YTS-RD01

Commercial Vertical Line Vessel Standardized Catch Rates of Yellowtail Snapper in southern Florida, 1993-2010

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Introduction

Handline, electric and hydraulic reel (bandit rig), and longline landings and fishing effort of commercial vessels operating in the Gulf of Mexico and U.S. South Atlantic have been reported to the National Marine Fisheries Service (NMFS) through the Coastal Fisheries Logbook Program (CFLP) conducted by the NMFS Southeast Fisheries Science Center. The program collects landings and effort data by fishing trip from vessels that are federally permitted to fish in a number of fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The coastal logbook program began in 1990 in the Gulf of Mexico and in 1992 in the US South Atlantic with the objective of a complete census of coastal fisheries permitted vessel activity, however in Florida a 20% sample of vessels was selected to report. Beginning in 1993, reporting in Florida was increased to include all vessels permitted for federally managed coastal fisheries.

The CFLP available catch per unit effort (CPUE) data were used to construct standardized abundance indices for yellowtail snapper. The index was constructed using data reported from commercial vertical line (handline and bandit rig) trips in southern Florida. More than 99 percent of all yellowtail snapper landings reported to the CFLP were caught in southern Florida. Yellowtail snapper data were sufficient to construct indices of abundance including the years 1993-2010.

Methods

Available Data

For each fishing trip, the coastal logbook database included a unique trip identifier, the landing date, fishing gear deployed, areas fished (Figure 1), number of days at sea, number of crew, gear specific fishing effort, species caught and weight of the landings. Fishing effort data available for vertical line gear included number of lines fished, number of hooks fished per line, and hours fished. Multiple areas fished and multiple gears fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations or gears was not possible; therefore, only trips which reported one area (i.e., subregion, as defined below) and one gear fished (vertical line) were included in these analyses.

Data were further restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip. Reporting delays beyond 45 days (some reporting delays were longer than one year) likely resulted in less reliable effort data. Landings data, however, may have been reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher.

Clear outliers in the data, e.g. values falling outside the 99.9 percentile of the data, were excluded from the analyses. These included vertical line data from trips reporting fishing more than 24 hours per day, more than 20 hooks per line (bandit rigs; 15 hooks/line for handline gear), or more than six lines fished (bandit; 12 handlines). Data from trips with reported crews of more than four (bandit; seven handline) or trips of more than 15 days at sea (bandit; 14 handline) were also excluded from the analyses. In addition, records with cpues of more than 205 pounds/hook hour (210 pounds/hook hour core area index) were excluded. Checks of several records with very high cpues (more than 205) found data entry errors. Approximately 70 percent of vertical line trips were retained for analyses following all data filtering. No management measures (change in minimum size, trip limits, or closed seasons) were implemented during the period 1993-2010 that may have had an affect on construction of indices of abundance.

Yellowtail snapper trips were identified using a data subsetting technique (modified from Stephens and MacCall, 2004) intended to restrict the data set to trips with fishing effort in presumptive yellowtail snapper habitat. Such an approach was necessary because fishing location was not reported to the CFLP at a spatial scale adequate to identify targeting based upon the habitat where the fishing occurred. The modified Stephens and MacCall method was an objective approach in which a logistic regression was applied to estimate the probability that yellowtail snapper could have been encountered given the presence or absence of other species reported from the trip. As a function of the species reported from a trip, a score was assigned to the trip and that score was converted into the probability of observing yellowtail snapper. Trips with scores above a critical value were included in the CPUE analysis. That critical value was set at the score that minimized the number of predictions of yellowtail snapper occurring when the species was actually absent (false positives) while also minimizing incorrect predictions of yellowtail snapper absence when the species was actually present (false negatives). Separate Stephens and MacCall analyses were used to identify trips targeting yellowtail snapper for each of the constructed indices. Figures 2 and 3 provide species-specific regression coefficients from each analysis. The magnitude of the coefficients indicates the predictive impact of each species. Patterns were similar among all three analyses.

Index Development

Two indices were constructed using coastal logbook commercial vertical line data. The first index (south Florida index) included effort and landings data reported from statistical areas 1, 2, 3, 4, 2482, 2481, 2480, 2479, 2579, 2580, 2679, 2680, 2779, and 2780 (see Figure 1). Landings of yellowtail snapper reported from those areas made up more than 99 percent of all yellowtail snapper landings in the coastal logbook data set. The second index (core area index) included data reported from areas 1, 2, 2482, 2481, 2480, 2579, 2580, 2679, and 2680. Approximately 96.5 percent of all yellowtail landings reported to the coastal logbook program were from those areas. Both indices were constructed using identical methods, as described below. Factor categories varied slightly between indices.

Vertical line catch rate was calculated as weight of yellowtail snapper per hook hour fished:

CPUE = pounds of yellowtail snapper/(number of lines fished*number of hooks/line*hours fished)

Five factors were considered as possible influences on the proportion of trips that landed yellowtail snapper and on the catch rate of yellowtail snapper. An additional factor, number of hooks fished, was examined for its affect on the proportion of positive trips. Spatially, the analyses were limited to the areas defined below. In order to develop a well balanced sample design it was necessary to define categories within some of the factors examined:

South Florida index

Factor	Levels	Value
Year	18	1993-2010
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	7	Stat areas 1, 2-4, 2482, 2481, 2480, 2479+2579+2580, 2679+2680+2779+2780 see Figure 1
Days at sea (seadays)*	2	1, 2+ days
Crew (crew1)*	3	1, 2, 3+ crew members
Hooks hours fished (hkhours)*[1]	4	<8, 8-15, >15-23, >23 hook hours

* Names in parentheses appear in some figures and tables.
[1] Hooks fished was examined only for the proportion positive analyses.

Core area index

Factor	Levels	Value
Year	18	1993-2010
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	5	Stat areas 1, 2+2482, 2481, 2480, 2579+2580+2679+2680 see Figure 1
Days at sea (seadays)*	2	1, 2+ days
Crew (crew1)*	3	1, 2, 3+ crew members
Hooks hours fished (hkhours)*[1]	4	0.1-8, >8-15, >15-24, >24 hook hours

* Names in parentheses appear in some figures and tables.
[1] Hooks fished was examined only for the proportion positive analyses

The delta lognormal model approach (Lo et al. 1992) was used to construct standardized indices of abundance. This method combines separate general linear model (GLM) analyses of the proportion of successful trips (trips that landed yellowtail snapper) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM analysis (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA).

