# SMALL COASTAL SHARK 2007 SEDAR DATA WORKSHOP DOCUMENT

## Standardized catch rates for Atlantic sharpnose sharks *Rhizoprionodon terraenovae* from the NMFS Northeast Longline Survey

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***Summary***

This document details Atlantic sharpnose shark *Rhizoprionodon terraenovae* catch from the Northeast Fisheries Science Center (NEFSC) Coastal Shark Survey, conducted by the Apex Predators Investigation, Narragansett Laboratory, Narragansett, RI from 1996-2004. The primary objective of this survey is to conduct a standardized, systematic survey of the shark populations off the US Atlantic coast to provide unbiased indices of the relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. It also provides an opportunity to tag sharks as part of the NEFSC Cooperative Shark Tagging Program and to collect biological samples and data used in analyses of life history characteristics (age, growth, reproductive biology, trophic ecology, etc.) and other research of sharks in US coastal waters. Data from this survey were used to look at the trends in relative abundance of Atlantic sharpnose sharks in the waters off the east coast the United States. Atlantic sharpnose shark catch per unit effort (CPUE) by set in number of sharks/(hooks*soak time) were examined for each year of the bottom longline survey, 1996, 1998, 2001 and 2004. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch. Nominal and standardized CPUE results from this survey indicate an increasing trend in Atlantic sharpnose shark relative abundance across the survey years.

***Methods***

**Sampling Gear and Data Collection**

The NEFSC Coastal Shark Survey (1996-2004) covers the US continental shelf waters from Key West, FL to Delaware in depths of 5-40 fm (30-80 m). The survey utilizes a fixed station design with stations generally located approximately 30 nm apart except where the continental shelf narrows off Cape Hatteras, NC (Fig. 1). Standard sampling gear consisting of a 300 hook 'Florida' commercial style bottom longline. This gear consists of a 940 lb test monofilament mainline with 12 foot (3.6 m) gangions composed of 730 lb test monofilament with a longline clip at one end and a 3/0 shark hook at the other. Gangions (referred to hereafter simply as 'hooks') baited with chunks of spiny dogfish are attached to the mainline at 60-70 ft (21 m) intervals; 5 lb (2.3 kg) weights are attached every 15 hooks and a bullet float and 15 lb (6.8 kg) weights are placed at 50 hook intervals. A 20 ft (6 m) staff buoy ('high flyer') equipped with radar reflectors and flashers (at night) is attached to a poly ('tag') buoy by a 12 ft (3.6 m) line. The poly buoy is then attached to the mainline and there is a set of these to mark each end of the mainline.

To ensure that the gear fishes on the bottom, 20 lb (9.1 kg) weights are placed at the beginning and end of the mainline after a length of line 2-3 times the water depth is deployed.

Once set, the gear is fished for three hours with approximately six hours from start of setting to completion of haulback. The mainline covers from 2.0 to 5.5 nm with an average of 3.7 nm. Fishing takes place at all times of the day. Number of sets completed per day varies from one to three with an average of 2.5 sets per day. The number of sets is dependent on distance between stations, weather conditions, and the length of time to complete previous sets during the day.

Data is recorded at the beginning and end of each set and haul, when available these data consist of: number of hooks, time, location, surface temperature, depth, air temperature, wind direction and strength, and sea state. During all surveys catch data recorded at each station include, at a minimum: species, sex and length (estimated or measured).

**Data Analysis**

Atlantic sharpnose CPUE for each set is defined as the number of sharks/(hooks*soak time). The CPUE was standardized using the Lo et al. (2002) method, which models the proportion of positive sets separately from the positive catch. After initial exploratory analysis, factors considered as potential influences on Atlantic sharpnose shark CPUE were: year (1996, 1998, 2001, 2004) and area (1 = <33.8 $^{o}$ latitude, 2 = 33.8 to 35.7 $^{o}$ latitude, and 3 = > 35.7 $^{o}$ latitude). The proportion of sets with positive catch values was modeled assuming a binomial distribution with a logit link function and the positive catch sets were modeled assuming a Poisson distribution with a log link function. For the positive catch sets an offset of the natural log of the number of hooks multiplied by the soak time of the gear was used for the Poisson model.

