Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from the annual baitfish survey, 2002-2012.

Theodore S. Switzer[1], Keith M. Fischer[1], and Robert H. McMichael, Jr.[1]

[1]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL 33701

Introduction:

Reef fishes, including Hogfish, are targeted commercially and recreationally 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 because these data reflect the status of fish populations as a whole, rather than just the portion of the population taken in the fishery.

To meet this need for fisheries-independent data for reef fishes, the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) has been working to expand regional monitoring capabilities and provide timely fisheries-independent data for a variety of state- and federally-managed reef fishes. In addition to the implementation of new surveys, this initiative also involves an examination of data from long-term surveys to determine where meaningful data are already being provided. Accordingly, results are summarized for Hogfish collected during an annual spring survey of baitfish populations in the nearshore waters of the West Florida Shelf conducted by FWRI.

Survey Design and Sampling Methods:

The annual spring baitfish survey, implemented in 1994 and completed in all years with the exception of 2000, covers the portion of the West Florida Shelf between 26° and 28° N latitude from 6 – 28 m (Figure 1). The survey employs a stratified-random survey design where the study area was first subdivided into two spatial strata based on latitude. Within each stratum, three randomly-selected transects (representing lines of latitude) were surveyed, and six stations were sampled per transect with three of these stations between 6 – 12 m and three stations between 12 – 28 m.

Each station was sampled with a 19.8-m balloon trawl towed for 30 minutes at a speed of approximately 3 kt during daylight hours. Temperature (° C), salinity (psu), and chlorophyll *a* ($\mu g\ L^{-1}$) were recorded at each station. All Hogfish collected in each sample were identified and enumerated, and up to 50 individuals were measured to the nearest mm fork length (FL). Location, date, and time were recorded at each sampling site.

Analytical Methods:

Due to inconsistencies with the early data, all data prior to 2002 were excluded prior to conducting statistical analyses. Nominal statistics were calculated for each year, including frequency of occurrence and mean (± SE) relative abundance (Individuals Per Set) of Hogfish. Annual length-frequency distributions were also constructed. For assessment purposes, indices of abundance have traditionally been calculated using delta-lognormal modeling methods. However, during the data workshop for SEDAR 33, the indices working group discussed the fact that this approach is likely inappropriate for many analyses because the distribution of positive catches often does not follow a lognormal distribution, as is the case with Hogfish (Figure 2). Accordingly, model-based estimates of annual abundance for Hogfish were calculated using generalized linear modeling methods. The downside to this approach is that traditional model diagnostic criteria, including residual diagnostics, are currently unavailable, and so it is difficult to select the most appropriate base model (e.g., negative binomial vs. Poisson). Nevertheless, exploratory analyses conducted during the SEDAR 33 data workshop indicated that model choice had little influence on annual relative abundance patterns among the various indices constructed.

Generalized linear modeling analyses were used to construct annual indices of relative abundance of Hogfish using SAS software and the GLIMMIX procedure. The relative abundance of Hogfish (Individuals Per Set) represents count data, the distribution of which is bound by zero and highly nonnormal; accordingly, data were fit using the negative binomial distribution. Year and zone were included as categorical explanatory variables in the model, while depth, temperature, salinity, and chlorophyll *a* were included as covariates. Variables identified as nonsignificant ($\alpha = 0.10$) were excluded, and the analysis was repeated in a stepwise fashion until only significant variables remained in the model. Results are reported only for final variables included in the model. For each model, annual least-square-mean estimates (± SE) of relative abundance of Hogfish were exported in the scale of the original data to assess temporal variability in Hogfish relative abundance. Based on final model results, annual coefficients of variation (mean / standard deviation) were calculated to assess the ability of the model to assess interannual recruitment variability. Because standard deviation values associated with annual least square means from generalized linear analyses are not available, we created a sampling distribution by repeatedly (n = 10,000 times) calculating a random deviate from the standard normal distribution ($\mu = 0$, $\sigma^2 = 1$). These deviates were then multiplied by the standard error, and products were added to the least square mean to generate the sampling distribution from which standard deviation values were calculated.

