# Young of Year Hogfish Index of Abundance from Seagrass Trawl Surveys of the Florida Big Bend

Brian Klimek and Theodore Switzer

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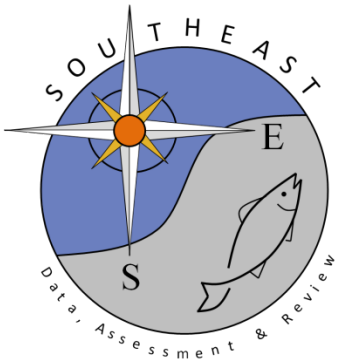

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# Young of Year Hogfish Index of Abundance from Seagrass Trawl Surveys of the Florida Big Bend

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## Abstract

An index of abundance for young of year Hogfish (*Lachnolaimus maximus*) in Big Bend, Florida was generated using catch data from the Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring program's polyhaline seagrass survey. A zero-inflated Poisson model incorporating year, month, zone, bycatch, temperature, depth, salinity and pH was used to model the young of year Hogfish catch data. Annual estimates of young of year Hogfish were relatively low most years, but several strong year classes were also apparent with the most recent being in 2021.

## Introduction

Hogfish (*Lachnolaimus maximus*) are a large, economically important member of the Labridae family that inhabit the Western Atlantic from Brazil to the Carolinas. Hogfish are haremic protogynous hermaphrodites that typically recruit to nearshore habitats, such as seagrass beds, before shifting to offshore live and hard-bottom habitats. The species supports both a recreational and commercial fishery within the United States. The majority of landings for both fisheries come from South Florida. Currently Hogfish are assessed as three separate stocks, Western Florida (WFL), Florida Keys and Eastern Florida (FLK/EFL) and Georgia to North Carolina (GA-NC) with the FLK/EFL stock considered to be overfished and experiencing overfishing (SEDAR 37 2013).

The Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring (FIM) program began in 1989 with seasonal stratified random sampling (SRS) in Tampa Bay. In 1996, sampling switched from seasonal to monthly, and long-term data sets have been established for seven estuaries throughout Florida (Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Northeast Florida, Northern Indian River Lagoon and Southern Indian River Lagoon). Beginning in 2008, FIM added a polyhaline seagrass survey (WI) in five estuaries (St. Andrew Bay, Apalachicola Bay, Big Bend, Tampa Bay and Charlotte Harbor) along the West Florida Shelf. This survey specifically samples seagrass beds (sites must have a minimum of 50% seagrass coverage). Unlike monthly SRS, the WI survey samples only part of the year, due to the expected dieback of seagrass during winter months. The estuaries in both survey designs are comprised of zones (geographically and/or hydrologically distinct areas) which are further subdivided into $0.1nm^2$ x $0.1nm^2$ sampling units. Pending gear requirements (depth limitations, presence of shorelines), sites are randomly selected from these sampling units.

A total of 1,819 Hogfish were caught across all estuaries, sampling gears and surveys. However, catches were low to non-existent in most estuaries (Table 1). Catches in Southern Indian River Lagoon were consistently low from 1997 to 2014 but have been near zero for much of the past

decade. The only estuary with suitable catches over its time series for index construction was Big Bend via the WI survey (Table 1). The Big Bend encompasses an area on Florida's Gulf Coast from the eastern panhandle to the northern half of peninsular Florida. The estuary as sampled by FIM is made up of four discontinuous zones; St. Mark's (A), Econfina (B), Keaton Beach (C), and Steinhatchee (D) (Figure 1). Sampling in Big Bend was conducted using a 6.1 m wide otter trawl with 38 mm stretched nylon mesh netting and a 3.2 mm knotless nylon Delta mesh cod-end liner. Prior to trawling, trawl paths were evaluated for depth (must be between 1.0 and 7.6 m) and seagrass coverage (minimum 50% of trawl path). If the randomly selected site did not meet both of these requirements, the site was randomly spiraled to a nearby location that did. Trawls were deployed by boat and towed at 1.2 kt for five minutes. In circumstances where the cod-end became completely inundated with bycatch, trawl times were shortened to three or even two minutes to ensure the trawl fished as intended. The effort of the set was calculated based on tow distance and the size of the net and recorded in 100s $m^2$. Bycatch of the trawl was recorded in gallons. Depth was recorded at the start point of the trawl to the nearest 0.1 m and temperature (°C), salinity (psu), pH and dissolved oxygen (mg $L^{-1}$) were recorded at the surface, bottom and all 1 m depth intervals and averaged to a mean value. All finfish and select invertebrates captured in the trawl were identified to the lowest taxonomic level and enumerated with up to 40 individuals measured for standard length to the nearest mm.

