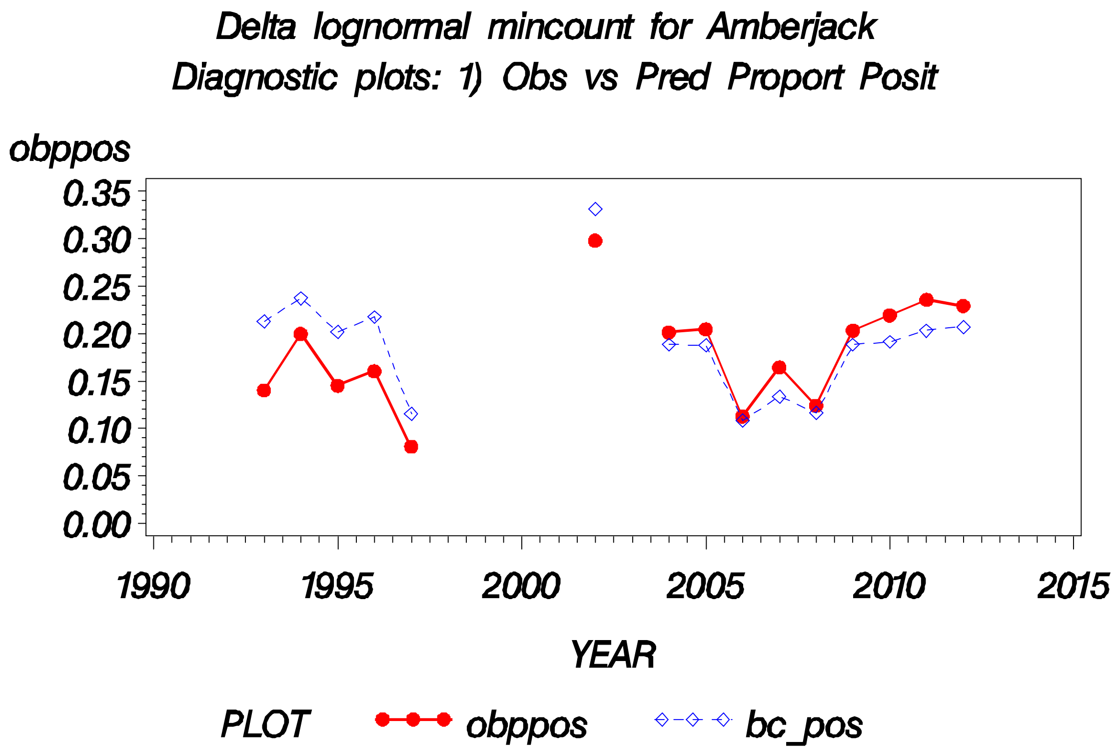

Figure 27. Chi-square residuals of proportion positives from east GOM design based model.

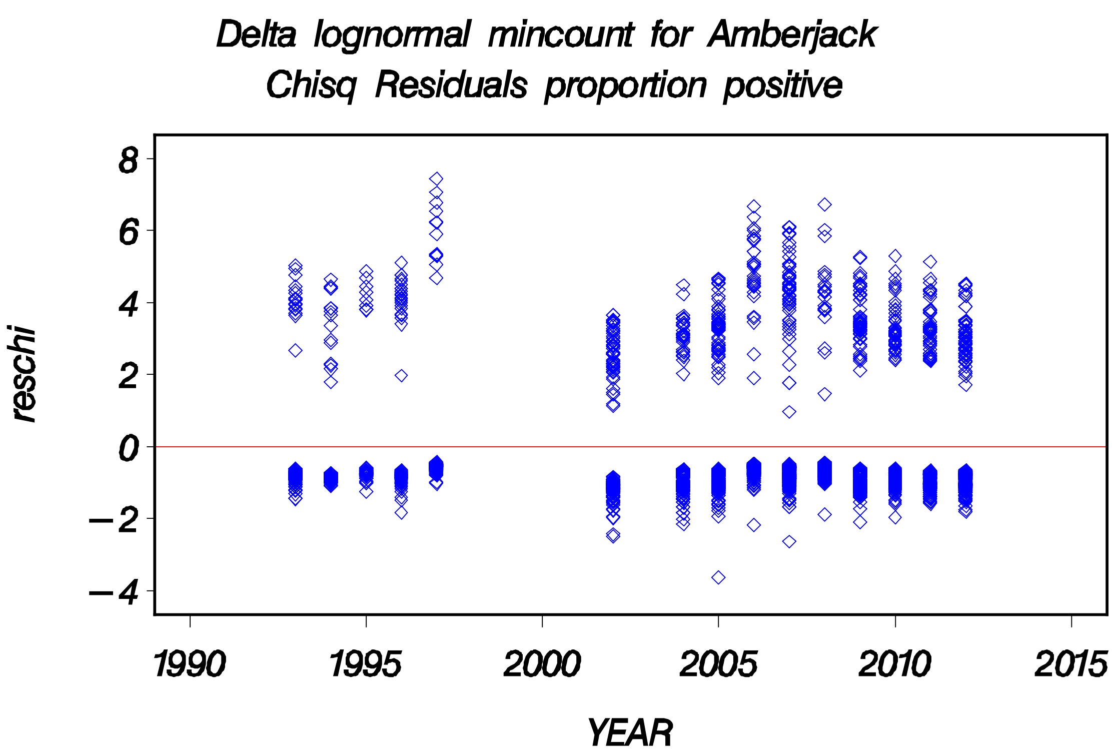

Table 5. East GOM greater amberjack lo and standardized index of abundance by year for design based model.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.14035	114	0.64732	1.53622	0.20248	0.31280	0.83382	2.83033
1994	0.20000	75	0.45663	1.08369	0.16067	0.35185	0.54722	2.14606
1995	0.14516	62	0.26972	0.64011	0.11642	0.43163	0.28005	1.46308
1996	0.16058	137	0.38681	0.91799	0.10971	0.28361	0.52631	1.60114
1997	0.08108	148	0.22434	0.53242	0.08965	0.39960	0.24657	1.14965
2002	0.29814	161	0.93279	2.21372	0.18087	0.19390	1.50750	3.25078
2004	0.20134	149	0.41616	0.98763	0.09836	0.23636	0.61956	1.57437
2005	0.20472	254	0.40330	0.95712	0.07432	0.18428	0.66410	1.37941
2006	0.11278	266	0.23918	0.56761	0.05935	0.24814	0.34812	0.92548
2007	0.16452	310	0.33847	0.80325	0.07119	0.21033	0.52983	1.21778
2008	0.12426	169	0.30125	0.71493	0.08757	0.29068	0.40447	1.26369
2009	0.20325	246	0.49640	1.17806	0.09672	0.19485	0.80076	1.73314
2010	0.21939	196	0.35834	0.85042	0.07642	0.21325	0.55779	1.29659
2011	0.23585	318	0.45902	1.08936	0.09148	0.19930	0.73409	1.61657
2012	0.22925	253	0.39082	0.92749	0.07153	0.18303	0.64512	1.33345

Table 6. 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	1372.4
AIC (smaller is better)	1374.4
AICC (smaller is better)	1374.4
BIC (smaller is better)	1378.6

b

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
year	14	489	1.17	0.2913
depth	1	489	3.35	0.0680
MAXRELIEF	1	489	0.36	0.5475

Figure 28. Observed and standardized mincounts from east GOM design based model.

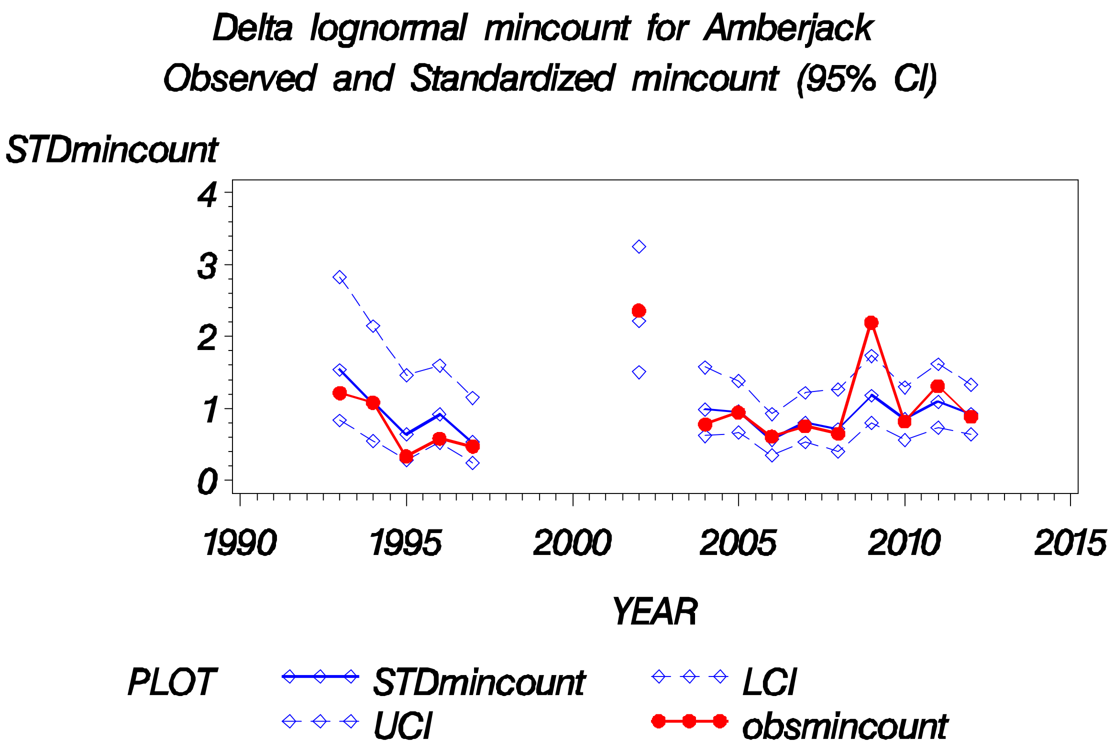

Figure 29. Observed versus predicted mincounts from east GOM design based model.

