

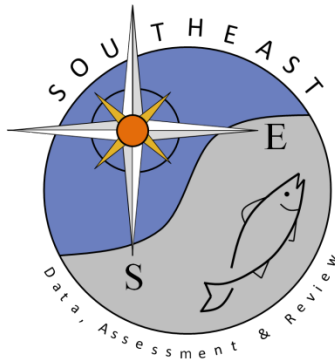
Hogfish Index of Abundance from the Annual FWRI-SEAMAP Trawl Survey along the West Florida Shelf

Brian Klimek and Theodore Switzer

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Abstract

An index of abundance for Hogfish (*Lachnolaimus maximus*) along the West Florida Shelf was generated using catch data from the Southeast Area Monitoring and Assessment Program/Florida Fish and Wildlife Research Institute's shrimp trawl survey. A negative binomial model incorporating year, statistical zone, depth and sponge bycatch was used to model Hogfish catch data. Annual estimates of Hogfish relative abundance were low from 2010 to 2017 before increasing from 2018 to present. The highest and most frequent catches of Hogfish were associated with high sponge bycatch indicating that live bottom habitats are preferred by this species.

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 harem protogynous hermaphrodites that typically recruit to nearshore habitats (seagrass beds, hard bottom habitats, etc.) before shifting to offshore live and hard-bottom habitats. The species supports both a recreational and commercial fishery within the United States however 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 Southeast Area Monitoring and Assessment Program (SEAMAP) was established in 1981 for conducting fishery independent surveys within the Gulf of America. The shrimp/groundfish trawl surveys began in 1982, mostly in the Western Gulf before extending to the West Florida Shelf (WFS; NMFS statistical zones 2-10) in 2008 (Figure 1). Sampling of the WFS was conducted by Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) in partnership with SEAMAP. Sampling within these zones was conducted using a stratified random survey design wherein each statistical zone was subdivided into two depth strata (10-36.6 m and 36.6 to 110 m). Sampling locations were randomly selected and allocated based on the proportion of area of each depth stratum and statistical zone. Sampling was conducted biannually during both the Summer and Fall. Initially only statistical zones 5-10 were sampled in 2008 with all the remaining statistical zones (2-4) being incorporated into survey design by 2011.

Each station was sampled with a 12.8 m shrimp trawl towed for 30 minutes at a speed of ~3 kt. Temperature (°C), salinity (psu) and dissolved oxygen (mg L⁻¹) were recorded at the bottom for each sampling station with depth being recorded to the nearest 0.1 m. All organisms were

identified to the lowest possible taxonomic level, enumerated and weighed as a whole. Up to 20 Hogfish were measured to the nearest mm standard length (SL) at each sampling location. For more information on SEAMAP trawl protocols please consult the SEAMAP Trawling operations manual (<https://seamapdata.gsmfc.org/trawl/03%20-%20SEAMAP%20Trawling%20Operations%20Manual%203-29-22.pdf>).

Data and Index Construction

A total of 2,055 Hogfish were caught via SEAMAP trawls from 1982 to 2024, all of which were caught along the WFS post-2007 (Table 1 and Figure 2). Examining just the WFS, no Hogfish were caught in statistical zones 8, 9 or 10 and they were rarely caught in zone 2 (20 total fish). Therefore, only statistical zones 3-7 were considered for further analysis. Since 2010 was the first year in which statistical zones 3-7 were all sampled, 2010 was chosen as the starting year for analysis. Due to the delineation of the WFL stock and FLK/EFL stock occurring within statistical zone 3 at 25° 9.00' N, all stations below this boundary were also dropped from analysis. All stations >40 m deep were also removed from analysis due to low Hogfish catches (Figure 3). Measured Hogfish (n=1,693) ranged from 47-760 mm SL with a mean size of 188 mm SL (Figure 4). Based on a von Bertalanffy growth function in McBride and Richardson (2007), the majority of Hogfish caught during SEAMAP are 0-6 years old. Annual length frequencies indicated no change in length distribution of Hogfish catches over time (Figure 5). No minimum or maximum size cutoff was selected. Both seasons were retained for initial IOA construction, however it must be noted that no Fall sampling was conducted in 2011 and no Summer sampling was conducted in 2020 (Table 2).