Results / Discussion:

A total of 361 trawl samples have been collected in association with the spring FWRI baitfish trawl survey from 2002 – 2012. Annual sampling effort varied somewhat from year to year due to weather and mechanical issues. Annual frequency of occurrence of Hogfish has varied from 16% to 37%, and mean nominal number of Hogfish collected per site has varied from 0.17 (± 0.069) to 2.43 (± 0.820). Hogfish lengths ranged from 50 – 500 mm FL (Figure 3), indicating that collected individuals were most likely between 1 and 10 years of age (Collins and McBride 2011). Length frequency distributions varied annually, largely due to pulses of strong year classes passing through the survey.

Year, depth, and chlorophyll *a* were retained for the final generalized linear model (zone, temperature, and salinity were not retained; Table 2). For the final model, the ratio of Pearson Chi-Square to degrees of freedom was approximately 1 (0.84). Abundance indices were constructed for 2002 – 2012 (Figure 4; Table 3); Hogfish relative abundance generally fluctuated without trend, with high values in 2003-2004, 2007, 2009, and 2012. Overall, coefficients of variation were marginal (between 0.52 and 1.04).

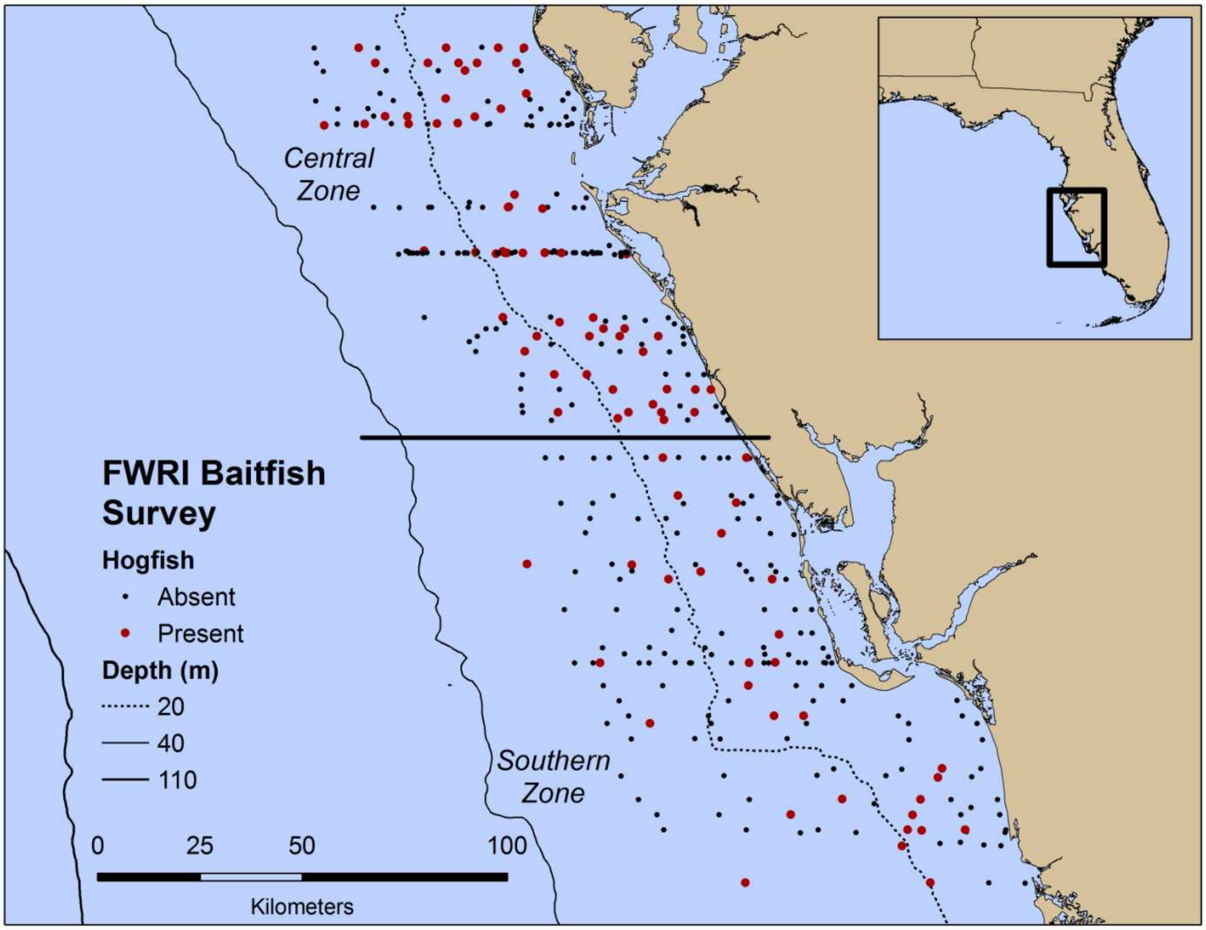

Figure 1. Locations of all stations sampled during the annual spring baitfish survey conducted by FWRI along the West Florida Shelf (2002 – 2012). Black dots represent stations where Hogfish were absent, whereas red dots represent stations where Hogfish were present within 19.8-m trawl samples.

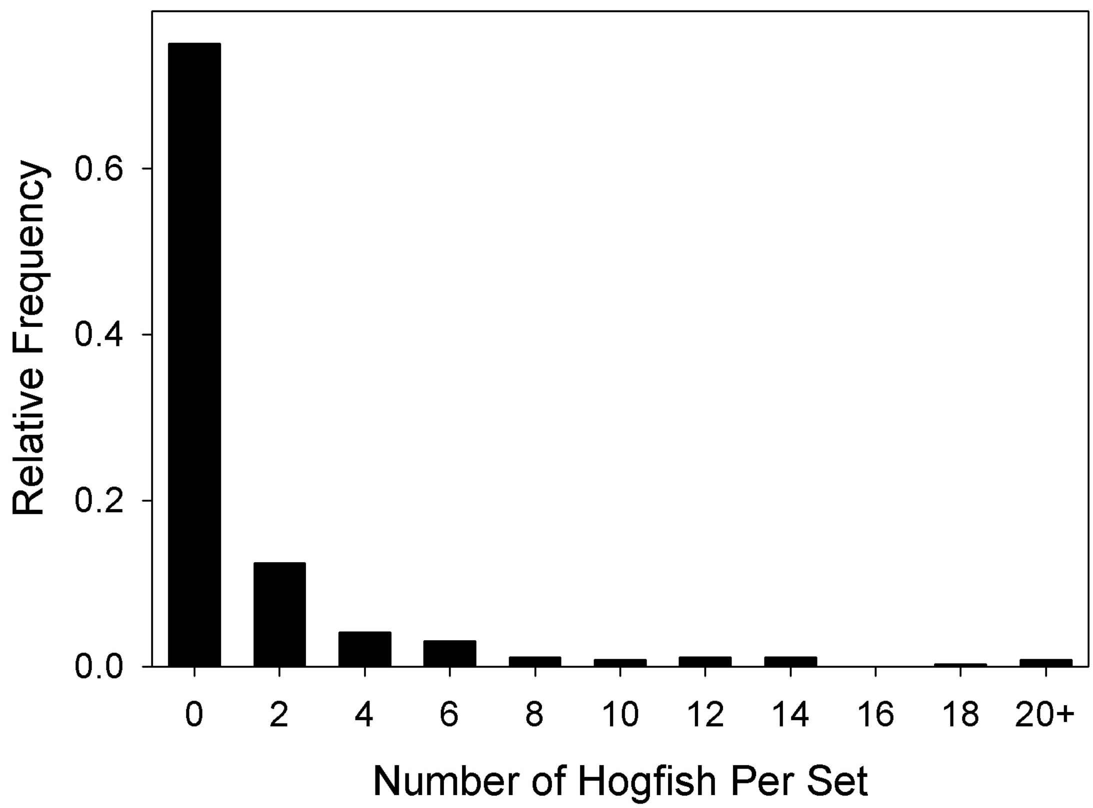

Figure 2. Frequency distribution of relative abundance (Individuals Per Set) values of Hogfish collected within the FWRI baitfish trawl survey. Values were calculated using censored data sets (see Analytical Methods section).

Table 1. Annual sample sizes, frequency of occurrence, and mean nominal number of individuals per set (± SE) for Hogfish collected in the FWRI baitfish trawl survey. Estimates calculated using censored data sets (see Analytical Methods section).

