Standardized catch rates of small coastal sharks from the United States Gulf of Mexico and south Atlantic bottom longline fishery, 1996-2005

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Introduction

Bottom longline landings and fishing effort of commercial vessels operating in the Gulf of Mexico and the Atlantic Ocean south of Virginia have been monitored by the National Marine Fisheries Service (NMFS) through the coastal logbook program (conducted by the NMFS Southeast Fisheries Science Center). The program collects data by fishing trip on landings and effort for vessels with permits to fish in a number of fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The reef fish logbook program began in 1990 with a complete census of reef fish fishery permitted vessel activity, with the exception of Florida, where a 20% sample of vessels was targeted. Beginning in 1993, the sampling in Florida was increased to require reports from all vessels permitted in the reef fish fishery. Also in July 1993, reporting requirements began for shark fishing trips.

The available catch per unit effort (CPUE) series, from 1996 - 2005, was used to develop abundance indices for the small coastal shark species complex. In addition, indices were developed for blacknose sharks Atlantic sharpnose sharks, bonnethead sharks, and finetooth sharks.

Methods

The coastal logbook data base includes information on trip identifier, landing date, fishing gear, areas fished, number of days at sea, gear specific fishing effort (for longline: number of sets fished, number of hooks per set, length of longline, and estimated total fishing time), species caught and whole weight of the catch. Multiple areas and gear fished may be recorded for a single fishing trip.

Coastal logbook bottom longline data from the period 1996-2005 were used to develop indices of abundance for small coastal sharks. Although fishing effort and landings from 1990-1995 were reported, species identification problems are apparent in those data (Brown, 2002). Nearly all landings were reported as unclassified sharks (Figure 1). The proportion of unclassified sharks decreased after 1995 and the proportion of small coastal sharks increased coincidentally (Figure 1). Data prior to 1996 was excluded from the analyses because of the apparent species identification problem. For the years beginning in 1996, the proportion of unclassified sharks assumed to be small coastal sharks was estimated as the observed proportion of small coastal species to all other identified sharks in each area fished. The area specific proportion of small costal shark landings to other shark landings was applied to the unclassified landings reported from each area. Landings of each small coastal shark species were then calculated by applying observed proportions of small coastal shark species reported in the NMFS longline observer program to the small coastal shark portion of unclassified shark landings.

Subsetting data for CPUE analysis using species composition

An objective approach, developed by Stephens and McCall (2004), was used to subset logbook trip records using species composition. This method uses the observed species composition of a fishing trip to infer if that trip's effort occurred in the habitat of the target species. Species composition was examined for the Gulf of Mexico and US south Atlantic longline trips. Only those species occurring on at least 1% of all trips were considered. The method is described in detail in Stephens and McCall (2004). A brief summary follows.

The species composition from catch records is used to estimate the parameters of a logistic regression. For example, Let Y_j be a categorical variable describing the presence/absence of the non-target species for trip j. Similarly, let x_{ij} describe the presence/absence of blacknose sharks.

$$Y_j = \begin{cases} 1 & \text{if the target species is caught} \\ 0 & \text{if the target species is not caught} \end{cases}$$

Then a logistic regression is applied to estimate the probability that blacknose sharks would have been encountered on a trip. Using the regression results, a score (S_j) is assigned to each trip j as a function of the species encountered during that trip:

$$S_j = \exp \sum_{i=0}^{k} x_{ij}\beta_i$$

where the coefficients $\beta_1,\beta_2,\ldots\beta_k$ quantify the predictive effect of each species and β_0 is the intercept of the logistic regression.

This score is then converted into the probability of observing blacknose sharks given the vector of presence/absence of the other species observed on the trip (j).

$$\pi_j = \Pr\{Y_j = 1\} = \frac{S_j}{1 + S_j}$$

Given the coefficients $\beta_0, \beta_1, \ldots, \beta_k$ and the presence/absence indicators $x_{1j},\ldots, x_{kj}$, the log-likelihood (excluding constants independent of the parameters) is the sum:

$$L\{Y|\beta_0, \ldots, \beta_k, x_{1j}, \ldots, x_{kj}\} = \sum_{j \in j+} \log(\pi_j) + \sum_{j \in j-} \log(1 - \pi_j)$$

where j+ indicates trips that landed blacknose sharks, and j- indicates trips where blacknose sharks were absent. The log-likelihood was maximized using the statistical package R (Ihaka and Gentleman, 1996). The estimated β coefficients reflect the association (positive or negative) between the non-target species and blacknose sharks, π_j is intended to estimate the probability that trip *j* occurred in the habitat of blacknose sharks.

Trips were selected for CPUE analysis using a critical value. The critical value was determined by examining the relationship between the critical value and the number of incorrect predictions. Both false positives (blacknose sharks predicted to occur when absent) and false negatives (blacknose sharks not expected to occur when present) were considered. The critical value that minimized the number of incorrect predictions was selected. Trips were included in the CPUE analysis if π (as calculated above) was above the critical value.

Index Development

Six factors were considered as possible influences on the proportion of trips that landed any of the small coastal shark species (SCS). The factors examined included Year, Season, Days (days at sea per trip), Permit (shark permit type), Veslen (vessel length in feet), and Subregion (areas fished). The factors are summarized below:

Factor	Levels	Value
YEAR	10	1996 - 2005
SEASON	4	1=January-March, 2=April-June, 3=July-September, 4=October-December
DAYS	5	1, 2, 3-4, 5-6, and 7+ days at sea
PERMIT	3	d = directed shark permit, i = incidental shark permit, n = no shark permit
VESLEN	5	1 = vessel < 32 feet, 2 = vessel 32-41 feet, 3 = vessel 42-54 feet, 4 = vessel 55 or more feet, 5 = length unknown
SUBREGION	7	Areas 1-3, 4, 5, 6-13, 2400-2880, 2900-2981, 3000-3575

Factors examined for index development of individual small coastal shark species varied from the list above only for the factor Subregion.

Species	Levels	Subregion Value
Sharpnose	7	Areas 1-3, 4, 5, 6-11, 2700-2880, 2900-3081, 3100-3575
Blacknose	6	Areas 1-3, 4, 5, 6-11, 2400-2880, 2900-3575
Finetooth	N/A	All areas included, Subregion not included as a factor
Bonnethead	N/A	All areas included, Subregion not included as a factor

The delta lognormal model approach (Lo et al. 1992) was used to develop standardized indices of abundance. This method combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed small coastal sharks) 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).

For each GLM procedure 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 employed. The linking function selected was "normal", and the response variable was ln(CPUE). The response variable was calculated as: ln(CPUE) = ln(pounds of SCS species/number of hooks fished). All 2-way interactions among significant main effects were examined.

A stepwise approach was used to quantify the relative importance of the factors. First a GLM model was fit on year. These results reflect the distribution of the nominal data. Next, 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. Higher order interaction terms were not examined.

The final delta-lognormal model was fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR which were modeled as random effects. To facilitate visual 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

Analyses were not completed for either finetooth or bonnethead sharks due to small sample sizes. Only 167 finetooth shark longline trips and 143 bonnethead shark longline trips were identified in the data subsetting procedure. Those data were included in the SCS complex analyses, however.

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

Small coastal shark (SCS) complex

PPT = YEAR + VESLEN + DAYS + SEASON + YEAR*DAYS

LN(CPUE) = YEAR + SUBREGION + DAYS + VESLEN + SEASON + SUBREGION*VESLEN + YEAR*SUBREGION + YEAR*VESLEN

When any of the interactions YEAR*VESLEN, VESLEN*SUBREGION, SUBREGION*SEASON, or PERMIT*SUBREGION were included in the binomial GLM, the model failed to converge, therefore those interaction terms were excluded from later analyses. Failure of the model to converge was likely due to insufficient sample size given the large number of terms included in the model.

