Standardized catch rates of yellowtail snapper (*Ocyurus chrysurus*) from the headboat fishery in southeast Florida and the Florida Keys

Introduction

Headboats are vessels with a capacity for carrying 10 or more recreational anglers. The Southeast Headboat Survey, administered by the SEFSC Laboratory in Beaufort, NC, has operated along the east coast since 1972 and in the Gulf of Mexico since 1986. Catch and effort records from every trip are provided using self-reported logbooks and biological samples are collected from dockside intercepts by port agents. Logbooks are mandatory and required for permit renewal. Each logbook form collects information about number and weight of each species caught, total number of anglers, location fished, trip duration, and numbers of fish released. Vessels are chosen by port agents in a systematic rotation with the flexibility to sample vessels opportunistically in order to sample all vessels equally each month. Port agents collect information on length and weight of a subsample of fish as well as biological samples (e.g. otoliths, gonads, stomachs) for use in life history studies.

Methods

Data Treatment

Catch and effort data from southeast Florida, Florida Keys, and Dry Tortugas (areas 11, 12, and 17) for the years 1981 to 2010 were used to generate a standardized index of CPUE for yellowtail snapper. Data from the years prior to 1981 were omitted because catch and angler estimates were not available for southeast Florida and the Florida Keys. Landings from the Gulf of Mexico and areas north of area 11 on the east coast were omitted because they make up less than 3% of the landings on average each year and are assumed to operate outside of the primary habitat for yellowtail snapper. There were 15 vessels that made less than 10 trips in this area over the entire time period and they were removed as well as any trips with less than 5 anglers under the assumption that these vessels and trips do not reflect the behavior of headboats in general or there was misreporting. Lastly, any trips with landings of yellowtail snapper in the 99.5^{th} percentile were also dropped as they may represent erroneous records. The filtered dataset resulted contains 163,160 trips.

Data Subsetting

The effective effort used in the index must include trips catching yellowtail snapper as well as those trips directed at yellowtail snapper (or occurring in yellowtail snapper habitat) that were unsuccessful in capturing them. In order to identify trips directed at yellowtail snapper, the method of Stephens and MacCall (2004) was used to subset the data. This method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught based on the species composition of the catch for that trip. To avoid computational errors, species that occurred in less than 1% of all trips were removed, resulting in 55 species for inclusion in the subsetting routine. The logistic regression was first run to identify species that are significant predictors (p-value <= 0.05) of yellowtail snapper presence, resulting in 49 species (Figure 1). Finally, a trip was selected as directed effort if the trip's probability of catching yellowtail snapper was higher than a threshold probability. The threshold probability of 0.51 is that which minimized the difference in predicted and observed positive trips (Figure 2 and Figure 3). The filtering constraints and subsetting procedure resulted in 93,443 trips to be used in creating the standardized CPUE index.

Possible Confounding Factors

One possible confounding factor is the 10 fish aggregate snapper per person per day limit that went into effect January 1992. To test for an effect of this regulation on landings of yellowtail snapper, I compared the proportion of positive trips with > 10 yellowtail snapper/angler/day before and after the 1992 regulation. Prior to 1992, the average proportion of trips where each angler landed at least 10 yts/day was 0.004 (< 1%). After the 1992 regulation, the average proportion of trips where each angler landed at least 10 yts/day was .008. A one sided t-test failed to reject the null hypothesis that the mean proportion of positive yts trips with more than 10 yts per angler per day prior to the regulation was less than or equal to the mean proportion of trips after the regulation (H_o: $\mu_{\text{pre-1992}} <= \mu_{\text{post-1992}}$; Welch Two Sample t-test: t = -2.75, df = 27.54, p-value = 0.99). Additionally, linear regression showed no significant change over time (slope not significantly different from 0) in the proportion of positive trips with 10 yts/person/day (slope = 7.51e-5, p-value = 0.33) (Figure 4). Thus the aggregate bag limit should not have an impact on CPUE of yellowtail snapper from headboats.

Response and Explanatory Variables

CPUE: the response variable is fish/angler-hour; calculated as number yellowtail snapper caught divided by number of anglers times hours fished.

YEAR: A summary of the total number of trips targeting yellowtail snapper (based on Stephens and MacCall subsetting) and number of positive trips per year is provided in Table 1 . The number of trips targeting yellowtail snapper ranged from 1,167 in 2003 to 5,110 in 1992 and the number of trips catching yellowtail snapper ranged from 996 in 2003 to 4,118 in 1992.

AREA: Three geographical areas (11, 12, and 17) were included in the model representing southeast Florida and the Florida Keys. The number trips and number of positive trips in each area are provided in Table 1. 68% of trips in southeast Florida (area 11) caught yellowtail snapper, 87% of trips in the Florida Keys (area 12) caught yellowtail snapper, while 97% of trips in the Dry Tortugas (area 17) caught yellowtail snapper. Catch rates were highest in the Florida Keys and lowest in southeast Florida (Figure 5a).

SEASON: Seasons were defined as winter (Jan to March), spring (Apr-June), summer (Jul-Sep) and fall (Oct-Dec). Yellowtail snapper CPUE was consistent across seasons indicating no seasonality in catch rates (Figure 5b).

TRIP TYPE: The original data recorded trip types as ½ day, ¾ day, full day, or multiday. Theses trip types were combined into a factor variable with levels less than 1 day and >= 1 day. Catch rates were higher for full and multi-day trips (Figure 5c).

ANGLERS: While the number of anglers is part of CPUE, it may be important if it influenced the location in which a vessel fished. Therefore, the numbers of anglers were grouped into four categories based on quantiles such that records were evenly distributed within each category. These were: 5-12 anglers, 13-18 anglers, 19-26 anglers, and 27-91 anglers. Because anglers is part of the denominator in the response variable the CPUE was lower in the larger angler categories, however there is no obvious difference in the change of catch rate over time among angler categories (Figure 5d).

Standaridization

CPUE was modeled using the delta-glm approach (Dick 2004; Lo et al. 1992; Maunder and Punt 2004) with R code provided by the SEFSC. This approach calculates an index as the product of the indices from binomial (presence/absence) and positive submodels. In this particular program, the response variable in the positive submodel can be defined by either lognormal or gamma distribution. To determine which distribution best described the data, I used the 'fitdistr' function of the MASS package in R to fit CPUE to the lognormal and gamma distributions. Positive CPUE of yellowtail snapper was described better by the lognormal distribution based on AIC criteria (Table 2, Figure 6). For both the positive and binomial submodels, explanatory variables were removed using backwards stepwise AIC model selection. In both cases, none of the predictor variables were removed. The least squared means for the year factor from each model were multiplied together with a bias correction applied to the positive CPUE to account for transformation of the response variable from log space to CPUE.

