Standardization of commercial catch per unit effort of hogfish (*Lachnolaimus maximus*) from South Carolina Trip Ticket landings, 2004-2012

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Introduction

An index of relative abundance was developed from the South Carolina Trip Ticket database for hogfish using data from 2004-2012. Appropriate zero-catch trips were identified by cluster analyses, and data were analyzed using a delta-lognormal GLM model to standardize the catch per unit effort.

Methods

Identification of Appropriate Surveys

To identify those commercial trips that were appropriate for catching hogfish, a cluster analysis was conducted to identify species often caught in association with hogfish. By identifying those trips that caught associated species but failed to catch hogfish, one can infer zero-catch trips that were appropriate to include in the analysis. The data was filtered to remove all uncommon species that occurred on only a small proportion of the total trips and in particular those species that were rarely caught with hogfish. Affinity propagation clustering (APC) was chosen to determine associated species, because it has been shown to perform well relative to other cluster techniques and does not require that the number of cluster be pre-specified (Frey and Dueck 2007). APC automatically chooses an optimal number of clusters in the dataset, thereby providing an objective criterion for which to group associated species. For the APC procedure, the Bray measure of similarity was used where data were converted to presence/absence of landings for each species and fishing trip. Once the associated species within the hogfish cluster were identified, all trips on which these species were caught for a specific gear type were used as suitable valid trips in the subsequent analyses. The APC technique was done in R 3.0.1 (R Core Team 2013) using the apcluster package (Bodenhofer et al. 2011).

Standardization Model

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:

$$I_y = c_y p_y \quad [1]$$

where c_y are estimated annual mean CPUEs of 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 trips in which a hogfish was caught (*i.e.*, non-zero catches). The binomial model considers all trips in which hogfish or associated species were caught. While other approaches exist to model zero-inflated data (i.e., Poisson and negative binomial distributions; zero-inflated models; Zuur et al. 2009), the two-part model used here is advantageous in that it provides inferences on both the presence-absence and abundance processes occurring within a population, and can easily accommodate different predictor variables for each sub-model in the statistical analysis.

To determine the most appropriate models, predictor variables were selected using a forward step-wise approach where each predictor was added to each submodel individually and the resulting reduction in deviance per degree of freedom (Dev/DF) analyzed. The factor causing the greatest reduction in Dev/DF was then added to the base model. Year was retained in all models to obtain an index of abundance over time. Other potential predictors included month and days fished. Criteria for model inclusion also include a reduction in Dev/DF≥0.5%. This process was then repeated until no factor met criteria for model inclusion. 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 (eq. 1) 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

Identification of Valid Commercial Trips

The APC procedure selected 19 clusters from a total of 108 species. The species group in which hogfish clustered comprised the largest cluster with a total of 27 other species (Table 1), including other reef fish species (groupers, snappers).

Standardization Model

The results from the forward-stepwise model selection procedure are presented in Tables 2 and 3. The final predictor variables for each model component were year, days fished, and month for the binomial model, and year and month for the positives model; each explaining greater than 0.5 % of the residual deviance/DF in the deviance tables (percent.reduction column). Figures 2-3 present the diagnostics plots for each component model. In general, the positives model had a moderate fit using a lognormal distribution, where the model did not handle well the large and relatively rare catches on some trips (Figure 1), leading to a positively skewed distribution in the residuals (Figure 3). The standardized CPUE (index of abundance) is presented in Table 4 and Figure 4. Overall the index had a moderately low coefficient of variation (CV) of 15 %. The abundance was relatively stable over the eight year period, with three separate peaks in 2006, 2008, and 2011.

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.

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. Species cluster for hogfish in the South Carolina Trip Ticket program using all gears combined.

APC Cluster Species
African Pompano
Amberjack
Banded Rudderfish
Black Sea Bass Unclassified
Cobia
Dolphin
Grouper Gag
Grouper Red
Grouper Snowy
Grouper Yellowfin
Grunt White
Hind Rock
Hogfish
Jack Almaco
King Mackerel
Porgy Knobbed
Porgy Red Large
Scamp
Snapper Cubera
Snapper Mutton
Snapper Red
Snapper Vermilion Large
Snapper Vermilion Medium
Snapper Vermilion Small
Snapper Yellowtail
Triggerfishes
Unclassified For Food
Wahoo

Table 2. Deviance table for the binomial component of the SC commercial Trip Ticket CPUE model. The null model with year as a predictor is listed as step 0, and subsequent steps list the most predictive factors.

