Commercial Vertical Line Vessel Standardized Catch Rates of Cobia in the US Gulf of Mexico, 1993-2010

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Commercial Vertical Line Vessel Standardized Catch Rates of Cobia in the US Gulf of Mexico, 1993-2010

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Introduction

NOAA Fisheries has been monitoring commercial landings and fishing effort of federally managed coastal finfishes in the Gulf of Mexico and U.S. South Atlantic through the Southeast Fisheries Science Center's Coastal Fisheries Logbook Program (CFLP). The CFLP collects landings and effort data by fishing trip which are submitted by fishers who own or operate a federally permitted commercial fishing vessel. Most data collected by the CFLP are for fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The CFLP data collection began in 1990 to obtain a complete census of the coastal fisheries in the Gulf of Mexico from vessels that possessed a Federal Reef fish permit, with the exception of Florida, where only 20 percent of vessels were selected to report until 1993. Also beginning in 1993, South Atlantic Snapper/Grouper and Shark permit holders were required to submit trip reports. Beginning in 1998, all Federal Spanish and King Mackerel permit holders were required to report.

Using the CFLP's available catch per unit effort (CPUE) data, an index of abundance of cobia was constructed for the U.S. Gulf of Mexico and the southeast Florida coast from 1993 through 2010. While cobia is not listed under any Federal permit, the index was constructed using data submitted by Federally permitted commercial vertical line vessels.

Methods

Available Data

Commercial fishing activity reported by fishers to the CFLP is at the trip level. For each fishing trip, the CFLP database includes a unique trip identifier, the landing date, fishing gear deployed, areas fished (Figure 6), 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 gear included number of lines, number of hooks per line, and total hours fished. Vertical gear includes handline (i.e. rod & reel), electric/bandit reel, and trolling. In the case of electric/bandit reel, these data were not collected separately until 2007. 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 always possible; therefore, only trips which reported one area category (see area factor below) and one gear fished were included in these analyses. For trips where both handline and electric reel were reported, these trips were kept and total effort summed.

Data were further restricted to include only those trips with landings and effort data received by the CFLP within 45 days of the completion of the trip. Reporting delays beyond 45 days likely results in less accurate effort data. Landings data may still be reliable even with lengthy reporting delays if dealer trip ticket reports

were referenced by the reporting fisher. Trips in which errant or missing data were present were removed from the analyses. These included missing number of lines, number of hooks, and hours fished for vertical gear. Vertical gear trips reporting 24 or more hours per day fishing were also excluded. Following the exclusion of trips listed above, outliers were removed in which number of lines, hooks, number of days fished, and number of crew fell outside the upper 99.5 percentile. Additional vertical line trips were removed from consideration when trips caught deep water grouper by trolling.

For this analysis, only one-day trips were used from 1993 through 2010. Only one day trips were used as the cobia trip limit is one per person per day with a maximum 1 day possession limit. The Gulf of Mexico for this region includes South Atlantic areas south of the 28th parallel, off of Florida, around southern Florida and into the Gulf of Mexico.

Index Development

Vertical line catch rate was calculated in gutted pounds per hook hour. For each trip, catch per unit effort was calculated as:

CPUE = gutted pounds of Cobia/ (number of lines * number of hooks per line * hours fished)

Five factors were considered as possible influences on vertical line catch rates of cobia. In order to develop a well balanced sample design, the factors were defined as:

Factor	Levels	Value
YEAR	18	1993-2010
CREW	3	1, 2, 3+
QUARTER	4	1, 2, 3, 4
GEAR_TYPE	2	TROLLING, VERTICAL
SUBREGION	4	WEST GOM (areas 13-21), EAST GOM (areas 3-12), FL KEYS (areas 1,2, 2479-2580), MID ECFL (areas 2679-2780)

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

Effects on the proportion of positive trips and on the CPUE of positive trips of the above factors were tested using general linear model (GLM) analyses. For the 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. For the analyses 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). The response variable of data was calculated as: log(CPUE) = ln(pounds of cobia/hook hour) for vertical line. 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 $\geq$1%. These significant factors were input as the base model, and the process was repeated, adding factors and

two-way interactions individually until no factor or interaction met the criteria for incorporation into the final model.

