Standardized catch rates of black sea bass from commercial fish traps in the US South Atlantic, 1993-2010

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Introduction

Landings and fishing effort of commercial fish trap vessels operating in the 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 South Atlantic Fishery Management Council. The coastal logbook program began in 1992 in the US South Atlantic with the objective of a complete census of coastal fisheries permitted vessel activity. During the initial year, however, a 20% sample of vessels in Florida was selected to report with all vessels in other states required 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 a standardized abundance index for black sea bass. The index was constructed using data reported from commercial fish trap (fish pot) trips in the US South Atlantic. Black sea bass data were sufficient to construct an index 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 fish traps included number of traps fished, number of hauls, and trap soak time. Changes in logbook reporting forms and apparent confusion regarding how fishing effort was to be reported have resulted in inconsistency within the data set. Number of hauls and trap soak time cannot be reliably included in calculations of fishing effort of fish traps. The number of traps fished, therefore, was used as the measure of fishing effort for construction of the fish trap index of abundance.

Several filters were applied to the data set. 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. only trips which reported one area (i.e., subregion, as defined below) and one gear fished (fish trap) were included in these analyses. Clear outliers in the data, e.g. values falling outside the 99.5 percentile of the data, were also excluded from the analyses. These included data from trips reporting fishing more than 500 traps fished per trip, more than four days at sea, or reporting crews of more than three.

Management measures, specifically closed seasons, required that additional data be excluded from the analyses. Closed seasons occurred during 2009 and 2010 due to quota restrictions and data reported during closed seasons were excluded from the analyses. Closures were particularly lengthy during 2010 when the commercial fishery

was open during June-October 7th and again from December 1-15. The fishery was closed during the remainder of the year.

The time series (1993-2010) included a change in the black sea bass commercial minimum size. In addition, minimum mesh size for escape panels on fish traps was implemented and changed during the period included in the index time series. The assumption was made that changes in catchability due to the minimum size change and/or minimum mesh size requirements would be accounted for in the assessment model(s). The index was constructed for the entire time series.

The index was constructed using all commercial fish trap trips reporting any black grouper landings. Only 1.6% of trap trips in the US South Atlantic did not report black grouper landings. With such a high proportion of positive trips, a delta-lognormal analysis was not appropriate.

Index Development

Fish trap catch rate was calculated as weight of black sea bass per trap fished:

CPUE = pounds of black sea bass/trap fished

Seven factors were considered as possible influences on the catch rate of black sea bass. Among those were number of traps fished and vessel identification number. The assumption was made that fishers reported the number of traps fished consistently, although the exact meaning (i.e., the quantity reported) of "traps fished" may have been interpreted differently among fishers. Number of traps fished and vessel identification number were included as factors as a means of standardizing for differences in how the quantity "traps fished" was reported by fisher. Spatially, the analysis was limited to the area between 28°N and 36°N due to very low sample size farther south and regulatory boundaries. 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	18	1993-2010
Quarter	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	3	Stat areas 2800-3280, 3300-3379, 3400-3575 see Figure 1
Days at sea (seadays)*	2	1, 2+ days
Crew (crew1)*	3	1, 2, 3 crew members
Number of traps fished (numgear)*	N/A	Continuous
Vessel identification number (vesid)*	220	Individual trap vessels

*Names in parentheses appear in some figures and tables.

The lognormal model on catch rates of trips reporting black sea bass landings was used to construct a standardized index of abundance. Parameterization of the model was accomplished using a GLM procedure (GENMOD; Version 9.1 of the SAS System for Windows © 2002-03. SAS Institute Inc., Cary, NC, USA).

For the analysis of catch rates, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was log(CPUE). The response variable of the fish trap data was calculated as: log(CPUE)=ln(pounds of black sea bass/trap fished). Only main effects were included in the model.

A forward stepwise regression procedure was used to determine the set of main effects 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 $\geq 1\%$. 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.

The final lognormal model was fit using a mixed model (PROC MIXED; Version 9.1 of the SAS System for Windows © 2002-03. SAS Institute Inc., Cary, NC, USA). 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

The final model for the lognormal on CPUE of successful trips:

LOG(CPUE) = Year + Vessel ID + Days at Sea + Quarter + Number of Traps Fished

The linear regression statistics for fixed effects are summarized in Table 1.

Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices are provided in Table 2. Yearly mean cpue ranged from 0.81 to 1.5 (in 2010). Coefficients of variation (CV) were very low, ranging from 0.06-0.09. Similarly, confidence intervals around the mean cpue were narrow.

