

Annual Indices of Abundance of Gag (*Mycteroperca microlepis*) for Florida Estuaries

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Gag abundance and habitat data collected throughout Florida estuaries [i.e., Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Southern Indian River Lagoon, Northern Indian River Lagoon, and Northeast Florida (St. Johns, Nassau, and St. Marks Rivers)] by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute's Fisheries-Independent Monitoring program from 1996 to 2004 were analyzed to develop annual indices of abundance. Monthly stratified-random sampling was conducted during the day by using three different seines. The estuaries was divided into 1 x 1 nautical-mile cartographic grids (1 nm²), and grids with appropriate water depths for each seine were selected as the sampling universe. Samples were stratified by depth and habitat type depending on gear. Due to the extremely low occurrence of gag in other gears only the data from samples collected with the 183-m center-bag haul seine (183 m x 3 m, 37.5-mm stretch mesh) were used for analyses. These sampling stations were stratified based on the presence or absence of overhanging shoreline vegetation (e.g., fringing mangroves). The seine was deployed by boat, in a rectangular shape (40 m x 103 m) along shorelines and on offshore flats inside the estuary and retrieved by hand. All fishes were identified to the lowest possible taxon, enumerated, and measured to the nearest millimeter (SL), and all juvenile gag were released alive in the field. For each sample, bottom type, seagrass species, shoreline vegetation species, and coverage of each were qualitatively measured by visual survey. Water-quality data such as salinity (ppt), dissolved oxygen (mg/l⁻¹), and temperature (°C) were recorded using a hand-held data sonde. Due to the extremely low occurrence of gag in all other bottom vegetation types but seagrass, only those samples taken in haul seines above seagrass were used in the analyses.

In order to develop standardized indices of annual average CPUE (catch per haul) for gag from Florida estuaries in the Gulf of Mexico, a delta-lognormal model, as described by Lo et al. (1992), was employed. This index is a mathematical combination of yearly CPUE estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive CPUEs (i.e., presence/absence) and lognormal model which describes variability in only the nonzero CPUE data. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. A backward stepwise selection procedure was employed to develop both sub-models. Type 3 analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set at an $\alpha = 0.05$. The parameters tested for inclusion in each sub-model were categorical variables of year, estuary, shoreline vegetation type, and the continuous variables of station depth, salinity and temperature, which were normalized to a mean of one. For the binomial sub-models, a logistic-type mixed model was employed. The fit of each model was evaluated using the fit statistics provided by the GLMMIX macro.

The models for gag from Florida estuaries for both the Gulf and Atlantic converged. Tables 1-3 summarize the model-building process by which the Gulf gag index was developed.

Table 1 summarizes the results of Type 3 analyses for those variables retained in the binomial sub-model. Table 2 summarizes the results of Type 3 analyses for those variables retained in the lognormal sub-model. Table 3 and Figure 1 summarize the index values for gag in Gulf estuaries of Florida. Tables 4-6 summarize the model-building process by which the Atlantic gag index was developed. Table 4 summarizes the results of Type 3 analyses for those variables retained in the binomial sub-model. Table 5 summarizes the results of Type 3 analyses for those variables retained in the lognormal sub-model. Table 6 and Figure 2 summarize the index values for gag in Atlantic estuaries of Florida. However, due to the lack of any significant variables in the lognormal model, we suggest an alternate index based on the modeled frequency of occurrence. As seen in Table 7, modeled nonzero mincounts do not vary significantly (Table 5). Therefore this sub-model may contribute undescribed variability to the final index values. As seen in Table 7 and Figure 3, a new standardized index based upon modeled frequency of occurrence provides lower CVs and smaller confidence intervals.

Length frequency histograms of gag collected from Florida estuaries from the Gulf and Atlantic are illustrated in Figures 4 and 5, respectively. Gag from Gulf Florida estuaries had a mean standard length (\pm standard error) of 187 (\pm 2) mm (N = 1369). Gag from Atlantic Florida estuaries had a mean standard length (\pm standard error) of 210 (\pm 5) mm (N = 215).

Lo, N. C. H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Can. J. Fish. Aquat. Sci.* 49: 2515-1526.

Table 1. Results of Type 3 analyses for those variables retained in the binomial sub-model for the Gulf.

