Fisheries-independent data for gag and greater amberjack from reef-fish video surveys on the West Florida Shelf, 2008-2012.

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Fisheries-independent data for gag and greater amberjack from reef-fish video surveys on the West Florida Shelf, 2008-2012.

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Introduction:

Reef fishes, including gag and greater amberjack, support extensive commercial and recreational fisheries along the West Florida Shelf (WFS). Historically, the assessment and management of reef fishes in the Gulf of Mexico has relied heavily on data from fisheries-dependent sources, although limitations and biases inherent to these data are admittedly a major source of uncertainty in current stock assessments. The accuracy of harvest estimates, particularly on the recreational side, has been challenged in recent years. Additionally, commercial, headboat, and recreational landings data are restricted to harvestable-sized fish, and thus are highly influenced by regulatory changes (i.e., size limits, recreational bag limits, and seasonal closures). These limitations render it difficult to forecast potential stock recovery associated with strong year classes entering the fishery. There has been a renewed emphasis in recent years to increase the availability of fisheries-independent data on reef fish populations in the Gulf of Mexico that reflect the status of fish populations as a whole, rather than just the portion of the population taken in the fishery. To meet the emerging needs of fisheries-independent data for reef fishes, the Florida Fish and Wildlife Conservation Commission (FWC) has been working collaboratively with scientists from the National Marine Fisheries Service (NMFS) to expand regional monitoring capabilities and provide timely fisheries-independent data for a variety of state- and federally-managed reef fishes. Results are summarized from a fisheries-independent reef fish survey initiated by FWC in 2008 to complement ongoing NMFS surveys of reef habitats along the shelf break (NMFS – Pascagoula) and in the northeastern Gulf of Mexico (NMFS – Panama City).

Survey Design, Sampling Methods, and Analyses:

The FWC reef fish survey includes a portion of the WFS bounded by 26^{o} and 28^{o} N latitude and depths from 10 – 110 m (Figure 1). The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS reef-fish surveys. To assure adequate spatial coverage of sampling effort, the WFS survey area is subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Nearshore: 10 – 37 m; Offshore: 37 – 110 m). Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1km x 1km sampling units. Results from 2008 indicated that 1km x 1km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of n = 200 sampling units) was proportionally allocated among the four sampling zones based on habitat availability (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore), and specific sampling units were selected randomly within each sampling zone.

Very little is known regarding the fine-scale distribution of reef habitat throughout much of the WFS, and due to anticipated cost and time requirements, mapping the entire WFS survey area was not feasible prior to initiating the WFS reef fish survey. For the 2008 reef fish survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100m-resolution interpolated bathymetry data. An examination of results from the 2008 survey indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1nm to the east and west of the pre-selected sampling unit prior to sampling. In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echosounder, while for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. Based on results from these acoustic surveys, sampling effort was randomly relocated to a nearby sampling unit should evidence of reef habitat be identified.

At each sampling station, two types of sampling gears were utilized: stationary underwater camera arrays (SUCA) and chevron traps. Gear deployments and collection and processing of field data followed established NMFS protocols. At each station, 1-2 SUCAs were deployed that consisted of a pair of stereo imaging system (SIS) units positioned at an angle of 180º from one another to maximize the total field of view. Each SIS unit consisted of an underwater housing containing a digital camcorder to record video and a pair of stereo cameras to capture still images at a rate of one per second. Each SUCA was baited (generally Atlantic mackerel) and deployed for thirty minutes to assure that twenty minutes of continuous video and stereo images were recorded. Video data from one SIS per SUCA deployment were processed to quantify the relative abundance of gag and greater amberjack observed (MaxN, or the maximum number of gag or greater amberjack observed on a single video frame). In addition, 1-4 chevron traps were baited (generally Atlantic mackerel) and deployed for ninety minutes prior to retrieval; since very few gag or greater amberjack were collected within the chevron traps, these data will not be explored further. All individual gear deployments (SUCA and chevron traps) were spaced a minimum of 100 m apart. In addition to data on gag and greater amberjack, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were recorded at each specific sampling site.

Prior to conducting analyses, data were processed to exclude video deployments that were too turbid to conducting meaningful reads as well as unsuccessful video deployments (i.e., array landed on the side, array that moved during video). Nominal statistics were summarized by first averaging data over each sampling site. For each year and sampling zone, frequency of occurrence as well as mean (± SE) relative abundance of gag and greater amberjack was calculated across stations for SUCA data. Relative abundance was calculated as the average MaxN.

Delta-lognormal modeling methods were also used to estimate relative abundance indices for both gag and 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). A backward stepwise selection procedure was employed to develop both sub-models. Type III analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set as $\alpha = 0.05$, although marginal values were also considered for inclusion; year was retained in all models regardless of significance level. The parameters tested for inclusion in each sub-model were categorical variables of year, month, depth (inshore and offshore), latitude (north = Tampa Bay and south = Charlotte Harbor), and whether or not reef habitat was observed in the frame (Y or N).

