Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from the annual FWRI SEAMAP trawl survey, 2008-2012.

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. Results are summarized for Hogfish collected during the annual summer SEAMAP trawl survey of the West Florida Shelf conducted by FWRI.

Survey Design and Sampling Methods:

The annual summer SEAMAP trawl survey of the WFS, implemented in 2008 by FWRI, covers waters from 10 – 110 m deep within NMFS statistical zones 2 – 10 (Figure 1). The survey employs a stratified-random survey design where the study area was first subdivided into two depth strata (10 – 36.6 m and 36.6 – 110 m) within each NMFS statistical zone. Within each stratum, sampling locations were randomly selected and allocated proportionally based on area within each stratum. Initially conducted as an exploratory survey, the SEAMAP trawl survey included statistical zones 5 – 10 in 2008 and was subsequently expanded to include statistical zone 4 in 2009, statistical zone 3 in 2010, and statistical zone 2 in 2011.

Each station was sampled with a 12.8-m shrimp trawl towed for 30 minutes at a speed of approximately 3 kt. Temperature (° C), salinity (psu), dissolved oxygen (mg L^{-1}) and chlorophyll *a* (µg L^{-1}) were recorded at each station. All Hogfish collected in each sample were identified and enumerated, and measured to the nearest mm fork length (FL). Location, date, and time were recorded at each sampling site.

Analytical Methods:

Data from NMFS statistical zones 2, 8, 9 and 10 were excluded from statistical analyses because no Hogfish were collected within these zones (Figure 1). Further, all samples from waters deeper than 40 m were excluded from statistical analyses because Hogfish were not collected at these depths. 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 was included as a covariate. Due to the loss of the CTD during the 2008 survey, water quality data are virtually absent for 2008; accordingly, temperature, salinity, and dissolved oxygen were not 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; year remained in the model regardless of significance so that annual estimates could be exported. 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 309 trawl samples have been collected within established zones and depths in association with the summer FWRI SEAMAP trawl survey from 2008 – 2012. Annual sampling effort varied somewhat from year to year due to funding, weather and mechanical issues. Annual frequency of occurrence of Hogfish has varied from 16% to 32%, and mean nominal number of Hogfish collected per site has varied from 0.86 (± 0.275) to 1.45 (± 0.373). Hogfish lengths ranged from 64 – 467 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, likely due to pulses of strong year classes passing through the survey.

Year, depth, and zone were retained for the final generalized linear model (Table 2). For the final model, the ratio of Pearson Chi-Square to degrees of freedom was approximately 1 (1.06). Abundance indices were constructed for 2008 – 2012 (Figure 4; Table 3); Hogfish relative abundance was high in 2008 and 2012 and lower during the intervening years. Overall, coefficients of variation were low with the exception of 2008 (0.89).