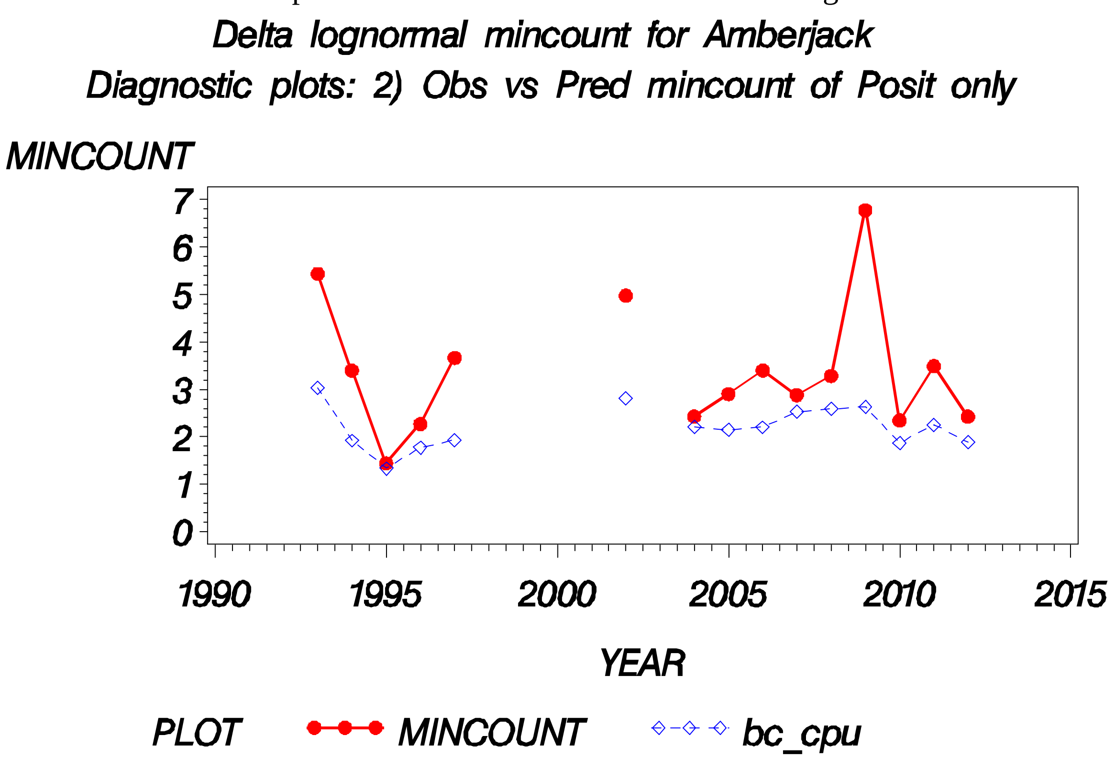

Figure 30. Observed versus predicted mincounts from east GOM design based models

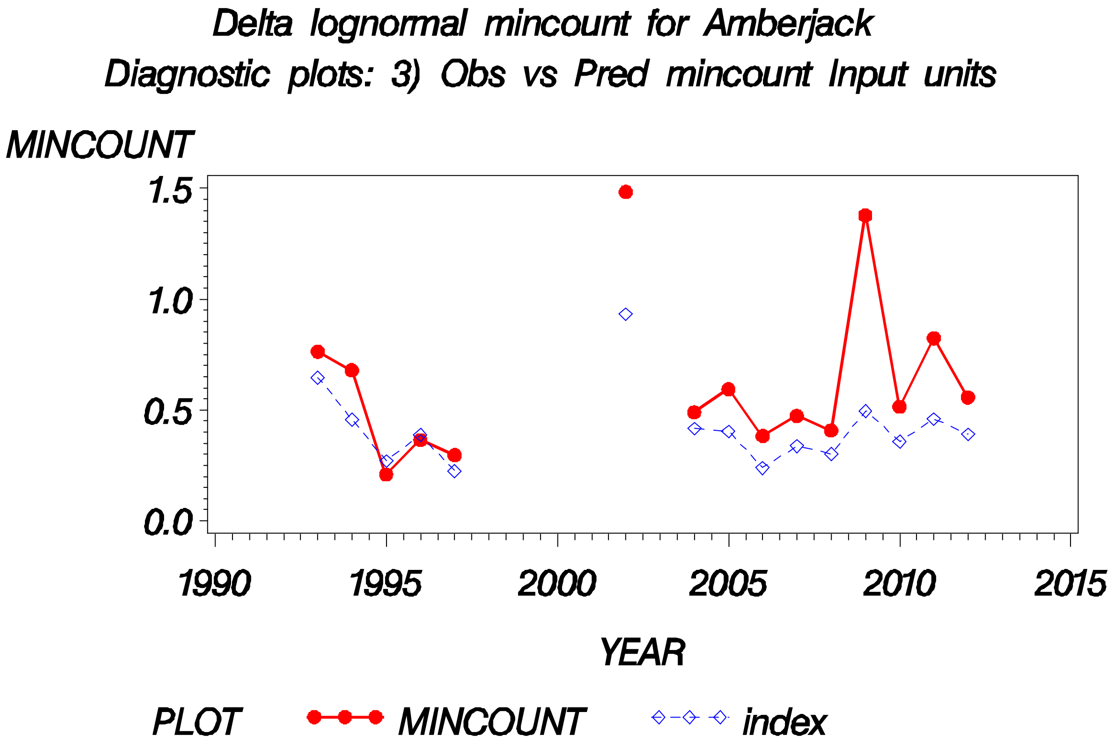

Figure 31 Residuals of positive mincounts for east GOM design based model.

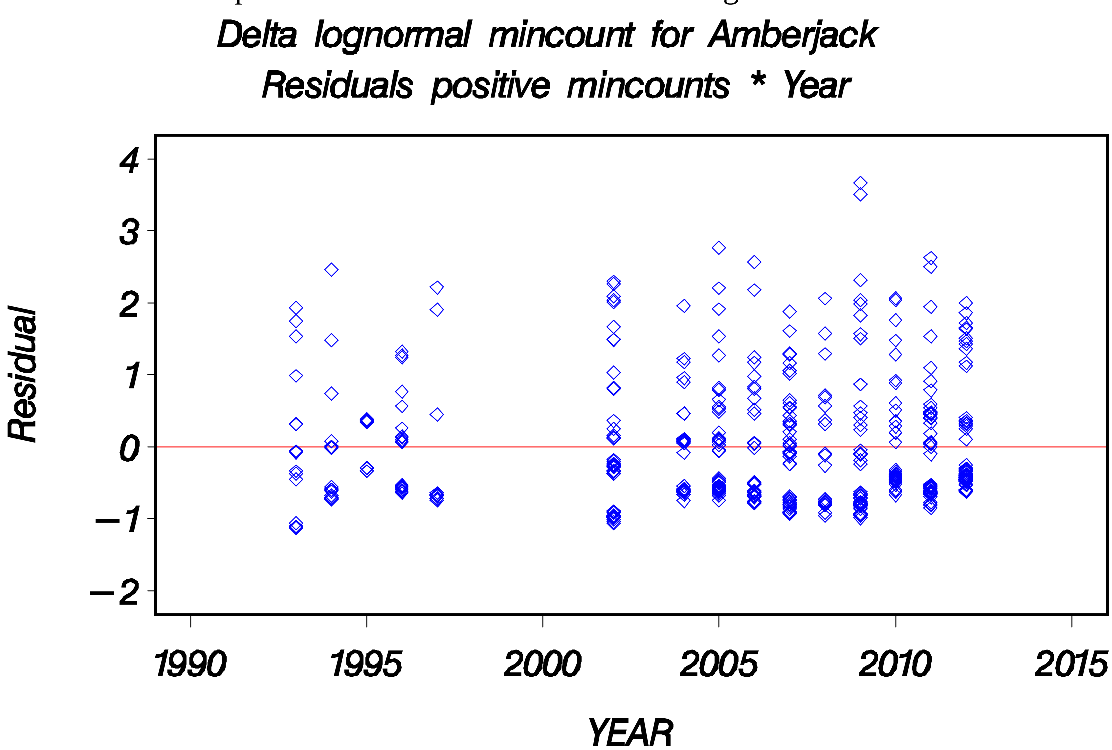

Figure 32. Positive mincount distribution from east GOM design based model.