Step	Variable	Deviance	Resid. Df	Resid. Dev	AIC	percent.reduction
0	year	NA	8411	8286.272	8306.272	0
1	days_fish	384.8195	8409	7901.453	7925.453	4.621381
2	month	65.01675	8398	7836.436	7882.436	0.660916

Table 3. Deviance table for the positives component of the SC commercial Trip Ticket CPUE model. The null model with year as a predictor is listed as step 0, and subsequent steps list the most predictive factors.

Step	Variable	Deviance	Resid. Df	Resid. Dev	AIC	percent.reduction
0	year	NA	1635	2394.716	5308.045	0
1	month	71.99672	1624	2322.719	5279.83	2.349507

Table 4. Standardized index of abundance from the SC commercial Trip Ticket CPUE model.

year	Total.num.trips	Num.pos	Mean	std.dev	CV
2004	870	165	1.845741	0.264268	0.143177
2005	844	162	2.069867	0.296465	0.143229
2006	915	200	2.792795	0.376814	0.134924
2007	1047	199	1.925927	0.26253	0.136313
2008	1019	248	3.067773	0.373736	0.121826
2009	853	152	2.126086	0.318356	0.149738
2010	743	129	2.595884	0.428779	0.165177
2011	757	163	3.086009	0.459381	0.148859
2012	765	125	1.669052	0.276312	0.16555