The final delta-lognormal model was fit using a SAS macro, GLMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR which were examined as random effects to be included in the final model. 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). For comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

Results and Discussion

The final models for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips were:

PPT = Year + Subregion

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

The linear regression statistics and analyses of the mixed model formulations of the final models are summarized in Table 1. Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index are provided in Table 2. The delta-lognormal abundance index constructed, with 95% confidence intervals, is shown in Figure 1.

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 2-5. Those diagnostic plots indicate that the fit of the data to the lognormal and binomial models were acceptable. There is a bimodal frequency distribution of log(CPUE), and is likely due to subregion (Figure 4) which was a factor included in the final model. Observed variations from the expected fit of the data were not sufficient to violate assumptions of the analyses. About 270,000 trips were used in the analysis with an observed proportion of positive trips ranging from approximately 2.3 to 4.0%.

Cobia standardized catch rates for vertical line showed no appreciable change between 1993 and 2010. Coefficients of variation remained relatively low and constant over the time series ranging mostly from 0.30-0.36, with a peak of 0.40 in 1993. Due to the 2 fish per person, per day, trip limit, there is a good reason to believe the index is not a true reflection of abundance. Since the cobia fishery tends to be an opportunistic fishery, there is no way to determine how much of a trip's effort is directed toward catching cobia. In addition, if the cobia landed were unintended catch, the commercial logbook does not reflect total cobia caught as there is a possibility of an indeterminate amount of cobia discarded after the trip limit was met.

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.

Table 1. Vertical line linear regression statistics for the GLM models on (**i**) catch rates on positive trips and (**ii**) proportion positive trips of cobia in the Gulf of Mexico for vessels reporting 1993-2010. (**iii**) Analysis of the mixed model formulations of the positive trip model. 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.

i.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	17	34	15.21	0.89	0.5801	0.5843
SUBREGION	3	51	165.68	55.23	<.0001	<.0001
CREW	2	34	163.86	81.93	<.0001	<.0001
GEAR_TYPE	1	8227	89.46	89.46	<.0001	<.0001
*SUBREGION*CREW*	6	8227	2438.42	406.40	<.0001	<.0001

ii.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	17	51	14.33	0.84	0.6439	0.6391
SUBREGION	3	51	376.00	125.33	<.0001	<.0001

iii.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
YEAR + SUBREGION + CREW + GEAR_TYPE + SUBREGION*CREW	26963.1	26965.1	26972.2	-	-
YEAR + SUBREGION + CREW + GEAR_TYPE + SUBREGION*CREW + SUBREGION*YEAR	26740.4	26744.4	26749.0	222.7	<0.0001
YEAR + SUBREGION + CREW + GEAR_TYPE + SUBREGION*CREW + SUBREGION*YEAR + CREW*YEAR	26692.6	26698.6	26705.4	47.8	<0.0001

Table 2. Gulf of Mexico Vertical line relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for cobia (1993-2010) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.97427	6,764	0.033856	0.62834	0.28600	1.38044	0.40928
1994	0.69071	10,586	0.029378	0.82735	0.41124	1.66452	0.36048
1995	0.75282	11,017	0.029318	0.76212	0.37851	1.53454	0.36093
1996	1.50812	10,156	0.039976	1.60522	0.85752	3.00487	0.32135
1997	1.22542	14,822	0.038254	1.09536	0.59495	2.01667	0.31243
1998	1.13343	19,967	0.034757	1.02538	0.56675	1.85513	0.30308
1999	0.96548	20,177	0.030133	0.91652	0.49748	1.68854	0.31279
2000	1.07147	19,418	0.029148	0.83320	0.44646	1.55497	0.31971
2001	0.87077	19,648	0.027942	0.78473	0.41783	1.47378	0.32311
2002	1.11941	18,262	0.038495	0.98875	0.54612	1.79011	0.30345
2003	1.22733	19,531	0.028007	0.96326	0.51959	1.78575	0.31613
2004	1.27146	17,321	0.029040	1.03168	0.55320	1.92401	0.31933
2005	0.76224	14,317	0.023469	0.64348	0.31682	1.30694	0.36569
2006	0.98464	13,876	0.031637	0.91683	0.48065	1.74884	0.33150
2007	0.86062	13,539	0.029470	1.31593	0.69288	2.49925	0.32915
2008	0.75687	13,635	0.025376	1.01992	0.52074	1.99763	0.34584
2009	0.73253	14,636	0.028833	1.08207	0.56834	2.06014	0.33048
2010	1.09241	12,316	0.031991	1.55988	0.82068	2.96490	0.32958

Figure 1. Cobia nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing Vertical line gear in the Gulf of Mexico.

