SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gag

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SEAMAP Reef Fish Video Survey:
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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-present 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 gag sampled over the history of the survey had total lengths ranging from 250 – 1450 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.

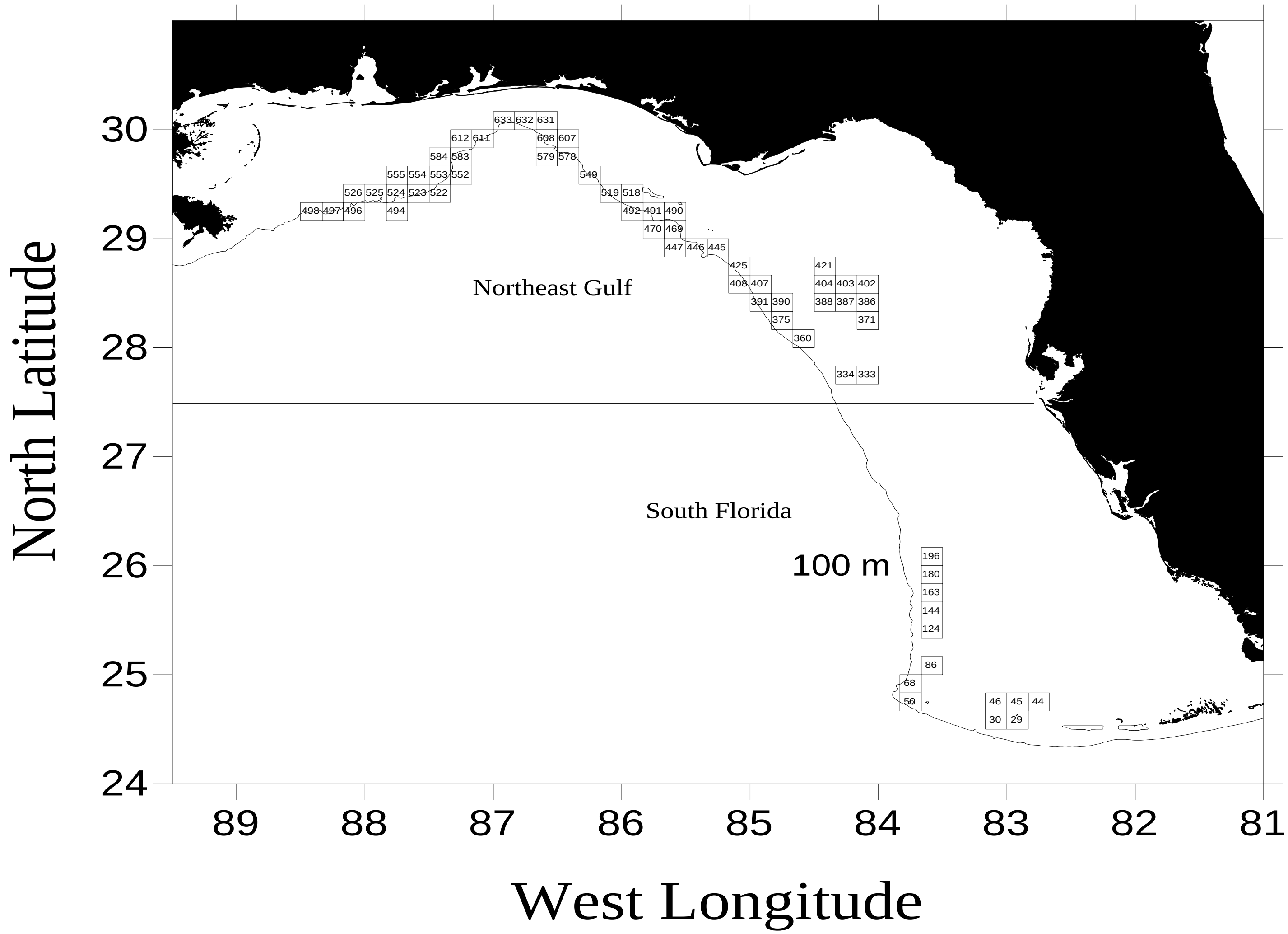

Figure 1. SEAMAP reef fish video survey sample blocks located in the eastern Gulf of Mexico.

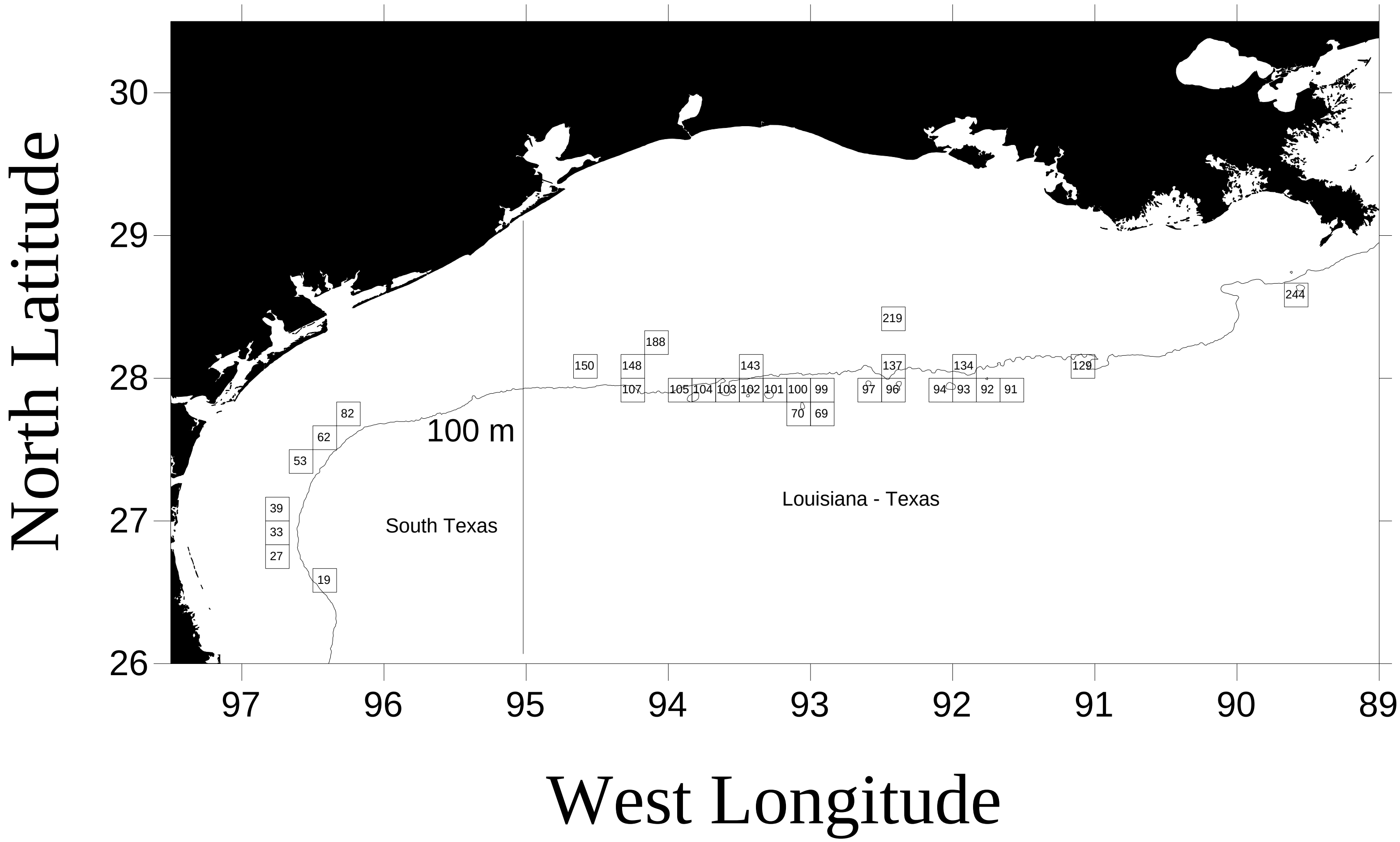

Figure 2. SEAMAP reef fish video survey sample blocks located in the western Gulf of Mexico.

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. Sites that did not receive a stratum assignment are also dropped.

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-present 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 and the Vision Measurement System (VMS, Geometrics Inc.) was used to estimate size of gag. Most years surveyed few gag were hit by lasers or measured using VMS therefore data were aggregated over years for each measurement technique used. Data is not aggregated over measurement technique employed (i.e. laser and stereo measurement).

Model based indices

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag (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) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

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, depth, and maxrelief. 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

Gag 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 and 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. Because of the scarcity of gag found in western Gulf of Mexico (west of the Mississippi river delta) an index could not be constructed for that sub-region.

Design based analysis retained year, depth, and max-relief in the binomial and log-normal GOM-wide sub-model. Design based gag proportion positives ranged from 0.0239 (2008) to 0.157 (2004) and reported a value of 0.059 in 2012 (Figure 18), while standardized index of abundance ranged from 0.252 (2008) to 2.228 (2002), and reported a value of 0.809 in 2012 (Table 2, Figure 20). Coefficients of variation (CVs) ranged from 19% (2004) to 61% (1994) and reported 22% in 2012. Mean fish lengths ranged from 429.0 mm (1996) to 833.12 (2009). Mean length as measured by lasers in the years 1996-2009 was 682.68 mm. Mean length as measured by stereo cameras in the years 2008-2012 was 771.41 mm. Only one year of overlap was available for comparison between laser and stereo measurements (2009), and results show that fish measured using stereo cameras were longer than those measured with lasers. Sample sizes in 2009 were small for both measurement methods (laser *n*=9: stereo *n*=5.

Design based analysis retained year, depth, and max-relief in the binomial and log-normal east-GOM sub-model. Design based east-GOM gag proportion positives ranged from 0.024 (2008) to 0.188 (2004), and reported a value of 0.09 in 2012 (Figure 26), and the standardized index of abundance ranged from 0.109 (2008) to 2.71 (2002) with a reported value of 0.66 in 2012 (Table 5, Figure 30). CVs ranged from a low of 25.3% (2002) to 71% in 1994 with a reported value of 27.6% in 2012.

Gag grouper observed during this survey are predominately found in the eastern GOM, and mapping would suggest that significant concentrations of those fish are located in Madison-Swanson MPA and the Florida Middle Grounds. When observed in western GOM habitats they are most often associated with hard bottoms offshore of Louisiana. Design based output for proportion positives, lo-index, and standardized index values in 2011 are the sixth highest reported in the 14 year history of the survey. Index trends suggest that gag grouper were at their lowest levels in 2008, but the population has increased in each subsequent year through 2011. However in 2012 the population appears to have trend back down and is on par with 2010. This trend from 2008 – 2012 is also reflected in the proportion positive submodel. Reported CVs continue to show fairly high amounts of variation. Model runs for the western GOM sub-region would not converge, and because there are few gag found in western habitats the trends reported here are driven in large part by fish in the east GOM.

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

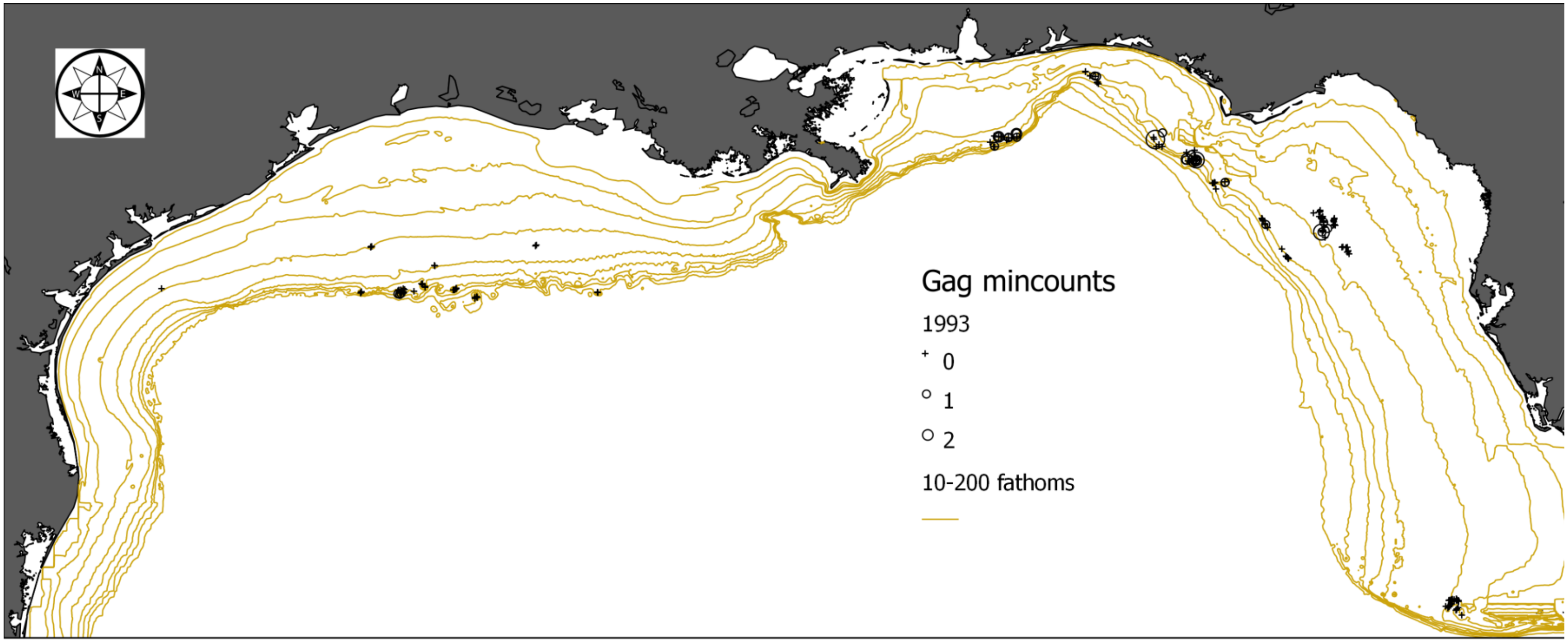

Figure 4. Spatial distribution of gag observed and associated min-count values during the 1994 reef fish video survey.

