Fisheries-independent data for juvenile Hogfish (*Lachnolaimus maximus*) from polyhaline seagrasses of the Florida Big Bend, 2008-2012.

Theodore S. Switzer[1], Sean F. Keenan[1], Robert H. McMichael, Jr.[1], and Keith M. Fischer[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 a survey of polyhaline seagrass habitats designed to supplement ongoing long-term monitoring efforts conducted in several estuarine systems along the West Florida Shelf by FWRI.

Survey Design and Sampling Methods:

The FWRI polyhaline seagrass survey was implemented in 2008 within five estuarine systems along the West Florida Shelf (St. Andrew Bay, Apalachicola Bay, the Big Bend, Tampa Bay, and Charlotte Harbor) and involved sampling with both a 183-m haul seine and a 6.1-m otter trawl. Hogfish were rarely collected in St. Andrew Bay, Apalachicola Bay, Tampa Bay, and Charlotte Harbor, so results are only presented for the Big Bend, within which only the otter trawl survey was conducted. The Big Bend sampling frame was constructed using the most up-to-date bathymetry and seagrass coverage data available. To ensure sampling effort was allocated spatially, three sampling zones within the Big Bend were identified; these sampling zones were centered near where the St. Mark's, Econfina, and Steinhatchee rivers empty into the Gulf of Mexico (Figure 1). Each of these zones was subdivided into a series of 0.1 nm^2 x 0.1 nm^2 sampling units; those sampling units that were between 1.0 and 7.6 m water depth and contained seagrass habitat were included in the sampling universe. Sampling occurred monthly from May through November (seagrass habitat is difficult to find between December and April due to winter dieback), and each month a set of ten randomly-selected sites were sampled within each of the three sampling zones.

Each randomly-selected site was sampled using a 6.1-m otter trawl (6.1-m wide with 38-mm stretched nylon-mesh netting and a 3.2-mm knotless nylon Delta mesh cod-end liner). Samples were only collected at sites that contained a minimum of 50% SAV coverage as estimated visually; sampling locations were randomly spiraled to another nearby location when 50% SAV coverage was not present or could not be confirmed. The trawl was deployed by boat and towed at a speed of 1.2 kt for five minutes unless excess bycatch (generally drift algae) clogged the net and prevented the net from fishing effectively at the time of sampling, in which case tow duration was subsequently reduced to three or two minutes. Temperature (° C), salinity (psu), and dissolved oxygen (mg L^{-1}) were recorded at the surface, at 1.0-m depth intervals, and near the bottom (~ 0.2 m above the bottom); these values were averaged for each sample. Water depth (m) was recorded at the point where the trawl was first placed in the water. All Hogfish collected in each sample were identified, enumerated, and measured to the nearest mm standard length (SL). Location, date, and time were recorded at each sampling site.

Analytical Methods:

Hogfish were rarely collected in May or November; accordingly, data from these months 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. Further, annual length frequency distributions were 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, month, and zone were included as categorical explanatory variables in the model, while depth, dissolved oxygen, distance towed, temperature, bycatch quantity, and salinity were included as a covariate. 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 748 trawl samples have been collected between the months of June and October in association with the FWRI polyhaline seagrass trawl survey from 2008 – 2012. Annual frequency of occurrence has varied from 13.3% to 43.0%, and mean nominal number of Hogfish collected per site has varied from 0.19 (± 0.048) to 1.16 (± 0.154). Hogfish lengths ranged from 15 – 160 mm SL (Figure 3), indicating that collected individuals were most likely young of the year (Collins and McBride 2011); length frequency distribution did vary among years.

All categorical explanatory variables (zone, year, and month) were retained for the final generalized linear model, as was the salinity covariate (depth, dissolved oxygen, distance towed, temperature, and bycatch quantity were not retained; Table 2). For the final model, the ratio of Pearson Chi-Square to degrees of freedom was approximately 1 (1.29). Combined abundance indices were constructed for 2008 – 2012 (Figure 4; Table 3); juvenile Hogfish recruitment was high in 2008 and 2012, but substantially lower during the intervening years. Overall, coefficients of variation appear to be satisfactorily low (all less than ~ 0.25).