Year	Total sites sampled	% Frequency of occurrence	Mean (± SE) nominal individuals per set
2002	30	16.7	0.17 ± 0.069
2003	32	21.9	0.88 ± 0.428
2004	29	24.1	0.90 ± 0.434
2005	21	19.0	0.76 ± 0.573
2006	37	18.9	0.46 ± 0.188
2007	38	26.3	2.08 ± 1.276
2008	35	25.7	1.37 ± 0.561
2009	35	37.1	1.94 ± 0.686
2010	34	23.5	1.15 ± 0.599
2011	35	22.9	1.00 ± 0.451
2012	35	34.3	2.43 ± 0.820

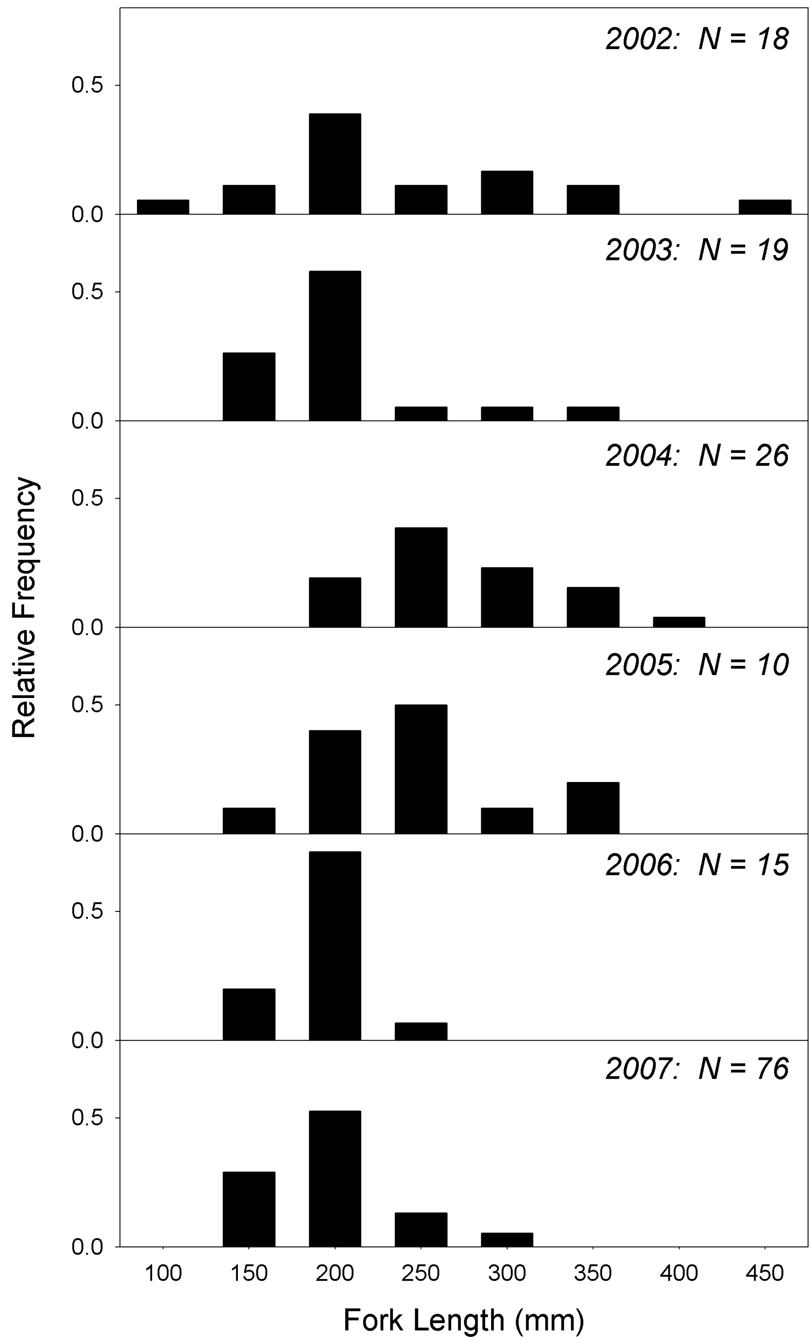

Figure 3. Annual length frequency distributions of Hogfish collected in the FWRI baitfish trawl survey. This summary only includes individuals from the censored data set (see Analytical Methods section).

