# Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Sink Gillnet Fishery: 2005-2011

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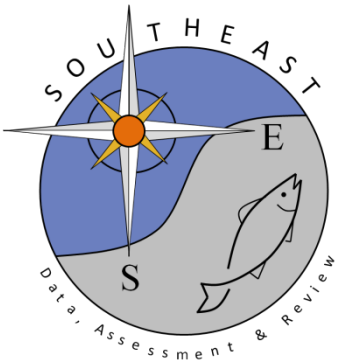
SEDAR34-WP-28

8 May 2013
Updated: 8 July 2013

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Please cite this document as:

Carlson, J., A. Mathers, and M. Passerotti. 2013. Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Sink Gillnet Fishery: 2005-2011. SEDAR34-WP-28. SEDAR, North Charleston, SC. 14 pp.

**Standardized Catch Rates of Bonnethead and Atlantic Sharpnose Shark from the Southeast Sink Gillnet Fishery: 2005-2011**

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SEDAR34-WP-28

**Abstract**

A standardized catch rate series was developed for Atlantic sharpnose and bonnethead shark using the Delta lognormal approach based on observer data collected in the southeast sink gillnet fishery. Depending on the species, differing factors were found to be significant as main effects in the final model. For Atlantic sharpnose shark, year, season, area, and meshsize were significant in the binomial model and year, target, season and area in the lognormal model. For the bonnethead sharks, year, area, target and season were significant in the binomial model whereas year and meshsize were significant in the lognormal model. The relative abundance index was relatively stable for both species from 2005-2011.

**Introduction**

Observer coverage of the Florida-Georgia shark gillnet fishery began in 1992, and has since documented the many changes to effort, gear characteristics, and target species the fishery has undergone following the implementation of multiple fisheries regulations (e.g., Passerotti et al. 2010 and references therein). In 2005, the shark gillnet observer program was expanded to include all vessels that have an active directed shark permit and fish with sink gillnet gear. These vessels were not previously subject to observer coverage because they either were targeting non-highly migratory species or were not fishing gillnets in a drift or strike fashion. These vessels were selected for observer coverage in an effort to determine their impact on finetooth shark, *Carcharhinus isodon*, landings and their overall fishing impact on shark resources when the gear is not targeting sharks. In 2006, the National Marine Fisheries Service Southeast Regional Office requested further expansion of the scope of the shark gillnet observer program to include all vessels fishing gillnets regardless of target, and for coverage to be extended to cover the full geographic range of gillnet fishing effort in the southeast United States. This was requested because of the need to monitor (at statistically adequate levels) all gillnet fishing effort to assess risks to right whales and other protected species. Further, in 2007 the regulations implementing the Atlantic Large Whale Take Reduction Plan were amended and included the removal of the mandatory 100% observer coverage for drift gillnet vessels during the right whale calving season but now prohibit all gillnets in an expanded southeast U.S. restricted area that covers an area from Cape Canaveral, FL, to the North Carolina/South Carolina border, from November 15 - April 15. The rule does posses limited exemptions, only in waters south of 29 degrees N latitude, for shark strikenet fishing during this same period and for Spanish mackerel gillnet fishing in the months of December and March. Based on these regulations and on current funding levels, the shark gillnet observer program now covers all anchored (sink, stab, set), strike, or drift gillnet fishing by vessels that fish from Florida to North Carolina and the Gulf of Mexico year-round. Current protocols for selection of vessels for observer coverage and collection of data are found in Passerotti et al. (2010). Herein, we develop a catch rate series for Atlantic sharpnose shark and bonnethead shark based on data collected by on-board observers from 2005-2011.

I. Fishery description

Vessel and gear descriptions are provided in detail in Passerotti et al. (2010 and references therein).

Catch rates analysis

A combined data set was developed based from Passerotti et al. (2010 and references therein). Catch rates were standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). For the purposes of analysis, several categorical variables were constructed:

-"Year" (7 levels)=2005-2011

- "Area" (4 levels)=location of net set (Figure 1).

South Florida=South of 27°51' N Latitude

Central Florida=27°51' N to 30°00' N LatitudeN. Florida/Georgia=30°00' N Latitude to 32°00' N Latitude

North Carolina= North of 32°00' N Latitude

Gulf of Mexico=All sets within the eastern Gulf of Mexico from -88.0 W longitude east.