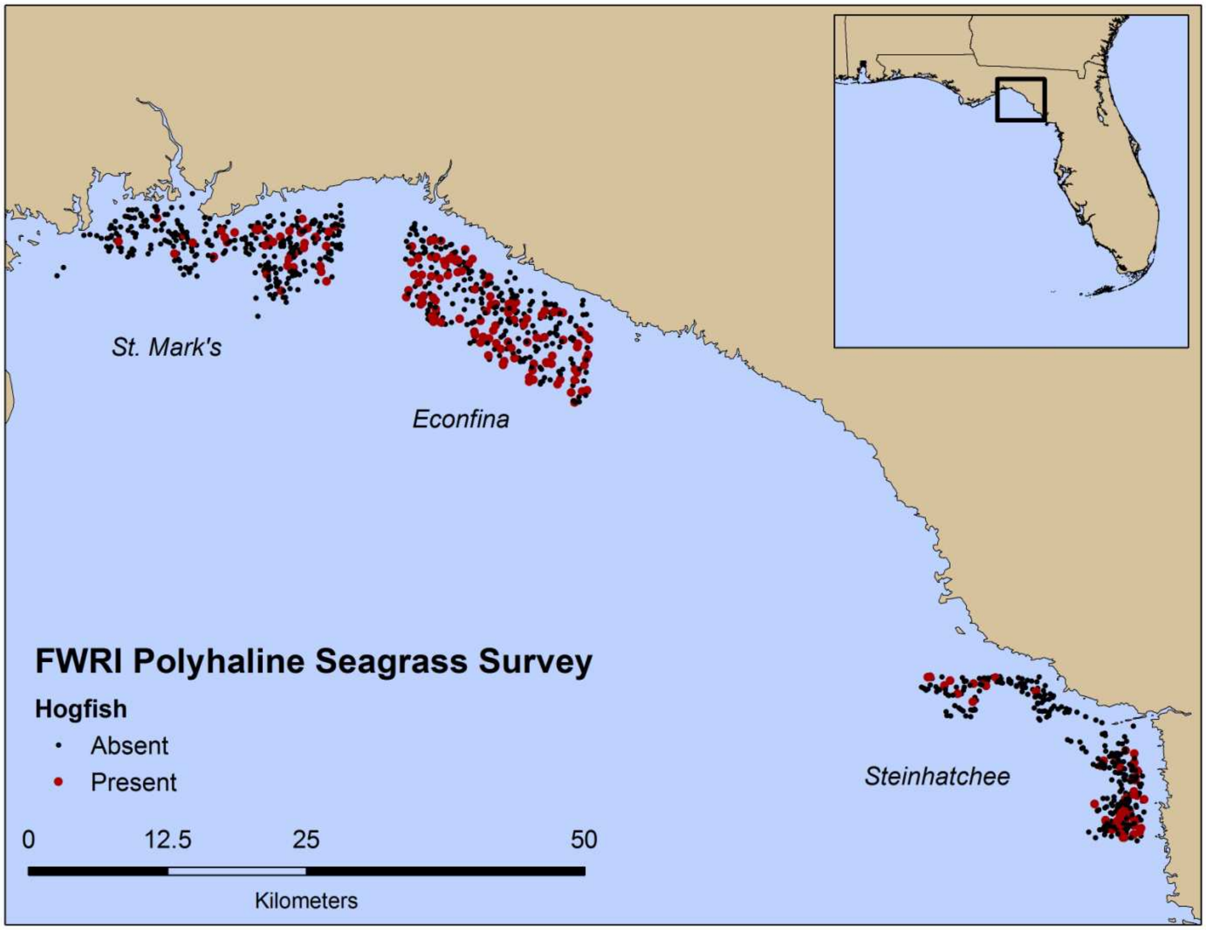

Figure 1. Locations of all stations sampled during monthly (May – November) polyhaline seagrass surveys conducted by FWRI in the Big Bend (2008 – 2012). Black dots represent stations where Hogfish were absent, whereas red dots represent stations where Hogfish were present within 6.1-m trawl samples.