Results

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the 'qres.binom' function of the 'statmod' package in R. Randomized quantile residuals for the binomial submodel were normally distributed and showed no pattern across predictor variables (Figure 7). Residuals from the positive submodel were also normal with no pattern across predictor variables (Figure 8). Diagnostic plots of the positive submodel indicate that residuals are normally distributed and exhibit no pattern, variance is homoscedastic, and there are no influential outliers in the dataset. The observed annual mean CPUE, modeled CPUE, and proportion of trips positive is provided in Table 3 and plotted in FiguresFigure 10 andFigure 11.

References

Dick, E. J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70:351-366.

Lo, N. C., L. D. Jacobson, and J. L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences 49:2515-2526.

Maunder, M. N., and A. E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70:141-159.

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

Table 1. Number of total trips and positive trips by area.

	Total Trips				Positive Trips			
year	**11**	**12**	**17**	**total**	**11**	**12**	**17**	**total**
1981	3101	1495	9	4605	2086	1160	9	3255
1982	3340	1502	16	4858	2375	1214	13	3602
1983	2605	1146	10	3761	1639	855	9	2503
1984	2071	1201	28	3300	1328	844	27	2199
1985	2142	980	24	3146	1162	752	22	1936
1986	2722	1111	39	3872	1743	984	38	2765
1987	2369	1342	39	3750	1600	1209	39	2848
1988	2410	1115	14	3539	1778	1027	12	2817
1989	2339	1073	57	3469	1844	976	55	2875
1990	2426	1356	6	3788	1746	1237	6	2989
1991	2303	1187	28	3518	1622	1099	25	2746
1992	2875	2189	46	5110	2129	1943	46	4118
1993	2612	2306	39	4957	1870	2037	39	3946
1994	2452	2293	57	4802	1950	2084	57	4091
1995	2041	2365	30	4436	1413	2175	30	3618
1996	641	2394	28	3063	362	2171	28	2561
1997	473	1784	27	2284	334	1659	26	2019
1998	554	2157	15	2726	279	1923	15	2217
1999	216	1881	3	2100	105	1689	3	1797
2000	189	1837	16	2042	84	1596	14	1694
2001	235	1445	27	1707	65	1283	27	1375
2002	168	1081	31	1280	52	978	31	1061
2003	93	1045	29	1167	43	925	28	996
2004	102	1077	21	1200	34	942	21	997
2005	152	1253	21	1426	57	1136	21	1214
2006	105	1313	44	1462	27	1104	42	1173
2007	216	1404	41	1661	92	1144	38	1274
2008	1319	1650	51	3020	941	1504	50	2495
2009	1673	1814	51	3538	1186	1559	48	2793
2010	2060	1759	37	3856	1532	1514	36	3082

Table 2. AIC table comparing the fit of CPUE to the lognormal and gamma distributions.

distribution	logLik	npar	AIC	deltaAIC
lognormal	41226	2	-82447	5956
gamma	38248	2	-76491	0

Table 3. Nominal mean CPUE and final modeled index.

Year	Nominal CPUE	N	Prop N Positive	Index	CV (index)
1981	0.141	4605	0.707	0.204	0.028
1982	0.114	4858	0.741	0.173	0.030
1983	0.101	3761	0.666	0.136	0.035
1984	0.097	3300	0.666	0.137	0.037
1985	0.083	3146	0.615	0.134	0.036
1986	0.103	3872	0.714	0.158	0.031
1987	0.138	3750	0.759	0.188	0.029
1988	0.133	3539	0.796	0.201	0.028
1989	0.142	3469	0.829	0.221	0.026
1990	0.172	3788	0.789	0.259	0.027
1991	0.181	3518	0.781	0.261	0.024
1992	0.190	5110	0.806	0.261	0.025
1993	0.193	4957	0.796	0.253	0.025
1994	0.237	4802	0.852	0.307	0.025
1995	0.194	4436	0.816	0.227	0.030
1996	0.215	3063	0.836	0.211	0.034
1997	0.199	2284	0.884	0.233	0.030
1998	0.192	2726	0.813	0.197	0.037
1999	0.228	2100	0.856	0.203	0.036
2000	0.214	2042	0.830	0.198	0.041
2001	0.205	1707	0.806	0.177	0.047
2002	0.215	1280	0.829	0.175	0.047
2003	0.258	1167	0.853	0.234	0.044
2004	0.279	1200	0.831	0.284	0.042
2005	0.281	1426	0.851	0.326	0.040
2006	0.204	1462	0.802	0.226	0.043
2007	0.170	1661	0.767	0.201	0.036
2008	0.204	3020	0.826	0.259	0.028
2009	0.161	3538	0.789	0.234	0.029
2010	0.201	3856	0.799	0.270	0.026