Sharpnose sharks

PPT = YEAR + DAYS + SUBREGION + SEASON + YEAR*DAYS

LN(CPUE) = YEAR + DAYS + SUBREGION + VESLEN + PERMIT + YEAR*SUBREGION + YEAR*VESLEN + DAYS*SUBREGION + SUBREGION*VESLEN + YEAR*PERMIT + DAYS*VESLEN

The binomial model failed to converge when any other interaction terms were included in the model. .

Blacknose sharks

PPT = YEAR + SUBREGION + DAYS + VESLEN + PERMIT + YEAR*SUBREGION + SUBREGION*VESLEN + SUBREGION*DAYS + YEAR*VESLEN

LN(CPUE) = YEAR + SUBREGION + SEASON + DAYS + YEAR*SUBREGION + SUBREGION*DAYS + SEASON*DAYS

The binomial GLM failed to converge when either SUBREGION*DAYS or SEASON*DAYS interaction terms were included in the model. Those terms were excluded from further analyses.

Nominal CPUE, relative nominal CPUE, number of trips, proportion positive trips, abundance indices, and relative abundance indices are provided in Tables 1-3 for the SCS complex, sharpnose, and blacknose sharks, respectively. In a number of cases, GLMMIX failed to converge when all the significant interaction terms identified in the GLM analyses were included in the GLMMIX model. As with the GLM models that failed to converge, small sample size and inclusion of many factors in the models is likely the cause of lack of convergence in the GLMMIX models.

The CPUE series for the small coastal complex had higher CPUEs over the second half of the time series, although no obvious trend was found during the first or second half of the time series (Figure 2).

Confidence intervals for the index were large. In the SCS complex analysis, GLMMIX failed to converge when any interaction terms other than YEAR*SUBREGION and YEAR*VESLEN were included in the model. Those terms were excluded from the analysis. Proportion positive trips, QQ plots of residuals for successful catch rates, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are provided in Figures 3-8. Frequency distributions of ln(CPUE) for positive catches and plots of residuals for lognormal models on successful catch rates by each main effect are shown in Figures 9-14. These data appear to have met the assumptions for the analysis.

The sharpnose index of abundance was similar to the SCS complex CPUE series (Figure 15). No clear trends were found in either the first half or the second half of the time series, taken separately, but the index values were larger in the second half of the time series. The large confidence intervals are likely due to few observations in the large matrix resulting from the numerous factors in the GLMMIX model. In this analysis, GLMMIX failed to converge when SUBREGION*VESLEN, YEAR*PERMIT, or DAYS*VESLEN were included in the model and the terms were excluded from the analysis. Diagnostic plots of proportion positive trips, QQ plots of residuals for successful catch rates, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are provided in Figures 16-21. Frequency distributions of ln(CPUE) for positive catches and plots of residuals for lognormal models on successful catch rates by each main effect are shown in Figures 22-27. These data appear to have met the assumptions for the analysis.

The CPUE series developed from blacknose shark data had generally increasing CPUEs over time (Figure 28). The confidence intervals also increased over the time series. In developing the blacknose shark index, GLMMIX failed to converge with any of the interactions SUBREGION*VESLEN, SUBREGION*DAYS, YEAR*VESLEN, or SEASON*DAYS was included in the model, and those interaction terms were excluded. Proportion positive trips, QQ plots of residuals for successful catch rates, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are provided in Figures 29-34. Frequency distributions of ln(CPUE) for positive catches and plots of residuals for lognormal models on successful catch rates by each main effect are shown in Figures 35-40. A few years of the time series have high proportion positive trips, however, overall these data appear to have met the assumptions for the analysis.

The SCS complex index appears to have been largely driven by sharpnose shark data. In all three indices however, relatively few observations and many significant factors included in the GLMMIX models were likely the cause of very large confidence intervals in the CPUE series. The calculated indices must be examined in the light of such uncertainty.

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Table 1. CPUE series for SCS complex in the US south Atlantic and Gulf of Mexico developed from coastal logbook longline trip data.

YEAR	Nominal CPUE	Relative Nominal CPUE	Trips	Proportion Successful Trips	Index	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1996	0.020	0.119	290	0.145	0.004	0.026	0.001	0.964	4.996
1997	0.051	0.299	180	0.278	0.023	0.157	0.012	2.095	2.086
1998	0.178	1.044	196	0.327	0.110	0.764	0.133	4.379	1.069
1999	0.100	0.587	176	0.318	0.058	0.407	0.056	2.971	1.298
2000	0.109	0.642	193	0.332	0.053	0.366	0.044	3.021	1.429
2001	0.440	2.587	273	0.403	0.244	1.697	0.407	7.070	0.815
2002	0.205	1.202	349	0.378	0.208	1.447	0.347	6.023	0.814
2003	0.229	1.348	401	0.411	0.192	1.335	0.321	5.544	0.812
2004	0.218	1.281	301	0.389	0.208	1.445	0.345	6.048	0.818
2005	0.152	0.891	348	0.316	0.338	2.356	0.599	9.257	0.773

Table 2. CPUE series for sharpnose sharks in the US south Atlantic and Gulf of Mexico developed from coastal logbook longline trip data.

YEAR	Nominal CPUE	Relative Nominal CPUE	Trips	Proportion Successful Trips	Index	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1996	0.042	0.352	298	0.809	0.013	0.572	0.073	4.500	1.378
1997	0.007	0.061	143	0.867	0.006	0.244	0.015	3.862	2.397
1998	0.020	0.166	132	0.758	0.008	0.354	0.025	5.021	2.194
1999	0.043	0.357	141	0.766	0.014	0.581	0.056	6.010	1.707
2000	0.026	0.215	101	0.792	0.007	0.319	0.021	4.828	2.309
2001	0.110	0.910	146	0.630	0.036	1.555	0.210	11.529	1.314
2002	0.157	1.304	150	0.600	0.040	1.693	0.240	11.964	1.265
2003	0.331	2.739	179	0.687	0.036	1.550	0.244	9.864	1.164
2004	0.217	1.795	133	0.504	0.041	1.736	0.224	13.443	1.360
2005	0.253	2.099	165	0.539	0.033	1.396	0.165	11.796	1.457

Table 3. CPUE series for blacknose sharks in the US south Atlantic and Gulf of Mexico developed from coastal logbook longline trip data.

YEAR	Nominal CPUE	Relative Nominal CPUE	Trips	Proportion Successful Trips	Index	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1996	0.042	0.287	306	0.807	0.014	0.311	0.055	1.765	1.062
1997	0.070	0.479	164	0.884	0.015	0.338	0.063	1.819	1.016
1998	0.111	0.759	151	0.821	0.023	0.507	0.108	2.371	0.902
1999	0.095	0.647	146	0.836	0.018	0.397	0.081	1.945	0.937
2000	0.075	0.514	147	0.694	0.024	0.536	0.095	3.011	1.052
2001	0.165	1.128	170	0.629	0.043	0.948	0.207	4.346	0.886
2002	0.078	0.530	190	0.605	0.035	0.777	0.149	4.058	0.989
2003	0.130	0.891	180	0.711	0.062	1.366	0.353	5.285	0.762
2004	0.281	1.919	122	0.607	0.139	3.048	0.886	10.486	0.682
2005	0.417	2.846	145	0.614	0.081	1.772	0.424	7.407	0.817

Figure 1. Coastal logbook bottom longline landings for small coastal sharks, 1993-2005 from the Gulf of Mexico and U.S. south Atlantic.

