Standardized discard rates of U.S. Atlantic red snapper (*Lutjanus campechanus*) from headboat at-sea observer data

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Background and Data Description

See SEDAR24-DW15 report for background information on the data provided for this index. The data used for this index were all trips in the headboat at-sea observer database which caught red snapper, vermilion snapper, gag, and Warsaw grouper during 2005-2009. The at-sea observer program occurred from 2004-2009 in North and South Carolina, but did not occur in Florida and Georgia in 2004. In addition, after 2007 the Florida Keys were no longer included in the at-sea observer program. Because the core red snapper area was covered by the at-sea observer program from 2005-2009, the index was computed for those years.

Trip-level information included state, county, Florida region, year, month, day, dock to dock hours (total trip hours), the number of hours fished (to the nearest half hour), the total number of anglers on the boat, the number of anglers observed on a trip, the number of red snapper discarded, minimum depth of the fishing trip, and maximum depth of the fishing trip. Depth information was not collected for South Carolina, North Carolina, and Georgia; therefore, it was not used in this analysis.

Methods

Data treatment

Data from 2004 were dropped from the analysis because the data collected did not include Georgia and Florida (the primary location of red snapper). In addition, trips with 30 hours fished or greater were also dropped (4 records total) as these trips likely do not represent trips common in the south Atlantic and are likely trips to the Dry Tortugas.

Subsetting trips

Trips to be included in the computation of the index need to be determined based on effort directed at red snapper. Effort can be determined directly for trips which had positive red snapper catches, but some trips likely directed effort at red snapper, but were unsuccessful at catching red snapper. Total effort was assumed to be any trips which had red snapper, vermilion snapper, gag, or Warsaw grouper catches. These species were chosen as they represented the species most likely to be caught with red snapper when the Stephens and MacCall method (2004) was applied to the full headboat data set for the northern region, which includes Georgia and northern Florida, the core area of red snapper (SEDAR24-DW03). This set of species also agreed with results from assemblage analysis (Shertzer and Williams 2008). The resulting data set, given the methods described above, contained 599 trips and 258 (43%) of those trips were positive for red snapper discards.

Response and explanatory variables
DPUE – Discards per unit effort (DPUE) has units of fish/angler-hour and was calculated as the number of red snapper discarded divided by the product of the number of observed anglers and the number of hours fished.

YEAR – A summary of the total number of trips with red snapper effort per year is provided in Table 1, and a summary of the total number of trips with positive red snapper discards per year is provided in Table 2.

AREA – Area was defined as south Florida, north Florida, and not Florida (which contained Georgia, South Carolina and North Carolina). The total effort by year and area and the proportion of that effort positive for red snapper discards are provided in Figure 1. The total number of trips and the proportion with positive red snapper discards by year and region is provided in Figure 2.

SEASON – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December). The total number of trips with red snapper effort was greatest in spring and summer (Figure 3).

PARTY – Two categories for the number of anglers on a boat were considered in the standardization process. In particular, the categories considered included: small (≤30 anglers) and large (>30 anglers). These categories were the same as those used for the overall headboat index (SEDAR24-DW03). The total number of trips and proportion of trips with positive red snapper discards over time by party size is provided in Figure 4.

DTD – The number of dock to dock hours was included as a factor with ≤8.75 hours representing a shorter trip and >8.75 hours representing a longer trip. This factor indicates trip type.

Standardization
I modeled DPUE using the delta-glm approach (cf., Lo et al. 1992; Dick 2004; Maunder and Punt 2004). In particular, I compared fits of lognormal and gamma models for positive DPUE, and examined which combination of predictor variables best explained DPUE patterns (both for positive DPUE and 0/1 DPUE). Jackknife estimates of variance were computed using the 'leave one out' estimator (Dick 2004). All analyses were performed in the R programming language, with much of the code adapted from Dick (2004).

BERNOULLI SUBMODEL
One component of the delta-GLM is a logistic regression model that attempts to explain the probability of either discarding or not discarding red snapper on a particular trip. First, I fit a model with all main effects in order to determine which effects should remain in the binomial component of the delta-GLM. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit (Appendix 1). In this case, the stepwise AIC procedure removed season and party as predictor variables. Recognizable patterns were not apparent in the randomized quantile residuals (Figure 5).

POSITIVE CPUE SUBMODEL

Then, to determine predictor variables important for predicting positive DPUE, I started by fitting the positive portion of the model with all main effects using both the lognormal and gamma distributions. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit (Appendix 1). All predictor variables were modeled as fixed effects (and as factors rather than continuous variables). Backwards model selection eliminated the dock to dock (DTD) variable for both the lognormal distribution and the gamma distribution.

I then fit both components of the model together (with the code adapted from Dick 2004) using the lognormal and gamma distributions and compared them using AIC. With DPUE as the dependent variable, the lognormal distribution (AIC: -253.3) outperformed the gamma distribution (AIC: -236.5) with lower AIC values when using only those factors that were selected in the previous steps.

Thus, the lognormal model with all factors except for the variable DTD was used for computing the positive component of the index, and the binomial with year, region, and DTD was used for computing the Bernoulli component of the index. Standard model diagnostics (Figure 6) appeared reasonable for the positive component of the model using raw residuals. The distribution of total effort (angler-hours), the proportion of positive effort, and the number of red snapper discards by factor in the headboat at sea observer data set used to construct the standardized index are presented in Table 3.