The models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $\alpha = 0.05$ based on a Chi-Square test, and the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS

MIXED procedure (Wolfinger, SAS Institute, Inc). The factor "year" was kept in all final models, regardless of its significance, to allow for calculation of indices. The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and Poisson components.

***Results***

A total of 171 Atlantic sharpnose sharks were caught during 334 sets in the NEFSC Coastal Longline Survey conducted in 1996, 1998, 2001 and 2004 (Table 1). Of these Atlantic sharpnose sharks, 129 were measured and ranged in size from 44.5 to 86.9 cm fork length (Figure 2). The nominal and relative nominal CPUE by year is reported in Table 1.

The percentage of sets with zero Atlantic sharpnose shark catch was 81.4%. The stepwise construction of the binomial model of the probability of catching an Atlantic sharpnose shark and the Poisson model of positive Atlantic sharpnose shark catch sets is in Table 2. The final binomial model was: proportion positive Atlantic sharpnose shark sets = area + year. The final Poisson model was: positive Atlantic sharpnose shark catch = year + area. Area was not significant in the final binomial model because the northernmost area (> 35.7 $^{o}$ latitude) had zero Atlantic sharpnose shark catch, which caused the model to drop this region with a zero proportion positive catch ratio from the final binomial analysis.

The resulting relative indices of abundance based on the standardized year effects obtained from the Lo et al. method for Atlantic sharpnose sharks are reported in Table 3 and illustrated in Figure 3. Even though the factor of year was significant in the binomial model and the factors of year and area were significant in the Poisson model (Table 2), results from this study indicate that any bias associated with these factors did not significantly change the trends between the nominal and standardized data (Figures 3). Both the nominal and standardized CPUE data indicate an increasing trend in Atlantic sharpnose shark relative abundance across the survey years.

***References Cited***

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (Thunnus albacares) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

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.

Table 1. Catch, nominal CPUE abundance indices, and the nominal relative (CPUE/mean) abundance indices for Atlantic sharpnose sharks. CPUE of a set = sharks/(hooks*soak time). LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed for the nominal relative abundance indices.

**Atlantic sharpnose sharks**

| YEAR | CATCH | NOM INDEX | REL INDEX | LCL | UCL | CV | N |
|---|---|---|---|---|---|---|---|
| 1996 | 4 | 1.999E-05 | 0.059 | 0.029 | 0.088 | 0.280 | 91 |
| 1998 | 19 | 1.359E-04 | 0.399 | 0.280 | 0.518 | 1.125 | 89 |
| 2001 | 55 | 3.905E-04 | 1.147 | 0.845 | 1.450 | 2.788 | 85 |
| 2004 | 93 | 8.153E-04 | 2.395 | 1.718 | 3.072 | 5.627 | 69 |

Table 2. Results of the stepwise procedure for development of the catch rate model for Atlantic sharpnose sharks. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model. L is the log likelihood.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% | L | CHISQ | PR>CHI |
|---|---|---|---|---|---|---|---|---|
| NULL | 333 | 320.5212 | 0.9625 | | | | | |
| AREA | 331 | 288.4922 | 0.8716 | 9.4442 | 9.4442 | -144.2461 | 32.03 | <.0001 |
| YEAR | 330 | 291.0394 | 0.8819 | 8.3740 | | -145.5197 | 29.48 | <.0001 |
| AREA + YEAR | 328 | 258.2494 | 0.7873 | 18.2026 | 8.7584 | -129.1247 | 30.24 | <.0001 |

**FINAL MODEL: AREA + YEAR**

| | |
|---|---|
| **Akaike's information criterion** | 1304.6 |
| **Schwartz's Bayesian criterion** | 1308.2 |
| **(-2) Res Log likelihood** | 1302.6 |

**Type 3 Test of Fixed Effects**

| **Significance (Pr>Chi) of Type 3 test of fixed effects for each factor** | AREA | YEAR |
|---|---|---|
| | 0.1776 | <.0001 |
| **DF** | 1 | 3 |
| **CHI SQUARE** | 1.83 | 21.48 |