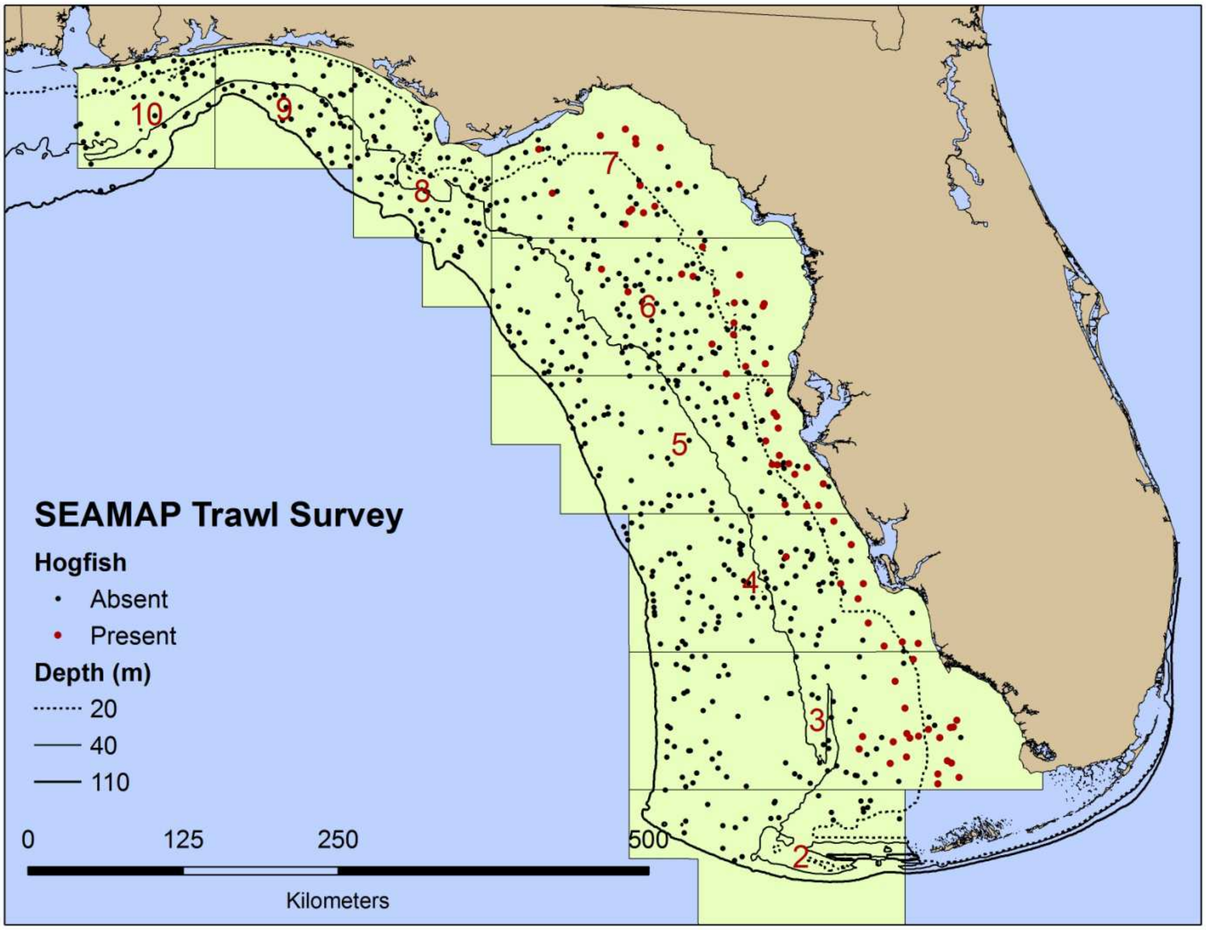

Figure 1. Locations of all stations sampled during the annual summer SEAMAP trawl survey conducted by FWRI along the West Florida Shelf (2008 – 2012). Black dots represent stations where Hogfish were absent, whereas red dots represent stations where Hogfish were present within 12.8-m trawl samples.