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

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

Results / Discussion:

From 2008 – 2012, a total of 968 SUCA deployments were made at 632 stations on the West Florida Shelf (Table 1). Due to weather and mechanical issues, annual sampling effort varied from 67 – 182 stations. Although all four spatial zones were sampled each year, allocation of completed sampling effort varied significantly; accordingly, data were summarized independently for each zone.

No gag were observed in either 2008 or 2009, although the zone-specific frequency of occurrence of gag has increased to 10-20% in all zones aside from the Charlotte Harbor – Nearshore zone (Figure 2). Mean nominal number of gag observed per station has generally varied between 0.1 and 0.2 individuals per video between 2010 and 2012 (Figure 3). No greater amberjack were observed in 2008; since then, frequency of occurrence of greater amberjack has fluctuated around 10% (Figure 4). Mean nominal number of greater amberjack observed per station has increased in recent years in most zones (Figure 5).

For gag, both year (non-significant) and month were retained for the binomial sub-model (Table 2), and year (non-significant), month and area were retained for the lognormal sub-model (Table 3). A Q-Q plot of the residuals is provided in Figure 6. Due to no gag being observed in 2008 and 2009, abundance indices were only produced from 2010 – 2012 (Figure 7; Table 4); these indices indicate a sharp increase in the relative abundance of gag from 2010 to 2011 with no discernible change in 2012. For greater amberjack year (non-significant), month, and the presence of observable reef habitat were retained for the binomial sub-model (Table 5), and only year (non-significant) was retained for the lognormal sub-model (Table 6). A Q-Q plot of the residuals is provided in Figure 8. Due to no greater amberjack being observed in 2008, abundance indices were only produced from 2009 – 2012 (Figure 9; Table 7); these indices indicate little change in the relative abundance of greater amberjack from 2009 to 2011 with a modest increase in 2012.

At present, this survey does not constitute a long-enough time series to be useful in the assessment of either gag or greater amberjack, especially with the dramatic increase in the proportion of stations sampled that actually contained reef habitat in conjunction with the incorporation of side scan sonar in 2010. However, in time this survey should provide valuable data that can be used in subsequent assessments. In addition to expanding the time series of this data through continued sampling, consideration should be given towards combining data from this survey with data from the NMFS – Panama City survey in developing indices of abundance that are representative of a broader spatial area. Even though these surveys employ similar methods, efforts to construct a single index of abundance would benefit significantly from some spatial overlap for a brief period of time (one to several years) so that results can be appropriately calibrated.