Index

The distribution of log DPUE for the index appeared reasonable (Figure 7), as did the QQ plot of the residuals (Figure 7). The index is presented in Table 4 and visually in Figure 8.

LITERATURE CITED

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Shertzer, K.W. and E.H. Williams. 2008. Fish assemblages and indicator species: reef fishes off the southeastern United States. Fish. Bull. 106:257-269.

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

Venables, W. N. and B. D. Ripley. 1997. Modern Applied Statistics with S-Plus, 2nd Edition. Springer-Verlag, New York.

Table 1. The number of trips by area across years that were observed at sea where notFL contains North Carolina, South Carolina, and Georgia; nFL is northern Florida; and sFL is southern Florida.

Year	notFL	nFL	sFL
2005	60	40	45
2006	48	34	26
2007	47	48	25
2008	38	48	28
2009	31	51	30

Table 2. The proportion of trips by area across years that had positive red snapper discards (notFL contains North Carolina, South Carolina, and Georgia; nFL is northern Florida; and sFL is southern Florida).

YEAR	notFL	nFL	sFL
2005	0.03	0.83	0.22
2006	0.08	0.76	0
2007	0.21	1	0.28
2008	0.26	0.92	0.29
2009	0.29	0.88	0.07

Table 3. Distribution of total effort (angler-hours), proportion effort positive, and discards by factor in the headboat at sea observer data set used to construct the standardized index.

Factor	Effort (angler hours)	Proportion positive	Discards
Year			
2005	9861	0.41	569
2006	6482	0.38	731
2007	7812	0.61	1650
2008	8177	0.67	1710
2009	7162	0.53	457
Season			
fall	8688.5	0.56	1936
spring	12707	0.49	1047
summer	11401.5	0.44	811
winter	6697	0.66	1323
Region			
nFL	18620.5	0.90	4858
notFL	11561.5	0.17	137
sFL	9312	0.20	122
Party size			
large	20823	0.54	2325
small	18671	0.50	2792

Table 4. The relative nominal DPUE, number of trips with positive effort, portion of trips with positive red snapper discards, standardized index, and CV for the red snapper headboat at sea observer data in the south Atlantic.

Year	Relative nominal DPUE	N	Proportion N positive	Standardized index	CV (index)
2005	0.440728	145	0.310345	0.555157	0.295791
2006	0.861367	108	0.277778	0.407914	0.367245
2007	1.613249	120	0.541667	2.017621	0.166459
2008	1.597283	114	0.54386	1.388151	0.207791
2009	0.487373	112	0.5	0.631157	0.268994

Figure 1. Total effort and the proportion of effort with red snapper discards by area.

