STANDARDIZED CATCH RATES OF YOUNG-OF-THE-YEAR GAG, *MYCTEROPERCA MICROLEPIS*, FROM AN OTTER TRAWL SURVEY OF SEAGRASS HABITAT OFF THE WEST FLORIDA COAST DURING 1991-1999

by

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Sustainable Fisheries Division Contribution SFD-00/01-130

Introduction

A major portion of the Gulf of Mexico gag (*Mycteroperca microlepis*) population spawns on deepwater reefs of the West Florida Shelf, primarily during February and March (Coleman *et al.* 1996), with juveniles recruiting to sea grass beds along the western Florida coast in April and May (Koenig and Coleman 1998a). A systematic trawl survey has been conducted since 1991 as part of a comprehensive study of the sea grass habitat of the western Florida coast between St. Andrew Bay and Fort Myers (Koenig and Coleman 1998b). The available catch per unit effort (CPUE) series, from 1991 - 1999, was used to develop abundance indices for young-of-the-year gag. The sampling efficiency depends upon a number of factors aside from the abundance of the target species, including behavior, size, distribution, sea grass habitat characteristics such as sea grass species composition, depth, water clarity, blade density, and blade length. Therefore, specific reference stations were established , sampled at seasonally specific times, in order to minimize the variation in these factors. In this paper, techniques are employed to further standardize the catch rate trends.

Material and Methods

The methods employed for the sea grass trawl survey are described in detail by Koenig and Coleman (1998b). A number of sampling sites were chosen in large, dense sea grass beds with close proximity to the open gulf. The sampling sites were grouped for analytical purposes into 10 locations, based upon geographic proximity (Table 1). Alternatively, Petronis Beach (PB) could be grouped into SAB, but was not for this analysis. The gear used was an otter trawl (5 m trawl, 3 mm mesh tailbag). Samples were collected diurnally and generally during flood tides. Each tow covered a 150 m transect and was made for about 5 minutes at a tow speed of 1.8 to 2.2 km/h.

Catch rate was calculated in number of gag per tow. The geographic distribution of sampling effort among the locations (1991-1999) is shown in Figure 1A, with each symbol scaled to reflect the number of tows at that location. In Figure 1B, each symbol is scaled to reflect the average catch rate at that location. Three larger zones were defined: Zone 1) is a warm-temperate region near the northwest extreme of seagrass habitat, containing sand beaches and barrier islands, Zone 2) is also warm-temperate, but lacks the barrier island complex and is considered a zero-energy coastline (Murali 1982), and Zone 3) is a semitropical region representing the southwest extreme of seagrass habitat in Florida, containing a beach barrier island interface similar to Zone 1.

The process of calculating the indices of abundance from this data involves the standardization of yearly changes in catch rate, accounting for the influence of those factors which have a significant effect. The available variables were year, month, location (LOCCODE), and zone; these were all considered as factors with possible influences on catch rates.

The Lo method (Lo et al. 1992) was used to develop standardized indices; with that method separate analyses are conducted of the positive catch rates and the proportions of the observed trips which were successful. This technique has been employed in calculating abundance indices for bluefin tuna, *Thunnus thynnus*, (Ortiz *et al.* 1999,Turner *et al.* 1999, Brown *et al.* 1999), wherein

a delta-lognormal model approach was used; this used a delta distribution with an assumed binomial error distribution for the proportion of positive observations (trips), and assumed a lognormal error distribution for the catch rates on successful trips. For the present analyses, the delta-Poisson model approach of Brown and Turner (2001) was used; differing from the delta-lognormal approach in that a Poisson error distribution is assumed for the catches on successful tows.

Parameterization of the model was accomplished using a Generalized Linear Model (GLM) structure: The proportion of successful (i.e. positive observations) tows per stratum was assumed to follow a binomial distribution where the estimated probability was a linearized function of fixed factors, such as year, month, LOCCODE, and zone. The logit function linked the linear component and the assumed binomial distribution. Similarly, the estimated catch observed on positive tows was a function of similar fixed factors with the log function as a link.

A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates. That is, first the Null model was run, in which no factors were entered in the model. These results reflect the distribution of the nominal data. Each potential factor was then tested one at a time. The results were then ranked from greatest to least reduction in deviance per degree of freedom when compared to the Null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model, provided two conditions were met: 1) the effect of the factor was determined to be significant at at least the 5% level based upon a χ^2 (Chi-Square) test, and 2) the deviance per degree of freedom was reduced by at least 1% from the less complex model. This process was repeated, adding factors (including factor interactions) one at a time at each step, until no factor met the criteria for incorporation into the final model.