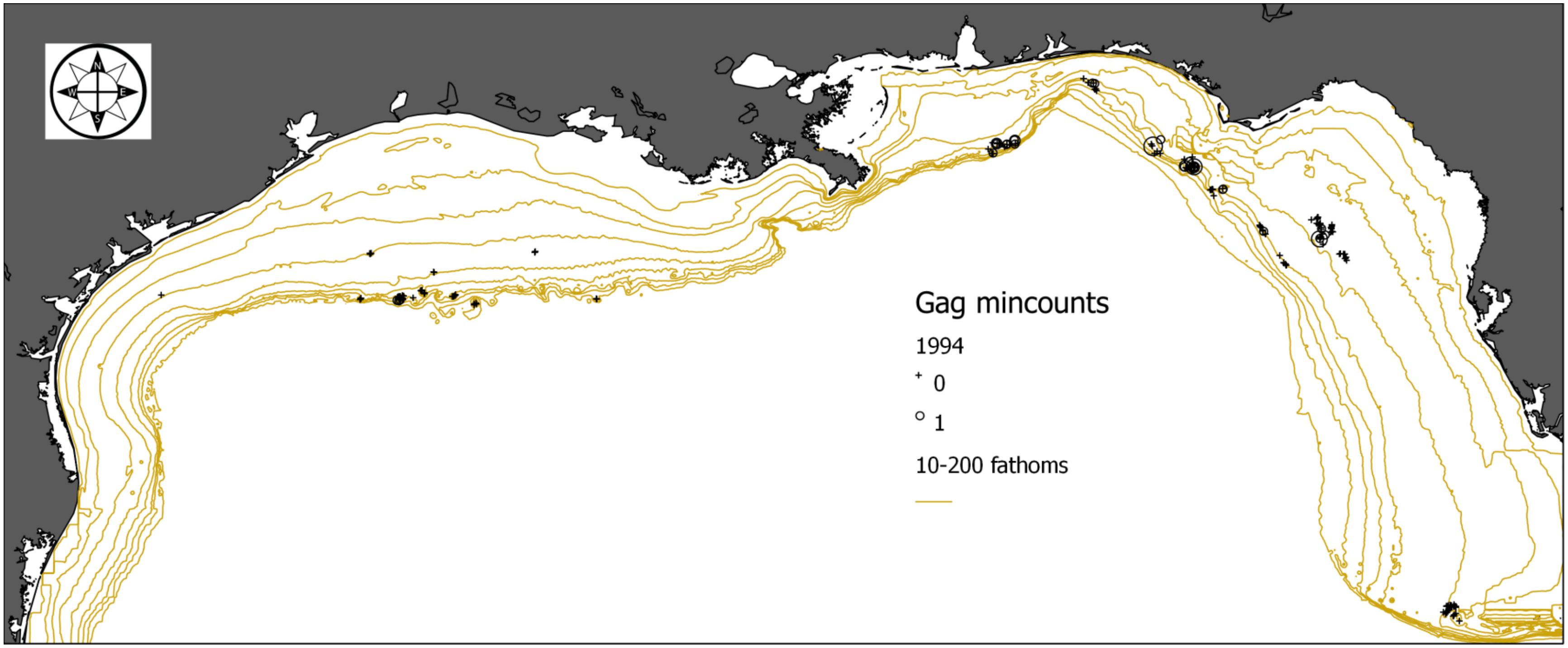

Figure 5. Spatial distribution of gag observed and associated min-count values during the 1995 reef fish video survey.

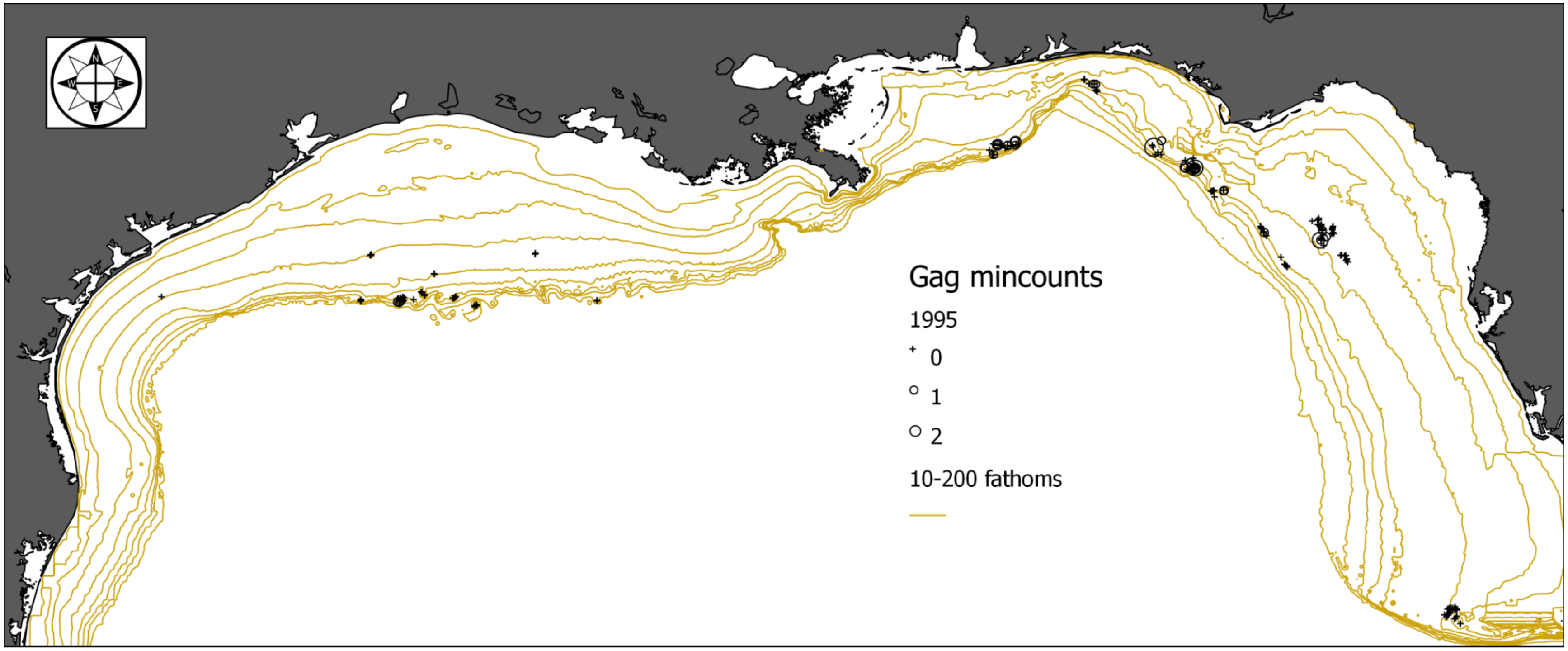

Figure 6. Spatial distribution of gag observed and associated min-count values during the 1996 reef fish video survey.

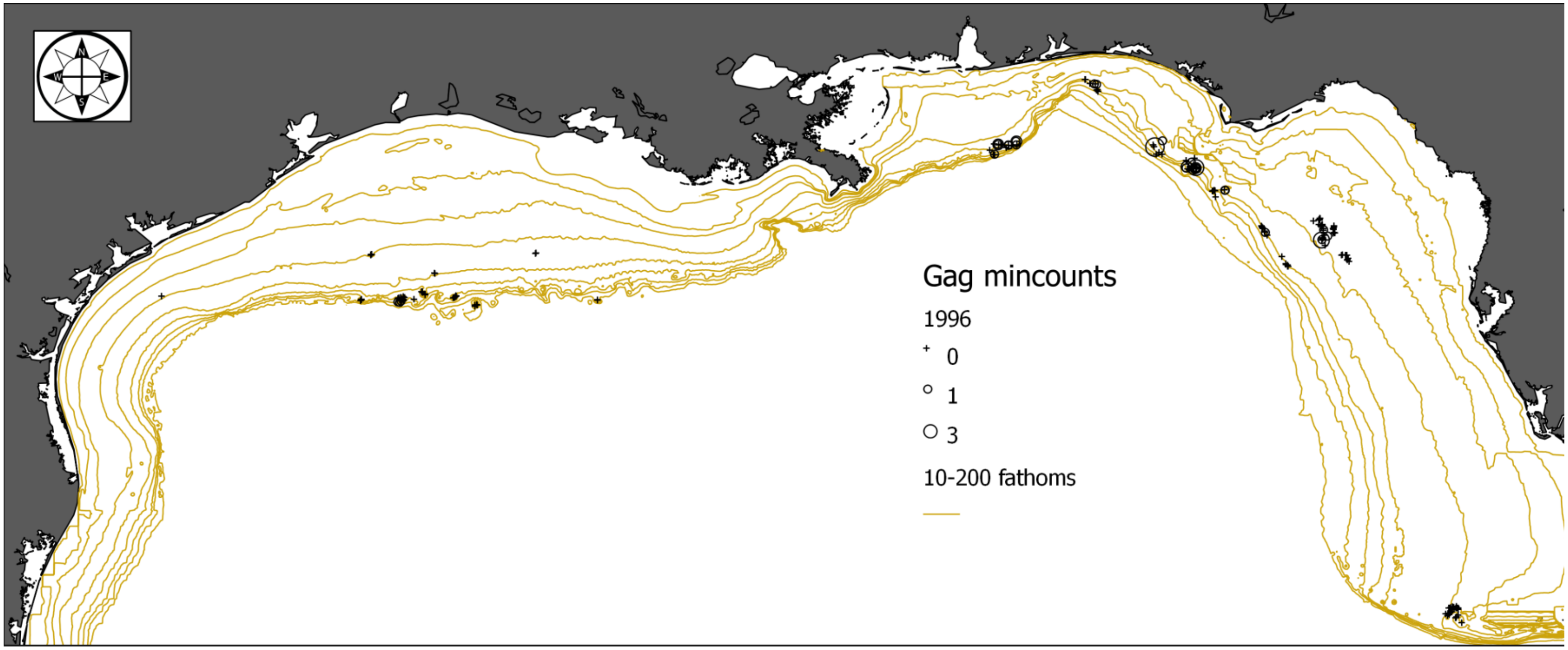

Figure 7. Spatial distribution of gag observed and associated min-count values during the 1997 reef fish video survey.

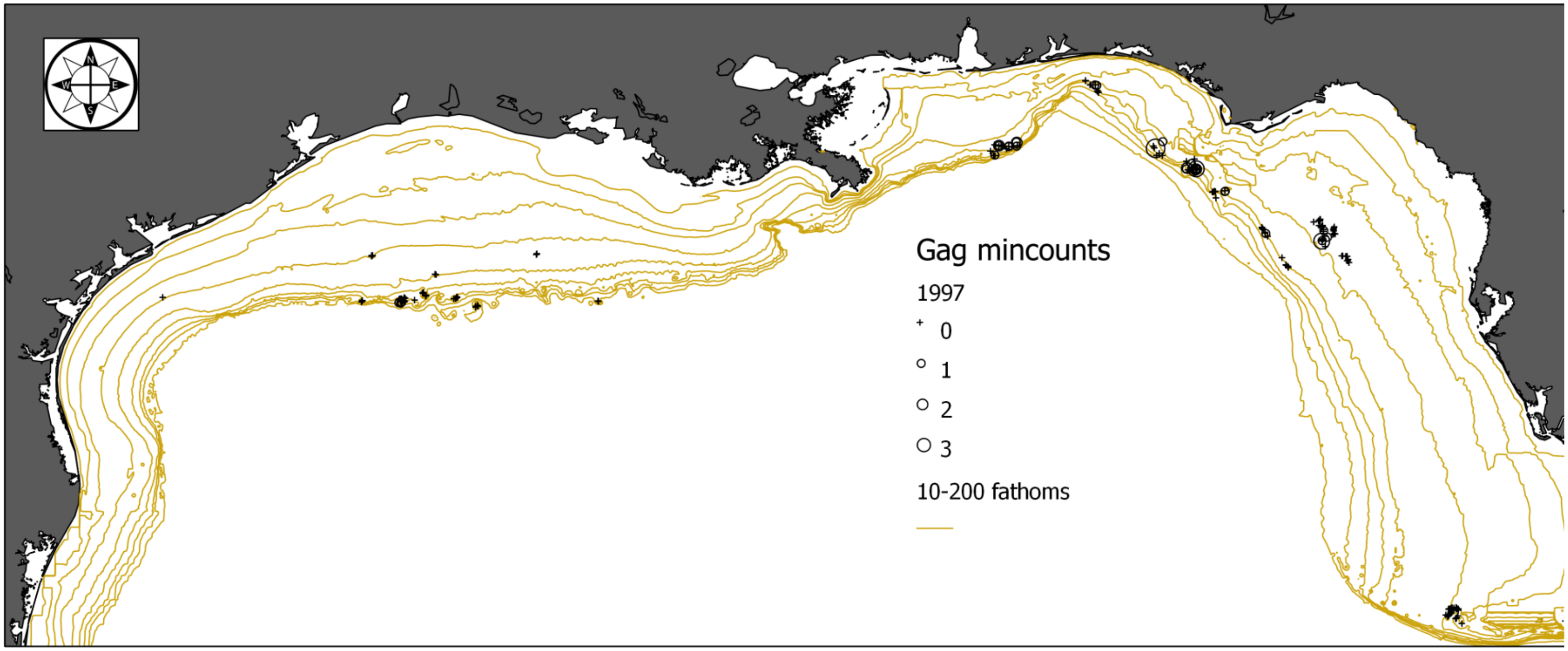

Figure 8. Spatial distribution of gag observed and associated min-count values during the 2002 reef fish video survey.

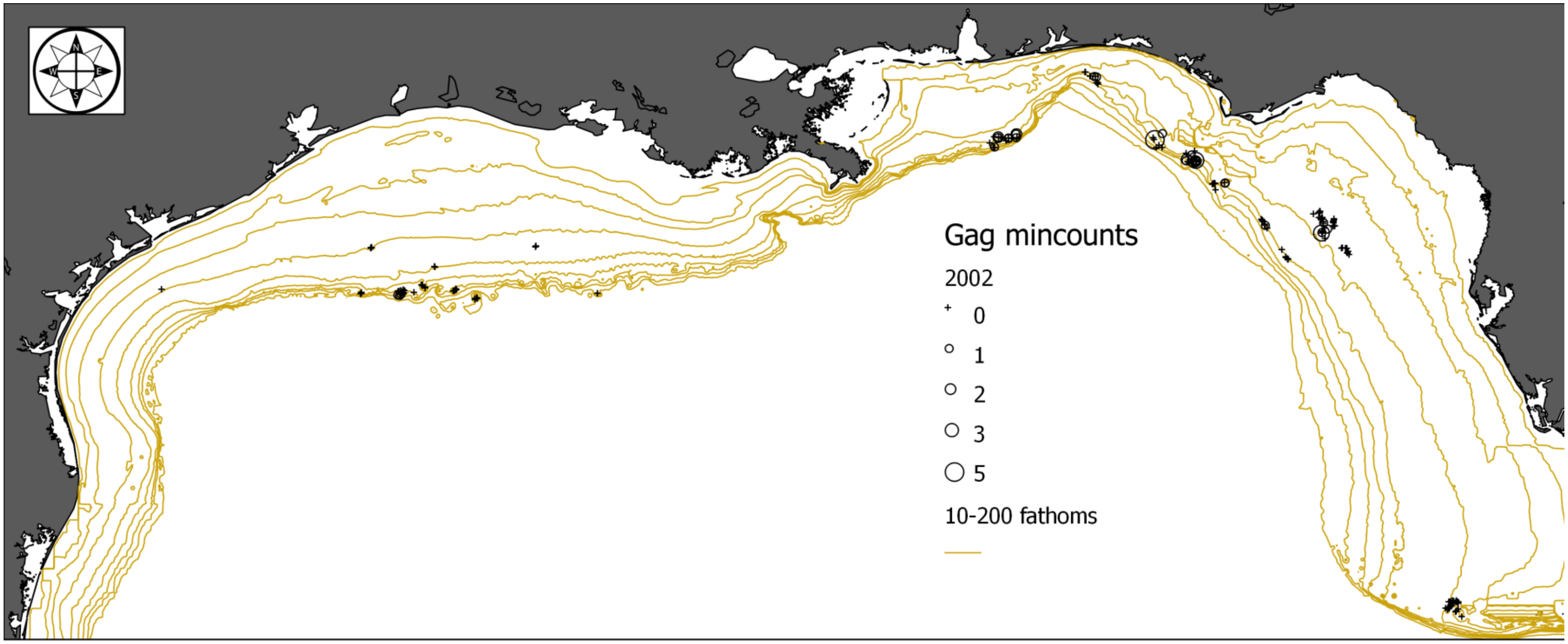

Figure 9. Spatial distribution of gag observed and associated min-count values during the 2004 reef fish video survey.