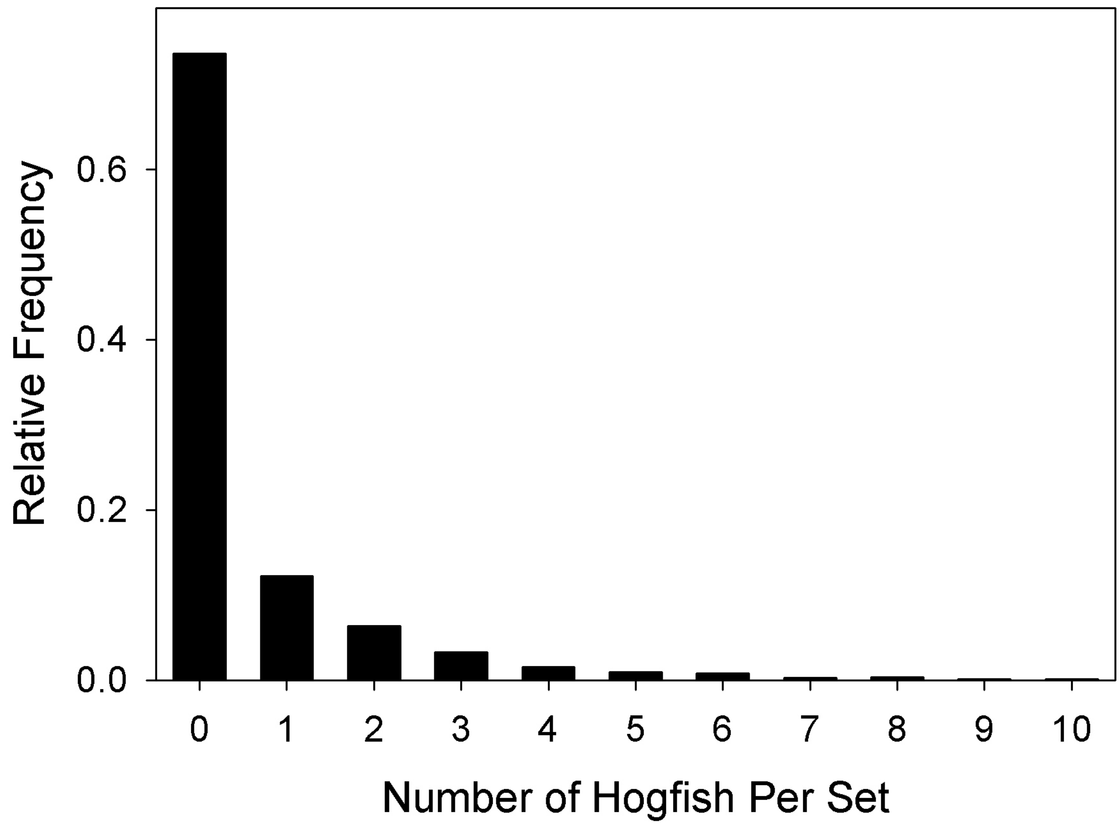

Figure 2. Frequency distribution of relative abundance (Individuals Per Set) values of Hogfish collected within the FWRI polyhaline seagrass trawl survey. Values were calculated using censored data sets (see Analytical Methods section).

Table 1. Annual sample sizes, frequency of occurrence, and mean nominal number of individuals per set (± SE) for Hogfish collected in the FWRI polyhaline seagrass 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	148	38.5	0.88 ± 0.130
2009	150	13.3	0.19 ± 0.048
2010	150	14.0	0.22 ± 0.050
2011	150	24.0	0.49 ± 0.094
2012	150	42.0	1.16 ± 0.154

