Relative indices of abundance for Red drum (*Sciaenops ocellatus*) inhabiting estuarine waters along the Atlantic coast of Florida, 1997-2014.

Mike Murphy
Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
100 8th Avenue SE, St. Petersburg, FL 33701

October 10, 2014 DRAFT

Introduction

Indices of relative abundance for young-of-the-year and subadult red drum were developed using catch rate and environmental data collected during fishery-independent surveys made along the Atlantic coast of Florida during. The Florida Fish and Wildlife Commission's Fish and Wildlife Research Institute scientists conduct monthly monitoring of Florida's inshore fish stocks in the Indian River Lagoon and the St. Johns River/Nassau Sound estuaries using a variety of gears (McMichael et al. 2014).

Methods

A detailed description of the survey program is provided in the FWC-FWRI Fishery Independent Monitoring Program's annual reports (e.g., McMichael et al. 2014). In developing indices of abundance for red drum data for young-of-the-year (≤ 40 mm SL) that were collected in stratified-random 21.3-m seine samples were examined. Observations were restricted to a fall/winter recruitment window of September through the following March. These indices were designated as the January 1 year included in the sample period, i.e., the September 1995-March 1996 was designated the 1996 index. An additional index of abundance was derived for subadult red drum, restricting the analysis to catches made using 183-m hauls seines that were also deployed monthly using a stratified random design. This analysis included all fish 300 mm SL and larger.

Standardized catch rates were estimated using a delta lognormal modeling approach (Lo et al.20XX) to account for the effect of environmental variables, location, and time on the availability of red drum and isolate the year effect as an index of true abundance change. Factors utilized in the model development were surface temperature and salinity, bay-zone location (approximate ecological zones set as part of sampling design and logistics) , year, month, bottom type category (mud or sand), bottom vegetation type (submerged aquatic vegetation, other), shore category (emergent vegetation, terrestrial managed, other), gr (various 21-m seine configurations), and effort (area coverage).

Standardized indices of abundance were calculated using a generalized linear modeling procedure that combined the analysis of the binomial information on presence/absence with the lognormal-distributed positive catch data (also known as two-part, hurdle, or zero-adjusted models, Zuur et al. 2009) as:

$$I_y = c_y p_y$$

where c_y are estimated annual mean catch rate for non-zero catches modeled as lognormal distributions and p_y are estimated annual mean probabilities of capture modeled as binomial distributions. The lognormal submodel considers only sets in which a red drum was caught (*i.e.*,

non-zero catches). The binomial model considers all sets. To determine the most appropriate submodels, categorical and covariates were sequentially added to a null model which included year. The factor resulting in the largest decline in deviance per degree of freedom (dev/df) was added to the model for the next step in the evaluation if the dev/df was reduced by at least 0.5% of the base model dev/df. We assume that there were no significant interaction terms with year in this model and consider only the main effects. The final year-specific marginal means estimates and standard errors of the two sub-models were used to generate distributions of estimates for each sub-model from a Monte Carlo simulation (5000 Student's t distributed realizations). The product of these distributions provided an estimate of the median catch rate with year-specific variability. . All analyses were done using R 3.0.1 (R Core Team 2013).

Results and Discussion

The number of gear sets, mean catch rate, and its standard deviation each year for each index in given in Table 1. Table 2 provides a summary of the standardized indices.

The significant factors included in the young-of the-year red drum index, other than year which was part of the null model, were: for binomial, bay zone and month; for lognormal, bay zone, month, and bottom type. A consistently high proportion of sets made in the survey each year did not catch young-of-the-year red drum and the catch distribution was highly skewed (Table 2, Fig. 1). Diagnostics for the model fit showed some skew in the residuals but a q-q plot of the standard ordered residuals didn't show a gross violation of the assumptions of normality (Fig. 2). Young-of-the-year red drum along the Florida coast fluctuated in abundance during 1998-2013 showing a peak in 2005 (fish hatched in late 2004). Recruitment in 2013 appeared to rebound from two consecutive years with low abundance (Fig. 4).