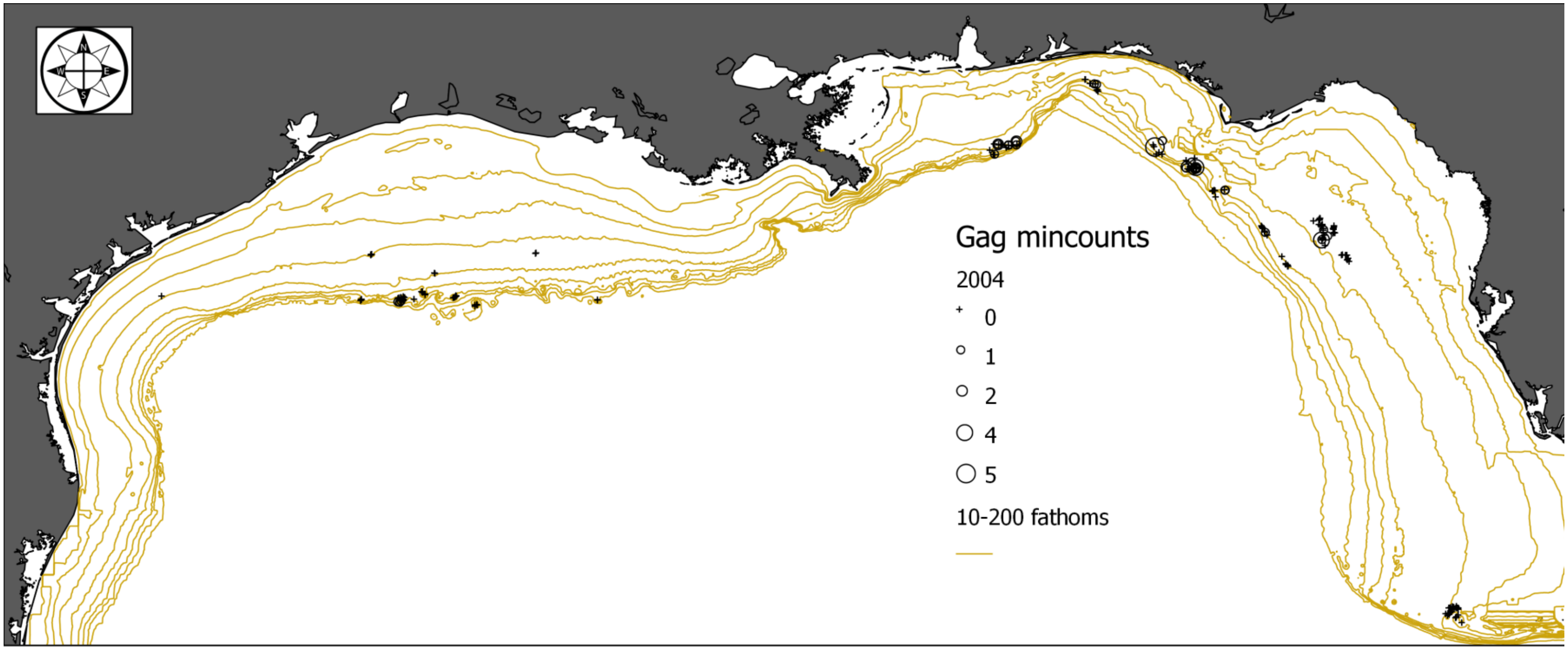

Figure 10. Spatial distribution of gag observed and associated min-count values during the 2005 reef fish video survey.

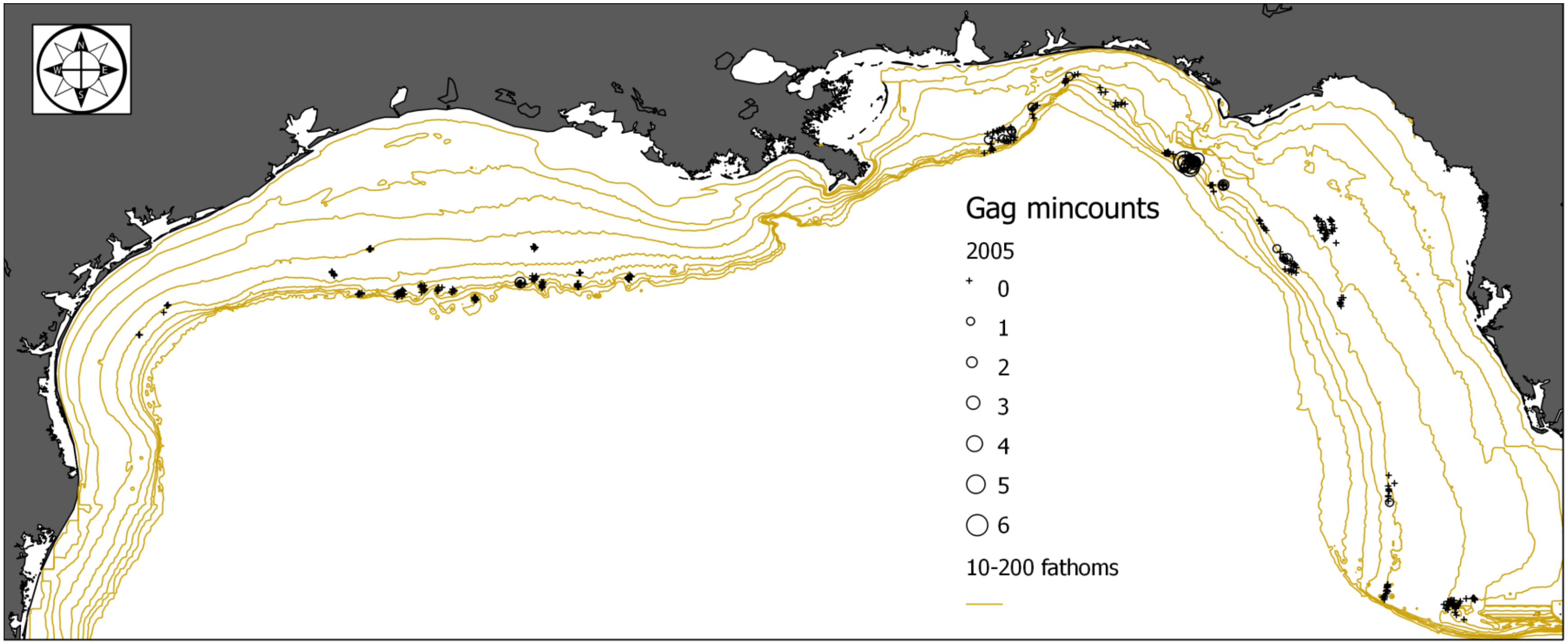

Figure 11. Spatial distribution of gag observed and associated min-count values during the 2006 reef fish video survey.

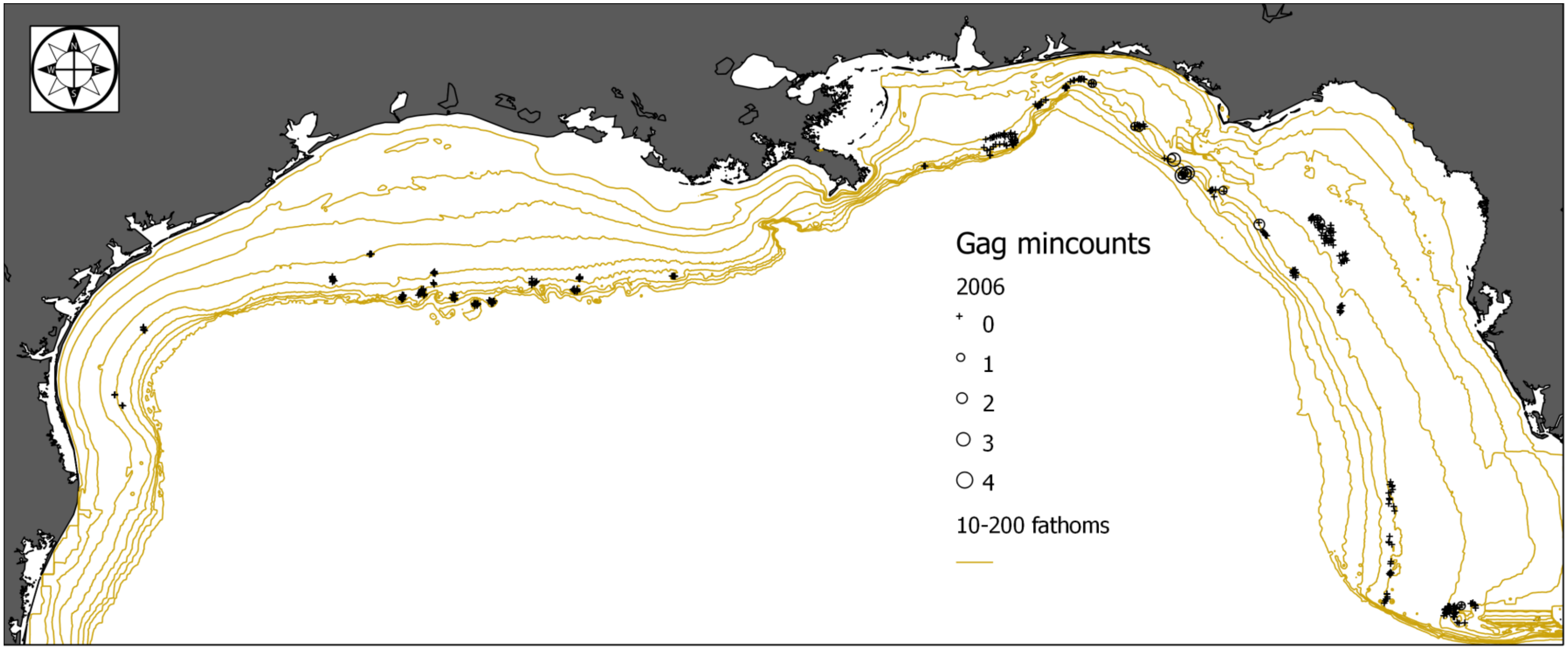

Figure 12. Spatial distribution of gag observed and associated min-count values during the 2007 reef fish video survey.

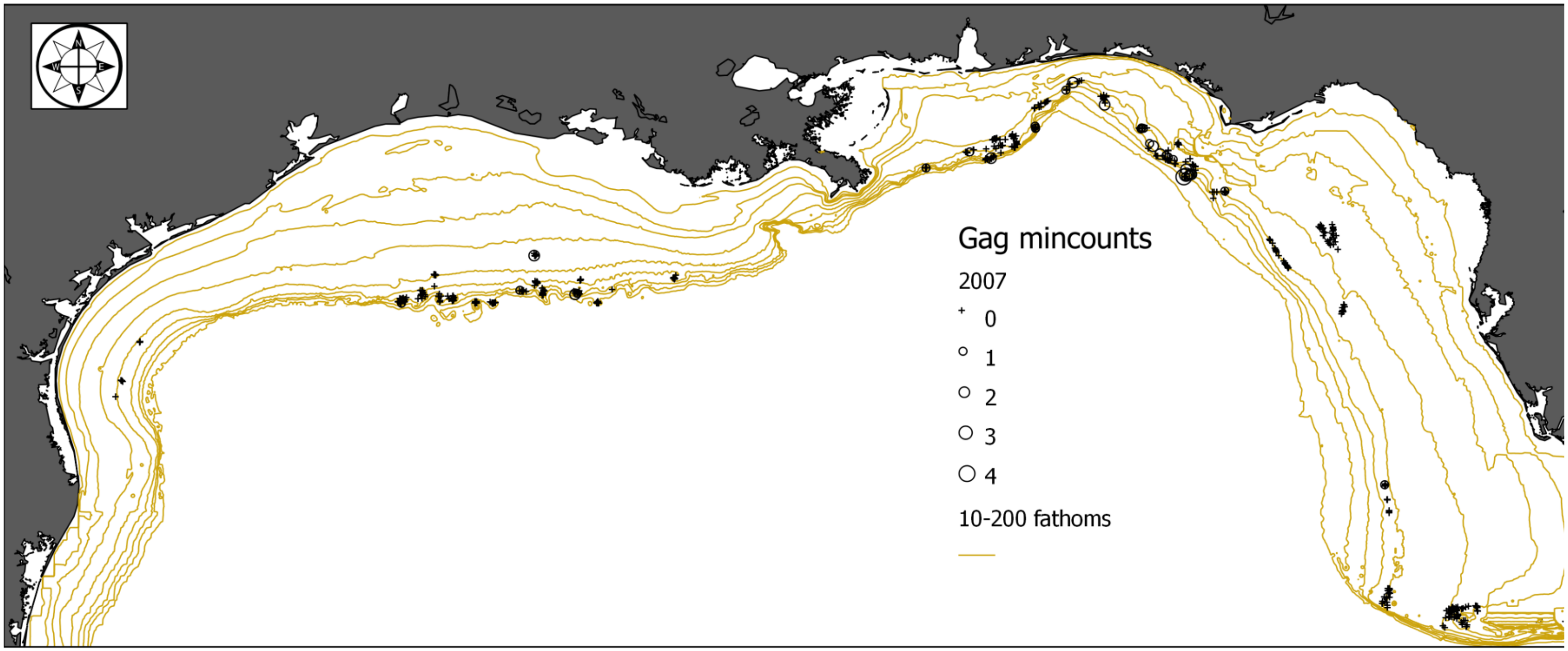

Figure 13. Spatial distribution of gag observed and associated min-count values during the 2008 reef fish video survey.