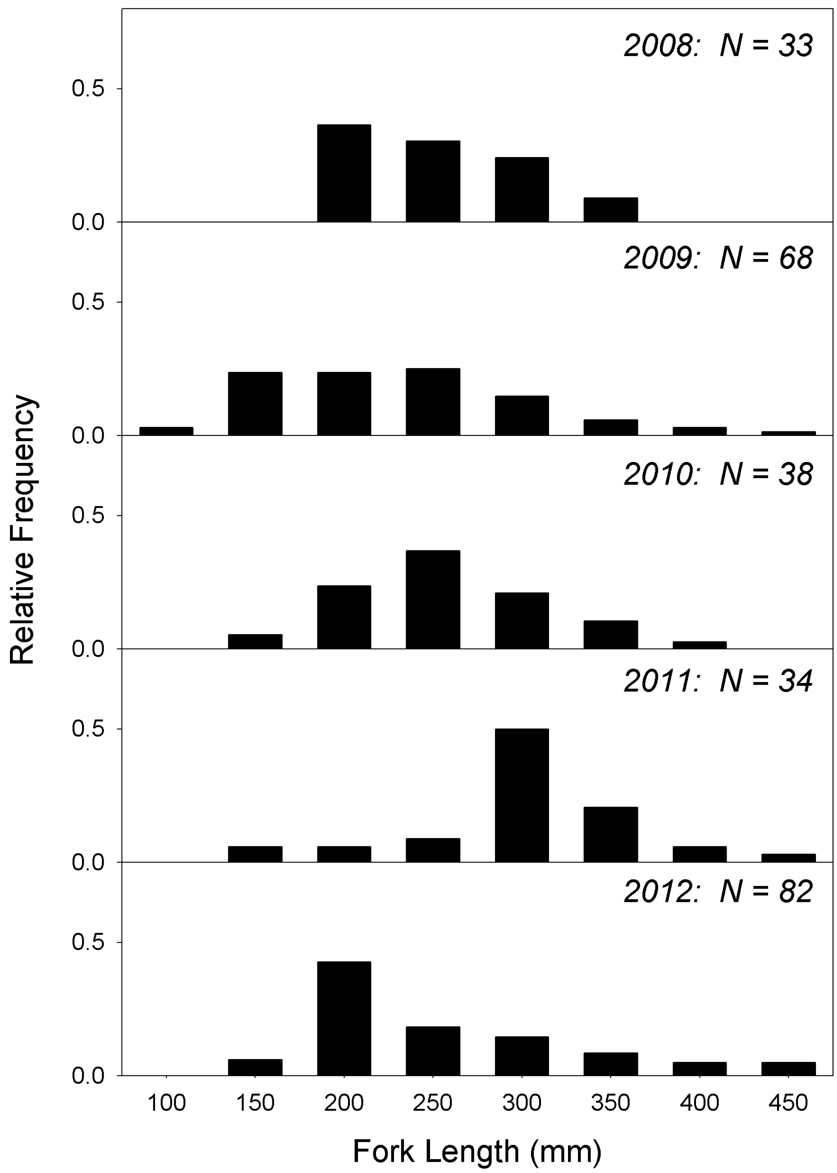

Figure 3 (cont.). Annual length frequency distributions of Hogfish collected in the FWRI baitfish trawl survey. This summary only includes individuals from the censored data set (see Analytical Methods section).

Table 2. Type III tests of fixed effects from the final generalized linear model of the relative abundance (Individuals Per Set) of Hogfish collected in the FWRI baitfish trawl survey. Analyses were calculated using censored data set (see Analytical Methods section).

Effect	Numerator DF	Denominator DF	F Value	Pr > F
Year	10	344	1.82	0.0566
Depth	1	344	4.43	0.0360
Chlorophyll *a*	1	344	9.49	0.0022