-'Target" (3 levels)

Shark

Mackerel (Spanish or King Mackerel)

Other Teleost

Dogfish

- "SetBegin" (4 levels)

Dawn=0401-1000 hrs

Day=1001-1600 hrs

Dusk=1601-2200 hrs

Night=2201-0400 hrs

-"Season" (4 levels): corresponds to the level of observer coverage as it pertains to the right whale calving season.

Rightwhale1=Jan-Mar

Nonrightwhale1=Apr-Jun

Nonrightwhale2=Jul-Sep

Rightwhale2=Oct-Dec

-"Meshsize" (3 levels): corresponds to the principal mesh size used in the fishing gear.

Small mesh=2"-6" stretched mesh

Medium mesh=7"-9" stretched mesh

Large mesh=>10" stretched mesh

The proportion of sets that caught a shark (when at least one shark was caught) was modeled assuming a binomial distribution with a logit link function. The positive catches were modeled assuming a lognormal distribution with a normal link function. Positive catches were modeled using a dependent variable of the natural logarithm of the number of sharks caught per $10^{-7}$ net area hours, i.e.:

CPUE=log [(shark kept+ shark released)/(net length*net depth*soak time/10000000)]

Initially, a null model was run with no factors entered into the model. Models were then fit in a stepwise forward manner adding one independent variable. Each factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $p<0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was

continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all final models. After selecting the set of fixed factors and interactions for each error distribution, all interactions that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final modeldetermination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC). Models with smaller AIC and BIC values are preferred to those with larger values. These models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models. The standard error of the combined index was estimated with the delta method (Appendix 1 in Lo et al., 1992).

## Results and Discussion

### Atlantic Sharpnose Shark

The proportion of positive sets (i.e. at least one shark was caught) was 30.8%. The stepwise construction of the models is summarized in Table 1. The index statistics can be found in Table 2.

The delta-lognormal abundance index is shown in Figure 2. To allow for visual comparison with the nominal values, both series were scaled to the maximum of their respective index. The average size of Atlantic sharpnose sharks caught by year is reported in Table 3. Table 4 provides a table of the frequency of observations by factor and level. Diagnostic plots assessing the fit of the models were deemed acceptable (Figure 3).

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear formulations of the proportion of positive and positive catches for Atlantic sharpnose shark.

| **Proportion positive-Binomial error distribution** | | | | | |
|---|---|---|---|---|---|
| **FACTOR** | **DEVIANCE/DF** | **%DIFF** | **DELTA%** | **CHISQUARE** | **PR>CHI** |
| NULL | 4.168 | | | | |
| YEAR | 3.5609 | 14.566 | 14.566 | 137.33 | <.0001 |
| | | | | | |
| YEAR+ | | | | | |
| SEASON | 2.7532 | 33.944 | 19.379 | 157.68 | <.0001 |
| AREA | 3.0994 | 25.638 | | 97.77 | <.0001 |
| TARGET | 3.3852 | 18.781 | | 42.66 | <.0001 |
| MESHSIZE | 3.4931 | 16.192 | | 19.52 | <.0001 |
| SETBEGIN | 3.5949 | 13.750 | | 4.48 | 0.2139 |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| YEAR+SEASON+ | | | | | |
| AREA | 2.5166 | 39.621 | 5.677 | 53.12 | <.0001 |
| MESHSIZE | 2.5977 | 37.675 | | 33.49 | <.0001 |
| TARGET | 2.7679 | 33.592 | | 5.62 | 0.1316 |
| | | | | | |
| YEAR+SEASON+AREA+ | | | | | |
| MESHSIZE | 2.3012 | 44.789 | 5.168 | 42.94 | <.0001 |
| | | | | | |
| **MIXED MODEL** | **AIC** | | | | |
| **YEAR+SEASON+AREA+MESHSIZE** | **219.4** | | | | |
| YEAR+SEASON+AREA+MESHSIZE YEAR*SEASON | 280.1 | | | | |
| YEAR+SEASON+AREA+MESHSIZE YEAR*AREA | 279.7 | | | | |
| YEAR+SEASON+AREA+MESHSIZE YEAR*MESHSIZE | 280.2 | | | | |
| **Positive catches-Lognormal error distribution** | | | | | |
| FACTOR | DEVIANCE/DF | %DIFF | DELTA% | CHISQUARE | PR>CHI |
| NULL | 2.105 | | | | |
| YEAR | 2.084 | 0.974 | 0.974 | 10.02 | 0.1238 |
| | | | | | |
| YEAR+ | | | | | |
| TARGET | 1.927 | 8.425 | 7.451 | 34.58 | <.0001 |
| AREA | 1.935 | 8.078 | | 34.09 | <.0001 |
| SETBEGIN | 1.977 | 6.049 | | 24.25 | <.0001 |
| SEASON | 2.016 | 4.191 | | 16.37 | 0.001 |
| MESHSIZE | 2.025 | 3.801 | | 12.69 | 0.0004 |
| | | | | | |
| YEAR+TARGET+ | | | | | |
| SEASON | 1.812 | 13.880 | 5.455 | 27.84 | <.0001 |
| AREA | 1.833 | 12.925 | | 24.42 | <.0001 |
| SETBEGIN | 1.877 | 10.829 | | 13.82 | 0.0032 |
| MESHSIZE | 1.919 | 8.829 | | 2.82 | 0.0934 |
| | | | | | |
| YEAR+TARGET+SEASON+ | | | | | |
| AREA | 1.714 | 18.565 | 4.685 | 26.70 | <.0001 |
| SETBEGIN | 1.757 | 16.526 | | 15.69 | 0.0013 |
| | | | | | |
| YEAR+TARGET+SEASON+AREA+ | | | | | |
| SETBEGIN | 1.700 | 19.225 | 0.660 | 6.43 | 0.0926 |
| | | | | | |
| **MIXED MODEL** | **AIC** | | | | |
| YEAR+TARGET+SEASON+AREA | 1373.6 | | | | |
| YEAR+TARGET+SEASON+AREA YEAR*TARGET | 1372.9 | | | | |
| YEAR+TARGET+SEASON+AREA YEAR*SEASON | 1370.8 | | | | |
| **YEAR+TARGET+SEASON+AREA YEAR*AREA** | **1357.8** | | | | |