Generalized linear models were used to construct an index of abundance (IOA) for Hogfish along the WFS using the subset of data as outlined above. Factor variables considered for IOA construction were year, season and statistical zone. Four covariates (depth, salinity, temperature and total sponge bycatch [kg]) were also included in the model with each being log transformed and normalized to 1. Fish per haul was used as the dependent variable. Due to the nonnormality and high numbers of zero catches in this data set, Poisson, negative binomial and their zero inflated counterparts were assessed for IOA construction. For each model stepwise selection was conducted to determine the variables and covariates to be included in the final model. Of these stepwise models, the one with the lowest Akaike information criterion (AIC) value would be chosen for the IOA. Least squares means (\pm 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 1,472 hauls and 1,701 Hogfish were included in the initial IOA construction (Table 3). Following the stepwise selection process for each model type, the negative binomial model had the lowest AIC value. Statistical zone, year, depth and total sponge bycatch were retained in the

model (Table 4). Least squares means indicated that Hogfish abundance was low through 2018 but appeared to be increasing from 2019 to present (Figure 6). Five of the six highest abundance years occur post-2018 including the year with the highest estimated abundance (2023). Statistical zone 3 had the most catches of Hogfish as well as the highest frequency of occurrence for Hogfish. Sponge catches in statistical zone 3 were much higher than in any of the other zones assessed in this analysis (Figure 7) indicating the presence of sponge (live bottom) is an important habitat feature for Hogfish. However, statistical zone 4 had similar sponge catches to zones 5-7 yet still had much lower and less frequent catches of Hogfish. These low and infrequent catches persist throughout the time series suggesting that some factor outside of this analysis may be impacting catches in this statistical zone. All calculated annual CVs were <0.4 except for the years of 2011 and 2020 (Table 5). In both of these years, an entire season of sampling was missed (Fall in 2011 and Summer in 2020).

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.

SEDAR. 2013. The 2013 Stock Assessment Report for Hogfish in the South Atlantic and Gulf of Mexico. Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL. 295 pages.

Table 2. Number of stations sampled and Hogfish caught by for statistical zones 3-7 by season and year for SEAMAP trawl sampling from 2010 to 2024. Only sites <40 m deep and north of 25° 9.00' N included).

Year	Statistical zone 3				Statistical zone 4				Statistical zone 5				Statistical zone 6				Statistical zone 7				Grant Total	
	Fall n	# of fish	Summer n	# of fish	Fall n	# of fish	Summer n	# of fish	Fall n	# of fish	Summer n	# of fish	Fall n	# of fish	Summer n	# of fish	Fall n	# of fish	Summer n	# of fish	Total n	Total # of fish
2010	.	.	13	54	8	0	14	5	11	3	11	2	20	11	20	11	18	33	10	4	125	123
2011	.	.	11	66	.	.	10	7	.	.	13	5	.	.	22	0	.	.	2	0	58	78
2012	2	0	19	50	3	0	11	11	4	3	17	29	6	0	24	18	16	15	19	26	121	152
2013	6	2	8	0	8	0	15	2	5	4	10	1	7	18	8	5	10	10	10	4	87	46
2014	14	46	18	24	17	0	14	1	10	0	11	9	17	29	18	10	13	3	18	7	150	129
2015	14	22	11	42	13	0	17	2	12	5	8	0	13	16	16	5	16	5	26	16	146	113
2016	2	0	6	0	2	0	14	0	4	0	12	12	2	0	14	8	5	2	16	11	77	33
2017	3	3	10	36	12	2	8	0	10	0	11	13	12	53	10	6	10	16	17	4	103	133
2018	11	53	12	0	13	0	13	2	7	3	9	7	5	0	16	13	8	2	17	4	111	84
2019	6	50	15	54	5	0	11	0	9	2	10	7	15	18	7	20	11	5	7	0	96	156
2020	8	22	.	.	11	5	.	.	8	4	.	.	6	8	.	.	4	0	.	.	37	39
2021	10	44	8	21	9	11	11	2	7	0	10	5	8	0	2	0	4	0	.	.	69	83
2022	7	15	10	29	9	2	9	0	3	2	8	3	7	7	16	11	8	15	2	0	79	84
2023	8	30	11	100	12	6	14	48	8	2	11	14	11	11	13	10	8	8	7	0	103	229
2024	8	19	12	94	11	14	12	3	7	7	11	16	12	5	15	16	13	27	9	18	110	219
Grand Total	99	306	164	570	133	40	173	83	105	35	152	123	141	176	201	133	144	141	160	94	1472	1701

Table 3. Frequency of occurrence and mean number of Hogfish caught by year in the 12.8 m shrimp trawl along the West Florida Shelf from 2010 to 2024. All values represent the dataset used for IOA construction (Only statistical zones 3-7, sites <40 m deep and north of 25° 9.00' N included).