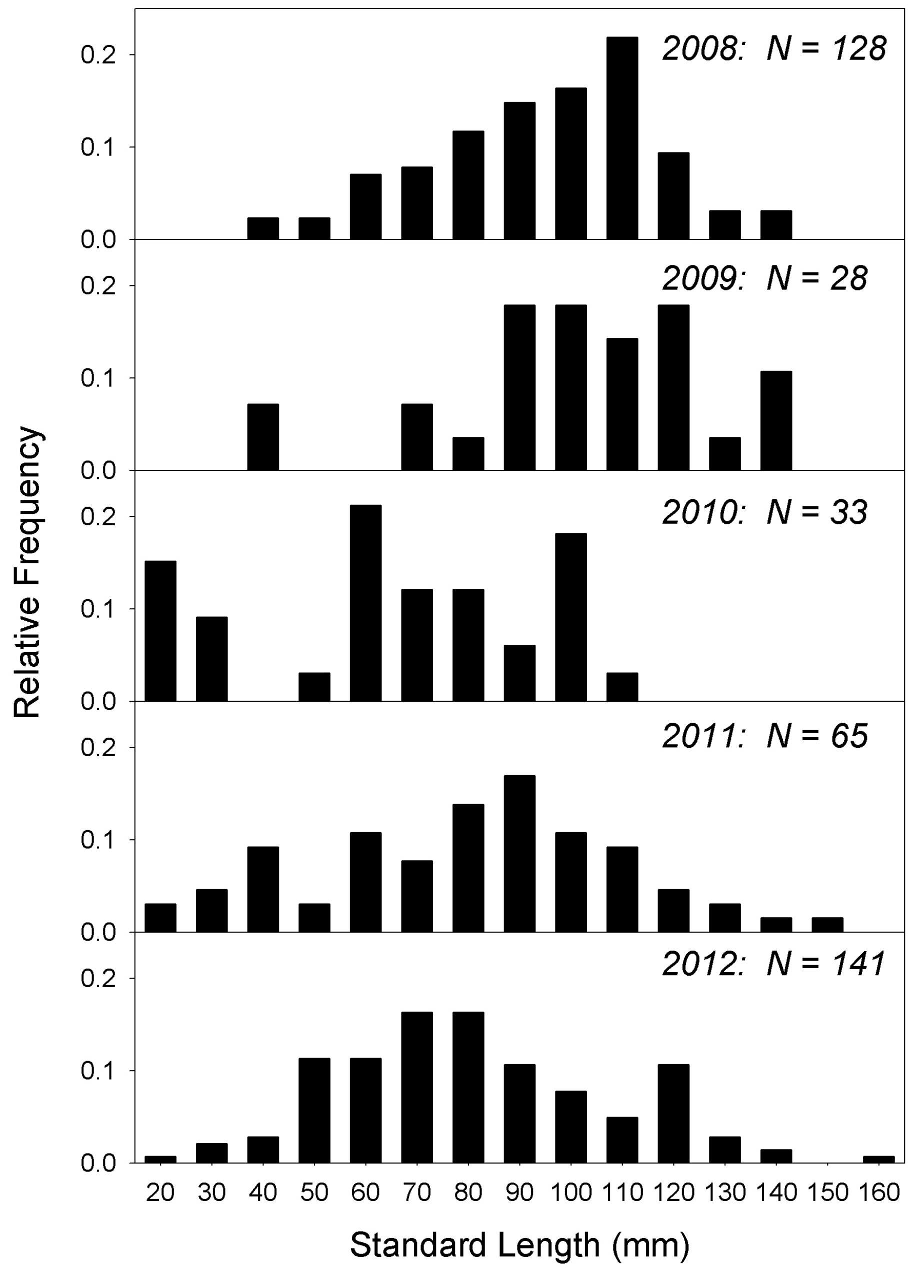

Figure 3. Annual length frequency distribution of Hogfish collected in the FWRI polyhaline seagrass trawl survey. This summary only includes individuals from the censored data set (see Analytical Methods section).

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

Effect	Numerator DF	Denominator DF	F Value	Pr > F
Zone	2	736	33.37	< 0.0001
Year	4	736	20.54	< 0.0001
Month	4	736	7.55	< 0.0001
Salinity	1	736	4.17	0.0414