For each GLM analysis of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was “normal”, and the response variable was log(CPUE) where log(CPUE)=ln(pounds of yellowtail snapper/hook hours fished). All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$), and the reduction in deviance per degree of freedom was ≥1%. This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike’s Information Criterion (AIC), Schwarz’s Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 log likelihood statistics between successive model formulations (Littell et al. 1996).

The final delta-lognormal models were fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean cpue of the series.

Results and Discussion

Models for the two indices differed slightly. The final model of the south Florida data set for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips for each species were:

PPT = Subregion + Year[1]

LOG(CPUE) = Year + Crew + Season + Subregion + Year*Subregion + Year*Season

[1]Year did not meet the inclusion criteria for the binomial model, but was included to allow for yearly mean cpue to be calculated

Final models for the core area data set were:

PPT = Subregion + Year[1]

LOG(CPUE) = Year + Season + Crew + Subregion + Year*Subregion + Year*Season

[1]Year did not meet the inclusion criteria for the binomial model, but was included to allow for yearly mean cpue to be calculated

The linear regression statistics for fixed effects and the analyses of the mixed model formulations of the final models are summarized in Tables 1 and 2.

Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices are provided in Tables 3 and 4 for each of the yellowtail snapper analyses. Differences in yearly sample sizes between the indices were obviously due to the inclusion of data from fewer statistical areas in the core area index analysis. Yearly mean cpue of both indices ranged from a low of 0.6 (core areas index; 0.66 south Florida index) in 1996 to approximately 1.6 (both indices) in 2009. A small decrease in mean cpue occurred in 2010. Coefficients of variation (CV) for both indices were low (0.18-0.19) and varied little over the time series.

The delta-lognormal abundance indices constructed for each time series, along with 95% confidence intervals, are shown in Figures 4 and 5. Plots of all both indices are provided in Figure 6. Plotted confidence intervals were those calculated for the south Florida index. The two indices were very similar. This result was not surprising, given that most of the yellowtail snapper landings and effort data were retained within the core area data set. The broader spatial range of the south Florida index included several areas with low reported yellowtail landings. Data from those areas were included when constructing the south Florida index in an attempt to examine affects on cpue due to any range expansion or contraction of yellowtail snapper.

Plots of the proportion of positive trips per year, nominal cpue, frequency distributions of the proportion of positive trips, frequency distributions of log(CPUE) for positive catch, cumulative normalized residuals, and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures 7-14. The proportion of positive trips was acceptable for the analyses. No obvious patterns were apparent in the residual plots, although there were a small number of outliers among those data (Figures 8a, 10a, 10b, 10d, 12a, 12b, 14a, 14b, 14c, and 14d). The frequency distributions log(CPUE) were somewhat negatively skewed (Figures 9a, 9b, 13a, and 13b), although the lack of fit was typical for fisheries dependent data.

Yellowtail snapper standardized catch rates for commercial vertical line vessels have generally increased since 1996. That increase has been stepwise, with periodic increases in mean cpue for two to three years interspersed with relatively constant yearly mean cpue for two to four years. As with any fishery dependent index of abundance, changes in catchability may mask true trends in population abundance.

Literature Cited

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC, USA:SAS Institute Inc., 1996. 663 pp.

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

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

Table 1. Linear regression statistics for the south Florida GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) of yellowtail snapper for vessels reporting vertical line gear landings. Analysis of the mixed model formulations of the positive trip model (**C**). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading. See text for factor (effect) definitions.

A.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	102	59.91	3.52	<.0001	<.0001
subregion	6	102	811.53	135.26	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	51	70.85	4.17	<.0001	<.0001
crew1	2	79E3	2035.00	1017.50	<.0001	<.0001
season	3	51	63.53	21.18	<.0001	<.0001
subregion	6	102	130.84	21.81	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
YEAR + crew1 + season + subregion	261007.1	261009.1	261018.4	-	-
YEAR + crew1 + season + subregion + year*subregion	259765.1	259769.1	259774.8	1242.0	<0.0001
YEAR + crew1 + season + subregion + year*subregion + year*season	258820.8	258826.8	258835.3	944.3	<0.0001

Table 2. Linear regression statistics for the core area GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) of yellowtail snapper for vessels reporting vertical line gear landings. Analysis of the mixed model formulations of the positive trip model (**C**). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading. See text for factor (effect) definitions.

A.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	68	44.60	2.62	0.0003	0.0026
subregion	4	68	309.45	77.36	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	51	81.05	4.77	<.0001	<.0001
season	3	51	66.05	22.02	<.0001	<.0001
crew1	2	79E3	2065.70	1032.85	<.0001	<.0001
subregion	4	68	70.41	17.60	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
YEAR + season + crew1 + subregion	260502.6	260504.6	260513.8	-	-
YEAR + season + crew1 + subregion + year*subregion	259333.8	259337.8	259342.8	1168.8	<0.0001
YEAR + season + crew1 + subregion + year*subregion + year*season	258324.4	258330.4	258337.9	1009.4	<0.0001

Table 3. South Florida vertical line relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for yellowtail snapper constructed using commercial vertical line data.
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YEAR	Normalized Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.78004	3,780	0.88	0.801506	0.554481	1.158583	0.185805
1994	0.721586	6,171	0.86	0.83499	0.579682	1.202741	0.183999
1995	0.689659	5,780	0.86	0.75149	0.521496	1.082918	0.184213
1996	0.614289	4,725	0.79	0.662653	0.458824	0.957032	0.185355
1997	0.693064	7,152	0.83	0.731318	0.508115	1.05257	0.18359
1998	0.838275	6,638	0.81	0.810017	0.562418	1.166619	0.183933
1999	0.932592	6,973	0.83	1.017357	0.706144	1.465727	0.184104
2000	0.82082	6,120	0.80	0.873469	0.606149	1.258682	0.184208
2001	0.952677	6,203	0.79	0.895314	0.621194	1.290398	0.184303
2002	0.947988	6,171	0.77	0.891586	0.618601	1.285038	0.184308
2003	0.875649	6,055	0.78	0.837022	0.580649	1.206592	0.184391
2004	1.068132	5,543	0.78	0.936827	0.649844	1.350547	0.184423
2005	1.068558	4,786	0.82	1.189224	0.824956	1.714337	0.184402
2006	1.2605	4,321	0.83	1.17046	0.811609	1.687977	0.184611
2007	1.223093	4,178	0.83	1.100732	0.762956	1.588048	0.184815
2008	1.523669	4,122	0.82	1.412812	0.977997	2.040945	0.185482
2009	1.444767	4,339	0.82	1.573268	1.090714	2.269314	0.184708
2010	1.544642	3,504	0.81	1.509954	1.045587	2.180556	0.185312

Table 4. The core area vertical line relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for yellowtail snapper constructed using commercial vertical line data.