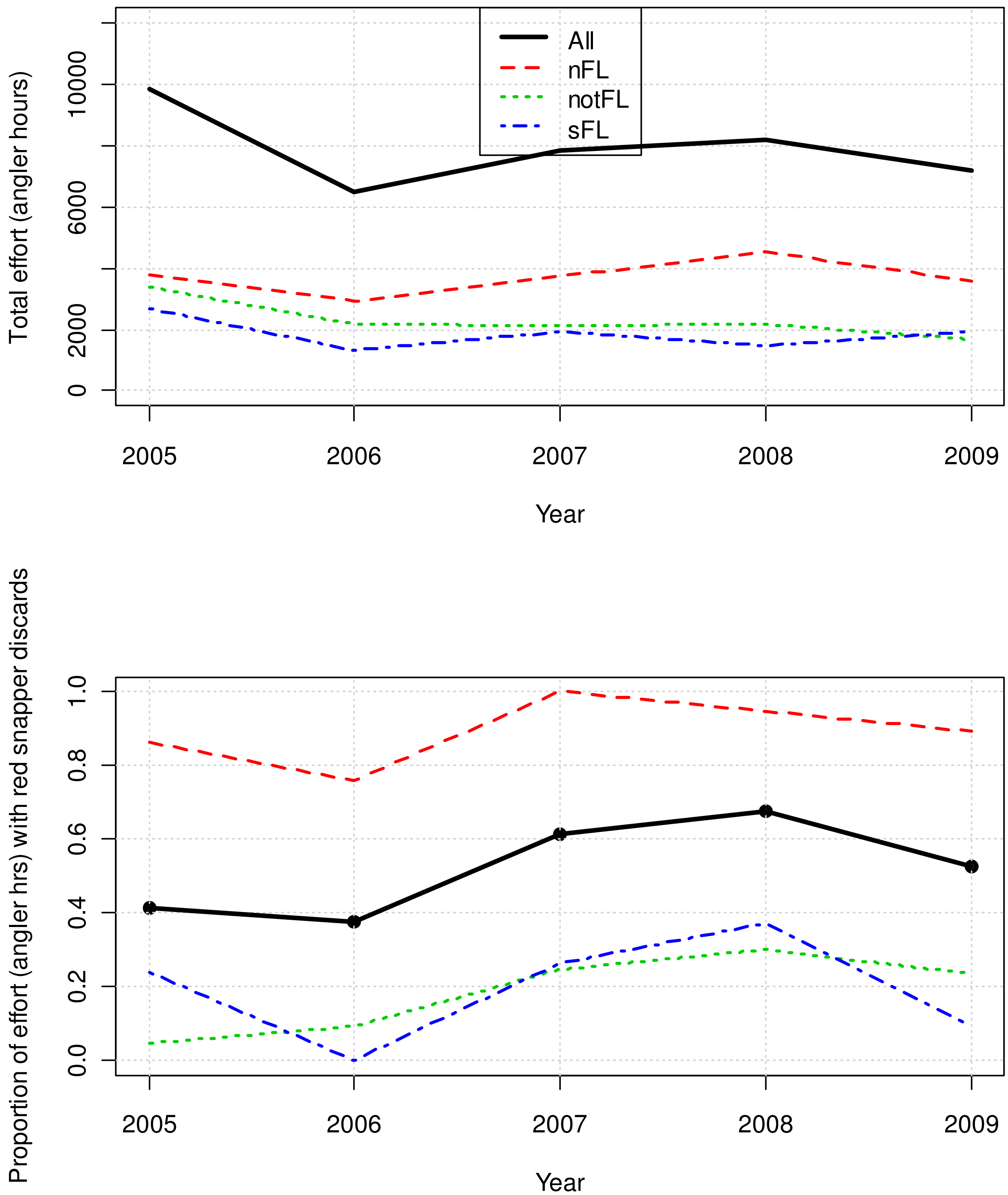


Figure 2. The total number of trips by area and the proportion of those trips that were positive for red snapper discards by area.

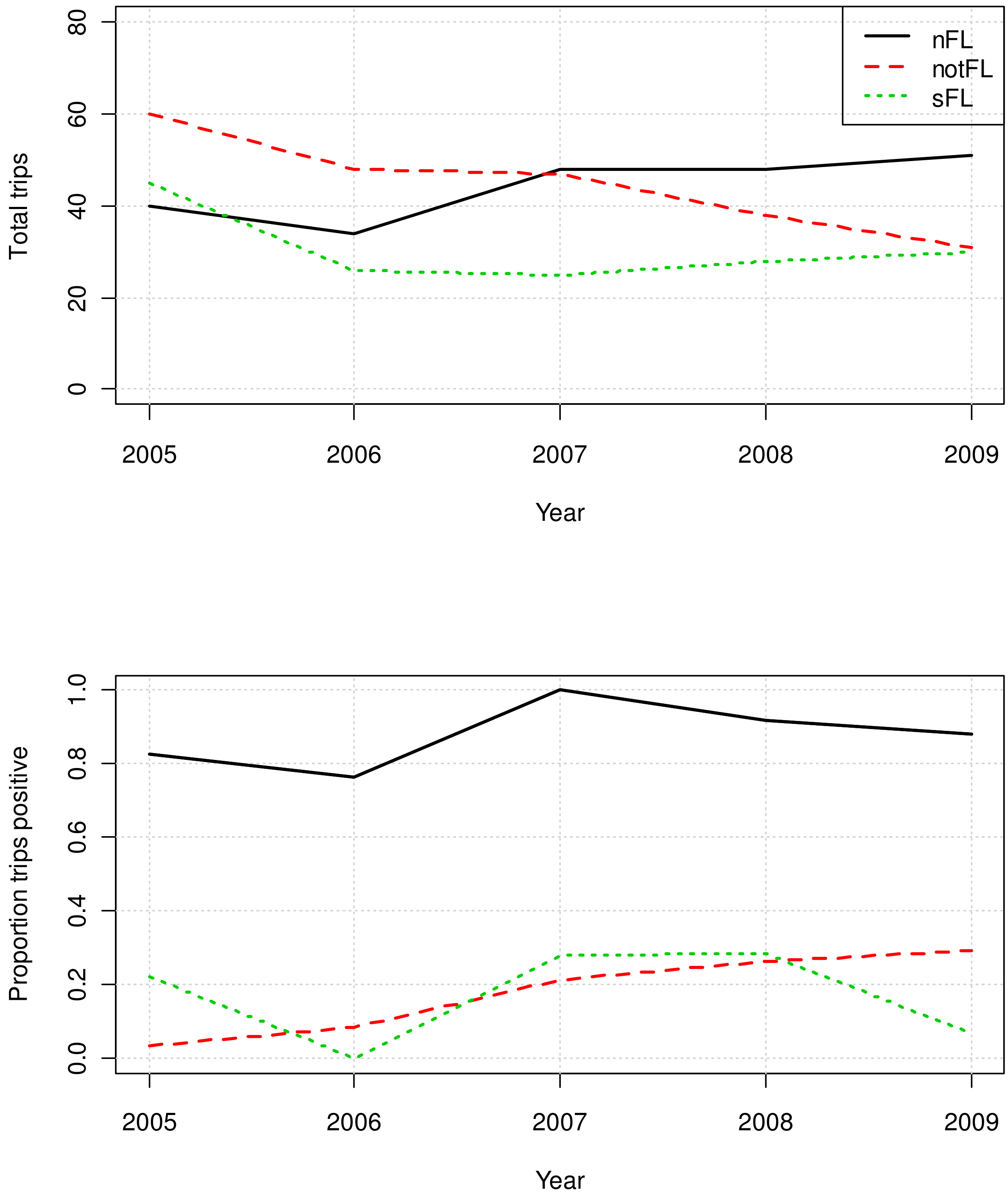


Figure 3. The total number of trips by season and the proportion of those trips which had positive red snapper discards.

