Calculated discards of yellowtail snapper from commercial vertical line fishing vessels in southern Florida

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Introduction

In August 2001, the Southeast Fisheries Science Center (SEFSC) initiated a program to collect commercial fishing vessel discard data from Gulf of Mexico and South Atlantic fisheries. A reporting form was developed that supplements the existing vessel coastal logbook forms that are currently mandatory for those fisheries (Poffenberger and McCarthy, 2004). Discard data from the SEFSC coastal fisheries discard logbook program were used to calculate the number of yellowtail snapper discards from commercial vertical line (handline and electric/hydraulic reel, aka bandit rig) vessels. Approximately 98.9 percent of reported yellowtail snapper discards were from vertical line vessels, therefore, only data from vertical line vessels were included in the analysis.

Data collection for the discard logbook program involves, each year, a 20% random sample of vessels with Gulf of Mexico reef fish, South Atlantic snapper-grouper, king mackerel, Spanish mackerel, dolphin/wahoo, and shark permits selected to report the number of animals discarded by species. To assure that the sample was representative of vessels with those Federal permits fishing in the Gulf of Mexico and South Atlantic, the universe of permitted vessels was stratified by region (Gulf of Mexico and South Atlantic) and gear fished. Fishing gear strata included handline, bandit rig, trolling, longline, fish trap, gillnet, and diving. A random sample was selected, without replacement, from each stratum. The selected fishers were instructed to complete a supplemental discard form for every fishing trip that they made. Trips with no discards were reported as such.

Reported data included the numbers of discards by species, estimated condition of the fish when released, reason for release (due to regulations or unmarketable/unwanted), and the fishing area where the animal was discarded. There are six options for the condition of released fish: all animals are dead, majority of the animals are dead, all animals are alive when released, majority of animals are alive, the fish are kept but not sold, and the condition of the animals is unknown. To calculate species specific discard rates, discard data were matched to the landings and effort data reported (for the appropriate trip) to the coastal logbook program.

Methods

The objective of this analysis was to calculate the numbers of yellowtail snapper discarded by commercial vessels that fished for species other than shrimp or other shellfish. The data set included all commercial vertical line fishing trips from federally permitted vessels that reported discards between January 1, 2002 and December 31, 2010, in southern Florida (statistical areas 1-4, 2479-2482, 2579-2580, 2679-2680, and 2779-2780; Figure 1). Reports of yellowtail snapper discards from vessels fishing other gears included less than 1.2 percent of all yellowtail snapper discard reports for the period 2002-2010. The available data for those gears were too few for discards to be calculated.

Commercial discards may be under reported. If selected, fishers are required to report to the discard logbook program in order to renew their federal fishing permits. Fishers remain in reporting compliance by

returning discard logbooks with reports of "no discards". The percentage of discard reports returned with "no discards" has increased from 42 to 73 percent in southern Florida. Commercial vertical line trips that had fishery observers onboard, however, report only 10 percent of trips had no discards. Sample size of the observer trips in southern Florida was low (30 trips in areas 1-4, no observer coverage in the southern Florida portion of the South Atlantic), however the large discrepancy between observer reports of "no discards" and self-reported "no discards" suggests that under reporting may be occurring. To reduce the likelihood of using discard rates that were erroneously low, the data set was filtered to remove records from vessels with more than 30 percent "no discards". Due to the low sample size of the observer data set and because the observer trips were spatially limited to a portion of the region of interest, the frequency of "no discards" retain in the data set was increased from the observer reported 10 percent to 30 percent. In addition, observers reported vessels which had two trips with no discards. Given that vessels with few trips may have had multiple trips with no discards, the records from vessels that had reported six or fewer trips were retained in the data set.

Discard rate was defined for vertical line gear as number of yellowtail snapper discarded per hook hour fished. Six factors were considered as possible influences on yellowtail snapper discard rate. In order to develop a well balanced sample design it was necessary to define categories within some of the factors examined:

Factor	**Levels**	**Value**
Year	9	2002-2010
Region	3	Statistical areas 1-4 (gom), 2480-2482 (keys), 2479+2579-2780 (sa) (Fig. 1)
Days at sea	2	1, 2+
Quarter	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Crew	2	1, 2+ crew members
Hook hours fished[1]	4	0.1-10, >10-16, >16-36, >36

[1] Hook hours fished was examined in the vertical line binomial GLM only.