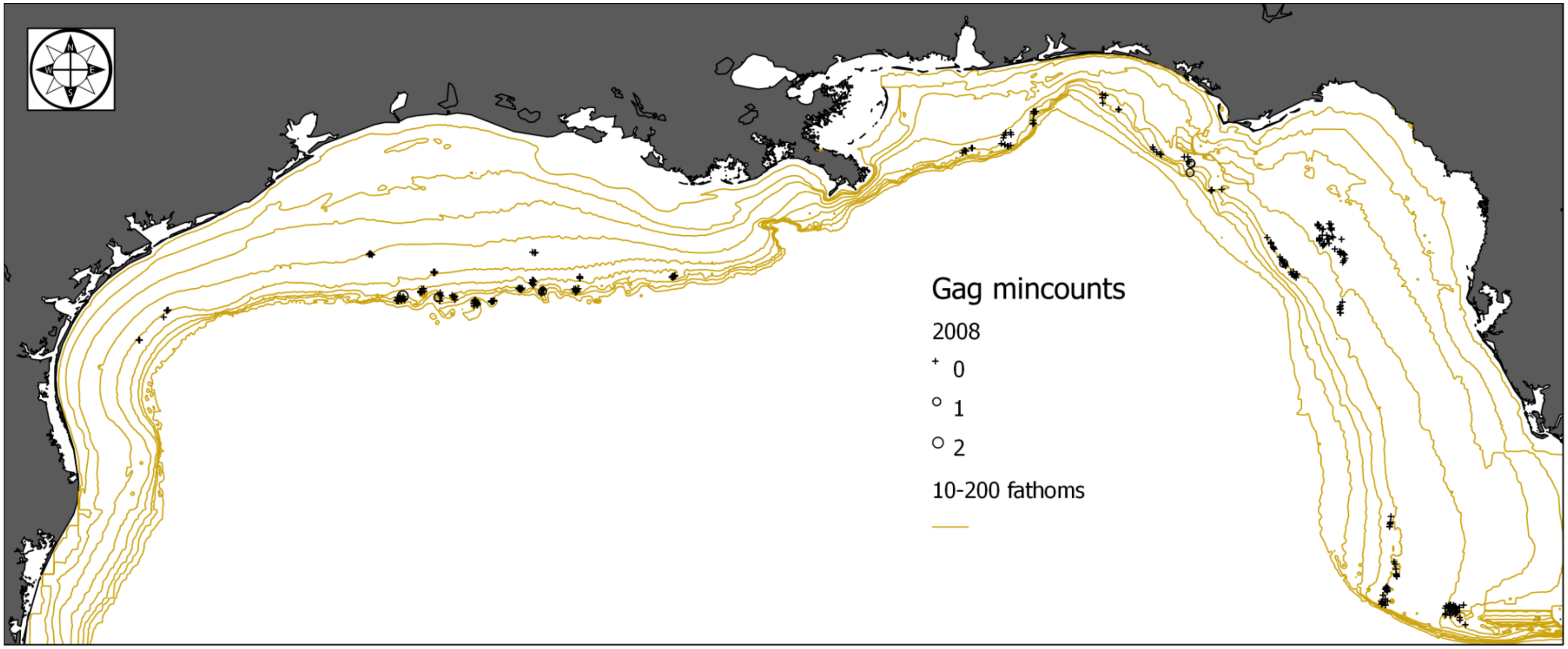

Figure 14. Spatial distribution of gag observed and associated min-count values during the 2009 reef fish video survey.

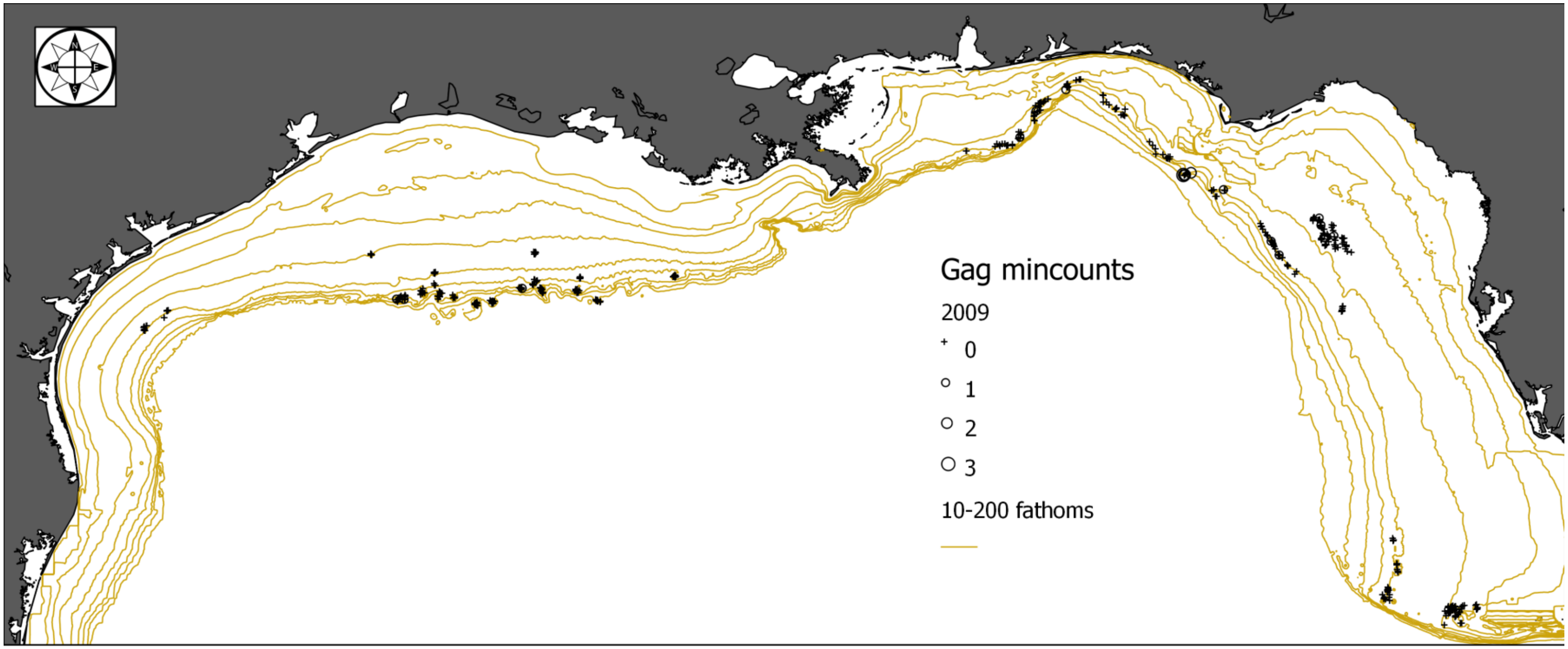

Figure 15. Spatial distribution of gag observed and associated min-count values during the 2010 reef fish video survey.

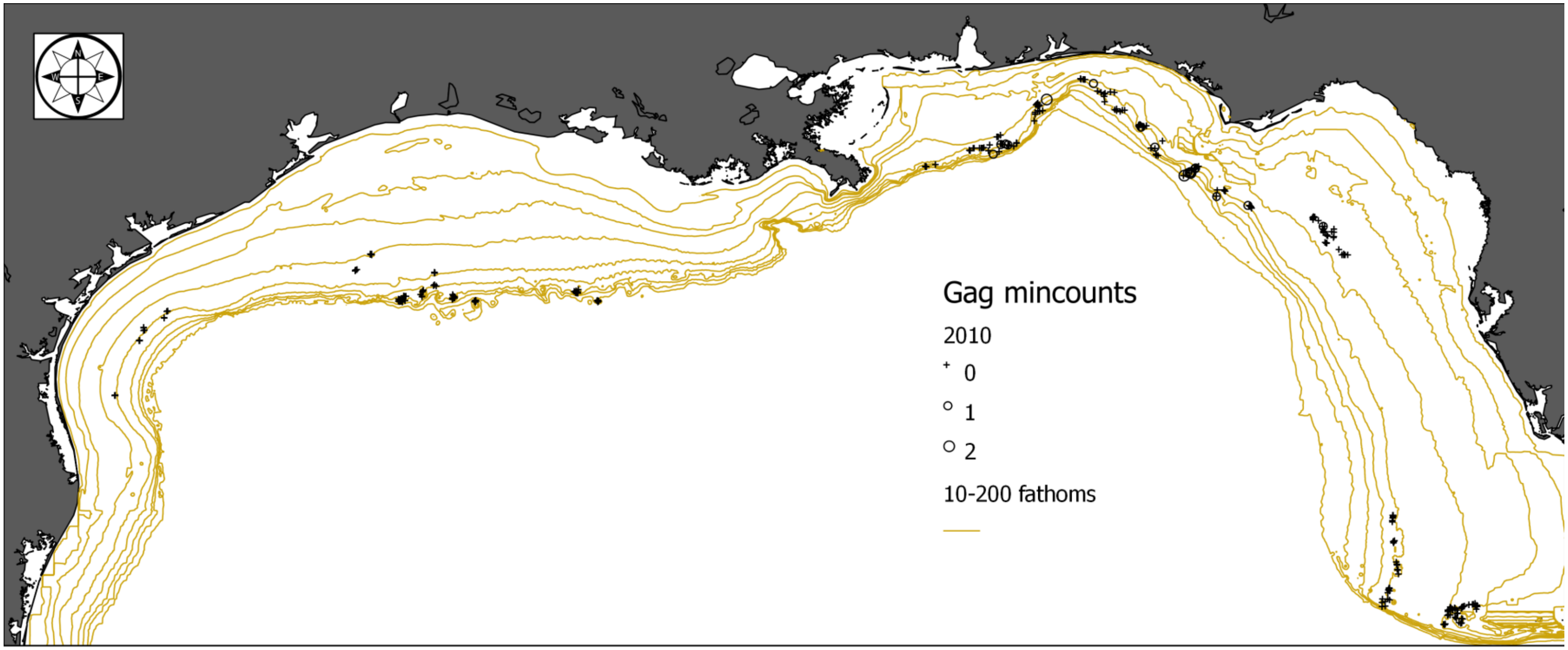

Figure 16. Spatial distribution of gag observed and associated min-count values during the 2011 reef fish video survey.

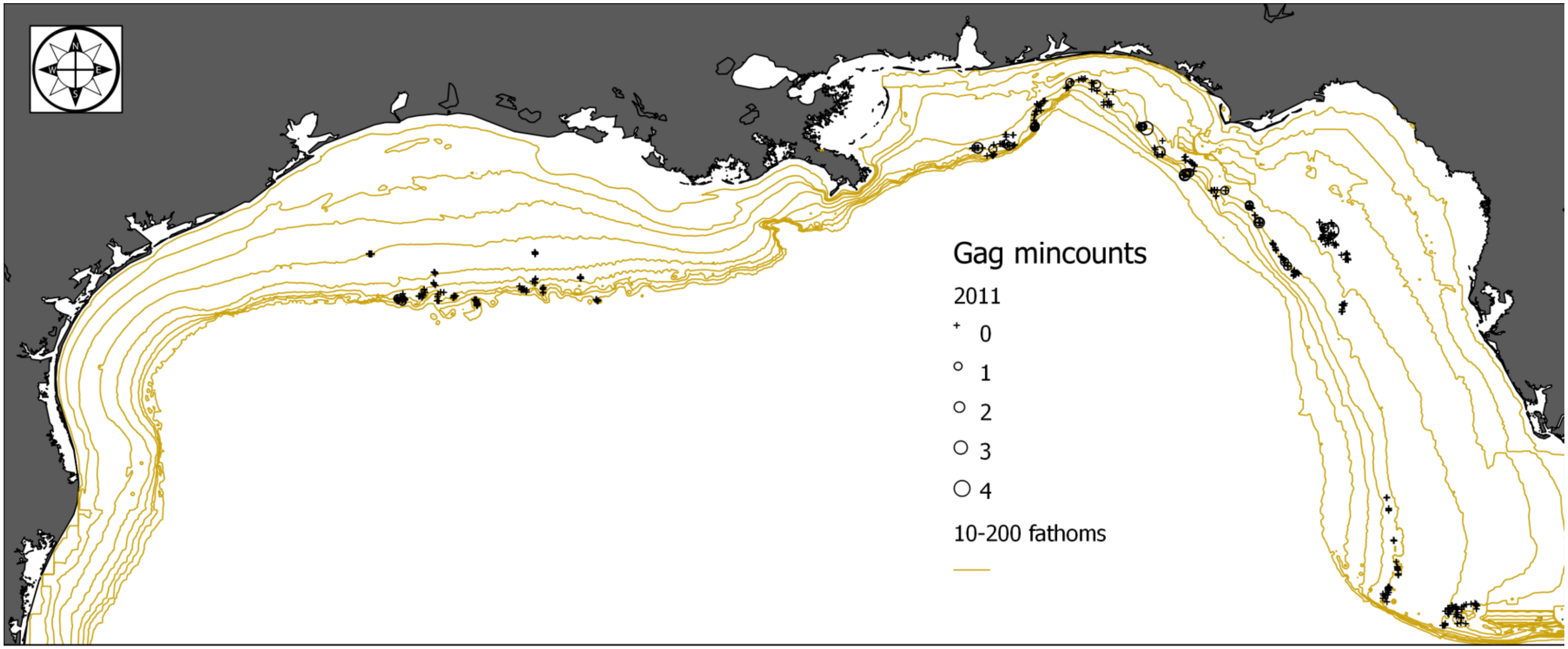

Figure 17. Spatial distribution of gag observed and associated min-count values during the 2012 reef fish video survey.