Year	Number of samples	Number of fish	% Frequency of occurrence	Mean fish per haul	Standard error
2010	125	123	24.00	0.984	0.289
2011	58	78	15.52	1.345	1.004
2012	121	152	29.75	1.256	0.281
2013	87	46	18.39	0.529	0.156
2014	150	129	16.00	0.860	0.260
2015	146	113	17.81	0.774	0.264
2016	77	33	14.29	0.429	0.171
2017	103	133	21.34	1.291	0.478
2018	111	84	14.41	0.757	0.436
2019	96	156	25.00	1.625	0.590
2020	37	39	32.43	1.054	0.383
2021	69	83	21.74	1.203	0.449
2022	79	84	22.78	1.063	0.397
2023	103	229	26.21	2.223	0.721
2024	110	219	28.18	1.991	0.621
Total	1472	1701	21.54	1.156	0.117

Table 4. Type III tests of fixed effects for the final negative binomial model for Hogfish relative abundance along the West Florida Shelf.

Effect	DF	Chi-Square	Probability > Chi-Square
Statistical Zone	4	12.97	<0.0001
Year	14	4.27	<0.0001
Log Depth +1	1	162.20	<0.0001
Log Sponge Bycatch +1	1	25.29	<0.0001

Table 5. Estimates of annual relative abundance (nominal and scaled) of Hogfish for the West Florida Shelf based on the final negative binomial 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	Scaled Mean	Scaled LCL	Scaled UCL
2010	0.429	0.112	0.286	0.258	0.715	0.828	0.657	1.114
2011	0.219	0.092	0.474	0.096	0.498	0.423	0.300	0.702
2012	0.495	0.128	0.264	0.299	0.821	0.955	0.759	1.281
2013	0.262	0.087	0.369	0.137	0.500	0.506	0.381	0.744
2014	0.195	0.051	0.278	0.117	0.326	0.376	0.298	0.507
2015	0.315	0.083	0.253	0.188	0.530	0.608	0.481	0.823
2016	0.266	0.100	0.397	0.127	0.558	0.513	0.374	0.805
2017	0.370	0.109	0.299	0.208	0.658	0.714	0.552	1.002
2018	0.202	0.064	0.313	0.109	0.375	0.390	0.297	0.563
2019	0.689	0.195	0.296	0.395	1.201	1.329	1.035	1.841
2020	0.771	0.348	0.481	0.319	1.867	1.488	1.036	2.584
2021	0.417	0.151	0.389	0.205	0.847	0.805	0.593	1.235
2022	0.574	0.178	0.313	0.313	1.055	1.108	0.847	1.589
2023	1.577	0.411	0.269	0.946	2.628	3.043	2.412	4.094
2024	0.993	0.255	0.262	0.600	1.642	1.916	1.523	2.565