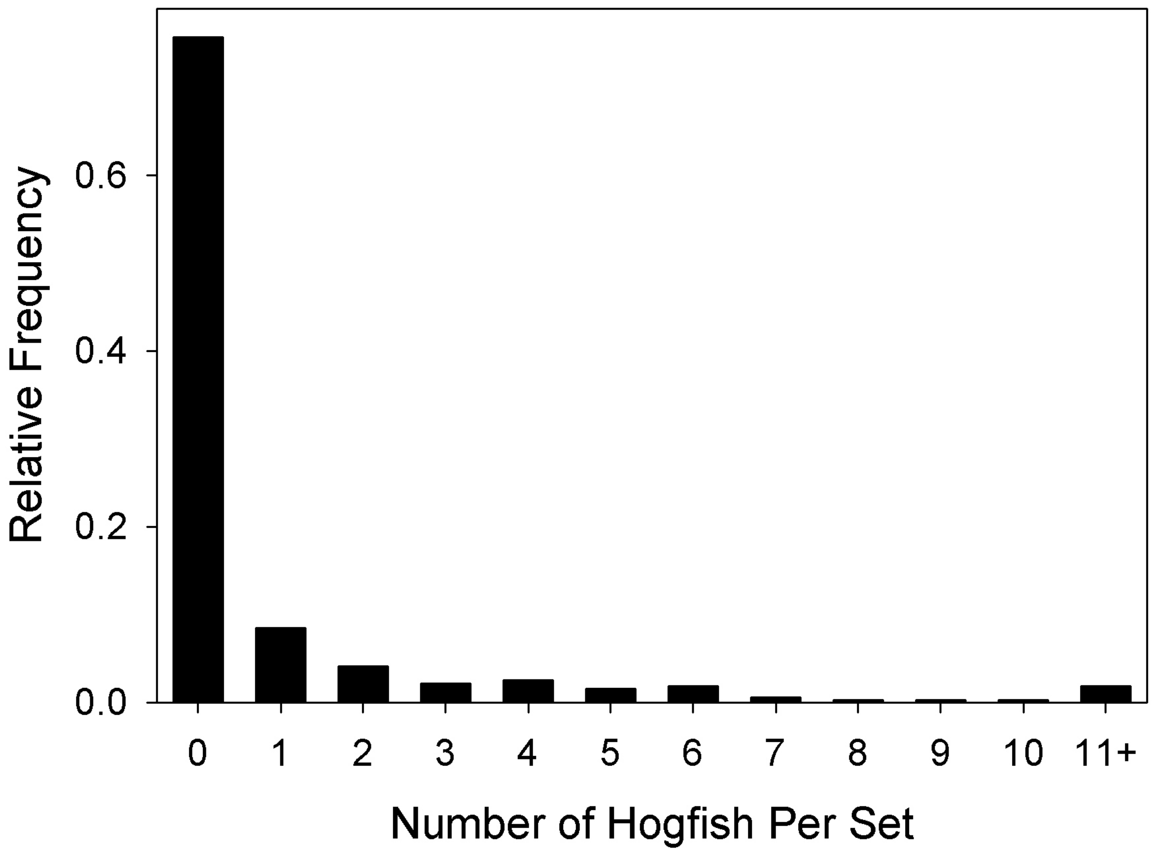

Figure 2. Frequency distribution of relative abundance (Individuals Per Set) values of Hogfish collected within the summer FWRI SEAMAP trawl survey. Values were calculated using censored data sets (see Analytical Methods section).

Table 1. Annual sample sizes, frequency of occurrence, and mean nominal number of individuals per set (± SE) for Hogfish collected in the summer FWRI SEAMAP 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
2008	13	30.8	1.00 ± 0.566
2009	71	22.5	0.86 ± 0.275
2010	71	26.8	1.07 ± 0.450
2011	68	16.2	1.24 ± 0.859
2012	86	31.4	1.45 ± 0.373

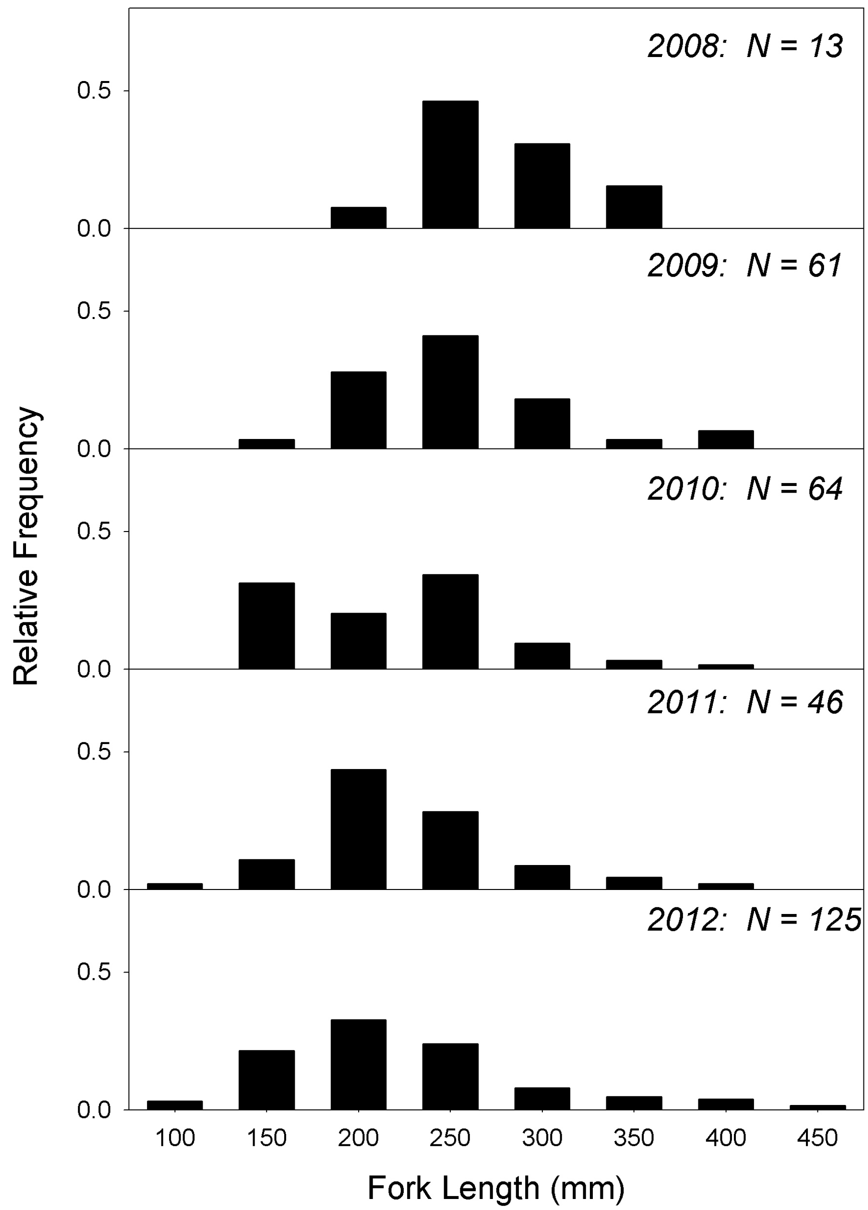

Figure 3. Annual length frequency distributions of Hogfish collected in the summer FWRI SEAMAP trawl survey. This summary only includes individuals from the censored data set (see Analytical Methods section).