Figures

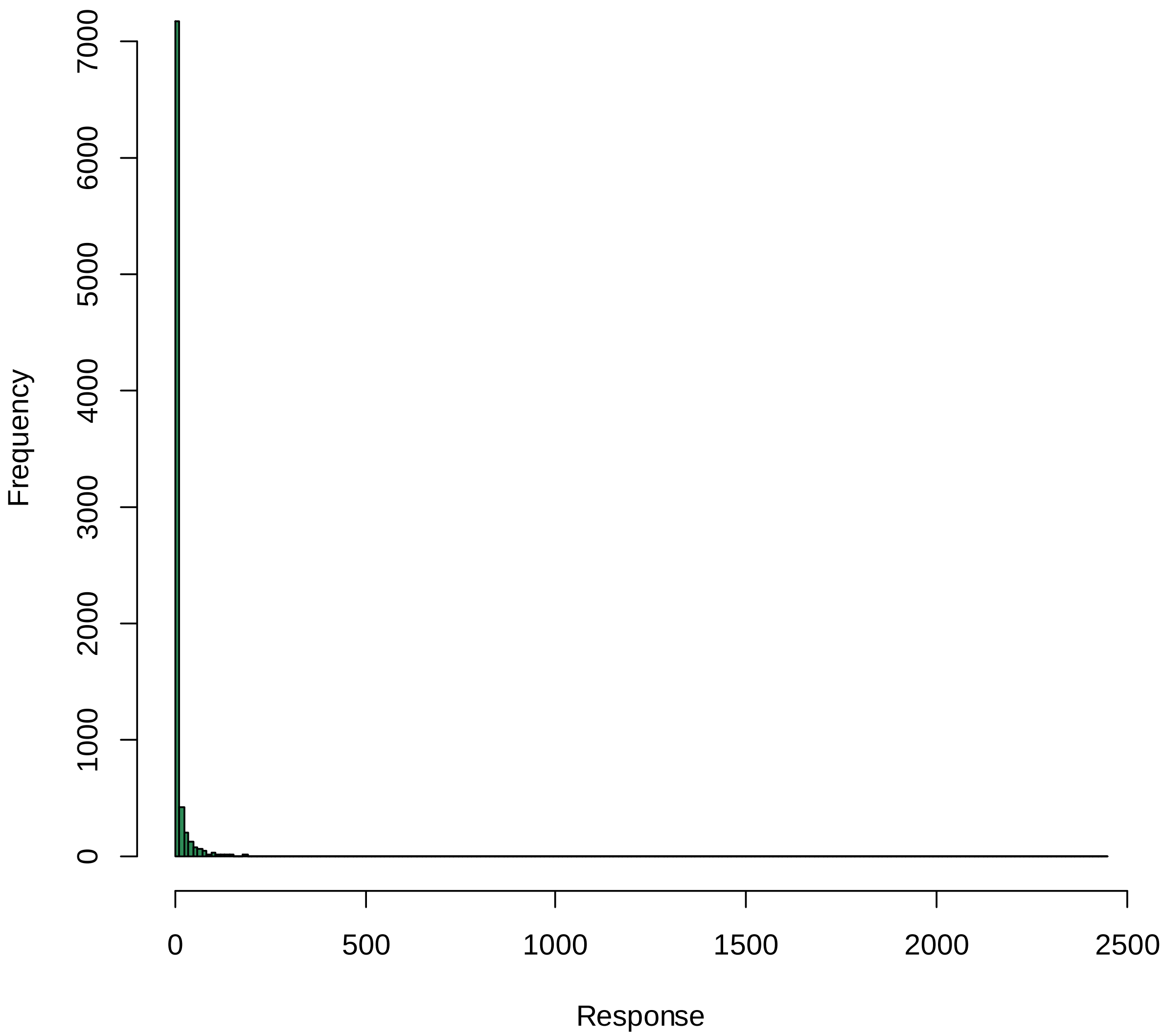

Figure 1. Frequency of the pounds of hogfish landed per trip for all gears in the South Carolina Trip Ticket data.