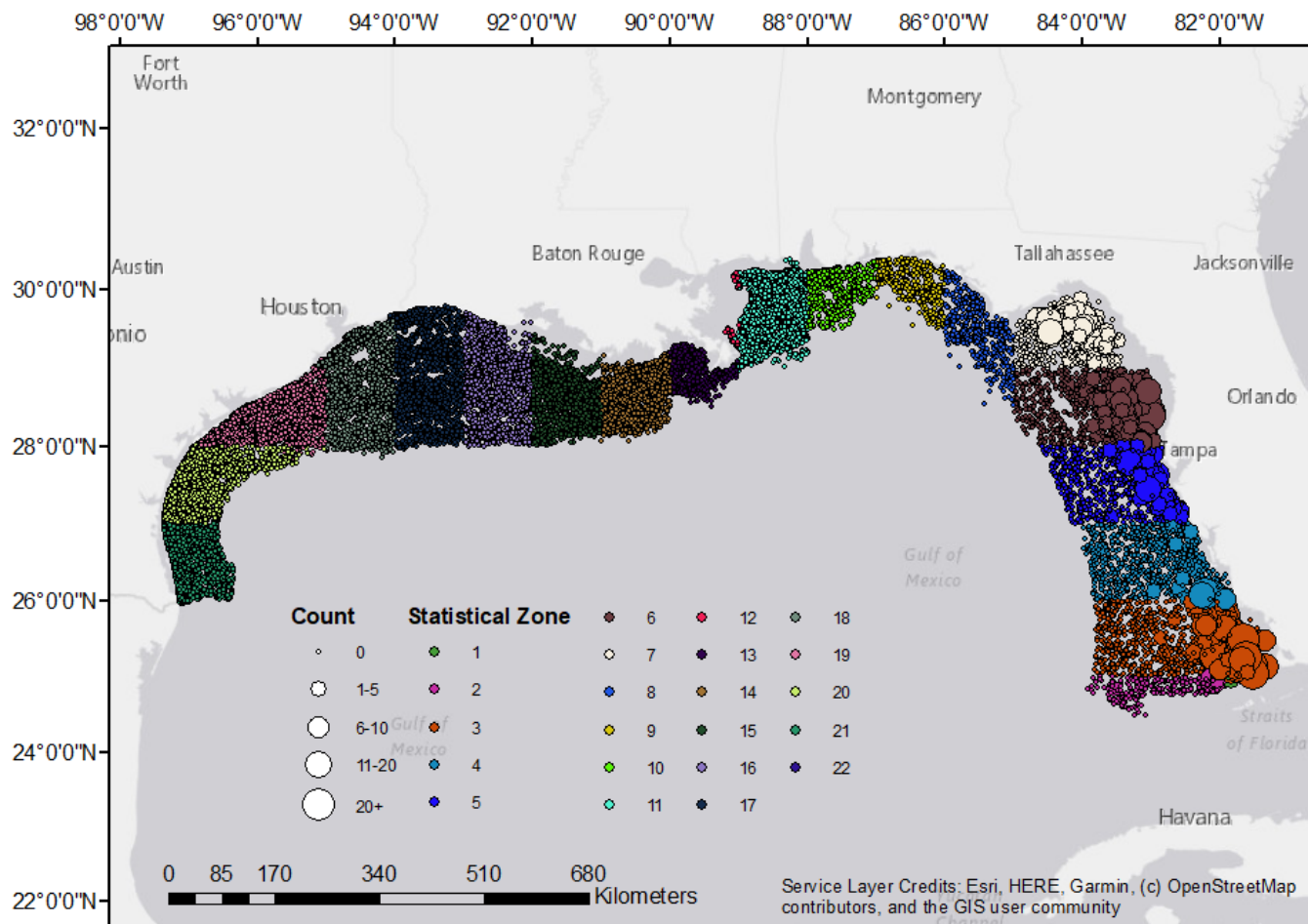


Figure 1. Sampling locations for SEAMAP's 12.8 m shrimp trawl in the Gulf of America from 1982 to 2024 by statistical zone. Circle color represents the statistical zone sampled while circle size represents the number of Hogfish caught during sampling.