YEAR	Normalized Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.771994	3,698	0.90	0.729073	0.501479	1.05996	0.188756
1994	0.704873	6,074	0.87	0.770778	0.531056	1.118712	0.187894
1995	0.676602	5,727	0.87	0.713097	0.491283	1.035061	0.187927
1996	0.593239	4,796	0.80	0.601174	0.41349	0.874047	0.188775
1997	0.685205	7,093	0.84	0.679875	0.468671	0.986259	0.187625
1998	0.826899	6,605	0.82	0.816866	0.562802	1.185622	0.187901
1999	0.921771	6,861	0.84	0.969	0.667721	1.406217	0.187823
2000	0.807324	6,047	0.82	0.852114	0.586781	1.237426	0.188169
2001	0.946559	6,076	0.81	0.922809	0.635416	1.340188	0.188207
2002	0.947674	5,990	0.80	0.935277	0.643989	1.358321	0.188216
2003	0.881349	5,896	0.80	0.895922	0.616869	1.301211	0.188234
2004	1.078191	5,354	0.81	0.987629	0.679831	1.434783	0.188371
2005	1.088574	4,640	0.85	1.19448	0.822284	1.735147	0.188329
2006	1.266215	4,175	0.86	1.176984	0.80988	1.710488	0.188556
2007	1.231023	4,047	0.86	1.10827	0.762354	1.611145	0.188721
2008	1.532369	3,997	0.85	1.552947	1.067806	2.258503	0.188928
2009	1.471643	4,081	0.85	1.560095	1.073328	2.267618	0.188638
2010	1.568497	3,341	0.83	1.533609	1.053652	2.232195	0.189346

Figure 1. Coastal Logbook defined fishing areas.

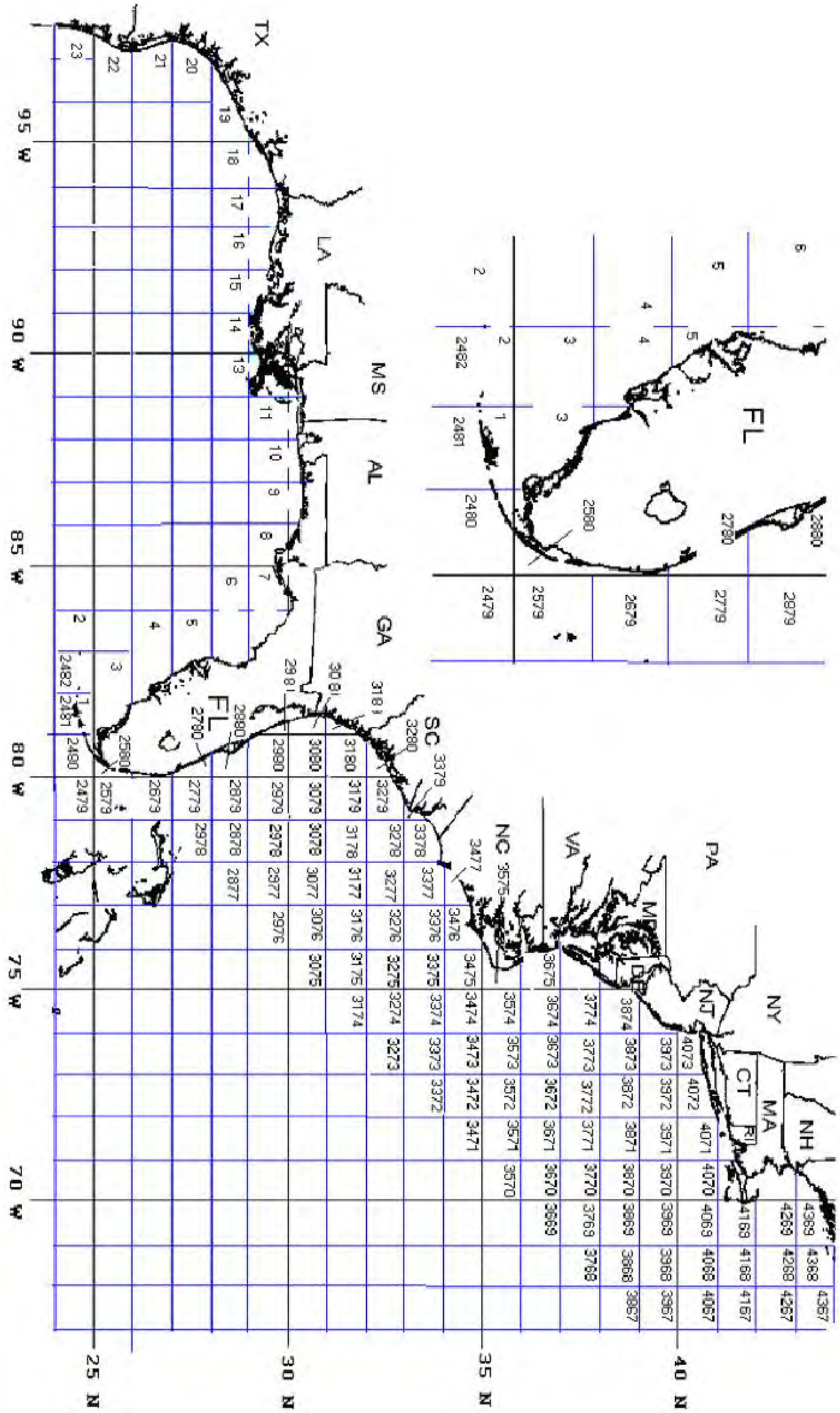


Figure 2. Regression coefficients from the south Florida Stephens & MacCall analyses. Positive coefficients signify species that had positive associations with the target species. The magnitude of the coefficients indicates the predictive impact of each species. The value for "non co-occurring" is the regression intercept and denotes the probability a trip was fishing in the target species' habitat, but did not report any of the listed species. Species included were reported on at least one percent of vertical line trips in the South Atlantic.