Table 2. The absolute standardized and nominal index of abundance for Atlantic sharpnose shark with the associated coefficients of variation (CV) and number of sets observed (N).

| Year | Standardized index | CV | N | Nominal index | CV |
|---|---|---|---|---|---|
| 2005 | 2319.97 | 0.30 | 73 | 7055.30 | 0.10 |
| 2006 | 1408.92 | 0.25 | 141 | 1521.48 | 0.24 |
| 2007 | 1615.35 | 0.47 | 79 | 472.94 | 1.59 |
| 2008 | 1189.67 | 0.38 | 119 | 1076.37 | 0.42 |
| 2009 | 2280.50 | 0.30 | 171 | 1021.63 | 0.68 |
| 2010 | 471.50 | 0.37 | 290 | 642.81 | 0.27 |
| 2011 | 291.17 | 0.29 | 415 | 541.85 | 0.16 |

Table 3. Mean size of Atlantic sharpnose shark from the sink gillnet fishery.

| Year | Mean | Standard Deviation | N |
|---|---|---|---|
| 2005 | 75.21 | 11.69 | 194 |
| 2006 | 72.92 | 9.92 | 145 |
| 2007 | 76.08 | 11.63 | 13 |
| 2008 | 77.76 | 5.48 | 72 |
| 2009 | 72.13 | 11.27 | 191 |
| 2010 | 74.51 | 11.13 | 79 |
| 2011 | 67.31 | 17.69 | 195 |

Table 4. Frequency of observations by factor and level used in the development of the standardized catch rate series.

| FACTOR | LEVEL | FREQUENCY OF TOTAL |
|---|---|---|
| YEAR | 2005 | 5.6 |
| | 2006 | 10.8 |
| | 2007 | 6.0 |
| | 2008 | 9.1 |
| | 2009 | 13.1 |
| | 2010 | 23.0 |
| | 2011 | 32.4 |
| | | |
| AREA | Central Florida | 35.8 |
| | Georgia | 10.5 |
| | Gulf of Mexico | 1.8 |
| | North Carolina | 47.7 |
| | South Florida | 4.2 |
| | | |
| TARGET | Mackerel | 51.4 |
| | Other | 32.1 |

| | | |
|---|---|---|
| | Shark | 14.5 |
| | Dogfish | 1.9 |
| | | |
| SETBEGIN | Dawn | 49.7 |
| | Day | 38.5 |
| | Dusk | 9.1 |
| | Night | 2.7 |
| | | |
| SEASON | Rightwhale1=Jan | 29.8 |
| | Nonrightwhale1=Apr | 23.4 |
| | Nonrightwhale2=Jul | 19.0 |
| | Rightwhale2=Oct | 27.8 |
| | | |
| MESHSIZE | Large | 1.3 |
| | Medium | 5.7 |
| | Small | 93.0 |

Figure 1. Distribution of fishing effort in the southeast US sink gillnet fishery 2005-2011. Fishing areas defined for GLM analysis are: South Florida, Central Florida, North Florida/Georgia, North Carolina and Gulf of Mexico. An individual plot by year and in some locations was not possible because of vessel confidentiality.