A delta-lognormal modeling technique (Lo et al. 1992) was used to calculate yearly mean discard rate. This method combines separate general linear model (GLM) analyses of the proportion of trips that discarded yellowtail snapper and the discard rates on trips reporting yellowtail snapper discards to determine a single standardized discard rate. 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 the proportion of trips with discards, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was the proportion of trips with yellowtail snapper discards. For the analysis of discard rates on trips with discards, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was log(discards per unit effort, DPUE). The response variable was calculated as: log(DPUE)=ln(pounds of yellowtail snapper/hook hour fished). All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

Final models for the delta-lognormal analysis were constructed using a forward stepwise regression procedure to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability in discard rate. 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 $\geq 1\%$. 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 model, fit using the SAS macro GLIMMIX (Russ Wolfinger, SAS Institute), were used to calculate discard rates for the years 2002-2010. Discard rate for the period 1993-2001 (prior to discard reporting) was assumed to be the mean discard rate over the years 2002-2010, weighted by sample size. Calculated discard rates were used along with the appropriate yearly total effort reported to the coastal logbook program as ratio estimators of yearly total discards. Discards were reported in numbers of yellowtail snapper.

Results and Discussion

The final models for the binomial on proportion of trips that reported yellowtail snapper discards and the lognormal on DPUE (discards per unit effort) of trips reporting discards were:

Proportion trips reporting discards = Region + Year + Hook Hours + Region*Hook Hours + Region*Year

LOG(DPUE) = Crew + Region + Seadays + Year + Quarter + Crew*Year + Year*Quarter + Region*Year + Region*Seadays

The linear regression statistics for fixed effects and the analyses of the mixed model formulations of the final models are summarized in Tables 1-3 for the three indices.

Calculated yellowtail snapper discards, discard rates, discard rate coefficients of variation, and total effort (hook hours reported to the coastal logbook program) are provided in Table 2. Coefficients of variation for the years prior to 2002 were calculated by using the mean variance from the 2002-2010 discard rates, weighted by sample size.

Plots of the proportion of trips reporting yellowtail snapper discards (positive trips) per year, nominal discard rate (labeled cpue), frequency distributions of the proportion of positive trips, frequency distributions of log(discard rate) (labeled CPUE) for positive trips (those with yellowtail snapper discards), cumulative normalized residuals, and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures 2-5. Those diagnostic plots indicate that the fit of the data to the lognormal and binomial models was acceptable. There were, however, a few outliers among the data, particularly in the binomial data sets (Figures 3 A-C). No clear patterns in the distribution of Chi-square residuals were apparent. The data appeared appropriate for the analysis.

During the period 2002-2010 when discards were reported to the SEFSC, discard rates were highest during 2006 and 2007. The highest proportion of trips with yellowtail snapper discards was also reported during 2006-07. A relatively high proportion of vertical line trips in southern Florida reported yellowtail snapper discards during 2008 as well, however, the nominal discard rate had declined after 2007. Total vertical line vessel yellowtail snapper discards were generally lowest during the period 2003-2010. During that period, yearly total discards varied greatly. For example, total calculated discards in 2006 (highest discard rate) were nearly four times that calculated for 2004 (lowest discard rate). In addition to yearly variability in discard rate, yearly changes in total effort contributed to the variability in total discards across the years 2002-2010. Variability in total discards calculated for the years 1993-2001 was due to changes in total effort reported to the coastal logbook program. Due to the possible under reporting of discards to the coastal logbook discard program, these results may underestimate total yellowtail snapper discards from commercial vertical line vessels.

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.

Poffenberger, J. and K. McCarthy. 2004. Estimates of red snapper discards by vessels with Federal permits in the Gulf of Mexico. SEDAR 7-DW-22.