**Data and Index Construction**

Data from the Big Bend survey is available from its inception in 2008 to the most recent fully sampled year of 2024 (Table 2). Some aspects of the survey have changed over time leading to the exclusion of some data prior to analysis. Sampling in the month of May was discontinued in 2015 and was thus removed from the dataset. Additionally, zones A and C were also removed due to sampling in those zones being discontinued in 2019 and 2009 respectively. Ten sites each were sampled monthly in zones B and D from 2008 to 2018. From 2019 to present, fifteen sites were sampled monthly in Zones B and D except for 2020 when sampling was reduced by half due to the Covid 19 pandemic. Hogfish caught in Big Bend ranged from 14 mm SL to 213 mm SL (mean 77 mm SL) with all but the largest individual being <168 mm SL (Figure 2). Based on a von Bertalanffy growth function in McBride and Richardson (2007), an age-1 Hogfish for this stock would be ~146 mm SL, meaning most Hogfish captured were young of year (YOY). Monthly length frequencies show a gradual increase in size throughout the year (Figure 3) further indicating that nearly all Hogfish sampled in Big Bend are YOY. Annual length frequencies did not indicate any differences in the size of fish caught through time (Figure 4). However, sure to extremely low catches (<30 fish) data from November were also excluded from analyses.

Generalized linear models were used to construct an index of abundance (IOA) for YOY Hogfish in Big Bend. Factor variables considered for IOA construction were year, month and zone. Seven covariates; depth, salinity, temperature, pH, bycatch, dissolved oxygen and effort were also included in the model with each being log transformed and normalized to 1. Total number of Hogfish captured per haul was used as the dependent variable. Due to the nonnormality and high numbers of zero catches in this dataset, Poisson, negative binomial and their zero inflated

counterparts were assessed for IOA construction. For each type of model, stepwise selection was conducted to determine the variables and covariates included in a best fit model. All four best fit models were then compared, with the one with the lowest Akaike information criterion (AIC) value selected for the actual IOA. Least squares means (±SE) were calculated for each year along with annual coefficients of variation (CV). These annual CVs were determined by multiplying the standard error of the model by deviates derived from a standard normal distribution (n=10,000) and adding these values to the calculated least squares mean. This new sampling distribution was then used to calculate the standard deviations from which the annual CVs could be derived. The IOA was conducted in SAS statistical software (SAS Institute 2013).

**Results and Discussion**

A total of 1,923 hauls and 1,063 Hogfish were included in the initial IOA construction (Table 3). Following the stepwise selection process for each model type, the zero-inflated Poisson model had the lowest AIC value. Month, zone, bycatch and pH were retained in the logistic component of the model (Table 4). Year, zone, month, temperature, salinity, pH and effort were returned in the Poisson component (Table 4). Least squares means indicated that recruitment of YOY Hogfish to Big Bend was relatively low with occasional strong year classes (Figure 5). The years of 2008, 2012, 2018 and 2021 showed high recruitment while 2013 and 2014 were notable due to the extremely low levels of recruitment. Based on these results, several factors may influence recruitment of YOY Hogfish to Big Bend. Gulf-wide factors such as upwelling may influence larval transport into Big Bend, potentially producing the observed strong year classes. Local factors such as river discharge (significance of pH and salinity in Poisson component) or algal blooms (significance of bycatch in logistic component) may have a smaller but more consistent indirect (loss of seagrass habitat) and direct (impact on trawl) influences on catches. The availability and quality of seagrass habitat is likely an important factor that cannot be properly assessed with our FIM datasets. All calculated annual CVs were <0.4 except for 2014, when only three total Hogfish were caught for the year (Table 5).

**Literature Cited**

McBride, R. S., & Richardson, A. K. (2007). Evidence of size-selective fishing mortality from an age and growth study of hogfish (Labridae: *Lachnolaimus maximus*), a hermaphroditic reef fish. *Bulletin of Marine Science*, *80*(2), 401-417.

SAS Institute Inc 2013. SAS/ACCESS® 9.4 Interface to ADABAS: Reference. Cary, NC: SAS Institute Inc.