The significant factors included in the subadult red drum index were: for binomial, bay zone, month, shore type, and bottom type; for lognormal, bay zone, month, and shore type type. The distribution of survey catches was skewed less than that for young-of-the-year with, on average, 21% of the annual sets containing subadult red drum (Table 2, Fig. 1). Diagnostics for the model fit showed some skew in the residuals but a q-q plot of the standard ordered residuals showed only a slight deviation from linearity (indicating normality) for the lognormal model, though a larger violation of that assumption for the binomial show (Fig. 3). Subadult red drum along the Florida coast fluctuated in abundance during 1997-2003, increased slightly during the mid-2000's before declining in abundance through 2013, except for 2012 (Fig. 4).

The nominal data for both indices fell within the estimated 95% confidence bands for the standardized index (Fig. 4)

References

Bodenhofer U, A Kothmeier, and S Hochreiter. 2011. APCluster: an R package for affinity propagation clustering. Bioinformatics 27:2463-2464. DOI: 10.1093/bioinformatics/btr406.

McMichael, R.J. and others. 2014. Fisheries-Independent Monitoring Program 2013 Annual Data Summary Report. Florida Fish and Wildlife Conservation Commission FWRI In-House Report IHR 2014-XX. St Petersburg.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Zuur, AF, EN Ieno, NJ Walker, AA Saveliev, GM Smith. 2009. Mixed effects models and extensions in ecology with R. Springer Science+Business Media, New York NY. 574pp.

Tables

Table 1. Observed catch rate (numbers) per gear set for young-of-the-year (<=40 mm SL) and for subadult (>=300 mm SL) red drum captured during fishery-independent monitoring surveys along the Florida Atlantic coast's inland waters.

	YOY			Subadults		
Year	N	Mean	SE	N	Mean	SE
1997				364	0.60	0.092
1998	140	0.34	0.211	434	0.73	0.118
1999	204	3.29	0.989	420	0.49	0.064
2000	252	0.97	0.621	420	0.55	0.064
2001	238	1.50	0.629	539	0.46	0.061
2002	458	0.77	0.197	602	0.52	0.065
2003	464	1.65	0.458	613	0.47	0.060
2004	465	2.28	0.825	614	0.51	0.056
2005	518	2.17	0.375	610	0.58	0.071
2006	632	0.71	0.193	611	0.68	0.132
2007	630	1.09	0.322	614	0.57	0.061
2008	642	1.11	0.332	592	0.63	0.116
2009	658	1.48	0.368	564	0.56	0.135
2010	658	1.30	0.388	564	0.44	0.049
2011	658	0.60	0.247	564	0.52	0.078
2012	595	0.34	0.109	564	0.62	0.098
2013	595	0.57	0.099	564	0.41	0.073

Table 2. Standardized index of abundance for the young-of-the-year red drum and subadults on the Atlantic coast of Florida. Year given for young of the year is the January 1 date year just after the spawning season.

Young of the Year

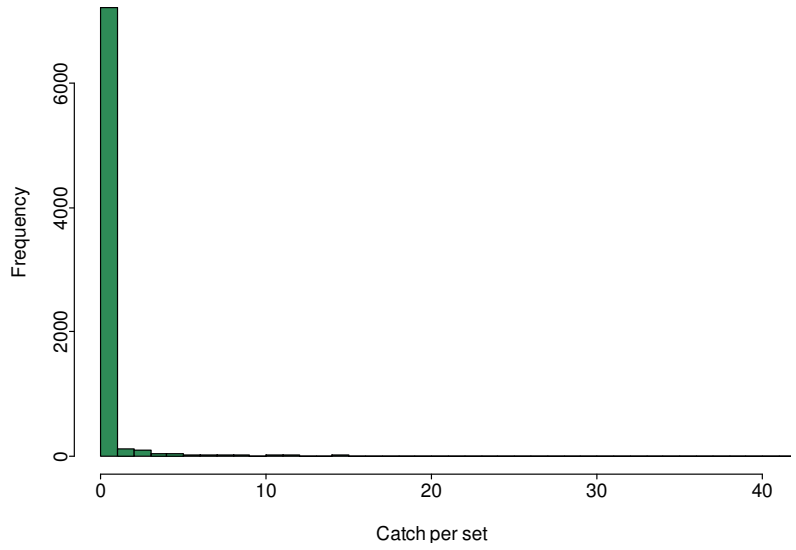
year	Total num sets	Num positive	Mean	std.dev	CV
1998	88	6	0.088	0.0849	0.9600
1999	148	32	0.286	0.1187	0.4158
2000	196	24	0.074	0.0340	0.4611
2001	182	36	0.150	0.0567	0.3782
2002	390	44	0.145	0.0478	0.3300
2003	400	69	0.313	0.0829	0.2644
2004	409	63	0.262	0.0742	0.2835
2005	462	98	0.425	0.0976	0.2296
2006	464	56	0.113	0.0337	0.2992
2007	462	63	0.212	0.0588	0.2768
2008	474	57	0.173	0.0510	0.2951
2009	490	73	0.224	0.0586	0.2623
2010	490	80	0.228	0.0568	0.2492
2011	490	47	0.084	0.0277	0.3287
2012	425	41	0.078	0.0269	0.3451
2013	427	58	0.167	0.0487	0.2912