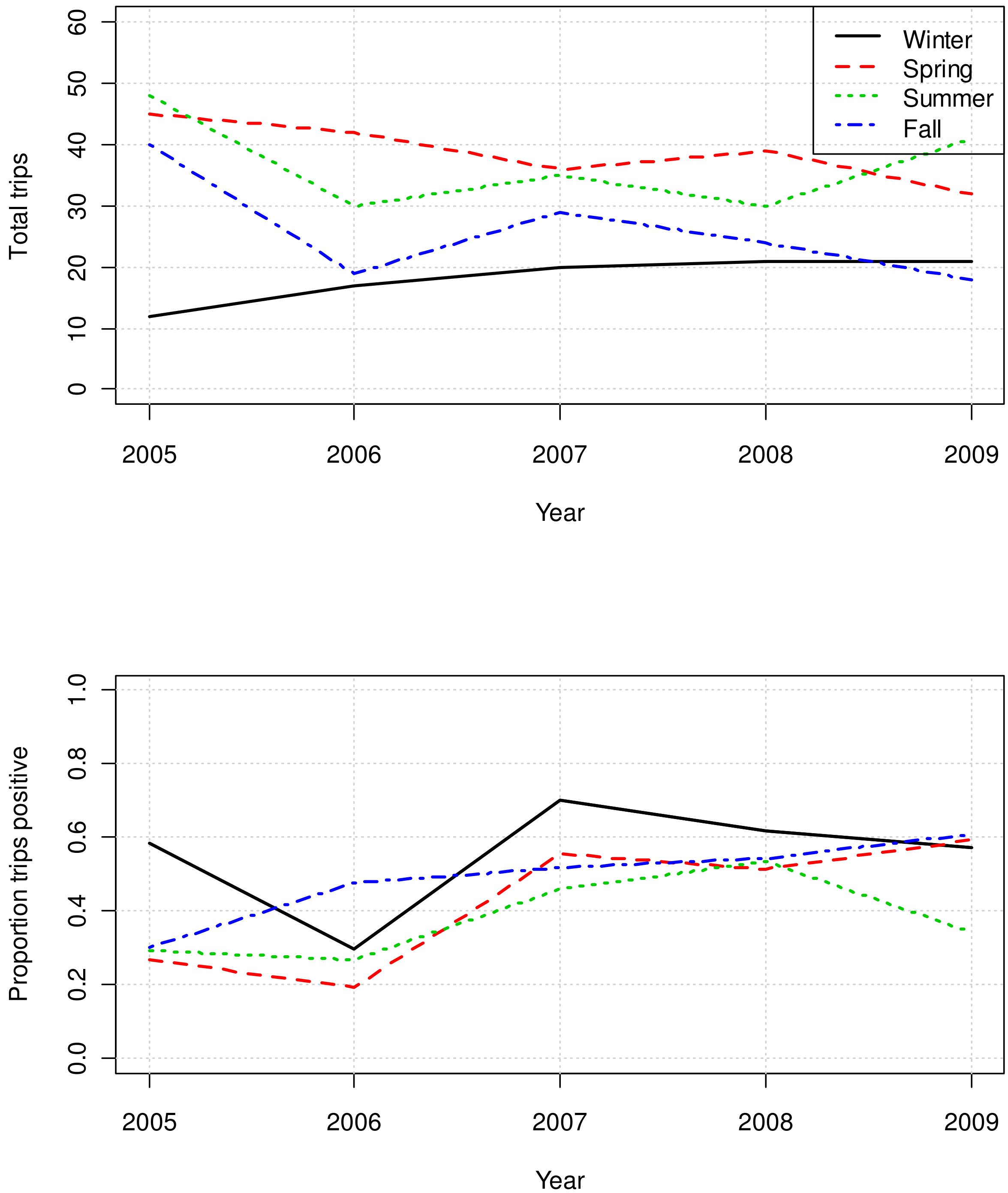
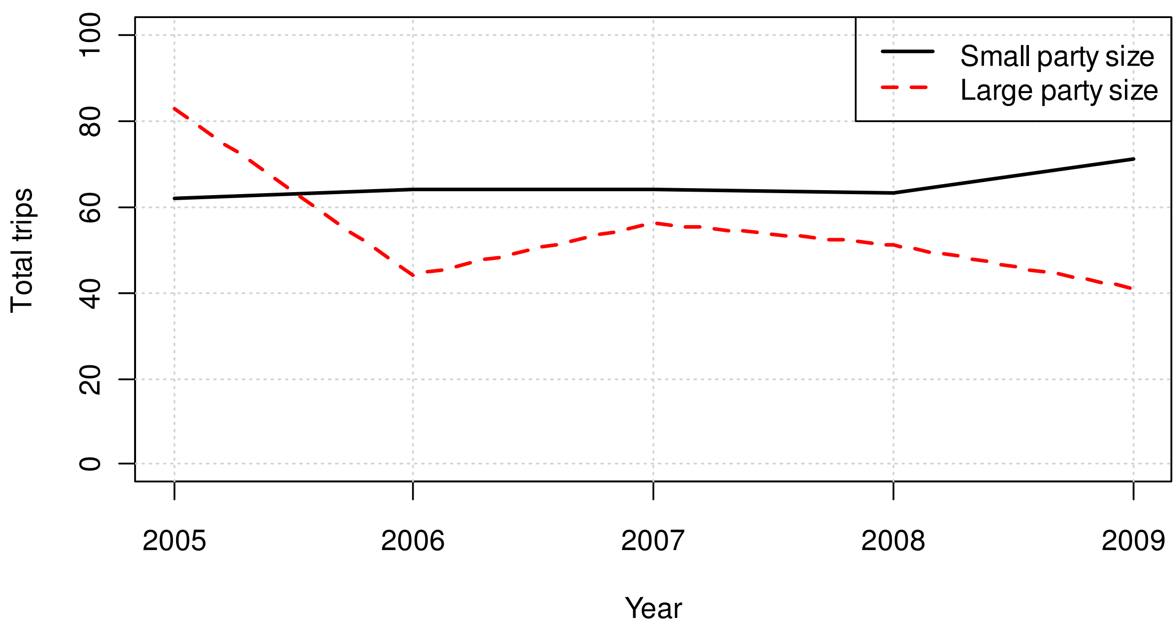