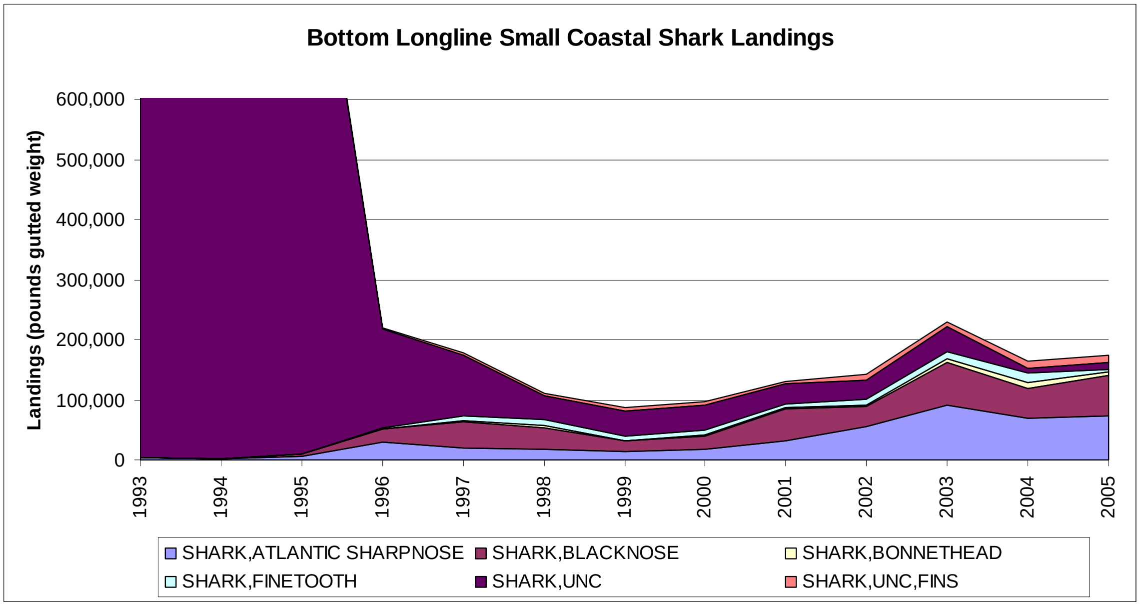

Figure 2. SCS complex nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

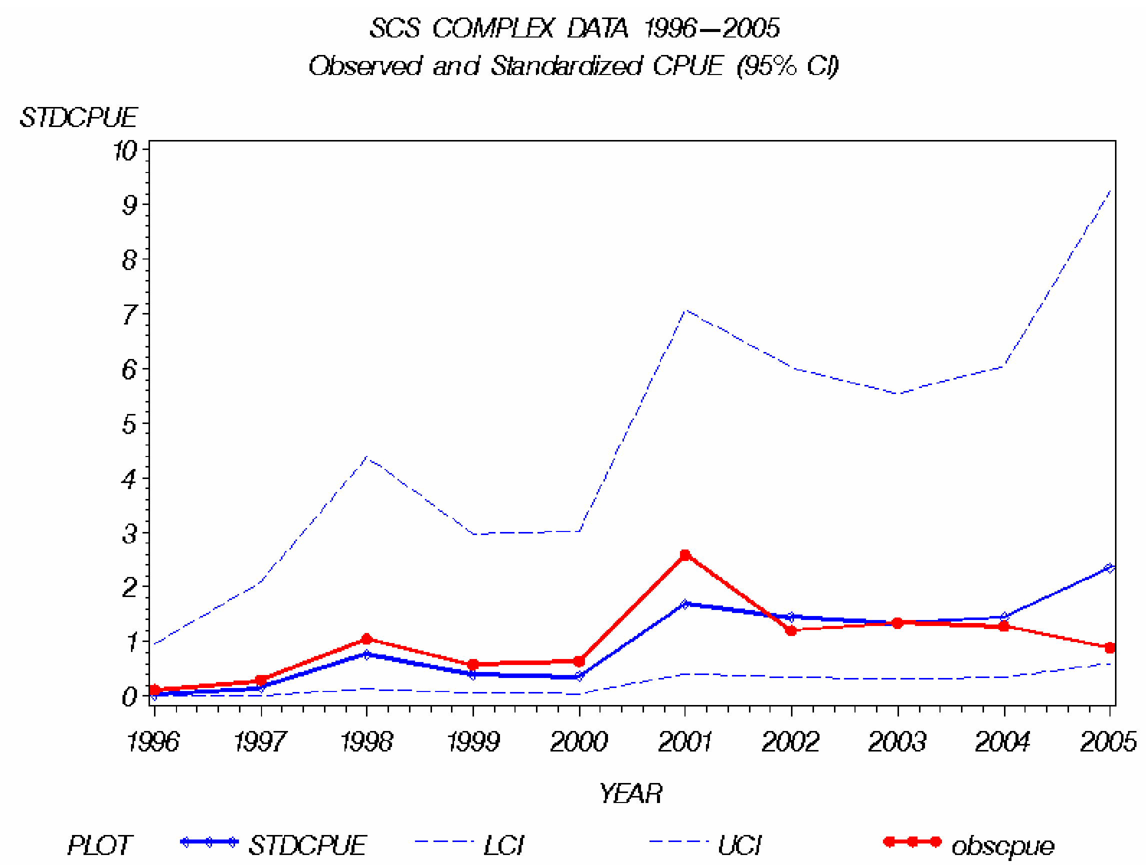

Figure 3. Observed proportion positive SCS complex trips in the Gulf of Mexico and U.S. south Atlantic.

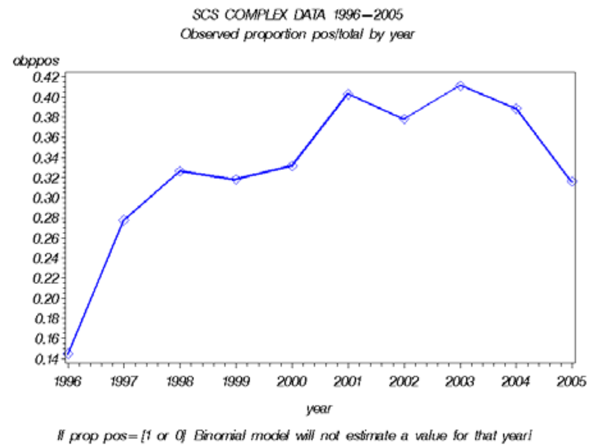

Figure 4. QQ plots of residuals for successful catch rates of the SCS complex from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic where CPUE=pounds landed/(hooks fished).

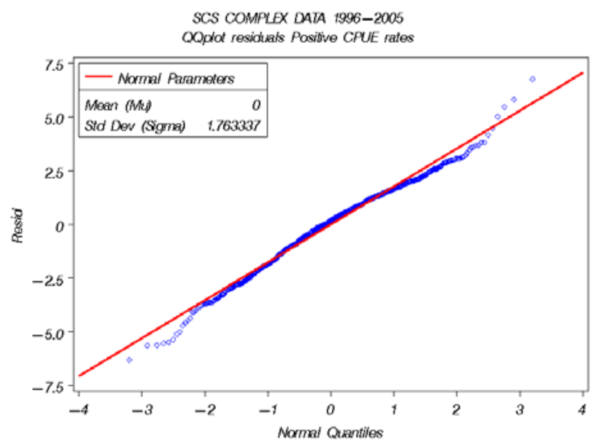

Figure 5. Chi-square residuals for the delta lognormal model on proportion successful SCS complex trips, by year, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

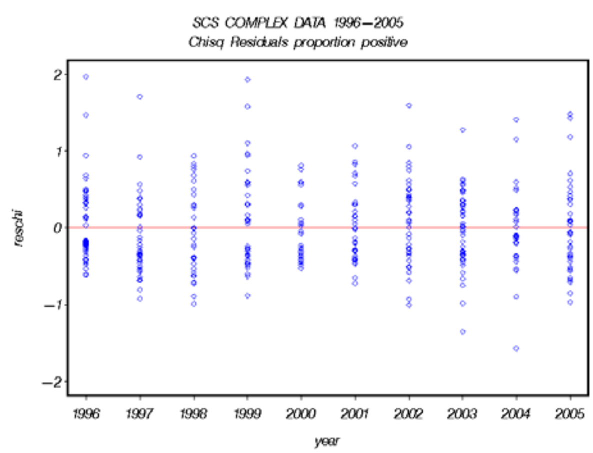

Figure 6. Chi-square residuals for the delta lognormal model on proportion successful SCS complex trips, by vessel length, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