Table 1. Linear regression statistics for the 1993-2010 series GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) for black sea bass in the South Atlantic for vessels reporting vertical line gear landings. Analysis of the mixed model formulations of the proportion 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	8	16	8.56	1.07	0.3804	0.4293
region	2	16	44.19	22.10	<.0001	<.0001
hkhrs	3	70	3.00	1.00	0.3920	0.3984
*region*hkhrs*	6	70	59.33	9.89	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	8	8	5.97	0.75	0.6511	0.6560
crew1	1	8	12.20	12.20	0.0005	0.0082
region	2	16	2.29	1.15	0.3179	0.3426
seadays	1	2734	8.25	8.25	0.0041	0.0041
quarter	3	24	8.87	2.96	0.0310	0.0526
*region*seadays*	2	2734	43.30	21.65	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
REGION + YEAR + HKHRS + REGION*HKHRS	272.9	274.9	277.4		
REGION + YEAR + HKHRS + REGION*HKHRS + REGION*YEAR	267.0	271.0	273.6	5.9	0.0151

Table 1 (continued). Analysis of the mixed model formulations of the positive trip model (**D**). 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.

D.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
CREW + REGION + SEADAYS + YEAR + QUARTER	8027.6	8029.6	8035.5	-	-
CREW + REGION + SEADAYS + YEAR + QUARTER + CREW*YEAR	7928.3	7932.3	7934.1	99.3	<0.0001
CREW + REGION + SEADAYS + YEAR + QUARTER + CREW*YEAR + YEAR*QUARTER	7890.8	7896.8	7899.5	37.5	<0.0001
CREW + REGION + SEADAYS + YEAR + QUARTER + CREW*YEAR + YEAR*QUARTER + REGION*YEAR	7861.4	7869.4	7872.9	29.4	<0.0001
CREW + REGION + SEADAYS + YEAR + QUARTER + CREW*YEAR + YEAR*QUARTER + REGION*YEAR + REGION*SEADAYS	7821.0	7829.0	7832.6	40.4	<0.0001

Table 2. Calculated yearly total discards of yellowtail snapper from vertical line vessels for each year. Discards are reported as number of fish.

Year	Trips (discards)	Trips (total effort)	Discard Rate	Discard Rate CV	Total Effort	Calculated Discards
1993		11,529	0.219	0.4712	744,952	163,165
1994		13,360	0.219	0.4712	1,313,018	287,587
1995		13,706	0.219	0.4712	831,195	182,054
1996		14,328	0.219	0.4712	868,133	190,144
1997		16,216	0.219	0.4712	1,020,674	223,555
1998		14,989	0.219	0.4712	768,831	168,395
1999		14,945	0.219	0.4712	868,038	190,124
2000		13,534	0.219	0.4712	943,095	206,563
2001		14,225	0.219	0.4712	644,938	141,259
2002	585	14,282	0.237	0.4546	696,486	165,154
2003	768	15,285	0.215	0.4453	550,347	118,371
2004	540	14,109	0.105	0.4688	487,564	51,337
2005	533	12,125	0.161	0.4443	420,355	67,594
2006	313	12,734	0.438	0.4831	448,889	196,619
2007	745	12,660	0.230	0.4257	407,089	93,455
2008	874	12,861	0.299	0.4079	396,876	118,560
2009	609	14,561	0.177	0.4441	504,285	89,464
2010	676	13,084	0.166	0.4819	442,946	73,545

Figure 1. Coastal logbook statistical areas.