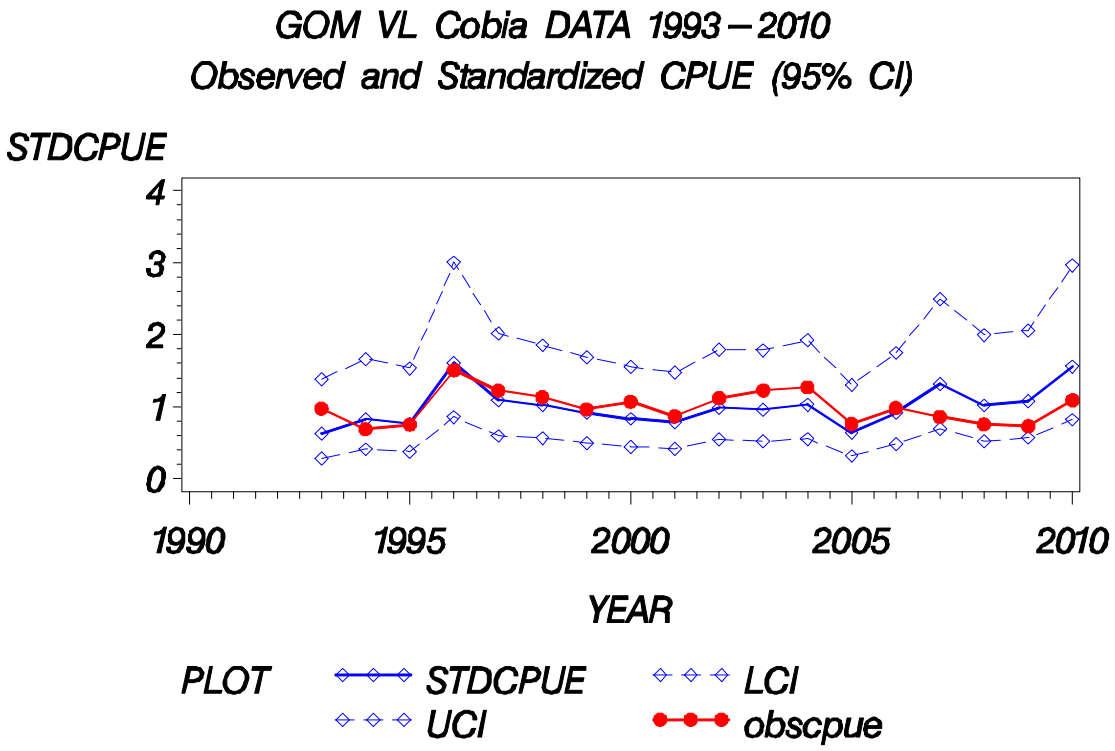
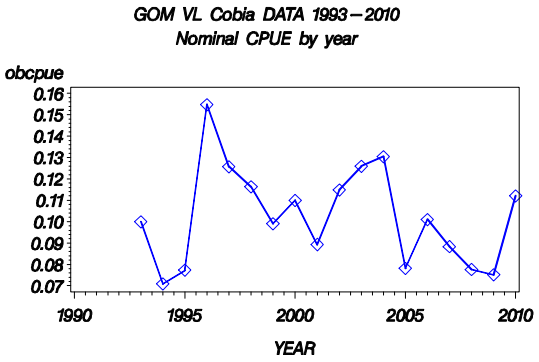


Figure 2. Annual trend in **(i)** the nominal CPUE and **(ii)** proportion of positive trips for 1993-2010 cobia commercial fishing Vertical line gear in the Gulf of Mexico.

i.