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Table 1. Hogfish catches by sampling estuary and year for all of FIM's sampling gears and both surveys (SRS and WI) combined.

| Year | Apalachicola | Big Bend | Charlotte Harbor | Cedar Key | Northern Indian River Lagoon | Northeast Florida | Tampa Bay | St. Andrew Bay | Southern Indian River Lagoon | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1996 | . | . | 0 | 0 | 0 | . | 0 | . | . | 0 |
| 1997 | . | . | 0 | 0 | 0 | . | 0 | . | 50 | 50 |
| 1998 | 0 | . | 0 | 0 | 0 | . | 0 | . | 7 | 7 |
| 1999 | 0 | . | 0 | 3 | 0 | . | 0 | . | 37 | 40 |
| 2000 | 0 | . | 0 | 0 | 1 | . | 1 | . | 16 | 18 |
| 2001 | 0 | . | 0 | 0 | 0 | 0 | 0 | . | 14 | 14 |
| 2002 | 0 | . | 0 | 0 | 0 | 0 | 0 | . | 30 | 30 |
| 2003 | 0 | . | 0 | 0 | 0 | 0 | 1 | . | 5 | 6 |
| 2004 | 0 | . | 2 | 6 | 0 | 0 | 1 | . | 36 | 45 |
| 2005 | 0 | . | 1 | 0 | 0 | 0 | 0 | . | 0 | 1 |
| 2006 | 0 | . | 0 | 2 | 1 | 0 | 4 | . | 12 | 19 |
| 2007 | 0 | . | 0 | 0 | 0 | 0 | 0 | . | 25 | 25 |
| 2008 | 4 | 166 | 8 | 1 | 5 | 0 | 7 | 0 | 18 | 209 |
| 2009 | 1 | 28 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 31 |
| 2010 | 2 | 34 | 0 | 0 | 0 | 0 | 1 | 0 | 12 | 49 |
| 2011 | 1 | 77 | 0 | 0 | 0 | 0 | 2 | 0 | 10 | 90 |
| 2012 | 0 | 182 | 5 | 0 | 0 | 0 | 0 | 0 | 50 | 237 |
| 2013 | 0 | 18 | 0 | 0 | 0 | 0 | 2 | 0 | 35 | 55 |
| 2014 | 0 | 3 | 3 | 0 | 0 | 0 | 7 | 0 | 25 | 38 |
| 2015 | 16 | 22 | 0 | 0 | 1 | 0 | 2 | 0 | 6 | 47 |
| 2016 | 0 | 43 | 7 | 0 | 0 | 0 | 3 | 0 | 0 | 53 |
| 2017 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 55 |
| 2018 | 0 | 151 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 161 |
| 2019 | 0 | 30 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 33 |
| 2020 | 0 | 35 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 38 |
| 2021 | 1 | 318 | 10 | 0 | 1 | 0 | 2 | 0 | 0 | 332 |
| 2022 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 22 |
| 2023 | 1 | 85 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 87 |
| 2024 | 0 | 17 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 27 |
| Total | 26 | 1280 | 39 | 19 | 9 | 0 | 51 | 2 | 393 | 1819 |

Table 2. Number of sets and YOY Hogfish caught by zone in Big Bend using the 6.1 m otter trawl from 2008 to 2024.

| | Zone A | | Zone B | | Zone C | | Zone D | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | n | number of fish | n | number of fish | n | number of fish | n | number of fish | n | number of fish |
| 2008 | 70 | 14 | 70 | 75 | 68 | 36 | 68 | 41 | 276 | 166 |
| 2009 | 70 | 0 | 70 | 13 | . | . | 70 | 15 | 210 | 28 |
| 2010 | 70 | 7 | 70 | 14 | . | . | 70 | 13 | 210 | 34 |
| 2011 | 70 | 14 | 70 | 60 | . | . | 70 | 3 | 210 | 77 |
| 2012 | 70 | 28 | 70 | 119 | . | . | 70 | 35 | 210 | 182 |
| 2013 | 70 | 9 | 70 | 9 | . | . | 70 | 0 | 210 | 18 |
| 2014 | 70 | 1 | 70 | 0 | . | . | 70 | 2 | 210 | 3 |
| 2015 | 70 | 12 | 70 | 9 | . | . | 70 | 1 | 210 | 22 |
| 2016 | 60 | 7 | 60 | 36 | . | . | 60 | 0 | 180 | 43 |
| 2017 | 60 | 18 | 60 | 24 | . | . | 60 | 8 | 180 | 50 |
| 2018 | 60 | 43 | 60 | 76 | . | . | 60 | 32 | 180 | 151 |
| 2019 | . | . | 90 | 28 | . | . | 90 | 2 | 180 | 30 |
| 2020 | . | . | 45 | 17 | . | . | 45 | 18 | 90 | 35 |
| 2021 | . | . | 90 | 263 | . | . | 90 | 55 | 180 | 318 |
| 2022 | . | . | 90 | 17 | . | . | 90 | 4 | 180 | 21 |
| 2023 | . | . | 90 | 66 | . | . | 90 | 19 | 180 | 85 |
| 2024 | | | 90 | 12 | | | 90 | 5 | 180 | 17 |
| Total | 740 | 153 | 1145 | 826 | 68 | 36 | 1143 | 248 | 3096 | 1263 |