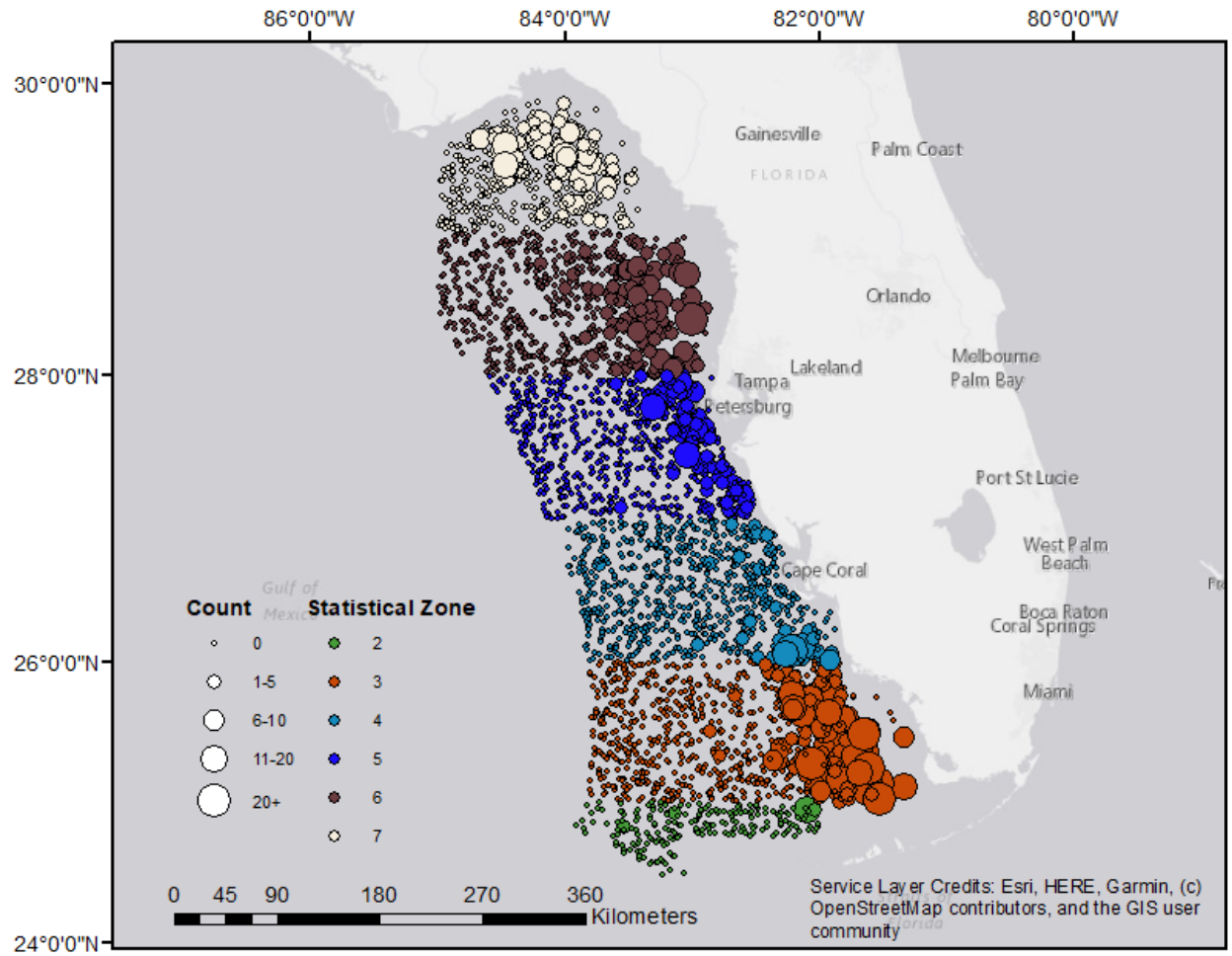


Figure 2. Sampling locations for SEAMAP's 12.8 m shrimp trawl for statistical zones with Hogfish catches from 1982 to 2024. Circle color represents the statistical zone sampled while circle size represents the number of Hogfish caught during sampling.

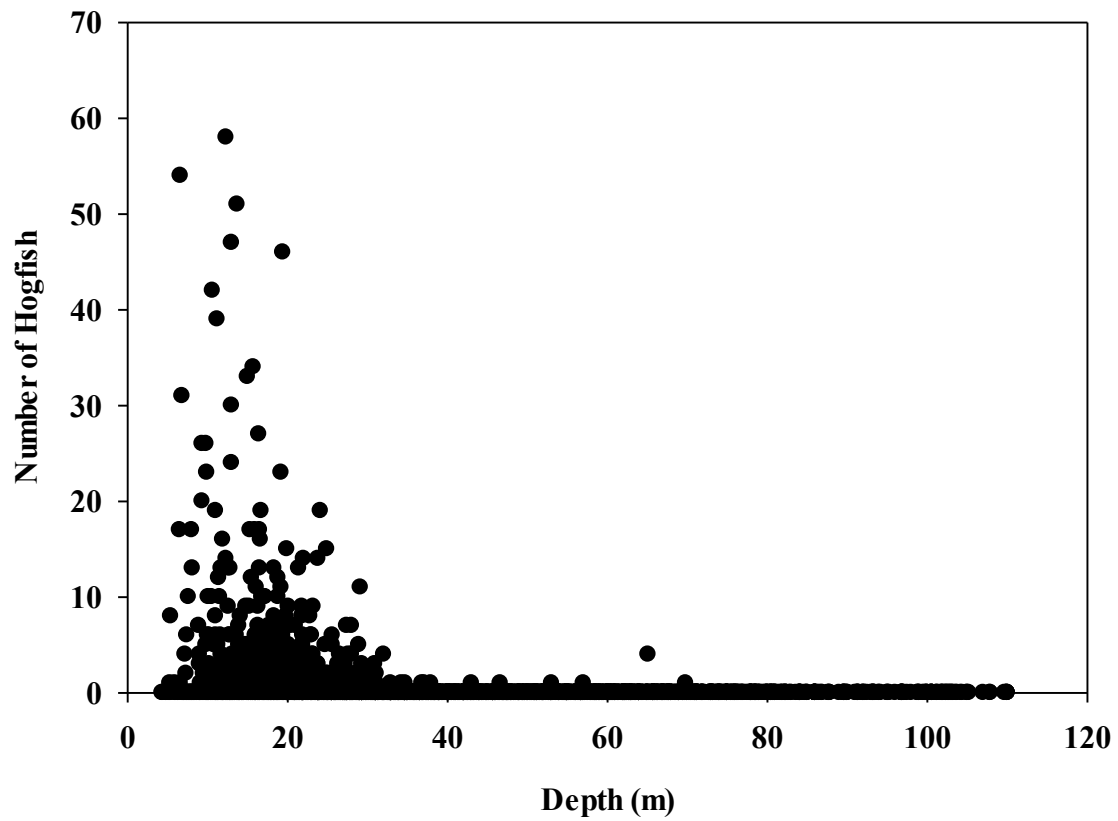


Figure 3. Number of Hogfish caught via the SEAMAP 12.8 m shrimp trawl by depth along the West Florida Shelf. Only data from statistical zones with Hogfish catches included (2-7)