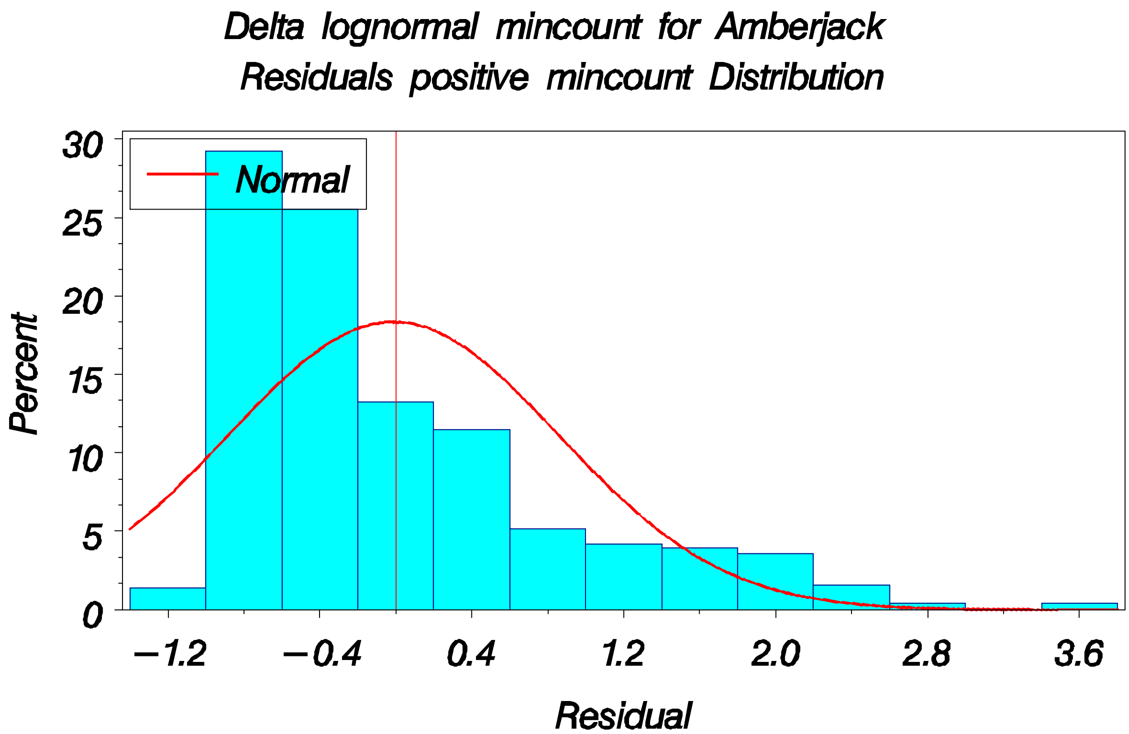

Figure 33. QQ plot of positive mincounts from east GOM design based model.

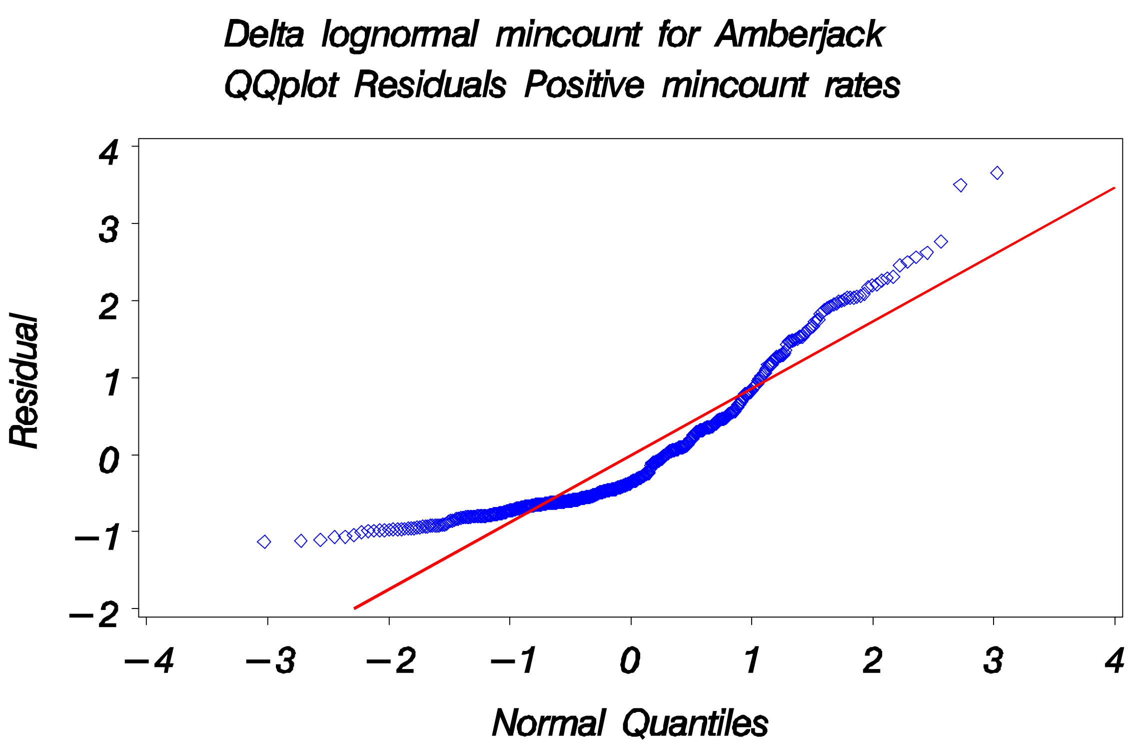

Table 7. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics (d) of the GLIMMIX binomial on proportion positives for the west GOM model.

a

Iteration History			
Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	8161.95087073	0.00000000

b

Fit Statistics	
-2 Res Log Likelihood	8162.0
AIC (smaller is better)	8192.0
AICC (smaller is better)	8192.2
BIC (smaller is better)	8273.7

c

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	14	490	54.97	3.86	<.0001	<.0001
depth	1	1357	8.27	8.27	0.0040	0.0041
MAXRELIEF	1	997	0.19	0.19	0.6588	0.6589

d

Description	*Value*
Deviance	799.6733
Scaled Deviance	1899.7182
Pearson Chi-Square	751.0466
Scaled Pearson Chi-Square	1784.1997
Extra-Dispersion Scale	0.4209

Figure 34. Observed versus predicted proportion positive from west GOM design based model.

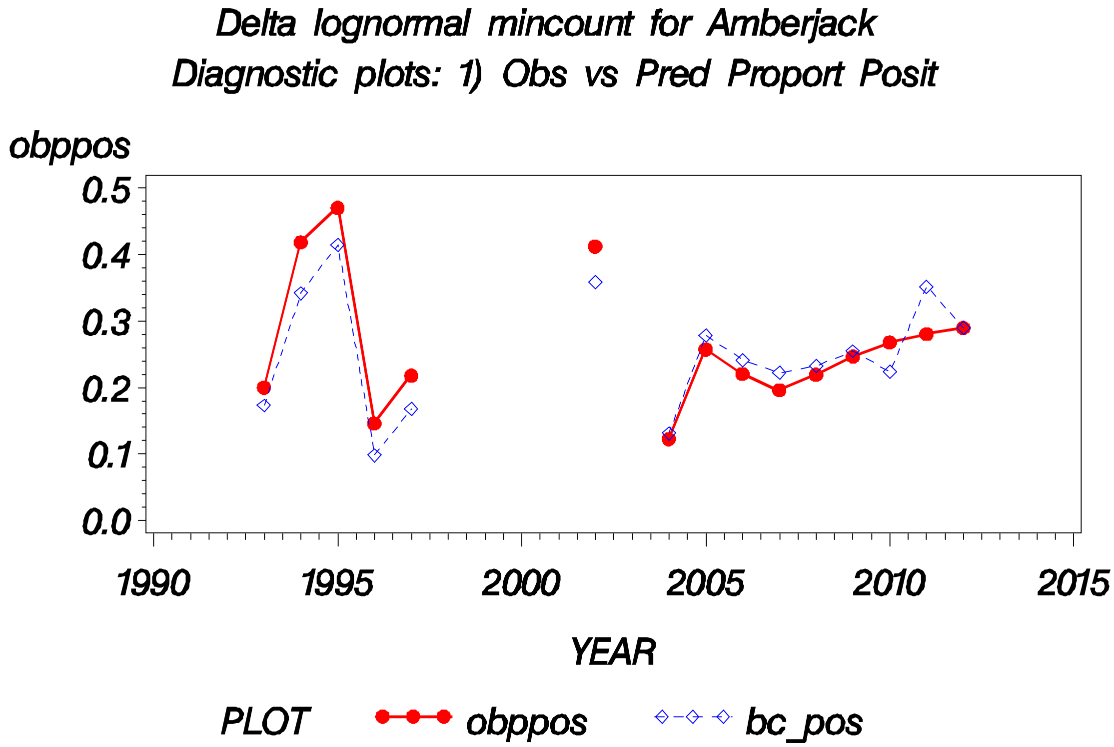

Figure 35. Chi-square residuals of proportion positives of west GOM design based model.