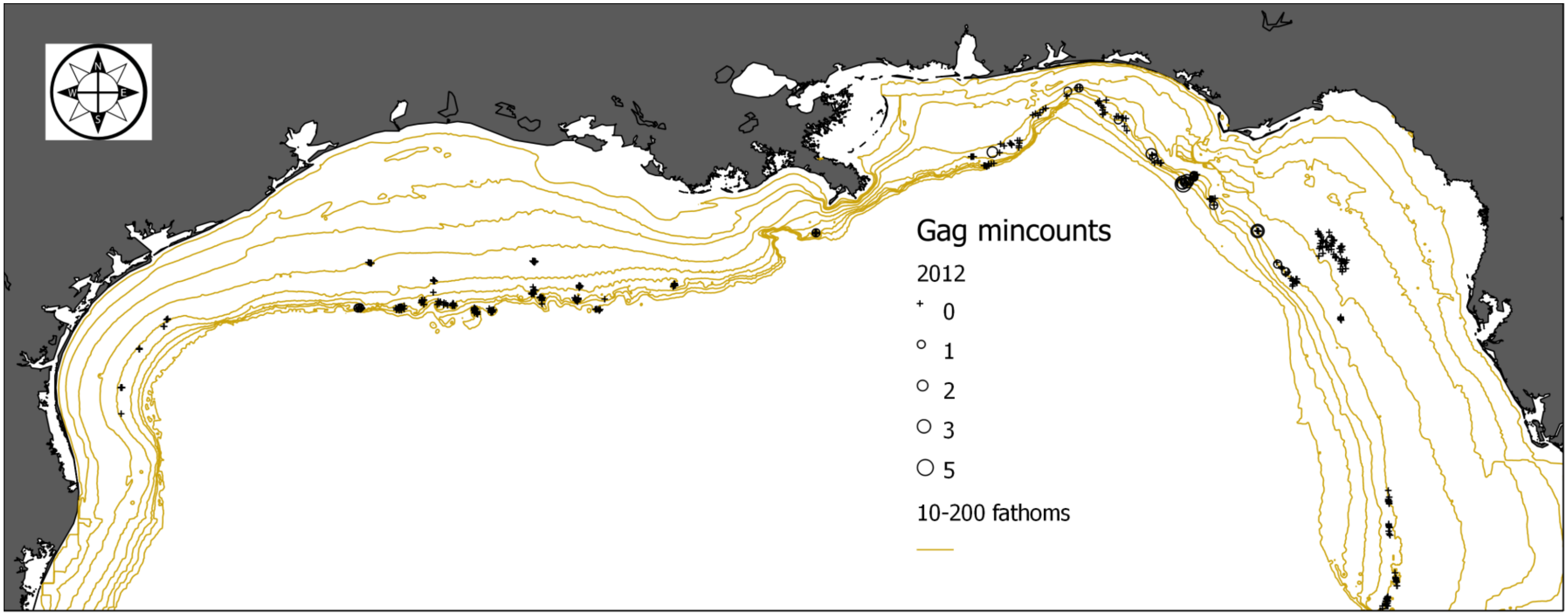

Table 1. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics of the GLIMMIX binomial on proportion positives for the GOM-wide model.

a

Iteration History

Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	26073.39288461	0.00000000

b

Fit Statistics

-2 Res Log Likelihood	26073.4
AIC (smaller is better)	26103.4
AICC (smaller is better)	26103.5
BIC (smaller is better)	26199.8

c

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	14	1395	51.04	3.62	<.0001	<.0001
depth	1	3325	34.95	34.95	<.0001	<.0001
MAXRELIEF	1	3043	84.83	84.83	<.0001	<.0001

d

Description	*Value*
Deviance	410.2776
Scaled Deviance	2509.8543
Pearson Chi-Square	829.5464
Scaled Pearson Chi-Square	5074.7121
Extra-Dispersion Scale	0.1635

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

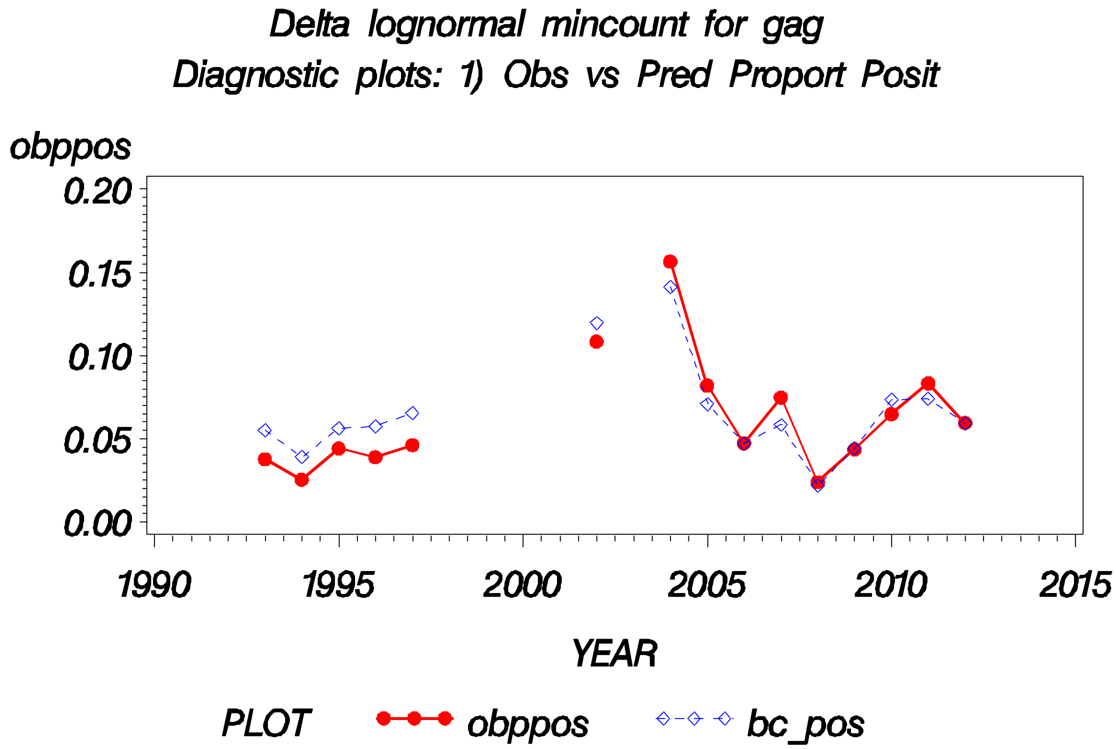

Figure 19. GOM-wide chi-square residuals of proportion positive design based model.

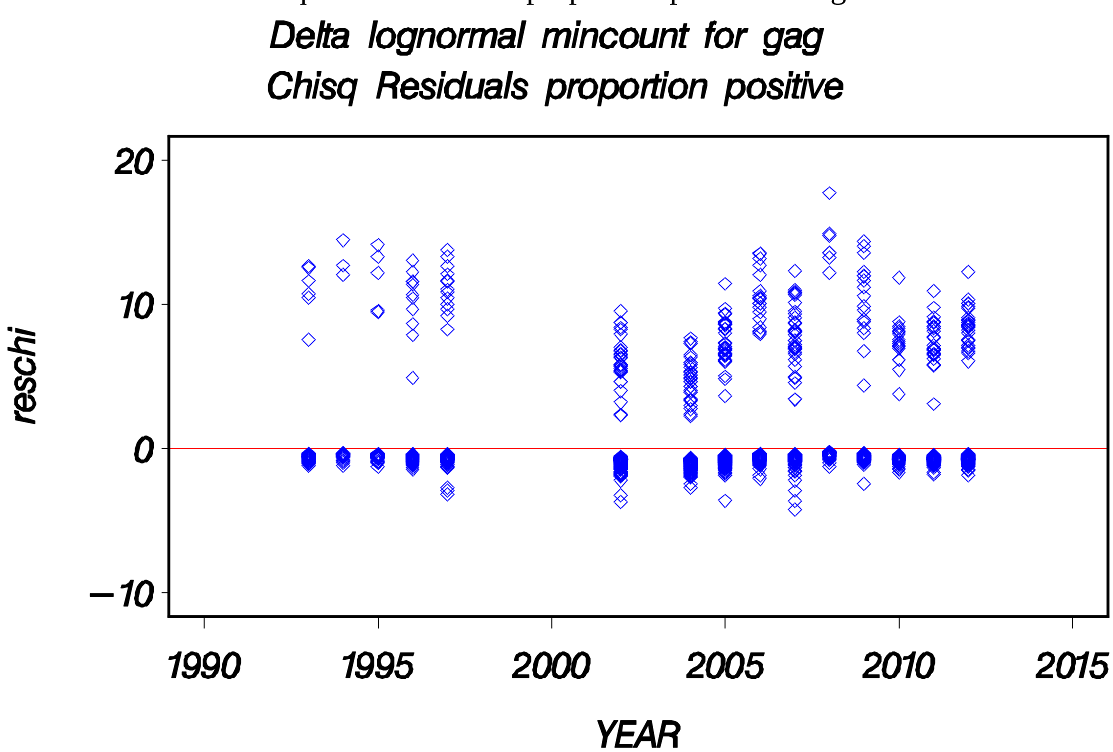

Table 2. GOM-wide gag lo and standardized index of abundance values by year design based model.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.03774	159	0.08879	1.02585	0.039103	0.44041	0.44194	2.38120
1994	0.02542	118	0.04680	0.54075	0.028641	0.61195	0.17504	1.67060
1995	0.04425	113	0.08218	0.94951	0.045435	0.55288	0.33800	2.66736
1996	0.03896	308	0.07450	0.86083	0.023549	0.31607	0.46440	1.59568
1997	0.04626	281	0.08774	1.01380	0.030626	0.34904	0.51458	1.99735
2002	0.10853	258	0.19292	2.22897	0.043687	0.22646	1.42515	3.48619
2004	0.15657	198	0.18211	2.10412	0.035465	0.19475	1.43050	3.09495
2005	0.08205	390	0.10006	1.15609	0.020494	0.20482	0.77075	1.73410
2006	0.04726	402	0.06166	0.71241	0.016607	0.26933	0.41964	1.20945
2007	0.07479	468	0.07343	0.84840	0.015072	0.20526	0.56513	1.27364
2008	0.02397	292	0.02184	0.25235	0.009447	0.43253	0.11023	0.57771
2009	0.04369	412	0.05187	0.59927	0.014084	0.27155	0.35151	1.02166
2010	0.06485	293	0.07958	0.91953	0.018693	0.23488	0.57847	1.46167
2011	0.08333	432	0.08475	0.97917	0.019709	0.23257	0.61874	1.54956
2012	0.05960	453	0.07001	0.80894	0.015378	0.21964	0.52406	1.24868

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	341.2
AIC (smaller is better)	343.2
AICC (smaller is better)	343.2
BIC (smaller is better)	346.7

b

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	14	263	1.18	0.2929
depth	1	263	14.67	0.0002
MAXRELIEF	1	263	2.80	0.0956

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

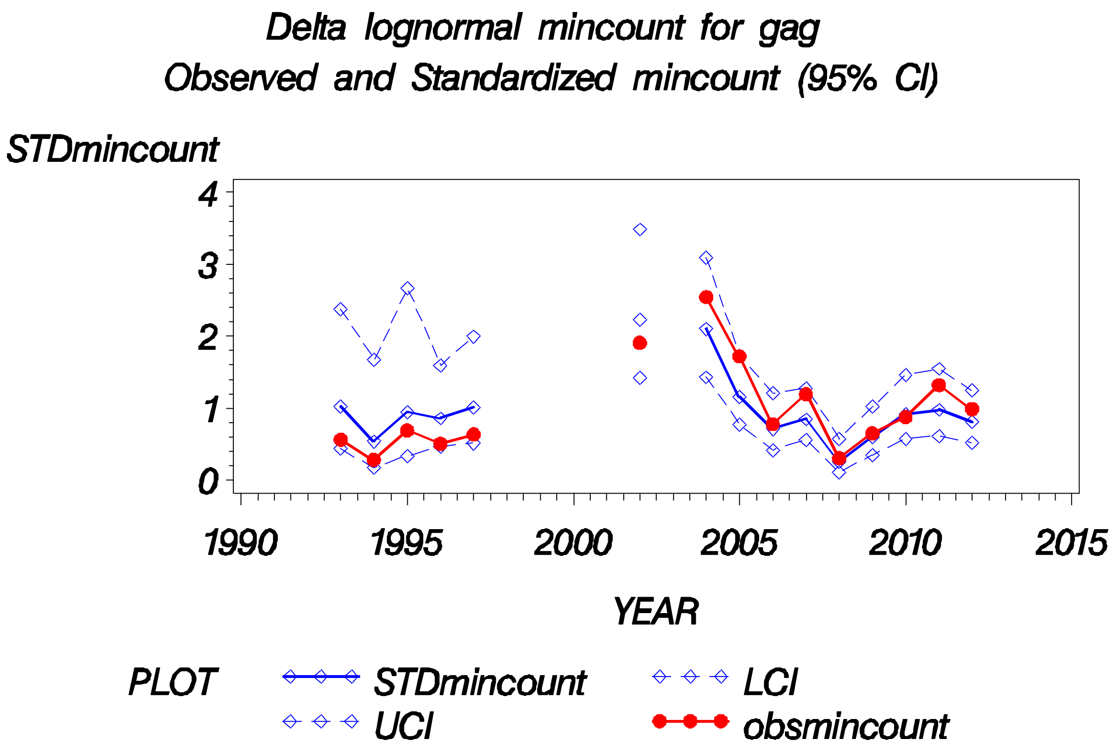

Figure 21. GOM-wide observed versus predicted mincount of positive data for design based model.

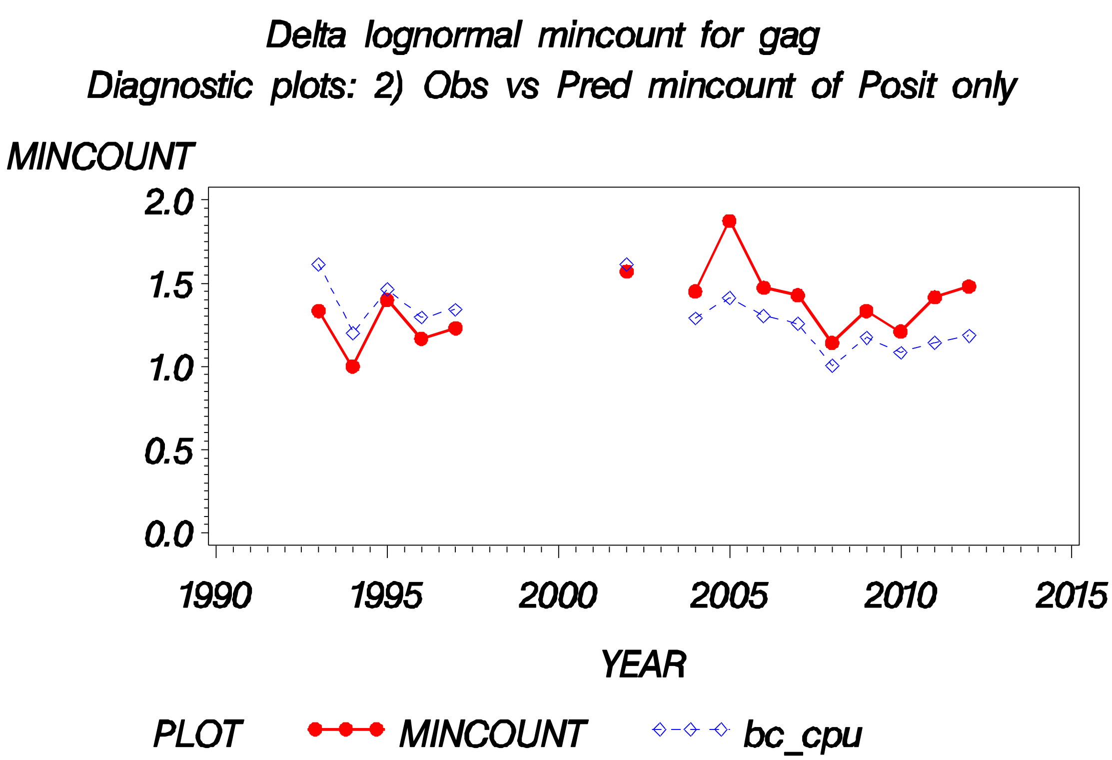

Figure 22. GOM-wide observed versus predicted mincount for design based model.