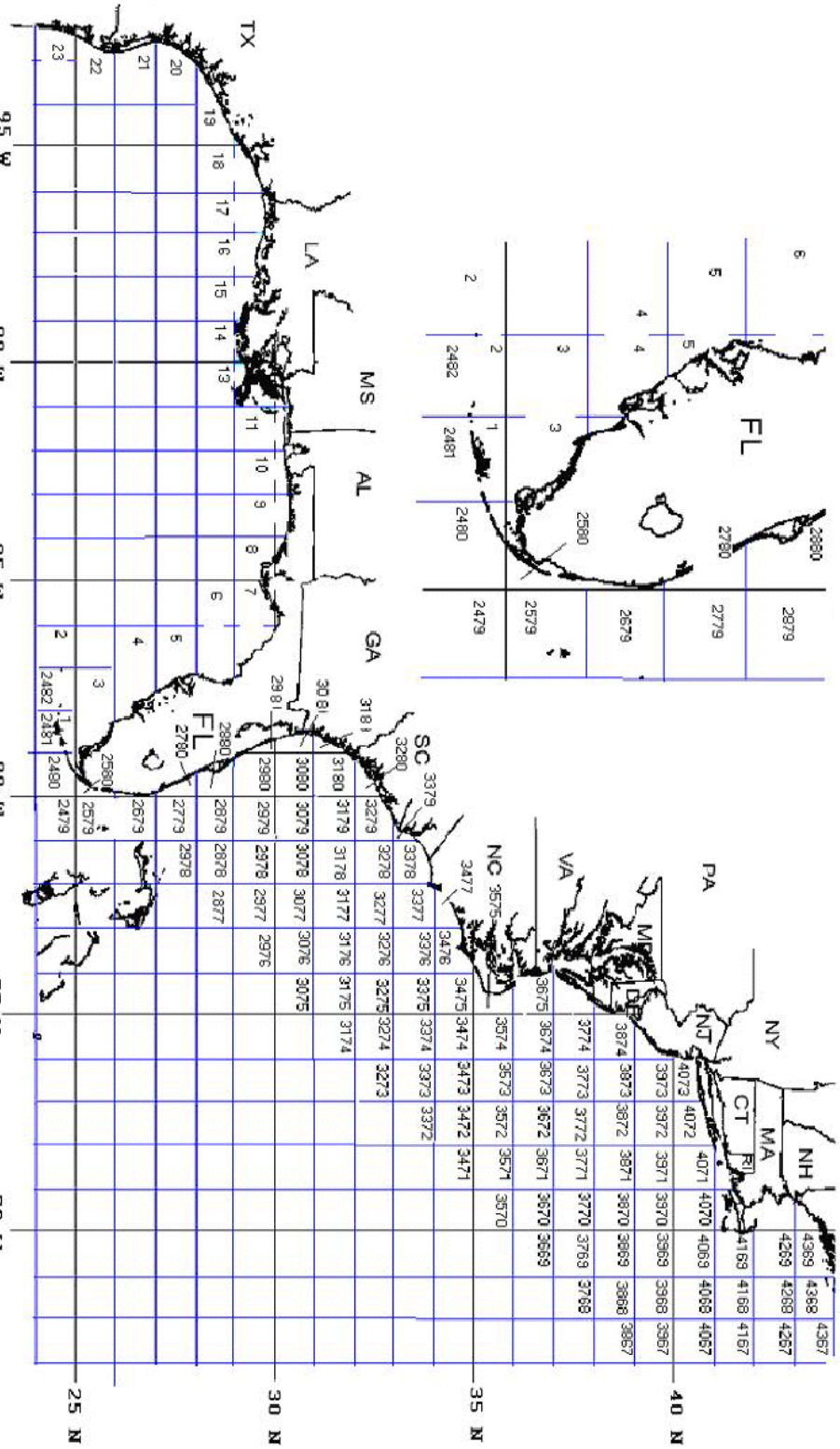
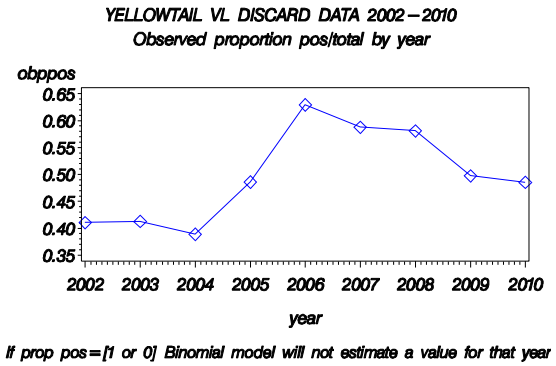


Figure 2. Yellowtail snapper annual trends in **A.** the proportion of positive trips (those reporting yellowtail snapper discards) and **B.** nominal yellowtail snapper discard rate (labeled CPUE) from southern Florida commercial vertical line gear data.