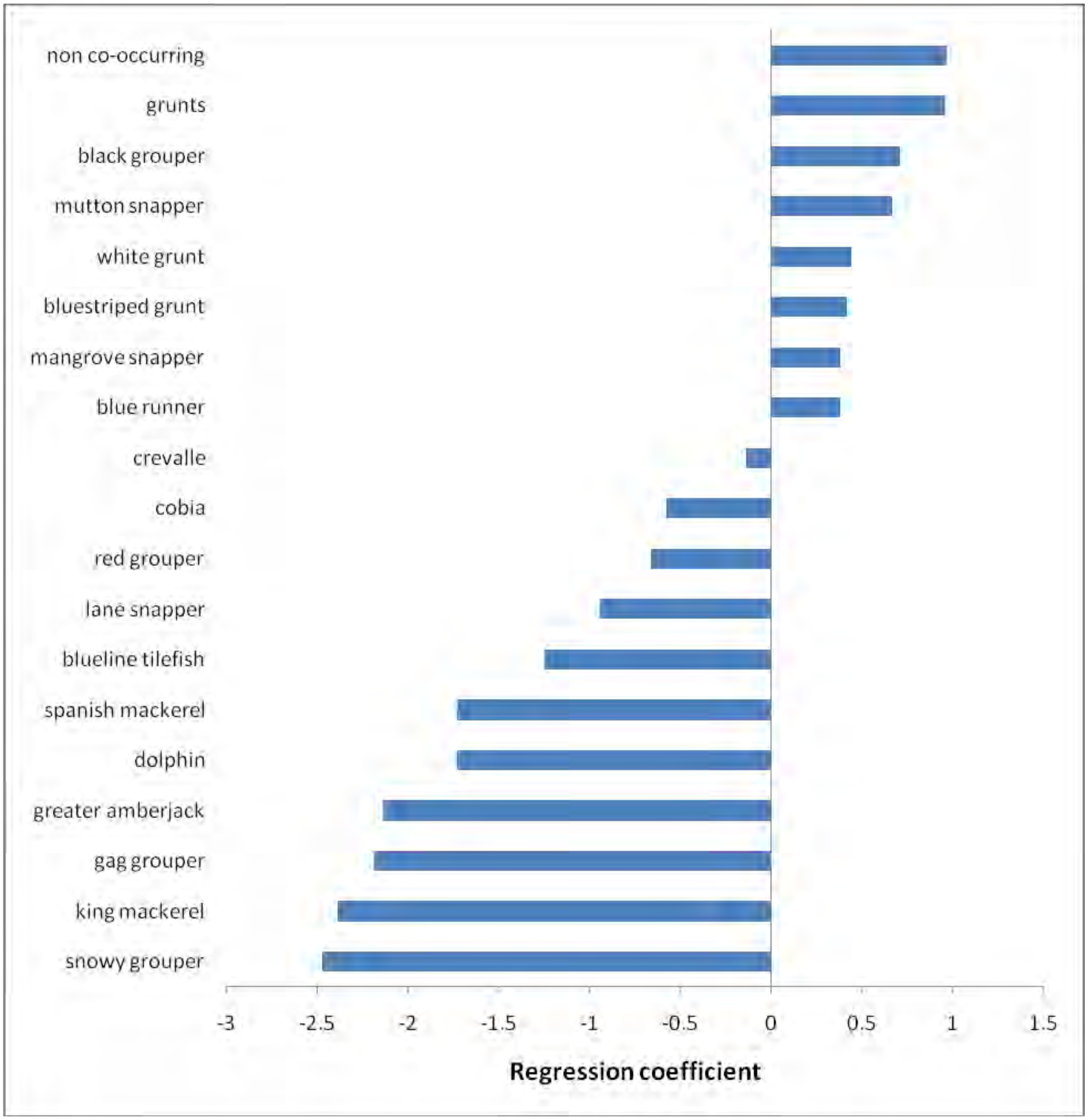


Figure 3. Regression coefficients from the core area Stephens & MacCall analyses. Positive coefficients signify species that had positive associations with the target species. The magnitude of the coefficients indicates the predictive impact of each species. The value for "non co-occurring" is the regression intercept and denotes the probability a trip was fishing in the target species' habitat, but did not report any of the listed species. Species included were reported on at least one percent of vertical line trips in the South Atlantic.