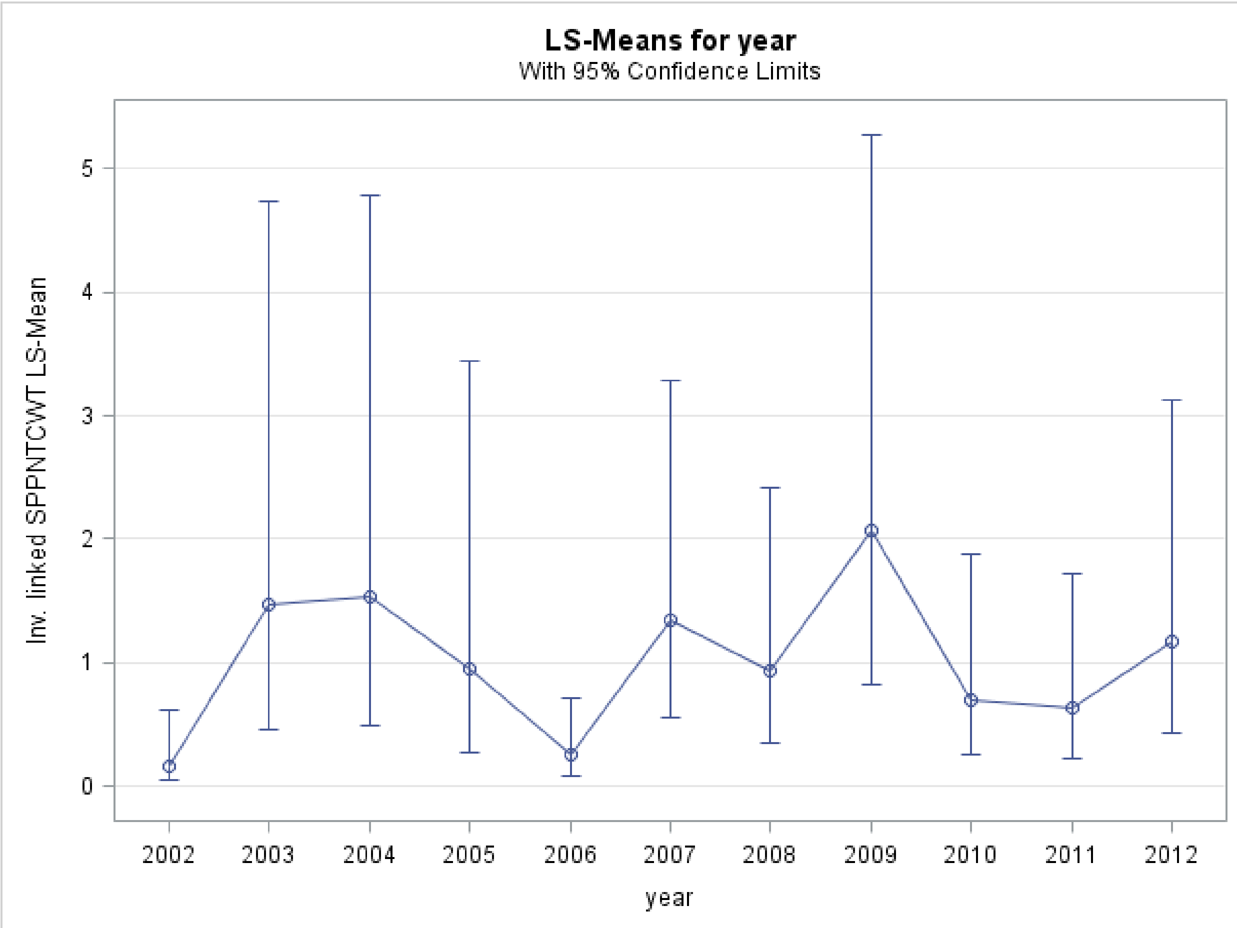

Figure 4. Annual estimates of relative abundance (Individuals Per Set) of Hogfish as determined via a generalized linear modeling analysis of data from the FWRI baitfish trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

Table 5. Annual indices of relative abundance (Individuals Per Set) as well as coefficient of variation (CV) and lower (LCL) and upper (UCL) 95% confidence limits for Hogfish as determined via a generalized linear modeling analysis of data from the FWRI baitfish trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

Year	Standardized Index	CV	LCL	UCL
2002	0.1619	0.9496	0.0427	0.6131
2003	1.4667	0.7135	0.4546	4.7320
2004	1.5352	0.7343	0.4928	4.7829
2005	0.9542	1.0380	0.2649	3.4381
2006	0.2487	0.6244	0.0866	0.7142
2007	1.3454	0.5198	0.5498	3.2922
2008	0.9278	0.5769	0.3567	2.4135
2009	2.0751	0.5393	0.8159	5.2773
2010	0.6966	0.5861	0.2584	1.8783
2011	0.6302	0.5914	0.2300	1.7263
2012	1.1644	0.5762	0.4345	3.1204