A.



B.

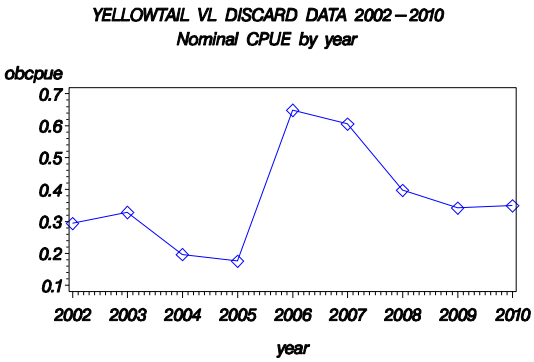
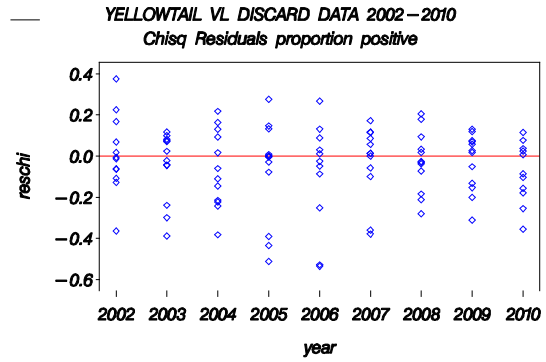
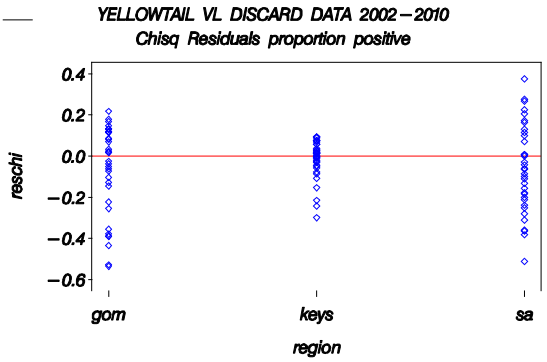


Figure 3. Diagnostic plots for the binomial component (proportion positive) of the southern Florida yellowtail snapper commercial vertical line gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by region; and **C**. the Chi-Square residuals by hook hours fished.

A.



B.



C.

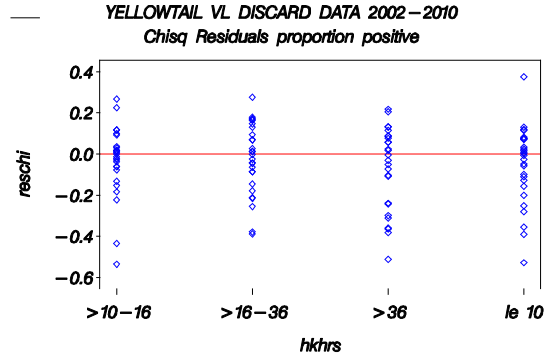


Figure 4. Diagnostic plots for the lognormal component of the southern Florida yellowtail snapper commercial vertical line gear model: **A.** the frequency distribution of log(discard rate) (labeled cpue) on positive trips (those reporting yellowtail snapper discards), **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