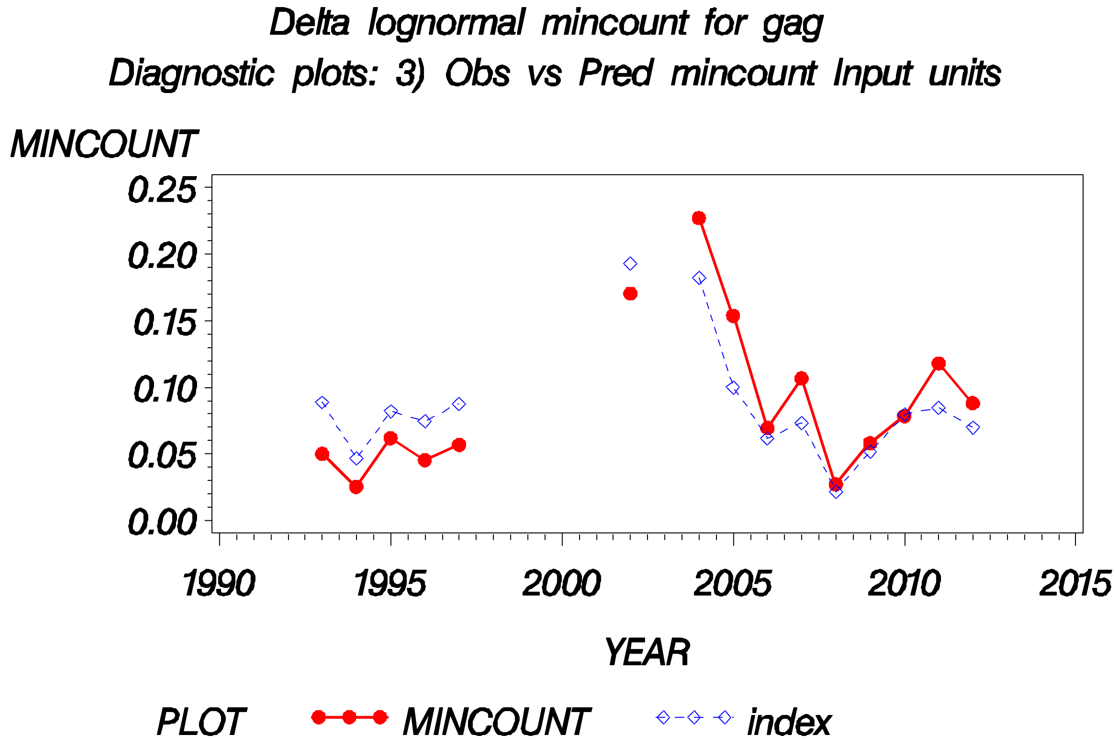

Figure 23. GOM wide residuals of positive mincounts by year for design based model.

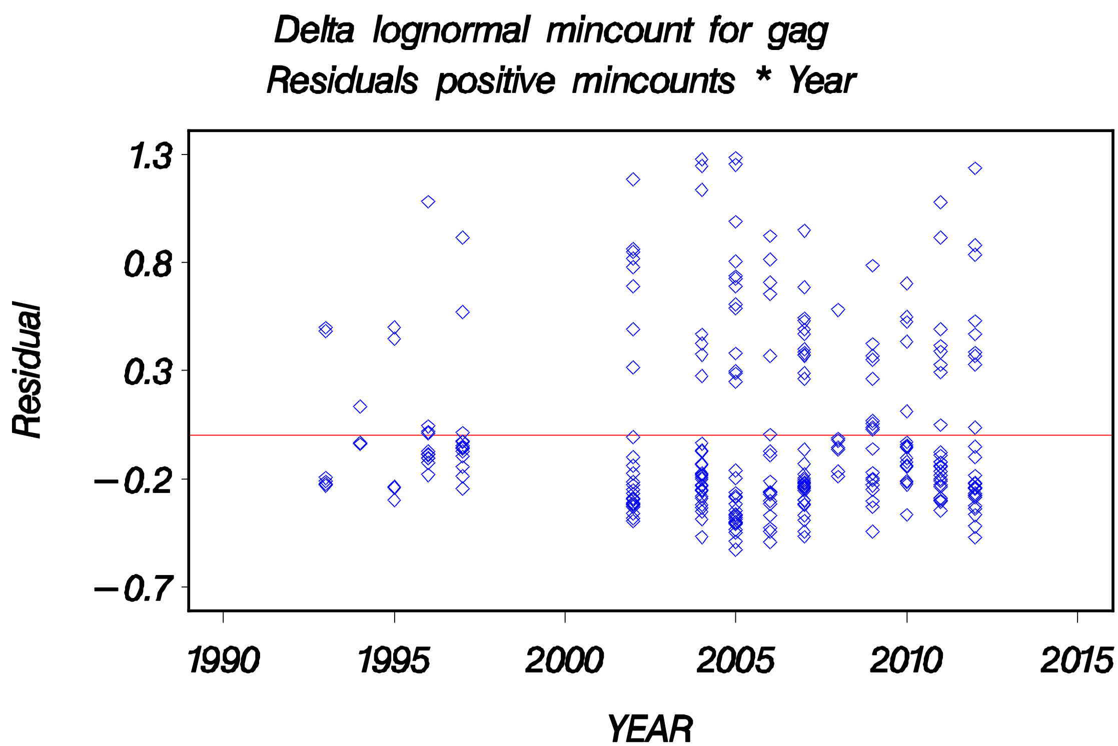

Figure 24 GOM-wide residuals distribution from positive mincount design based model.

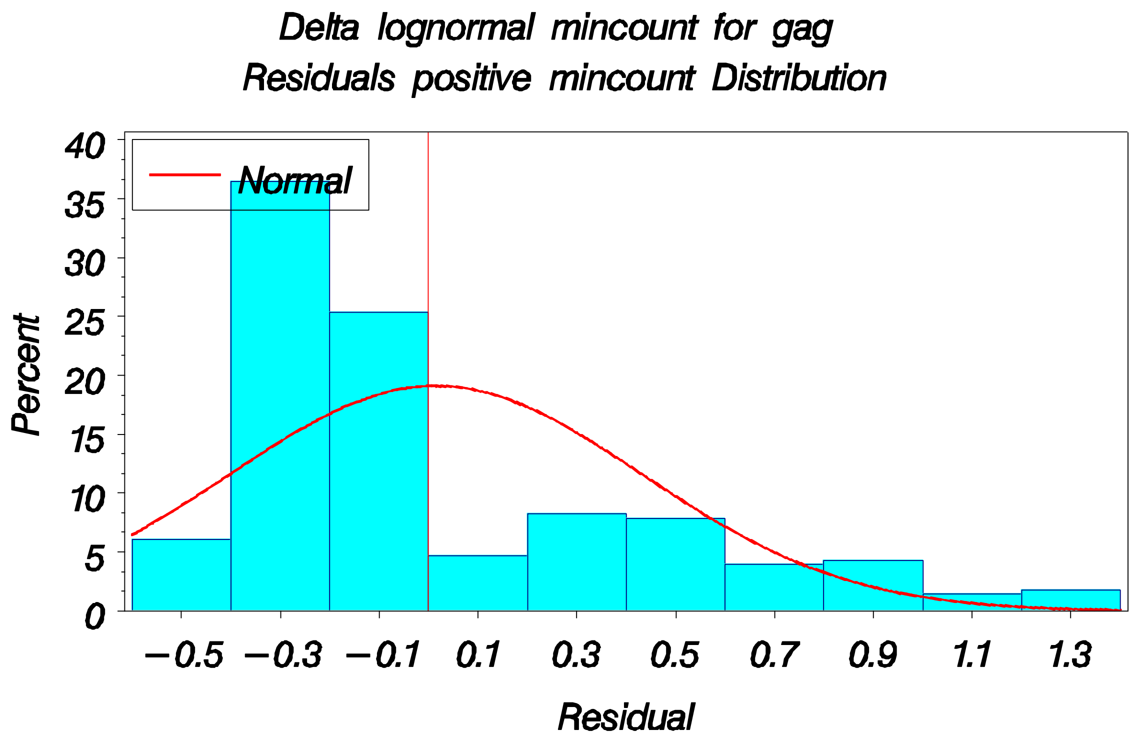

Figure 25 GOM-wide qqplot of residuals of positive mincounts from design based model.

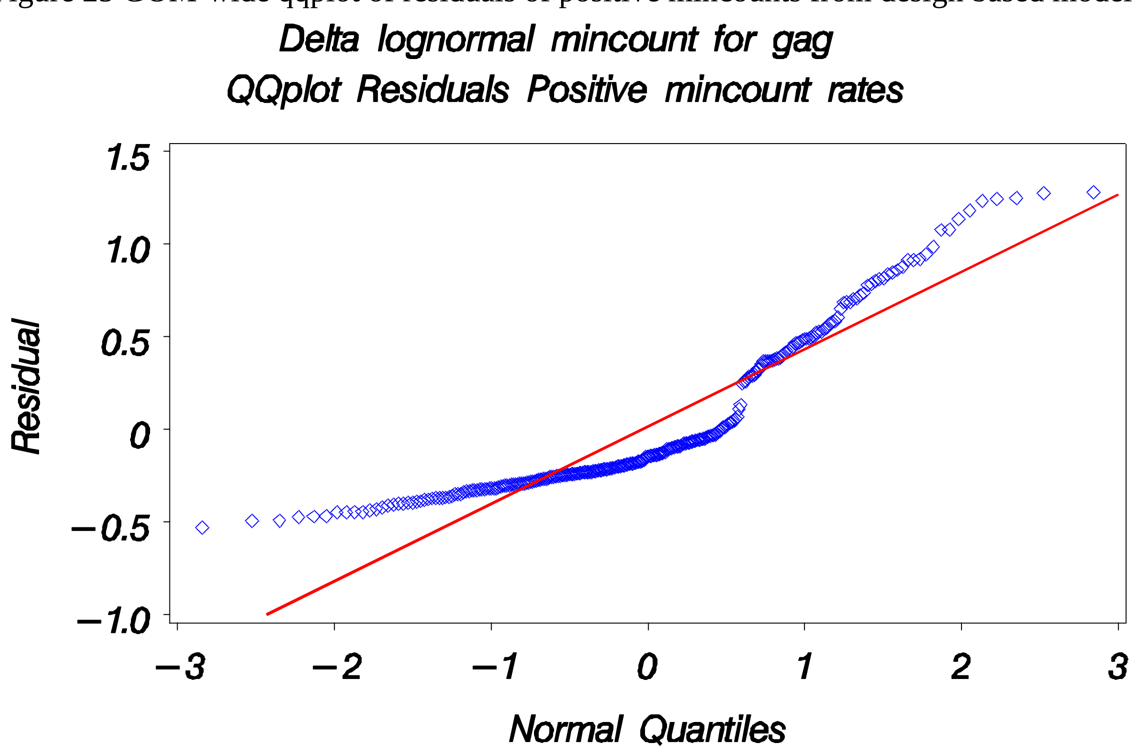

Table 4. Iteration history (a), fit statistics (b), type III tests (c), and over-dispersion diagnostics of the GLIMMIX binomial on proportion positives for the east GOM model.

a

Iteration History			
Iteration	*Evaluations*	*-2 Res Log Like*	*Criterion*
1	1	15742.99241617	0.00000000

b

Fit Statistics	
-2 Res Log Likelihood	15743.0
AIC (smaller is better)	15773.0
AICC (smaller is better)	15773.2
BIC (smaller is better)	15862.4

c

Type 3 Tests of Fixed Effects						
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	14	861	47.70	3.37	<.0001	<.0001
depth	1	2082	79.15	79.15	<.0001	<.0001
MAXRELIEF	1	1842	86.24	86.24	<.0001	<.0001

d

Description	*Value*
Deviance	482.6421
Scaled Deviance	1853.9602
Pearson Chi-Square	874.4687
Scaled Pearson Chi-Square	3359.0732
Extra-Dispersion Scale	0.2603

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

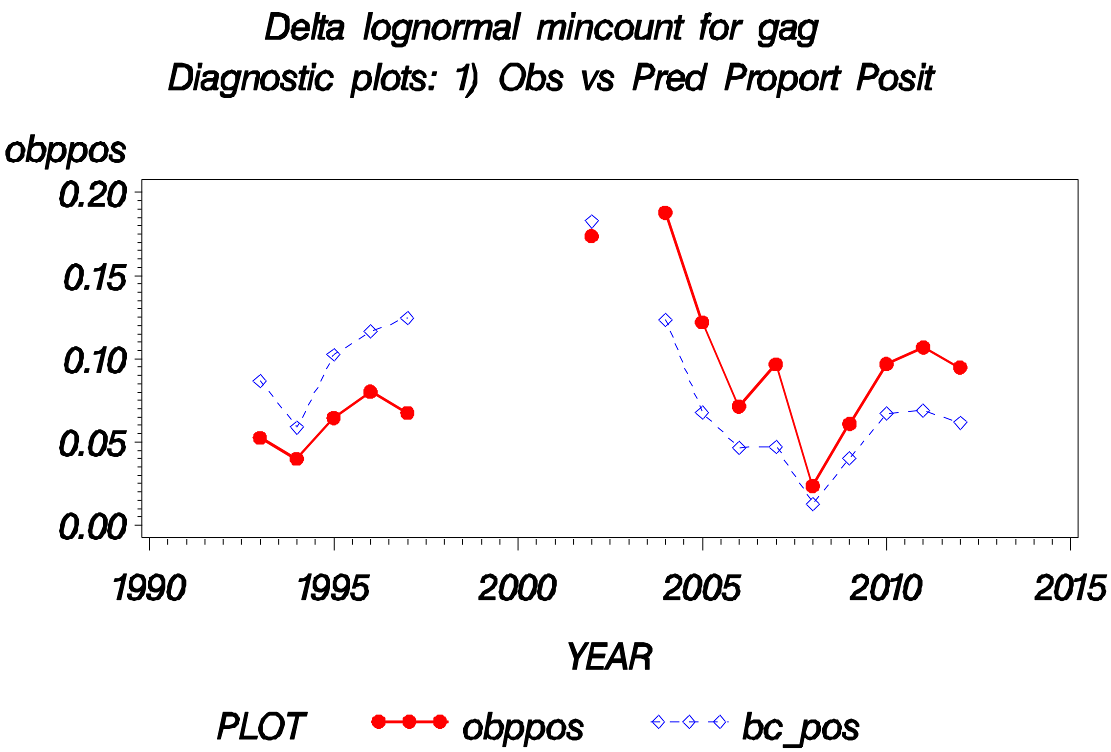

Figure 27. Chi-square residuals of proportion positives from east GOM design based model.