Subadult

year	Total num sets	Num positive	Mean	std.dev	CV
1997	364	73	0.238	0.0360	0.1510
1998	434	91	0.270	0.0371	0.1373
1999	420	100	0.235	0.0309	0.1312
2000	420	106	0.281	0.0360	0.1281
2001	539	97	0.224	0.0290	0.1293
2002	602	134	0.283	0.0308	0.1086
2003	613	112	0.241	0.0290	0.1203
2004	614	137	0.286	0.0307	0.1072
2005	610	140	0.300	0.0319	0.1062
2006	611	114	0.278	0.0322	0.1158
2007	614	144	0.320	0.0334	0.1046
2008	592	129	0.280	0.0311	0.1110
2009	564	102	0.221	0.0280	0.1269
2010	564	119	0.233	0.0267	0.1148
2011	564	121	0.241	0.0280	0.1162
2012	564	123	0.290	0.0326	0.1123
2013	564	104	0.182	0.0229	0.1252

Figures

Young-of-the-year



Subadults

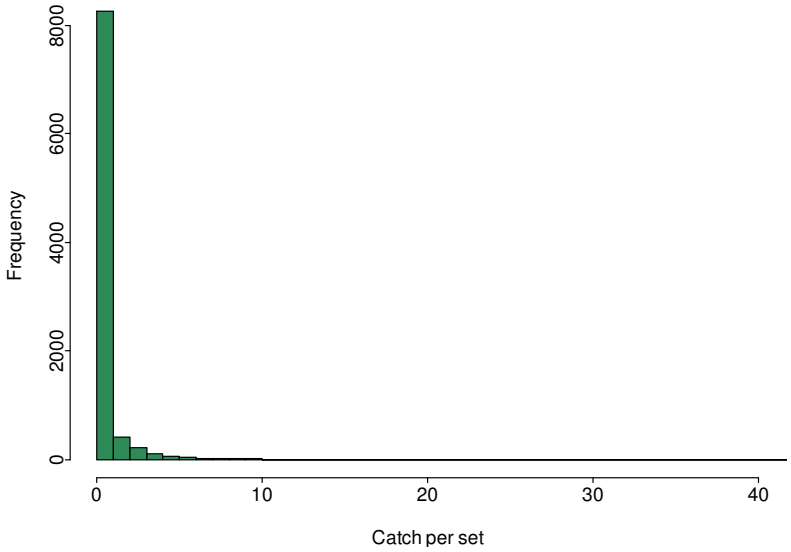


Figure 1. Frequencies for the number of red drum caught per set using 21.3-m seines (young-of-the-year) and using 183-m haul seines (subadults) deployed in inland waters along the Atlantic coast of Florida during 1997-2013.