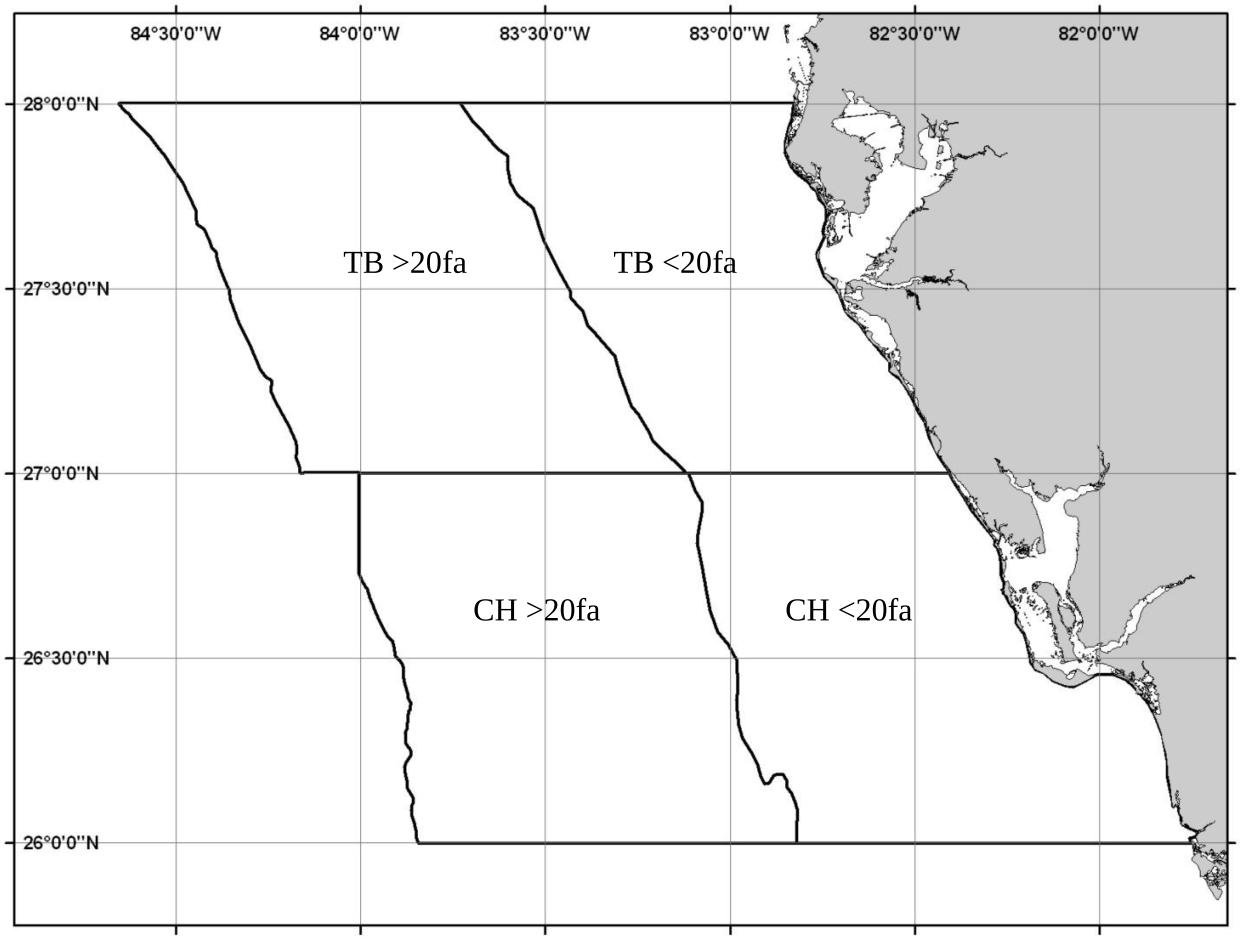

Figure 1. The West Florida Shelf survey area. The 20fa (37m) contour separates nearshore (i.e., TBN and CHN) and offshore (TBO and CHO) sampling zones. The sampling area includes waters 10m – 110m.

Table 1. Summary of annual stationary underwater camera array (SUCA) sampling effort by spatial zone from 2008 – 2012. Values represent total number of sampling stations, while values in parentheses represent the total number of individual gear deployments (1 – 2 arrays deployed per station).

Region	2008	2009	2010	2011	2012	Total
TBN	5 (10)	25 (34)	16 (24)	56 (84)	54 (82)	156 (234)
TBO	18 (33)	33 (66)	25 (50)	49 (57)	36 (47)	161 (253)
CHN	20 (38)	28 (43)	23 (46)	35 (37)	36 (47)	142 (211)
CHO	24 (48)	30 (60)	29 (56)	42 (45)	48 (61)	173 (270)
Total	67 (129)	116 (203)	93 (176)	182 (223)	174 (237)	632 (968)

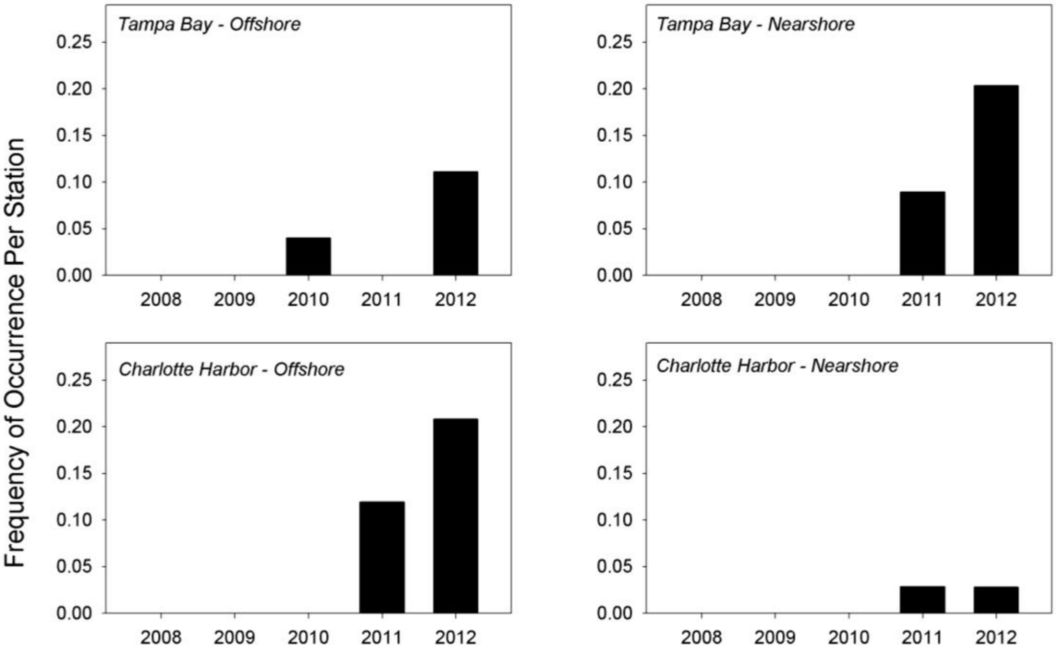

Figure 2. Annual frequency of occurrence of gag observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2012.