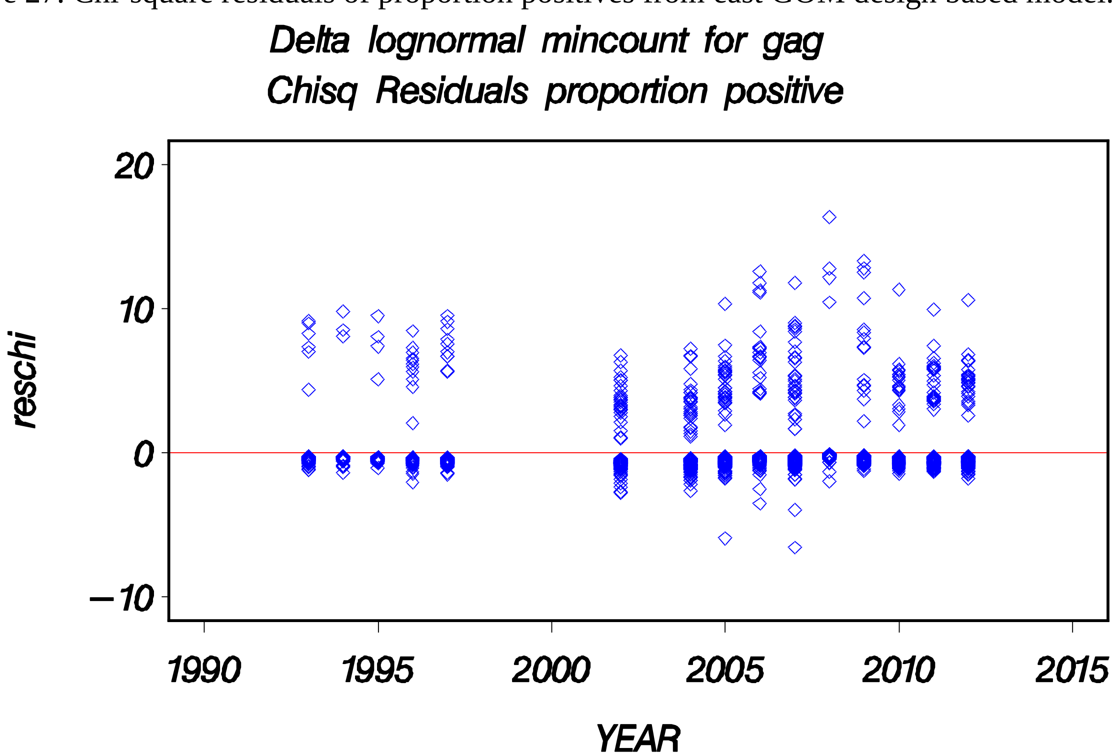

Table 5. East GOM gag lo and standardized index of abundance by year for design based model.

SurveyYear	Frequency	N	LoIndex	StdIndex	SE	CV	LCL	UCL
1993	0.05263	114	0.14567	1.30734	0.07221	0.49573	0.51195	3.33849
1994	0.04000	75	0.07285	0.65383	0.05204	0.71429	0.18104	2.36132
1995	0.06452	62	0.16047	1.44017	0.10436	0.65035	0.43908	4.72371
1996	0.08029	137	0.15597	1.39982	0.05844	0.37470	0.67802	2.89002
1997	0.06757	148	0.17032	1.52856	0.07024	0.41238	0.69193	3.37679
2002	0.17391	161	0.30234	2.71344	0.07660	0.25336	1.64766	4.46861
2004	0.18792	149	0.16300	1.46292	0.04173	0.25598	0.88389	2.42129
2005	0.12205	254	0.09444	0.84758	0.02413	0.25551	0.51256	1.40157
2006	0.07143	266	0.06083	0.54597	0.02095	0.34440	0.27949	1.06652
2007	0.09677	310	0.05897	0.52926	0.01650	0.27982	0.30562	0.91655
2008	0.02367	169	0.01214	0.10893	0.00861	0.70961	0.03037	0.39069
2009	0.06098	246	0.04948	0.44405	0.01890	0.38198	0.21226	0.92894
2010	0.09694	196	0.07190	0.64532	0.02098	0.29171	0.36438	1.14286
2011	0.10692	318	0.07929	0.71162	0.02266	0.28580	0.40631	1.24633
2012	0.09486	253	0.07367	0.66119	0.02035	0.27627	0.38438	1.13734

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	314.6
AIC (smaller is better)	316.6
AICC (smaller is better)	316.6
BIC (smaller is better)	320.0

b

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
year	14	238	1.17	0.3010
depth	1	238	17.17	<.0001
MAXRELIEF	1	238	2.51	0.1148

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

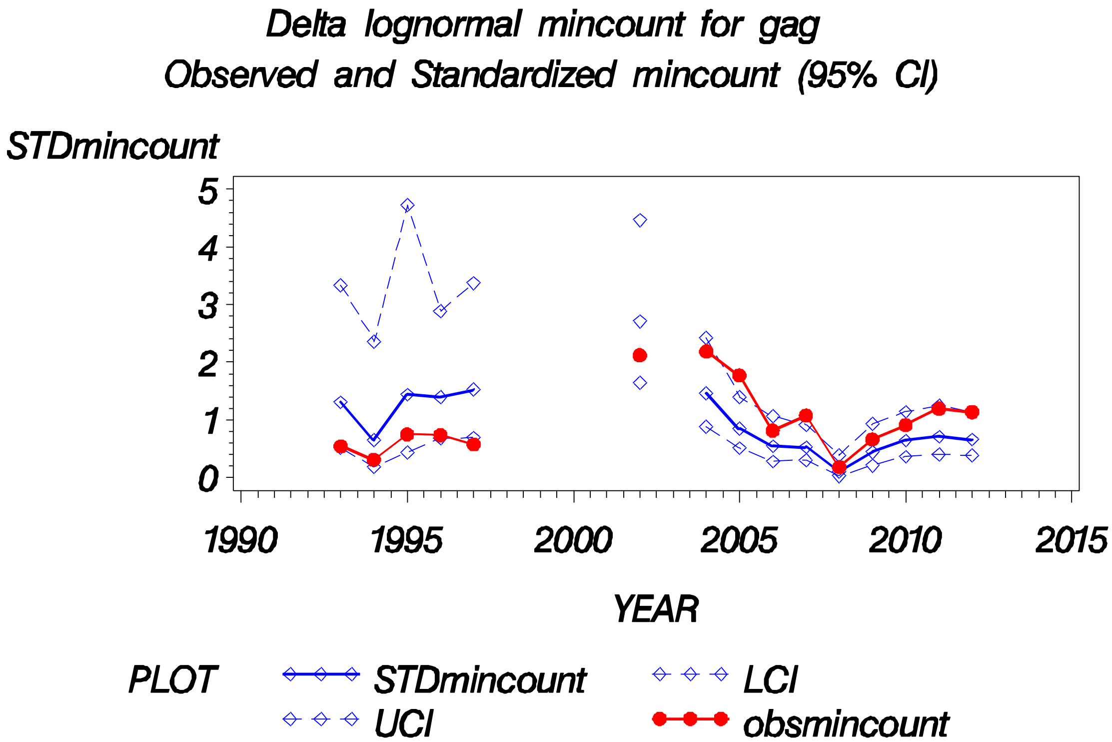

Figure 29. Observed versus predicted mincounts from east GOM design based model.

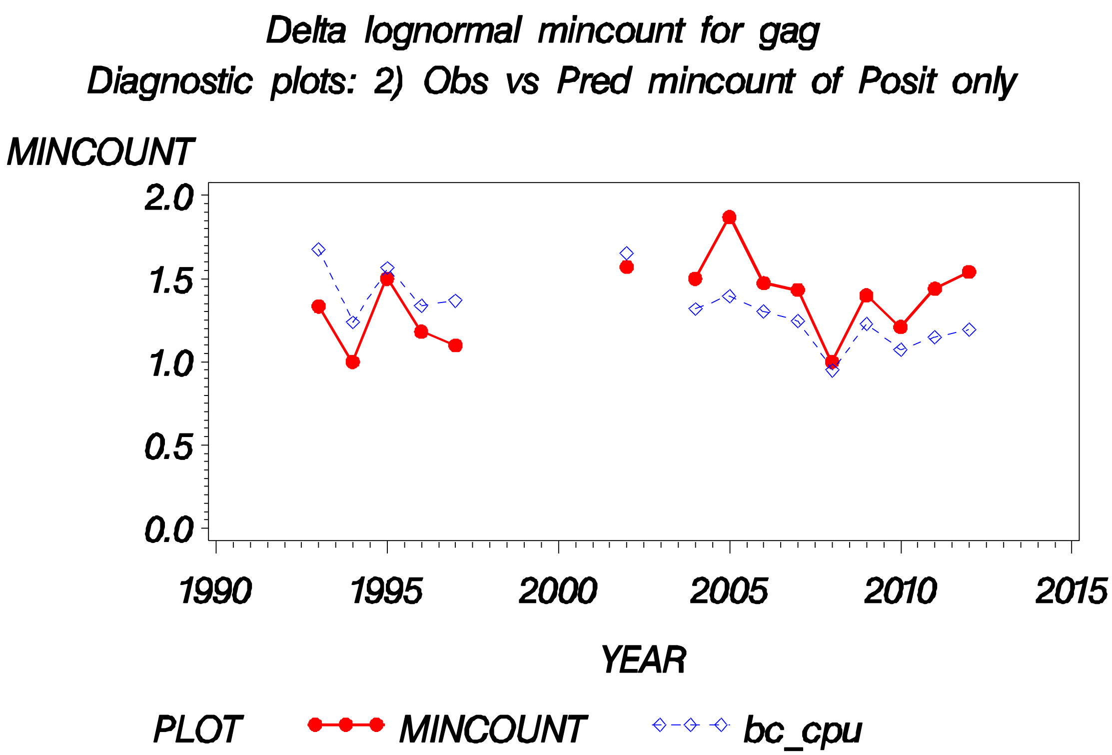

Figure 30. Observed versus predicted mincounts from east GOM design based models

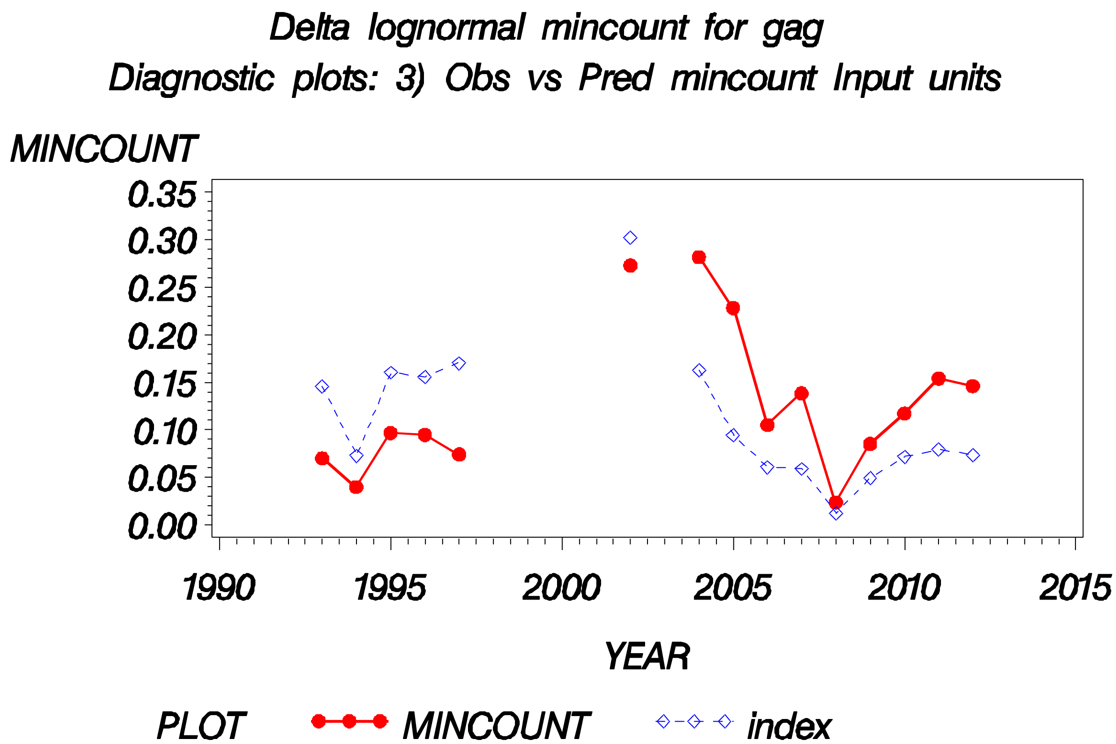

Figure 31 Residuals of positive mincounts for east GOM design based model.