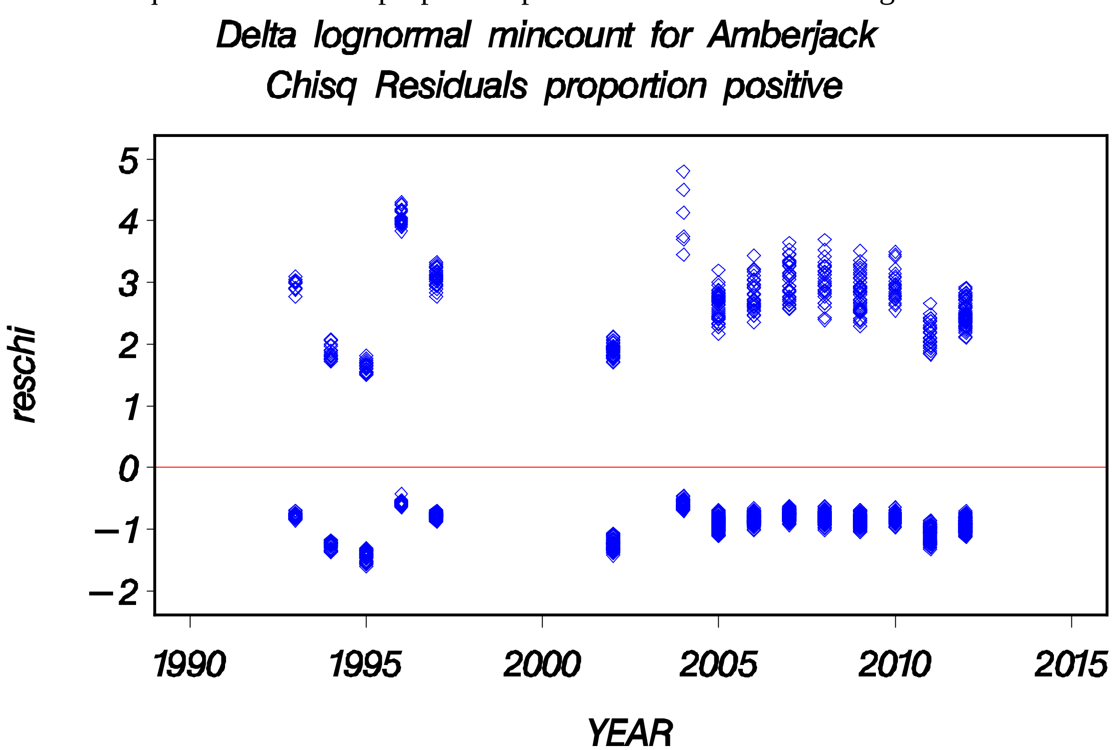

Table 8. West GOM greater amberjack Lo and standardized index of abundance by year for design based model.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.20000	45	0.19660	0.44445	0.07140	0.36315	0.21984	0.89854
1994	0.41860	43	0.61393	1.38790	0.16047	0.26139	0.82996	2.32091
1995	0.47059	51	0.73571	1.66321	0.15628	0.21242	1.09264	2.53174
1996	0.14620	171	0.16059	0.36303	0.04264	0.26555	0.21538	0.61190
1997	0.21805	133	0.29453	0.66583	0.07043	0.23913	0.41547	1.06705
2002	0.41237	97	0.53543	1.21043	0.09404	0.17564	0.85416	1.71531
2004	0.12245	49	0.26854	0.60708	0.12007	0.44714	0.25848	1.42584
2005	0.25735	136	0.52155	1.17906	0.09489	0.18195	0.82183	1.69156
2006	0.22059	136	0.63467	1.43479	0.12416	0.19563	0.97378	2.11405
2007	0.19620	158	0.51631	1.16721	0.10005	0.19378	0.79503	1.71363
2008	0.21951	123	0.37467	0.84701	0.08165	0.21793	0.55054	1.30312
2009	0.24699	166	0.38130	0.86199	0.06781	0.17784	0.60567	1.22679
2010	0.26804	97	0.29601	0.66919	0.07528	0.25433	0.40560	1.10409
2011	0.28070	114	0.66394	1.50096	0.12004	0.18080	1.04855	2.14855
2012	0.29000	200	0.44139	0.99785	0.06506	0.14741	0.74425	1.33787

Table 9. 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	946.1
AIC (smaller is better)	948.1
AICC (smaller is better)	948.1
BIC (smaller is better)	952.1

b

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	14	411	2.55	0.0016
depth	1	411	0.02	0.8849
MAXRELIEF	1	411	1.62	0.2042

Figure 36. Observed and standardized mincounts from west GOM design based model.

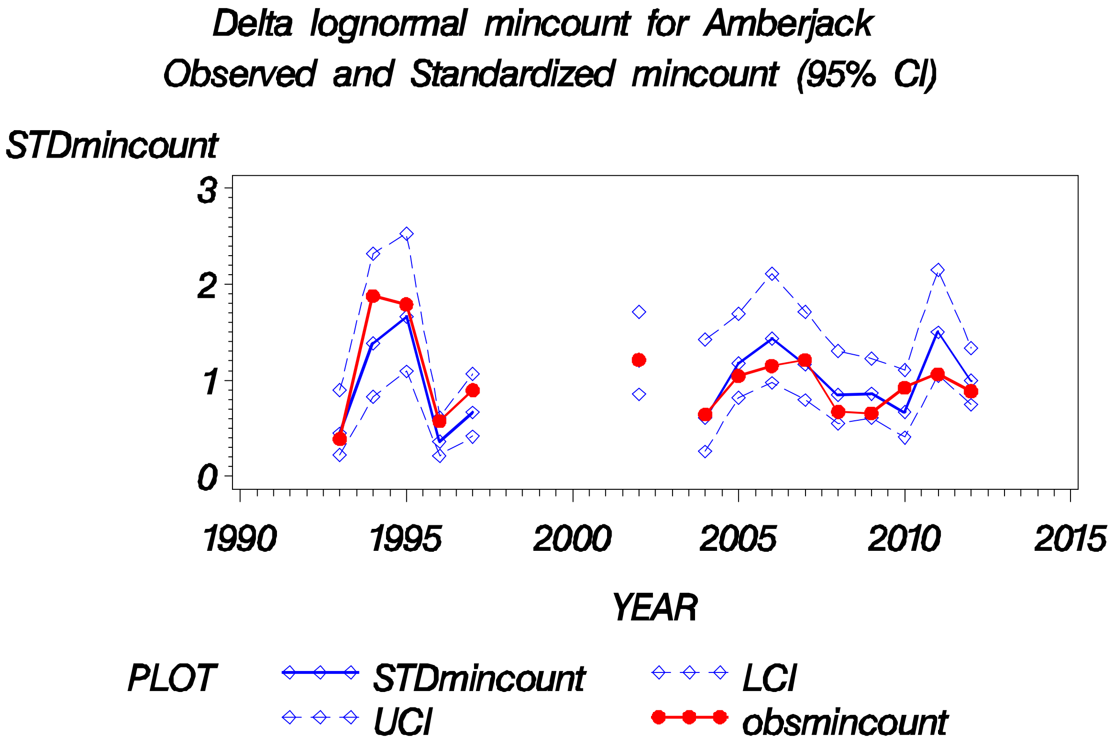

Figure 37. Observed versus predicted mincounts of positive data from west GOM design based model.