Figure 4. The total number of trips and the proportion of trips with positive red snapper discards over time by party size (small: ≤30 anglers and large: >30 anglers).



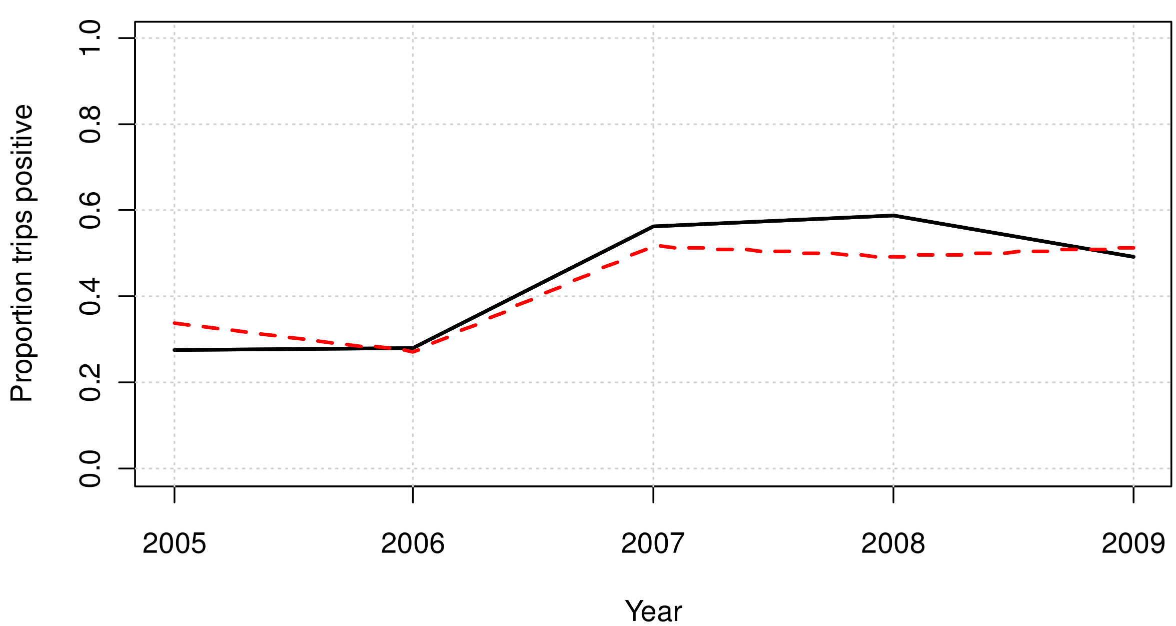


Figure 5. Standardized (quantile) residuals from the binomial portion of the index across the explanatory variables of year, region, and dock to dock hours.