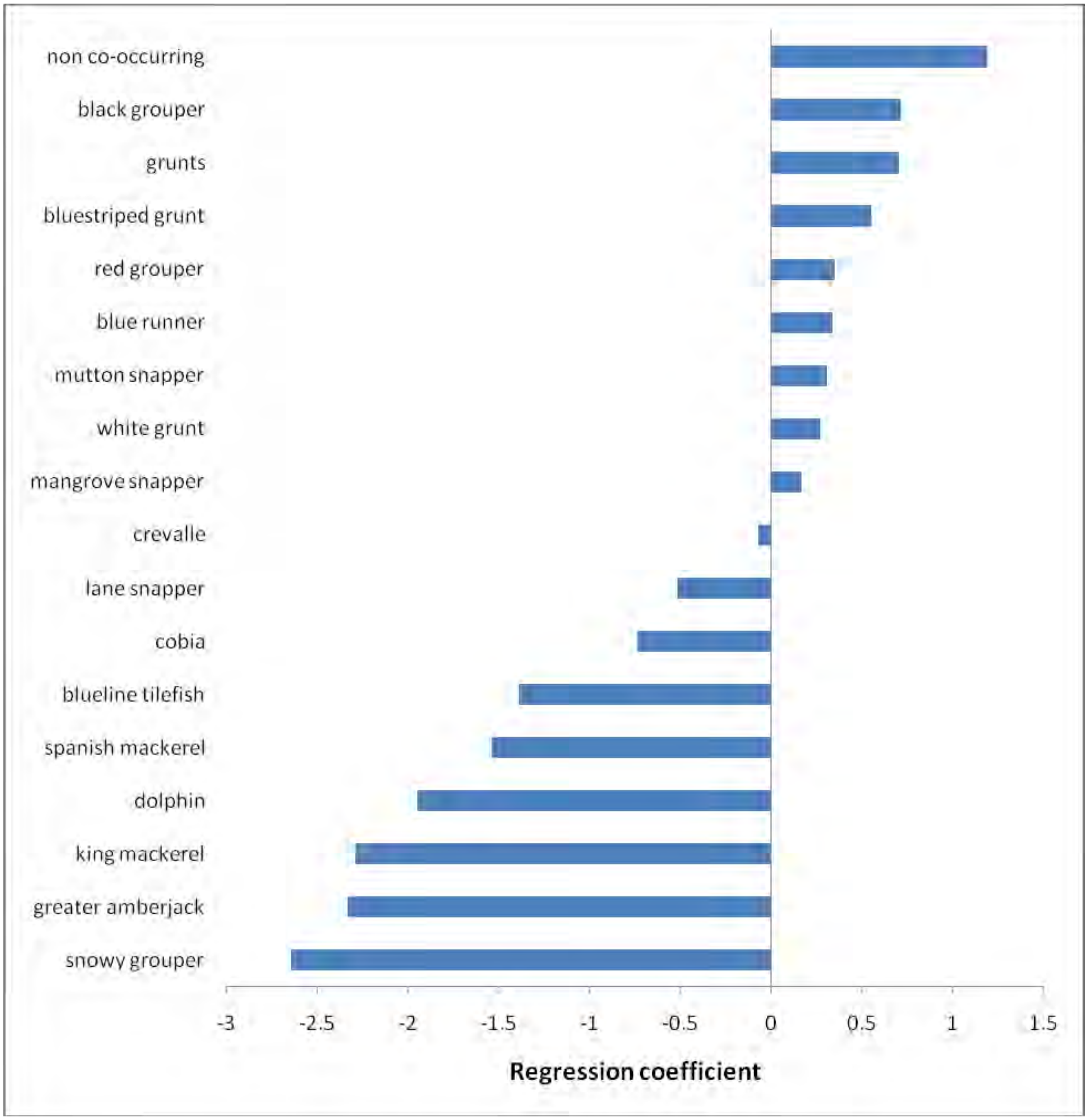


Figure 4. Yellowtail snapper south Florida nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for commercial vessels fishing vertical line gear.

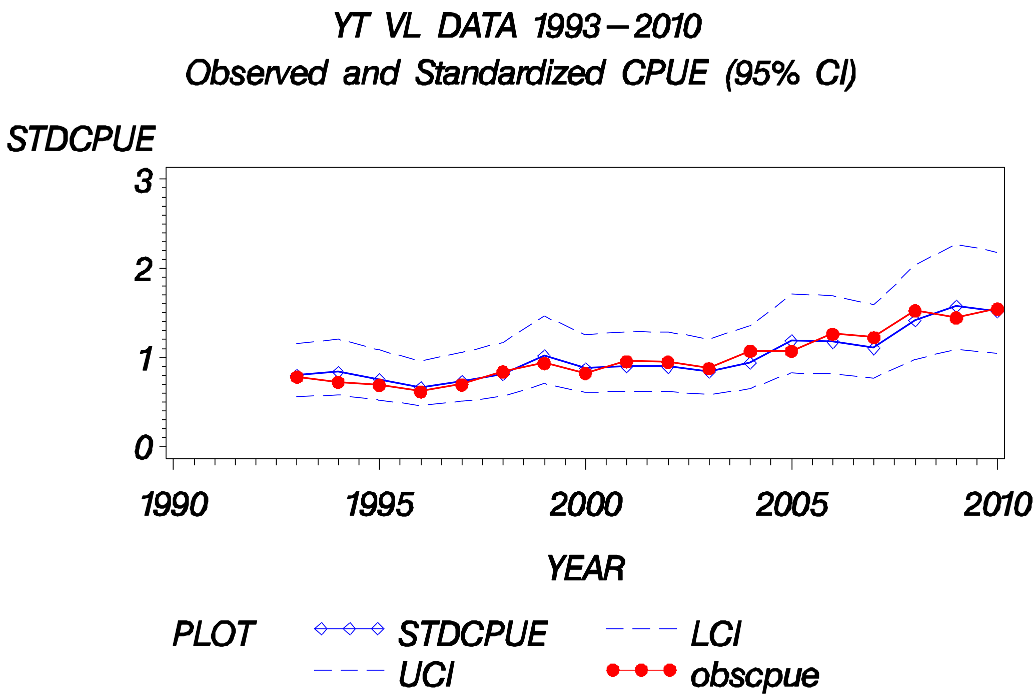


Figure 5. Yellowtail snapper core area nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for commercial vessels fishing vertical line gear.

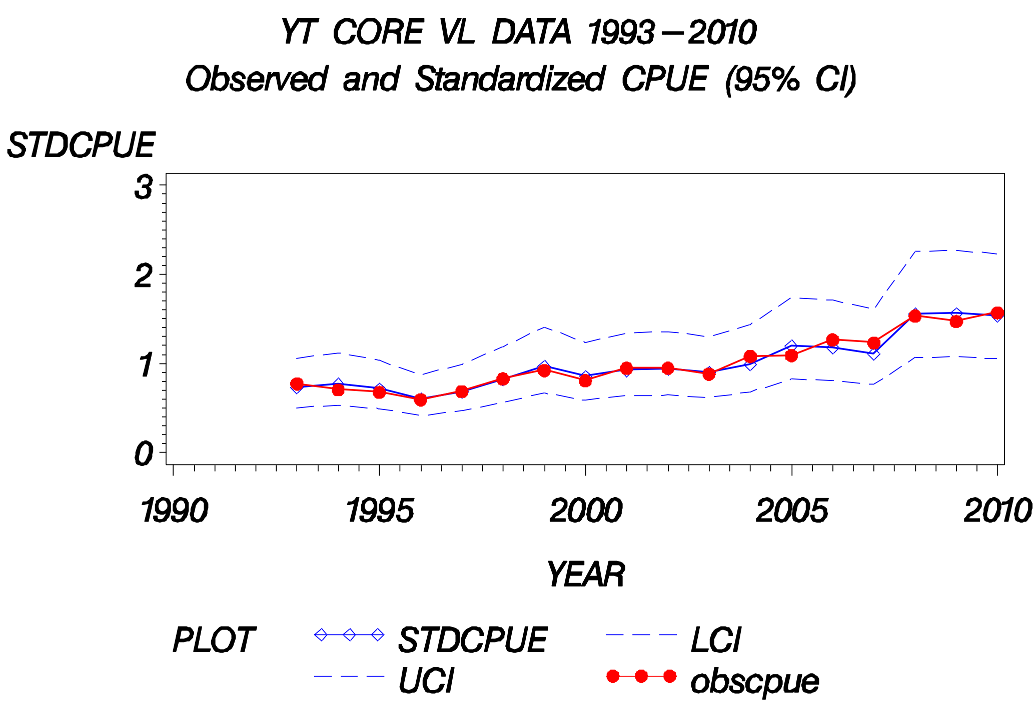


Figure 6. Comparison of the south Florida index with the core area index. Confidence intervals of the south Florida index are also provided.