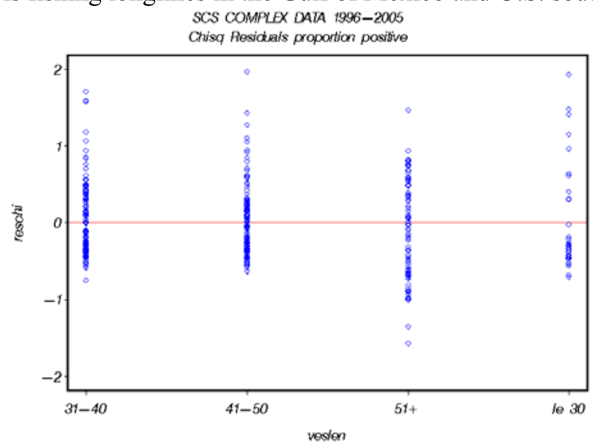

Figure 7. Chi-square residuals for the delta lognormal model on proportion successful SCS complex trips, by days at sea, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

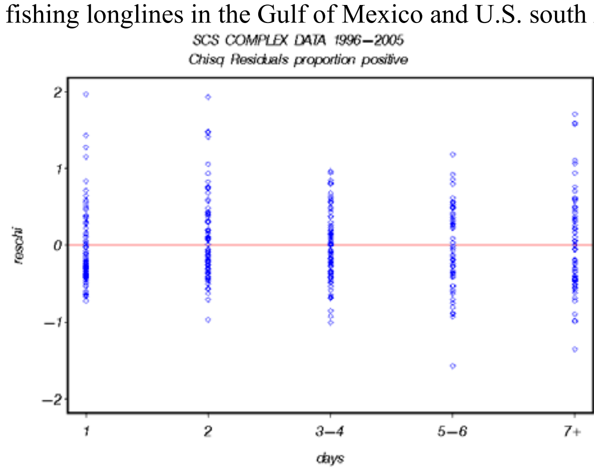

Figure 8. Chi-square residuals for the delta lognormal model on proportion successful SCS complex trips, by season, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

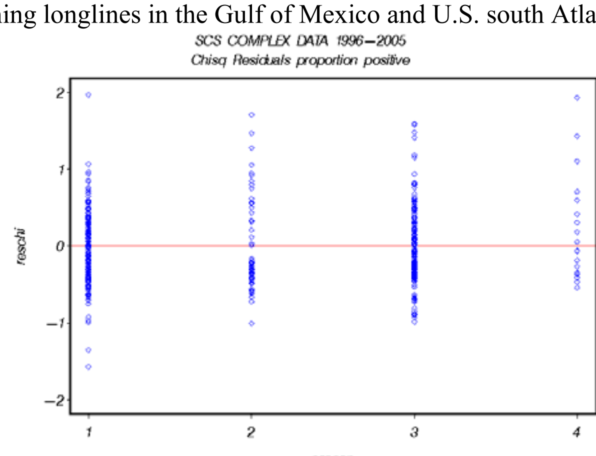

Figure 9. Frequency distribution of ln(CPUE) for positive catches of SCS complex reported from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic. The solid line is the expected normal distribution.

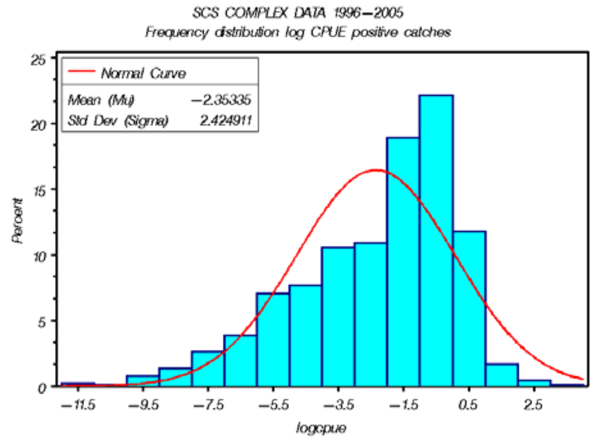

Figure 10. Residuals for the lognormal model on successful catch rates for SCS complex from vessels fishing longlines, by year, in the Gulf of Mexico and U.S. south Atlantic.

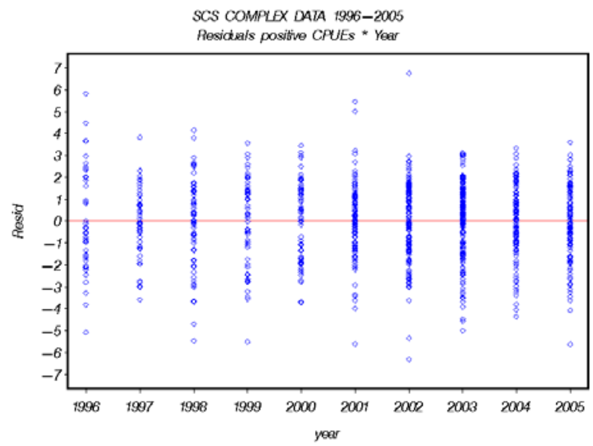

Figure 11. Residuals for the lognormal model on successful catch rates for SCS complex from vessels fishing longlines, by subregion, in the Gulf of Mexico and U.S. south Atlantic.

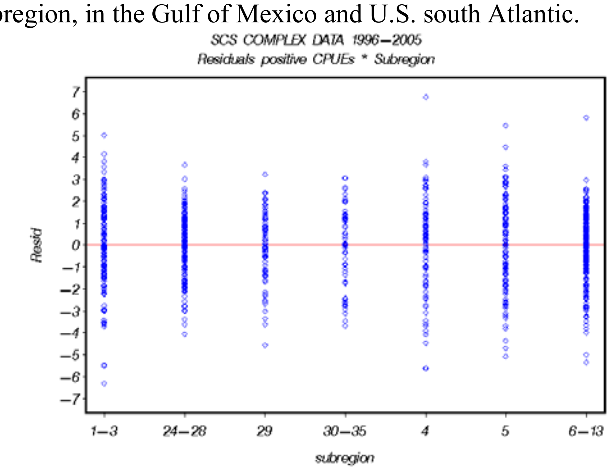

Figure 12. Residuals for the lognormal model on successful catch rates for SCS complex from vessels fishing longlines, by days at sea, in the Gulf of Mexico and U.S. south Atlantic.

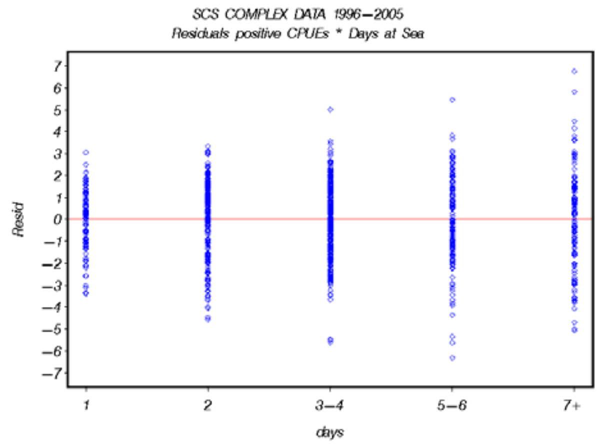

Figure 13. Residuals for the lognormal model on successful catch rates for SCS complex from vessels fishing longlines, by vessel length, in the Gulf of Mexico and U.S. south Atlantic.

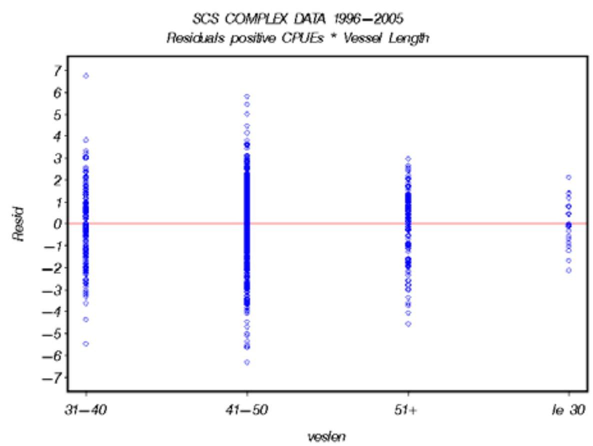

Figure 14. Residuals for the lognormal model on successful catch rates for SCS complex from vessels fishing longlines, by season, in the Gulf of Mexico and U.S. south Atlantic.