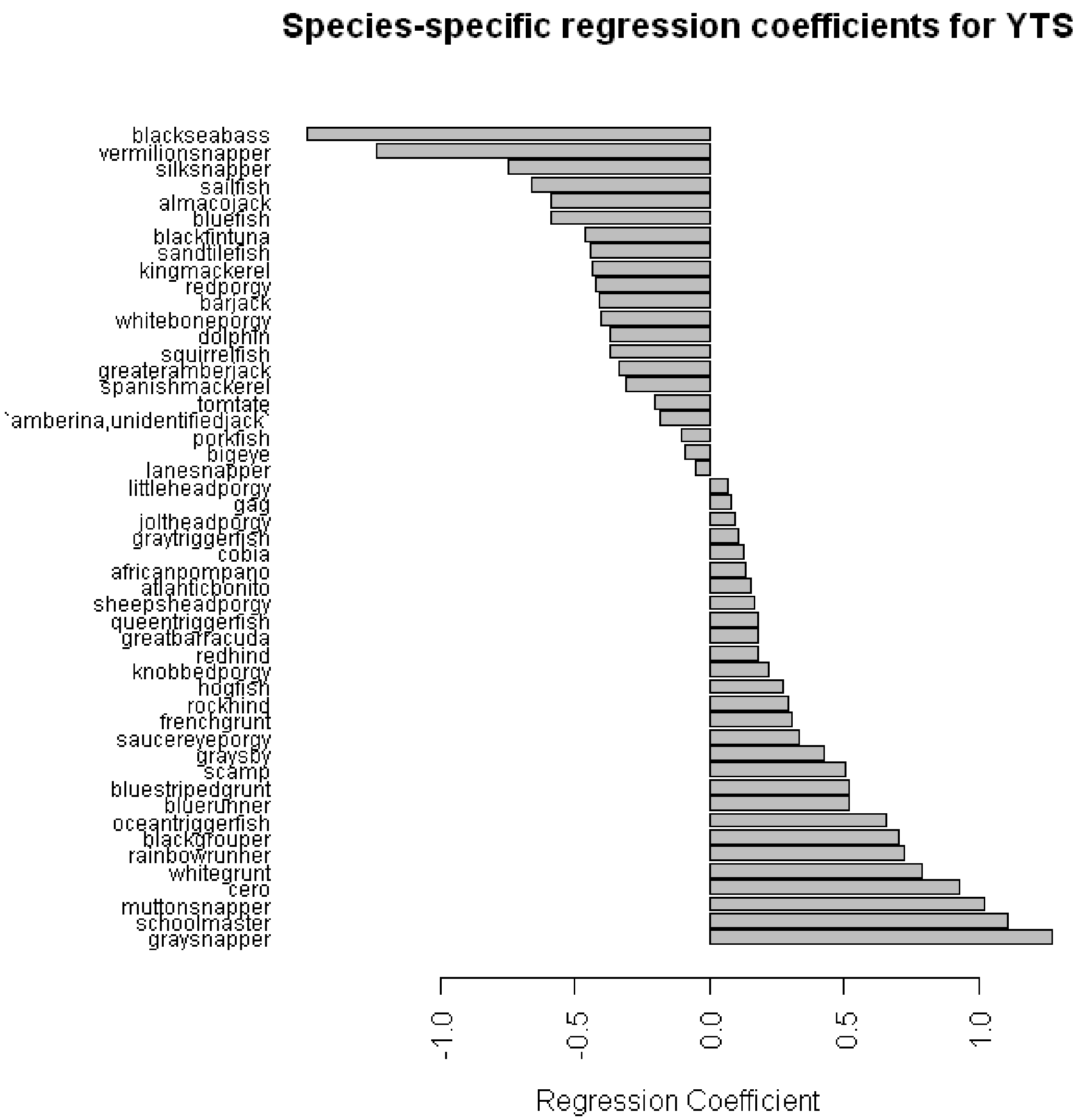

Figure 1. Species-specific regression coefficients from the Stephens and MacCall subsetting routine.

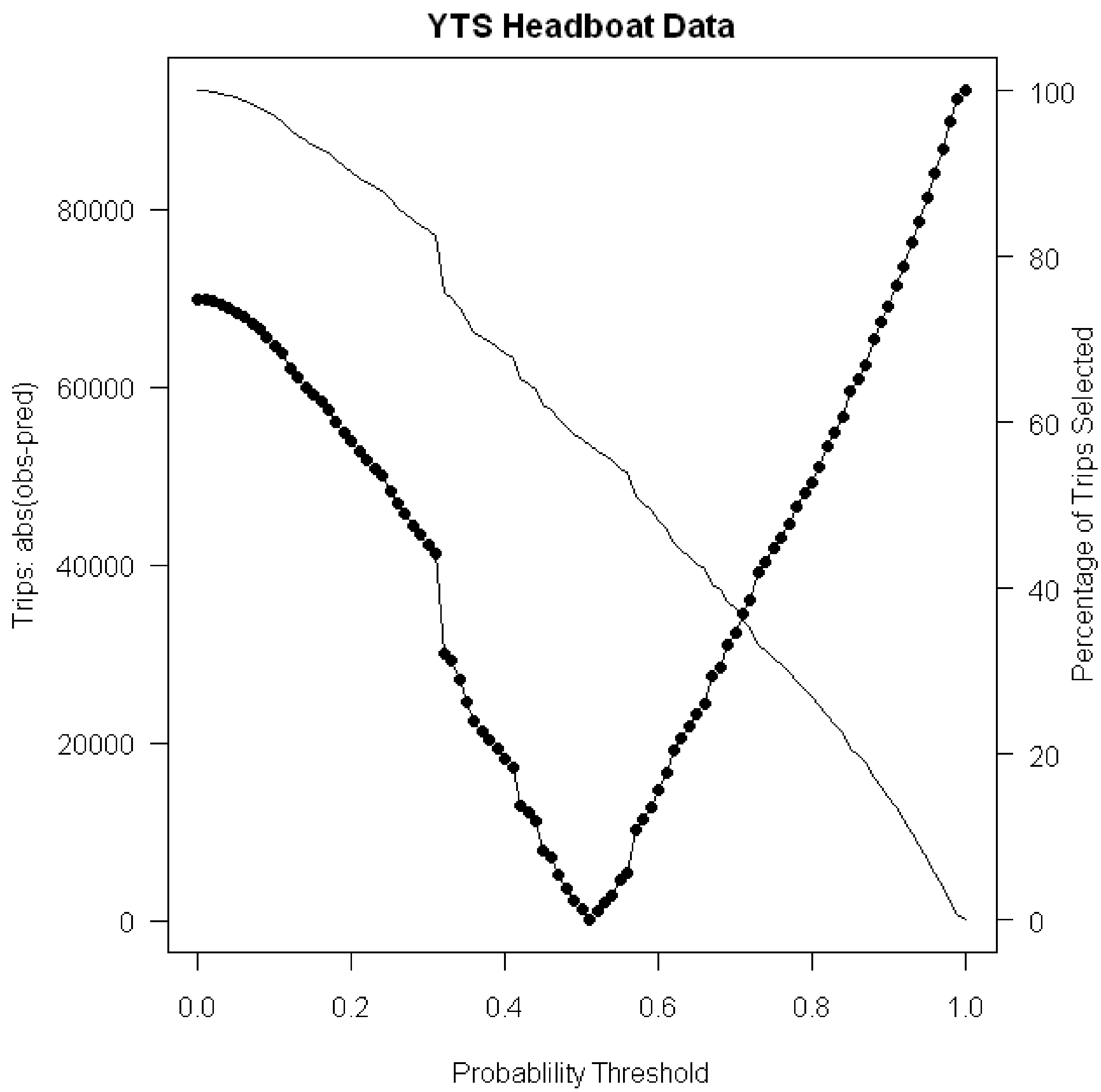

Figure 2. Difference between predicted and observed positive trips (dotted line) and the percent of trips retained for a range of probability thresholds used to subset the headboat data.