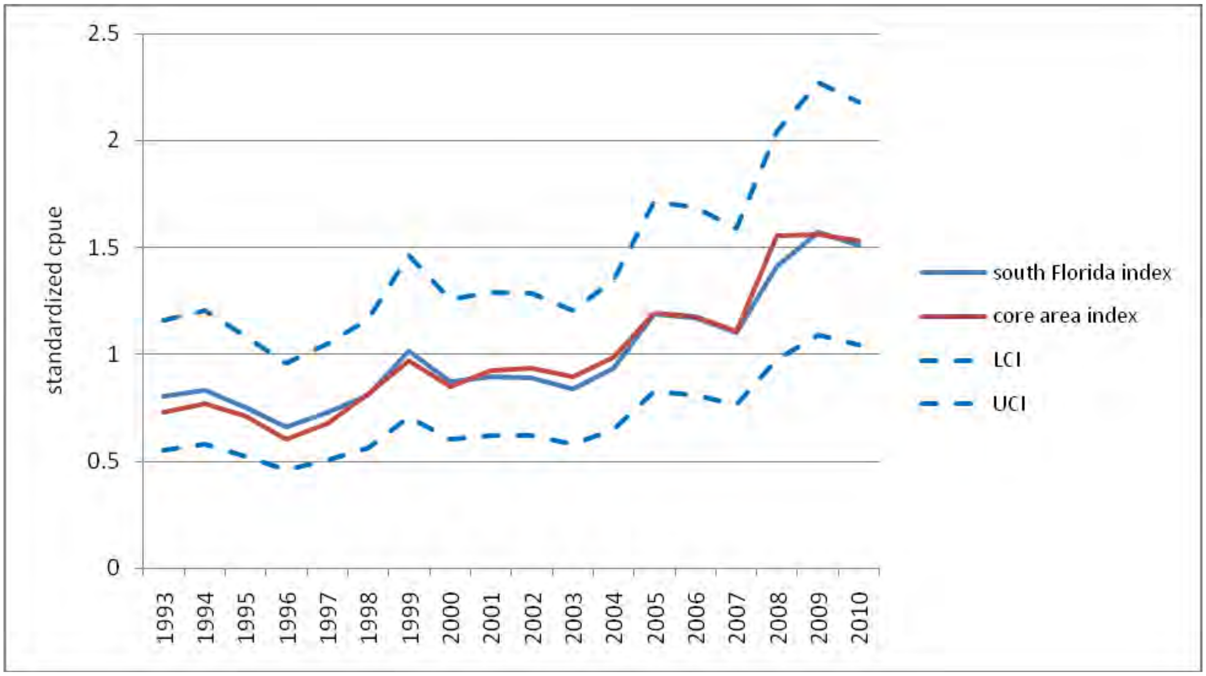


Figure 7. South Florida yellowtail snapper commercial vertical line gear data set annual trends in **A.** the proportion of positive trips and **B.** nominal CPUE.

A. **B.**

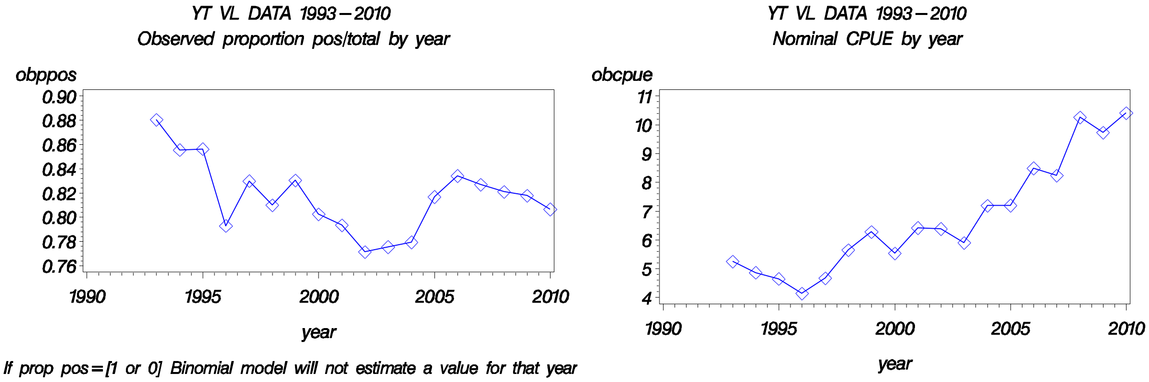


Figure 8. Diagnostic plots for the binomial component of the yellowtail snapper commercial vertical line gear south Florida model: **A**. the Chi-Square residuals by year and **B**. the Chi-Square residuals by subregion.

A. **B.**

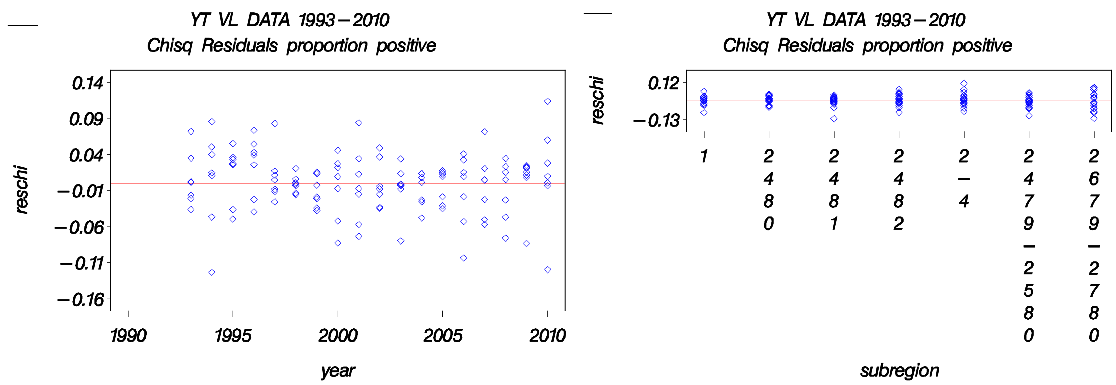
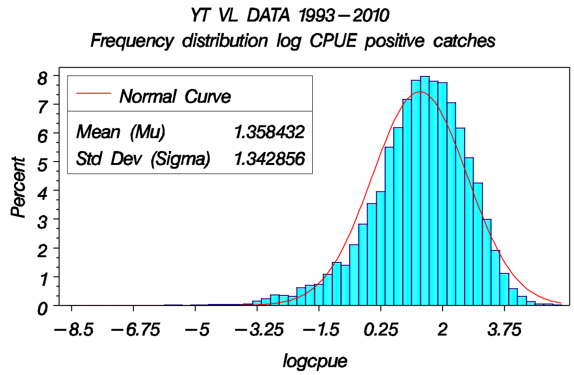


Figure 9. Diagnostic plots for the lognormal component of the south Florida yellowtail snapper commercial vertical line gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A.