Table 3. Frequency of occurrence and mean number of YOY Hogfish caught by year in the 6.1 m otter trawl in Big Bend from 2008 to 2024. Only months June-October and zones B and D included as outlined for initial IOA construction.

| Year | Number of samples | Number of fish | % Frequency of occurrence | Mean fish per haul | Standard error |
|---|---|---|---|---|---|
| 2008 | 98 | 116 | 27.90 | 1.18 | 0.18 |
| 2009 | 100 | 28 | 9.52 | 0.28 | 0.07 |
| 2010 | 100 | 26 | 10.48 | 0.26 | 0.06 |
| 2011 | 100 | 60 | 18.10 | 0.60 | 0.13 |
| 2012 | 100 | 148 | 32.38 | 1.48 | 0.21 |
| 2013 | 100 | 9 | 5.71 | 0.09 | 0.05 |
| 2014 | 100 | 2 | 1.43 | 0.02 | 0.01 |
| 2015 | 100 | 10 | 6.67 | 0.10 | 0.04 |
| 2016 | 100 | 26 | 15.00 | 0.26 | 0.07 |
| 2017 | 100 | 32 | 17.22 | 0.32 | 0.07 |
| 2018 | 100 | 108 | 31.11 | 1.08 | 0.19 |
| 2019 | 150 | 30 | 11.67 | 0.20 | 0.05 |
| 2020 | 75 | 33 | 21.11 | 0.44 | 0.12 |
| 2021 | 150 | 314 | 47.22 | 2.09 | 0.25 |
| 2022 | 150 | 20 | 7.22 | 0.13 | 0.04 |
| 2023 | 150 | 85 | 23.89 | 0.57 | 0.10 |
| 2024 | 150 | 16 | 7.33 | 0.11 | 0.04 |
| Total | 1923 | 1063 | 22.78 | 0.55 | 0.03 |

Table 4. Type III tests of fixed effects for final zero-inflated Poisson model for YOY Hogfish relative abundance in Big Bend.

| Effect | DF | Chi-Square | Probability > Chi-Square |
|---|---|---|---|
| Zone (Poisson) | 1 | 72.66 | <.0001 |
| Year (Poisson) | 16 | 367.64 | <.0001 |
| Month (Poisson) | 4 | 34.51 | <.0001 |
| Log temperature+1 (Poisson) | 1 | 6.78 | <0.009 |
| Log salinity+1 (Poisson) | 1 | 24.16 | <0.001 |
| Log pH +1 (Poisson) | 1 | 23.04 | <0.001 |
| Log Effort +1 (Poisson) | 1 | 30.49 | <0.001 |
| Month (logistic) | 4 | 34.81 | <0.001 |
| Log bycatch+1 (logistic) | 1 | 54.49 | <0.001 |
| Log ph+1 (logistic) | 1 | 1.92 | 0.165 |
| Zone (logistic) | 1 | 1.57 | 0.210 |

Table 5. Estimates of annual relative abundance of YOY Hogfish for Big Bend based on the final zero-inflated Poisson model. Standard error (SE), coefficient of variation (CV) and lower (LCL) and upper (UCL) confidence limits (95%) also provided.

| Year | Mean | SE | CV | LCL | UCL |
|---|---|---|---|---|---|
| 2008 | 1.311 | 0.165 | 0.129 | 1.025 | 1.677 |
| 2009 | 0.589 | 0.146 | 0.245 | 0.362 | 0.957 |
| 2010 | 0.533 | 0.121 | 0.231 | 0.341 | 0.832 |
| 2011 | 0.785 | 0.128 | 0.166 | 0.571 | 1.081 |
| 2012 | 1.798 | 0.200 | 0.113 | 1.446 | 2.236 |
| 2013 | 0.162 | 0.058 | 0.386 | 0.080 | 0.329 |
| 2014 | 0.033 | 0.023 | 0.761 | 0.008 | 0.134 |
| 2015 | 0.206 | 0.070 | 0.368 | 0.106 | 0.402 |
| 2016 | 0.519 | 0.115 | 0.226 | 0.337 | 0.800 |
| 2017 | 0.599 | 0.124 | 0.204 | 0.399 | 0.900 |
| 2018 | 2.379 | 0.295 | 0.126 | 1.866 | 3.033 |
| 2019 | 0.451 | 0.095 | 0.204 | 0.298 | 0.682 |
| 2020 | 1.118 | 0.240 | 0.216 | 0.734 | 1.704 |
| 2021 | 3.167 | 0.245 | 0.081 | 2.721 | 3.685 |
| 2022 | 0.245 | 0.060 | 0.241 | 0.151 | 0.396 |
| 2023 | 0.899 | 0.121 | 0.141 | 0.691 | 1.169 |
| 2024 | 0.219 | 0.064 | 0.302 | 0.123 | 0.389 |