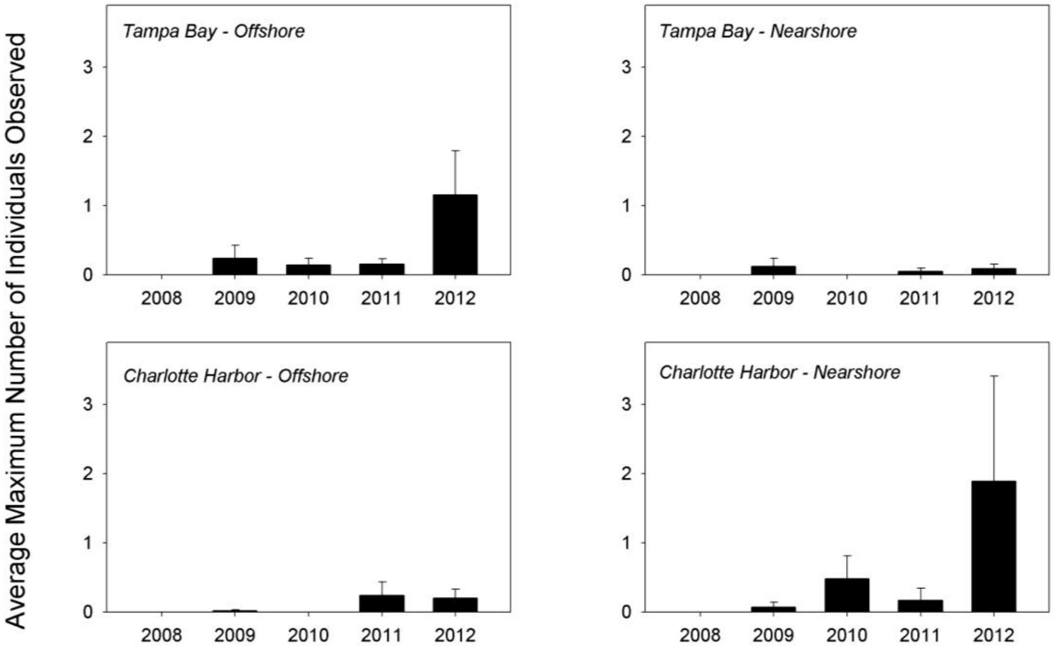

Figure 3. Mean (± SE) annual relative abundance of gag observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2012.

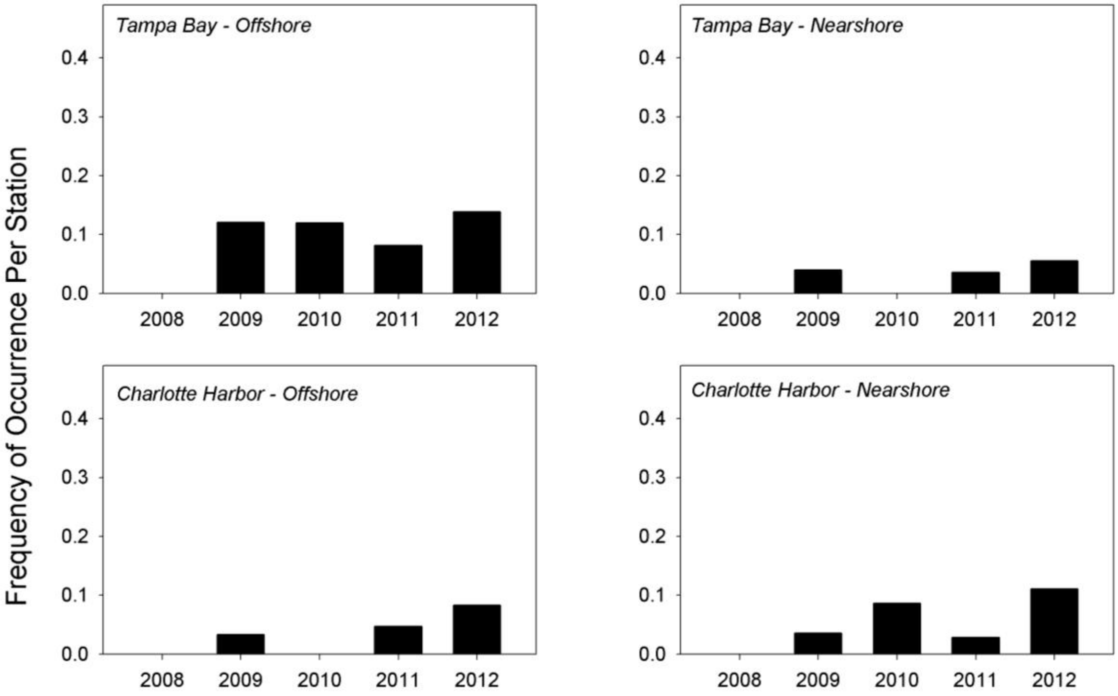

Figure 4. Annual frequency of occurrence of greater amberjack observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2012.