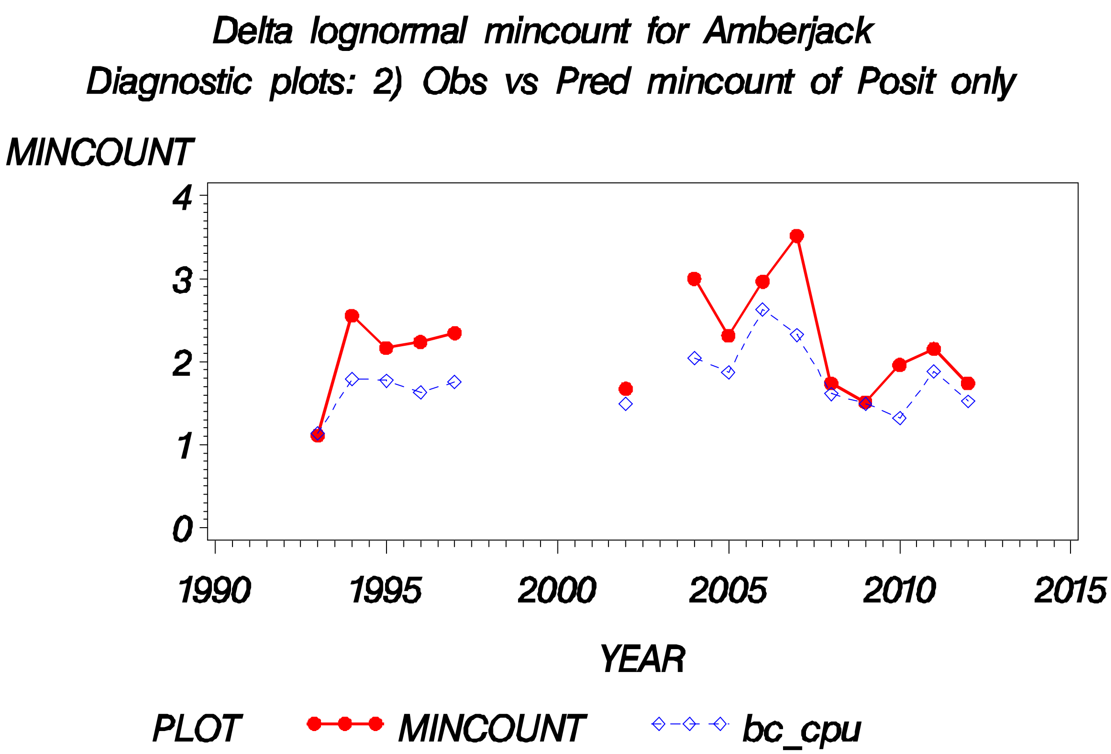

Figure 38. Observed versus predicted mincounts of west GOM design based model.

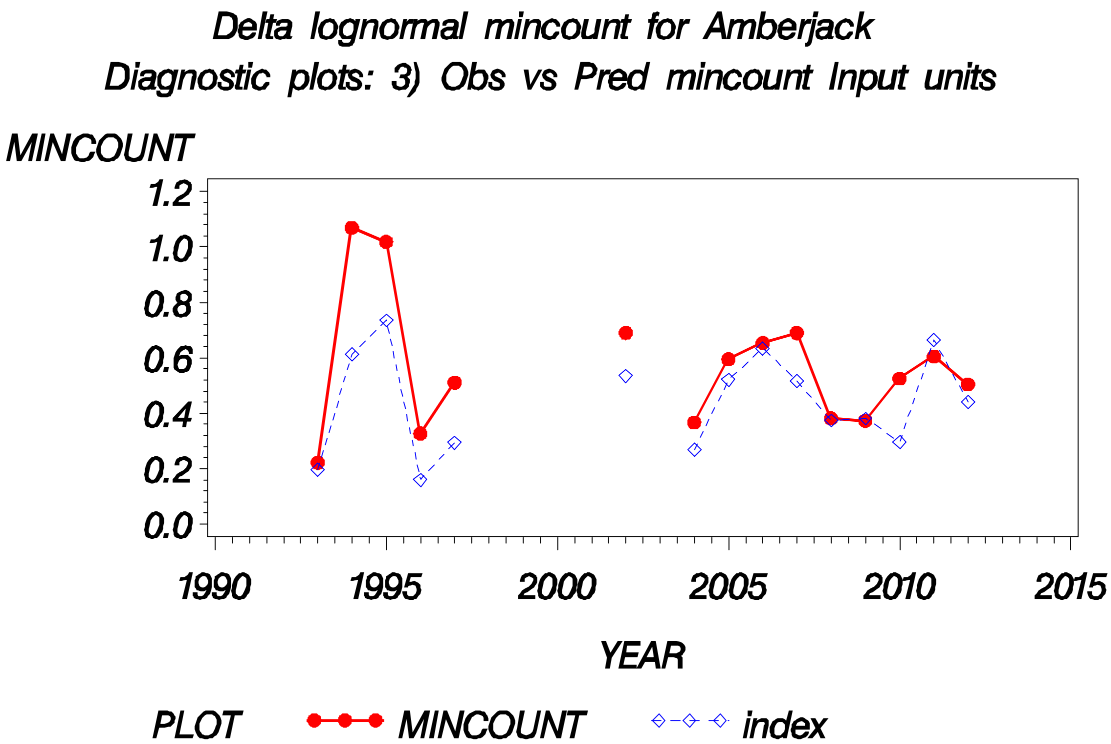

Figure 39. Residuals of positive mincounts for west GOM design based model.

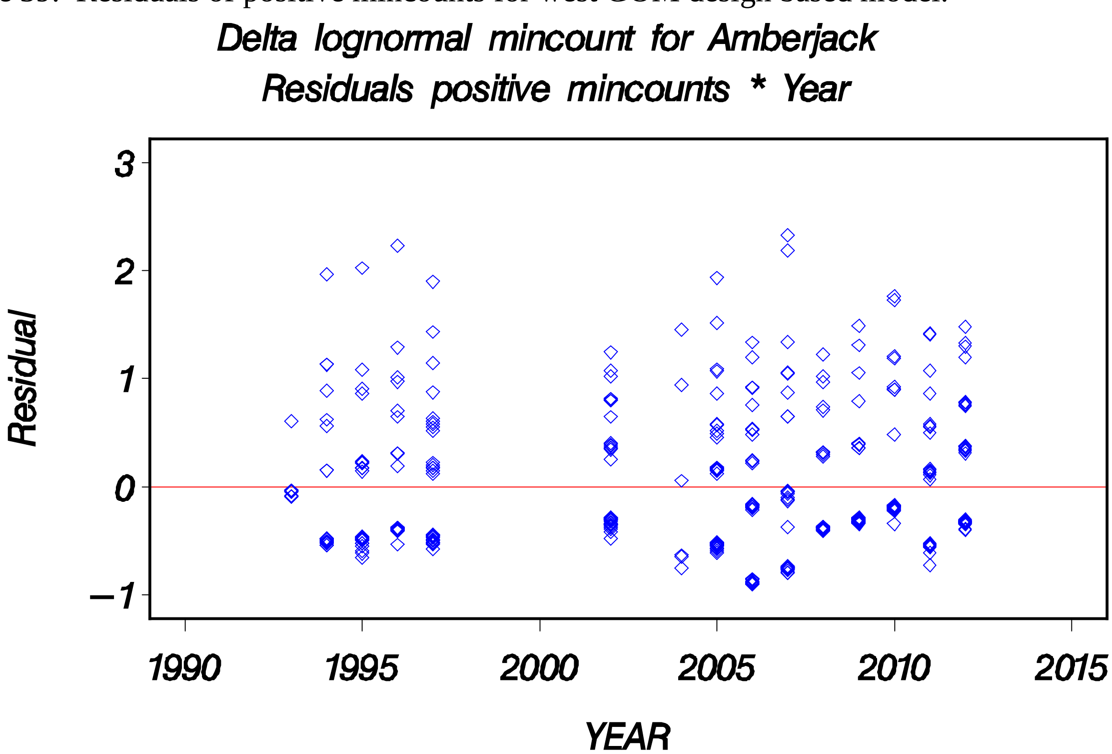

Figure 40. Positive mincount distribution of residuals for west GOM design based model.

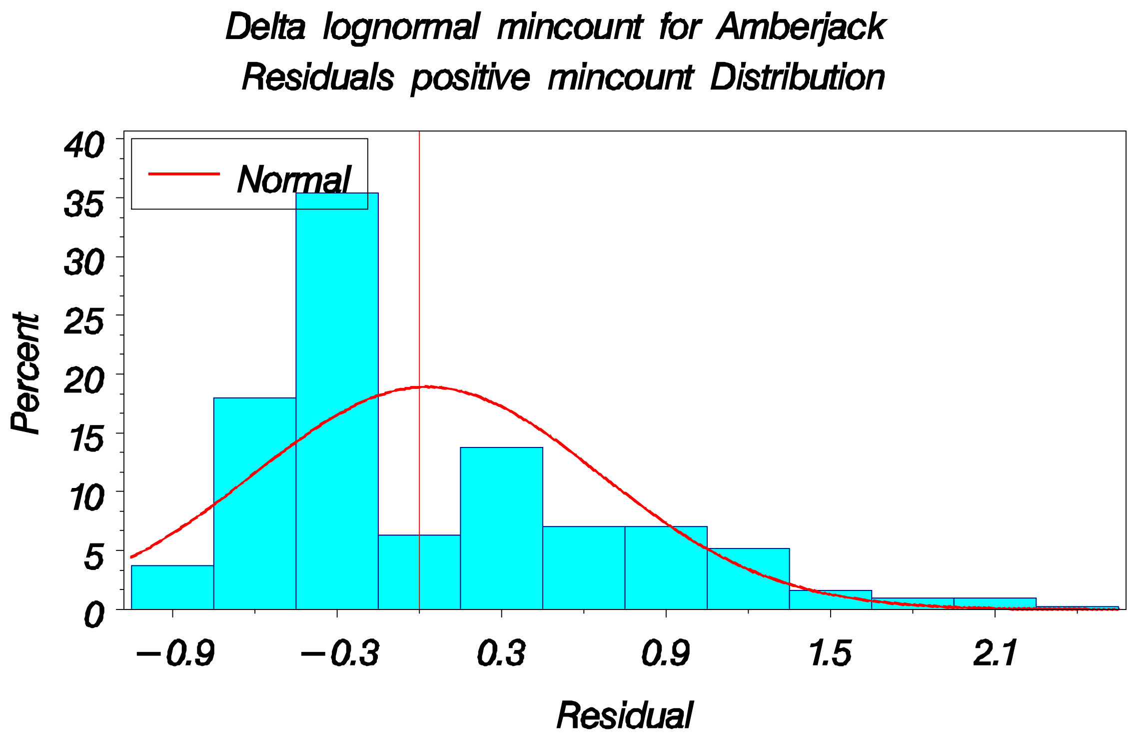

Figure 41. QQ plot of positive mincounts for west GOM design based model.