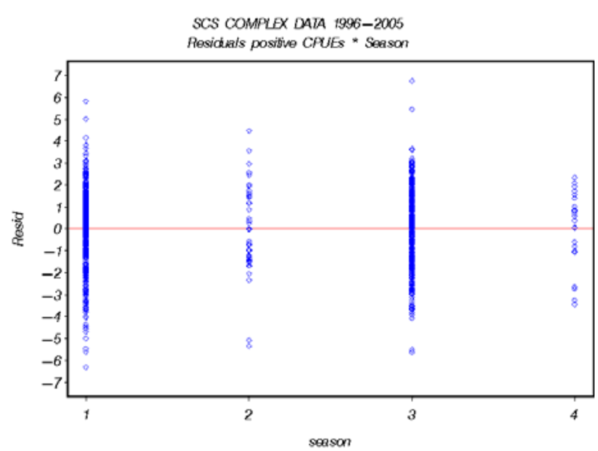

Figure 15. Sharpnose shark nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

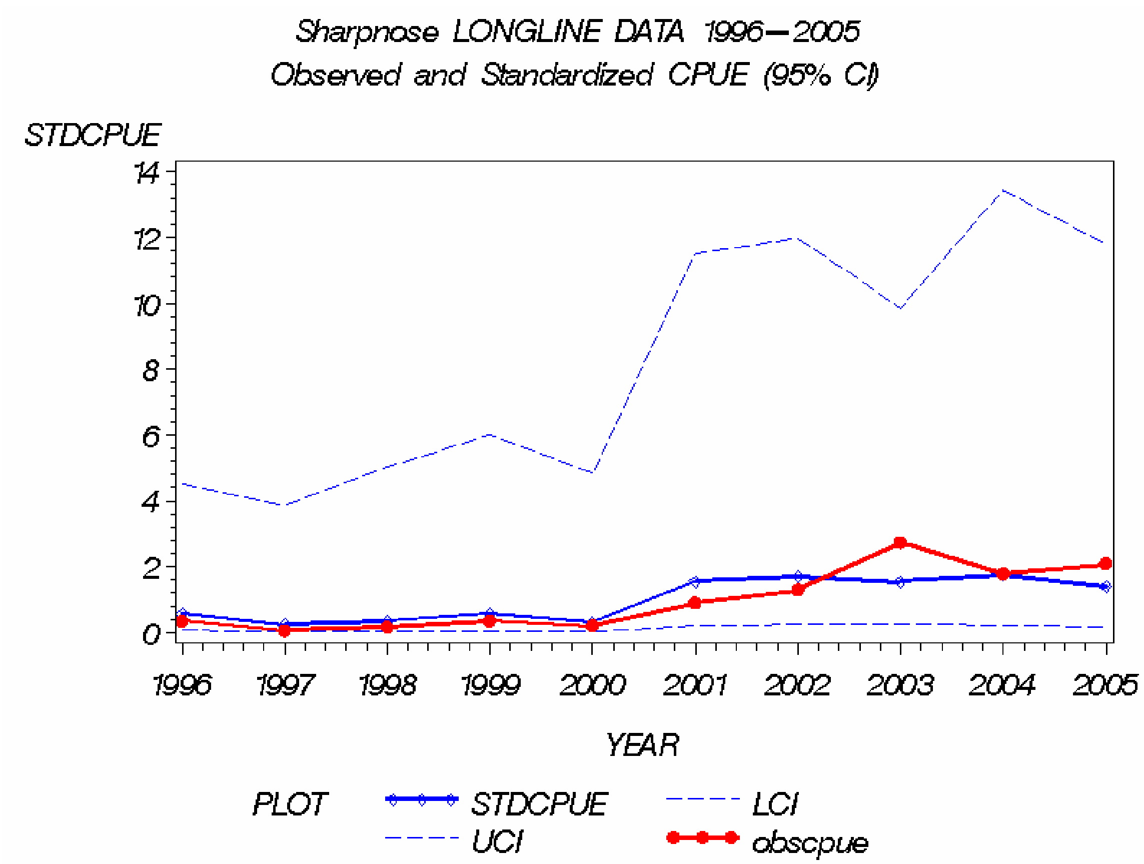

Figure 16. Observed proportion positive sharpnose shark trips in the Gulf of Mexico and U.S. south Atlantic.

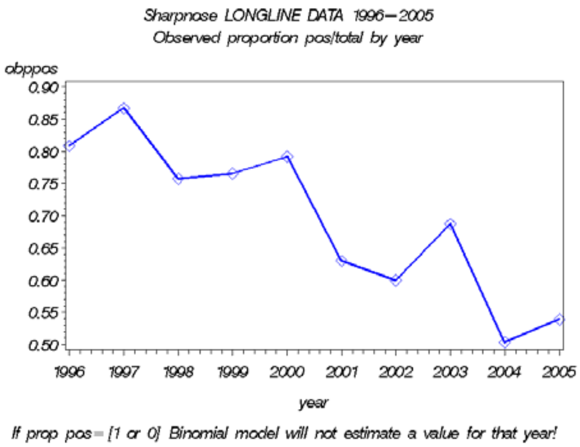

Figure 17. QQ plots of residuals for successful catch rates of the sharpnose sharks from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic where CPUE=pounds landed/(hooks fished).

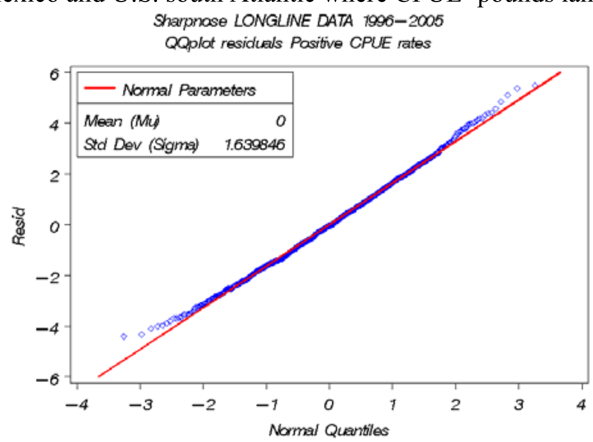

Figure 18. Chi-square residuals for the delta lognormal model on proportion successful sharpnose shark trips, by year, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

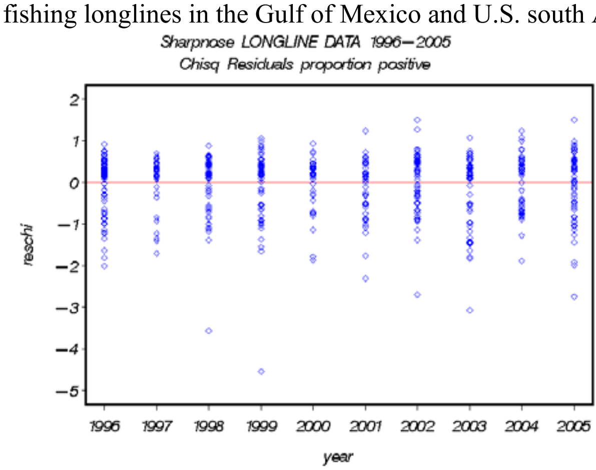

Figure 19. Chi-square residuals for the delta lognormal model on proportion successful sharpnose shark trips, by subregion, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