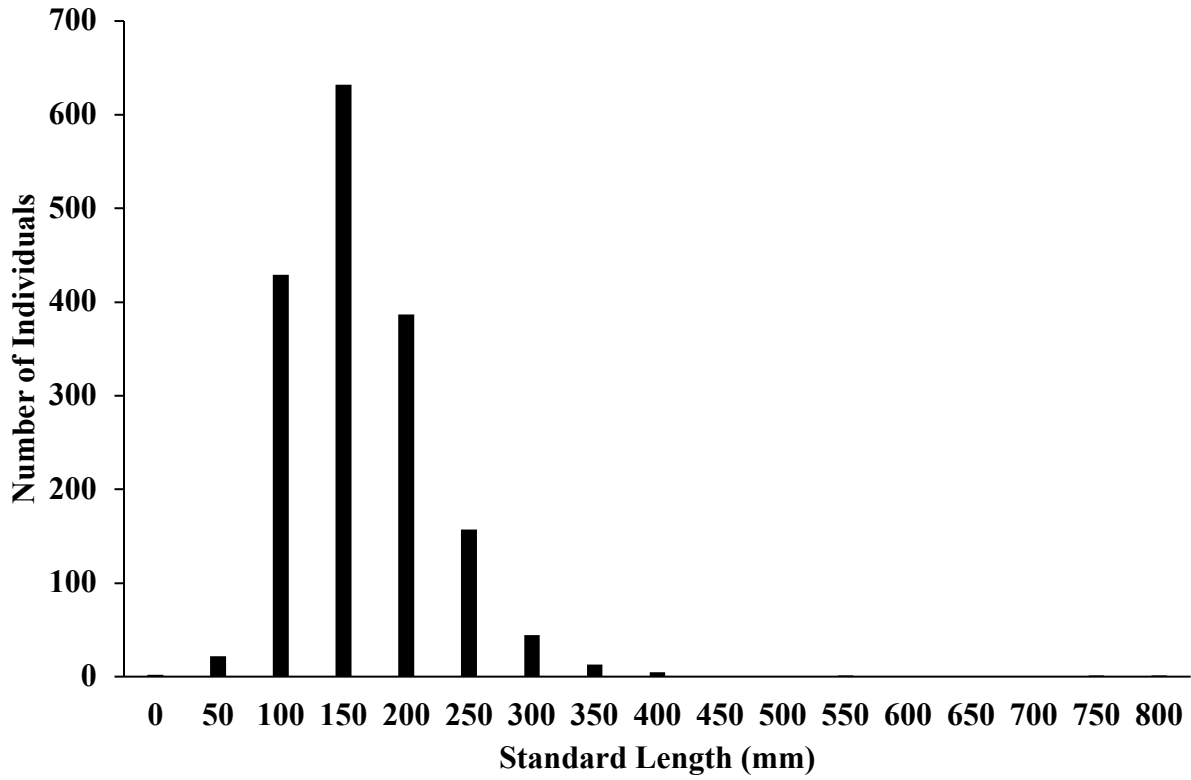


Figure 4. Length frequency of Hogfish captured by SEAMAP's 12.8 m shrimp trawl along the West Florida Shelf from 2010 to 2024.