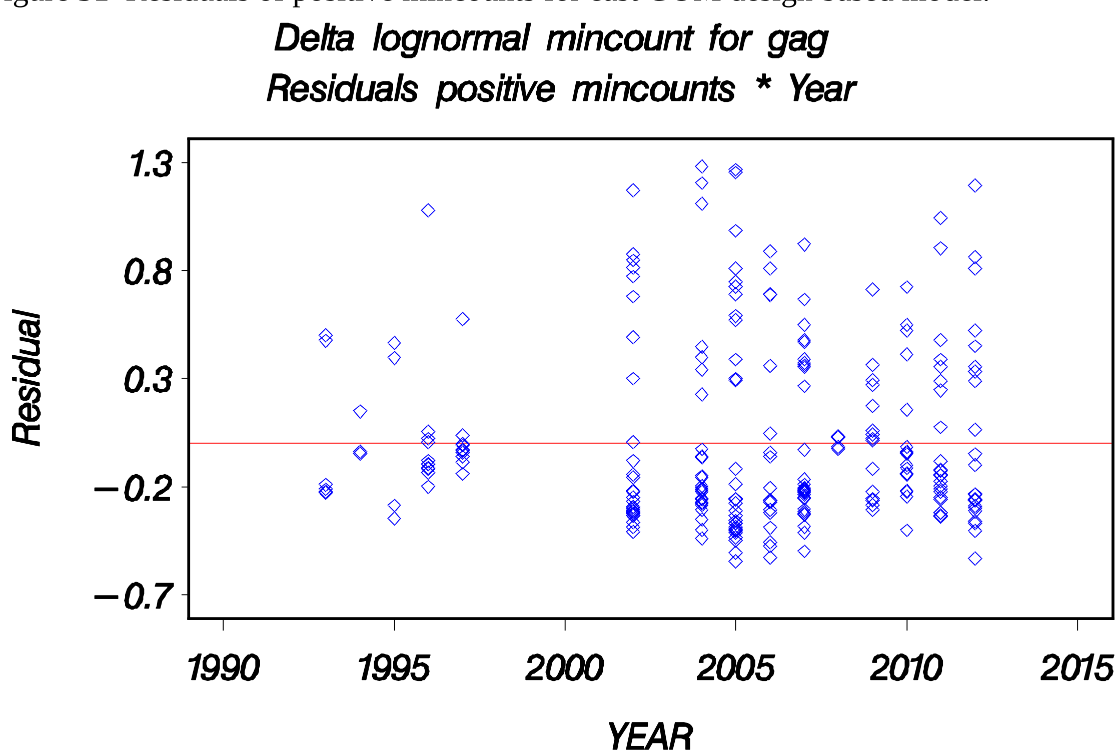

Figure 32. Positive mincount distribution from east GOM design based model.

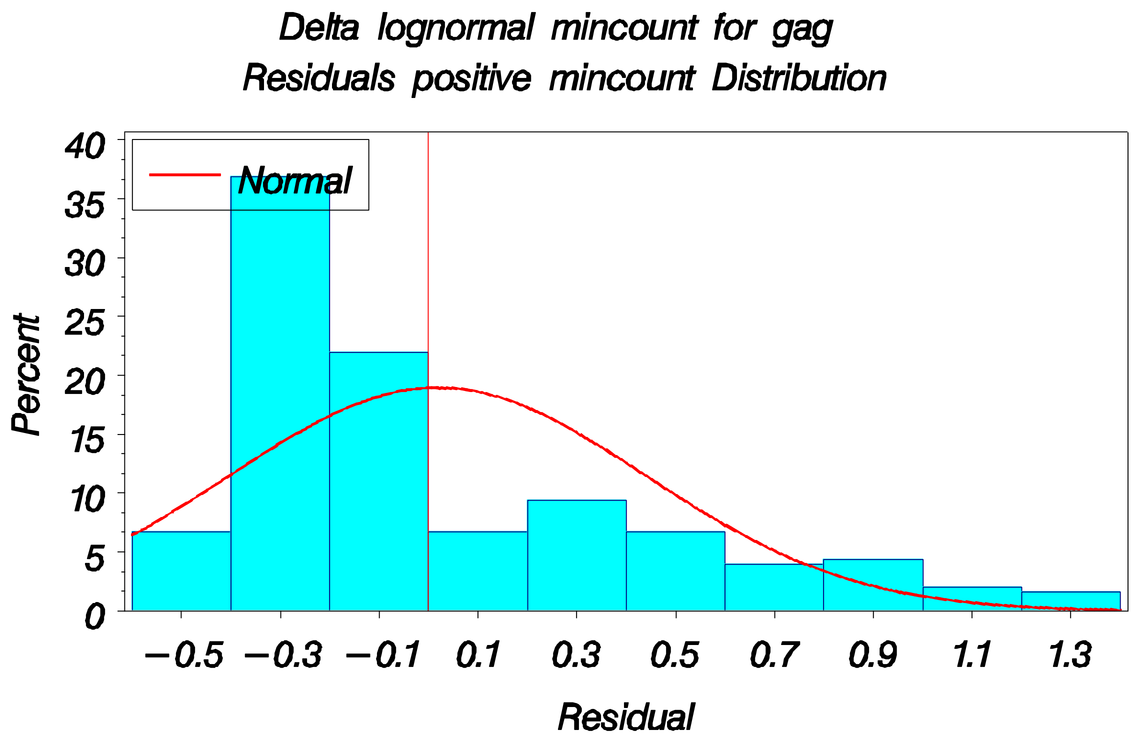

Figure 33. QQ plot of positive mincounts from east GOM design based model.

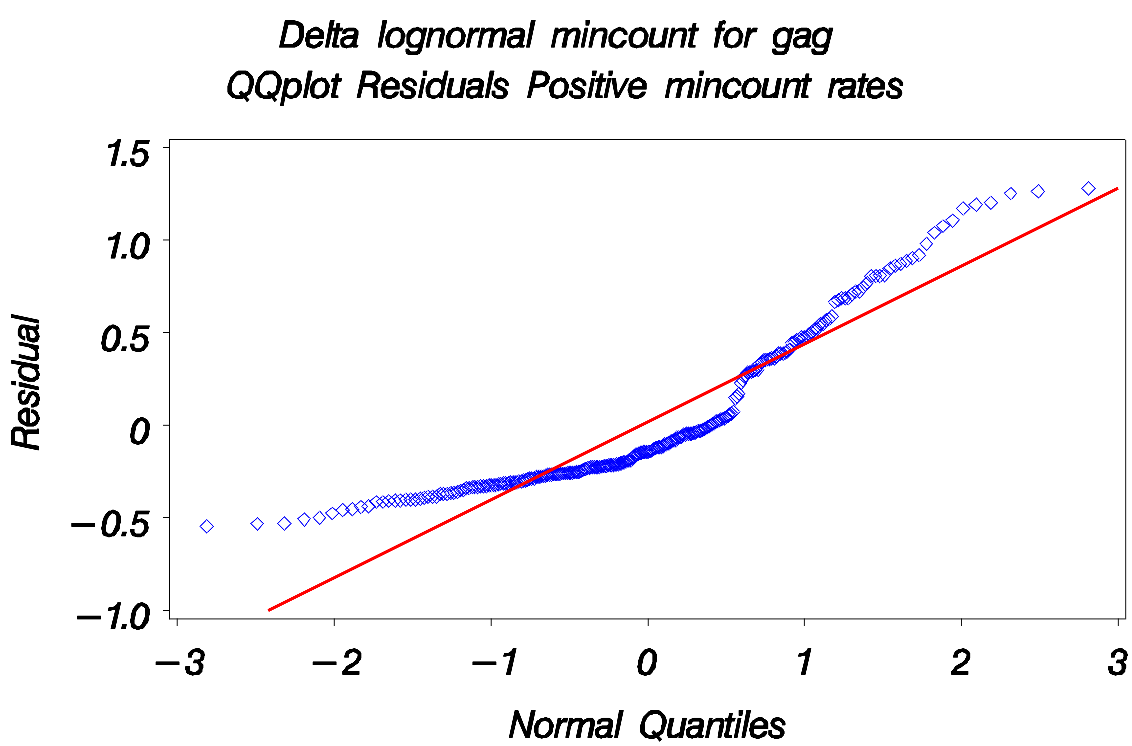

Figure 34. Gag length frequency of fish measured from video with lasers in 1995-2009.

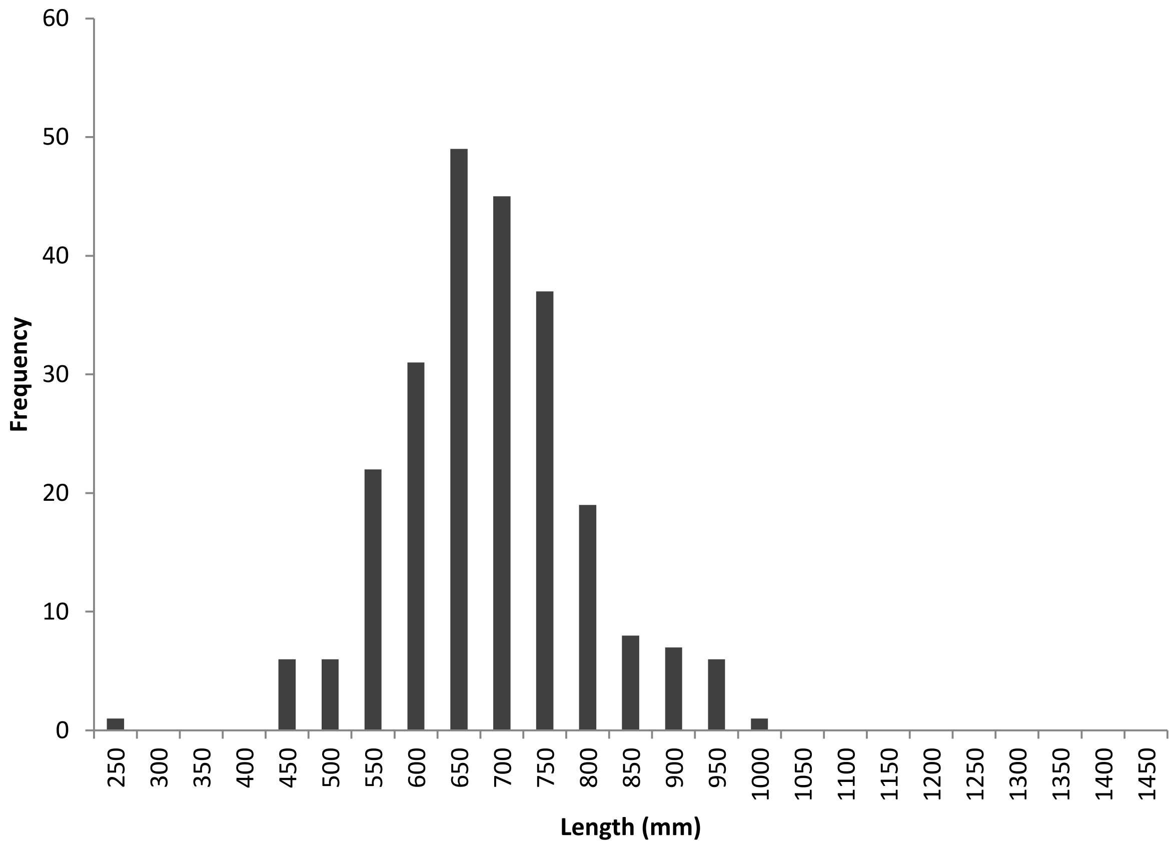

Figure 35. Gag length frequency of fish measured from video with stereo cameras in 1998-2012.

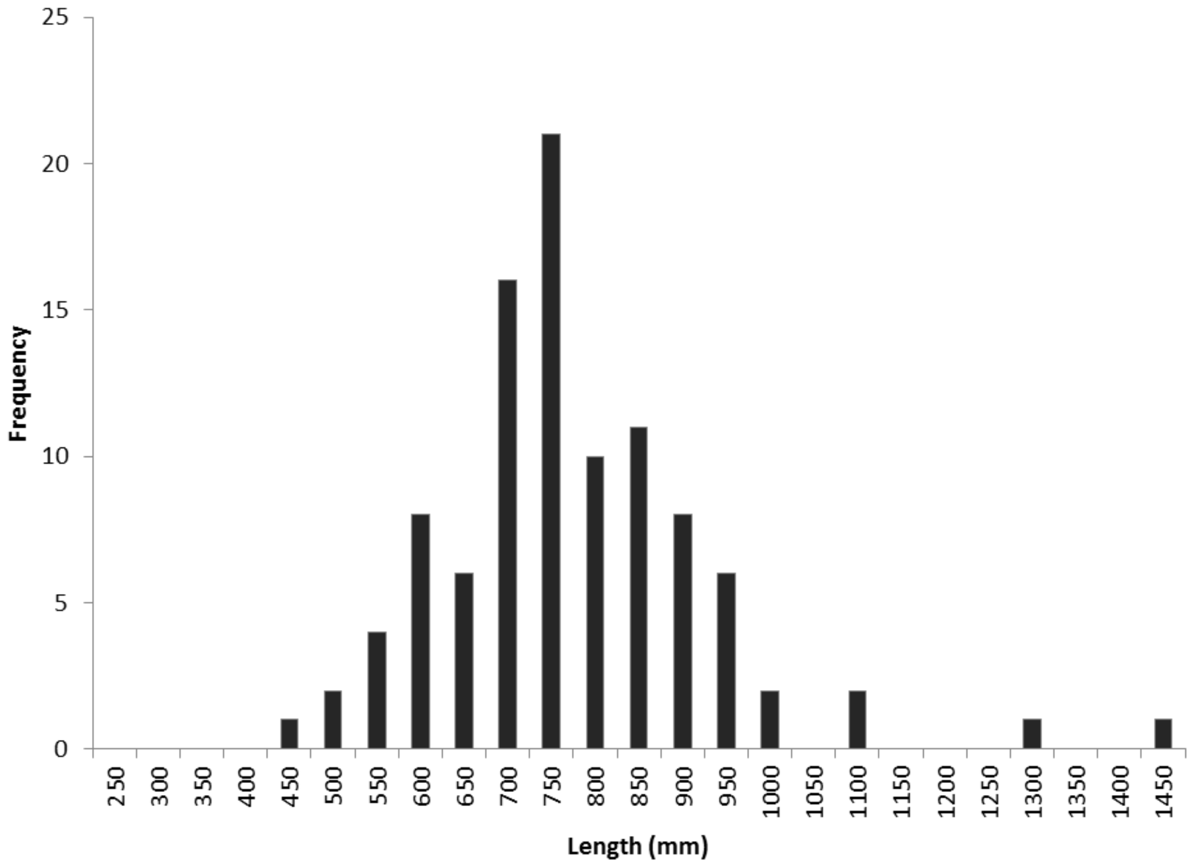

Table 7. Gag lengths (fork lengths in mm) measured by laser from video tapes (1995-2007) and by stereo still cameras (2008-2012).

	Stereo measurements		Laser measurements	
Year	**Mean**	**SD**	**Mean**	**SD**
1996	-	-	429.00	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	718.91	77.20
2003	-	-	653.63	136.21
2004	-	-	692.13	77.20
2005	-	-	721.40	105.42
2006	-	-	624.64	100.63
2007	-	-	720.80	82.79
2008	782.16	172.23	-	-
2009	833.12	270.67	640.00	86.15
2010	768.03	104.26	-	-
2011	774.11	144.35	-	-
2012	734.42	149.13	-	-
Total	771.42	152.92	682.68	108.93