<i>Type 3 Tests of Fixed Effects</i>						
<i>Effect</i>	<i>Num DF</i>	<i>Den DF</i>	<i>Chi-Square</i>	<i>F Value</i>	<i>Pr > ChiSq</i>	<i>Pr > F</i>
<i>Year</i>	8	3059	63.80	7.98	<.0001	<.0001
<i>Estuary</i>	3	3059	39.45	13.15	<.0001	<.0001
<i>Shore Vegetation Type</i>	3	3059	9.62	3.21	0.0221	0.0222
<i>Station Depth</i>	1	3059	76.65	76.65	<.0001	<.0001
<i>Temperature</i>	1	3059	110.11	110.11	<.0001	<.0001
<i>Salinity</i>	1	3059	17.35	17.35	<.0001	<.0001

Table 2. Results of Type 3 analyses for those variables retained in the lognormal sub-model for the Gulf.

<i>Type 3 Tests of Fixed Effects</i>					
<i>Effect</i>	<i>Num DF</i>	<i>Den DF</i>	<i>F Value</i>	<i>Pr > F</i>	
<i>Year</i>	8	250	3.58	0.0006	
<i>Station Depth</i>	1	250	3.60	0.0591	
<i>Salinity</i>	1	250	6.77	0.0098	

Table 3. Index values for gag collected from Florida estuaries in the Gulf of Mexico. Frequency is the nominal frequency of occurrence, N is the number of stations, Lo Index is the index in CPUE units, Standardized Index is that same index normalized to a mean of one, CV is the coefficient of variation on the mean, and LCL and UCL are lower and upper 95% confidence limits.

<i>Survey Year</i>	<i>Frequency</i>	<i>N</i>	<i>Lo Index</i>	<i>Standardized</i>			
				<i>Index</i>	<i>CV</i>	<i>LCL</i>	<i>UCL</i>
1996	0.11521	217	0.11670	1.13399	0.66560	0.33775	3.80734
1997	0.06137	277	0.03270	0.31773	1.07858	0.05484	1.84104
1998	0.04688	320	0.02384	0.23170	1.28399	0.03219	1.66788
1999	0.08081	396	0.06377	0.61968	0.74320	0.16450	2.33439
2000	0.07123	365	0.04536	0.44081	0.84245	0.10189	1.90706
2001	0.07104	366	0.07288	0.70821	0.78985	0.17595	2.85066
2002	0.17582	364	0.33866	3.29081	0.40103	1.52012	7.12409
2003	0.09836	366	0.18436	1.79145	0.49632	0.70083	4.57929
2004	0.04866	411	0.04792	0.46561	0.94286	0.09447	2.29478

Table 4. Results of Type 3 analyses for those variables retained in the binomial sub-model for the Atlantic.

<i>Type 3 Tests of Fixed Effects</i>						
<i>Effect</i>	<i>Num DF</i>	<i>Den DF</i>	<i>Chi-Square</i>	<i>F Value</i>	<i>Pr > ChiSq</i>	<i>Pr > F</i>
<i>Year</i>	7	1982	29.97	4.28	<.0001	0.0001
<i>Estuary</i>	1	1982	14.99	14.99	0.0001	0.0001
<i>Shore Vegetation Type</i>	3	1982	11.70	3.90	0.0085	0.0086
<i>Station Depth</i>	1	1982	22.73	22.73	<.0001	<.0001
<i>Temperature</i>	1	1982	23.37	23.37	<.0001	<.0001
<i>Salinity</i>	1	1982	52.29	52.29	<.0001	<.0001

Table 5. Results of Type 3 analyses for those variables retained in the lognormal sub-model for the Atlantic.

<i>Type 3 Tests of Fixed Effects</i>				
<i>Effect</i>	<i>Num DF</i>	<i>Den DF</i>	<i>F Value</i>	<i>Pr > F</i>
<i>Year</i>	7	68	1.82	0.0976

Table 6. Index values for gag collected from Florida estuaries in the Atlantic. Frequency is the nominal frequency of occurrence, N is the number of stations, Lo Index is the index in CPUE units, Standardized Index is that same index normalized to a mean of one, CV is the coefficient of variation on the mean, and LCL and UCL are lower and upper 95% confidence limits.