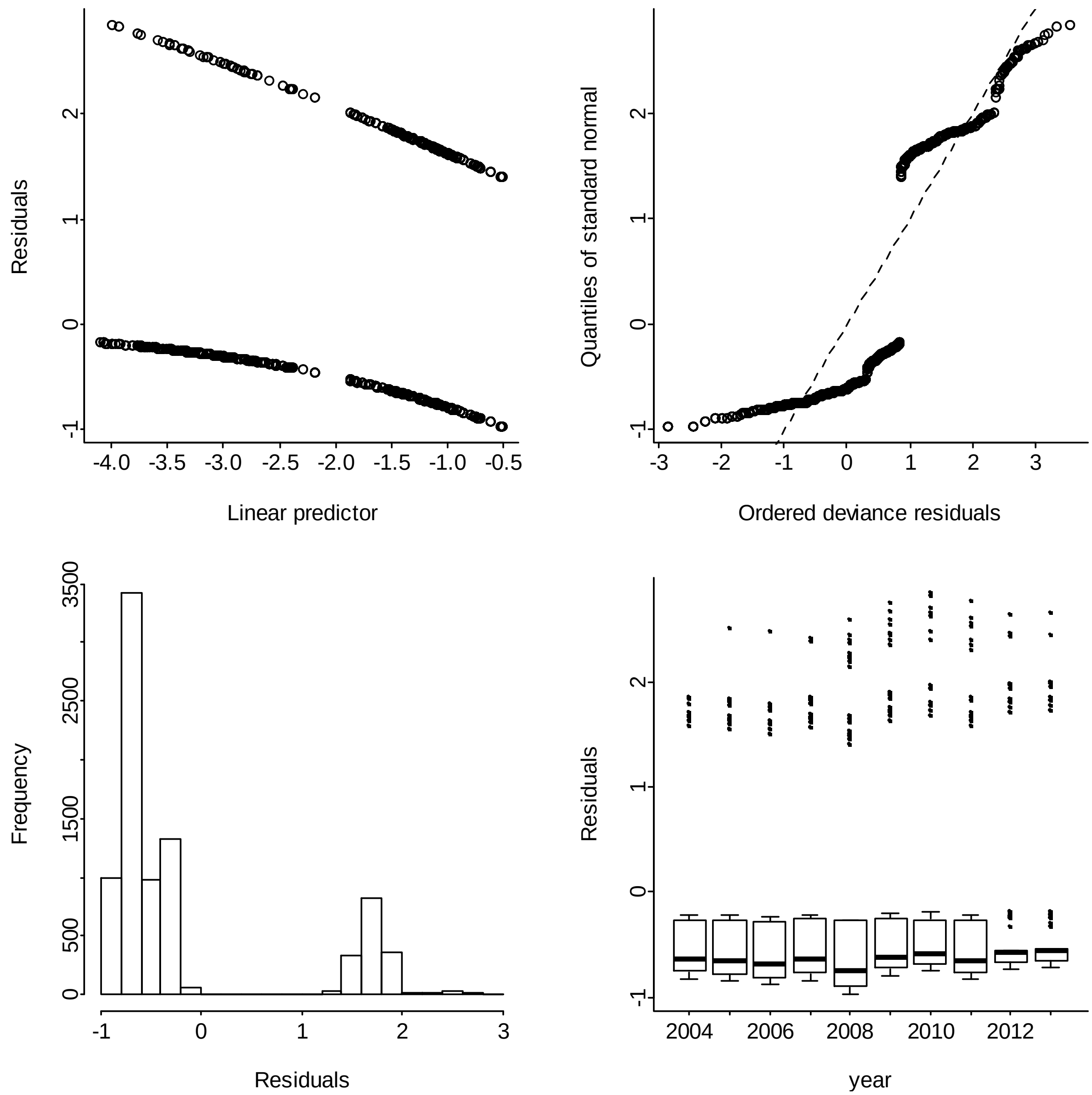

Figure 2. Diagnostic plots from the binomial component of the SC commercial Trip Ticket CPUE model.