The abundance index, along with 95% confidence intervals, is shown in Figure 2. Plots of the nominal cpue, frequency distribution of log(CPUE), cumulative normalized residuals (Q-Q plot), and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures 3-5. Those diagnostic plots indicate that the fit of the data to the lognormal model was acceptable. There were, however, a few outliers among the data, particularly in the Chi-Square residual by year (Figure 5A). No clear patterns in the distribution of Chi-square residuals were apparent and the data appear appropriate for the analysis.

No long term trend was found in black sea bass standardized catch rates for fish trap vessels. There were occasional increases in cpue (1996, 2004, 2010, perhaps 1993) over the time series. For much of the index period (1994-2002), however, there was no apparent trend in cpue. Over the final eight years of the index, mean yearly cpue increased during 2003-04 and 2009-10, but declined during the period 2005-07. Variability around those yearly means was low (CVs were <0.1), perhaps due to including only positive trips in the model. In addition, only main effects were modeled which tends to decrease the confidence intervals around the mean cpue.

Results of this analysis should be used cautiously because the data were reported from fishers using the principle gear of the black sea bass fishery. Yearly mean cpue may not reflect black sea bass abundance, but rather the ability of fishers to successfully target the species.

Table 1. Linear regression statistics for the catch rates on positive trips for black sea bass in the South Atlantic for vessels reporting fish trap landings. See text for factor (effect) definitions.

Type 3 Tests of Fixed Effects				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	17	619	4.70	<.0001
Vessel ID	219	619	9.73	<.0001
Days at Sea	1	8831	508.00	<.0001
Quarter	3	8831	166.73	<.0001
Number of traps fished	1	8831	222.64	<.0001

Table 2. Commercial black sea bass fish trap relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index in the South Atlantic.

YEAR	Normalized Nominal CPUE	Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.729847	381	1.105655	0.934545	1.308093	0.084215
1994	0.857059	685	0.887262	0.78183	1.006913	0.063315
1995	1.035019	518	0.818744	0.720329	0.930604	0.064097
1996	0.992321	592	1.057404	0.935806	1.194802	0.061139
1997	0.803158	768	0.872493	0.775536	0.981572	0.058951
1998	0.76163	719	0.92844	0.822667	1.047812	0.060533
1999	0.849602	735	0.982249	0.869774	1.109269	0.060862
2000	0.920932	609	0.884093	0.782371	0.99904	0.061174
2001	0.660173	875	0.849191	0.756354	0.953422	0.057936
2002	0.693901	591	0.878011	0.77349	0.996655	0.063437
2003	0.894929	526	1.037586	0.911369	1.181284	0.064921
2004	1.353283	491	1.272091	1.11255	1.454509	0.067079
2005	1.046789	391	1.091702	0.9428	1.26412	0.073418
2006	0.947272	487	1.04258	0.904562	1.201658	0.071091
2007	1.189896	373	0.814032	0.709125	0.934459	0.069066
2008	1.265201	316	0.920328	0.793481	1.067454	0.074253
2009	1.243028	405	1.060157	0.911857	1.232575	0.075451
2010	1.755959	230	1.497983	1.249364	1.796076	0.09093

Figure 1. Coastal Logbook defined fishing areas.