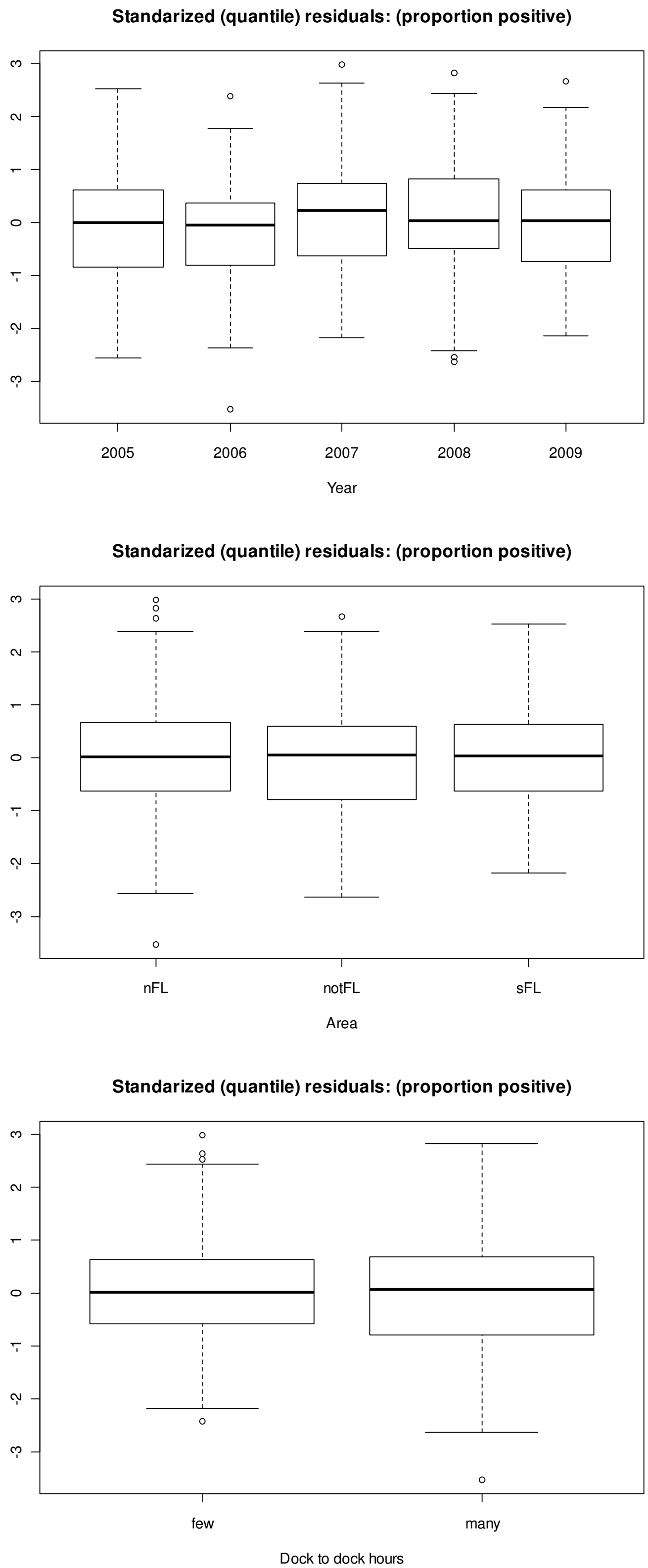


Figure 6. Raw residuals from the positive portion of the index, estimated using a lognormal distribution, across