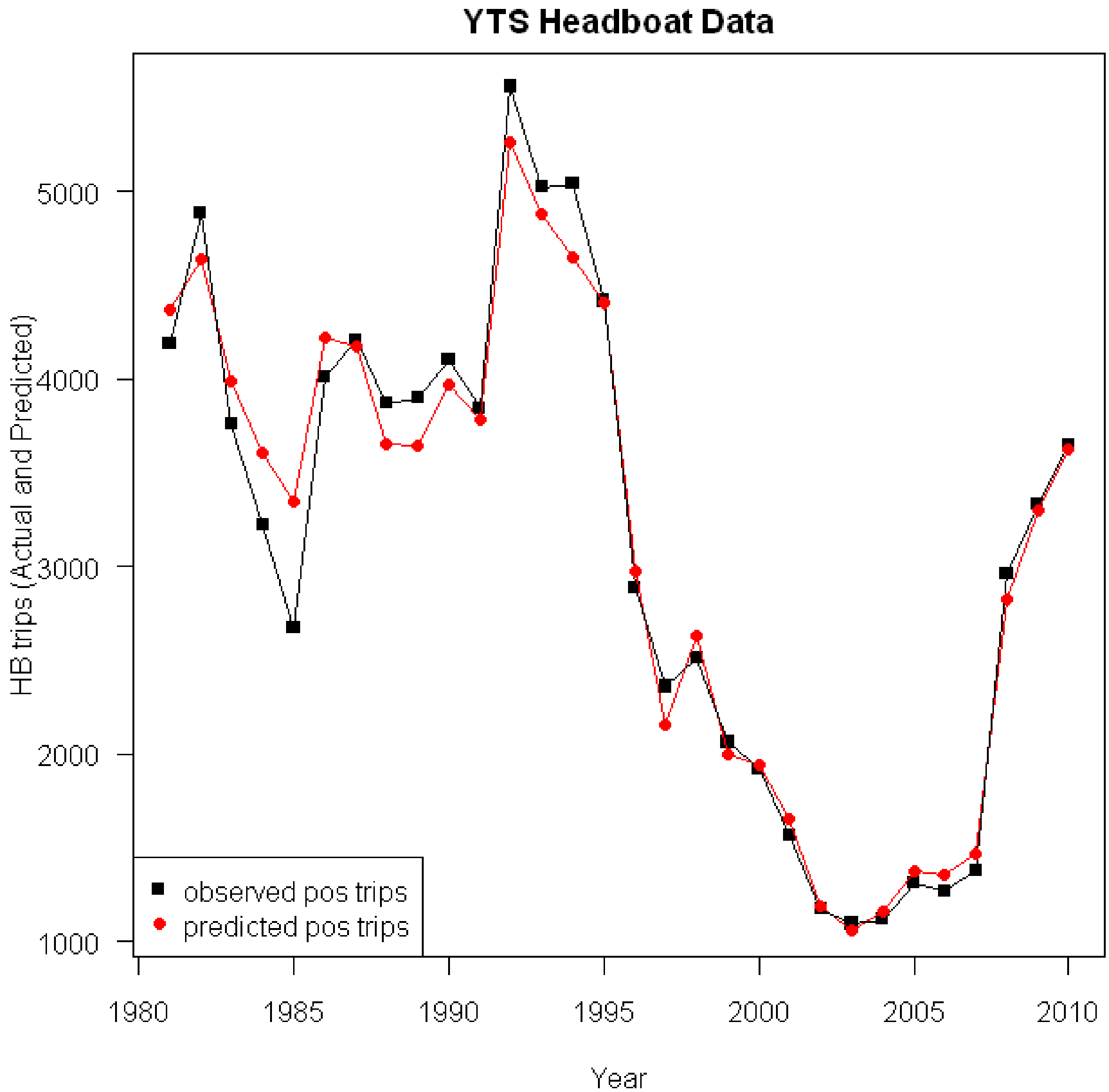

Figure 3. Number of headboat trips observed successfully capturing yellowtail snapper and predicted according to logistic regressions of the Stephens and MacCall subsetting.

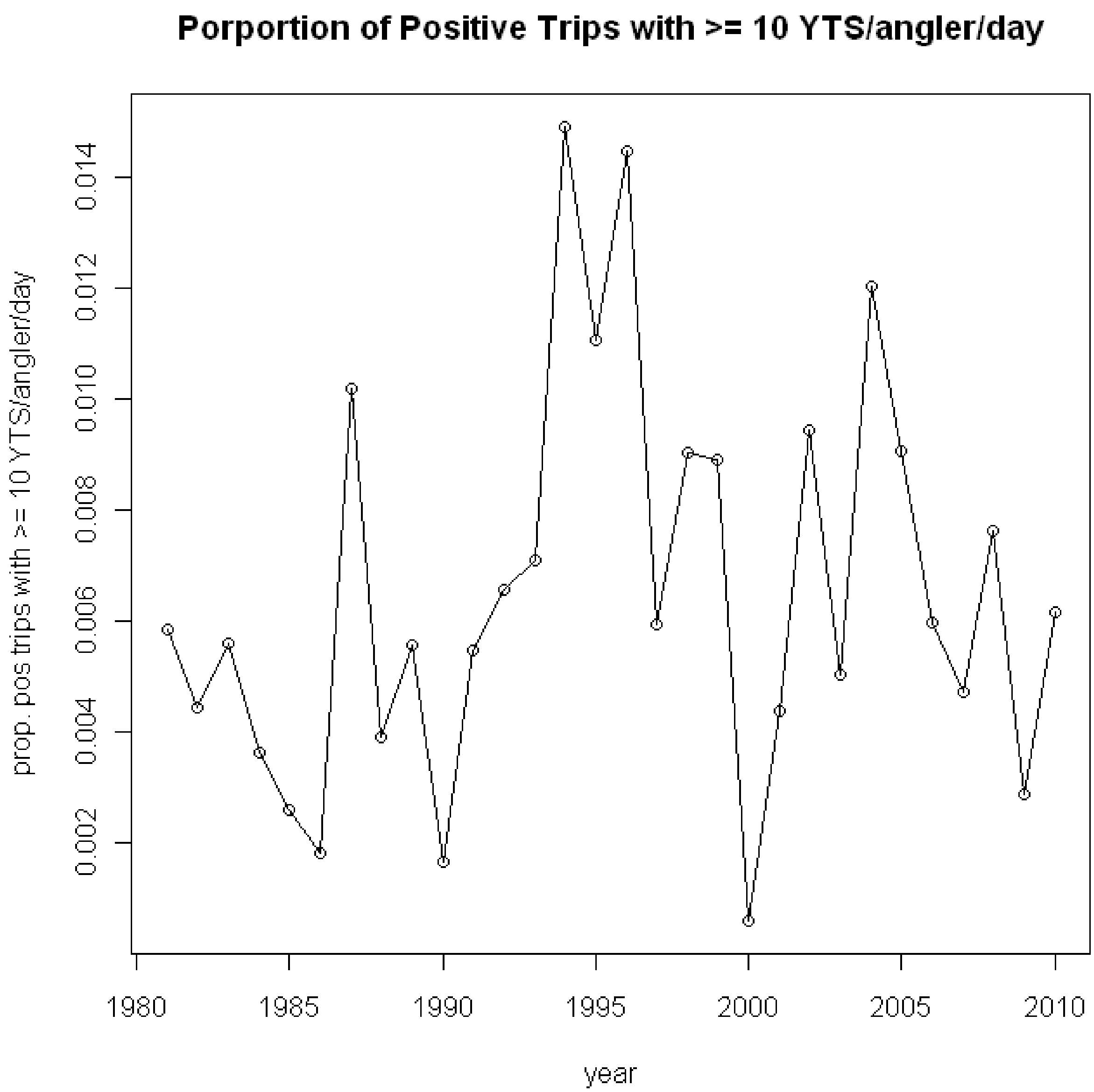

Figure 4. Proportion of positive trips in which each angler caught at least 10 yellowtail snapper each day.