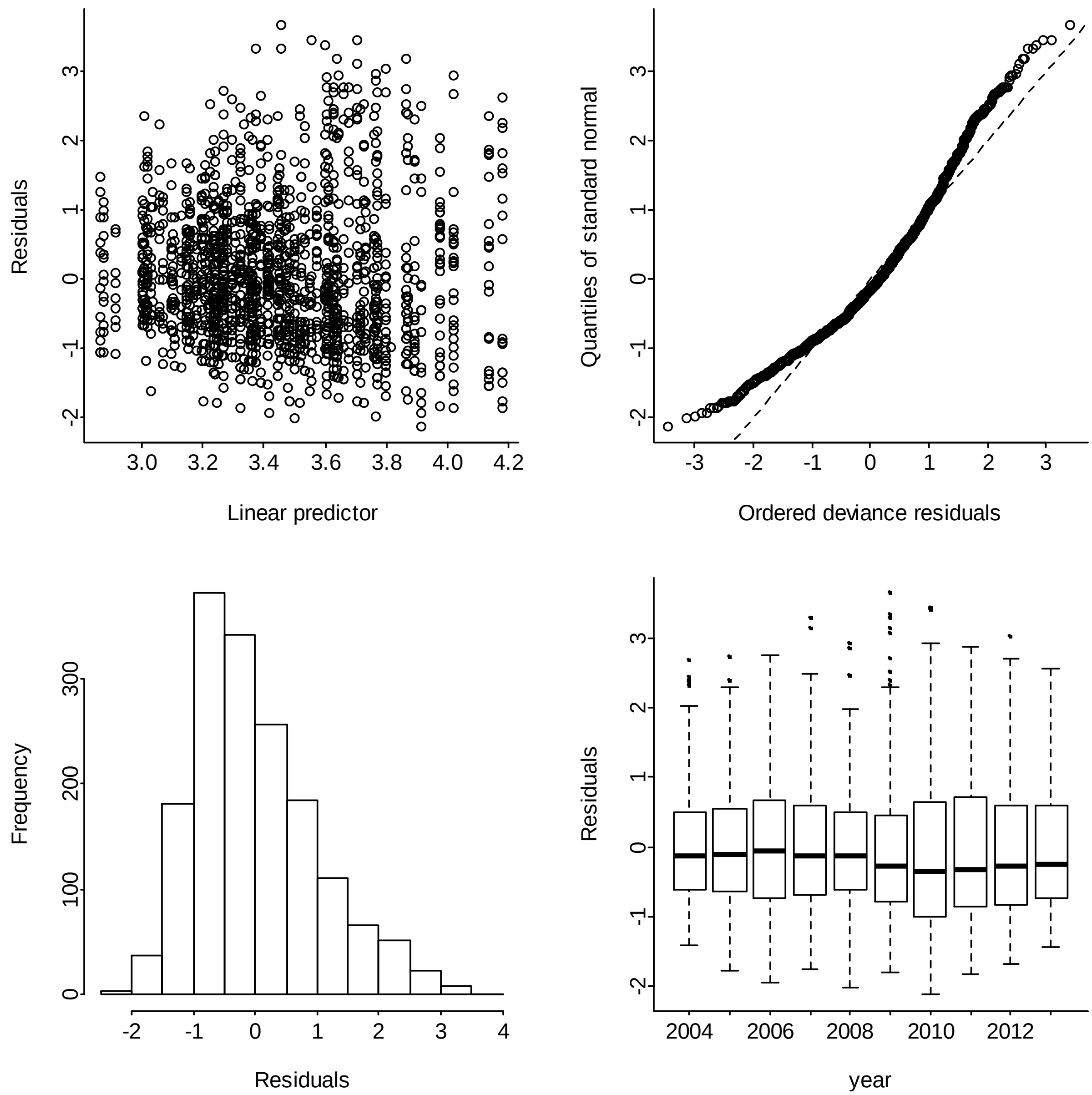

Figure 3. Diagnostic plots from the positives component of the SC commercial Trip Ticket CPUE model.

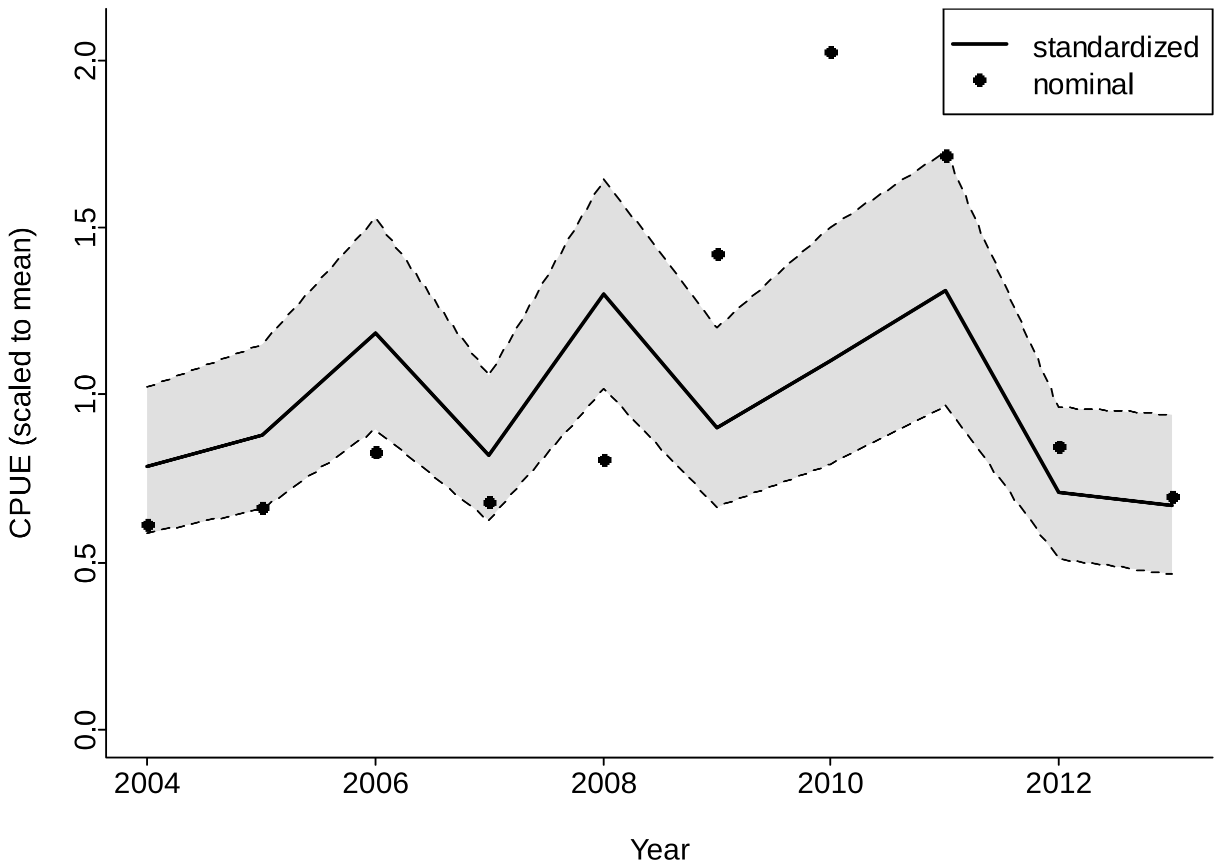

Figure 4. Standardized index of abundance for the SC commercial Trip Ticket CPUE model.