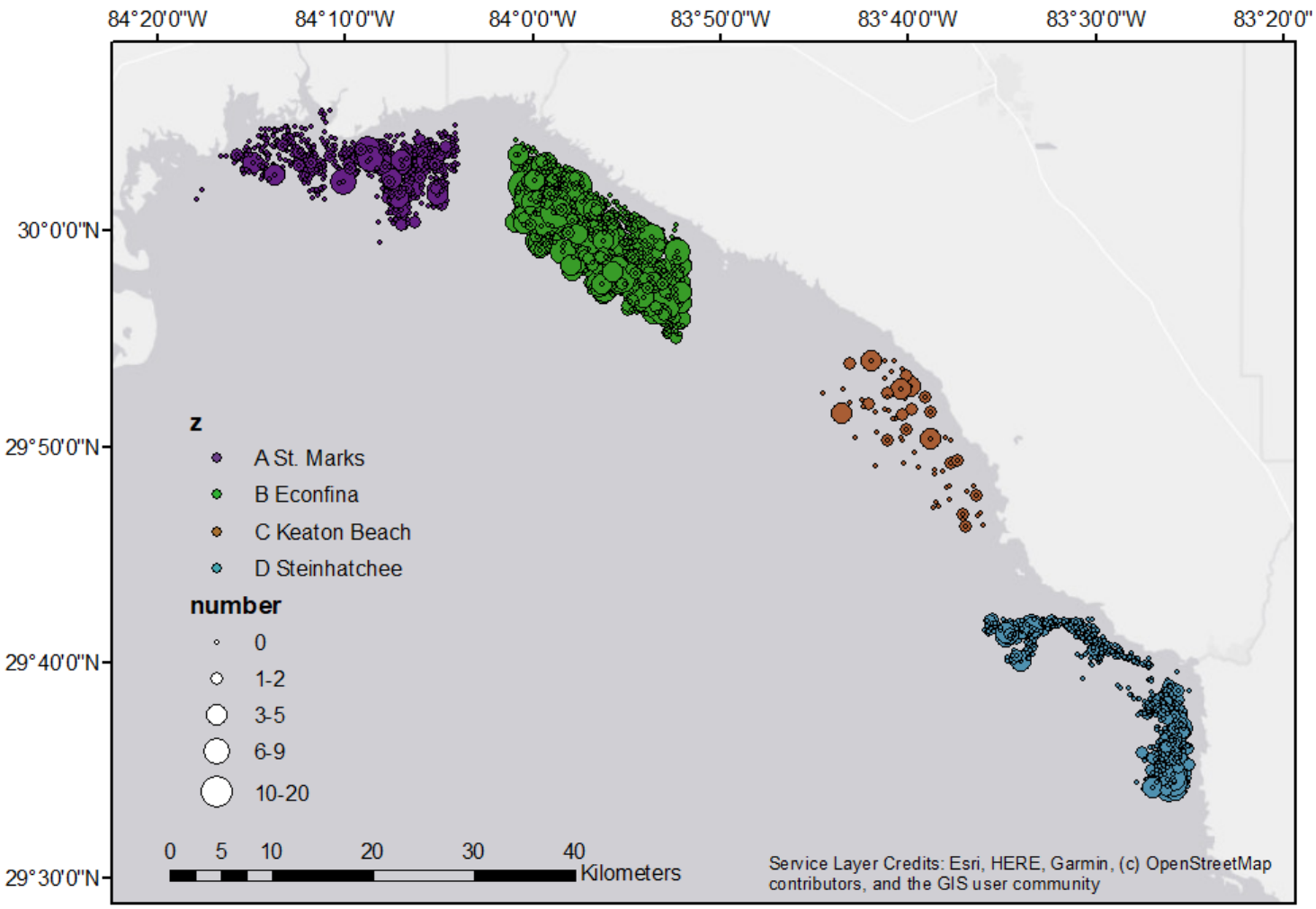


Figure 1. Sampling locations for FIM's polyhaline seagrass survey (WI) using the 6.1 m otter trawl in Big Bend from 2008 to 2024. Different colors represent the different zones while bubble size represents number of Hogfish caught at each site. Zone C Keaton Beach (orange) was only sampled in 2008. Zone A St Marks (purple) was sampled from 2008 to 2018.