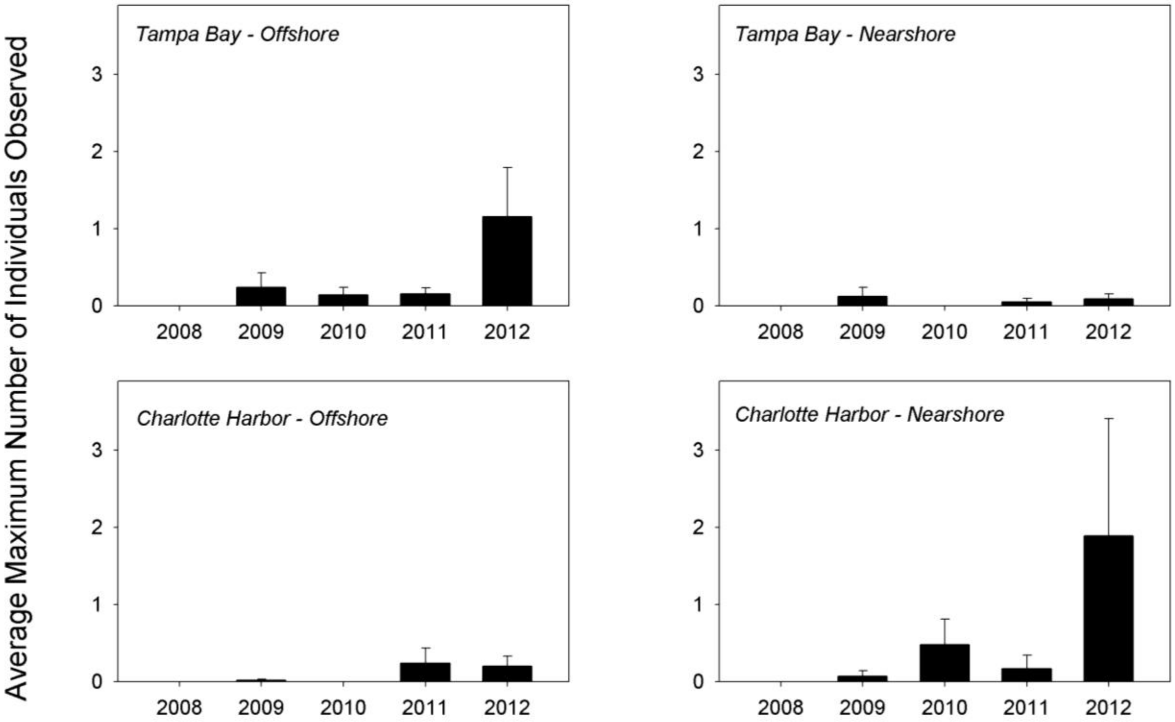

Figure 5. Mean (± SE) annual relative abundance of greater amberjack observed during stationary underwater camera array (SUCA) surveys by spatial zone from 2008 – 2012.

Table 2. Type III tests of fixed effects for the binomial sub-model for gag from 2008 – 2012.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	2	513	1.86	0.93	0.3947	0.3954
month	3	513	8.80	2.93	0.0321	0.0331

Table 3. Type III tests of fixed effects for the lognormal sub-model for gag from 2008 – 2012.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	2	20	1.43	0.2635
month	3	20	3.15	0.0477
area	1	20	5.59	0.0283