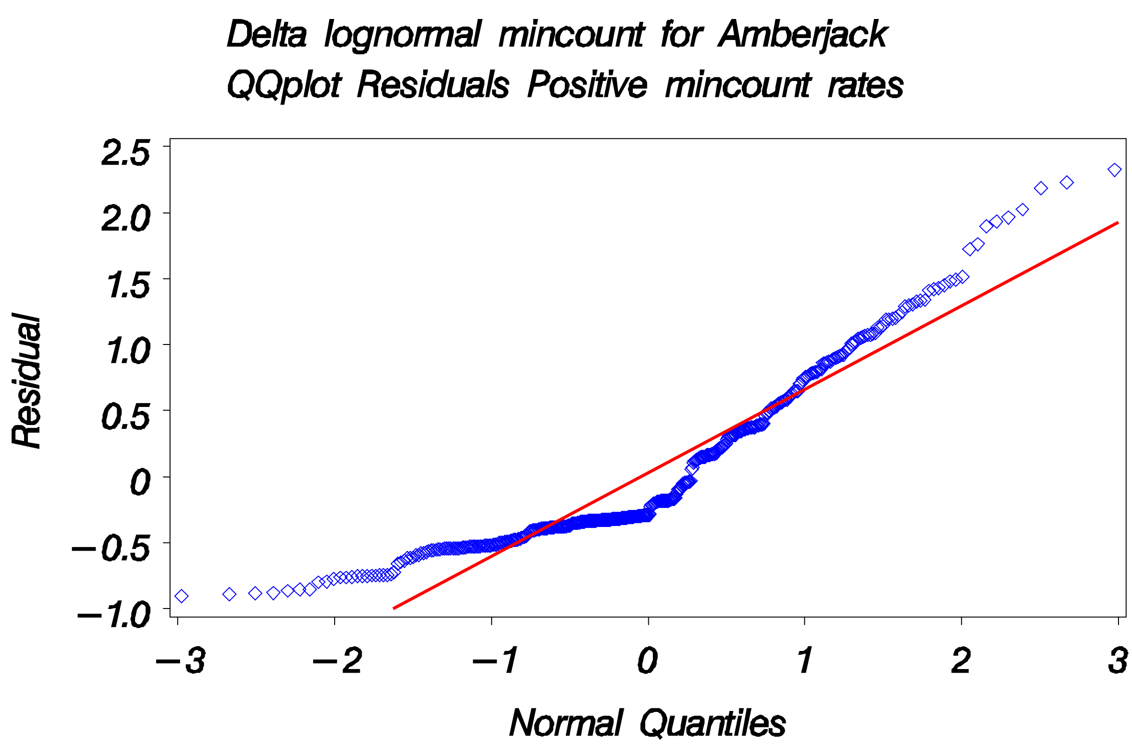

Figure 42. Greater amberjack length frequency of fish measured from video with lasers in 1995.

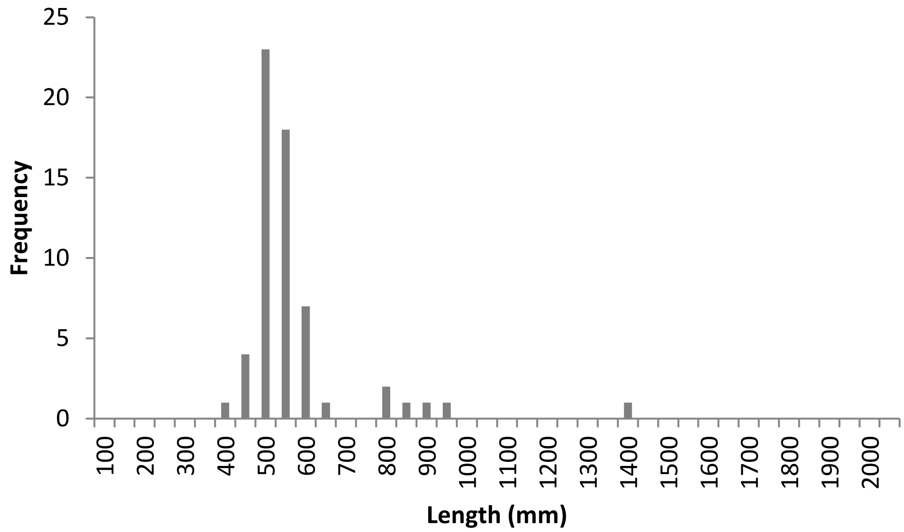

Figure 43. Greater amberjack length frequency of fish measured from video with lasers in 1996.

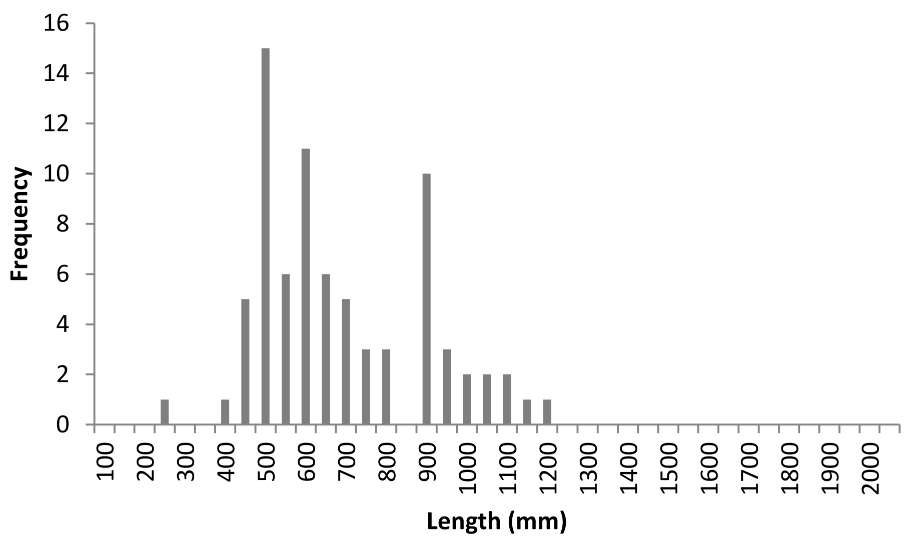

Figure 44. Greater amberjack length frequency of fish measured from video with lasers in 1997.

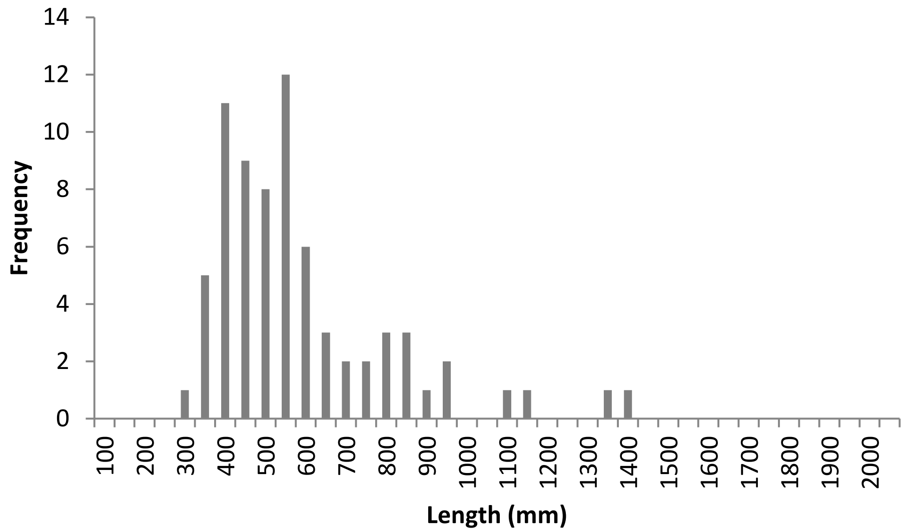

Figure 45. Greater amberjack length frequency of fish measured from video with lasers in 2001.