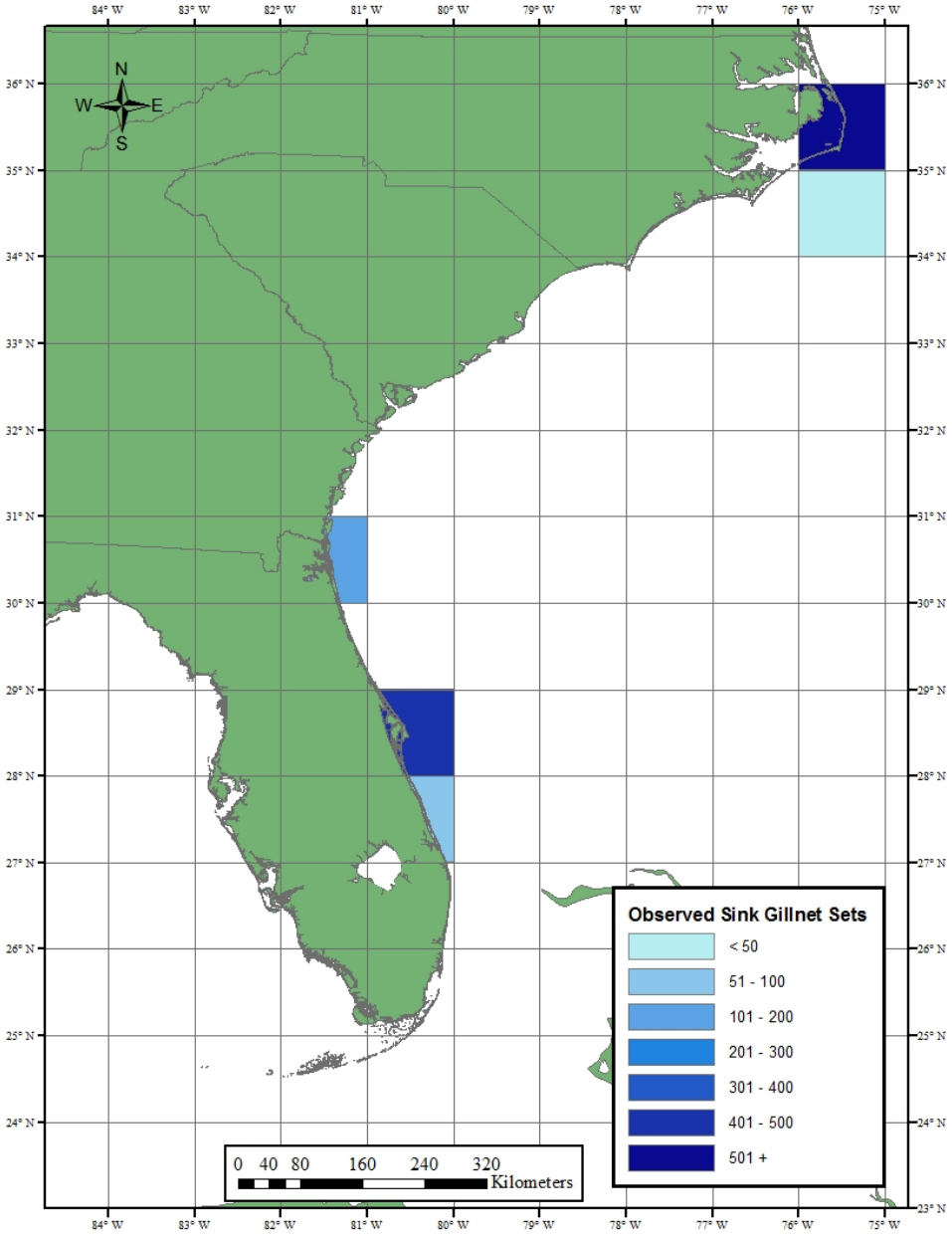



Figure 2. Nominal and standardized indices of abundance for Atlantic sharpnose shark. The dashed lines are the 95% confidence limits for the standardized index. Each index has been divided by the maximum of the index.

