

STANDARDIZED CATCH RATES OF BLACKTIP SHARKS
(*CARCHARHINUS LIMBATUS*) COLLECTED DURING A GILLNET SURVEY
IN MISSISSIPPI COASTAL WATERS, 1998-2011.

Eric R. Hoffmayer¹, Glenn R. Parsons², Jill M. Hendon³, and Adam G. Pollack¹

Beginning in 1998, an ongoing monthly standardized gillnet survey has been conducted in Mississippi coastal waters from March to October each year. This fisheries independent dataset was developed to monitor the abundance and distribution of various elasmobranch and teleost species within Mississippi's coastal waters. As a result of 282 net sets and 924 hours of effort, 833 blacktip sharks were collected. Because the work was conducted in a known blacktip nursery area, blacktip shark catch was further divided into young-of-the-young (YOY, age-0) and juvenile catch. Due to the low occurrences of adults in the data, an abundance index was not produced. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regressions. Other than slight peaks in 2000 and 2005, standardized total blacktip catch rates remained stable across the time series. Both YOY and juvenile catch rates mimicked the total blacktip index.

¹NOAA, National Marine Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Pascagoula, Mississippi 39567; ²Department of Biology, The University of Mississippi, University, MS 38677. ³Center for Fisheries Research and Development, The University of Southern Mississippi. Gulf Coast Research Laboratory. 703 East Beach Drive. Ocean Springs, MS 39564.

INTRODUCTION

Through the combined effort of the University of Mississippi and the University of Southern Mississippi's Gulf Coast Research Laboratory (GCRL) a standardized gillnet survey within the waters of the Mississippi Sound has been conducted monthly from March to October, since 1998. The dataset began in 1998 in the north central GOM, with a three year study funded by NOAA's Marine Fisheries Initiative (MARFIN). The study focused on identifying and characterizing shark nursery grounds in Mississippi and Alabama waters and established a baseline for shark abundance in these areas (Parsons and Hoffmayer, 2005; Parsons and Hoffmayer, 2007). In 2001, the survey was partially continued (unfunded) in an effort to preserve some of the long-term monitoring of shark numbers. The following year (2002) no effort was put towards continuing the survey. Beginning in 2003, the gillnet survey was funded through combined efforts of the Gulfspan Program (NOAA) and the Mississippi Department of Marine Resources through the U.S. Fish and Wildlife Service (Sports Fish Restoration Act). The primary objective of this survey was to collect data on the seasonal abundance and distribution of local shark species in Mississippi waters. The funding for this survey has continued through 2012 and will most likely continue in the foreseeable future.

METHODOLOGY

Sampling Locations

From 1998 to 2011 sharks were collected at various sites along the Mississippi coast extending east to west from Petit Bois Island to St. Louis Bay. In general, collections were made from March to October with two to three locations sampled each month. Sampling was confined to the waters of the Mississippi Sound. Initially, sampling locations were selected such that a large geographical area and a range of environmental conditions could be covered. However, unless sampling was limited by conditions such as weather, sea state, and shrimp boat activity, we typically selected locations in close proximity to the barrier islands.

From 1998 to 2000 two locations were sampled each month, with one location (Horn Island) established as a long-term sampling location. During 2001, because no funding was available, the long-term Horn Island location was sampled monthly, along with a few other locations when available. With limited funding in 2003, only a few locations were sampled, primarily locations where previous sampling was conducted. From 2004 to 2009, two to three regions were sampled monthly, with waters around west Horn, west Cat, and southwest Round Islands as the three primary sampling regions. Each region was defined by a 3.8 x 2.8 km sampling area where monthly locations were randomly selected (Figure 1). In addition to the three primary sampling regions, sampling occurred in other areas, opportunistically. In 2010, the sampling protocol was modified to increase the number of monthly locations (7-8 per month), and new sampling regions were added to the Mississippi Sound sampling universe, including east Cat, east Ship, west Ship, Deer, east Horn, Sand, and Petit Bois Islands (Figure 1). To increase the number of sampling locations, the soak times were reduced from five to two hours.

Sampling Protocol

Sampling was conducted with a 152.4 x 3 m gillnet consisting of five 30.5 meter panels of 4.5, 5.1, 5.7, 6.4, and 7.0 cm square mesh. The net was typically fished between the hours of 0800 and 2000. Depending upon the rate of capture and the environmental conditions prevalent, the net was checked every 0.5 to 1.0 hour. Each time the net was checked, the time of day over which those sharks were captured was recorded. As expeditiously as possible, each shark captured was identified and measured (fork length, FL) and its sex and, when possible, maturity state recorded. Water temperature (°C), salinity (psu), and dissolved oxygen (mg/l) were measured at the water's surface and near the bottom at each sampling location. We also recorded depth (m), turbidity (cm), sea state (m) and used a GPS to record latitude and longitude.

Analysis

For the purpose of analysis, blacktip sharks were divided into size classes based on estimates of their growth rates and size at maturity. Blacktip sharks were designated young-of-year (YOY) when between 400 and 650 mm fork length (FL), juvenile when between 660 and 1034 mm FL (male) and between 660 and 1173 mm FL (female), and adult when >1035 mm FL (male) and >1174 mm FL (female) (Carlson et al. 2006). Detailed analysis of adult catch rates was not performed because of their small number of positive catches in the dataset (6.8%). Catch rates were standardized as catch per unit effort (CPUE) in sharks 100 m net⁻¹ hour⁻¹ for each size class of blacktip sharks and blacktip sharks as a whole. Length frequency distributions were constructed for blacktip sharks ranging from 380 to 1210+ mm using 100 mm increments.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for blacktip sharks (Lo *et al.* 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al.* 1992).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al.* (1992) was estimated as:

$$(1) \quad I_y = c_y p_y,$$

where c_y is the estimate of mean CPUE for positive catches only for year y , and p_y is the estimate of mean probability of occurrence during year y . Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

$$(2) \quad \ln(c) = X\beta + \varepsilon$$

and

$$(3) \quad p = \frac{e^{X\beta + \varepsilon}}{1 + e^{X\beta + \varepsilon}},$$

respectively, where c is a vector of the positive catch data, p is a vector of the presence/absence data, X is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2 . Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, $SE(c_y)$ and $SE(p_y)$, respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated as:

$$(4) \quad V(I_y) \approx V(c_y)p_y^2 + c_y^2V(p_y) + 2c_y p_y \text{Cov}(c, p),$$

where:

$$(5) \quad \text{Cov}(c, p) \approx \rho_{c,p} [SE(c_y)SE(p_y)],$$

and $\rho_{c,p}$ denotes correlation of c and p among years.

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.10$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC.

For all indices developed, the factors YEAR, MONTH, LOCATION, DEPTH, SET TIME, EFFORT, MONTHLY RAINFALL (MONTHLY R), and PREVIOUS MONTH RAIN (PREV MON R), SURFACE (SUR) and BOTTOM (BOT) TEMPERATURE (TEMP), SALINITY (SAL), and DISSOLVED OXYGEN (DO) were examined for inclusion in the catch rate models. The factor MONTH includes the months that sampling was conducted from March to October. The Mississippi Sound was divided into two zones: east to west (1 and 2) which is represented by factor LOCATION. The factor SET TIME refers to the time of day the gillnet was first deployed at the sampling location. Since soak time changed throughout the duration of the survey, the hours the net soaked is represented by the factor EFFORT. The factors MONTHLY R and PREV MON R included the mean monthly rainfall (inches) in Mississippi's three coastal counties. The factors DEPTH, TEMP, SAL, and DO included values present in the data set. The factor YEAR included each year in the time series from 1998 to 2011, and was included in the model whether it explained the data or not, so that an annual catch rate series was produced.

RESULTS

From 1998 to 2011, 282 locations in Mississippi were sampled resulting in 924 hours of effort. During this time 833 blacktip sharks were collected (Figure 2). The total number of blacktip sharks captured ranged from 9 to 174 (Table 1). The blacktip shark catch consisted primarily of juvenile (n = 459) and YOY (n = 351), with relatively few adults (n = 23). Approximately 41% of the stations contained positive catches of blacktip sharks, with YOY, juvenile, and adult sharks occurring at 21.4, 29.3, and 6.8% of the stations, respectively. Due to the low occurrence of adults in the dataset, no further analysis was performed.

In the Mississippi gillnet survey, blacktip sharks ranged in size from 410 to 1,280 mm FL (mean: 663 ± 5.2 mm FL). The length frequency histogram (Figure 3) indicated that 93.5% of the sharks were between 400 and 900 mm FL. The nominal CPUE and number of stations with a positive catch for total, YOY, and juvenile blacktip are presented in Figures 4-6, which indicated annual variation in nominal CPUE, with varying proportion of positive catches over the years.

Total Blacktip Catch

For the total blacktip model, YEAR, MONTH, DEPTH, EFFORT, TEMPSUR, TEMPBOT, SALSUR, and PREV MON R were retained in the binomial submodel. The variables retained in the lognormal submodel were YEAR, LOCATION, TEMPBOT, MONTHLY R, and SET TIME. Table 2 summarizes the backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 1452.5 and 312.0, respectively. The AIC for the lognormal submodel increased slightly from model run #1 to #2, but steadily declined for each subsequent run when non-significant variables were removed. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 7-9, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Figure 10 and Table 3. Nominal and standardized blacktip catch rates remained relatively stable throughout the survey with slight peaks in abundance occurring in 2000, 2005, and 2007 (Figure 10).

YOY Blacktip Catch

For the YOY blacktip model, YEAR, MONTH, EFFORT, and TEMPSUR were retained in the binomial submodel. The variables retained in the lognormal submodel were YEAR, MONTH, and SET TIME. Table 4 summarizes the backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 1343.6 and 138.5, respectively. The AIC for the lognormal submodel increased slightly when the LOCATION variable was removed; however, based upon the p-value (0.1515), it was determined that the slight increase was acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 11-13, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Figure 14 and Table 5. The standardized YOY blacktip shark catch rates exhibited an increase from 1999 to 2001, but then remained stable from 2003 to 2011 (Figure 14). Nominal catch rates were relatively stable throughout the time series, with slight increases observed in 2000 and 2005 (Figure 14).

Juvenile Blacktip Catch

For the juvenile blacktip model, YEAR, MONTH, DEPTH, EFFORT, TEMPBOT, SALSUR, and PREV MON R were retained in the binomial submodel. The variables retained in the lognormal submodel were YEAR, LOCATION, and TEMPBOT. Table 6 summarizes the backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 1441.9 and 213.3, respectively. The AIC for the lognormal submodel increased slightly from model run #6 to #7, but steadily declined for each subsequent run when non-significant variables were removed. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 13-15, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Figure 18 and Table 7. Both the nominal and standardized juvenile blacktip shark catch rates exhibited a peak in 2000, but then remained relatively stable throughout the rest of the time series (Figure 18).

REFERENCES

- Carlson, J.K., J.R. Sulikowski, and I.E. Baremore. 2006. Do differences in life history exist for blacktip sharks, *Carcharhinus limbatus*, from the United States South Atlantic Bight and Eastern Gulf of Mexico? *Environmental Biology of Fishes* 25:279-292.
- Lo, N.C., L.D. Jacobson, and 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.
- Ortiz, M. 2006. Standardized catch rates for gag grouper (*Mycteroperca microlepis*) from the marine recreational fisheries statistical survey (MRFSS). Southeast Data Assessment and Review (SEDAR) Working Document S10 DW-09
- Parsons, G.R. and E.R. Hoffmayer. (2005). Seasonal changes in the distribution and availability of the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, in the north central Gulf of Mexico. *Copeia* 2005:313-319.
- Parsons, G.R. and E.R. Hoffmayer. 2007. Identification and characterization of shark nursery grounds along the Mississippi and Alabama gulf coasts. *In: Shark nursery grounds of the U.S. Atlantic and Gulf of Mexico.* (Eds. C. McCandless). AFS Publication 50:301-316.

Table 1. Summary of the blacktip shark data used in these analyses collected during the Mississippi gillnet survey conducted between 1998 and 2011.

| Survey Year | Number of Stations | Number Collected | Number Measured | Minimum Fork Length (mm) | Maximum Fork Length (mm) | Mean Fork Length (mm) | Standard Deviation |
|-----------------------|--------------------------|------------------------|-----------------------|--------------------------|--------------------------|-------------------------------|--------------------|
| 1998 | 15 | 36 | 36 | 416 | 1011 | 670 | 150 |
| 1999 | 16 | 27 | 27 | 504 | 846 | 675 | 100 |
| 2000 | 14 | 171 | 171 | 448 | 1084 | 660 | 120 |
| 2001 | 5 | 12 | 12 | 652 | 789 | 700 | 40 |
| 2002 | 0 | 0 | 0 | - | - | - | - |
| 2003 | 7 | 55 | 55 | 466 | 878 | 593 | 70 |
| 2004 | 12 | 30 | 30 | 498 | 1223 | 684 | 200 |
| 2005 | 13 | 138 | 138 | 451 | 1257 | 637 | 130 |
| 2006 | 24 | 48 | 48 | 410 | 1227 | 736 | 220 |
| 2007 | 19 | 91 | 91 | 43.5 | 1280 | 723 | 190 |
| 2008 | 22 | 72 | 72 | 430 | 880 | 580 | 110 |
| 2009 | 20 | 50 | 50 | 450 | 940 | 674 | 120 |
| 2010 | 59 | 78 | 78 | 420 | 1180 | 659 | 160 |
| 2011 | 56 | 25 | 25 | 529 | 1120 | 793 | 130 |
| Total Number of Years | Total Number of Stations | Total Number Collected | Total Number Measured | | | Overall Mean Fork Length (mm) | |
| 13 | 282 | 833 | 833 | | | 633 | |

Table 2. Summary of the backward selection procedure for building delta-lognormal submodels for the total blacktip shark full index of relative abundance from 1998 to 2011.