Once the set of fixed effects was specified, possible random year interaction effects were evaluated. These random effects were tested for significance using the likelihood ratio taken as the difference of the –2*log likelihood estimator between the complete model (*i.e.* including the random variate) and the reduced model (*i.e.* dropping the random variate). The –2*log likelihood difference statistics follows a χ^2 distribution. Values greater than 3.84 (α=0.05, df=1) were considered significant. The final model then, included any significant fixed and random (year)*factors interactions.

The product of the standardized proportion positives and the standardized positive catch rates was used to calculate overall standardized catch rates. A standardized proportion positive could not be calculated for 1993 because of a lack of contrast in the data; there were only 13 observations for 1993, all of which were positive for gag. In order to calculate the overall standardized catch rate for 1993, a proportion positive of 1.0 was assumed, with a variance of 0. For comparative purposes, each relative index of abundance was then obtained by dividing the standardized catch rates by the mean value in the series.

Results and Discussion

The stepwise construction of the fixed effect model is shown in Table 2 for the proportion positive analysis and in Table 3 for the positive catch rate analysis. The results of the model fits for the indices are shown in Tables 4 and 5. For the positive catch rate analysis, two random effects (YEAR*LOCCODE and YEAR*MONTH) met the criterion as significant effects and were included in the final model (Table 6). The index values are shown in Table 7 and in Figure 2.

The index value for 1993 may be biased high as a result of the assumption of a 1.0 proportion positive. All 13 observations for 1993 were collected off Turkey Point (location code TP), a location for which the proportion positive tends to be one of the highest among all locations (see parameter estimates in Table 4), although it is also the standard location in the model fit. It may be safely postulated that, had a larger sample size been collected for 1993, it is quite possible that not all tows would have been positive for gag, resulting in a lower index for that year.

Literature Cited

Brown, C.A., S.C. Turner and M. Ortiz. 1999. Standardized catch rates of large (> 195 cm) and large medium (178-195 cm) bluefin tuna, *Thunnus thynnus,* from the rod and reel/handline fishery off the northeast United States during 1983-1997. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 49(2): 347-359.

Brown, C.A. and S.C. Turner. 2001. Updated standardized catch rates of bluefin tuna, *Thunnus thynnus,* from the rod and reel/handline fishery off the northeast United States during 1980-1999. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 52: 984-1006.

Koenig, C. C., F. C. Coleman. 1998a. Absolute abundance and survival of juvenile gag, *Mycteroperca microlepis*, in seagrass beds of the N.E. Gulf of Mexico. Trans. Am. Fish. Soc. 127(1), 44-55.

Koenig, C. C., F. C. Coleman. 1998b. Recruitment indices and seagrass habitat relationships of the early juvenile stages of gag, gray snapper, and other economically important reef fishes in the eastern Gulf of Mexico. Final Report: MARFIN Award No. NA57FF0055.

Lo, N.C. L.D. Jackson and J.L. Squire. 1992. Indices of relative abundance form fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

Murali, R.S. 1982. Zero-energy coast, pp. 883 in M.L. Schwartz, ed. The encyclopedia of beaches and coastal environments. Hutchinson Ross Publ. Co., Narberth, Pa.

Ortiz, M., S.C. Turner and C.A. Brown. 1999. Standardized catch rates of small bluefin tuna, *Thunnus thynnus,* from the rod and reel/handline fishery off the northeast United States during 1983-1997. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 49(2): 254-286.

Turner, S.C. and C.A. Brown. 1998. Update of standardized catch rates for large and small bluefin tuna, *Thunnus thynnus*, in the Virginia - Massachusetts (U.S.) rod and reel fishery. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 48(1): 94-102.

Turner, S.C., C.A. Brown and M. Ortiz. 1999. Review of the available information on medium bluefin tuna, *Thunnus thynnus,* from the rod and reel/handline fishery off the northeast United States. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 49(2): 334-343.