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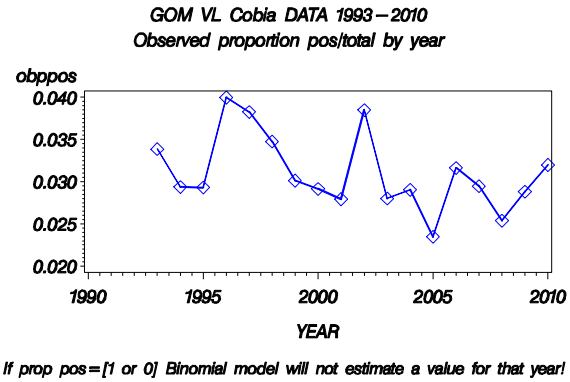
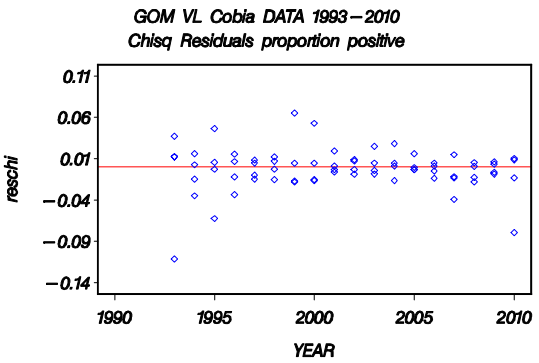


Figure 3. Diagnostic plots for the binomial component of Gulf of Mexico 1993-2010 cobia commercial vertical gear model: (**i)** the Chi-Square residuals by year; and (**ii)** the Chi-Square residuals by subregion.

i.



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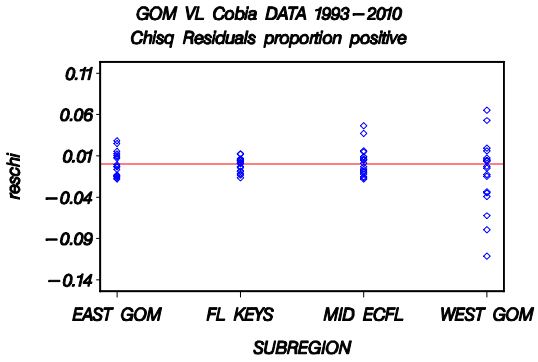
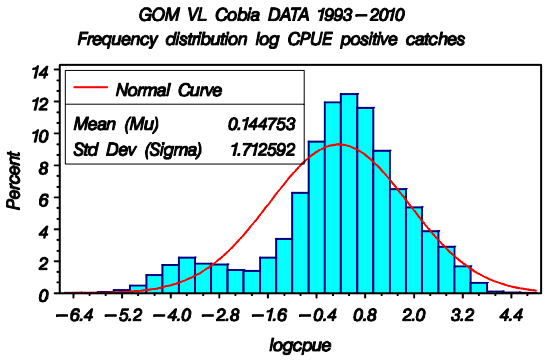


Figure 4. Diagnostic plots for the lognormal component of Vertical line of Cobia in the Gulf of Mexico, 1993-2010 gear model: **(i)** the frequency distribution of log(CPUE) on positive trips, **(ii)** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution. To explore the bimodal frequency distribution of log(CPUE), frequency distributions were broken into **(iii)** the Western Gulf of Mexico and **(iv)** the Eastern Gulf of Mexico (subregions: EAST GOM, FL KEYS, and MID ECFL).

i.



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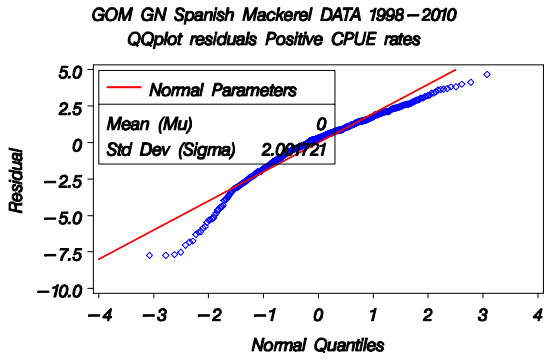

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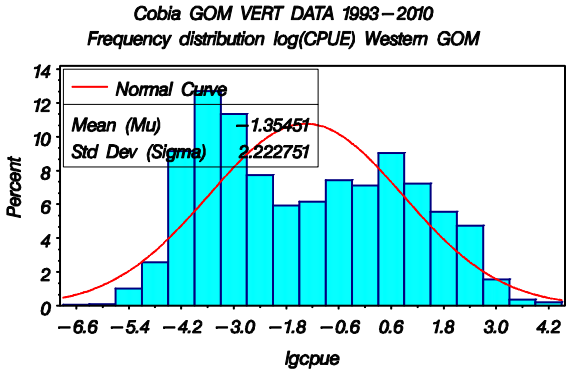


iv.