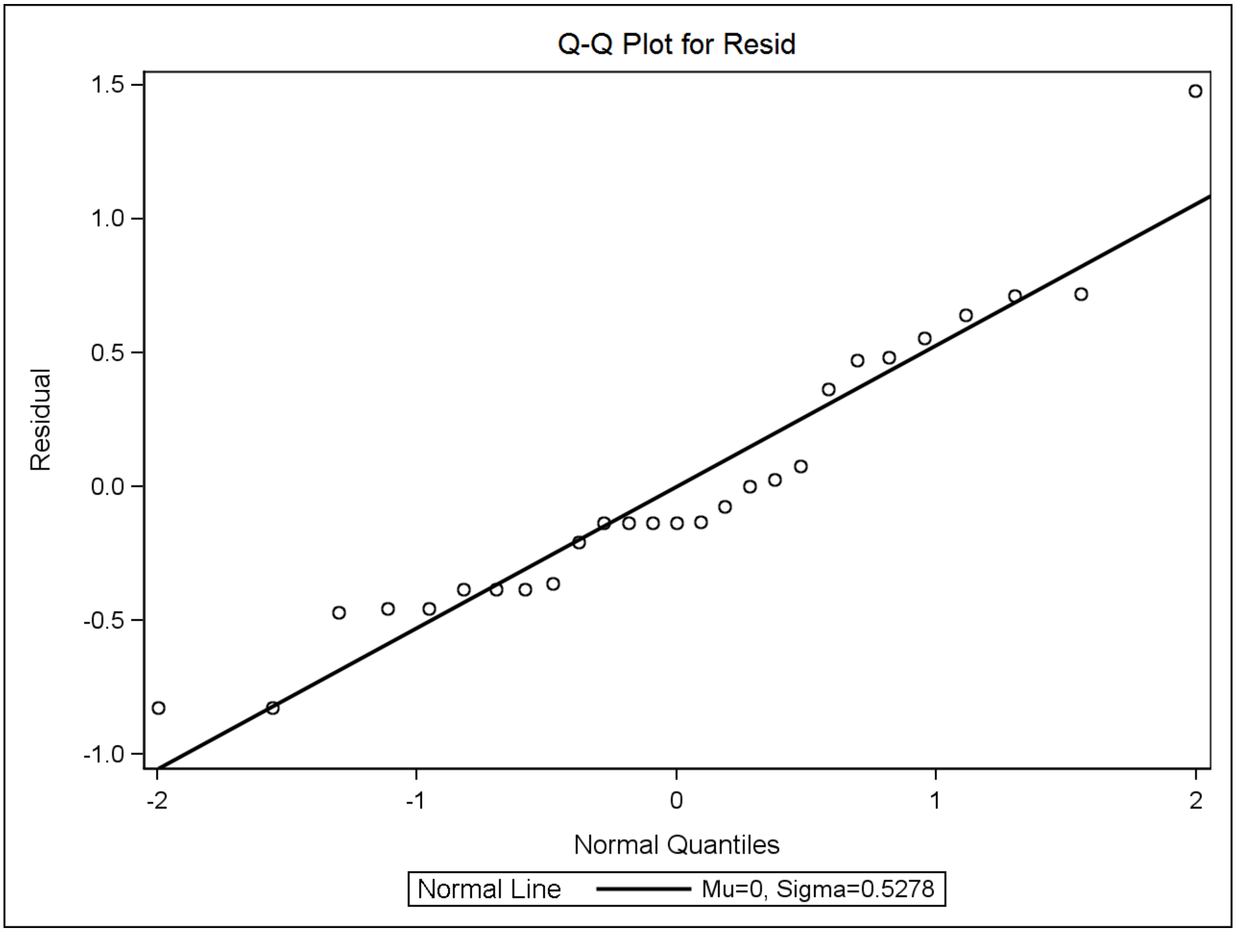

Figure 6. Q-Q plot of residuals from the lognormal sub-model for gag from 2008 – 2012