| <i>Model Run #1</i> | <i>Binomial Submodel Type 3 Tests (AIC 1470.6)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 300.9)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 250 | 21.30 | 1.78 | 0.0461 | 0.0526 | 12 | 84 | 1.68 | 0.0870 |
| <i>location</i> | 1 | 250 | 0.12 | 0.12 | 0.7309 | 0.7311 | 1 | 84 | 3.40 | 0.0686 |
| <i>Month</i> | 7 | 250 | 19.94 | 2.85 | 0.0057 | 0.0071 | 7 | 84 | 0.67 | 0.6929 |
| <i>Depth</i> | 1 | 250 | 9.92 | 9.92 | 0.0016 | 0.0018 | 1 | 84 | 0.56 | 0.4555 |
| <i>Effort_h_</i> | 1 | 250 | 5.01 | 5.01 | 0.0253 | 0.0262 | 1 | 84 | 1.05 | 0.3073 |
| <i>Tempsur</i> | 1 | 250 | 3.77 | 3.77 | 0.0520 | 0.0532 | 1 | 84 | 1.89 | 0.1724 |
| <i>Tempbot</i> | 1 | 250 | 2.35 | 2.35 | 0.1255 | 0.1268 | 1 | 84 | 6.74 | 0.0111 |
| <i>Salsur</i> | 1 | 250 | 1.95 | 1.95 | 0.1629 | 0.1641 | 1 | 84 | 0.85 | 0.3597 |
| <i>Prev_Mon_R</i> | 1 | 250 | 4.21 | 4.21 | 0.0402 | 0.0412 | 1 | 84 | 3.61 | 0.0609 |
| <i>DObot</i> | 1 | 250 | 0.22 | 0.22 | 0.6423 | 0.6427 | 1 | 84 | 2.82 | 0.0967 |
| <i>Monthly_R</i> | 1 | 250 | 0.09 | 0.09 | 0.7636 | 0.7638 | 1 | 84 | 5.26 | 0.0243 |
| <i>DOsur</i> | 1 | 250 | 0.01 | 0.01 | 0.9149 | 0.9150 | 1 | 84 | 0.69 | 0.4092 |
| <i>Set_Time</i> | 1 | 250 | 0.01 | 0.01 | 0.9128 | 0.9129 | 1 | 84 | 2.74 | 0.1016 |
| <i>Salbot</i> | 1 | 250 | 0.00 | 0.00 | 0.9564 | 0.9564 | 1 | 84 | 1.90 | 0.1720 |

| <i>Model Run #2</i> | <i>Binomial Submodel Type 3 Tests (AIC 1467.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 335.3)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 251 | 21.86 | 1.82 | 0.0392 | 0.0452 | 12 | 91 | 1.55 | 0.1200 |
| <i>location</i> | 1 | 251 | 0.14 | 0.14 | 0.7115 | 0.7118 | 1 | 91 | 3.71 | 0.0571 |
| <i>Month</i> | 7 | 251 | 20.31 | 2.90 | 0.0049 | 0.0062 | | | Dropped | |
| <i>Depth</i> | 1 | 251 | 10.71 | 10.71 | 0.0011 | 0.0012 | 1 | 91 | 0.33 | 0.5648 |
| <i>Effort_h_</i> | 1 | 251 | 5.03 | 5.03 | 0.0249 | 0.0258 | 1 | 91 | 0.21 | 0.6465 |
| <i>Tempsur</i> | 1 | 251 | 4.86 | 4.86 | 0.0275 | 0.0284 | 1 | 91 | 1.58 | 0.2126 |
| <i>Tempbot</i> | 1 | 251 | 3.17 | 3.17 | 0.0749 | 0.0761 | 1 | 91 | 8.33 | 0.0049 |
| <i>Salsur</i> | 1 | 251 | 5.99 | 5.99 | 0.0144 | 0.0151 | 1 | 91 | 0.62 | 0.4327 |
| <i>Prev_Mon_R</i> | 1 | 251 | 4.30 | 4.30 | 0.0380 | 0.0390 | 1 | 91 | 2.48 | 0.1187 |
| <i>DObot</i> | 1 | 251 | 0.22 | 0.22 | 0.6387 | 0.6391 | 1 | 91 | 2.68 | 0.1048 |
| <i>Monthly_R</i> | 1 | 251 | 0.10 | 0.10 | 0.7574 | 0.7577 | 1 | 91 | 5.44 | 0.0219 |
| <i>DOsur</i> | 1 | 251 | 0.01 | 0.01 | 0.9105 | 0.9106 | 1 | 91 | 0.85 | 0.3588 |
| <i>Set_Time</i> | 1 | 251 | 0.01 | 0.01 | 0.9143 | 0.9144 | 1 | 91 | 2.93 | 0.0905 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 91 | 1.69 | 0.1966 |

| <i>Model Run #3</i> | <i>Binomial Submodel Type 3 Tests (AIC 1464.9)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 333.2)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 252 | 22.87 | 1.91 | 0.0288 | 0.0341 | 12 | 92 | 1.56 | 0.1173 |
| <i>location</i> | 1 | 252 | 0.14 | 0.14 | 0.7078 | 0.7081 | 1 | 92 | 3.85 | 0.0529 |
| <i>Month</i> | 7 | 252 | 20.50 | 2.93 | 0.0046 | 0.0058 | | | dropped | |
| <i>Depth</i> | 1 | 252 | 10.78 | 10.78 | 0.0010 | 0.0012 | 1 | 92 | 0.37 | 0.5428 |
| <i>Effort_h_</i> | 1 | 252 | 5.04 | 5.04 | 0.0248 | 0.0257 | | | dropped | |
| <i>Tempsur</i> | 1 | 252 | 5.11 | 5.11 | 0.0238 | 0.0246 | 1 | 92 | 1.43 | 0.2351 |
| <i>Tempbot</i> | 1 | 252 | 3.17 | 3.17 | 0.0748 | 0.0760 | 1 | 92 | 8.20 | 0.0052 |
| <i>Salsur</i> | 1 | 252 | 6.01 | 6.01 | 0.0142 | 0.0149 | 1 | 92 | 0.55 | 0.4606 |
| <i>Prev_Mon_R</i> | 1 | 252 | 4.36 | 4.36 | 0.0369 | 0.0379 | 1 | 92 | 2.30 | 0.1326 |
| <i>DObot</i> | 1 | 252 | 0.22 | 0.22 | 0.6370 | 0.6374 | 1 | 92 | 2.70 | 0.1035 |
| <i>Monthly_R</i> | 1 | 252 | 0.09 | 0.09 | 0.7586 | 0.7588 | 1 | 92 | 5.29 | 0.0238 |
| <i>DOsur</i> | 1 | 252 | 0.02 | 0.02 | 0.8991 | 0.8992 | 1 | 92 | 0.81 | 0.3697 |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 92 | 3.67 | 0.0585 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 92 | 1.60 | 0.2096 |

| <i>Model Run #4</i> | <i>Binomial Submodel Type 3 Tests (AIC 1461.8)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 330.5)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 253 | 22.96 | 1.91 | 0.0280 | 0.0332 | 12 | 93 | 1.57 | 0.1152 |
| <i>location</i> | 1 | 253 | 0.14 | 0.14 | 0.7061 | 0.7064 | 1 | 93 | 4.30 | 0.0409 |
| <i>Month</i> | 7 | 253 | 20.81 | 2.97 | 0.0041 | 0.0052 | | | Dropped | |
| <i>Depth</i> | 1 | 253 | 11.30 | 11.30 | 0.0008 | 0.0009 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 253 | 5.05 | 5.05 | 0.0246 | 0.0254 | | | Dropped | |
| <i>Tempsur</i> | 1 | 253 | 5.24 | 5.24 | 0.0221 | 0.0229 | 1 | 93 | 1.33 | 0.2512 |
| <i>Tempbot</i> | 1 | 253 | 3.30 | 3.30 | 0.0693 | 0.0705 | 1 | 93 | 8.25 | 0.0050 |
| <i>Salsur</i> | 1 | 253 | 6.23 | 6.23 | 0.0126 | 0.0132 | 1 | 93 | 0.49 | 0.4872 |
| <i>Prev_Mon_R</i> | 1 | 253 | 4.38 | 4.38 | 0.0363 | 0.0373 | 1 | 93 | 2.35 | 0.1289 |
| <i>DObot</i> | 1 | 253 | 0.29 | 0.29 | 0.5888 | 0.5893 | 1 | 93 | 2.38 | 0.1265 |
| <i>Monthly_R</i> | 1 | 253 | 0.10 | 0.10 | 0.7538 | 0.7540 | 1 | 93 | 5.40 | 0.0223 |
| <i>DOsur</i> | | | | | Dropped | | 1 | 93 | 0.65 | 0.4231 |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 93 | 3.41 | 0.0681 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 93 | 1.28 | 0.2602 |

| <i>Model Run #5</i> | <i>Binomial Submodel Type 3 Tests (AIC 1457.2)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 326.9)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 254 | 23.78 | 1.98 | 0.0218 | 0.0263 | 12 | 94 | 1.74 | 0.0709 |
| <i>location</i> | 1 | 254 | 0.17 | 0.17 | 0.6791 | 0.6795 | 1 | 94 | 5.18 | 0.0251 |
| <i>Month</i> | 7 | 254 | 22.57 | 3.22 | 0.0020 | 0.0027 | | | Dropped | |
| <i>Depth</i> | 1 | 254 | 11.55 | 11.55 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 254 | 5.06 | 5.06 | 0.0245 | 0.0253 | | | Dropped | |
| <i>Tempsur</i> | 1 | 254 | 5.30 | 5.30 | 0.0213 | 0.0221 | 1 | 94 | 0.85 | 0.3585 |
| <i>Tempbot</i> | 1 | 254 | 3.28 | 3.28 | 0.0702 | 0.0713 | 1 | 94 | 10.01 | 0.0021 |
| <i>Salsur</i> | 1 | 254 | 6.59 | 6.59 | 0.0102 | 0.0108 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 254 | 4.64 | 4.64 | 0.0313 | 0.0322 | 1 | 94 | 2.43 | 0.1224 |
| <i>DObot</i> | 1 | 254 | 0.29 | 0.29 | 0.5926 | 0.5931 | 1 | 94 | 2.87 | 0.0937 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 94 | 5.04 | 0.0271 |
| <i>DOsur</i> | | | | | Dropped | | 1 | 94 | 0.80 | 0.3722 |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 94 | 3.83 | 0.0534 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 94 | 0.96 | 0.3306 |

| <i>Model Run #6</i> | <i>Binomial Submodel Type 3 Tests (AIC 1454.2)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 324.9)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 255 | 24.13 | 2.01 | 0.0195 | 0.0238 | 12 | 95 | 1.68 | 0.0825 |
| <i>location</i> | | | | | Dropped | | 1 | 95 | 5.10 | 0.0262 |
| <i>Month</i> | 1 | 255 | 11.58 | 11.58 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Depth</i> | 1 | 255 | 5.26 | 5.26 | 0.0218 | 0.0226 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 255 | 5.47 | 5.47 | 0.0194 | 0.0202 | | | Dropped | |
| <i>Tempsur</i> | 1 | 255 | 3.42 | 3.42 | 0.0646 | 0.0657 | 1 | 95 | 0.72 | 0.3983 |
| <i>Tempbot</i> | 1 | 255 | 7.93 | 7.93 | 0.0049 | 0.0052 | 1 | 95 | 9.22 | 0.0031 |
| <i>Salsur</i> | 1 | 255 | 4.70 | 4.70 | 0.0302 | 0.0311 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 255 | 0.29 | 0.29 | 0.5879 | 0.5884 | 1 | 95 | 2.56 | 0.1131 |
| <i>DObot</i> | 1 | 254 | 0.29 | 0.29 | 0.5926 | 0.5931 | 1 | 95 | 2.21 | 0.1401 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 95 | 4.52 | 0.0361 |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 95 | 3.98 | 0.0490 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 95 | 0.92 | 0.3400 |

| <i>Model Run #7</i> | <i>Binomial Submodel Type 3 Tests (AIC 1452.5)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 322.0)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 256 | 24.31 | 2.03 | 0.0185 | 0.0225 | 12 | 96 | 1.65 | 0.0911 |
| <i>location</i> | | | | | Dropped | | 1 | 96 | 5.42 | 0.0220 |
| <i>Month</i> | 7 | 256 | 24.23 | 3.46 | 0.0010 | 0.0015 | | | Dropped | |
| <i>Depth</i> | 1 | 256 | 11.47 | 11.47 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 256 | 5.57 | 5.57 | 0.0183 | 0.0190 | | | Dropped | |
| <i>Tempsur</i> | 1 | 256 | 5.19 | 5.19 | 0.0228 | 0.0236 | | | Dropped | |
| <i>Tempbot</i> | 1 | 256 | 3.68 | 3.68 | 0.0551 | 0.0562 | 1 | 96 | 19.12 | <.0001 |
| <i>Salsur</i> | 1 | 256 | 7.77 | 7.77 | 0.0053 | 0.0057 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 256 | 4.50 | 4.50 | 0.0339 | 0.0348 | 1 | 96 | 2.34 | 0.1291 |
| <i>DObot</i> | | | | | Dropped | | 1 | 96 | 1.85 | 0.1766 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 96 | 4.96 | 0.0283 |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 96 | 3.42 | 0.0675 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 96 | 0.70 | 0.4064 |

| <i>Model Run #8</i> | <i>Binomial Submodel Type 3 Tests (AIC 1452.5)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 317.5)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 256 | 24.31 | 2.03 | 0.0185 | 0.0225 | 12 | 97 | 1.60 | 0.1053 |
| <i>location</i> | | | | | Dropped | | 1 | 97 | 5.84 | 0.0176 |
| <i>Month</i> | 7 | 256 | 24.23 | 3.46 | 0.0010 | 0.0015 | | | Dropped | |
| <i>Depth</i> | 1 | 256 | 11.47 | 11.47 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 256 | 5.57 | 5.57 | 0.0183 | 0.0190 | | | Dropped | |
| <i>Tempsur</i> | 1 | 256 | 5.19 | 5.19 | 0.0228 | 0.0236 | | | Dropped | |
| <i>Tempbot</i> | 1 | 256 | 3.68 | 3.68 | 0.0551 | 0.0562 | 1 | 97 | 18.58 | <.0001 |
| <i>Salsur</i> | 1 | 256 | 7.77 | 7.77 | 0.0053 | 0.0057 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 256 | 4.50 | 4.50 | 0.0339 | 0.0348 | 1 | 97 | 1.76 | 0.1873 |
| <i>DObot</i> | | | | | Dropped | | 1 | 97 | 2.31 | 0.1319 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 97 | 4.66 | 0.0334 |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 97 | 3.44 | 0.0669 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #9</i> | <i>Binomial Submodel Type 3 Tests (AIC 1452.5)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 313.9)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 256 | 24.31 | 2.03 | 0.0185 | 0.0225 | 12 | 98 | 1.49 | 0.1398 |
| <i>location</i> | | | | | Dropped | | 1 | 98 | 5.72 | 0.0186 |
| <i>Month</i> | 7 | 256 | 24.23 | 3.46 | 0.0010 | 0.0015 | | | Dropped | |
| <i>Depth</i> | 1 | 256 | 11.47 | 11.47 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 256 | 5.57 | 5.57 | 0.0183 | 0.0190 | | | Dropped | |
| <i>Tempsur</i> | 1 | 256 | 5.19 | 5.19 | 0.0228 | 0.0236 | | | Dropped | |
| <i>Tempbot</i> | 1 | 256 | 3.68 | 3.68 | 0.0551 | 0.0562 | 1 | 98 | 17.30 | <.0001 |
| <i>Salsur</i> | 1 | 256 | 7.77 | 7.77 | 0.0053 | 0.0057 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 256 | 4.50 | 4.50 | 0.0339 | 0.0348 | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | 1 | 98 | 1.78 | 0.1855 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 98 | 3.77 | 0.0552 |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 98 | 3.70 | 0.0572 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #10</i> | <i>Binomial Submodel Type 3 Tests (AIC 1452.5)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 312.0)</i> | | | |
|----------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 256 | 24.31 | 2.03 | 0.0185 | 0.0225 | 12 | 99 | 1.73 | 0.0709 |
| <i>location</i> | | | | | Dropped | | 1 | 99 | 5.15 | 0.0254 |
| <i>Month</i> | 7 | 256 | 24.23 | 3.46 | 0.0010 | 0.0015 | | | Dropped | |
| <i>Depth</i> | 1 | 256 | 11.47 | 11.47 | 0.0007 | 0.0008 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 256 | 5.57 | 5.57 | 0.0183 | 0.0190 | | | Dropped | |
| <i>Tempsur</i> | 1 | 256 | 5.19 | 5.19 | 0.0228 | 0.0236 | | | Dropped | |
| <i>Tempbot</i> | 1 | 256 | 3.68 | 3.68 | 0.0551 | 0.0562 | 1 | 99 | 21.02 | <.0001 |
| <i>Salsur</i> | 1 | 256 | 7.77 | 7.77 | 0.0053 | 0.0057 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 256 | 4.50 | 4.50 | 0.0339 | 0.0348 | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 99 | 2.94 | 0.0898 |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 99 | 3.87 | 0.0518 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