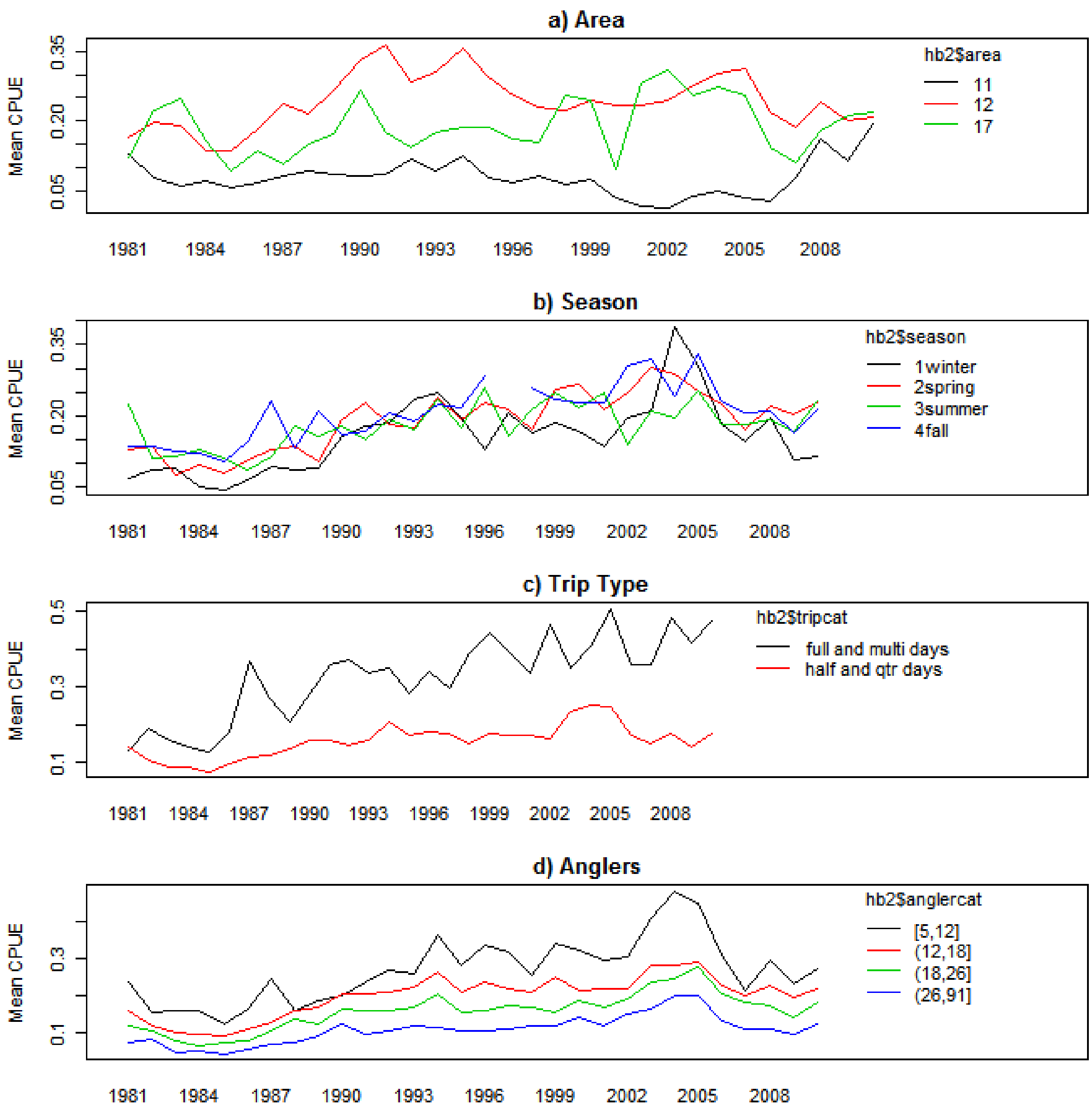

Figure 5. Interaction plots for potential explanatory variables used in standardization procedure.

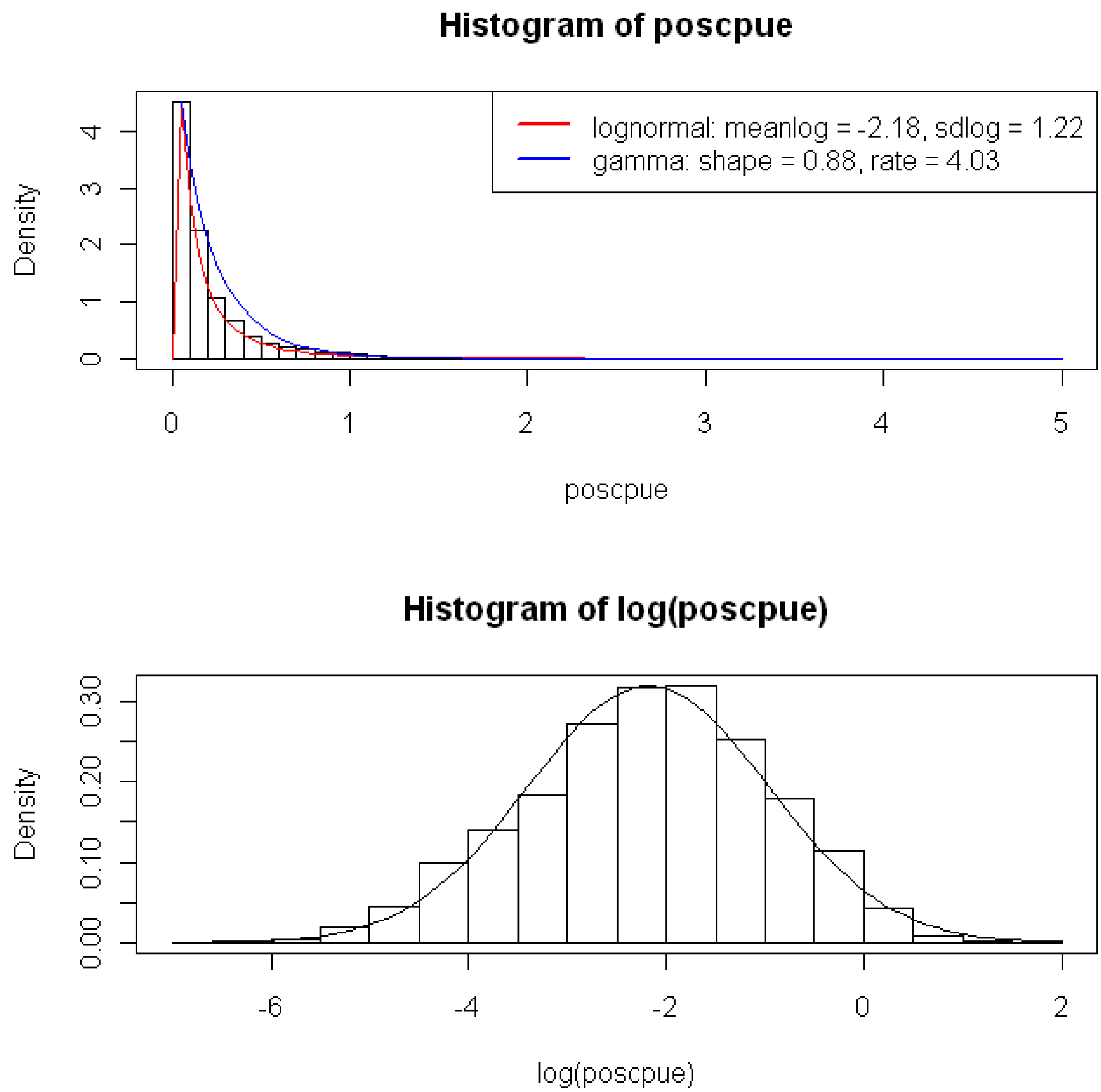

Figure 6. Comparison of fit of lognormal and gamma distributions to positive CPUE data (top) and distribution of lognormal CPUE (bottom).