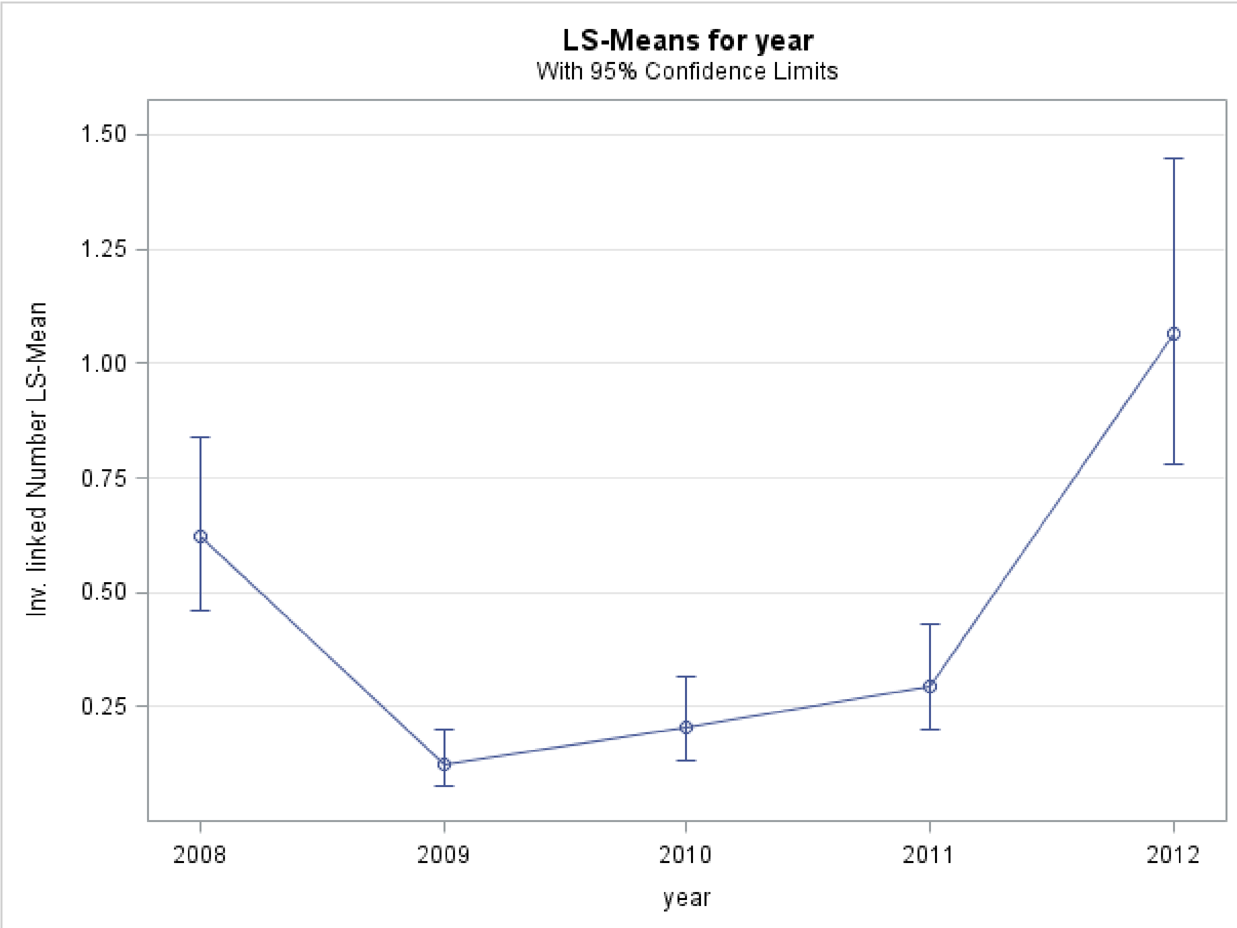

Figure 4. Annual estimates of relative abundance (Individuals Per Set) of Hogfish as determined via a generalized linear modeling analysis of data from the FWRI polyhaline seagrass trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

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 polyhaline seagrass trawl survey. Analyses were calculated using censored data sets (see Analytical Methods section).

Year	Standardized Index	CV	LCL	UCL
2008	0.6218	0.1553	0.4605	0.8397
2009	0.1235	0.2507	0.0767	0.1990
2010	0.2047	0.2260	0.1320	0.3174
2011	0.2960	0.1943	0.2029	0.4319
2012	1.0638	0.1617	0.7812	1.4487