Table 3. Indices for total blacktip shark catch rates from 1998 to 2011 developed using the delta-lognormal model. The nominal frequency of occurrence, the number of samples (n), the Lo Index (numbers per 100 GN per hour), the Lo indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| SurveyYear | Frequency | n | Lo Index | Scaled Index | CV | LCL | UCL |
|------------|-----------|----|----------|--------------|---------|---------|---------|
| 1998 | 0.53333 | 15 | 0.31763 | 0.75847 | 0.49491 | 0.29743 | 1.93419 |
| 1999 | 0.50000 | 16 | 0.20735 | 0.49513 | 0.51013 | 0.18923 | 1.29552 |
| 2000 | 0.92857 | 14 | 1.34005 | 3.19989 | 0.27302 | 1.87171 | 5.47057 |
| 2001 | 0.60000 | 5 | 0.25755 | 0.61499 | 0.87746 | 0.13569 | 2.78730 |
| 2003 | 0.42857 | 7 | 0.22808 | 0.54463 | 0.87122 | 0.12116 | 2.44823 |
| 2004 | 0.33333 | 12 | 0.14300 | 0.34148 | 0.80987 | 0.08251 | 1.41319 |
| 2005 | 0.61538 | 13 | 0.64684 | 1.54458 | 0.58474 | 0.52211 | 4.56940 |
| 2006 | 0.41667 | 24 | 0.13562 | 0.32384 | 0.61371 | 0.10453 | 1.00323 |
| 2007 | 0.78947 | 19 | 0.77604 | 1.85310 | 0.34041 | 0.95563 | 3.59344 |
| 2008 | 0.36364 | 22 | 0.49511 | 1.18227 | 0.52194 | 0.44298 | 3.15540 |
| 2009 | 0.45000 | 20 | 0.35789 | 0.85461 | 0.54507 | 0.30815 | 2.37013 |
| 2010 | 0.32203 | 59 | 0.40709 | 0.97209 | 0.42818 | 0.42789 | 2.20840 |
| 2011 | 0.14286 | 56 | 0.13188 | 0.31491 | 0.65464 | 0.09538 | 1.03974 |

Table 4. Summary of the backward selection procedure for building delta-lognormal submodels for the YOY blacktip shark full index of relative abundance from 1998 to 2011.

| <i>Model Run #1</i> | <i>Binomial Submodel Type 3 Tests (AIC 1388.3)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 160.4)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 223 | 14.46 | 1.20 | 0.2725 | 0.2809 | 12 | 31 | 1.70 | 0.1140 |
| <i>location</i> | 1 | 223 | 0.02 | 0.02 | 0.8839 | 0.8840 | 1 | 31 | 0.44 | 0.5117 |
| <i>Month</i> | 6 | 223 | 12.62 | 2.10 | 0.0496 | 0.0540 | 6 | 31 | 0.55 | 0.7631 |
| <i>Depth</i> | 1 | 223 | 0.80 | 0.80 | 0.3708 | 0.3718 | 1 | 31 | 1.08 | 0.3068 |
| <i>Effort_h_</i> | 1 | 223 | 5.76 | 5.76 | 0.0164 | 0.0172 | 1 | 31 | 0.58 | 0.4532 |
| <i>Tempsur</i> | 1 | 223 | 4.52 | 4.52 | 0.0334 | 0.0345 | 1 | 31 | 0.04 | 0.8424 |
| <i>Tempbot</i> | 1 | 223 | 0.08 | 0.08 | 0.7768 | 0.7770 | 1 | 31 | 0.02 | 0.9019 |
| <i>Salsur</i> | 1 | 223 | 0.62 | 0.62 | 0.4308 | 0.4316 | 1 | 31 | 0.26 | 0.6155 |
| <i>Prev_Mon_R</i> | 1 | 223 | 0.01 | 0.01 | 0.9108 | 0.9109 | 1 | 31 | 0.11 | 0.7416 |
| <i>DObot</i> | 1 | 223 | 0.13 | 0.13 | 0.7235 | 0.7239 | 1 | 31 | 0.06 | 0.8127 |
| <i>Monthly_R</i> | 1 | 223 | 0.12 | 0.12 | 0.7296 | 0.7299 | 1 | 31 | 0.04 | 0.8363 |
| <i>DOsur</i> | 1 | 223 | 1.12 | 1.12 | 0.2889 | 0.2901 | 1 | 31 | 0.62 | 0.4360 |
| <i>Set_Time</i> | 1 | 223 | 2.59 | 2.59 | 0.1074 | 0.1088 | 1 | 31 | 2.71 | 0.1097 |
| <i>Salbot</i> | 1 | 223 | 0.36 | 0.36 | 0.5508 | 0.5514 | 1 | 31 | 0.08 | 0.7765 |

| <i>Model Run #2</i> | <i>Binomial Submodel Type 3 Tests (AIC 1384.8)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 159.3)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 224 | 14.63 | 1.22 | 0.2622 | 0.2707 | 12 | 32 | 1.76 | 0.0993 |
| <i>location</i> | 1 | 224 | 0.02 | 0.02 | 0.8824 | 0.8826 | 1 | 32 | 0.45 | 0.5085 |
| <i>Month</i> | 6 | 224 | 12.68 | 2.11 | 0.0484 | 0.0528 | 6 | 32 | 0.59 | 0.7371 |
| <i>Depth</i> | 1 | 224 | 0.82 | 0.82 | 0.3647 | 0.3657 | 1 | 32 | 1.13 | 0.2967 |
| <i>Effort_h_</i> | 1 | 224 | 5.90 | 5.90 | 0.0151 | 0.0159 | 1 | 32 | 0.58 | 0.4512 |
| <i>Tempsur</i> | 1 | 224 | 4.54 | 4.54 | 0.0331 | 0.0341 | 1 | 32 | 0.03 | 0.8719 |
| <i>Tempbot</i> | 1 | 224 | 0.09 | 0.09 | 0.7659 | 0.7661 | | | Dropped | |
| <i>Salsur</i> | 1 | 224 | 0.64 | 0.64 | 0.4232 | 0.4240 | 1 | 32 | 0.25 | 0.6191 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | 1 | 32 | 0.10 | 0.7526 |
| <i>DObot</i> | 1 | 224 | 0.13 | 0.13 | 0.7208 | 0.7211 | 1 | 32 | 0.06 | 0.8023 |
| <i>Monthly_R</i> | 1 | 224 | 0.11 | 0.11 | 0.7432 | 0.7436 | 1 | 32 | 0.04 | 0.8480 |
| <i>DOsur</i> | 1 | 224 | 1.13 | 1.13 | 0.2877 | 0.2888 | 1 | 32 | 0.65 | 0.4255 |

| Model Run #2 | <i>Binomial Submodel Type 3 Tests (AIC 1384.8)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 159.3)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Set_Time</i> | 1 | 224 | 2.59 | 2.59 | 0.1072 | 0.1086 | 1 | 32 | 2.78 | 0.1050 |
| <i>Salbot</i> | 1 | 224 | 0.36 | 0.36 | 0.5495 | 0.5501 | 1 | 32 | 0.12 | 0.7283 |

| Model Run #3 | <i>Binomial Submodel Type 3 Tests (AIC 1383.9)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 156.8)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 225 | 14.96 | 1.25 | 0.2437 | 0.2525 | 12 | 33 | 1.84 | 0.0826 |
| <i>location</i> | | | | | Dropped | | 1 | 33 | 0.47 | 0.4966 |
| <i>Month</i> | 6 | 225 | 12.77 | 2.13 | 0.0468 | 0.0511 | 6 | 33 | 1.32 | 0.2774 |
| <i>Depth</i> | 1 | 225 | 0.88 | 0.88 | 0.3477 | 0.3487 | 1 | 33 | 1.13 | 0.2950 |
| <i>Effort_h_</i> | 1 | 225 | 5.96 | 5.96 | 0.0147 | 0.0154 | 1 | 33 | 0.69 | 0.4129 |
| <i>Tempsur</i> | 1 | 225 | 4.56 | 4.56 | 0.0328 | 0.0338 | | | Dropped | |
| <i>Tempbot</i> | 1 | 225 | 0.11 | 0.11 | 0.7433 | 0.7436 | | | Dropped | |
| <i>Salsur</i> | 1 | 225 | 0.63 | 0.63 | 0.4257 | 0.4265 | 1 | 33 | 0.24 | 0.6307 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | 1 | 33 | 0.11 | 0.7378 |
| <i>DObot</i> | 1 | 225 | 0.12 | 0.12 | 0.7305 | 0.7308 | 1 | 33 | 0.05 | 0.8200 |
| <i>Monthly_R</i> | 1 | 225 | 0.10 | 0.10 | 0.7513 | 0.7516 | 1 | 33 | 0.04 | 0.8479 |
| <i>DOsur</i> | 1 | 225 | 1.12 | 1.12 | 0.2905 | 0.2916 | 1 | 33 | 0.70 | 0.4087 |
| <i>Set_Time</i> | 1 | 225 | 2.64 | 2.64 | 0.1045 | 0.1059 | 1 | 33 | 2.85 | 0.1008 |
| <i>Salbot</i> | 1 | 225 | 0.34 | 0.34 | 0.5611 | 0.5617 | 1 | 33 | 0.14 | 0.7148 |

| Model Run #4 | <i>Binomial Submodel Type 3 Tests (AIC 1381.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 153.4)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 226 | 14.90 | 1.24 | 0.2468 | 0.2555 | 12 | 34 | 2.08 | 0.0469 |
| <i>location</i> | | | | | Dropped | | 1 | 34 | 0.51 | 0.4795 |
| <i>Month</i> | 6 | 226 | 12.76 | 2.13 | 0.0470 | 0.0513 | 6 | 34 | 1.43 | 0.2322 |
| <i>Depth</i> | 1 | 226 | 0.89 | 0.89 | 0.3453 | 0.3463 | 1 | 34 | 1.14 | 0.2931 |
| <i>Effort_h_</i> | 1 | 226 | 5.96 | 5.96 | 0.0146 | 0.0154 | 1 | 34 | 0.86 | 0.3605 |
| <i>Tempsur</i> | 1 | 226 | 4.58 | 4.58 | 0.0324 | 0.0335 | | | Dropped | |
| <i>Tempbot</i> | 1 | 226 | 0.09 | 0.09 | 0.7605 | 0.7607 | | | Dropped | |
| <i>Salsur</i> | 1 | 226 | 0.90 | 0.90 | 0.3415 | 0.3425 | 1 | 34 | 0.24 | 0.6306 |

| Model Run #4 | <i>Binomial Submodel Type 3 Tests (AIC 1381.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 153.4)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Prev_Mon_R</i> | | | | | | | 1 | 34 | 0.09 | 0.7652 |
| <i>DObot</i> | 1 | 226 | 0.14 | 0.14 | 0.7047 | 0.7051 | 1 | 34 | 0.05 | 0.8237 |
| <i>Monthly_R</i> | | | | | | | | | | Dropped |
| <i>DOsur</i> | 1 | 226 | 1.16 | 1.16 | 0.2811 | 0.2823 | 1 | 34 | 0.68 | 0.4141 |
| <i>Set_Time</i> | 1 | 226 | 2.77 | 2.77 | 0.0958 | 0.0971 | 1 | 34 | 3.04 | 0.0905 |
| <i>Salbot</i> | 1 | 226 | 0.42 | 0.42 | 0.5180 | 0.5187 | 1 | 34 | 0.23 | 0.6344 |

| Model Run #5 | <i>Binomial Submodel Type 3 Tests (AIC 1380.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 151.2)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 227 | 14.93 | 1.24 | 0.2455 | 0.2542 | 12 | 35 | 2.13 | 0.0405 |
| <i>location</i> | | | | | | | 1 | 35 | 0.55 | 0.4618 |
| <i>Month</i> | 6 | 227 | 12.73 | 2.12 | 0.0475 | 0.0517 | 6 | 35 | 1.59 | 0.1804 |
| <i>Depth</i> | 1 | 227 | 0.95 | 0.95 | 0.3288 | 0.3298 | 1 | 35 | 1.29 | 0.2646 |
| <i>Effort_h_</i> | 1 | 227 | 5.99 | 5.99 | 0.0144 | 0.0151 | 1 | 35 | 0.83 | 0.3681 |
| <i>Tempsur</i> | 1 | 227 | 14.30 | 14.30 | 0.0002 | 0.0002 | | | | Dropped |
| <i>Tempbot</i> | | | | | | | | | | Dropped |
| <i>Salsur</i> | 1 | 227 | 1.45 | 1.45 | 0.2278 | 0.2290 | 1 | 35 | 0.25 | 0.6231 |
| <i>Prev_Mon_R</i> | | | | | | | 1 | 35 | 0.14 | 0.7112 |
| <i>DObot</i> | 1 | 227 | 0.13 | 0.13 | 0.7162 | 0.7166 | | | | Dropped |
| <i>Monthly_R</i> | | | | | | | | | | Dropped |
| <i>DOsur</i> | 1 | 227 | 1.33 | 1.33 | 0.2485 | 0.2497 | 1 | 35 | 0.65 | 0.4253 |
| <i>Set_Time</i> | 1 | 227 | 2.77 | 2.77 | 0.0960 | 0.0974 | 1 | 35 | 3.67 | 0.0638 |
| <i>Salbot</i> | 1 | 227 | 0.83 | 0.83 | 0.3623 | 0.3633 | 1 | 35 | 0.21 | 0.6487 |