B.

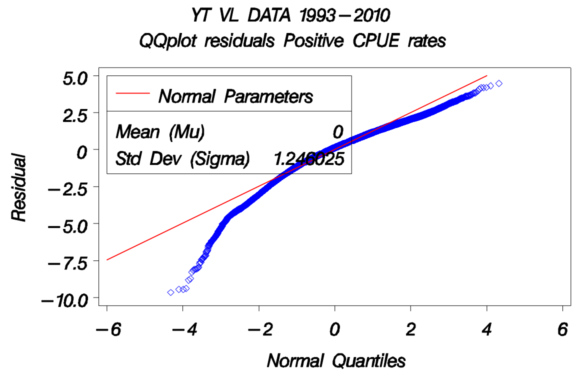
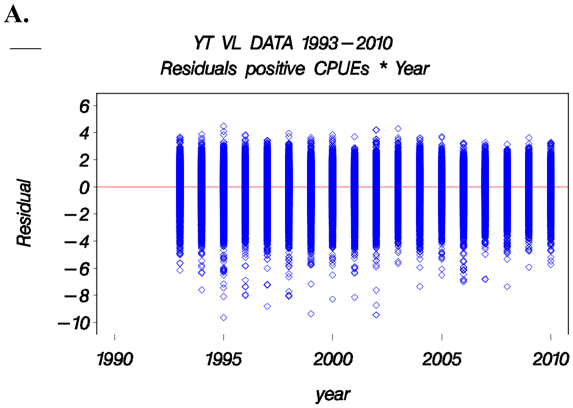
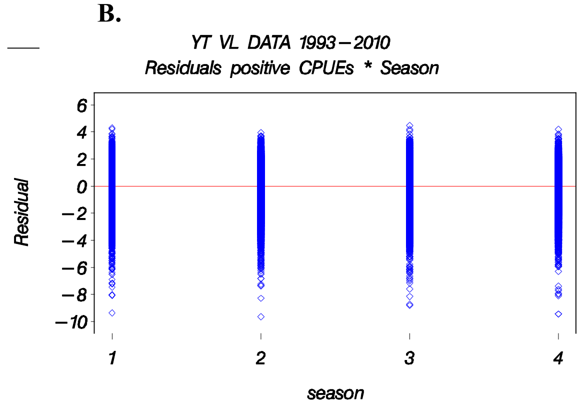


Figure 10. Diagnostic plots for the lognormal component of the south Florida yellowtail snapper commercial vertical line gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by season; **C**. the Chi-Square residuals by subregion; and **D**. the Chi-Square residuals by number of crew.

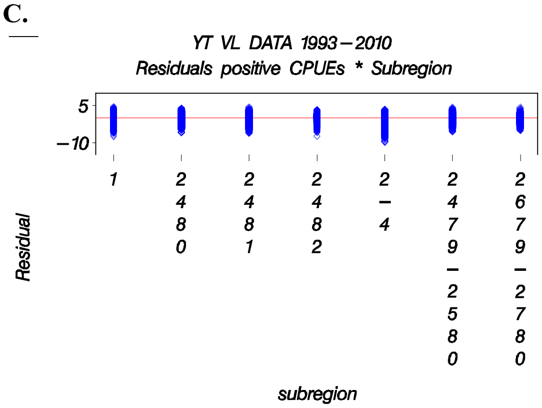
A.



B.



C.



D.

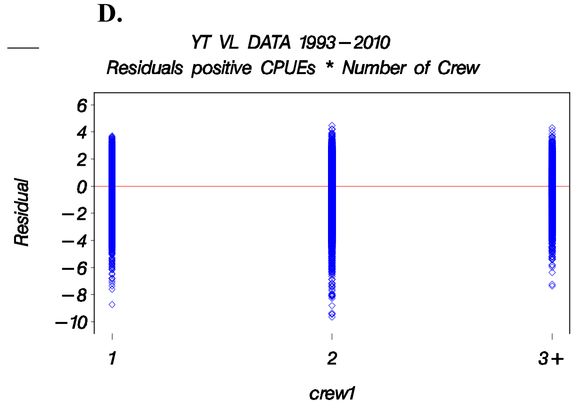
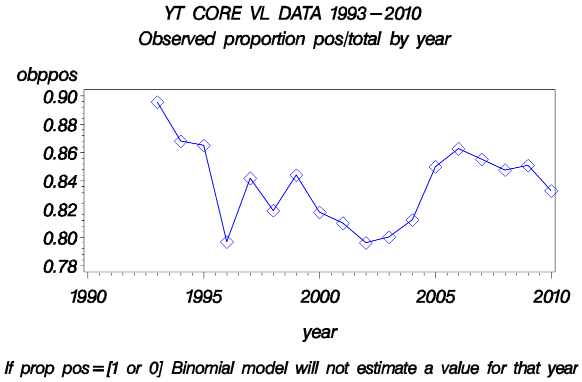


Figure 11. Core area yellowtail snapper commercial vertical line gear data set annual trends in **A.** the proportion of positive trips and **B.** nominal CPUE.

A.



B.