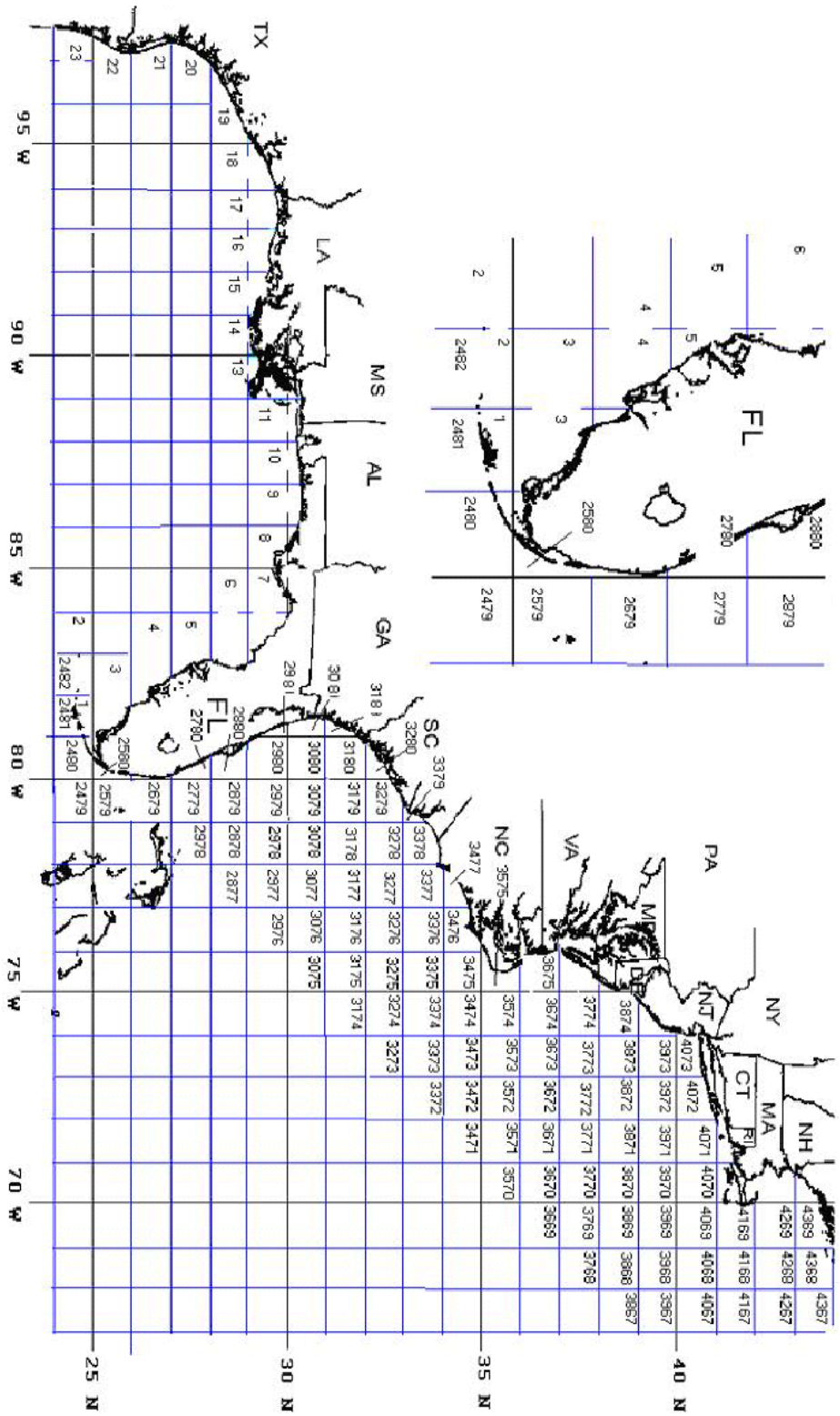


Figure 2. Black sea bass nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for commercial vessels fishing fish traps in the South Atlantic. CPUE = pounds black sea bass/trap/trip