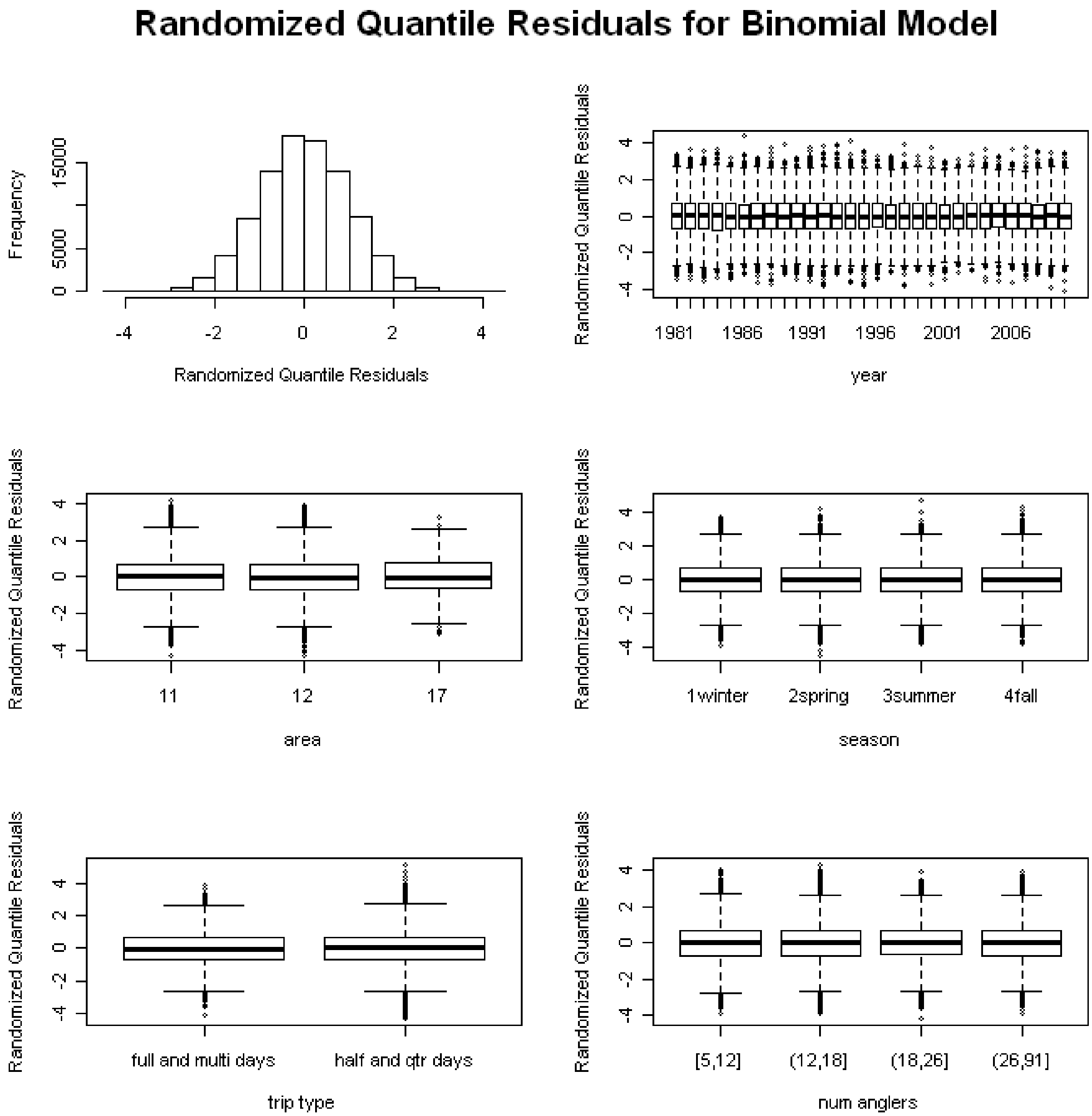

Figure 7. Plots of residuals for binomial submodel.