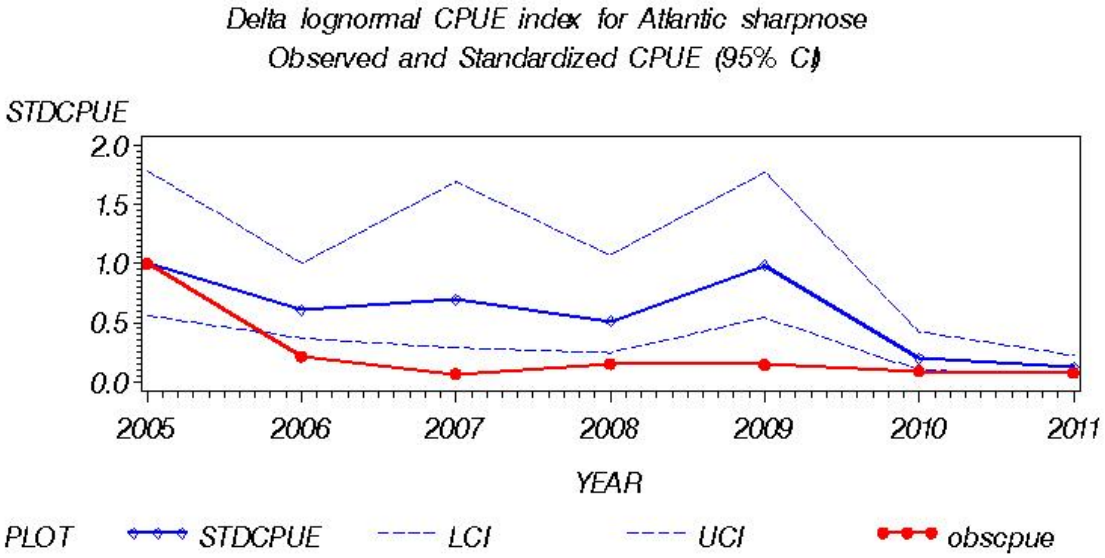
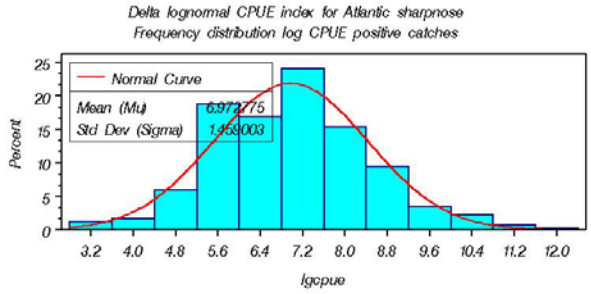
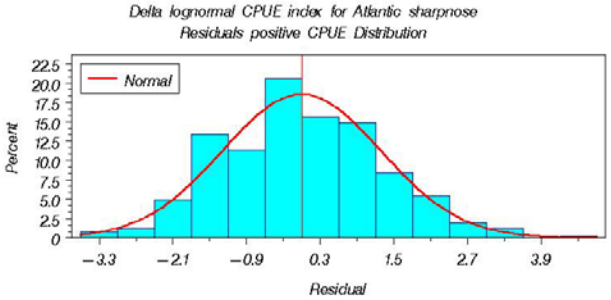
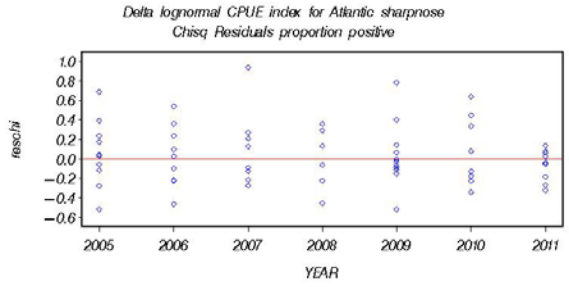
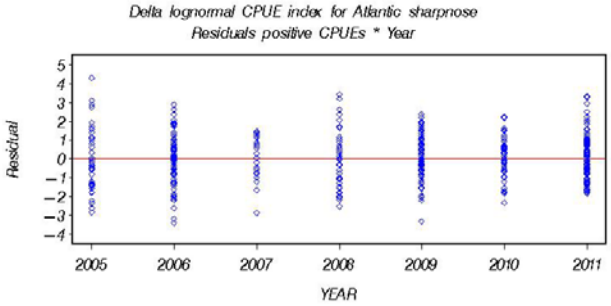