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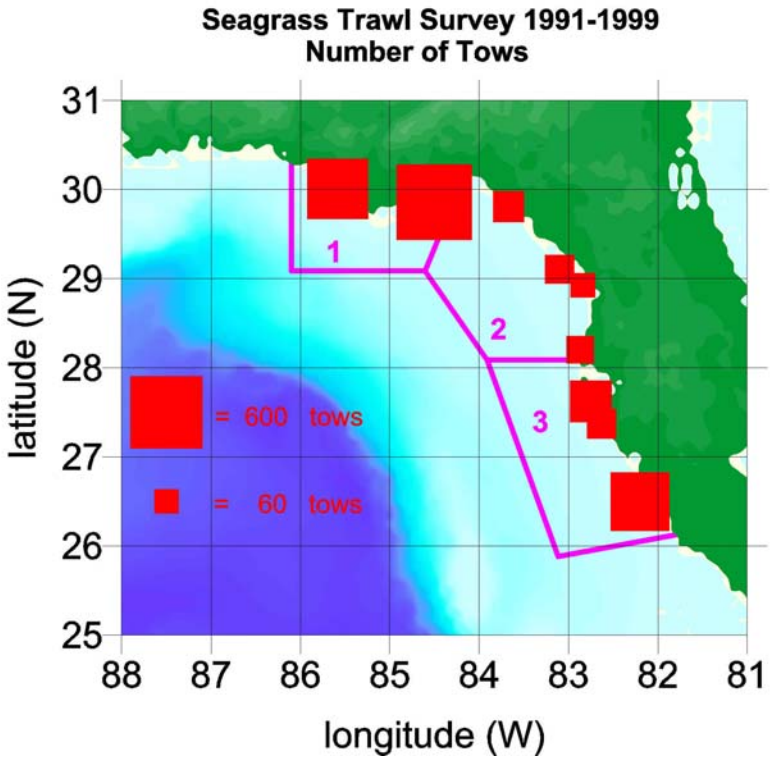

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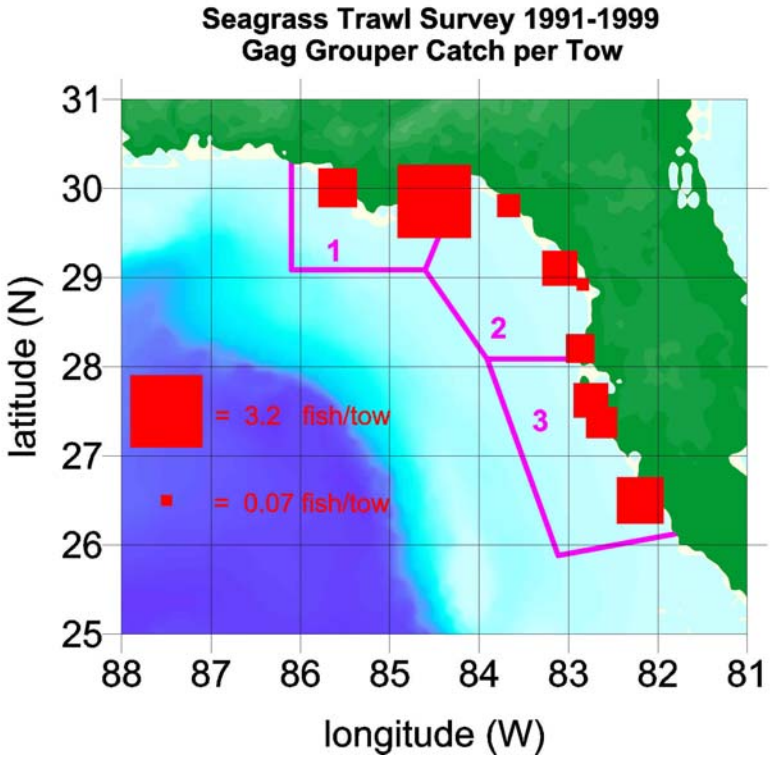

FIGURE 1: The geographic distribution of survey tows (1991-1999). Each symbol is scaled to reflect the number of tows during the time period (A) or the average gag catch per tow at that approximate location (B).

TABLE 1: Seagrass Trawl Survey sampling locations		
Sampling Site	**Location Code**	**Zone**
Petronis Beach	PB*	1
St. Andrews Bay Crooked Island Sound St. Joe Bay	SAB	1
Turkey Point Dog Island Shoal Lanark	TP	1
Keaton Beach	KB	2
Cedar Key Suwanee River Sound Waccasassa Bay	CK	2
Crystal River Aripeka	CR	2
Anclote Key	AK	2
Mullet Key Bunces Pass Egmont Key	MK	3
Sarasota Bay New Pass	SB	3
Sanibel Jug Creek Shoal Smoke House Bay Redfish Pass Wulford Pass Sanibel Causeway Fisherman Key Punta Rassa	S	3

* Alternatively, Petronis Beach may be classified as SAB for future analyses.