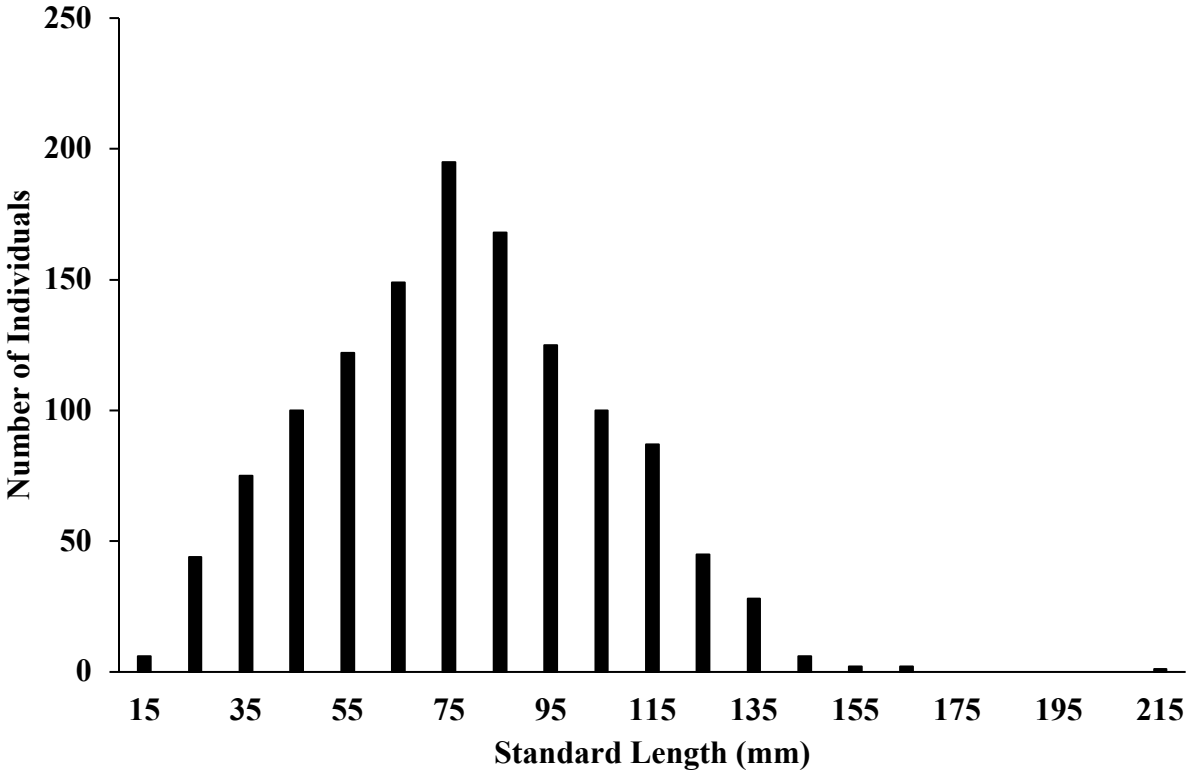


Figure 2. Length frequency of Hogfish captured by the 6.1 m otter trawl in Big Bend from 2008 to 2023. Only catches from zone B and D from June through November included.