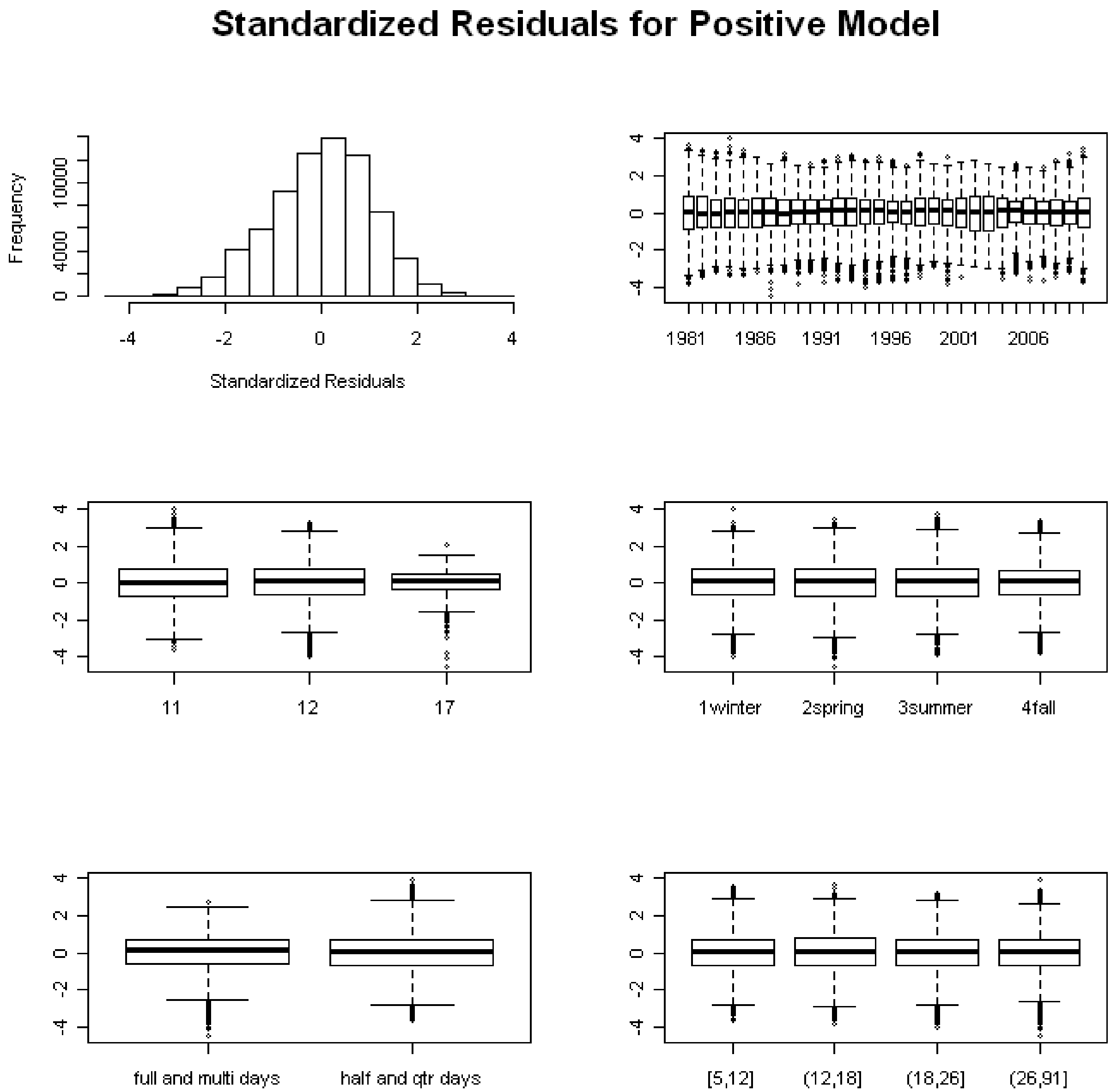

Figure 8. Plots of residuals for positive submodel.

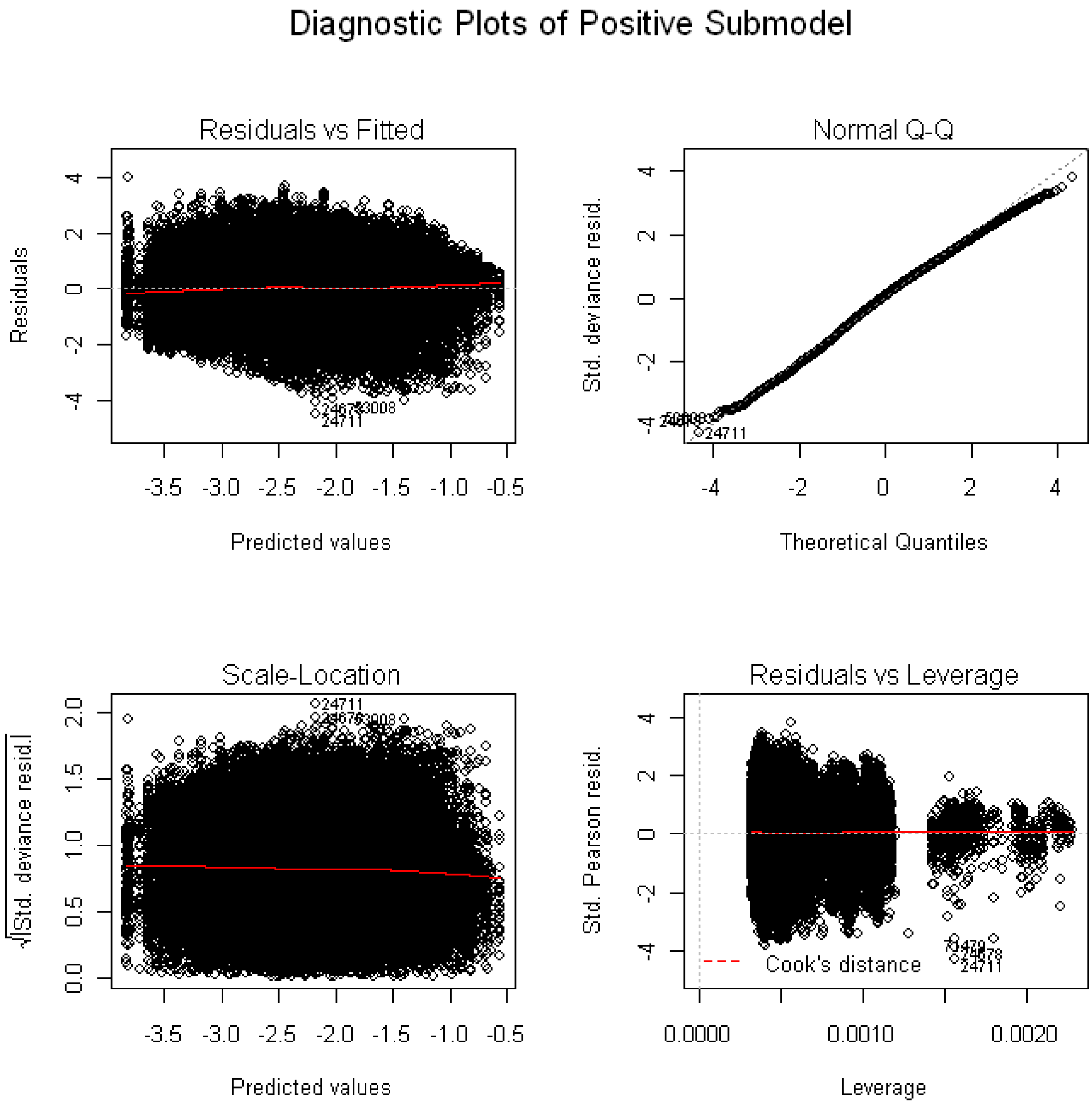

Figure 9. Diagnostic plots for positive submodel.