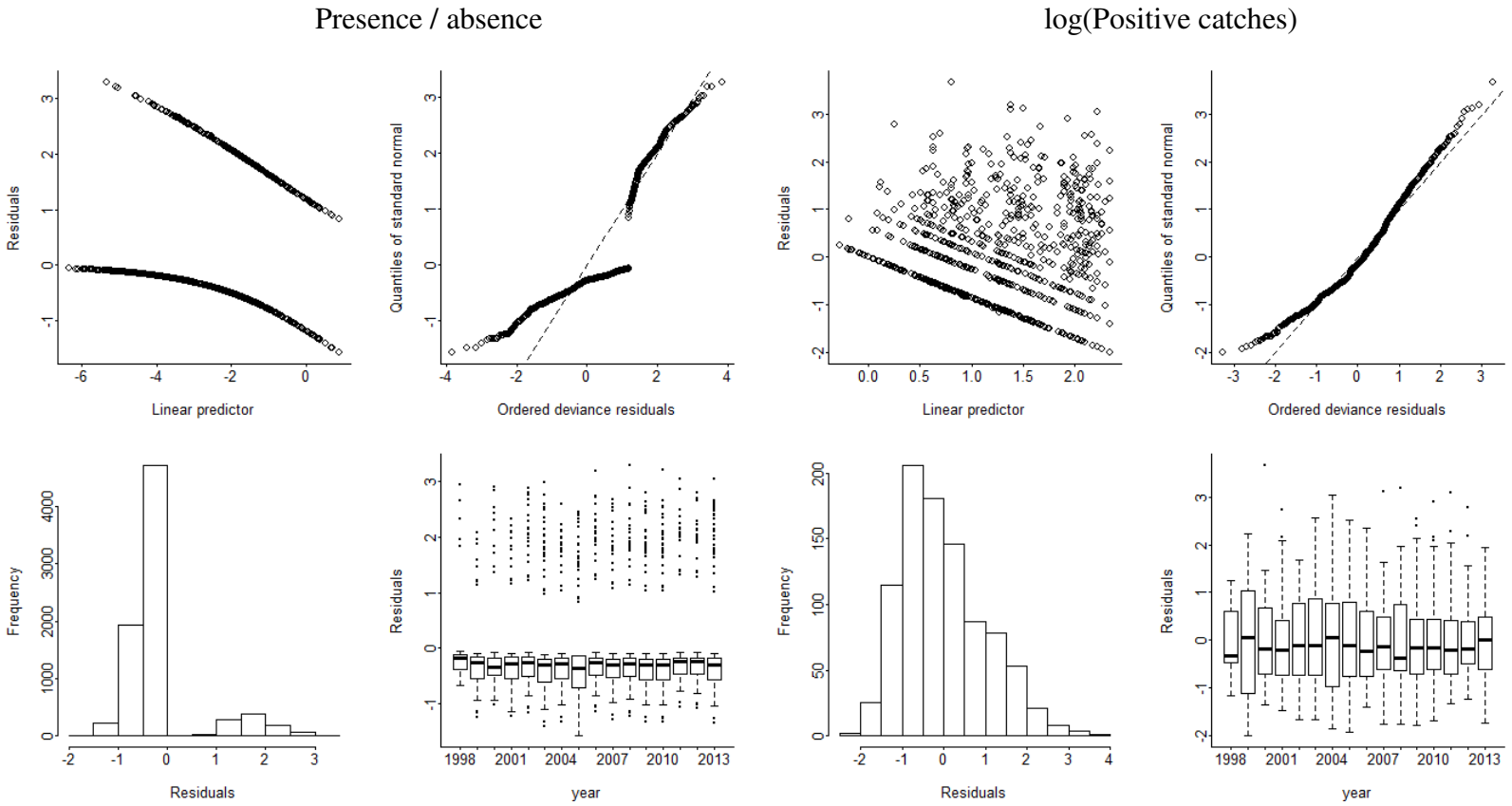


Figure 2. Diagnostic plots from the binomial and lognormal components of the young-of-the-year delta lognormal model used to estimate year-specific marginal means (lsmeans).