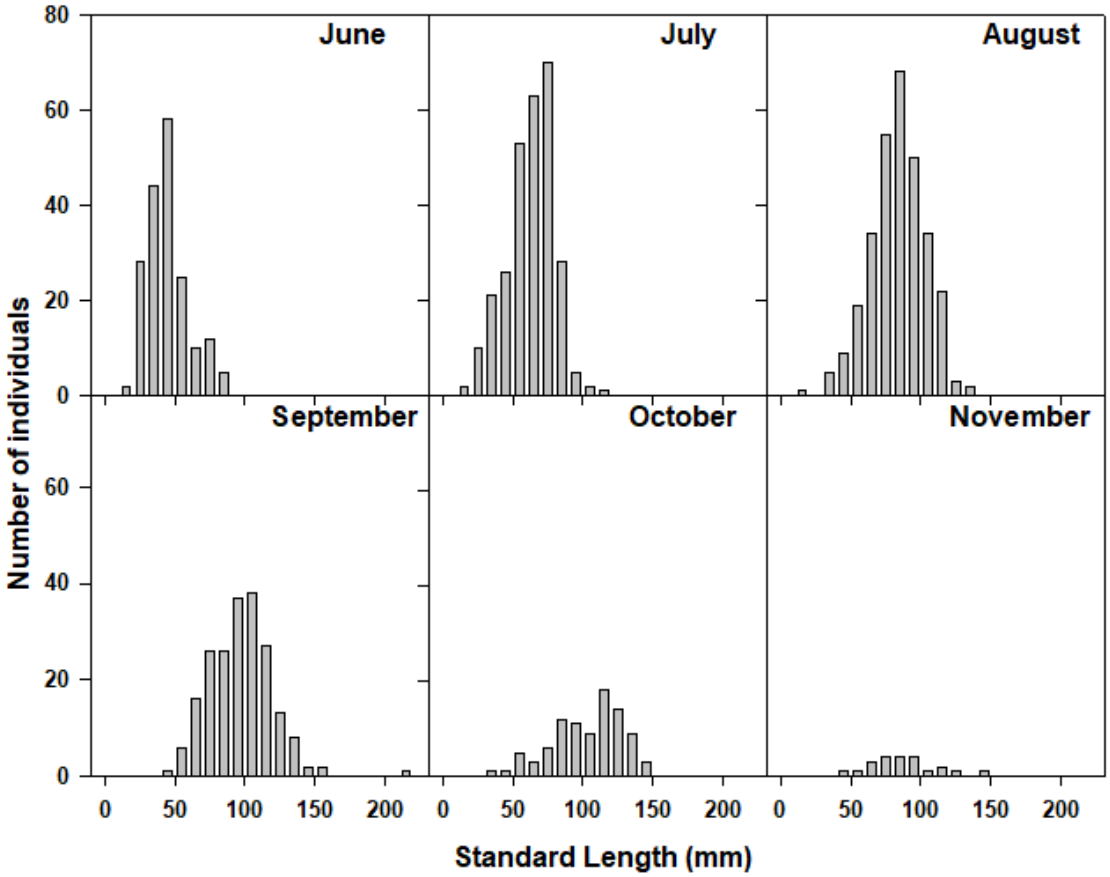


Figure 3. Monthly length frequencies for Hogfish caught in Big Bend for the 6.1 m otter trawl from 2008 to 2024. Size bins are in 10mm increments. Only catches from Zones B and D from June to November included. Due to low catches, November was excluded from analysis.