POSITIVE CATCHES-POISSON ERROR DISTRIBUTION

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% | L | CHISQ | PR>CHI |
|---|---|---|---|---|---|---|---|---|
| NULL | 61 | 156.0781 | 2.5587 | | | | | |
| YEAR | 58 | 127.7587 | 2.2027 | 13.9133 | 13.9133 | 14.0730 | 28.32 | <.0001 |
| AREA | 60 | 146.8476 | 2.4475 | 4.3460 | | 4.5286 | 9.23 | 0.0024 |
| YEAR + AREA | 57 | 111.214 | 1.9511 | 23.7464 | 9.8331 | 22.3454 | 16.54 | <.0001 |

**FINAL MODEL: YEAR + AREA**

| | |
|---|---|
| **Akaike's information criterion** | 174.0 |
| **Schwartz's Bayesian criterion** | 176 |
| **(-2) Res Log likelihood** | 172.0 |

**Type 3 Test of Fixed Effects**

| **Significance (Pr>Chi) of Type 3 test of fixed effects for each factor** | YEAR | AREA |
|---|---|---|
| | 0.0051 | 0.0164 |
| **DF** | 3 | 1 |
| **CHI SQUARE** | 12.80 | 5.76 |

Table 3. Relative (index/mean) standardized abundance indices for Atlantic sharpnose sharks based on the standardized year effects obtained from the Lo et al. analyses. LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed.

**Atlantic sharpnose sharks**

| YEAR | INDEX | REL INDEX | LCL | UCL | CV | N |
|---|---|---|---|---|---|---|
| 1996 | 0.002 | 0.055 | -13.463 | 13.573 | 125.124 | 91 |
| 1998 | 0.017 | 0.396 | -17.199 | 17.990 | 22.672 | 89 |
| 2001 | 0.047 | 1.065 | -17.904 | 20.034 | 9.090 | 85 |
| 2004 | 0.109 | 2.484 | -21.072 | 26.041 | 4.838 | 69 |