| Model Run #6 | <i>Binomial Submodel Type 3 Tests (AIC 1374.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 148.1)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 228 | 15.02 | 1.25 | 0.2404 | 0.2491 | 12 | 36 | 2.17 | 0.0361 |
| <i>location</i> | | | | | | | 1 | 36 | 0.61 | 0.4382 |
| <i>Month</i> | 6 | 228 | 13.23 | 2.20 | 0.0396 | 0.0436 | 6 | 36 | 2.18 | 0.0677 |
| <i>Depth</i> | 1 | 228 | 0.86 | 0.86 | 0.3532 | 0.3542 | 1 | 36 | 1.19 | 0.2820 |

| Model Run #6 | <i>Binomial Submodel Type 3 Tests (AIC 1374.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 148.1)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Effort_h_</i> | 1 | 228 | 5.93 | 5.93 | 0.0149 | 0.0156 | 1 | 36 | 0.88 | 0.3539 |
| <i>Tempsur</i> | 1 | 228 | 14.48 | 14.48 | 0.0001 | 0.0002 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | 1 | 228 | 1.35 | 1.35 | 0.2456 | 0.2468 | 1 | 36 | 0.30 | 0.5878 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | 1 | 228 | 1.58 | 1.58 | 0.2081 | 0.2094 | 1 | 36 | 0.84 | 0.3650 |
| <i>Set_Time</i> | 1 | 228 | 2.69 | 2.69 | 0.1007 | 0.1021 | 1 | 36 | 3.61 | 0.0653 |
| <i>Salbot</i> | 1 | 228 | 0.72 | 0.72 | 0.3966 | 0.3975 | 1 | 36 | 0.13 | 0.7213 |

| Model Run #7 | <i>Binomial Submodel Type 3 Tests (AIC 1369.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 144.5)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 229 | 14.88 | 1.24 | 0.2483 | 0.2568 | 12 | 37 | 2.22 | 0.0316 |
| <i>location</i> | | | | | Dropped | | 1 | 37 | 0.83 | 0.3686 |
| <i>Month</i> | 6 | 229 | 13.19 | 2.20 | 0.0401 | 0.0441 | 6 | 37 | 2.30 | 0.0551 |
| <i>Depth</i> | 1 | 229 | 1.68 | 1.68 | 0.1944 | 0.1957 | 1 | 37 | 1.16 | 0.2880 |
| <i>Effort_h_</i> | 1 | 229 | 6.05 | 6.05 | 0.0139 | 0.0146 | 1 | 37 | 0.83 | 0.3671 |
| <i>Tempsur</i> | 1 | 229 | 13.97 | 13.97 | 0.0002 | 0.0002 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | 1 | 229 | 0.65 | 0.65 | 0.4217 | 0.4225 | 1 | 37 | 0.96 | 0.3325 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | 1 | 229 | 1.86 | 1.86 | 0.1722 | 0.1736 | 1 | 37 | 0.81 | 0.3735 |
| <i>Set_Time</i> | 1 | 229 | 2.66 | 2.66 | 0.1031 | 0.1045 | 1 | 37 | 3.79 | 0.0592 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| Model Run #8 | <i>Binomial Submodel Type 3 Tests (AIC 1366.9)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 143.4)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 230 | 14.31 | 1.19 | 0.2816 | 0.2895 | 12 | 38 | 2.17 | 0.0346 |
| <i>location</i> | | | | | Dropped | | 1 | 38 | 1.44 | 0.2376 |
| <i>Month</i> | 6 | 230 | 13.85 | 2.31 | 0.0314 | 0.0349 | 6 | 38 | 2.22 | 0.0617 |
| <i>Depth</i> | 1 | 230 | 1.31 | 1.31 | 0.2517 | 0.2529 | 1 | 38 | 1.16 | 0.2876 |
| <i>Effort_h_</i> | 1 | 230 | 5.89 | 5.89 | 0.0152 | 0.0160 | 1 | 38 | 0.70 | 0.4075 |
| <i>Tempsur</i> | 1 | 230 | 13.32 | 13.32 | 0.0003 | 0.0003 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | | | | | Dropped | | 1 | 38 | 1.38 | 0.2476 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | 1 | 230 | 2.92 | 2.92 | 0.0874 | 0.0888 | | | Dropped | |
| <i>Set_Time</i> | 1 | 230 | 2.45 | 2.45 | 0.1172 | 0.1185 | 1 | 38 | 3.82 | 0.0580 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| Model Run #9 | <i>Binomial Submodel Type 3 Tests (AIC 1361.3)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 142.3)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 231 | 14.03 | 1.17 | 0.2986 | 0.3061 | 12 | 39 | 2.49 | 0.0158 |
| <i>location</i> | | | | | Dropped | | 1 | 39 | 1.89 | 0.1767 |
| <i>Month</i> | 6 | 231 | 13.55 | 2.26 | 0.0351 | 0.0388 | 6 | 39 | 2.17 | 0.0666 |
| <i>Depth</i> | | | | | Dropped | | 1 | 39 | 1.24 | 0.2721 |
| <i>Effort_h_</i> | 1 | 231 | 5.68 | 5.68 | 0.0171 | 0.0179 | | | Dropped | |
| <i>Tempsur</i> | 1 | 231 | 12.82 | 12.82 | 0.0003 | 0.0004 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | | | | | Dropped | | 1 | 39 | 1.07 | 0.3067 |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | 1 | 231 | 2.98 | 2.98 | 0.0844 | 0.0857 | | | Dropped | |
| <i>Set_Time</i> | 1 | 231 | 2.20 | 2.20 | 0.1385 | 0.1398 | 1 | 39 | 6.29 | 0.0164 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #10 Binomial Submodel Type 3 Tests (AIC 1352.0)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 138.8)</i> | | | |
|--|---------------|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 232 | 12.99 | 1.08 | 0.3701 | 0.3760 | 12 | 40 | 2.46 | 0.0165 |
| <i>location</i> | | | | | Dropped | | 1 | 40 | 1.67 | 0.2032 |
| <i>Month</i> | 6 | 232 | 13.08 | 2.18 | 0.0418 | 0.0457 | 6 | 40 | 2.46 | 0.0408 |
| <i>Depth</i> | | | | | Dropped | | 1 | 40 | 0.80 | 0.3779 |
| <i>Effort_h_</i> | 1 | 232 | 4.87 | 4.87 | 0.0273 | 0.0283 | | | Dropped | |
| <i>Tempsur</i> | 1 | 232 | 14.96 | 14.96 | 0.0001 | 0.0001 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | 1 | 232 | 2.05 | 2.05 | 0.1522 | 0.1535 | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 40 | 5.64 | 0.0225 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #11 Binomial Submodel Type 3 Tests (AIC 1343.6)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 137.3)</i> | | | |
|--|---------------|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 233 | 13.46 | 1.12 | 0.3366 | 0.3432 | 12 | 41 | 2.42 | 0.0175 |
| <i>location</i> | | | | | Dropped | | 1 | 41 | 2.14 | 0.1515 |
| <i>Month</i> | 6 | 233 | 11.75 | 1.96 | 0.0677 | 0.0724 | 6 | 41 | 2.56 | 0.0336 |
| <i>Depth</i> | | | | | Dropped | | | | Dropped | |
| <i>Effort_h_</i> | 1 | 233 | 4.52 | 4.52 | 0.0335 | 0.0345 | | | Dropped | |
| <i>Tempsur</i> | 1 | 233 | 14.23 | 14.23 | 0.0002 | 0.0002 | | | Dropped | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | |
| <i>Salsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 41 | 4.98 | 0.0312 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| Model Run #12 | | <i>Binomial Submodel Type 3 Tests (AIC 1343.6)</i> | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 138.5)</i> | | | | |
|----------------------|---------------|--|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|--|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> | |
| <i>Year</i> | 12 | 267 | 11.93 | 0.99 | 0.4514 | 0.4548 | 12 | 42 | 2.36 | 0.0200 | |
| <i>location</i> | | | | | Dropped | | | | Dropped | | |
| <i>Month</i> | 6 | 233 | 11.75 | 1.96 | 0.0677 | 0.0724 | 6 | 42 | 2.73 | 0.0251 | |
| <i>Depth</i> | | | | | Dropped | | | | Dropped | | |
| <i>Effort_h_</i> | 1 | 267 | 3.40 | 3.40 | 0.0651 | 0.0662 | | | Dropped | | |
| <i>Tempsur</i> | 1 | 267 | 25.40 | 25.40 | <.0001 | <.0001 | | | Dropped | | |
| <i>Tempbot</i> | | | | | Dropped | | | | Dropped | | |
| <i>Salsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Prev_Mon_R</i> | | | | | Dropped | | | | Dropped | | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Set_Time</i> | | | | | Dropped | | 1 | 42 | 4.28 | 0.0447 | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | | |

Table 5. Indices of YOY blacktip shark catch rates from 1998-2011 developed using the delta-lognormal model. The nominal frequency of occurrence, the number of samples (n), the Lo Index (number per 100 GN per hour), the Lo indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Frequency | n | Lo Index | Scaled Index | CV | LCL | UCL |
|-------------|-----------|----|----------|--------------|---------|---------|---------|
| 1998 | 0.33333 | 15 | 0.06786 | 0.36239 | 0.99347 | 0.06909 | 1.9007 |
| 1999 | 0.25000 | 16 | 0.02677 | 0.14296 | 1.48270 | 0.01654 | 1.2354 |
| 2000 | 0.42857 | 14 | 0.33729 | 1.80110 | 0.68319 | 0.52235 | 6.2104 |
| 2001 | 0.40000 | 5 | 0.67327 | 3.59525 | 0.93710 | 0.73477 | 17.5917 |
| 2003 | 0.42857 | 7 | 0.08622 | 0.46041 | 1.28009 | 0.06421 | 3.3015 |
| 2004 | 0.33333 | 12 | 0.08865 | 0.47339 | 1.02190 | 0.08725 | 2.5686 |
| 2005 | 0.30769 | 13 | 0.12879 | 0.68772 | 0.96739 | 0.13536 | 3.4942 |
| 2006 | 0.20833 | 24 | 0.08320 | 0.44427 | 0.94078 | 0.09038 | 2.1839 |
| 2007 | 0.26316 | 19 | 0.19138 | 1.02196 | 0.78504 | 0.25561 | 4.0859 |
| 2008 | 0.31818 | 22 | 0.30802 | 1.64481 | 0.61133 | 0.53293 | 5.0764 |
| 2009 | 0.40000 | 20 | 0.22907 | 1.22322 | 0.59501 | 0.40674 | 3.6787 |
| 2010 | 0.13559 | 59 | 0.20878 | 1.11487 | 0.64309 | 0.34373 | 3.6160 |
| 2011 | 0.01786 | 56 | 0.00518 | 0.02765 | 5.31994 | 0.00070 | 1.0914 |

Table 6. Summary of the backward selection procedure for building delta-lognormal submodels for the juvenile blacktip shark full index of relative abundance from 1998 to 2011.

| <i>Model Run #1</i> | <i>Binomial Submodel Type 3 Tests (AIC 1470.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 227.6)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 250 | 25.72 | 2.14 | 0.0118 | 0.0150 | 12 | 50 | 0.80 | 0.6475 |
| <i>Month</i> | 7 | 250 | 18.01 | 2.57 | 0.0119 | 0.0141 | 7 | 50 | 1.24 | 0.2991 |
| <i>location</i> | 1 | 250 | 0.06 | 0.06 | 0.8031 | 0.8033 | 1 | 50 | 2.65 | 0.1100 |
| <i>Depth</i> | 1 | 250 | 14.80 | 14.80 | 0.0001 | 0.0002 | 1 | 50 | 0.33 | 0.5675 |
| <i>Effort_h_</i> | 1 | 250 | 6.88 | 6.88 | 0.0087 | 0.0092 | 1 | 50 | 2.82 | 0.0992 |
| <i>Tempsur</i> | 1 | 250 | 0.51 | 0.51 | 0.4733 | 0.4739 | 1 | 50 | 0.33 | 0.5671 |
| <i>Tempbot</i> | 1 | 250 | 3.23 | 3.23 | 0.0725 | 0.0737 | 1 | 50 | 2.99 | 0.0898 |
| <i>Salsur</i> | 1 | 250 | 2.57 | 2.57 | 0.1086 | 0.1099 | 1 | 50 | 0.03 | 0.8623 |
| <i>Prev_Mon_R</i> | 1 | 250 | 2.69 | 2.69 | 0.1011 | 0.1024 | 1 | 50 | 1.62 | 0.2088 |
| <i>DObot</i> | 1 | 250 | 1.13 | 1.13 | 0.2884 | 0.2894 | 1 | 50 | 1.32 | 0.2557 |
| <i>Monthly_R</i> | 1 | 250 | 0.05 | 0.05 | 0.8270 | 0.8272 | 1 | 50 | 0.64 | 0.4264 |
| <i>DOsur</i> | 1 | 250 | 0.70 | 0.70 | 0.4013 | 0.4021 | 1 | 50 | 1.02 | 0.3178 |
| <i>Set_Time</i> | 1 | 250 | 0.31 | 0.31 | 0.5788 | 0.5793 | 1 | 50 | 0.31 | 0.5810 |
| <i>Salbot</i> | 1 | 250 | 0.00 | 0.00 | 0.9893 | 0.9893 | 1 | 50 | 0.09 | 0.7665 |

| <i>Model Run #2</i> | <i>Binomial Submodel Type 3 Tests (AIC 1467.4)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 224.3)</i> | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 251 | 27.74 | 2.31 | 0.0060 | 0.0082 | 12 | 51 | 0.91 | 0.5429 |
| <i>Month</i> | 7 | 251 | 18.52 | 2.65 | 0.0098 | 0.0118 | 7 | 51 | 1.27 | 0.2844 |
| <i>location</i> | 1 | 251 | 0.07 | 0.07 | 0.7923 | 0.7925 | 1 | 51 | 2.94 | 0.0922 |
| <i>Depth</i> | 1 | 251 | 15.70 | 15.70 | <.0001 | <.0001 | 1 | 51 | 0.40 | 0.5292 |
| <i>Effort_h_</i> | 1 | 251 | 6.92 | 6.92 | 0.0085 | 0.0091 | 1 | 51 | 2.88 | 0.0960 |
| <i>Tempsur</i> | 1 | 251 | 0.64 | 0.64 | 0.4227 | 0.4234 | 1 | 51 | 0.34 | 0.5644 |
| <i>Tempbot</i> | 1 | 251 | 4.63 | 4.63 | 0.0314 | 0.0323 | 1 | 51 | 3.43 | 0.0698 |
| <i>Salsur</i> | 1 | 251 | 6.92 | 6.92 | 0.0085 | 0.0091 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 251 | 2.75 | 2.75 | 0.0972 | 0.0984 | 1 | 51 | 1.63 | 0.2068 |
| <i>DObot</i> | 1 | 251 | 1.19 | 1.19 | 0.2748 | 0.2758 | 1 | 51 | 1.39 | 0.2441 |
| <i>Monthly_R</i> | 1 | 251 | 0.05 | 0.05 | 0.8270 | 0.8272 | 1 | 51 | 0.63 | 0.4324 |