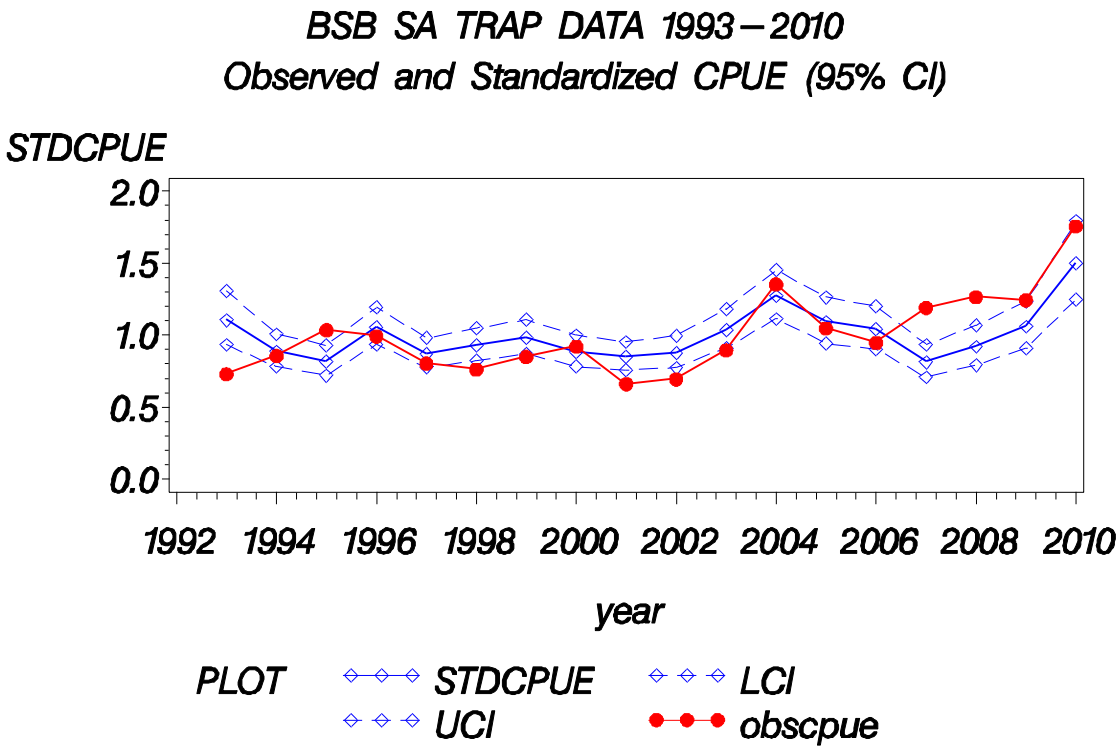


Figure 3. 1993-2010 time series annual trends in nominal CPUE (pounds/trap/trip) of the South Atlantic black sea bass commercial fish trap data.

A.

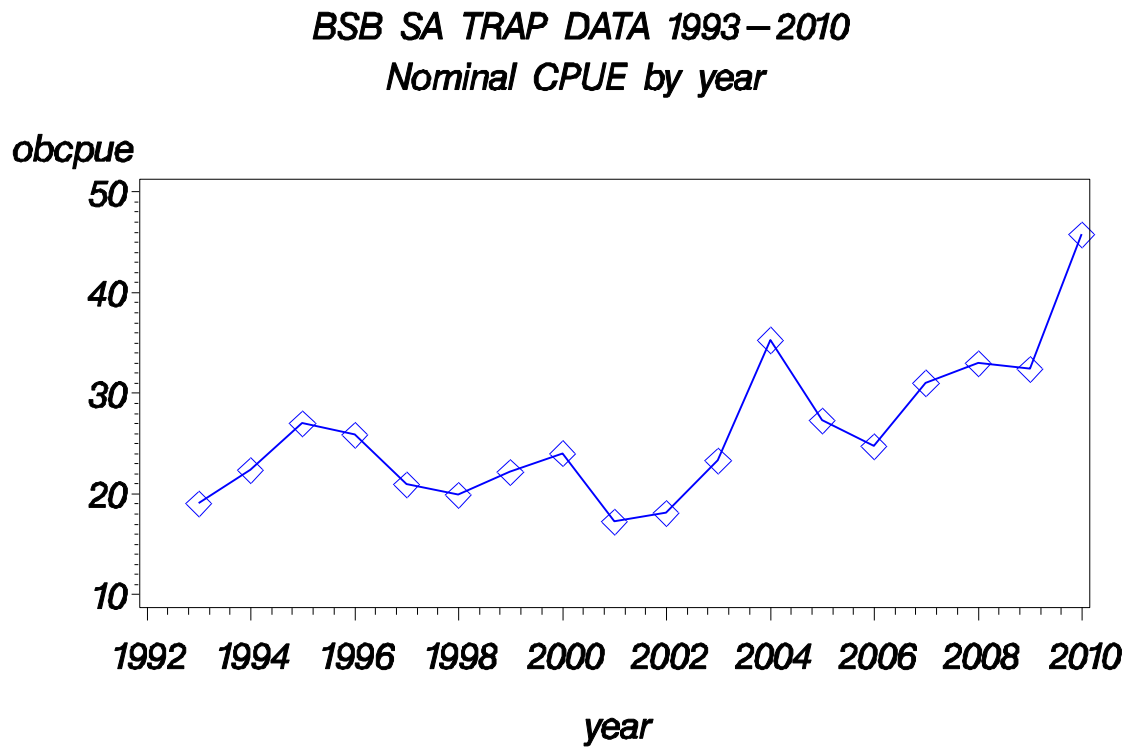


Figure 4. Diagnostic plots for the lognormal component of the South Atlantic 1993-2010 black sea bass commercial fish trap gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A. **B.**