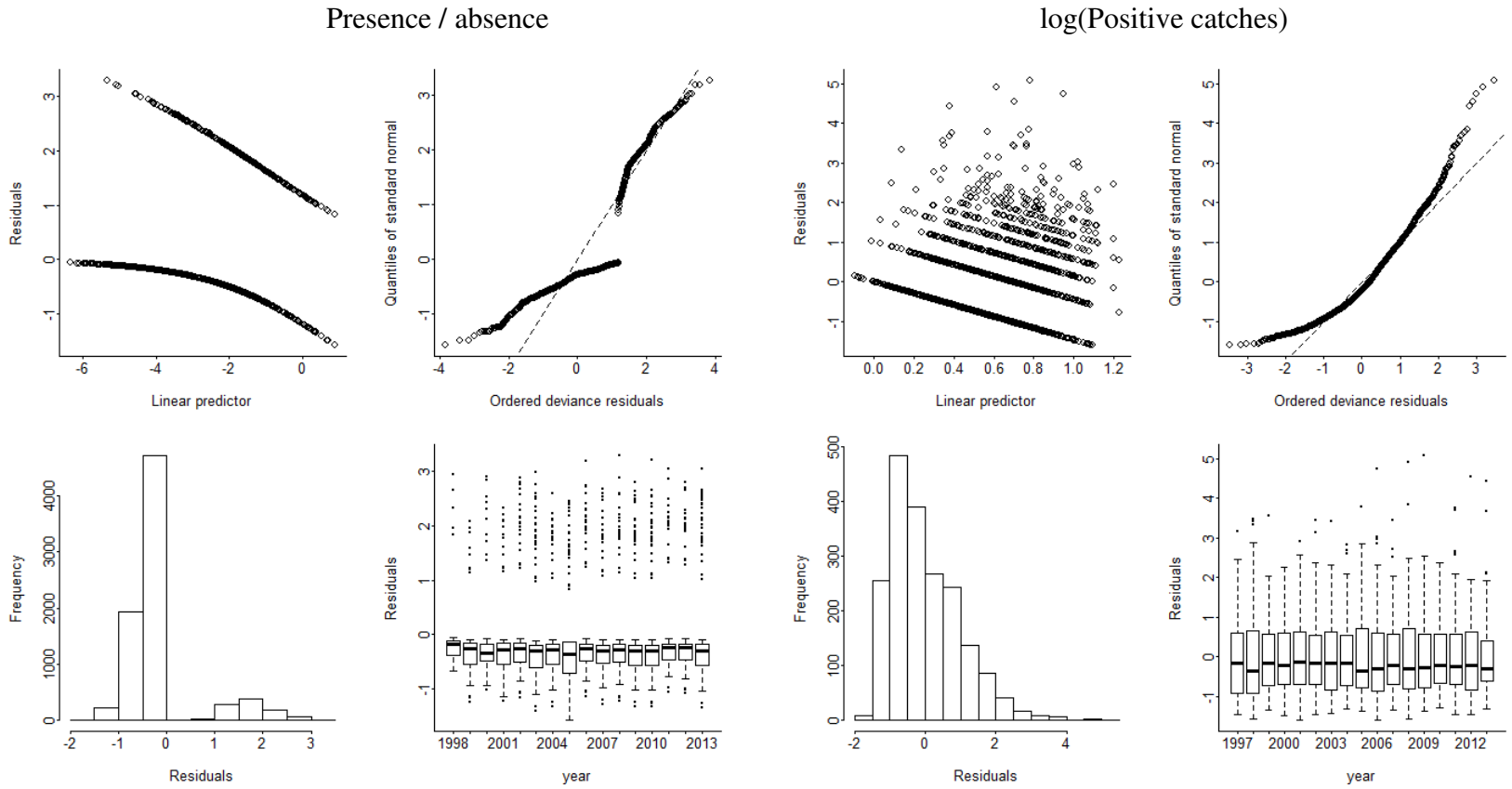


Figure 3. Diagnostic plots from the binomial and lognormal components of the subadult delta lognormal model used to estimate year-specific marginal means (lsmeans).