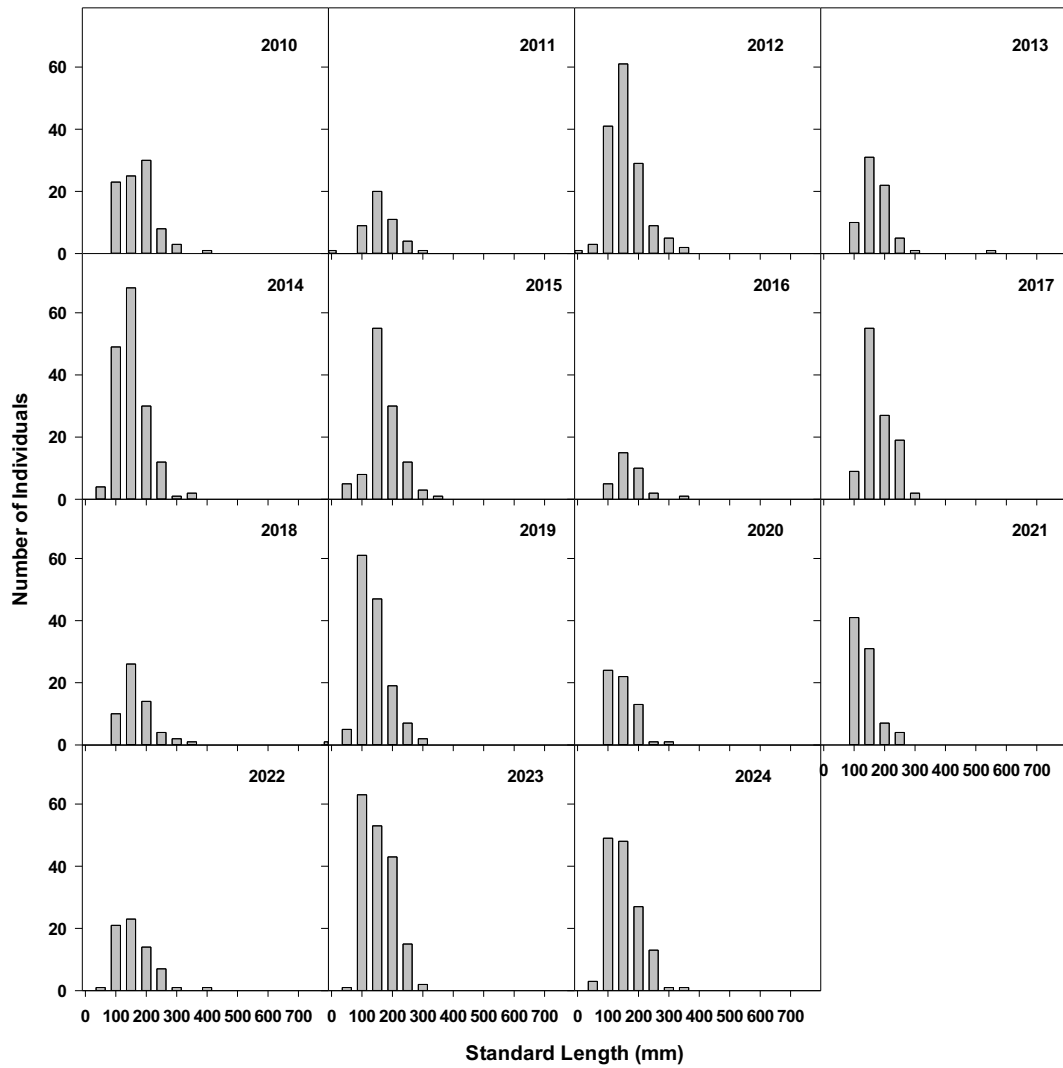


Figure 5. Annual length frequencies for Hogfish caught along the West Florida Shelf for the 12.8 m shrimp trawl from 2010 to 2024. Size bins are in 50 mm increments. Only fish caught in statistical zones 3-7 included.