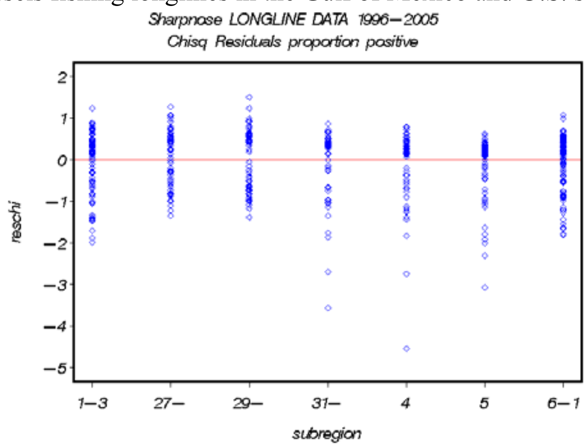

Figure 20. Chi-square residuals for the delta lognormal model on proportion successful sharpnose shark trips, by season, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

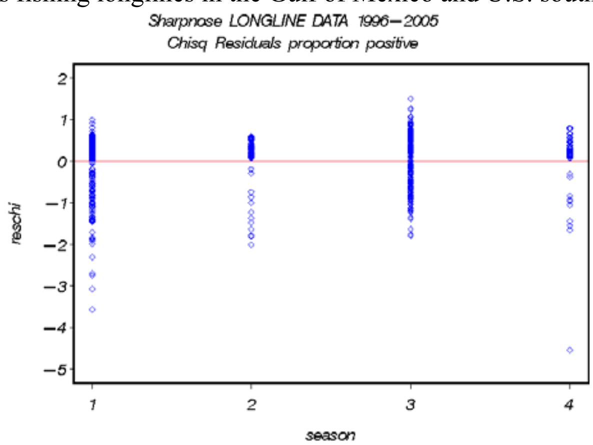

Figure 21. Chi-square residuals for the delta lognormal model on proportion successful sharpnose shark trips, by days at sea, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

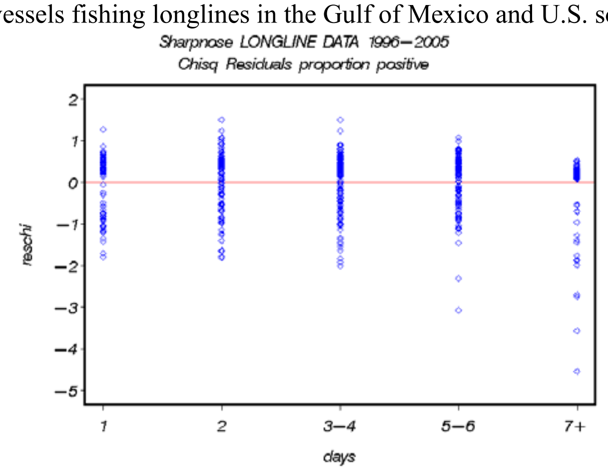

Figure 22. Frequency distribution of ln(CPUE) for positive catches of sharpnose shark reported from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic. The solid line is the expected normal distribution.

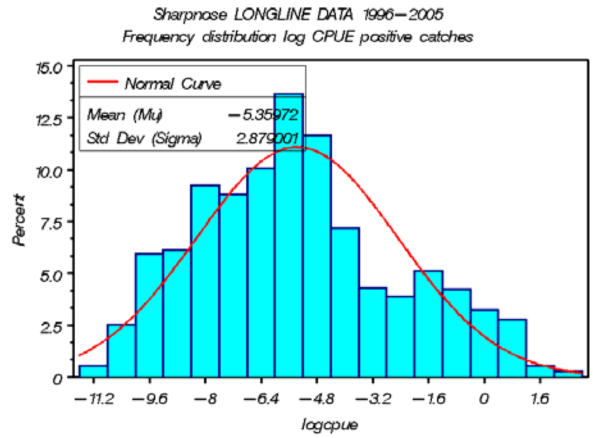

Figure 23. Residuals for the lognormal model on successful catch rates for sharpnose sharks from vessels fishing longlines, by year, in the Gulf of Mexico and U.S. south Atlantic.

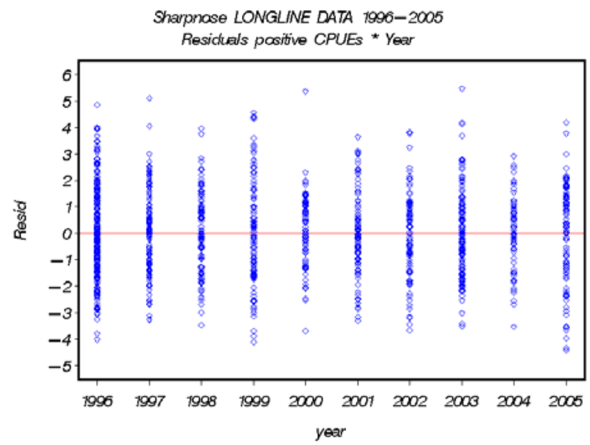

Figure 24. Residuals for the lognormal model on successful catch rates for sharpnose sharks from vessels fishing longlines, by subregion, in the Gulf of Mexico and U.S. south Atlantic.

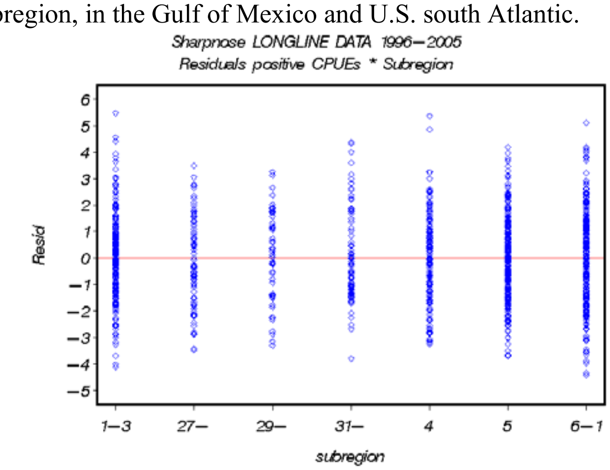

Figure 25. Residuals for the lognormal model on successful catch rates for sharpnose sharks from vessels fishing longlines, by days at sea, in the Gulf of Mexico and U.S. south Atlantic.

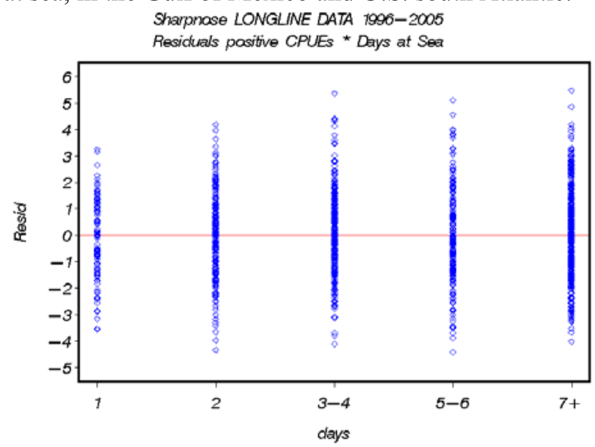

Figure 26. Residuals for the lognormal model on successful catch rates for sharpnose sharks from vessels fishing longlines, by vessel length, in the Gulf of Mexico and U.S. south Atlantic.

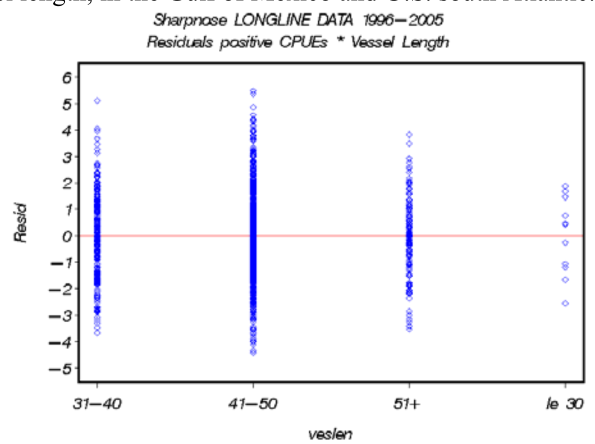

Figure 27. Residuals for the lognormal model on successful catch rates for sharpnose sharks from vessels fishing longlines, by permit type, in the Gulf of Mexico and U.S. south Atlantic.