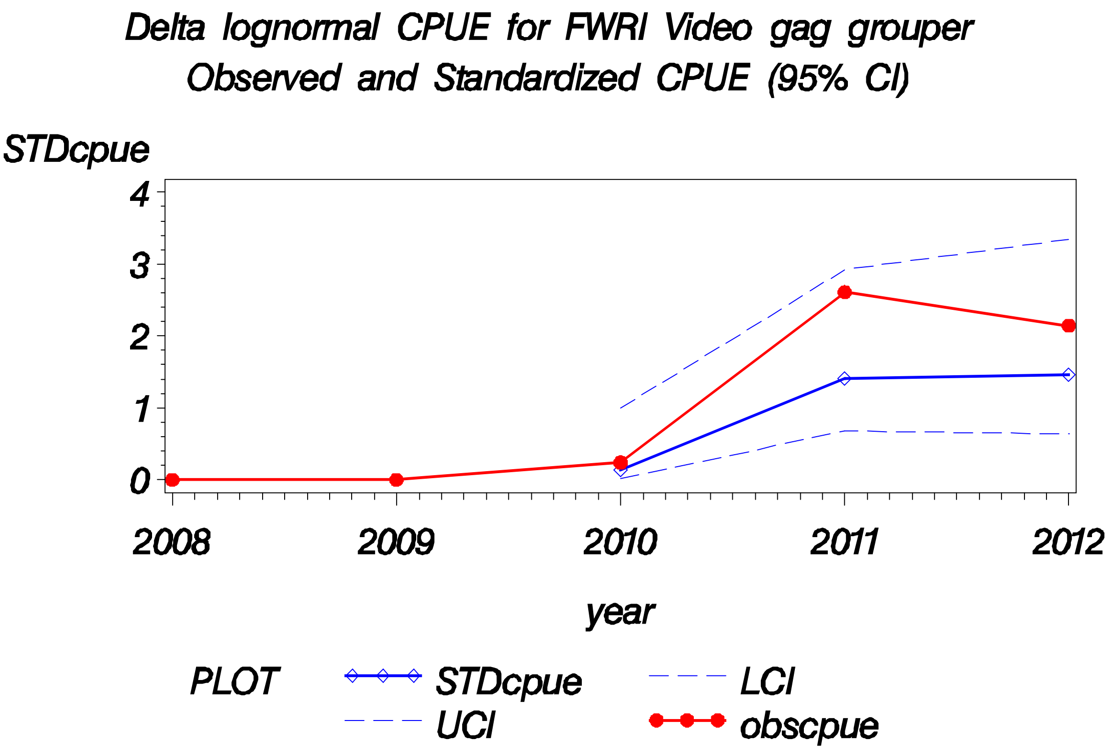

Figure 7. Abundance indices for gag from 2008 – 2012.

Table 4. Abundance indices for gag from 2008 – 2012.

Survey Year	*Frequency*	*N*	*Index*	*Standardized Index*	*CV*	*LCL*	*UCL*
2008	0.000000	109	.	.	.	.	.
2009	0.000000	182	.	.	.	.	.
2010	0.013699	73	0.01229	0.13338	1.32353	0.01783	0.99763
2011	0.064815	216	0.12951	1.40589	0.37851	0.67628	2.92267
2012	0.052174	230	0.13456	1.46073	0.43245	0.63816	3.34355

Table 5. Type III tests of fixed effects for the binomial sub-model for greater amberjack from 2008 – 2012.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	3	693	2.36	0.79	0.5010	0.5015
month	3	693	7.43	2.48	0.0594	0.0603
reef	1	693	4.45	4.45	0.0350	0.0353

Table 6. Type III tests of fixed effects for the lognormal sub-model for greater amberjack from 2008 – 2012.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	3	36	0.25	0.8620