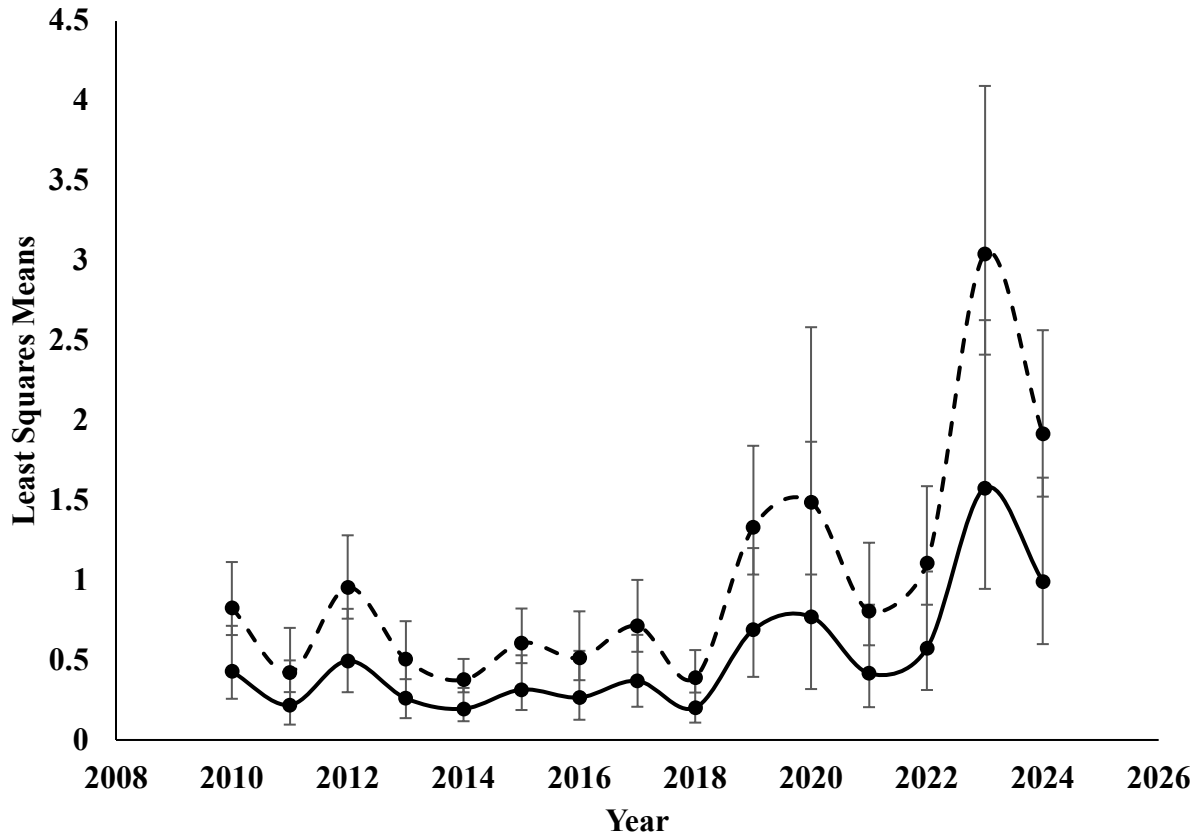


Figure 6. Nominal (solid) and scaled (dashed) annual estimates of Hogfish relative abundance (nominal and scaled) for the West Florida Shelf from 2010 to 2024. Least squares means with upper and lower confidence limits estimated using the final negative binomial model.

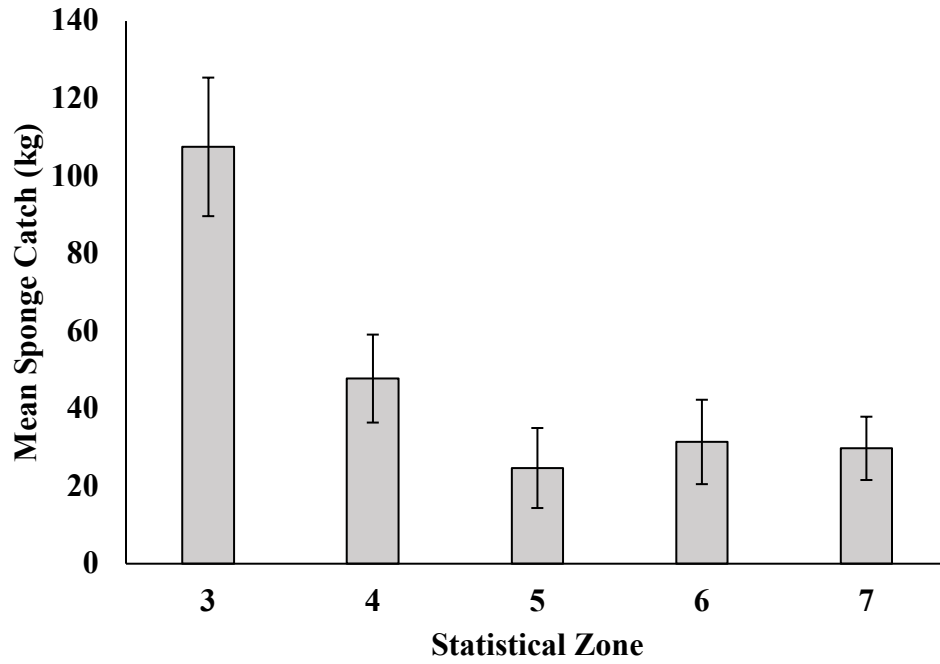


Figure 7. Mean total sponge catch (kg) for the 12.8 m shrimp trawl from 2010 to 2024 with 95% confidence intervals. Only statistical zones 3-7, sites <40 m deep and north of 25° 9.00' N included.