the explanatory variables year, area, season, and party size.

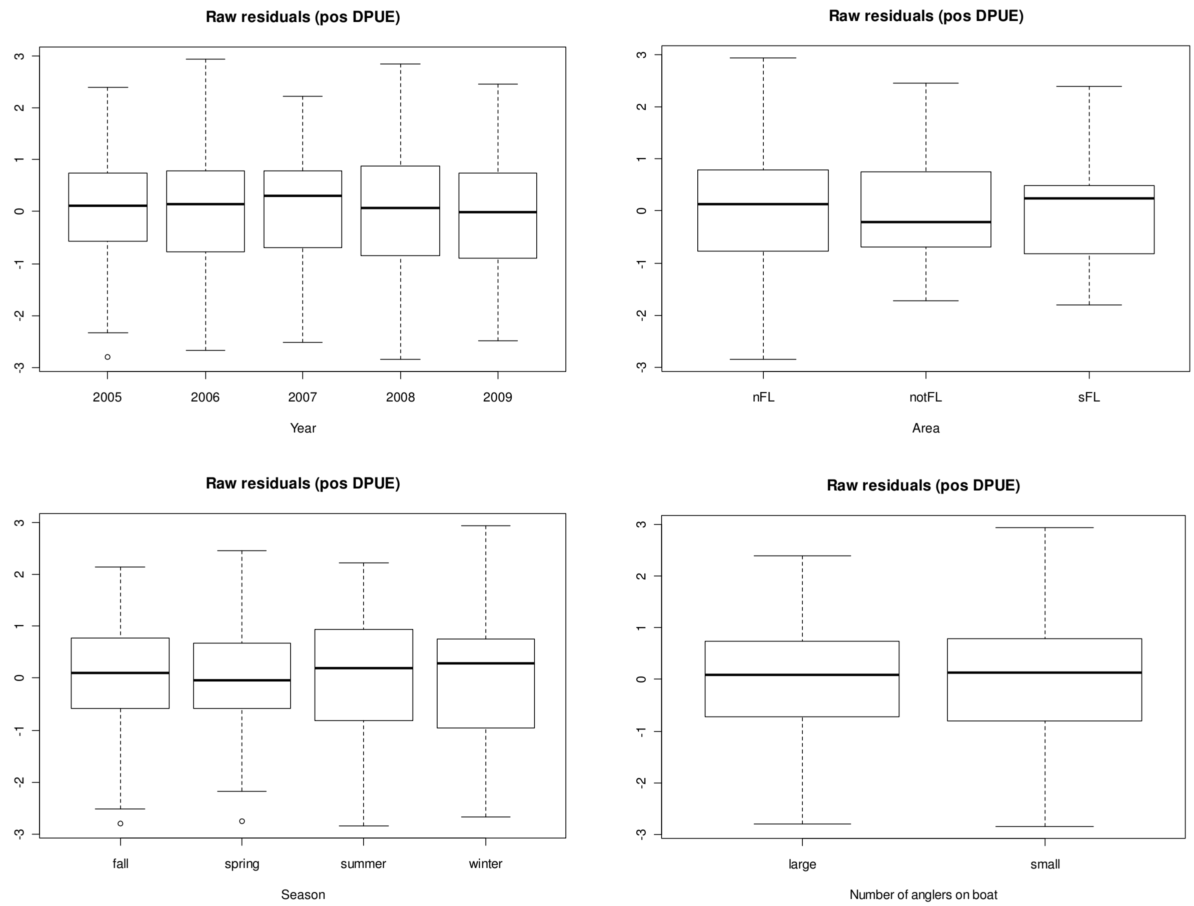
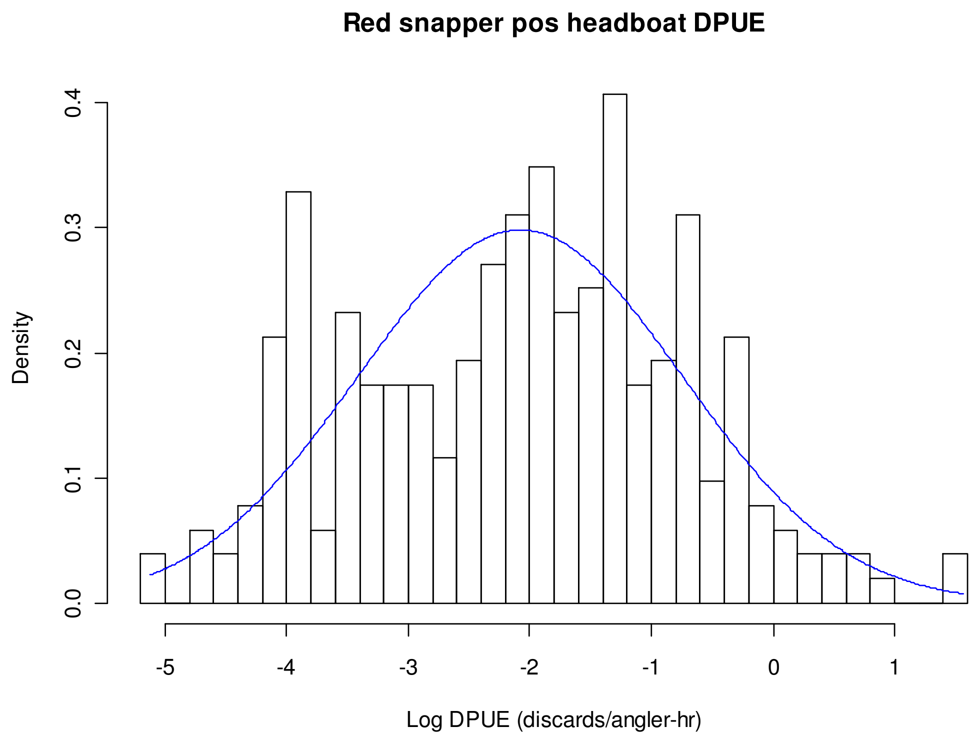