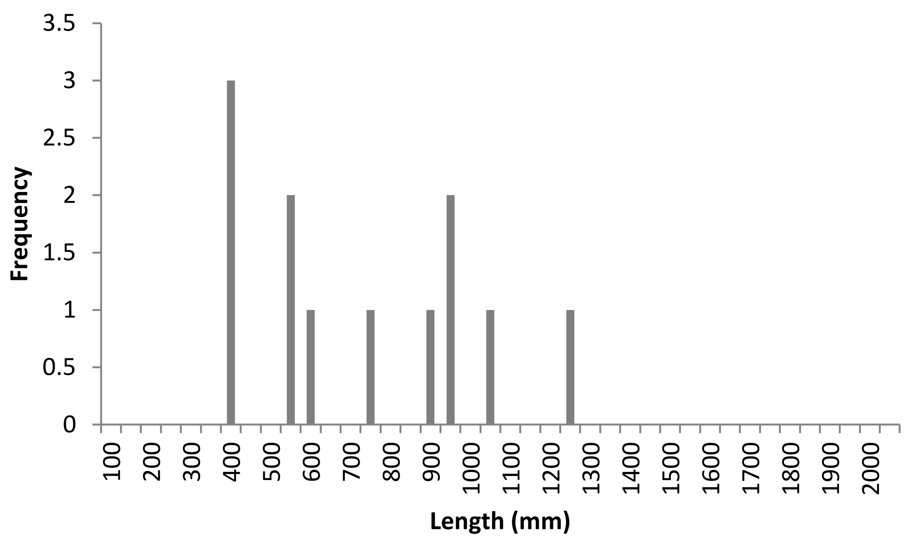

Figure 46. Greater amberjack length frequency of fish measured from video with lasers in 2002.

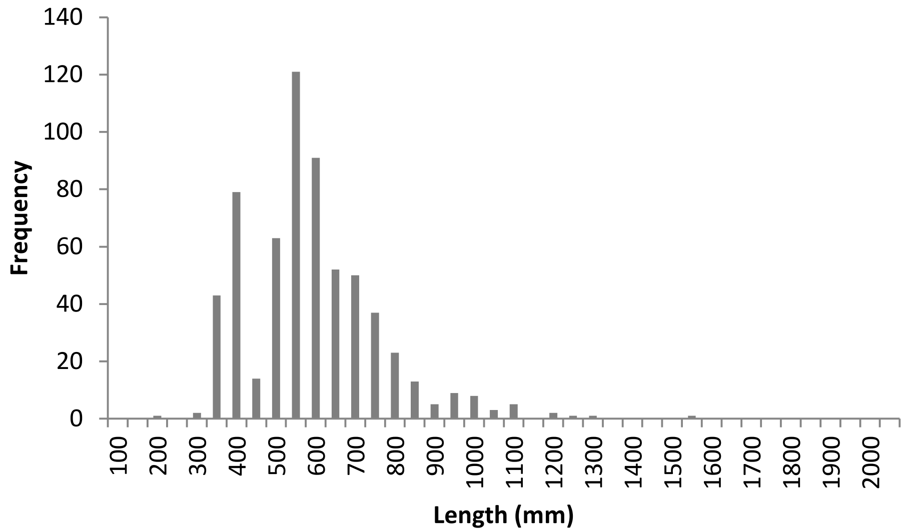

Figure 47. Greater amberjack length frequency of fish measured from video with lasers in 2004.

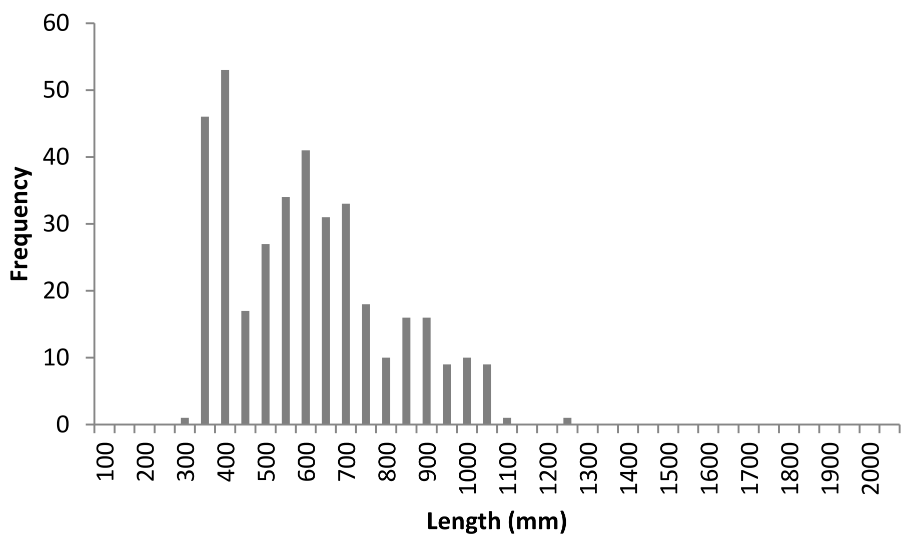

Figure 48. Greater amberjack length frequency of fish measured from video with lasers in 2005.

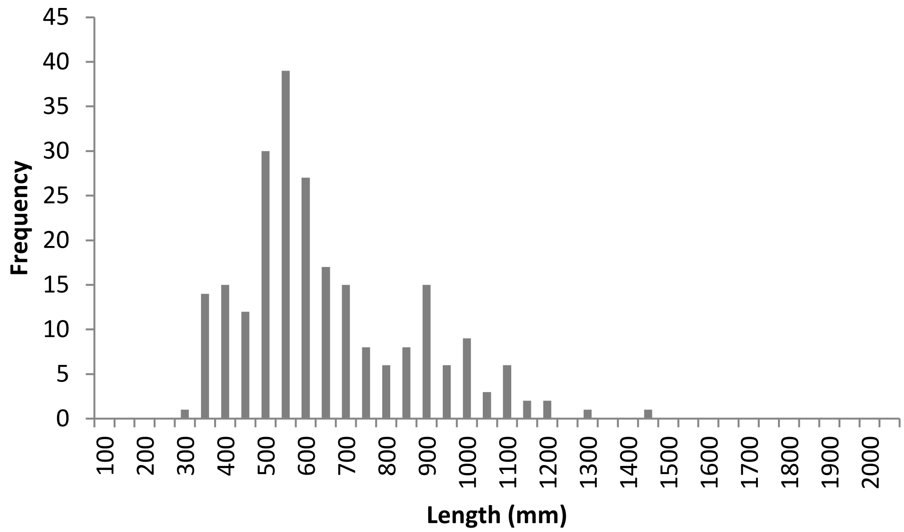

Figure 49. Greater amberjack length frequency of fish measured from video with lasers in 2006.

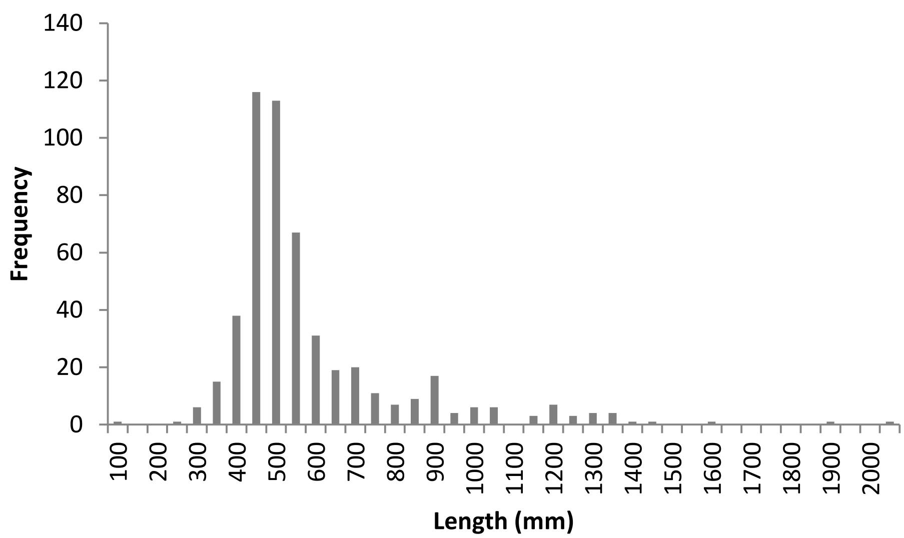

Figure 50. Greater amberjack length frequency of fish measured from video with lasers in 2007.

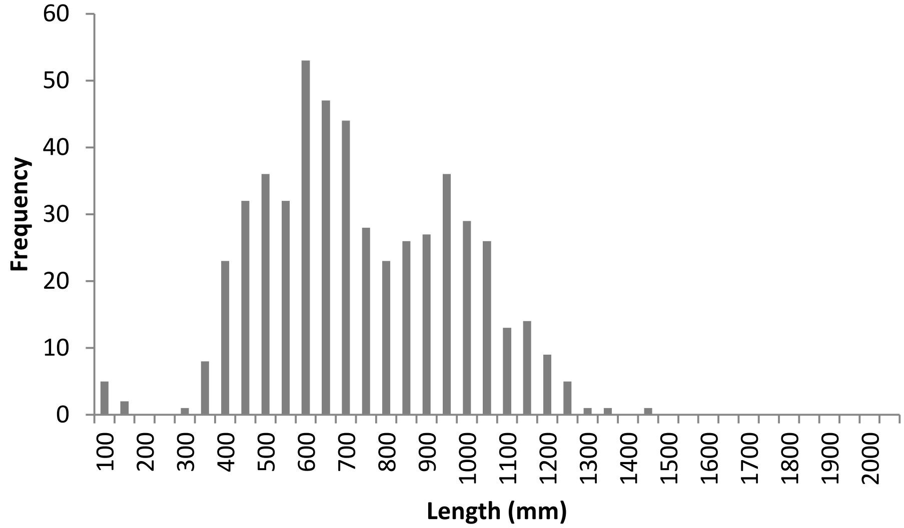

Figure 51. Greater amberjack length frequency of fish measured with stereo cameras in 2008.