<i>Survey Year</i>	<i>Frequency</i>	<i>N</i>	<i>Lo Index</i>	<i>Standardized Index</i>	<i>CV</i>	<i>LCL</i>	<i>UCL</i>
1997	0.023346	257	0.009222	0.27152	0.96255	0.05376	1.37135
1998	0.058824	272	0.052941	1.55863	0.54170	0.56513	4.29870
1999	0.021459	233	0.025489	0.75042	1.08950	0.12792	4.40219
2000	0.023438	256	0.019258	0.56698	1.03518	0.10287	3.12489
2001	0.040179	224	0.025060	0.73779	0.98131	0.14276	3.81298
2002	0.072581	248	0.080476	2.36929	0.49230	0.93323	6.01513
2003	0.045113	266	0.045805	1.34855	0.55106	0.48149	3.77704
2004	0.016000	250	0.013479	0.39683	1.59513	0.04183	3.76414

Table 7. Index values for gag collected from Florida estuaries in the Atlantic based on modeled frequency of occurrence. Standardized Index is based on the Modeled Frequency of Occurrence index normalized to a mean of one, CV is the coefficient of variation on the mean, and LCL and UCL are lower and upper 95% confidence limits.

Year	Modeled		Standardized Index	CV	LCL	UCL
	Average CPUE	Modeled Frequency of Occurrence				
1997	1.12998	0.007947	0.542480481	0.415223	0.23980545	1.220393
1998	1.85529	0.023212	1.584504458	0.329814	0.82645164	3.006886
1999	2.40615	0.008878	0.606032681	0.460624	0.24485686	1.488118
2000	2.19270	0.007634	0.521114382	0.42494	0.22601647	1.194795
2001	1.80582	0.009673	0.660301207	0.391565	0.30567857	1.417808
2002	1.94876	0.029577	2.018993984	0.297349	1.12202739	3.594693
2003	1.54021	0.024911	1.700482102	0.301317	0.93826528	3.05385
2004	2.13580	0.005363	0.366090704	0.516669	0.13263364	1.004411

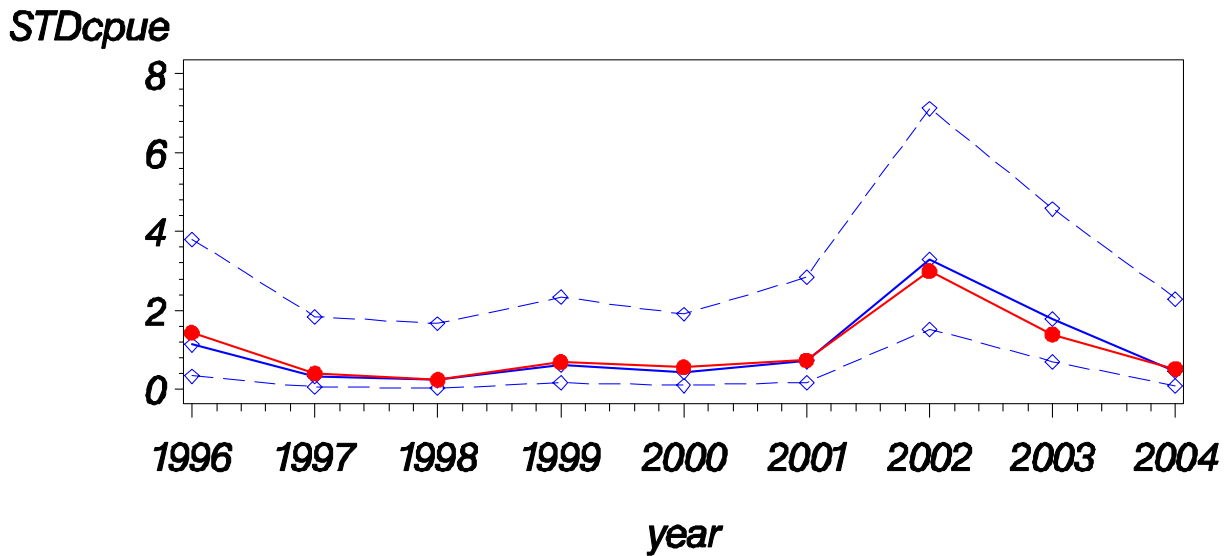


Figure 1. Gag index values for Florida estuaries in the Gulf of Mexico. STDcpue is synonymous with Standardized Index in Table 3. Solid circles indicate nominal index values, while open circles indicate model-based index values with corresponding lower and upper 95% confidence limits.