| <i>Binomial Submodel Type 3 Tests (AIC 1467.4)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 224.3)</i> | | | |
|--|------------|------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Model Run #2</i> | <i>Num</i> | <i>Den</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>DOsur</i> | 1 | 251 | 0.71 | 0.71 | 0.4000 | 0.4008 | 1 | 51 | 1.12 | 0.2949 |
| <i>Set_Time</i> | 1 | 251 | 0.31 | 0.31 | 0.5772 | 0.5777 | 1 | 51 | 0.32 | 0.5721 |
| <i>Salbot</i> | | | | | Dropped | | 1 | 51 | 0.07 | 0.7957 |

| <i>Binomial Submodel Type 3 Tests (AIC 1463.0)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 220.7)</i> | | | |
|--|------------|------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Model Run #3</i> | <i>Num</i> | <i>Den</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 252 | 28.15 | 2.35 | 0.0053 | 0.0072 | 12 | 52 | 0.95 | 0.5052 |
| <i>Month</i> | 7 | 252 | 20.78 | 2.97 | 0.0041 | 0.0052 | 7 | 52 | 1.29 | 0.2760 |
| <i>location</i> | 1 | 252 | 0.06 | 0.06 | 0.8042 | 0.8044 | 1 | 52 | 3.30 | 0.0751 |
| <i>Depth</i> | 1 | 252 | 15.75 | 15.75 | <.0001 | <.0001 | 1 | 52 | 0.48 | 0.4914 |
| <i>Effort_h_</i> | 1 | 252 | 7.05 | 7.05 | 0.0079 | 0.0084 | 1 | 52 | 2.98 | 0.0902 |
| <i>Tempsur</i> | 1 | 252 | 0.64 | 0.64 | 0.4223 | 0.4231 | 1 | 52 | 0.28 | 0.5960 |
| <i>Tempbot</i> | 1 | 252 | 4.73 | 4.73 | 0.0297 | 0.0306 | 1 | 52 | 4.43 | 0.0401 |
| <i>Salsur</i> | 1 | 252 | 8.23 | 8.23 | 0.0041 | 0.0045 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 252 | 3.47 | 3.47 | 0.0626 | 0.0638 | 1 | 52 | 1.60 | 0.2109 |
| <i>DObot</i> | 1 | 252 | 1.18 | 1.18 | 0.2779 | 0.2790 | 1 | 52 | 1.53 | 0.2211 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 52 | 0.72 | 0.3998 |
| <i>DOsur</i> | 1 | 252 | 0.70 | 0.70 | 0.4016 | 0.4024 | 1 | 52 | 1.08 | 0.3031 |
| <i>Set_Time</i> | 1 | 252 | 0.32 | 0.32 | 0.5724 | 0.5729 | 1 | 52 | 0.30 | 0.5884 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Binomial Submodel Type 3 Tests (AIC 1462.3)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 218.0)</i> | | | |
|--|------------|------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Model Run #4</i> | <i>Num</i> | <i>Den</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 253 | 28.59 | 2.38 | 0.0045 | 0.0063 | 12 | 53 | 0.94 | 0.5116 |
| <i>Month</i> | 7 | 253 | 21.72 | 3.10 | 0.0028 | 0.0037 | 7 | 53 | 1.30 | 0.2698 |
| <i>location</i> | | | | | Dropped | | 1 | 53 | 3.39 | 0.0711 |
| <i>Depth</i> | 1 | 253 | 15.75 | 15.75 | <.0001 | <.0001 | 1 | 53 | 0.49 | 0.4878 |
| <i>Effort_h_</i> | 1 | 253 | 7.12 | 7.12 | 0.0076 | 0.0081 | 1 | 53 | 2.80 | 0.0999 |
| <i>Tempsur</i> | 1 | 253 | 0.65 | 0.65 | 0.4211 | 0.4219 | | | Dropped | |
| <i>Tempbot</i> | 1 | 253 | 4.88 | 4.88 | 0.0272 | 0.0281 | 1 | 53 | 4.48 | 0.0391 |

| Model Run #4 | Binomial Submodel Type 3 Tests (AIC 1462.3) | | | | | | Lognormal Submodel Type 3 Tests (AIC 218.0) | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Salsur</i> | 1 | 253 | 9.07 | 9.07 | 0.0026 | 0.0029 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 253 | 3.47 | 3.47 | 0.0624 | 0.0636 | 1 | 53 | 1.46 | 0.2322 |
| <i>DObot</i> | 1 | 253 | 1.19 | 1.19 | 0.2761 | 0.2771 | 1 | 53 | 1.36 | 0.2490 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 53 | 0.66 | 0.4192 |
| <i>DOsur</i> | 1 | 253 | 0.71 | 0.71 | 0.3998 | 0.4006 | 1 | 53 | 0.96 | 0.3325 |
| <i>Set_Time</i> | 1 | 253 | 0.34 | 0.34 | 0.5577 | 0.5582 | 1 | 53 | 0.24 | 0.6227 |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| Model Run #5 | Binomial Submodel Type 3 Tests (AIC 1457.6) | | | | | | Lognormal Submodel Type 3 Tests (AIC 215.0) | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 254 | 30.32 | 2.53 | 0.0025 | 0.0037 | 12 | 54 | 1.10 | 0.3786 |
| <i>Month</i> | 7 | 254 | 21.83 | 3.12 | 0.0027 | 0.0036 | 7 | 54 | 1.30 | 0.2665 |
| <i>location</i> | | | | | Dropped | | 1 | 54 | 3.65 | 0.0615 |
| <i>Depth</i> | 1 | 254 | 15.89 | 15.89 | <.0001 | <.0001 | 1 | 54 | 0.49 | 0.4857 |
| <i>Effort_h_</i> | 1 | 254 | 6.92 | 6.92 | 0.0085 | 0.0090 | 1 | 54 | 4.25 | 0.0442 |
| <i>Tempsur</i> | 1 | 254 | 0.90 | 0.90 | 0.3428 | 0.3437 | | | Dropped | |
| <i>Tempbot</i> | 1 | 254 | 4.71 | 4.71 | 0.0300 | 0.0309 | 1 | 54 | 4.38 | 0.0410 |
| <i>Salsur</i> | 1 | 254 | 8.83 | 8.83 | 0.0030 | 0.0032 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 254 | 3.63 | 3.63 | 0.0569 | 0.0580 | 1 | 54 | 1.93 | 0.1706 |
| <i>DObot</i> | 1 | 254 | 1.15 | 1.15 | 0.2839 | 0.2849 | 1 | 54 | 1.64 | 0.2064 |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 54 | 1.09 | 0.3017 |
| <i>DOsur</i> | 1 | 254 | 0.77 | 0.77 | 0.3817 | 0.3825 | 1 | 54 | 1.12 | 0.2944 |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| Model Run #6 | Binomial Submodel Type 3 Tests (AIC 1447.2) | | | | | | Lognormal Submodel Type 3 Tests (AIC 213.0) | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 255 | 30.20 | 2.52 | 0.0026 | 0.0038 | 12 | 55 | 1.10 | 0.3816 |
| <i>Month</i> | 7 | 255 | 21.81 | 3.12 | 0.0027 | 0.0036 | 7 | 55 | 1.28 | 0.2764 |
| <i>location</i> | | | | | Dropped | | 1 | 55 | 3.72 | 0.0589 |

| Model Run #6 | <i>Binomial Submodel Type 3 Tests (AIC 1447.2)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 213.0)</i> | | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|--|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> | |
| <i>Depth</i> | 1 | 255 | 17.57 | 17.57 | <.0001 | <.0001 | | | | Dropped | |
| <i>Effort_h_</i> | 1 | 255 | 7.08 | 7.08 | 0.0078 | 0.0083 | 1 | 55 | 4.70 | 0.0345 | |
| <i>Tempsur</i> | 1 | 255 | 1.11 | 1.11 | 0.2928 | 0.2938 | | | | Dropped | |
| <i>Tempbot</i> | 1 | 255 | 4.21 | 4.21 | 0.0402 | 0.0412 | 1 | 55 | 3.94 | 0.0522 | |
| <i>Salsur</i> | 1 | 255 | 8.25 | 8.25 | 0.0041 | 0.0044 | | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 255 | 3.29 | 3.29 | 0.0696 | 0.0708 | 1 | 55 | 2.36 | 0.1300 | |
| <i>DObot</i> | 1 | 255 | 0.71 | 0.71 | 0.3986 | 0.3994 | 1 | 55 | 2.73 | 0.1040 | |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 55 | 1.22 | 0.2735 | |
| <i>DOsur</i> | | | | | Dropped | | 1 | 55 | 1.58 | 0.2142 | |
| <i>Set_Time</i> | | | | | Dropped | | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | | Dropped | |

| Model Run #7 | <i>Binomial Submodel Type 3 Tests (AIC 1441.9)</i> | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 224.0)</i> | | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|--|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> | |
| <i>Year</i> | 12 | 256 | 30.36 | 2.53 | 0.0025 | 0.0036 | 12 | 62 | 0.90 | 0.5543 | |
| <i>Month</i> | 7 | 256 | 21.89 | 3.13 | 0.0027 | 0.0035 | | | | Dropped | |
| <i>location</i> | | | | | Dropped | | 1 | 62 | 4.61 | 0.0357 | |
| <i>Depth</i> | 1 | 256 | 20.54 | 20.54 | <.0001 | <.0001 | | | | Dropped | |
| <i>Effort_h_</i> | 1 | 256 | 6.86 | 6.86 | 0.0088 | 0.0094 | 1 | 62 | 2.13 | 0.1494 | |
| <i>Tempsur</i> | 1 | 256 | 1.47 | 1.47 | 0.2255 | 0.2267 | | | | Dropped | |
| <i>Tempbot</i> | 1 | 256 | 3.97 | 3.97 | 0.0464 | 0.0475 | 1 | 62 | 8.03 | 0.0062 | |
| <i>Salsur</i> | 1 | 256 | 8.68 | 8.68 | 0.0032 | 0.0035 | | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 256 | 3.57 | 3.57 | 0.0589 | 0.0600 | 1 | 62 | 3.65 | 0.0608 | |
| <i>DObot</i> | | | | | Dropped | | 1 | 62 | 1.75 | 0.1912 | |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 62 | 1.85 | 0.1788 | |
| <i>DOsur</i> | | | | | Dropped | | 1 | 62 | 0.79 | 0.3779 | |
| <i>Set_Time</i> | | | | | Dropped | | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | | Dropped | |

| Model Run #8 | Binomial Submodel Type 3 Tests (AIC 1441.9) | | | | | | Lognormal Submodel Type 3 Tests (AIC 222.5) | | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|--|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> | |
| <i>Year</i> | 12 | 257 | 29.61 | 2.47 | 0.0032 | 0.0046 | 12 | 63 | 0.84 | 0.6055 | |
| <i>Month</i> | 7 | 257 | 21.06 | 3.01 | 0.0037 | 0.0047 | | | Dropped | | |
| <i>location</i> | | | | | Dropped | | 1 | 63 | 5.03 | 0.0285 | |
| <i>Depth</i> | 1 | 257 | 23.11 | 23.11 | <.0001 | <.0001 | | | Dropped | | |
| <i>Effort_h_</i> | 1 | 257 | 6.22 | 6.22 | 0.0126 | 0.0133 | 1 | 63 | 1.65 | 0.2035 | |
| <i>Tempsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Tempbot</i> | 1 | 257 | 13.50 | 13.50 | 0.0002 | 0.0003 | 1 | 63 | 7.41 | 0.0084 | |
| <i>Salsur</i> | 1 | 257 | 7.68 | 7.68 | 0.0056 | 0.0060 | | | Dropped | | |
| <i>Prev_Mon_R</i> | 1 | 257 | 3.47 | 3.47 | 0.0625 | 0.0636 | 1 | 63 | 3.52 | 0.0653 | |
| <i>DObot</i> | | | | | Dropped | | 1 | 63 | 1.20 | 0.2765 | |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 63 | 1.59 | 0.2125 | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | | |

| Model Run #9 | Binomial Submodel Type 3 Tests (AIC 1441.9) | | | | | | Lognormal Submodel Type 3 Tests (AIC 220.5) | | | | |
|---------------------|--|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|--|
| | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> | |
| <i>Year</i> | 12 | 258 | 28.19 | 2.35 | 0.0052 | 0.0071 | 12 | 64 | 0.86 | 0.5925 | |
| <i>Month</i> | 7 | 258 | 18.98 | 2.71 | 0.0082 | 0.0099 | | | Dropped | | |
| <i>location</i> | | | | | Dropped | | 1 | 64 | 4.70 | 0.0339 | |
| <i>Depth</i> | 1 | 258 | 22.42 | 22.42 | <.0001 | <.0001 | | | Dropped | | |
| <i>Effort_h_</i> | 1 | 258 | 5.11 | 5.11 | 0.0238 | 0.0247 | 1 | 64 | 1.72 | 0.1939 | |
| <i>Tempsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Tempbot</i> | 1 | 258 | 12.75 | 12.75 | 0.0004 | 0.0004 | 1 | 64 | 10.05 | 0.0023 | |
| <i>Salsur</i> | 1 | 258 | 7.81 | 7.81 | 0.0052 | 0.0056 | | | Dropped | | |
| <i>Prev_Mon_R</i> | 1 | 257 | 3.47 | 3.47 | 0.0625 | 0.0636 | 1 | 64 | 3.34 | 0.0723 | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | | |
| <i>Monthly_R</i> | | | | | Dropped | | 1 | 64 | 0.93 | 0.3376 | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | | |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | | |

| <i>Model Run #10 Binomial Submodel Type 3 Tests (AIC 1441.9)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 216.9)</i> | | | |
|--|---------------|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 258 | 28.19 | 2.35 | 0.0052 | 0.0071 | 12 | 65 | 0.79 | 0.6576 |
| <i>Month</i> | 7 | 258 | 18.98 | 2.71 | 0.0082 | 0.0099 | | | Dropped | |
| <i>location</i> | | | | | Dropped | | 1 | 65 | 4.61 | 0.0356 |
| <i>Depth</i> | 1 | 258 | 22.42 | 22.42 | <.0001 | <.0001 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 258 | 5.11 | 5.11 | 0.0238 | 0.0247 | 1 | 65 | 1.32 | 0.2546 |
| <i>Tempsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Tempbot</i> | 1 | 258 | 12.75 | 12.75 | 0.0004 | 0.0004 | 1 | 65 | 9.13 | 0.0036 |
| <i>Salsur</i> | 1 | 258 | 7.81 | 7.81 | 0.0052 | 0.0056 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 257 | 3.47 | 3.47 | 0.0625 | 0.0636 | 1 | 65 | 2.75 | 0.1022 |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #11 Binomial Submodel Type 3 Tests (AIC 1441.9)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 216.5)</i> | | | |
|--|---------------|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 258 | 28.19 | 2.35 | 0.0052 | 0.0071 | 12 | 66 | 0.72 | 0.7245 |
| <i>Month</i> | 7 | 258 | 18.98 | 2.71 | 0.0082 | 0.0099 | | | Dropped | |
| <i>location</i> | | | | | Dropped | | 1 | 66 | 5.74 | 0.0194 |
| <i>Depth</i> | 1 | 258 | 22.42 | 22.42 | <.0001 | <.0001 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 258 | 5.11 | 5.11 | 0.0238 | 0.0247 | | | Dropped | |
| <i>Tempsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Tempbot</i> | 1 | 258 | 12.75 | 12.75 | 0.0004 | 0.0004 | 1 | 66 | 9.08 | 0.0037 |
| <i>Salsur</i> | 1 | 258 | 7.81 | 7.81 | 0.0052 | 0.0056 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 257 | 3.47 | 3.47 | 0.0625 | 0.0636 | 1 | 66 | 1.96 | 0.1663 |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

| <i>Model Run #11 Binomial Submodel Type 3 Tests (AIC 1441.9)</i> | | | | | | | <i>Lognormal Submodel Type 3 Tests (AIC 213.3)</i> | | | |
|--|---------------|---------------|-------------------|----------------|----------------------|------------------|--|---------------|----------------|------------------|
| <i>Effect</i> | <i>Num DF</i> | <i>Den DF</i> | <i>Chi-Square</i> | <i>F Value</i> | <i>Pr > ChiSq</i> | <i>Pr > F</i> | <i>Num DF</i> | <i>Den DF</i> | <i>F Value</i> | <i>Pr > F</i> |
| <i>Year</i> | 12 | 258 | 28.19 | 2.35 | 0.0052 | 0.0071 | 12 | 67 | 0.64 | 0.7967 |
| <i>Month</i> | 7 | 258 | 18.98 | 2.71 | 0.0082 | 0.0099 | | | Dropped | |
| <i>location</i> | | | | | Dropped | | 1 | 67 | 6.09 | 0.0161 |
| <i>Depth</i> | 1 | 258 | 22.42 | 22.42 | <.0001 | <.0001 | | | Dropped | |
| <i>Effort_h_</i> | 1 | 258 | 5.11 | 5.11 | 0.0238 | 0.0247 | | | Dropped | |
| <i>Tempsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Tempbot</i> | 1 | 258 | 12.75 | 12.75 | 0.0004 | 0.0004 | 1 | 67 | 8.05 | 0.0060 |
| <i>Salsur</i> | 1 | 258 | 7.81 | 7.81 | 0.0052 | 0.0056 | | | Dropped | |
| <i>Prev_Mon_R</i> | 1 | 257 | 3.47 | 3.47 | 0.0625 | 0.0636 | | | Dropped | |
| <i>DObot</i> | | | | | Dropped | | | | Dropped | |
| <i>Monthly_R</i> | | | | | Dropped | | | | Dropped | |
| <i>DOsur</i> | | | | | Dropped | | | | Dropped | |
| <i>Set_Time</i> | | | | | Dropped | | | | Dropped | |
| <i>Salbot</i> | | | | | Dropped | | | | Dropped | |

Table 7. Indices of juvenile blacktip shark catch rates from 1998 to 2011 developed using the delta-lognormal model. The nominal frequency of occurrence, the number of samples (n), the Lo Index (number per 100 GN per hour), the Lo indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

| Survey Year | Frequency | n | Lo Index | Scaled Index | CV | LCL | UCL |
|-------------|-----------|----|----------|--------------|---------|---------|---------|
| 1998 | 0.40000 | 15 | 0.23495 | 1.09858 | 0.70083 | 0.31031 | 3.88931 |
| 1999 | 0.37500 | 16 | 0.17376 | 0.81246 | 0.68854 | 0.23374 | 2.82402 |
| 2000 | 0.78571 | 14 | 1.11149 | 5.19713 | 0.31511 | 2.80875 | 9.61644 |
| 2001 | 0.40000 | 5 | 0.04573 | 0.21384 | 1.82687 | 0.01896 | 2.41112 |
| 2003 | 0.14286 | 7 | 0.03126 | 0.14618 | 2.66245 | 0.00811 | 2.63462 |
| 2004 | 0.25000 | 12 | 0.07357 | 0.34398 | 1.20511 | 0.05175 | 2.28654 |
| 2005 | 0.46154 | 13 | 0.24131 | 1.12833 | 0.81169 | 0.27196 | 4.68134 |
| 2006 | 0.20833 | 24 | 0.04088 | 0.19116 | 1.29434 | 0.02629 | 1.39007 |
| 2007 | 0.57895 | 19 | 0.27742 | 1.29717 | 0.62410 | 0.41194 | 4.08472 |
| 2008 | 0.13636 | 22 | 0.08121 | 0.37971 | 1.19124 | 0.05795 | 2.48784 |
| 2009 | 0.30000 | 20 | 0.10648 | 0.49788 | 0.88835 | 0.10830 | 2.28888 |
| 2010 | 0.23729 | 59 | 0.23066 | 1.07853 | 0.52936 | 0.39913 | 2.91436 |
| 2011 | 0.14286 | 56 | 0.13154 | 0.61506 | 0.71628 | 0.16980 | 2.22781 |

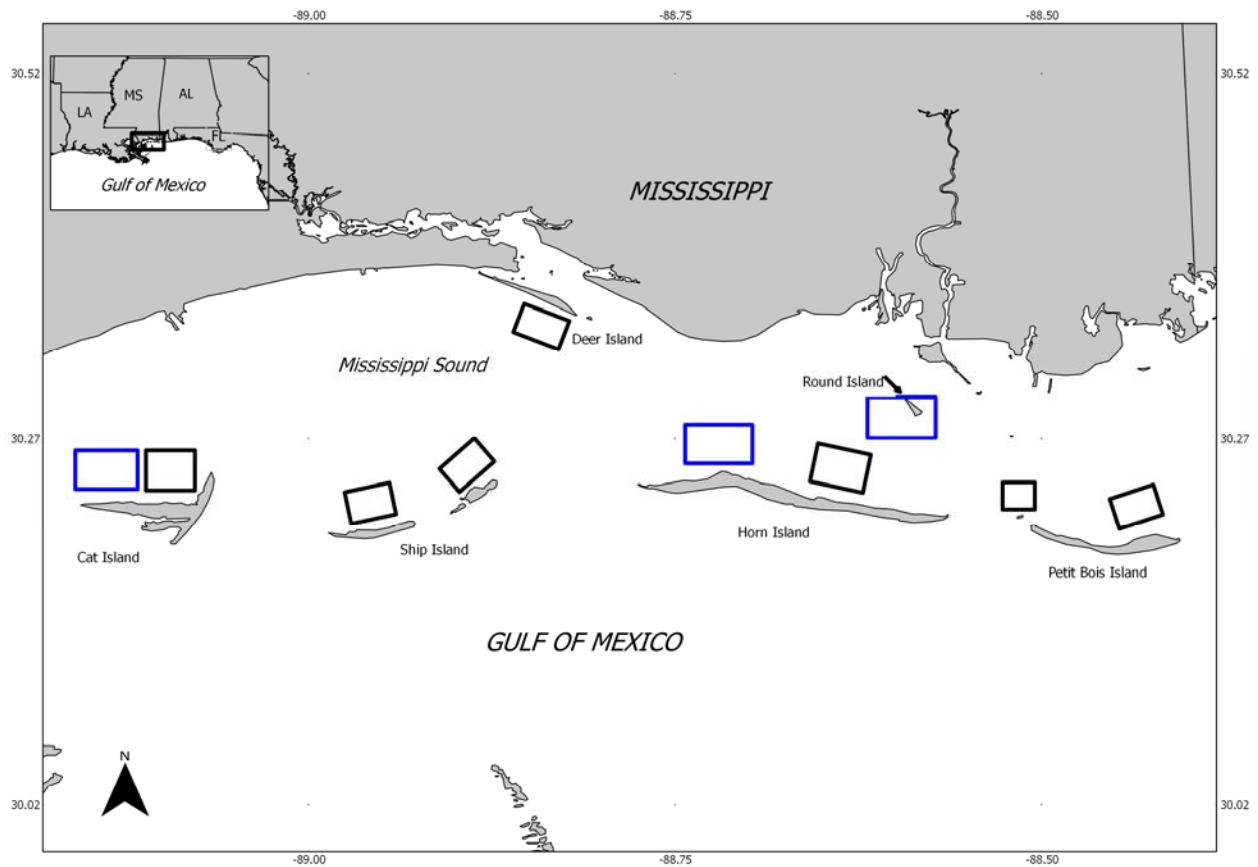


Figure 1. Sampling universe for the Mississippi gillnet survey from 1998-2011. Each rectangle represents a sampling region, from which randomly selected sampling locations were chosen. The blue rectangles represent the primary sampling regions that were sampled from 1998-2009, and the black rectangles represent the expanded sampling regions which were incorporated in 2010.

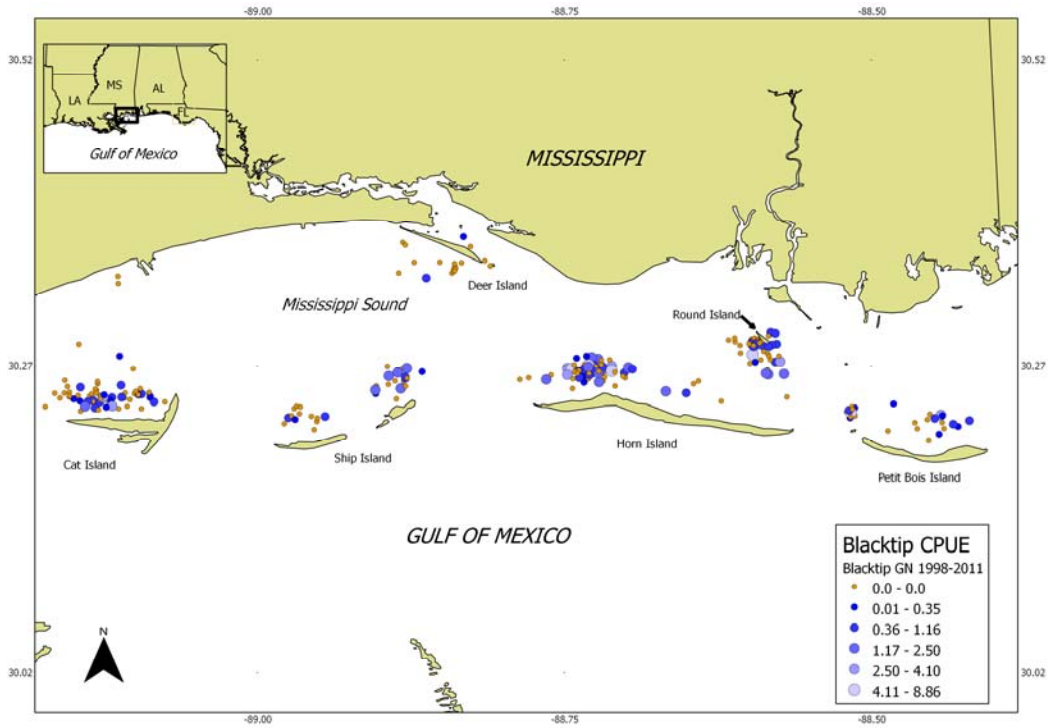


Figure 2. Stations sampled from 1998 to 2011 during the Mississippi gillnet survey with total blacktip shark CPUE presented.

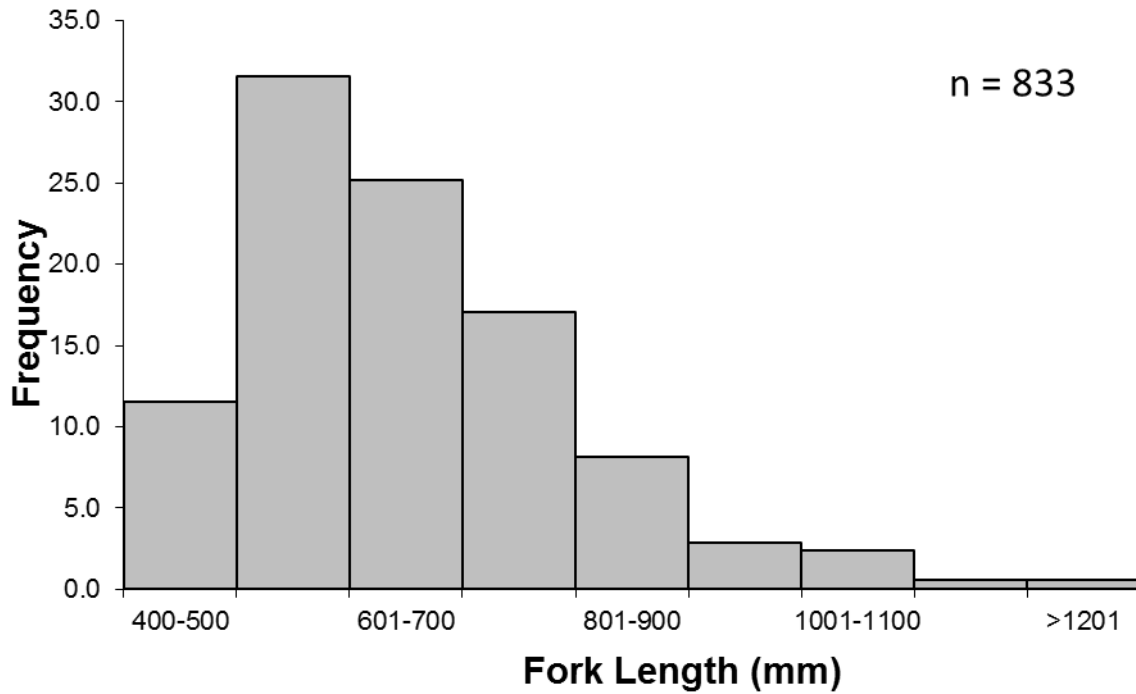
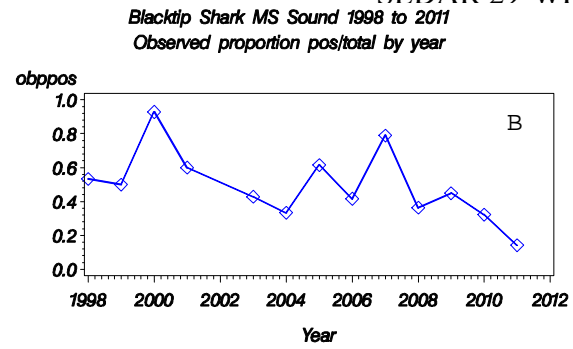
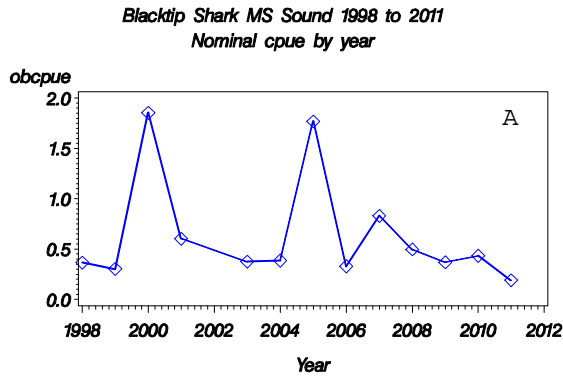
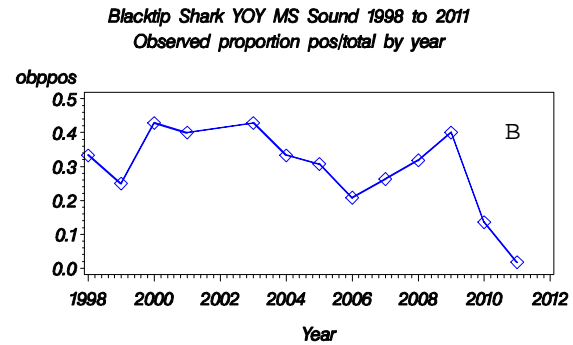
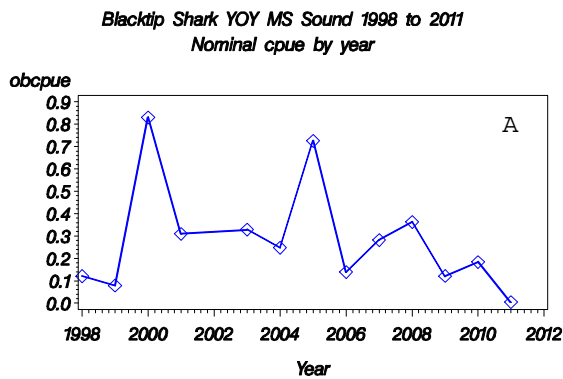