Delta lognormal CPUE index for Atlantic sharpnose
Observed and Standardized CPUE (95% CI)
STDCPUE
2.0
1.5
1.0
0.5
0.0
2005
2006
2007
2008
2009
2010
2011
YEAR
PLOT
STDCPUE
LCI
UCI
obscpue

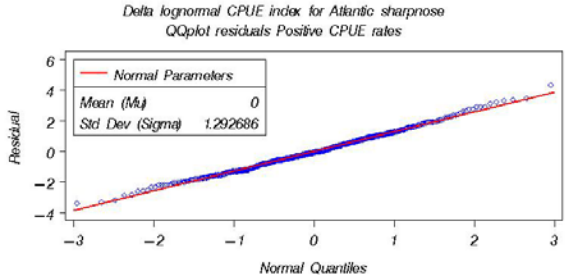
Figure 3. Diagnostic plots of the model outputs for Atlantic sharpnose shark.



**Bonnethead Shark**

The proportion of positive sets (i.e. at least one shark was caught) was 18.4%. The stepwise construction of the models is summarized in Table 5. The index statistics can be found in Table 6.

The delta-lognormal abundance index is shown in Figure 4. To allow for visual comparison with the nominal values, both series were scaled to the maximum of their respective index. The average size of bonnethead sharks caught by year is reported in Table 7. Diagnostic plots assessing the fit of the models were deemed acceptable (Figure 5).

Table 5. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear formulations of the proportion of positive and positive catches for Atlantic sharpnose shark.

| **Proportion positive-Binomial error distribution** | | | | | |
|---|---|---|---|---|---|
| **FACTOR** | **DEVIANCE/DF** | **%DIFF** | **DELTA%** | **CHISQUARE** | **PR>CHI** |
| NULL | 3.9765 | | | | |
| YEAR | 2.7109 | 31.827 | 31.827 | 257.98 | <.0001 |
| | | | | | |
| YEAR+ | | | | | |
| AREA | 1.8735 | 52.886 | 21.059 | 162.43 | <.0001 |
| TARGET | 2.2012 | 44.645 | | 100.91 | <.0001 |
| SEASON | 2.3711 | 40.372 | | 69.98 | <.0001 |
| SETBEGIN | 2.7052 | 31.970 | | 9.17 | 0.0271 |
| MESHSIZE | 2.7154 | 31.714 | | 4.6 | 0.1 |
| | | | | | |
| YEAR+AREA+ | | | | | |
| TARGET | 1.6364 | 58.848 | 5.963 | 47.81 | <.0001 |
| SEASON | 1.7036 | 57.158 | | 35.86 | <.0001 |
| SETBEGIN | 1.8775 | 52.785 | | 4.91 | 0.1785 |
| | | | | | |
| YEAR+AREA+TARGET+ | | | | | |
| SEASON | 1.575 | 60.392 | 1.544 | 15.65 | 0.0013 |
| | | | | | |
| **MIXED MODEL** | **AIC** | | | | |
| YEAR+AREA+TARGET+SEASON | **383.8** | | | | |
| YEAR+AREA+TARGET+SEASON YEAR*AREA | 410.3 | | | | |
| YEAR+AREA+TARGET+SEASON YEAR*TARGET | 426.7 | | | | |
| YEAR+AREA+TARGET+SEASON YEAR*SEASON | 414.5 | | | | |
| **Positive catches-Lognormal error distribution** | | | | | |
| **FACTOR** | **DEVIANCE/DF** | **%DIFF** | **DELTA%** | **CHISQUARE** | **PR>CHI** |
| NULL | 2.061 | | | | |
| YEAR | 1.851 | 10.180 | 10.180 | 31.87 | <.0001 |
| | | | | | |
| YEAR+ | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MESHSIZE | 1.734 | 15.847 | 5.667 | 17.71 | 0.0001 |
| AREA | 1.830 | 11.184 | | 6.86 | 0.1434 |
| SETBEGIN | 1.836 | 10.932 | | 5.13 | 0.1626 |
| TARGET | 1.837 | 10.859 | | 3.89 | 0.1427 |
| SEASON | 1.863 | 9.627 | | 1.63 | 0.6518 |
| | | | | | |
| **MIXED MODEL** | **AIC** | | | | |
| **YEAR+MESHSIZE** | **813.8** | | | | |
| YEAR+MESHSIZE YEAR*MESHSIZE | 815.6 | | | | |