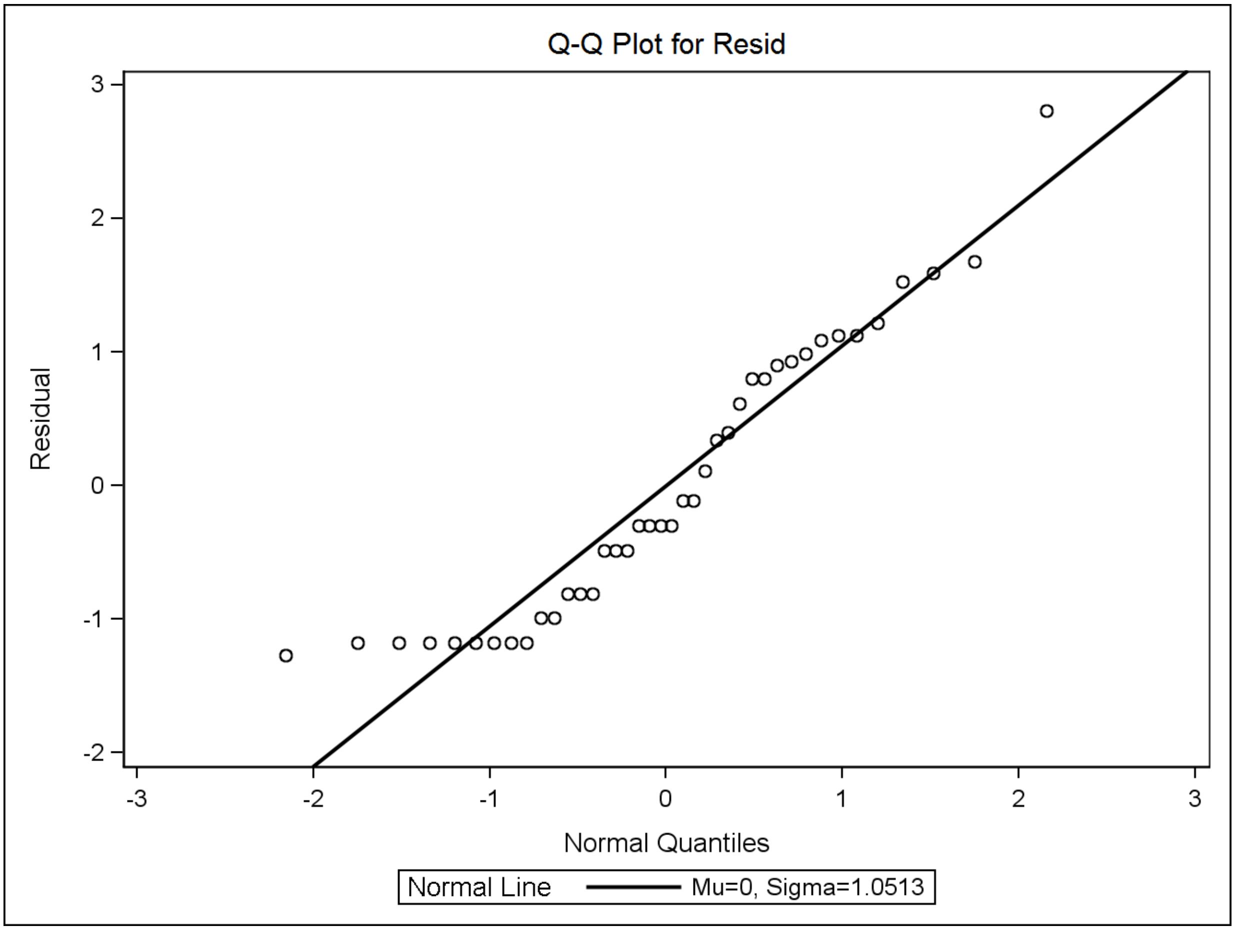

Figure 8. Q-Q plot of residuals from the lognormal sub-model for greater amberjack from 2008 – 2012

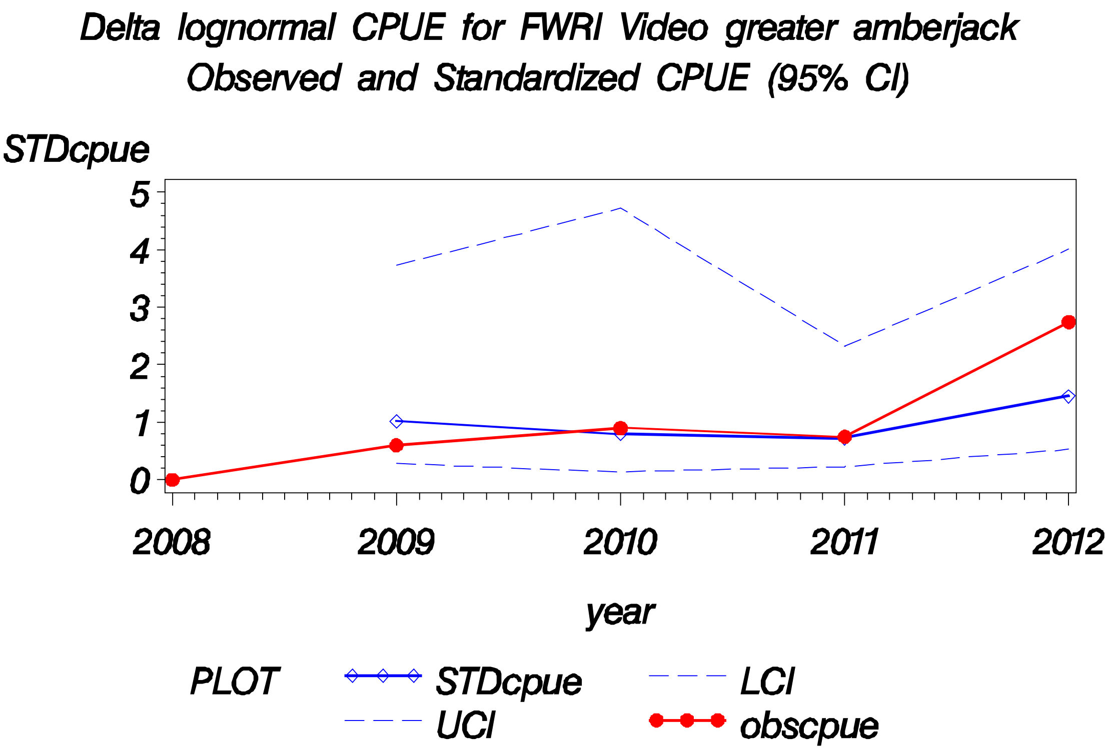

Figure 9. Abundance indices for greater amberjack from 2008 – 2012.

Table 7. Abundance indices for greater amberjack from 2008 – 2012.

Survey Year	*Frequency*	*N*	*Index*	*Standardized Index*	*CV*	*LCL*	*UCL*
2008	0.000000	109	.	.	.	.	.
2009	0.038462	182	0.23145	1.01914	0.72365	0.27834	3.73158
2010	0.041096	73	0.18192	0.80106	1.09366	0.13592	4.72127
2011	0.050926	216	0.16452	0.72444	0.63640	0.22569	2.32541
2012	0.082609	230	0.33052	1.45537	0.54180	0.52760	4.01458