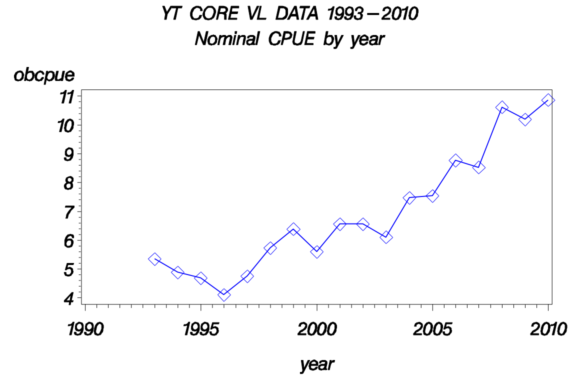
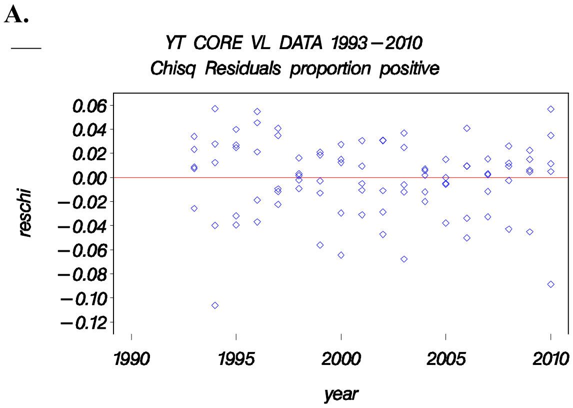


Figure 12. Diagnostic plots for the binomial component of the core area yellowtail snapper commercial vertical line gear core area model: **A**. the Chi-Square residuals by year and **B**. the Chi-Square residuals by subregion.

A.



B.

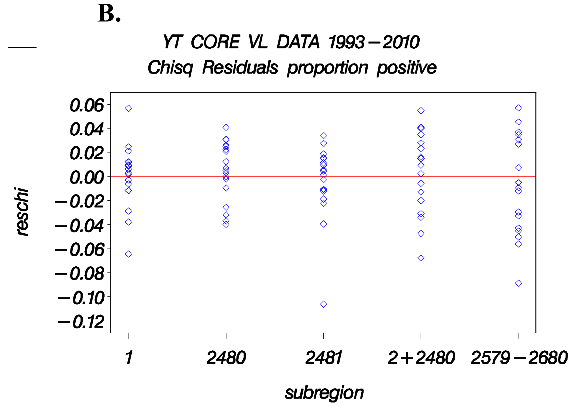
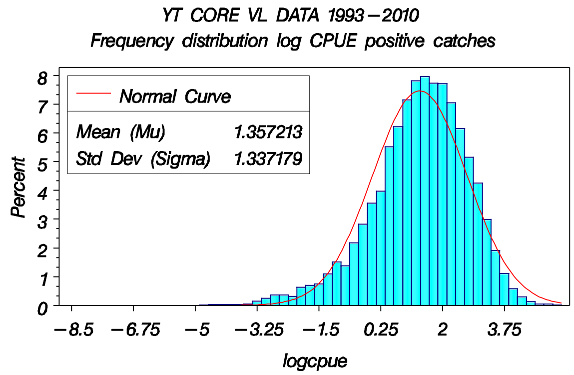


Figure 13. Diagnostic plots for the lognormal component of the core area yellowtail snapper commercial vertical line gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A.



B.

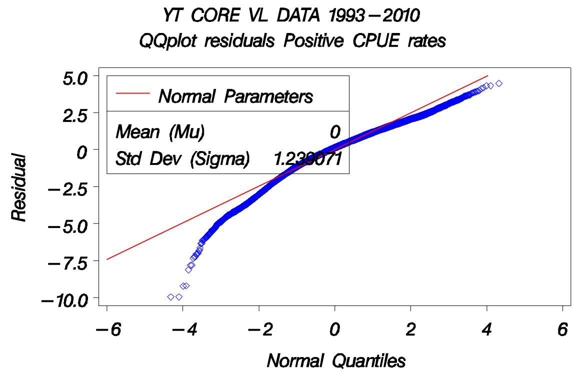
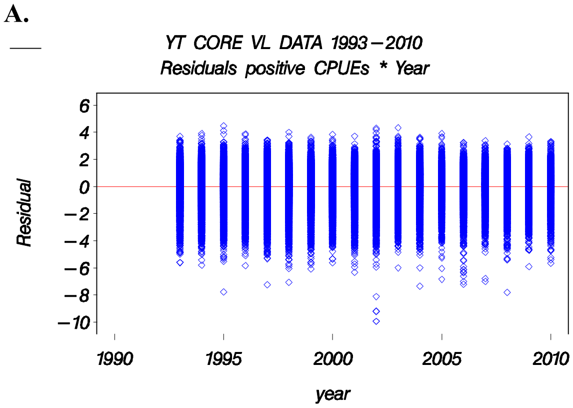
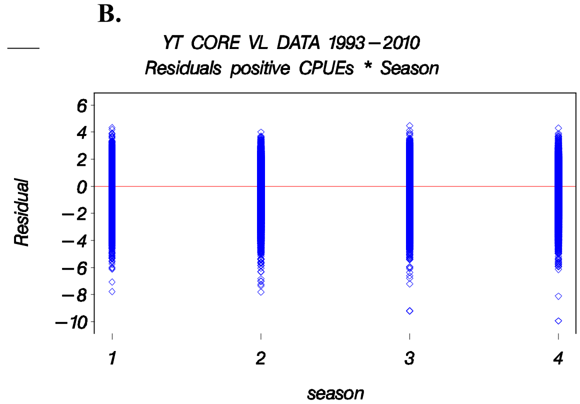


Figure 14. Diagnostic plots for the lognormal component of the core area yellowtail snapper commercial vertical line gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by season; **C**. the Chi-Square residuals by subregion; **D**. the Chi-Square residuals by number of crew; and **E**. the Chi-Square residuals by days at sea.

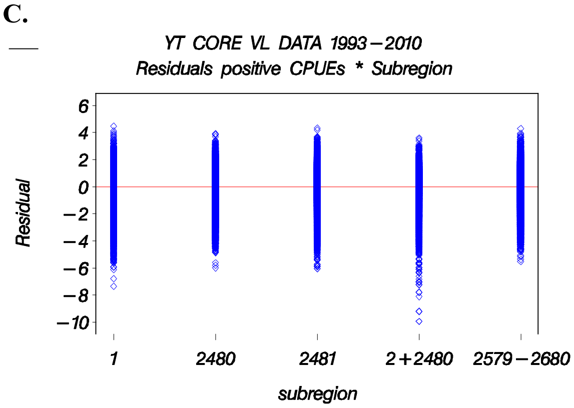
A.



B.



C.



D.