TABLE 2: Results of the stepwise procedure to develop the proportion positive catch rate model.

FACTOR	df	deviance	deviance/df	%diff.	delta%	L	ChiSquare	Pr>Chi
NULL	1830	2530.0	1.38			-1265.0	.	.
YEAR	1822	1836.5	1.01	27.1	27.1	-918.2	693.6	<0.001
LOCCODE	1821	2199.4	1.21	12.6		-1099.7	330.6	<0.001
ZONE	1828	2369.1	1.30	6.3		-1184.6	160.9	<0.001
MONTH	1826	2485.8	1.36	1.5		-1242.9	44.2	<0.001
YEAR+								
LOCCODE	1813	1748.0	0.96	30.3	3.2	-874.0	88.4	<0.001
ZONE	1820	1806.2	0.99	28.2		-903.1	30.2	<0.001
MONTH	1818	1829.7	1.01	27.2		-914.9	6.8	0.149
YEAR+LOCCODE+								
MONTH	1809	1736.7	0.96	30.6	0.3	-868.4	11.3	0.024
FINAL MODEL: YEAR+LOCCODE								

% diff: percent difference in deviance/df between each factor and the null model**;** delta%: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; L: log likelihood; ChiSquare: Pearson Chi-square statistic; Pr>Chi: significance level of the Chi-square statistic.

TABLE 3: Results of the stepwise procedure to develop the positive catch rate model (fixed effects).

FACTOR	df	deviance	deviance/df	%diff.	delta%	L	ChiSquare	Pr>Chi
NULL	853	1717.5	2.01			729.3	.	.
YEAR	845	1010.2	1.20	40.6	40.6	1082.9	707.3	<0.001
LOCCODE	844	1285.2	1.52	24.4		754.9	51.3	<0.001
ZONE	851	1503.0	1.77	12.3		836.5	214.5	<0.001
MONTH	849	1666.3	1.96	2.5		945.4	432.3	<0.001
YEAR+								
MONTH	841	967.0	1.15	42.9	2.3	130877.4	7451.4	<0.001
LOCCODE	836	967.8	1.16	42.5		129665.9	5028.3	<0.001
ZONE	843	1000.9	1.19	41.0		129073.0	3842.4	<0.001
YEAR+MONTH+								
LOCCODE	832	930.6	1.12	44.4	1.5	1122.7	36.3	<0.001
ZONE	839	959.5	1.14	43.2		1108.3	7.5	0.024
FIXED EFFECTS MODEL: YEAR+MONTH+LOCCODE								

% diff: percent difference in deviance/df between each factor and the null model**;** delta%: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; L: log likelihood; ChiSquare: Pearson Chi-square statistic; Pr>Chi: significance level of the Chi-square statistic.

TABLE 4: Results of the analysis (1991-1999). Lo method with binomial error assumption for proportion positives.

Class Level Information

Class	Levels	Values
year	9	1991 1992 1993 1994 1995 1996 1997 1998 1999
loccode	10	AK CK CR KB MK PB S SAB SB TP

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	1813	1748.0199	0.9642
Scaled Deviance	1813	1748.0199	0.9642
Pearson Chi-Square	1813	1855.8048	1.0236
Scaled Pearson X2	1813	1855.8048	1.0236
Log Likelihood		-874.0099	

Algorithm converged.