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 summer FWRI SEAMAP trawl survey. Analyses were calculated using censored data set (see Analytical Methods section).

Effect	Numerator DF	Denominator DF	F Value	Pr > F
Year	4	299	1.45	0.2166
Zone	4	299	5.24	0.0004
Chlorophyll *a*	1	299	57.02	<0.0001

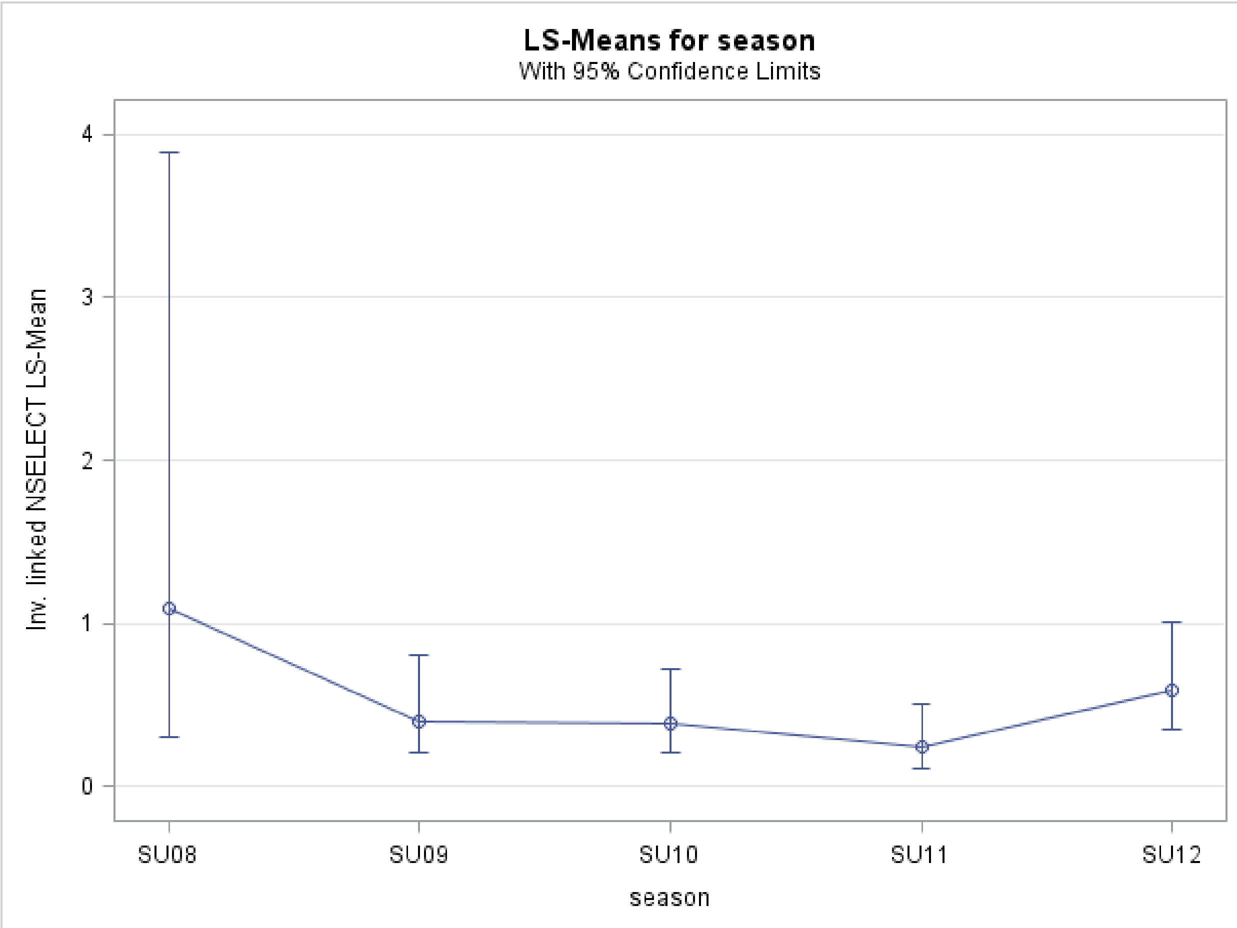

Figure 4. Annual estimates of relative abundance (Individuals Per Set) of Hogfish as determined via a generalized linear modeling analysis of data from the summer FWRI SEAMAP trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

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 summer FWRI SEAMAP trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

Year	Standardized Index	CV	LCL	UCL
2008	1.0888	0.8898	0.3047	3.8909
2009	0.4009	0.3689	0.2012	0.7985
2010	0.3861	0.3269	0.2071	0.7197
2011	0.2366	0.4044	0.1118	0.5006
2012	0.5875	0.2762	0.3448	1.0021