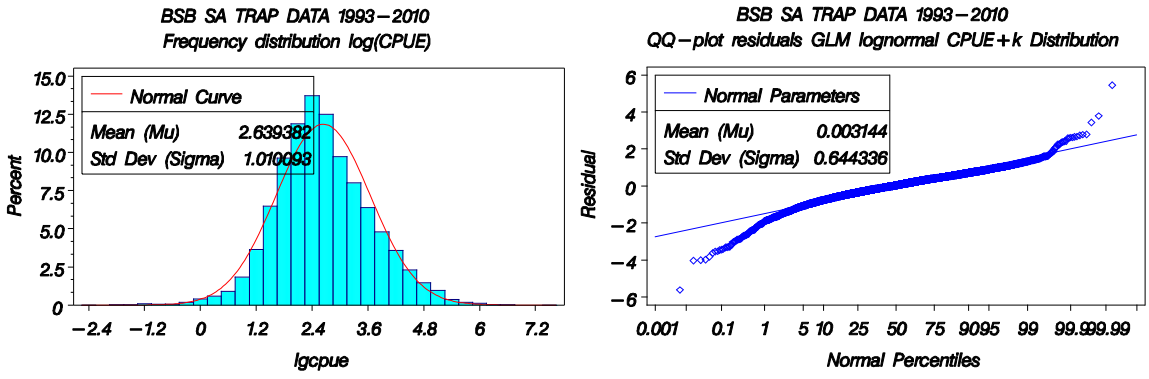
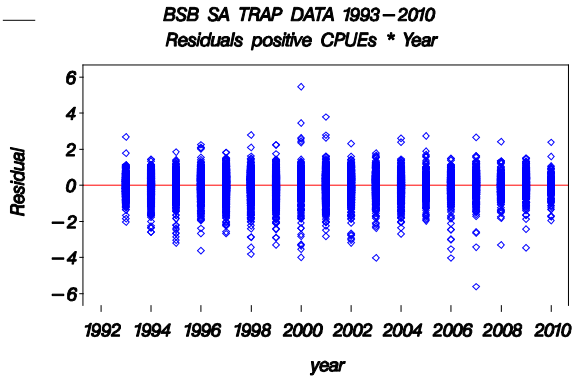
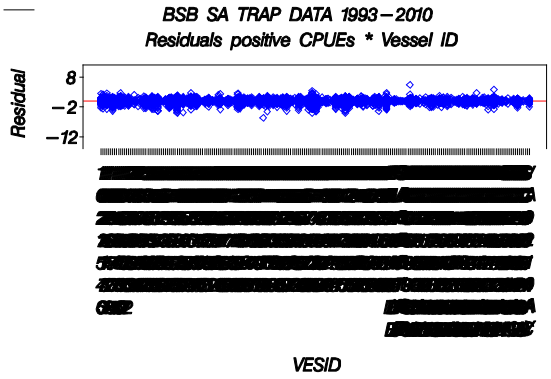


Figure 5. Diagnostic plots of the South Atlantic 1993-2010 black sea bass commercial fish trap lognormal model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by vessel identification (vessel id numbers obscured); **C**. the Chi-Square residuals by days at sea; **D**. the Chi-Square residuals by number quarter; and **E**. the Chi-Square residuals by number of traps fished (continuous variable).

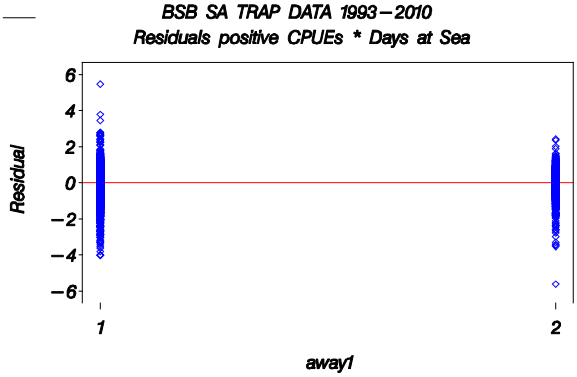
A.



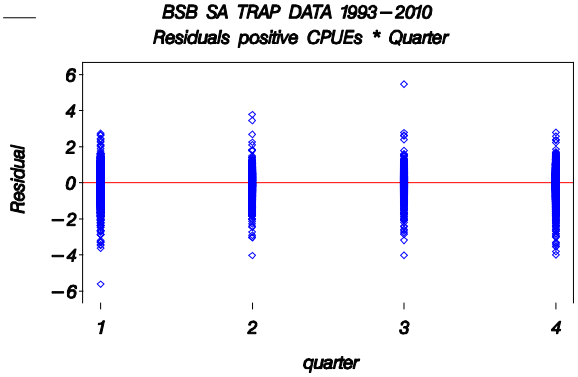
B.



C.



D.



E.