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	-0.2643	0.2882	-0.8292	0.3006	0.84	0.3591
year	1991	1	3.7553	0.4204	2.9313	4.5793	79.79	<.0001
year	1992	1	0.3329	0.2996	-0.2544	0.9201	1.23	0.2665
year	1993	1	23.6296	32865.76	-64392.1	64439.34	0.00	0.9994
year	1994	1	-1.6973	0.4580	-2.5951	-0.7996	13.73	0.0002
year	1995	1	1.1038	0.2990	0.5178	1.6898	13.63	0.0002
year	1996	1	-0.5240	0.2944	-1.1011	0.0531	3.17	0.0751
year	1997	1	-0.3584	0.2953	-0.9371	0.2203	1.47	0.2248
year	1998	1	-0.1766	0.3805	-0.9224	0.5693	0.22	0.6426
year	1999	0	0.0000	0.0000	0.0000	0.0000		.
loccode	AK	1	-0.9496	0.3350	-1.6062	-0.2931	8.04	0.0046
loccode	CK	1	-0.6524	0.3221	-1.2838	-0.0211	4.10	0.0428
loccode	CR	1	-2.4700	0.5471	-3.5424	-1.3976	20.38	<.0001
loccode	KB	1	-1.3428	0.3739	-2.0757	-0.6099	12.90	0.0003
loccode	MK	1	-0.4485	0.2420	-0.9228	0.0258	3.44	0.0638
loccode	PB	1	1.3364	0.6316	0.0985	2.5743	4.48	0.0344
loccode	S	1	0.0065	0.1902	-0.3662	0.3792	0.00	0.9728
loccode	SAB	1	-1.0702	0.2081	-1.4781	-0.6624	26.45	<.0001
loccode	SB	1	-0.9515	0.3212	-1.5811	-0.3218	8.77	0.0031
loccode	TP	0	0.0000	0.0000	0.0000	0.0000		.
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
year	8	451.39	<.0001
loccode	9	88.44	<.0001

TABLE 5: Results of the analysis (1991-1999). Lo method with Poisson error assumption for positive trips (fixed effects).

Class Level Information

Class	Levels	Values
year	9	1991 1992 1993 1994 1995 1996 1997 1998 1999
month	5	Aug July June Oct Sep
loccode	10	AK CK CR KB MK PB S SAB SB TP

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	832	930.6404	1.1186
Scaled Deviance	832	930.6404	1.1186
Pearson Chi-Square	832	1042.1292	1.2526
Scaled Pearson X2	832	1042.1292	1.2526
Log Likelihood		1122.7170	

Algorithm converged.

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	0.7750	0.1506	0.4797	1.0703	26.47	<.0001
year	1991	1	0.6671	0.1431	0.3867	0.9476	21.74	<.0001
year	1992	1	-0.1729	0.1527	-0.4722	0.1265	1.28	0.2577
year	1993	1	1.1310	0.1729	0.7922	1.4699	42.79	<.0001
year	1994	1	-1.0831	0.3641	-1.7969	-0.3694	8.85	0.0029
year	1995	1	-0.5503	0.1660	-0.8756	-0.2250	10.99	0.0009
year	1996	1	-0.4316	0.1751	-0.7747	-0.0885	6.08	0.0137
year	1997	1	-0.5862	0.1750	-0.9291	-0.2432	11.22	0.0008
year	1998	1	-0.4993	0.1994	-0.8901	-0.1084	6.27	0.0123
year	1999	0	0.0000	0.0000	0.0000	0.0000	.	.
month	Aug	1	0.1095	0.0680	-0.0238	0.2428	2.59	0.1074
month	July	1	0.3081	0.0597	0.1912	0.4251	26.67	<.0001
month	June	1	0.2618	0.0675	0.1296	0.3941	15.05	0.0001
month	Oct	1	-0.2042	0.3071	-0.8062	0.3977	0.44	0.5060
month	Sep	0	0.0000	0.0000	0.0000	0.0000	.	.
loccode	AK	1	-0.2478	0.2316	-0.7018	0.2062	1.14	0.2847
loccode	CK	1	0.2613	0.1979	-0.1265	0.6492	1.74	0.1867
loccode	CR	1	-0.6078	0.5099	-1.6072	0.3916	1.42	0.2333
loccode	KB	1	-0.2819	0.2989	-0.8677	0.3039	0.89	0.3455
loccode	MK	1	-0.1107	0.1483	-0.4013	0.1799	0.56	0.4553
loccode	PB	1	0.3558	0.2204	-0.0763	0.7878	2.60	0.1066
loccode	S	1	0.3606	0.1009	0.1628	0.5585	12.76	0.0004
loccode	SAB	1	0.1637	0.1373	-0.1055	0.4329	1.42	0.2332
loccode	SB	1	-0.0767	0.2110	-0.4901	0.3368	0.13	0.7163
loccode	TP	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
year	8	265.95	<.0001
month	4	37.18	<.0001
loccode	9	36.33	<.0001

TABLE 6: Results of the procedure to develop the positive catch rate model (random effects). A difference of greater than 3.84 between the –2*log likelihood estimators of the complete model (*i.e.* including the random variate) and the reduced model (*i.e.* dropping the random variate) was considered significant. Random effects which did not meet this criteria are not shown.