STDcpue

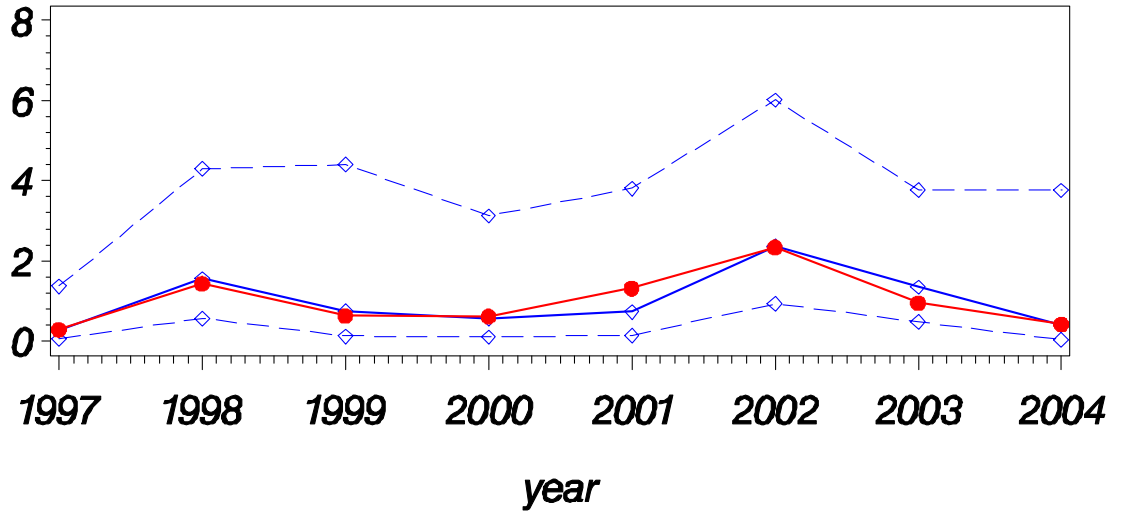


Figure 2. Gag index values for Florida estuaries in the Atlantic based on the delta-lognormal model. *STDcpue* is synonymous with Standardized Index in Table 3. Solid circles indicate nominal index values, while open circles indicate model-based index values with corresponding lower and upper 95% confidence limits.

STD_modfreq

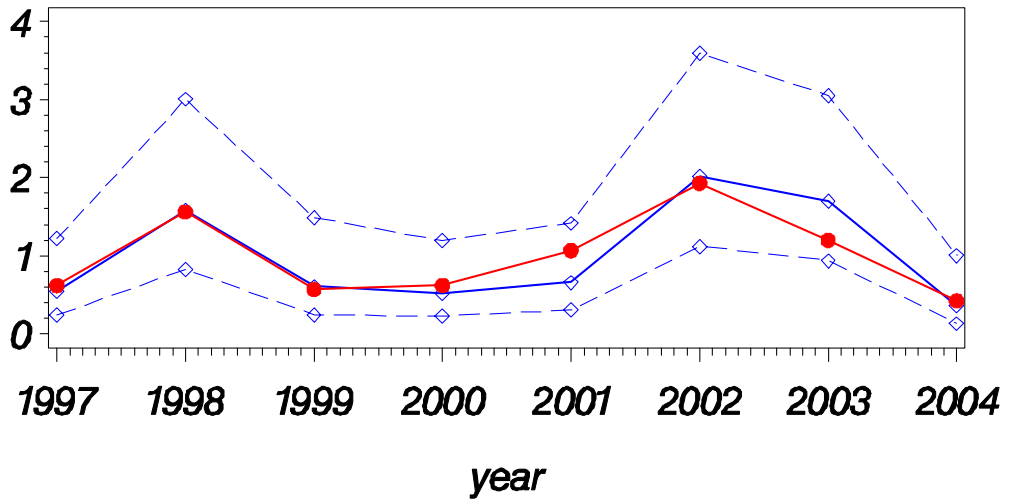


Figure 3. Gag index values for Florida estuaries in the Atlantic based on the binomial model only. *STDmodfreq* is synonymous with Standardized Index in Table 7. Solid circles indicate nominal index values, while open circles indicate model-based index values with corresponding lower and upper 95% confidence limits.