Figure 3. Length frequency distribution for blacktip sharks caught during the Mississippi gillnet survey from 1998-2011.



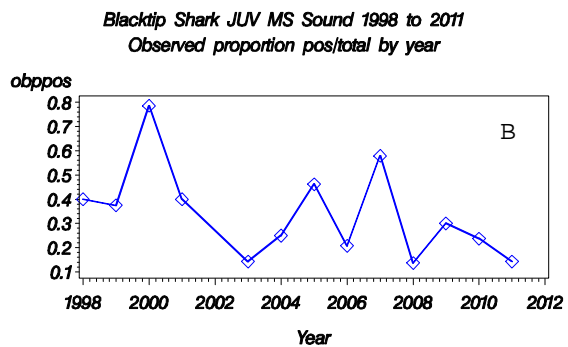
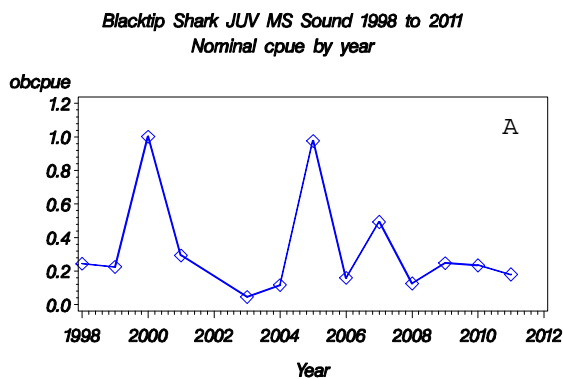
If prop pos=[1 or 0] Binomial model will not estimate a value for that year!

Figure 4. Annual trends for total blacktip sharks captured during Mississippi gillnet surveys from 1998 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.



If prop pos=[1 or 0] Binomial model will not estimate a value for that year!

Figure 5. Annual trends for YOY blacktip sharks captured during Mississippi gillnet surveys from 1998 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.



If prop pos=[1 or 0] Binomial model will not estimate a value for that year!

Figure 6. Annual trends for juvenile blacktip sharks captured during Mississippi gillnet surveys from 1998 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.

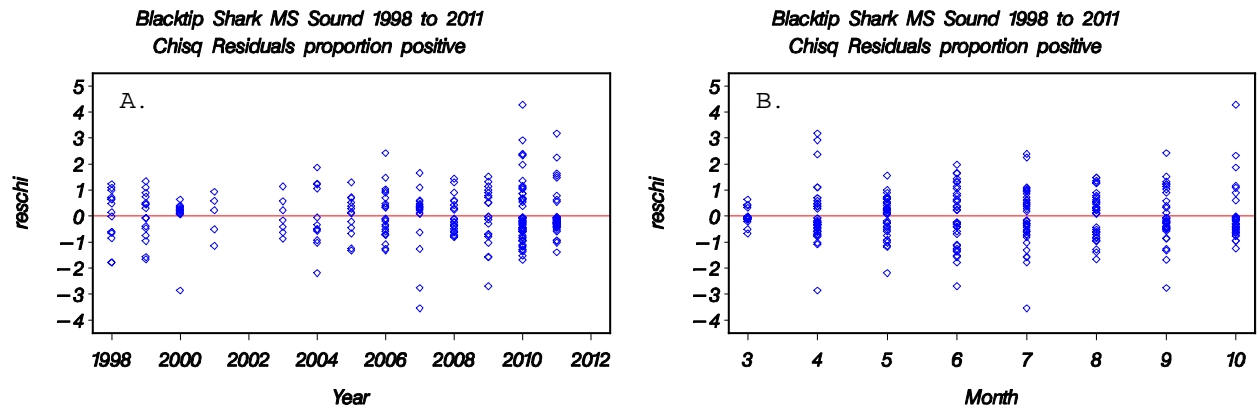


Figure 7. Diagnostic plots for the binomial component of the total blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by month.

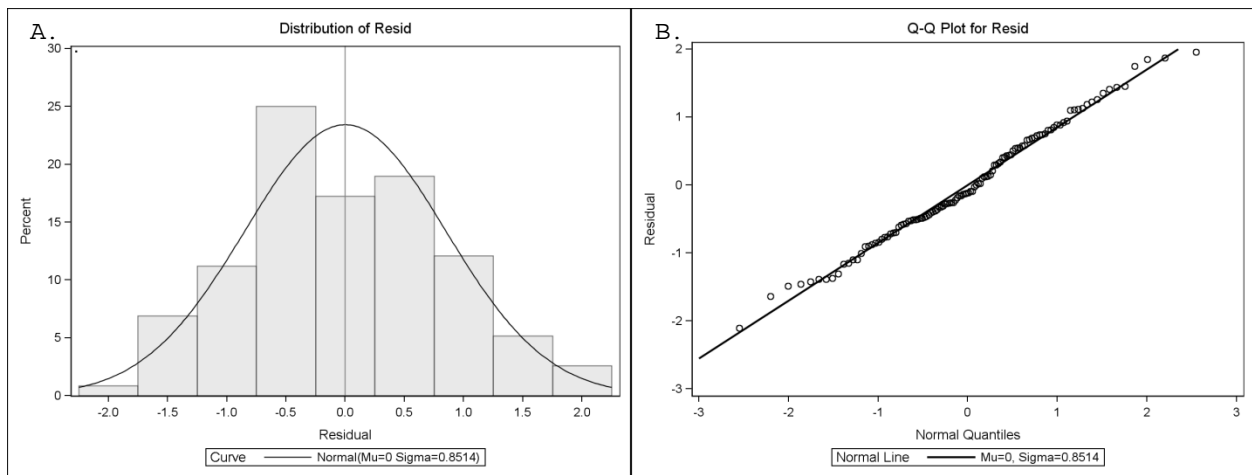


Figure 8. Diagnostic plots for the lognormal component of the total blacktip shark Mississippi gillnet survey model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

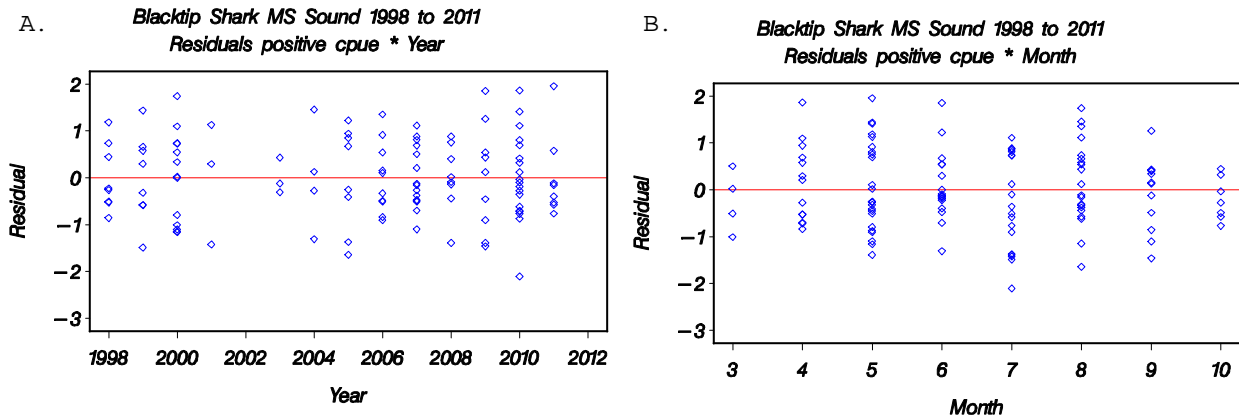


Figure 9. Diagnostic plots for the lognormal component of the total blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by month.

**Blacktip Shark MS Sound 1998 to 2011
Observed and Standardized CPUE (95% CI)**

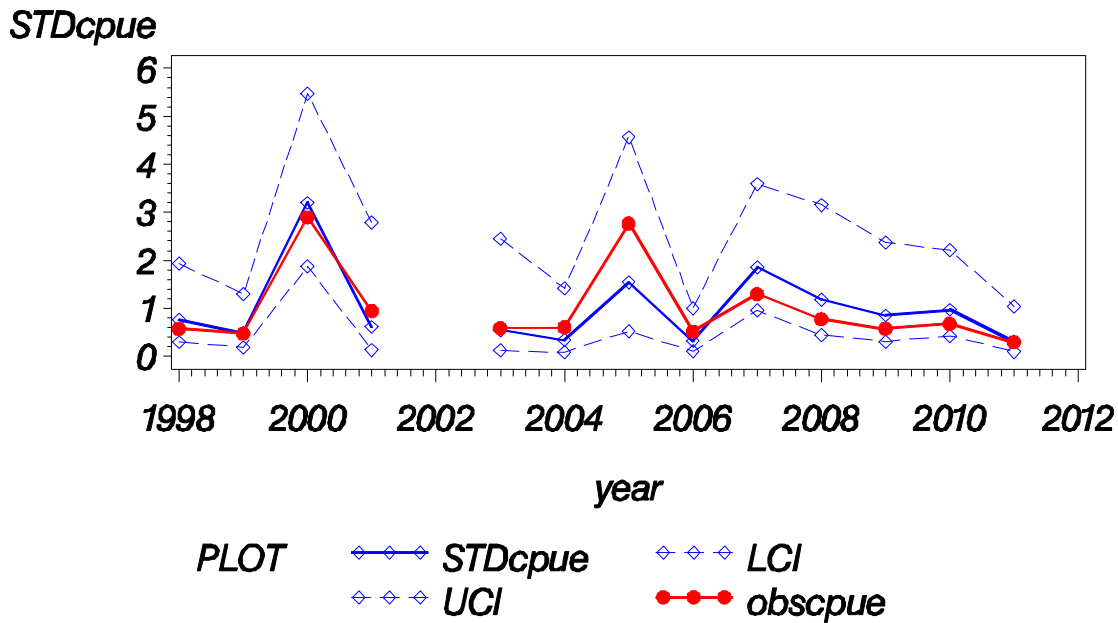


Figure 10. Observed and standardized CPUE for total blacktip shark catch in the Mississippi gillnet survey from 1998-2011.

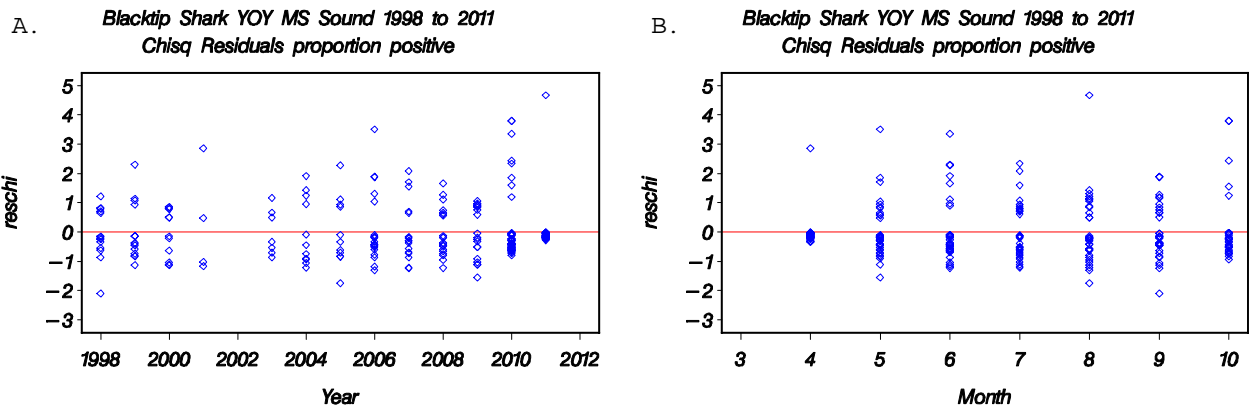


Figure 11. Diagnostic plots for the binomial component of the YOY blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, and **B.** the Chi-Square residuals by month.