Figure 7. The distribution of log DPUE for the south Atlantic red snapper headboat at sea observer program during 2005-2009, with the normal distribution (empirical mean and variance) overlaid. Q-Q plot of the log residuals of the positive DPUE.



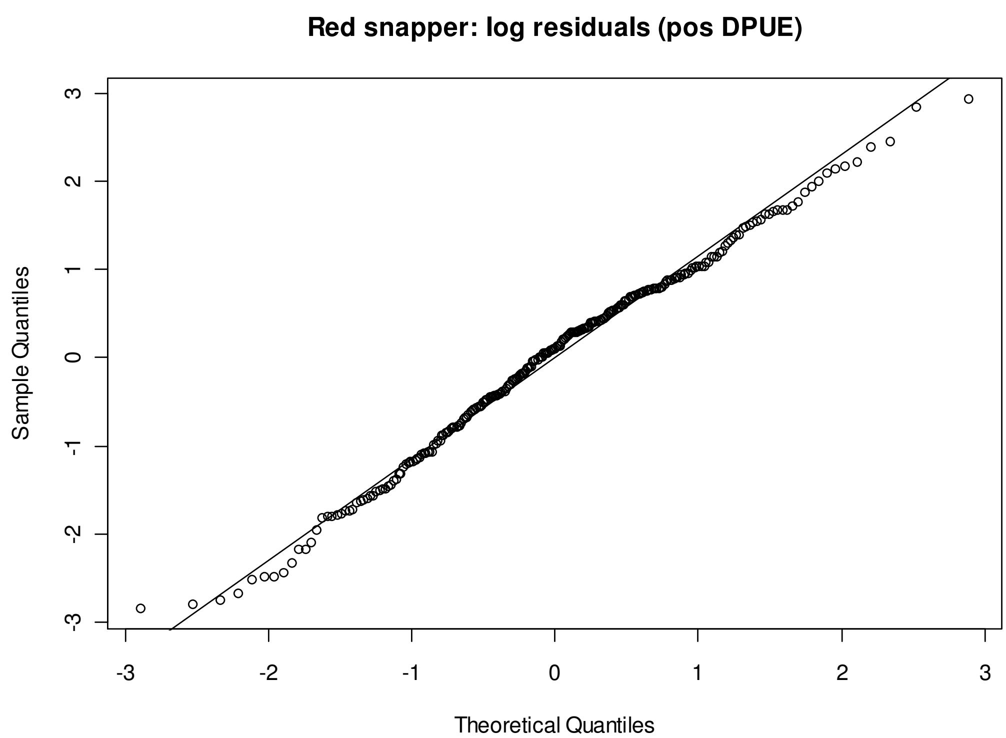
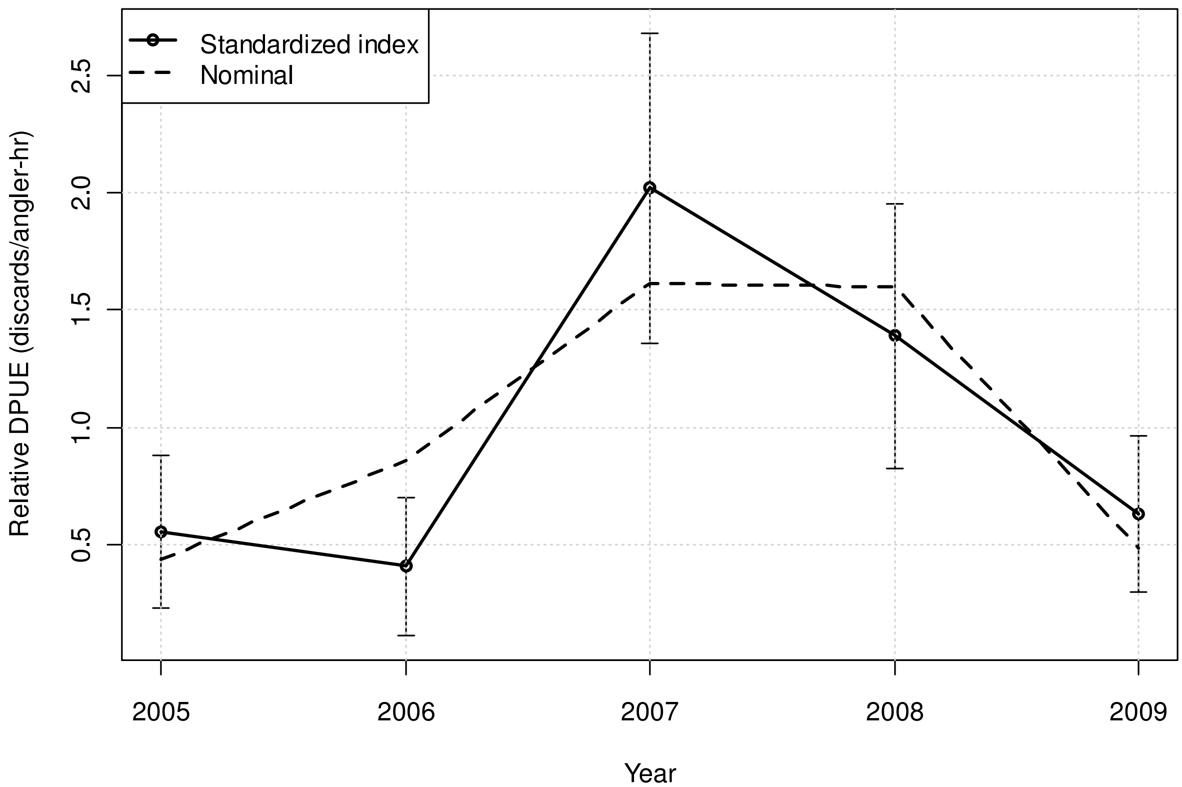


Figure 8. The standardized and nominal DPUE index computed for red snapper in the south Atlantic using the headboat at sea observer data during 2005-2009.



Appendix 1. The stepwise AIC output for the binomial (a), the lognormal (b), and the gamma (c) distributions, with selected variables to be included in the delta-glm. The variable flreg is the area variable above.

(a) Start: AIC=483.38
cpue ~ YEAR + flreg + season + party + dtd

	Df	Deviance	AIC
- season	3	460.82	478.82
- party	1	460.46	482.46
<none>		459.38	483.38
- dtd	1	462.84	484.84
- YEAR	4	488.16	504.16
- flreg	2	775.16	795.16

Step: AIC=478.82
cpue ~ YEAR + flreg + party + dtd

	Df	Deviance	AIC
- party	1	461.71	477.71
<none>		460.82	478.82
- dtd	1	464.23	480.23
- YEAR	4	489.87	499.87
- flreg	2	781.95	795.95

Step: AIC=477.71
cpue ~ YEAR + flreg + dtd

	Df	Deviance	AIC
<none>		461.71	477.71
- dtd	1	464.81	478.81
- YEAR	4	490.80	498.80
- flreg	2	782.07	794.07

(b) Start: AIC=819.71
log(cpue) ~ YEAR + flreg + season + party + dtd

	Df	Deviance	AIC
- dtd	1	330.01	819.68
<none>		327.50	819.71
- season	3	339.63	823.09
- YEAR	4	352.53	830.72
- party	1	350.17	834.98
- flreg	2	401.79	868.46

Step: AIC=819.68

log(cpue) ~ YEAR + flreg + season + party

```
          Df Deviance    AIC
<none>          330.01 819.68
- season  3   342.65 823.38
- YEAR    4   355.98 831.22
- party   1   351.49 833.95
- flreg   2   402.05 866.63
```

(c) Start: AIC=-231.39
cpue ~ YEAR + flreg + season + party + dtd

```
          Df Deviance     AIC
- dtd     1   296.48 -233.29
<none>          296.32 -231.39
- season  3   309.14 -228.92
- YEAR    4   317.21 -225.58
- party   1   328.36 -212.22
- flreg   2   350.60 -199.51
```

Step: AIC=-233.23
cpue ~ YEAR + flreg + season + party

```
          Df Deviance     AIC
<none>          296.48 -233.23
- season  3   309.33 -230.59
- YEAR    4   317.59 -227.04
- party   1   328.41 -213.77
- flreg   2   350.83 -200.71
```