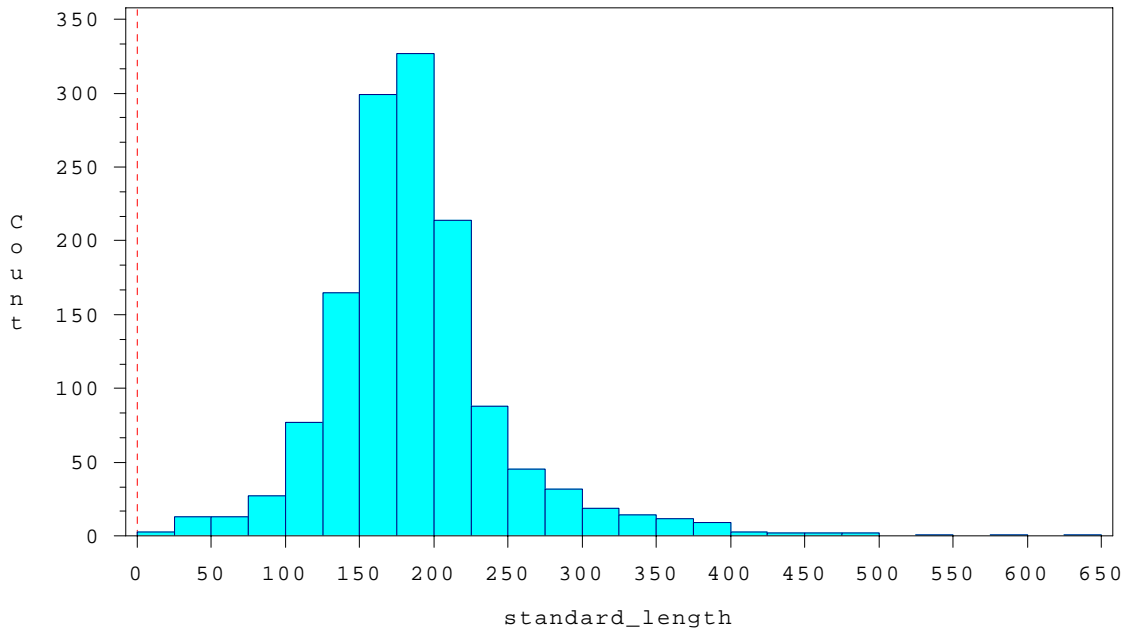


Figure 4. Standard length (mm) frequency histograms for gag collected from Florida estuaries in Gulf of Mexico (N = 1369).

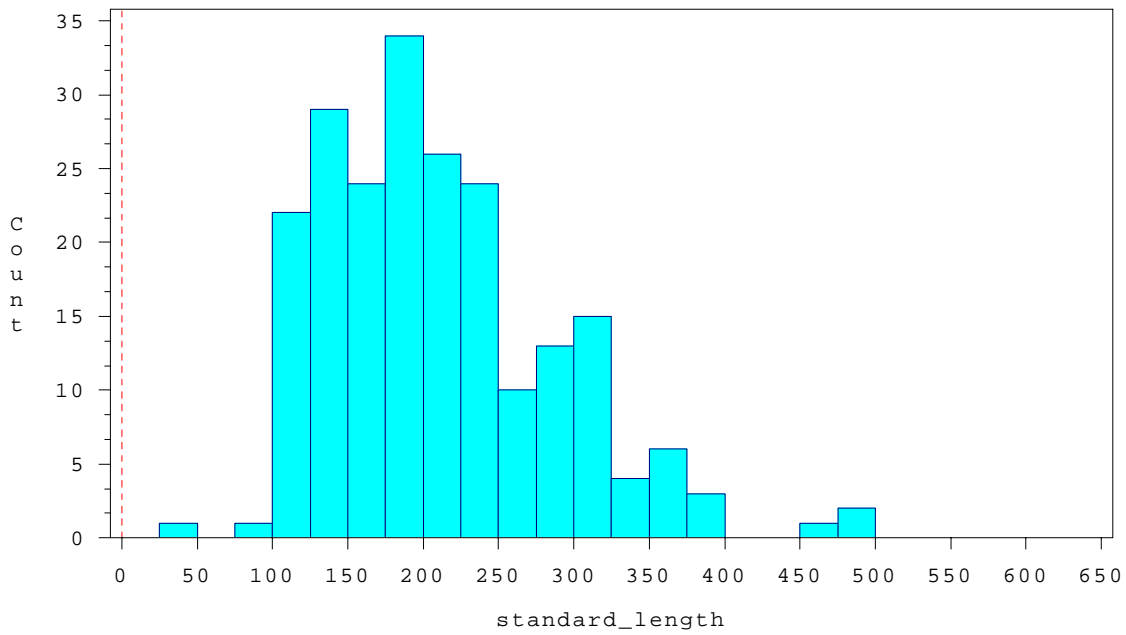


Figure 5. Standard length (mm) frequency histograms for gag collected from Florida estuaries in Atlantic (N = 215).