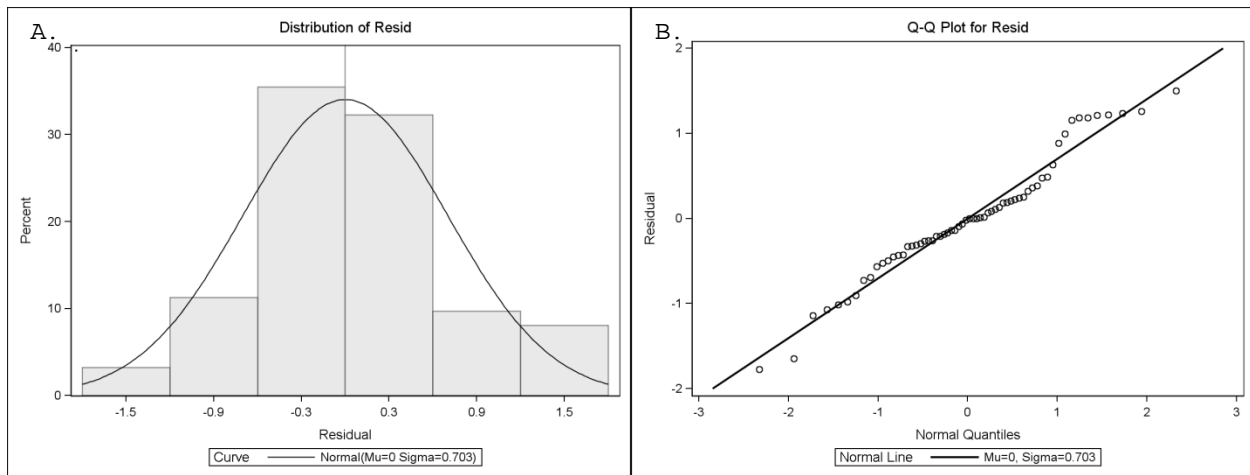


Figure 12. Diagnostic plots for the lognormal component of the YOY blacktip shark Mississippi gillnet survey model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

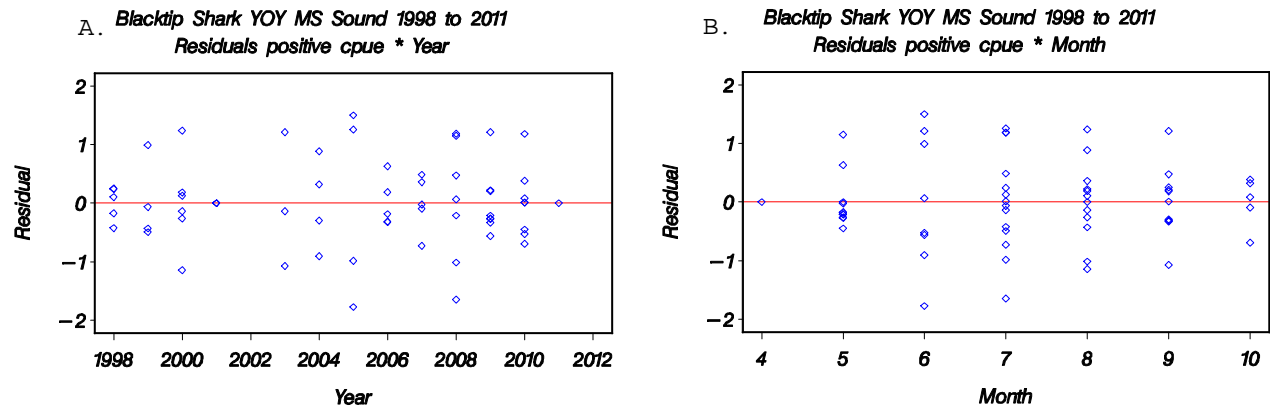


Figure 13. Diagnostic plots for the lognormal component of the YOY blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, and **B.** the Chi-Square residuals by month.

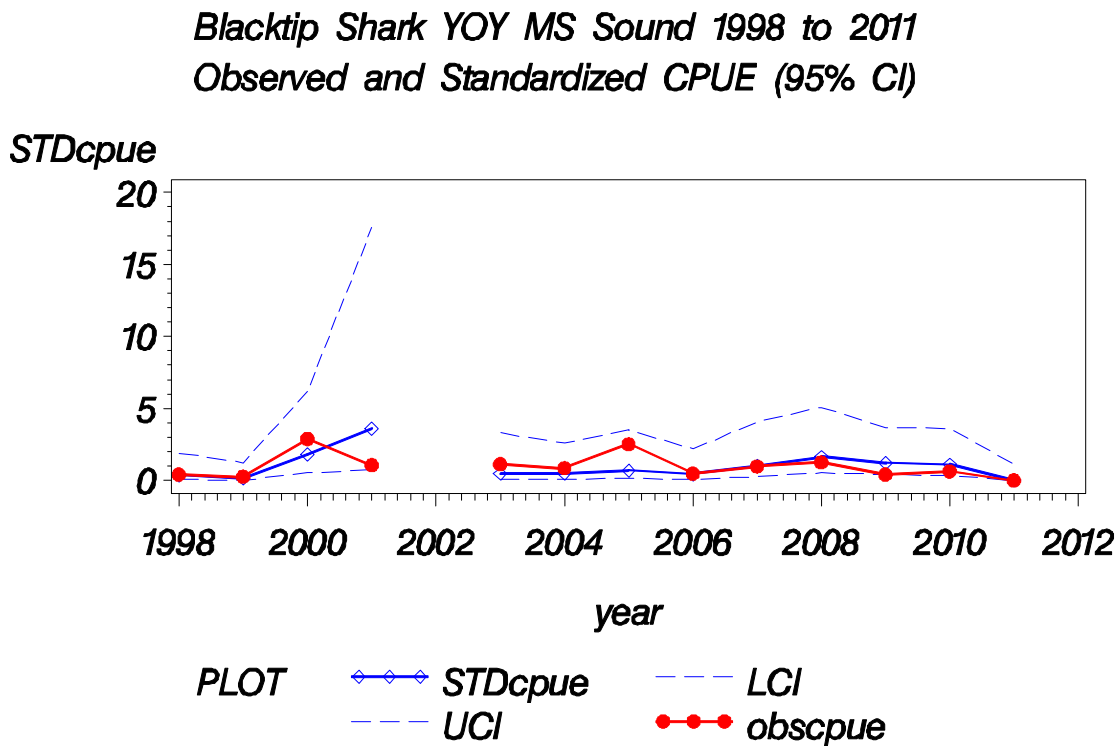


Figure 14. Observed and standardized CPUE for YOY blacktip shark catch in the Mississippi gillnet survey from 1998-2011.

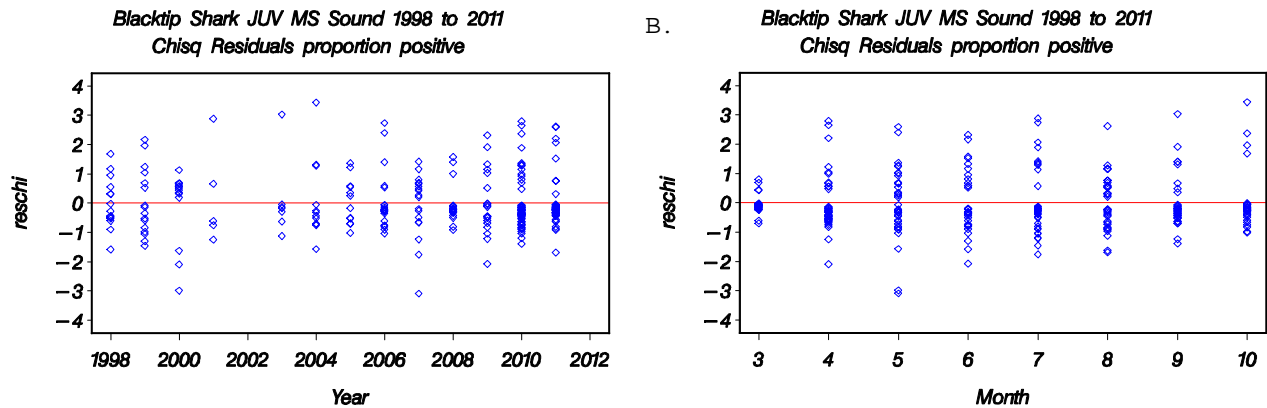


Figure 15. Diagnostic plots for the binomial component of the juvenile blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by month.

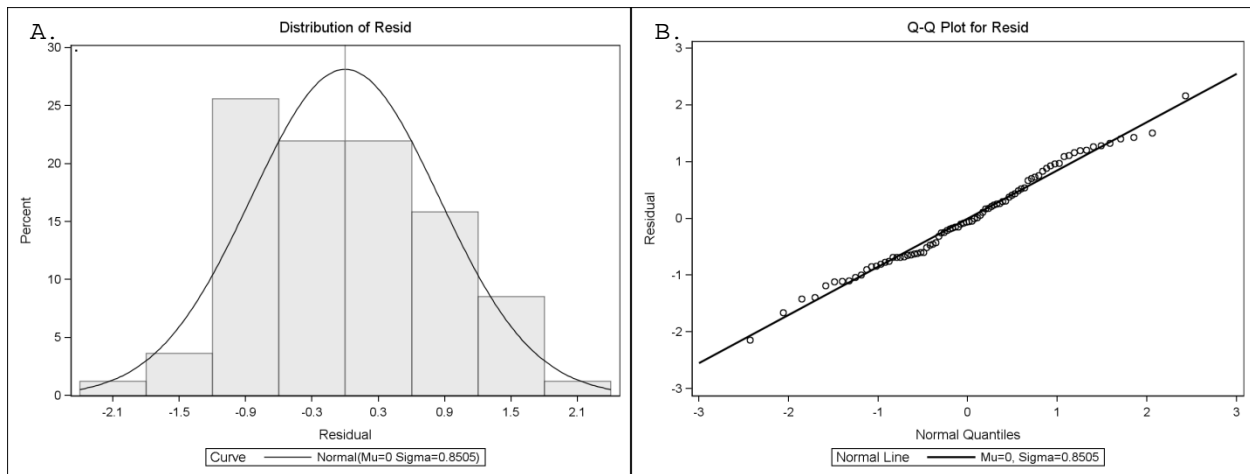


Figure 16. Diagnostic plots for the lognormal component of the juvenile blacktip shark Mississippi gillnet survey model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

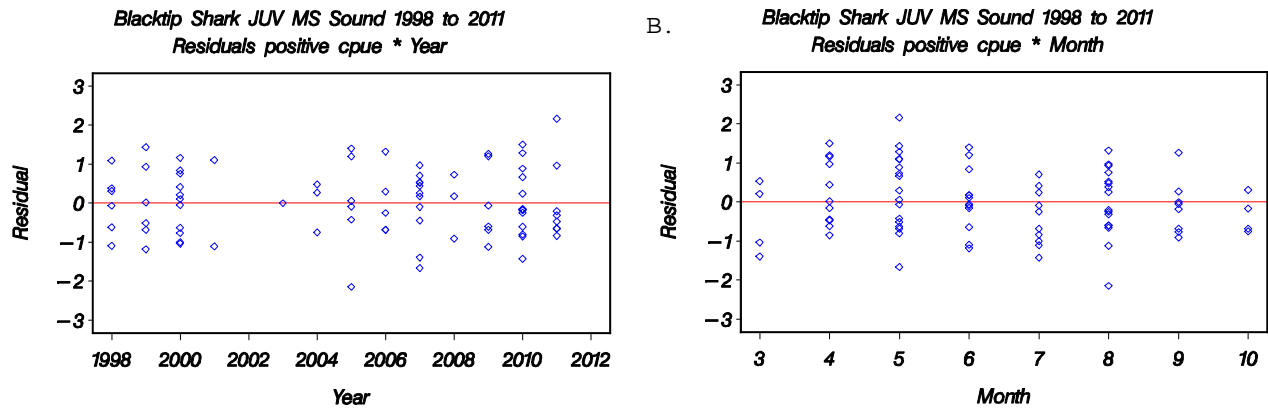


Figure 17. Diagnostic plots for the lognormal component of the juvenile blacktip shark Mississippi gillnet survey model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by month.

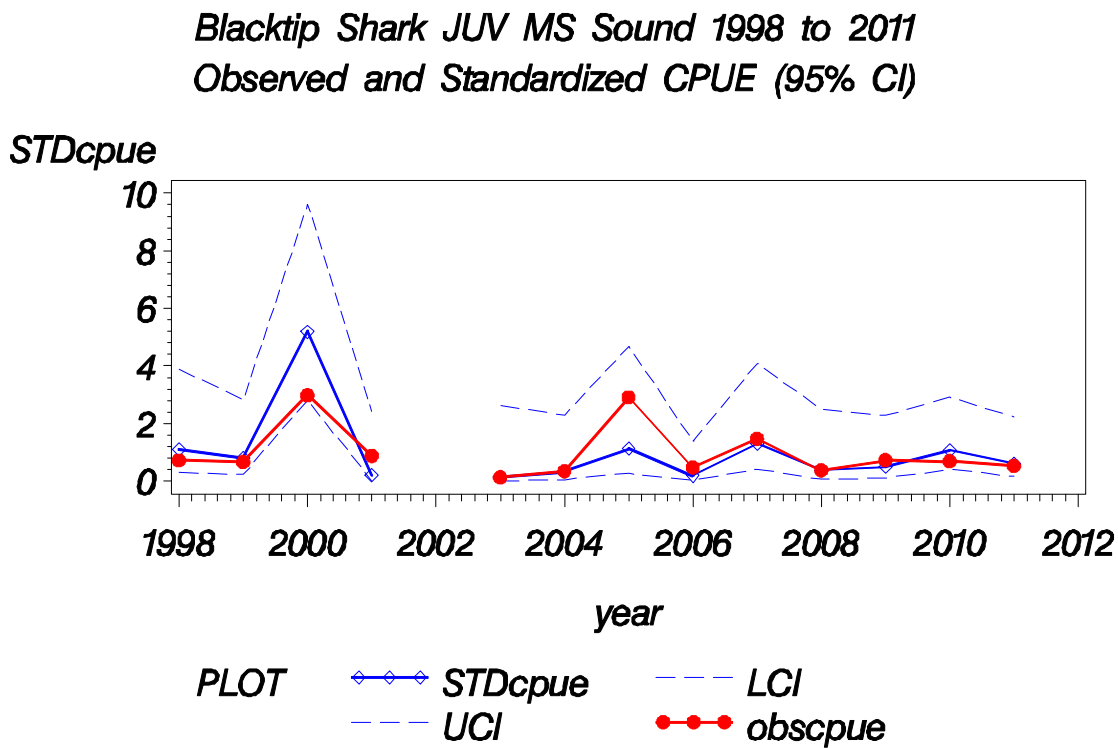


Figure 18. Observed and standardized CPUE for juvenile blacktip shark catch in the Mississippi gillnet survey from 1998-2011.

Appendix:
Annual Effort and Catch

Appendix Figure 1. Annual survey effort and catch of blacktip sharks from the Mississippi gill net survey from 1998-2011.