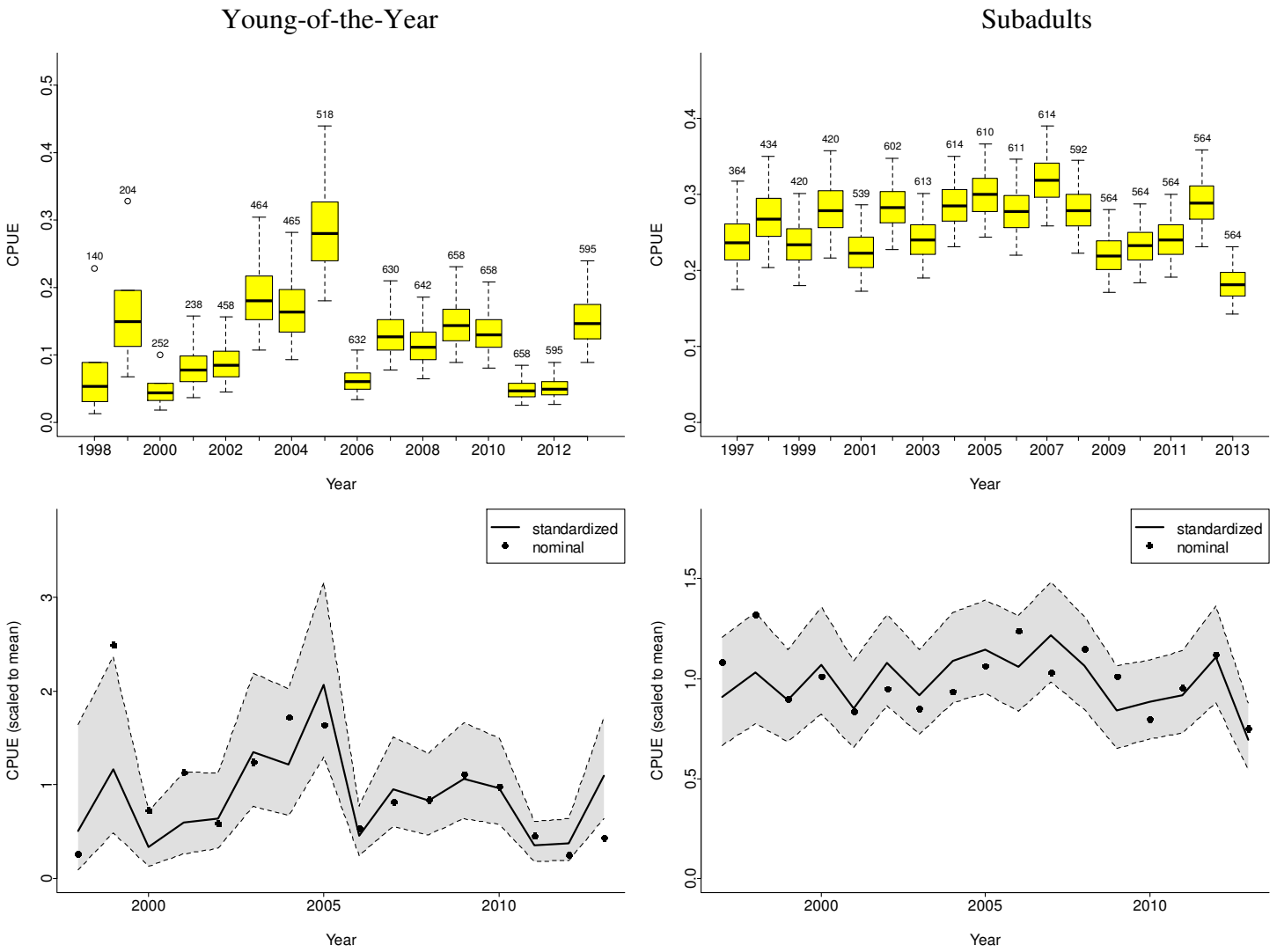


Figure 4. Standardized index of abundance for young-of-the-year (left) and subadult (right) red drum from Florida Atlantic estuarine waters, 1997-2013. Top graph shows Monte Carlo distribution of index and sample size. Lower graphs show the standardized index (line) with 95% confidence bounds (shaded) and the nominal means (points) relative to the overall time series mean.