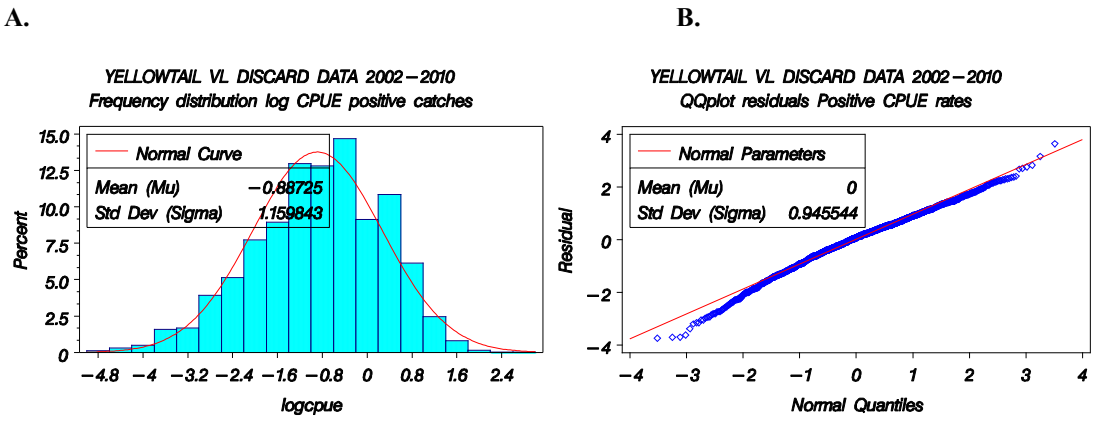


Figure 5. Diagnostic plots for the lognormal component of the southern Florida yellowtail snapper commercial vertical line gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by quarter; **C**. the Chi-Square residuals by region; **D**. the Chi-Square residuals by number of crew; and **E**. the Chi-Square residuals by days at sea.

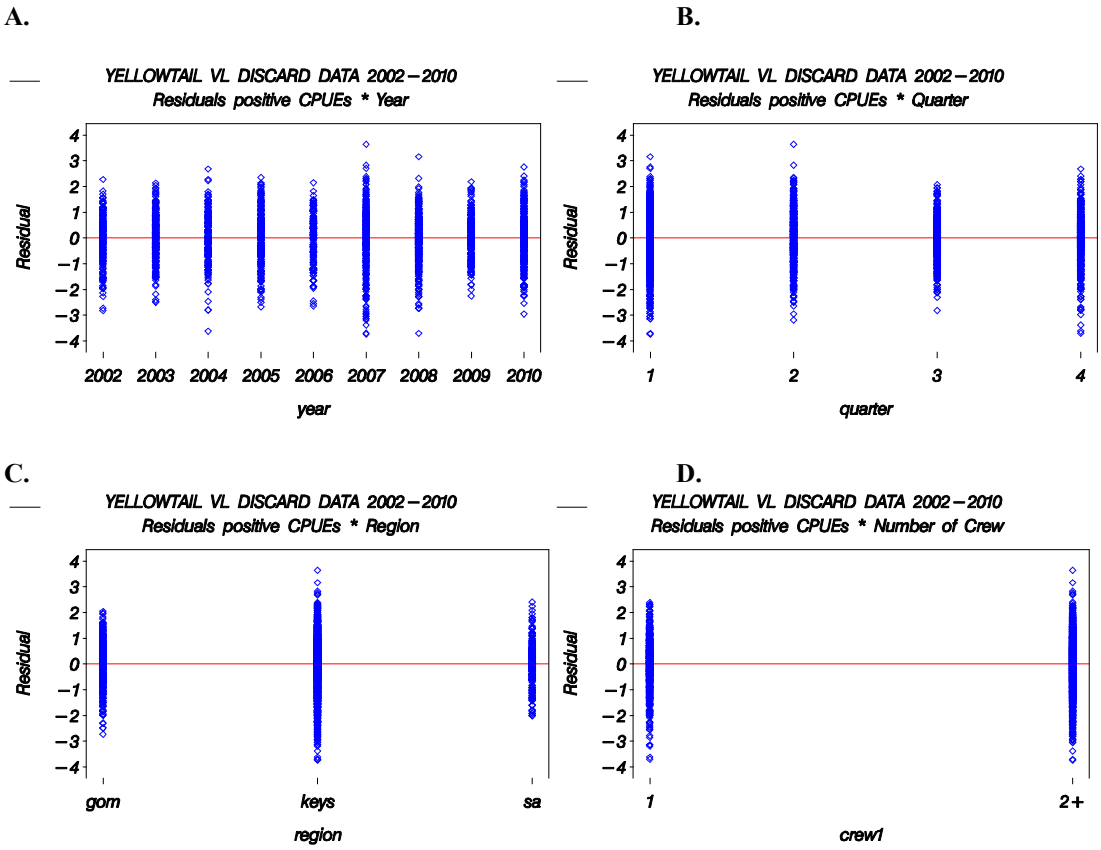


Figure 5. (continued)

E.