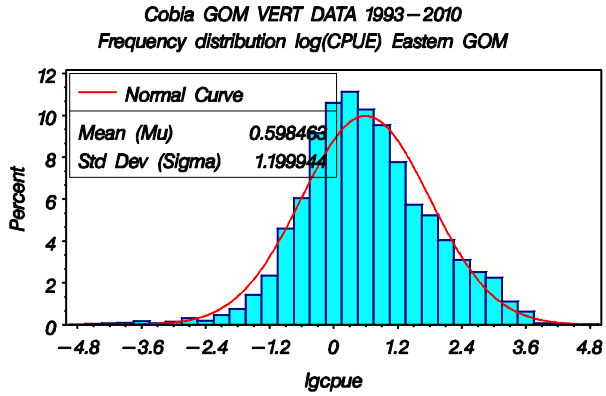
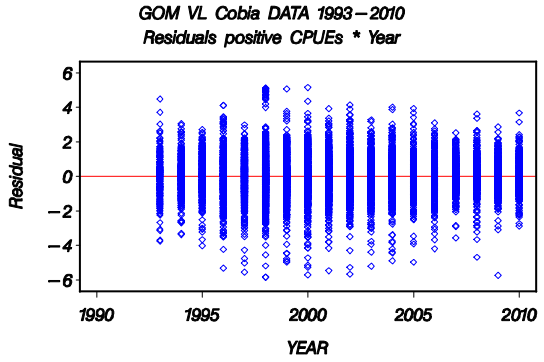


Figure 5. Diagnostic plots for the lognormal component of Vertical line of cobia in the Gulf of Mexico, 1993-2010 gear model: **(i)** the Chi-Square residuals by year; **(ii)** the Chi-Square residuals by subregion; **(iii)** the Chi-Square residuals by crew and **(iv)** the Chi-Square residuals by gear type.

i.



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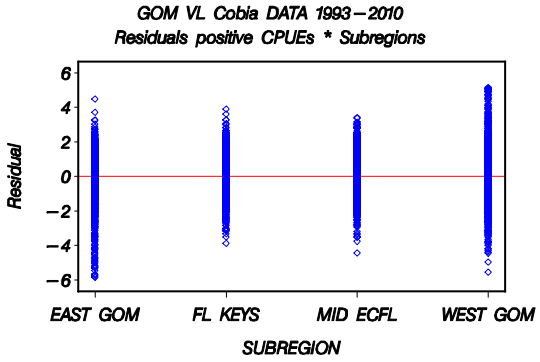

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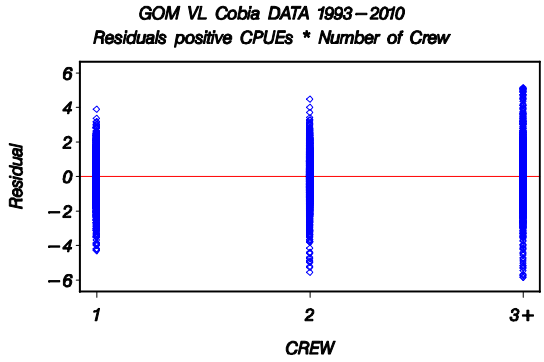

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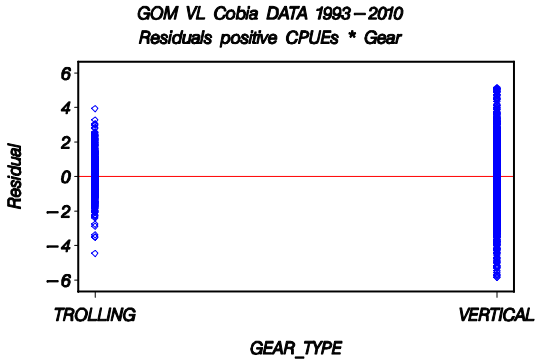

Figure 6. CFLP statistical grid area map