FINAL POSITIVE CATCH RATE MODEL: **YEAR+MONTH+LOCCODE** (fixed effects)+**YEAR*LOCCODE**+**YEAR*MONTH** (random effects)

MODEL	–2*log likelihood estimator	–2*log likelihood difference
YEAR+MONTH+LOCCODE (fixed effects)	1701.3	.
YEAR+MONTH+LOCCODE (fixed effects) + **YEAR*LOCCODE** (random effect)	1673.5	27.8
YEAR+MONTH+LOCCODE (fixed effects) +**YEAR*LOCCODE**+**YEAR*MONTH** (random effects)	1667.0	6.5

TABLE 7: Relative Abundance Indices for Young-of-the-Year Gag in the Gulf of Mexico (based upon the Seagrass Trawl Survey)

YEAR	INDEX	LCI	UCI	CV
1991	2.596	1.015	4.178	0.311
1992	0.273	-0.056	0.602	0.615
1993*	4.632	1.765	7.500	0.316
1994	0.020	-0.115	0.156	3.422
1995	0.341	0.032	0.650	0.463
1996	0.311	-0.002	0.623	0.513
1997	0.267	-0.014	0.547	0.536
1998	0.226	-0.112	0.564	0.762
1999	0.334	-0.130	0.798	0.709

*1993 calculated assuming proportion positive =1.0 with variance=0.0

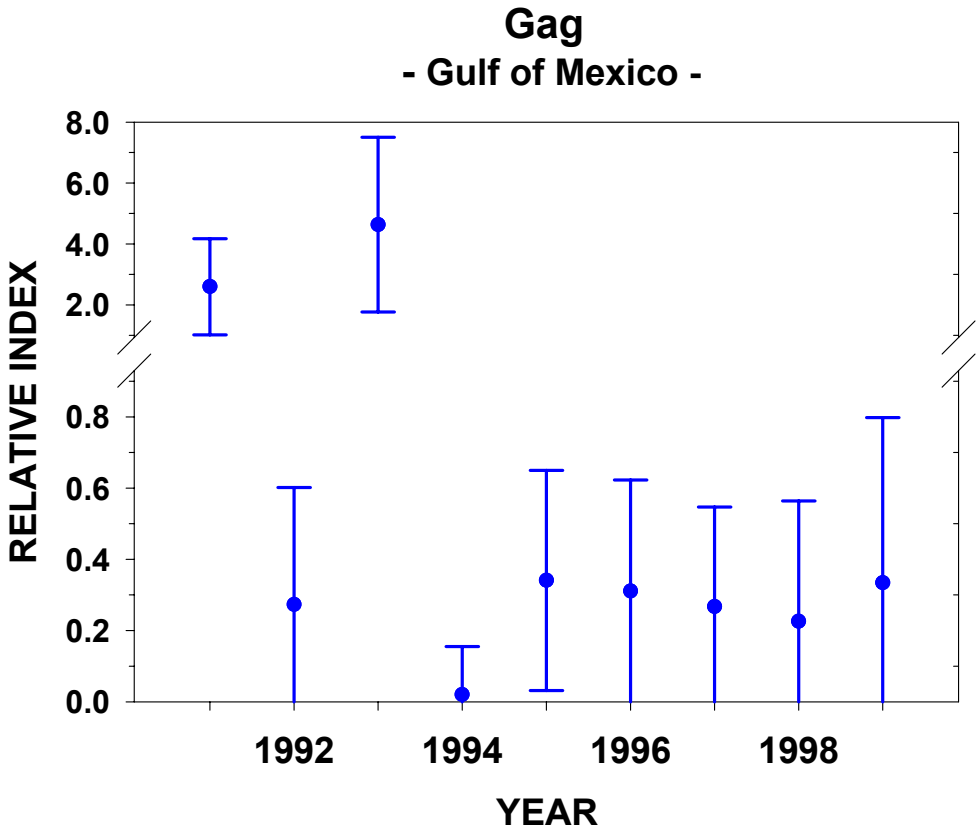

FIGURE 2. Relative abundance indices for young-of-the-year gag in the Gulf of Mexico with approximate 95% confidence intervals.
Proportion Positive Model = YEAR+LOCCODE (success, error distribution: binomial)
Positive Trip Model= YEAR+MONTH+LOCCODE+YEAR*LOCCODE+YEAR*MONTH (fish caught per tow, error distribution: Poisson)