Table 6. The absolute standardized and nominal index of abundance for bonnethead shark with the associated coefficients of variation (CV) and number of sets observed (N).

| Year | Standardized index | CV | N | Nominal index | CV |
|---|---|---|---|---|---|
| 2005 | 2114.30 | 0.26 | 73 | 1861.91 | 0.30 |
| 2006 | 651.80 | 0.25 | 141 | 626.75 | 0.26 |
| 2007 | 3308.05 | 0.37 | 79 | 2150.92 | 0.57 |
| 2008 | 301.33 | 0.45 | 119 | 310.45 | 0.44 |
| 2009 | 470.19 | 0.29 | 171 | 304.39 | 0.45 |
| 2010 | 7.58 | 1.41 | 290 | 2.45 | 4.35 |
| 2011 | 136.84 | 0.42 | 416 | 75.19 | 0.77 |

Table 7. Mean size of bonnethead shark from the sink gillnet fishery.

| Year | Mean | Standard Deviation | N |
|---|---|---|---|
| 2005 | 79.7 | 18.2 | 84 |
| 2006 | 66.13 | 15.24 | 30 |
| 2007 | 75.18 | 27.68 | 11 |
| 2008 | 72.34 | 11.94 | 41 |
| 2009 | 74.27 | 9.62 | 56 |
| 2010 | 78.33 | 29.94 | 3 |
| 2011 | 61.52 | 20.19 | 88 |

Figure 4. Nominal and standardized indices of abundance for bonnethead shark. The dashed lines are the 95% confidence limits for the standardized index. Each index has been divided by the maximum of the index.

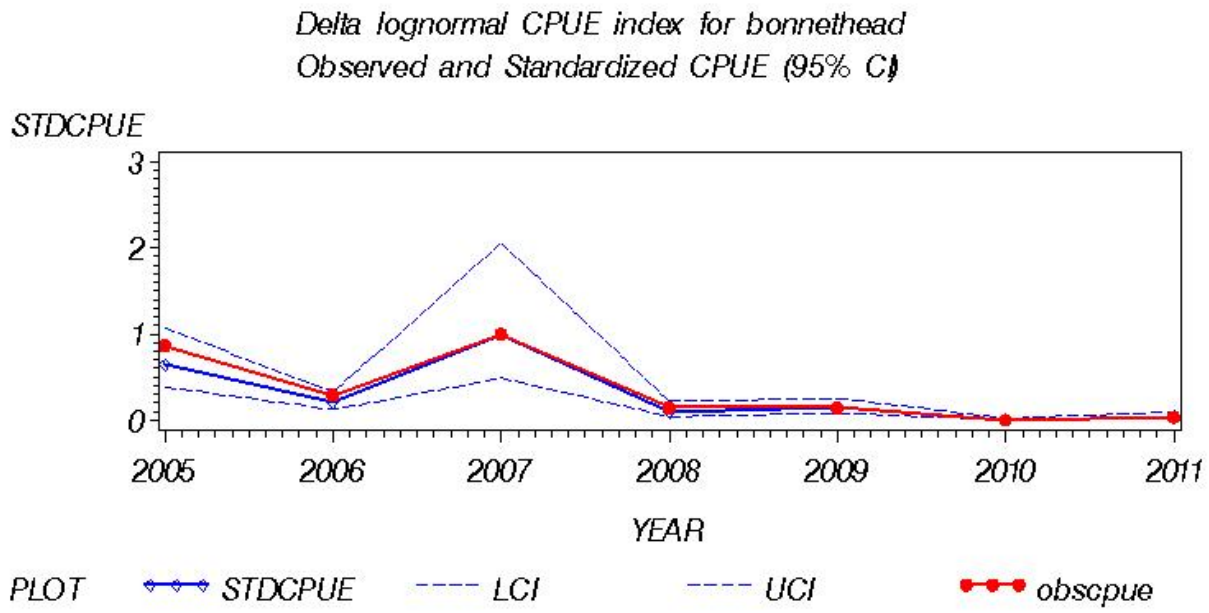


Figure 5. Diagnostic plots of the model outputs for bonnethead shark.