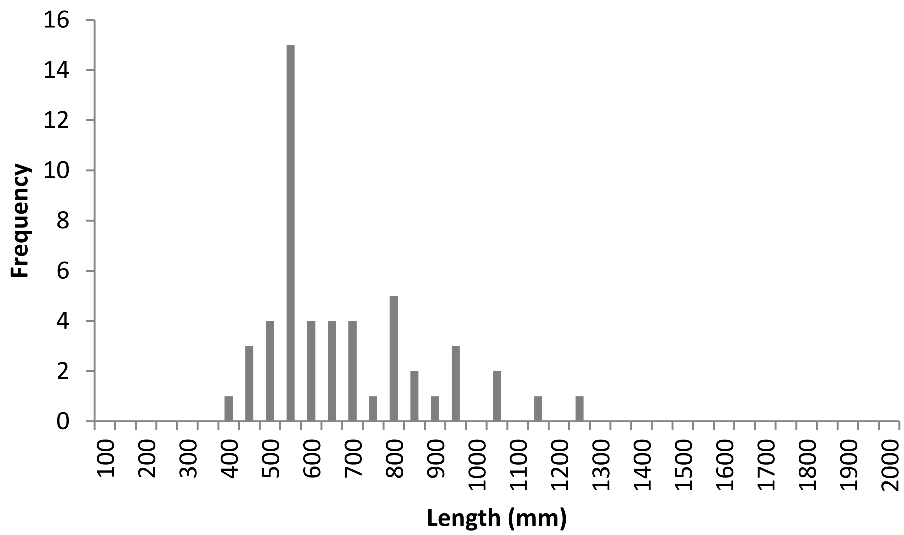

Figure 52. Greater amberjack length frequency of fish measured with stereo cameras in 2009.

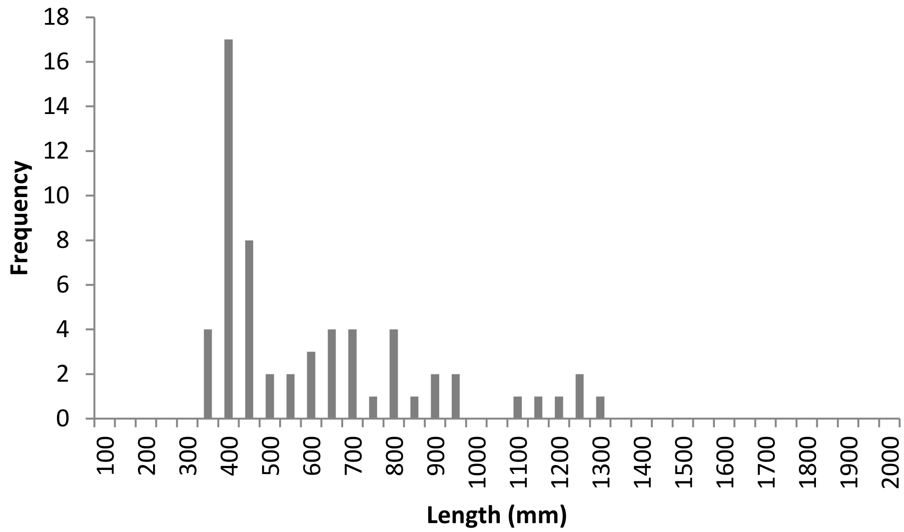

Figure 53. Greater amberjack length frequency of fish measured with stereo cameras in 2010.

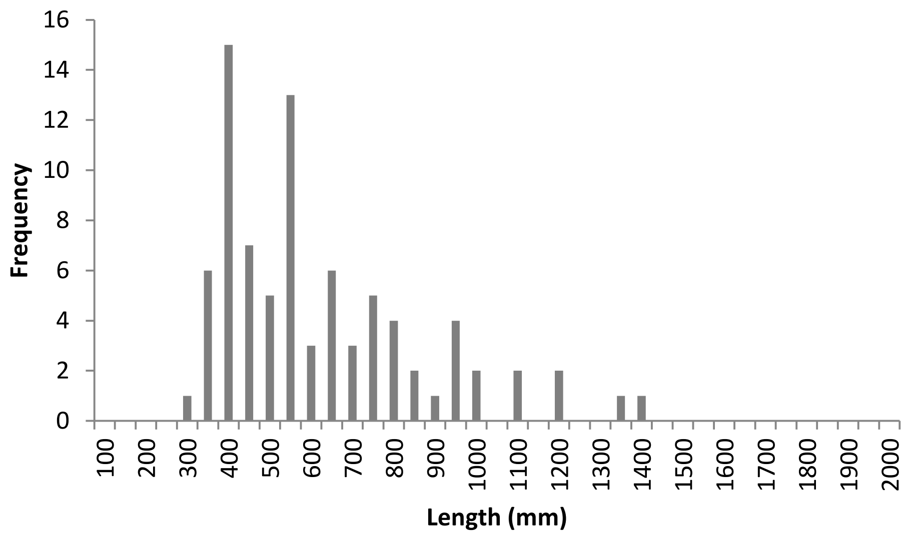

Figure 54. Greater amberjack length frequency of fish measured with stereo cameras in 2011.

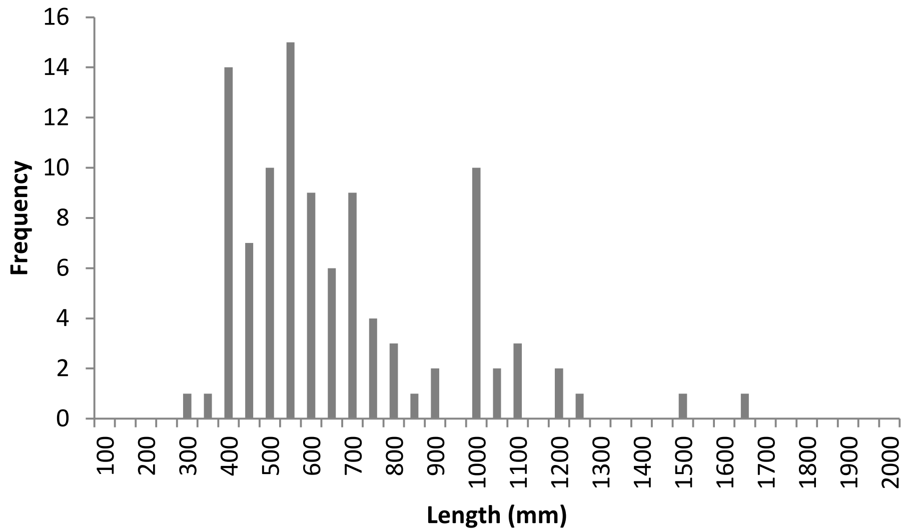

Figure 55. Greater amberjack length frequency of fish measured with stereo cameras in 2012.

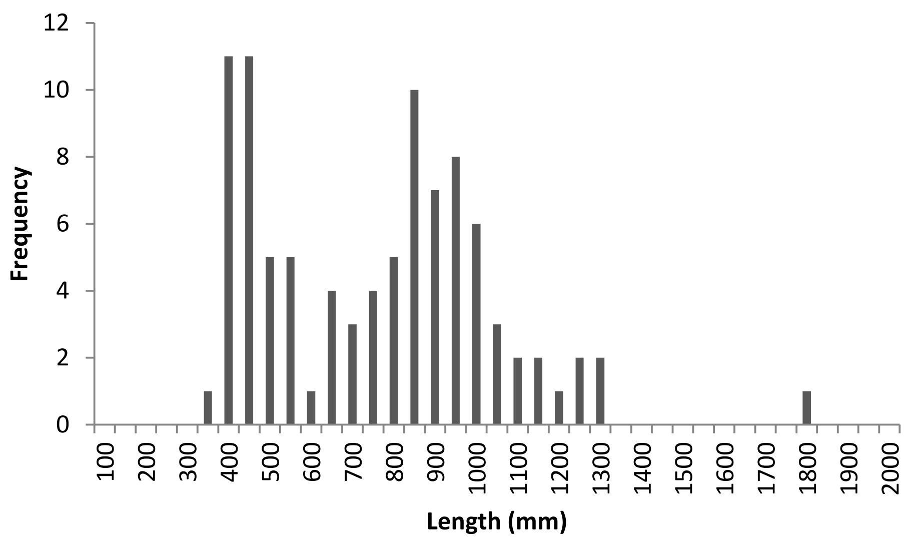

Figure 56. Greater amberjack mean lengths by year. Upper and lower quartiles represented within boxes, whiskers extend to subsequent quartiles, and non-overlapping notches indicate groups for which median responses are likely different.