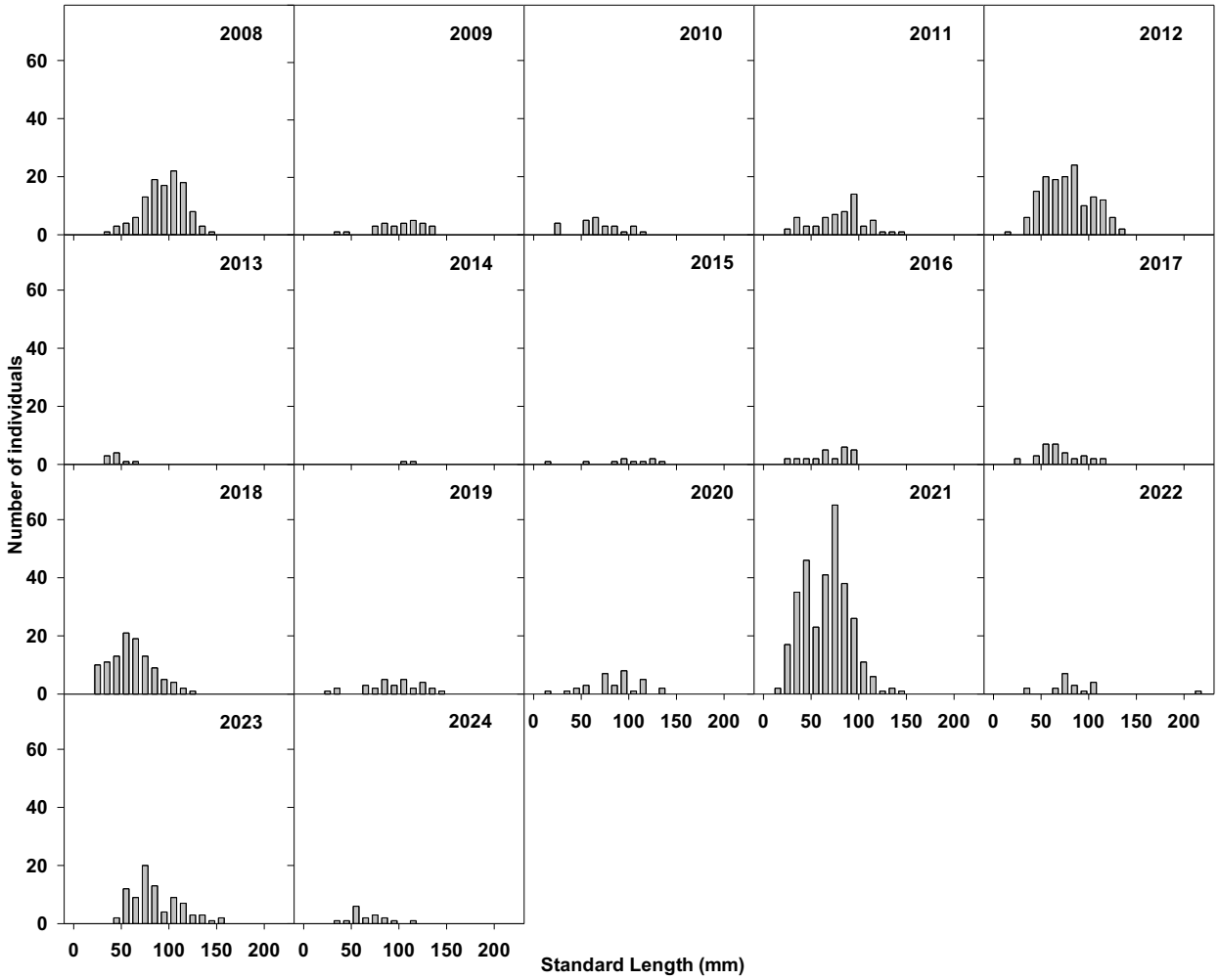


Figure 4. Annual length frequencies for Hogfish caught in Big Bend for the 6.1 m otter trawl from 2008 to 2024. Size bins are in 10mm increments. Only catches from Zones B and D from June to November included.

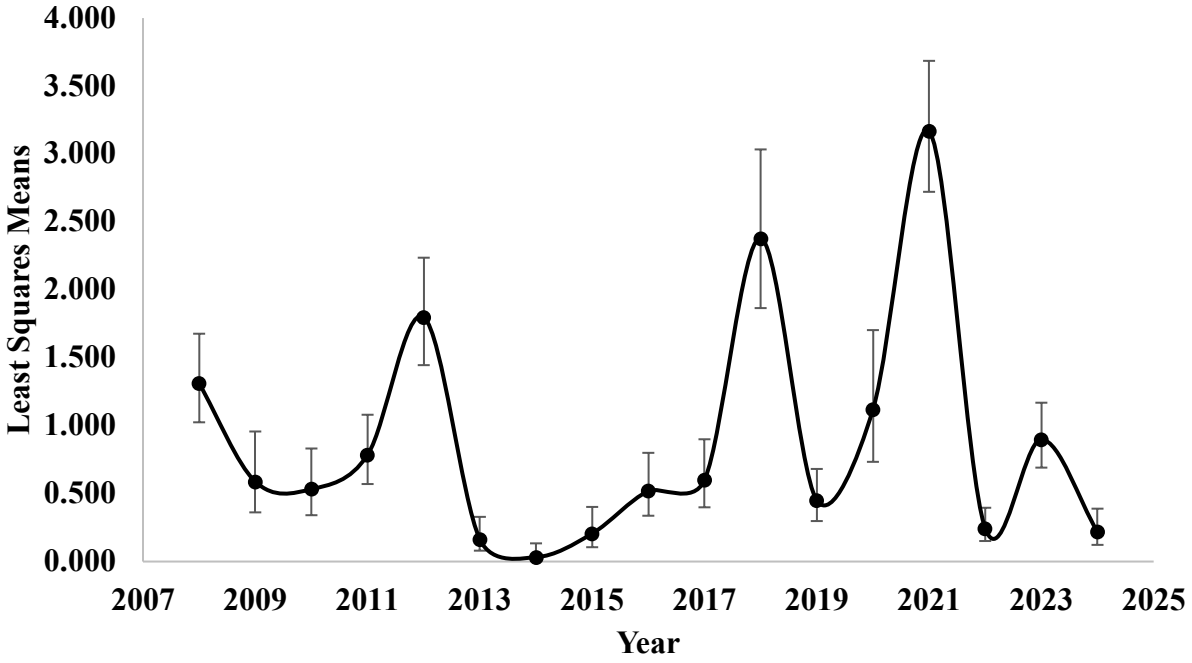


Figure 5. Annual estimates of YOY Hogfish relative abundance for Big Bend from 2008 to 2024. Least squares means with upper and lower confidence limits estimated using the final zero inflated-Poisson model.