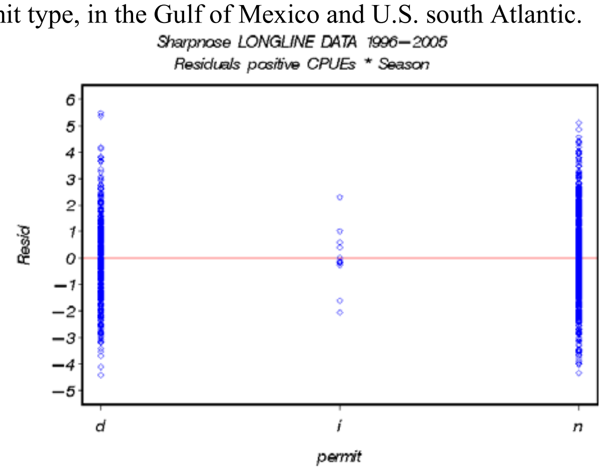

Figure 28. Blacknose shark nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

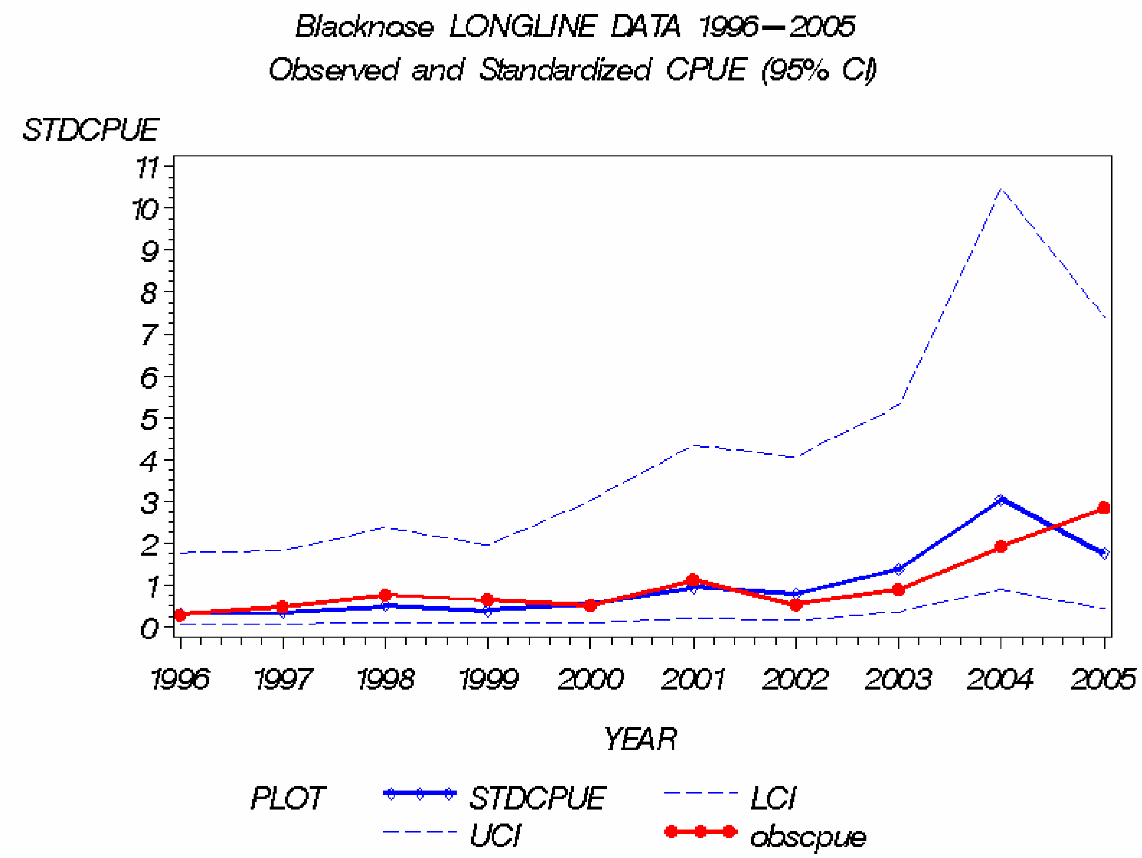

Figure 29. Observed proportion positive blacknose shark trips in the Gulf of Mexico and U.S. south Atlantic

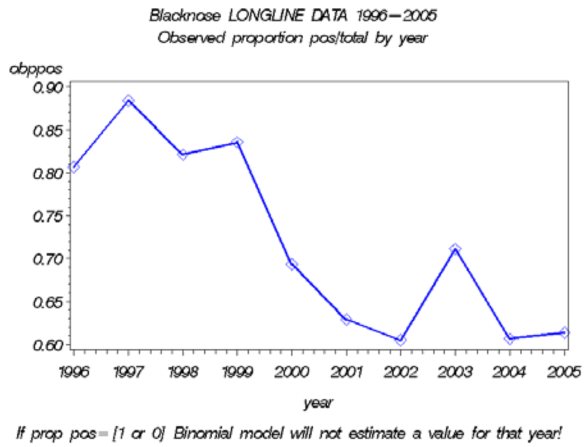

Figure 30. QQ plots of residuals for successful catch rates of the blacknose sharks from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic where CPUE=pounds landed/(hooks fished).

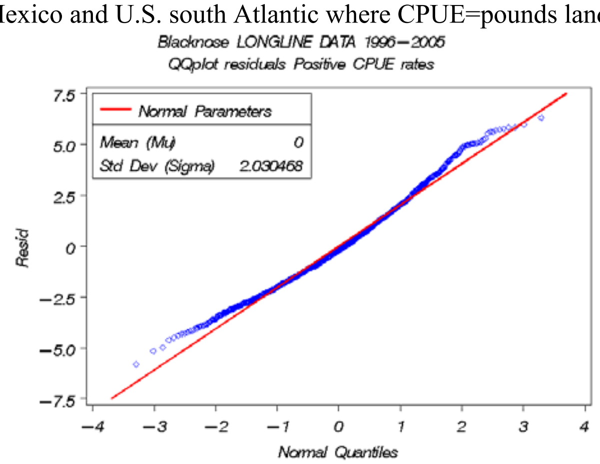

Figure 31. Chi-square residuals for the delta lognormal model on proportion successful blacknose shark trips, by year, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

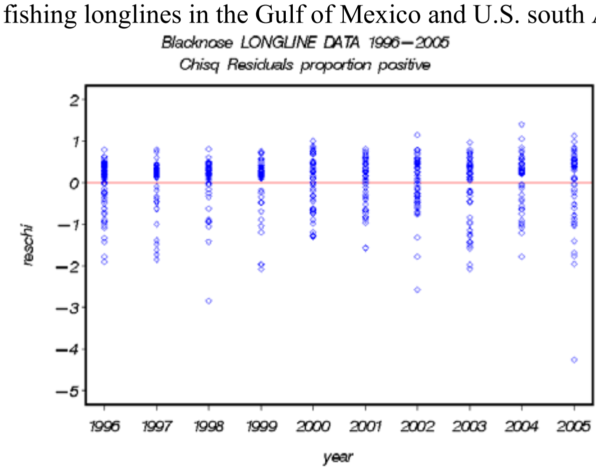

Figure 32. Chi-square residuals for the delta lognormal model on proportion successful blacknose shark trips, by subregion, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

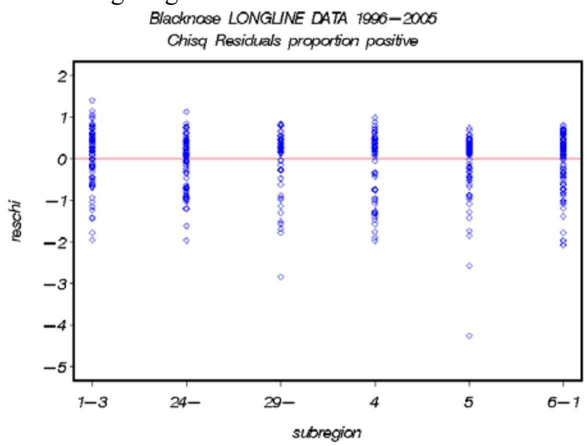

Figure 33. Chi-square residuals for the delta lognormal model on proportion successful blacknose shark trips, by season, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