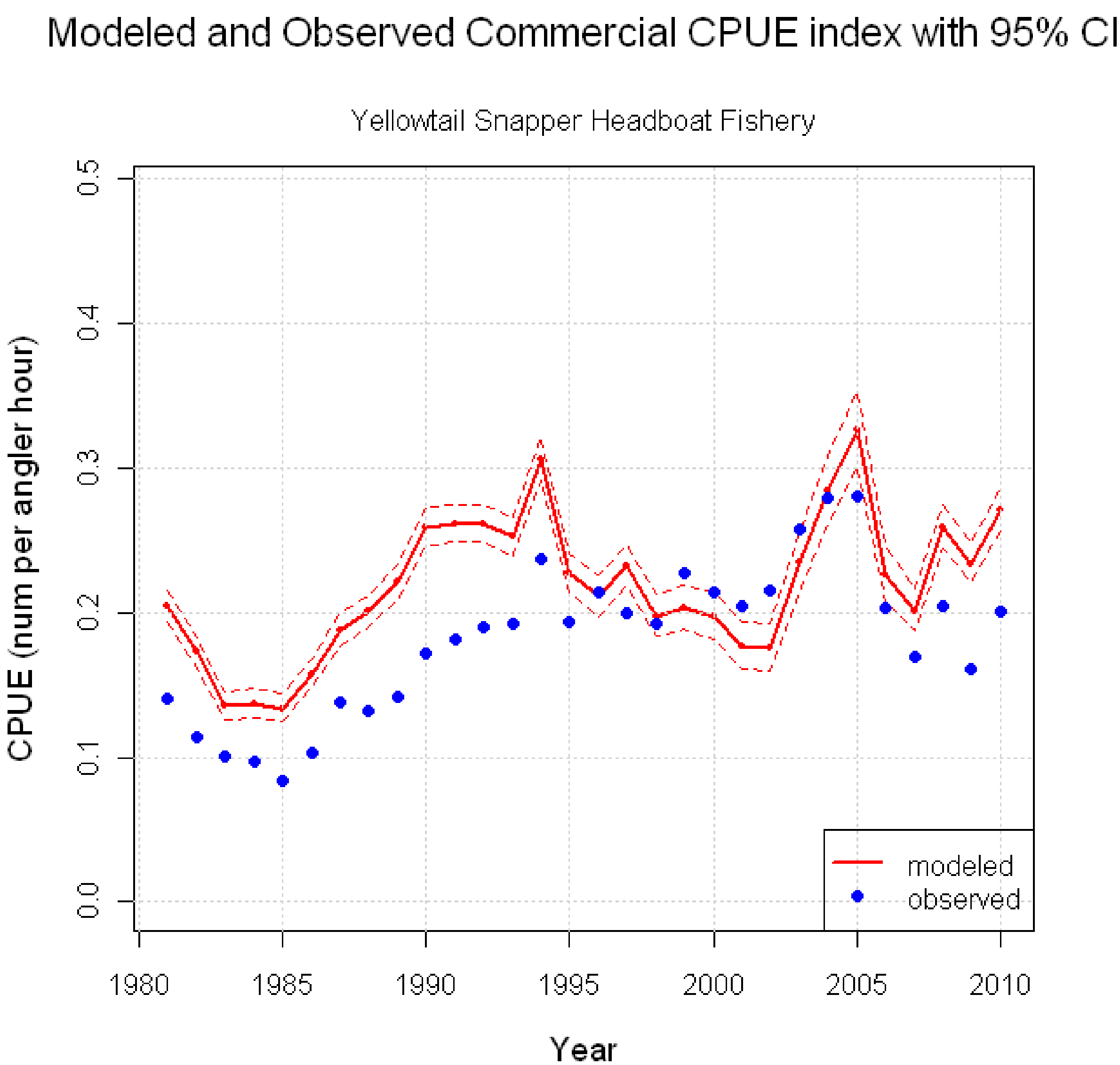

Figure 10. Modeled and observed CPUE of yellowtail snapper in the headboat fishery.

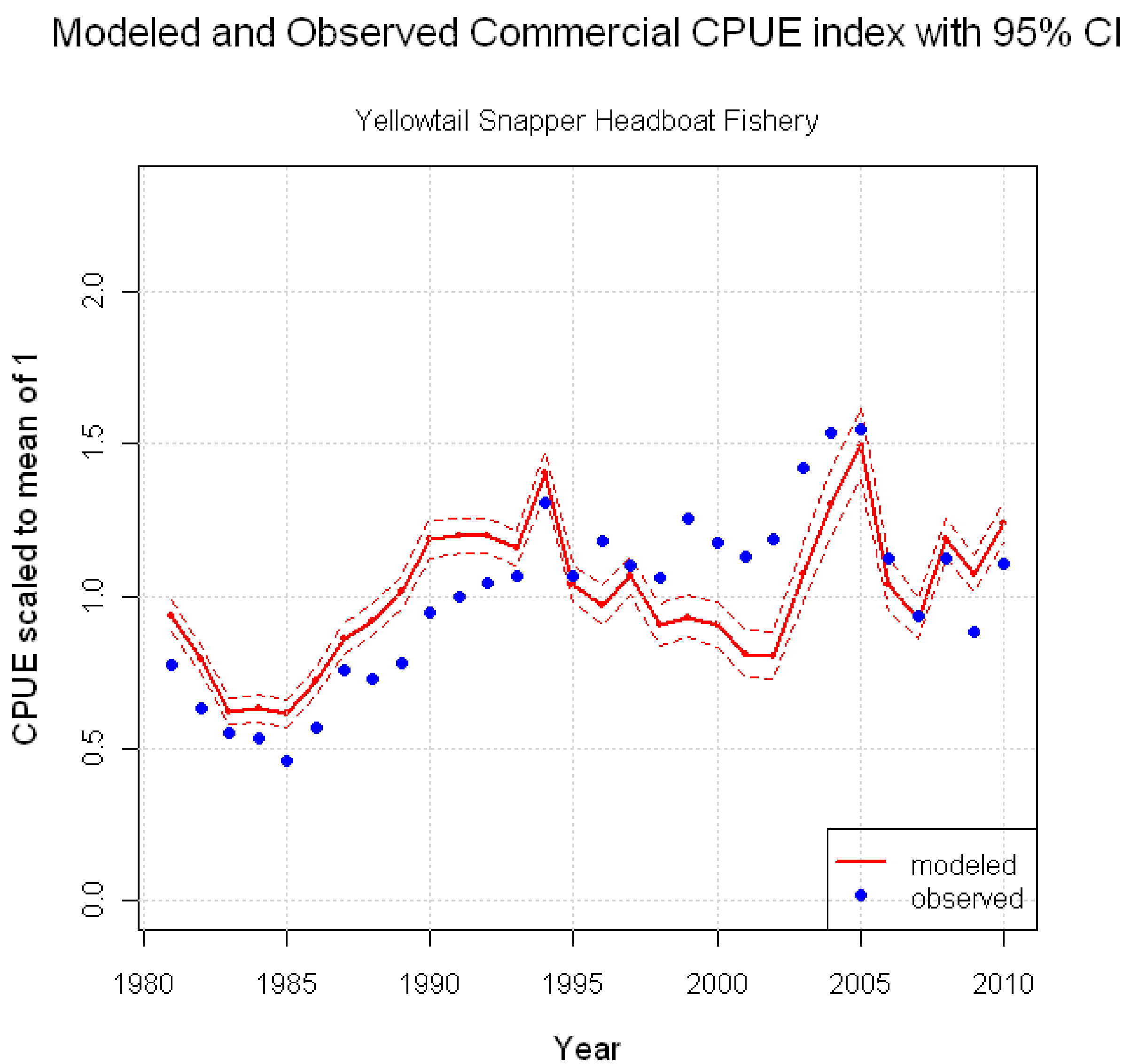

Figure 11. Modeled and observed CPUE, scaled to mean = 1, of yellowtail snapper in the headboat fishery.