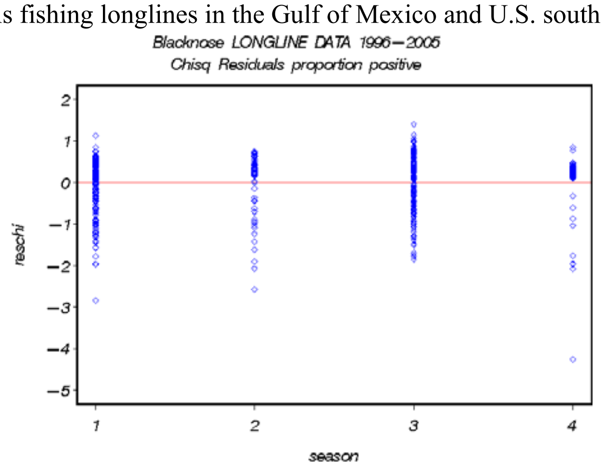

Figure 34. Chi-square residuals for the delta lognormal model on proportion successful blacknose shark trips, by days at sea, for vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic.

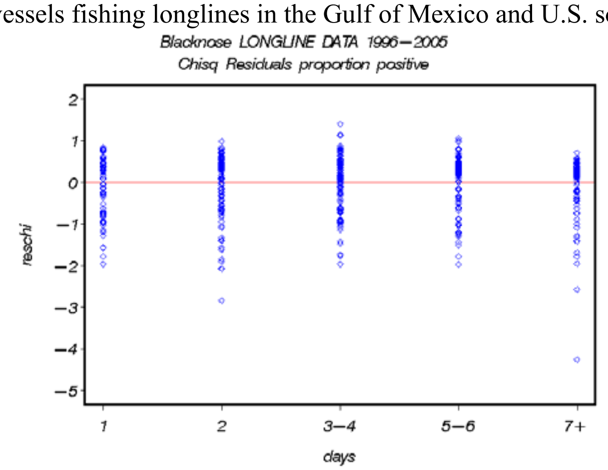

Figure 35. Frequency distribution of ln(CPUE) for positive catches of blacknose sharks reported from vessels fishing longlines in the Gulf of Mexico and U.S. south Atlantic. The solid line is the expected normal distribution.

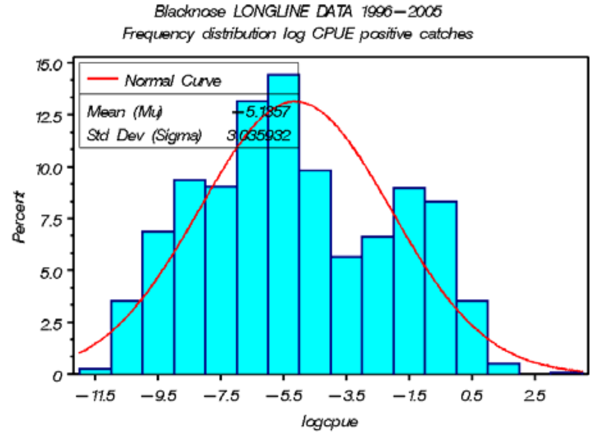

Figure 36. Residuals for the lognormal model on successful catch rates for blacknose sharks from vessels fishing longlines, by year, in the Gulf of Mexico and U.S. south Atlantic.

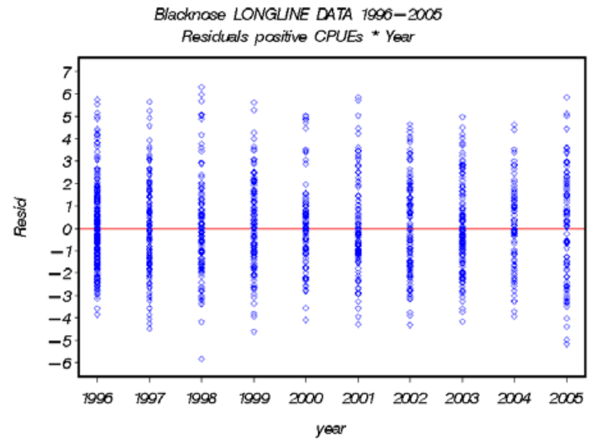

Figure 37. Residuals for the lognormal model on successful catch rates for blacknose sharks from vessels fishing longlines, by subregion, in the Gulf of Mexico and U.S. south Atlantic.

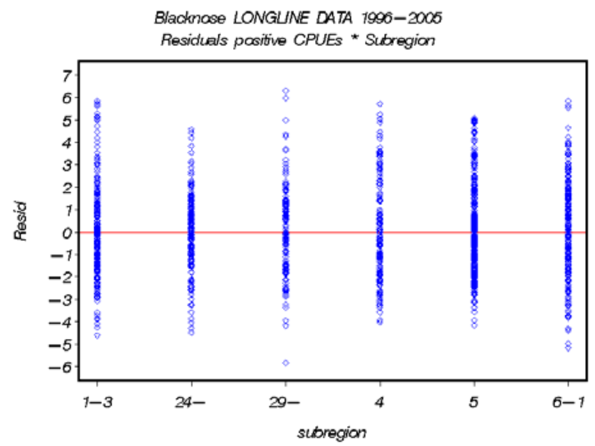

Figure 38. Residuals for the lognormal model on successful catch rates for blacknose sharks from vessels fishing longlines, by days at sea, in the Gulf of Mexico and U.S. south Atlantic.

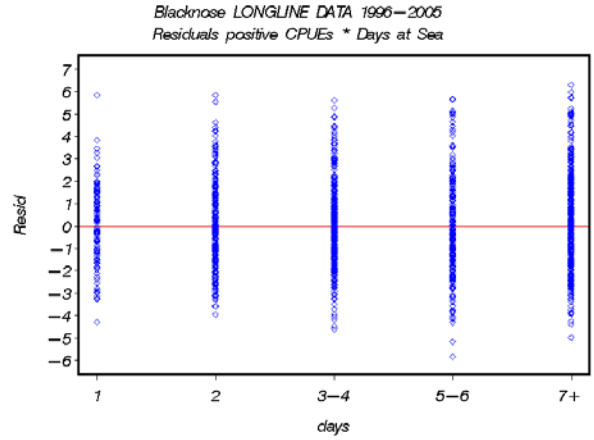

Figure 39. Residuals for the lognormal model on successful catch rates for blacknose sharks from vessels fishing longlines, by vessel length, in the Gulf of Mexico and U.S. south Atlantic.

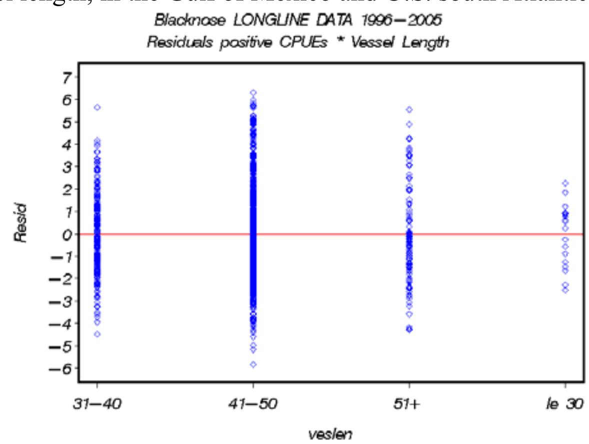

Figure 40. Residuals for the lognormal model on successful catch rates for blacknose sharks from vessels fishing longlines, by permit type, in the Gulf of Mexico and U.S. south Atlantic.