Figure 1. Current Survey Stations

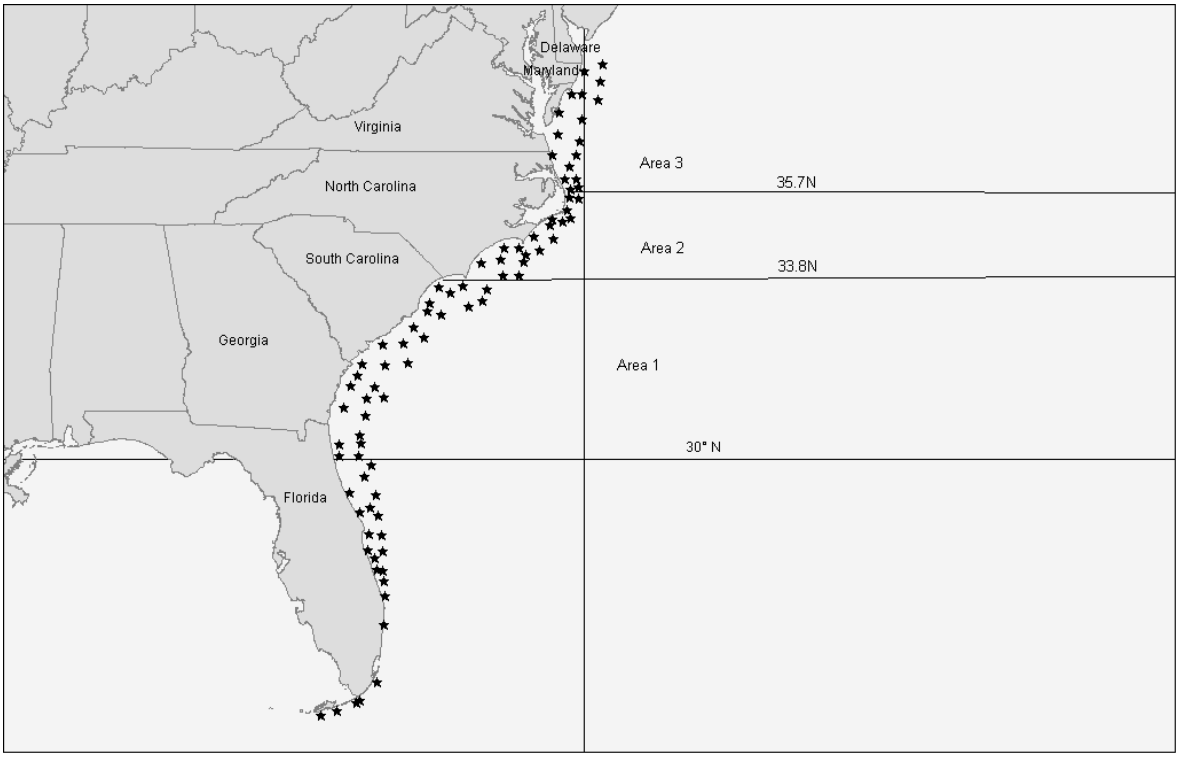


Figure 2. Length frequency of Atlantic sharpnose sharks caught and measured during the NEFSC Coastal Longline Survey (1996-2004).

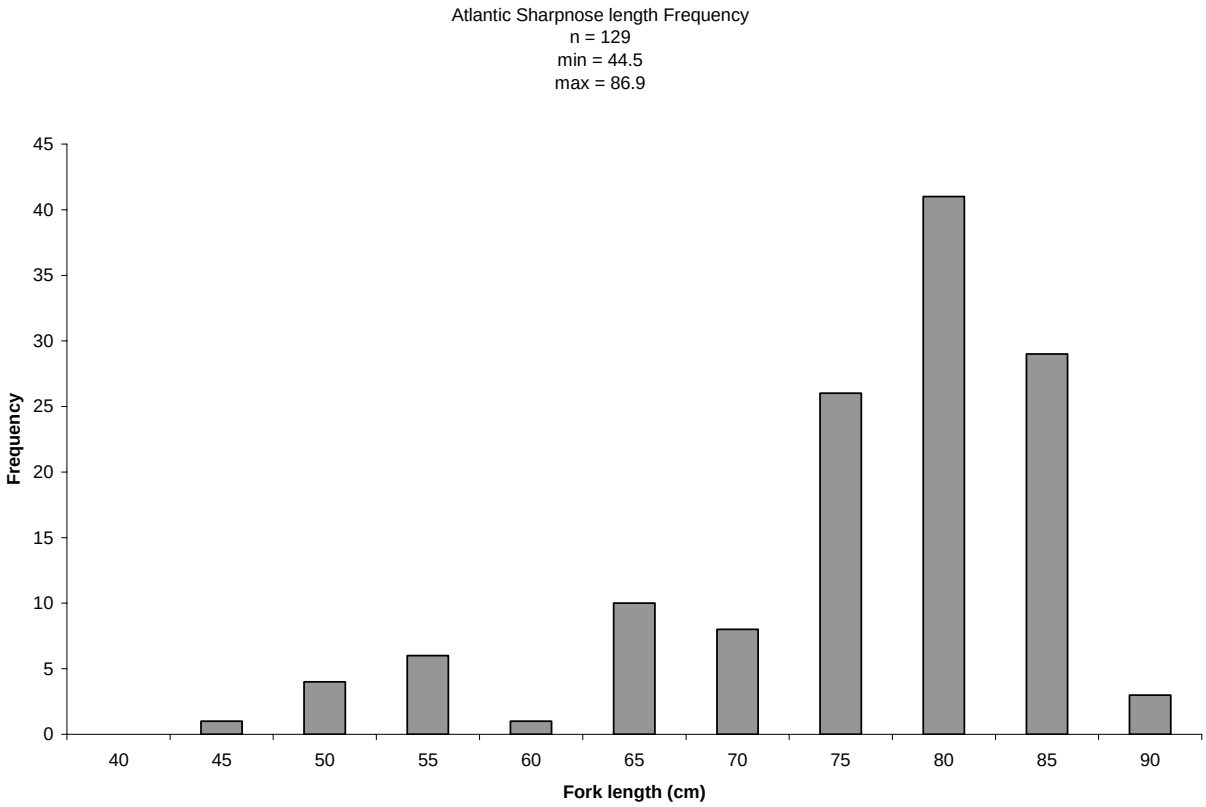
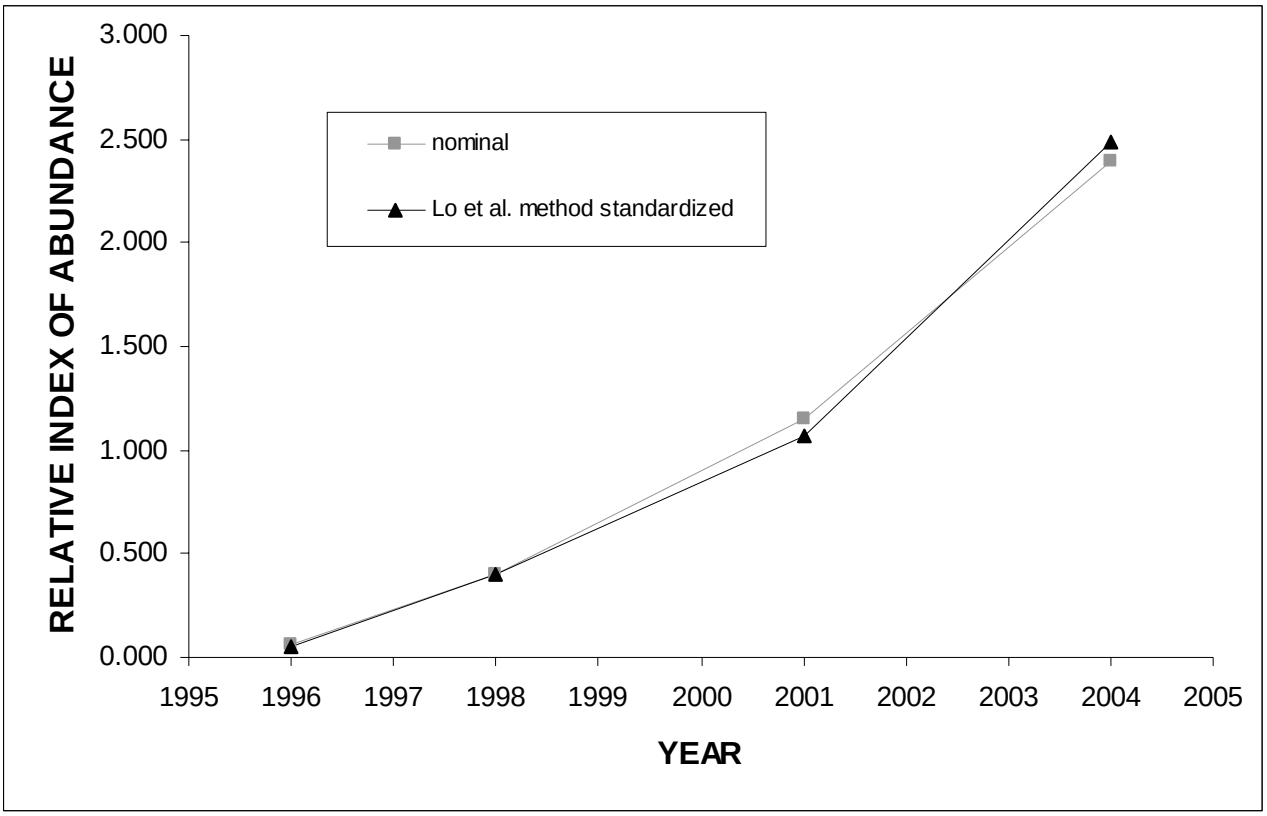


Figure 3. Relative (index/mean) indices of abundance by survey year for Atlantic sharpnose sharks.



Addendum to SEDAR 13-DW-29, by Camilla T. McCandless

After initial review of this document it was decided that the proportion positives were quite low and may have inflated the resulting CVs and that the same analysis should be run again excluding the northern area (3) to possibly improve these values. There was very little improvement after the re-analysis and it was decided not to recommend this time series for inclusion in the stock assessment. The results from this re-analysis are reported here.

Table 1. Catch, nominal CPUE abundance indices, and the nominal relative (CPUE/mean) abundance indices for Atlantic sharpnose sharks. CPUE of a set = sharks/(hooks*soak time). LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed for the nominal relative abundance indices.

**Atlantic sharpnose sharks**

| YEAR | CATCH | NOM INDEX | REL INDEX | LCL | UCL | CV | N |
|---|---|---|---|---|---|---|---|
| 1996 | 4 | 0.246E-04 | 0.059 | 0.030 | 0.089 | 0.253 | 74 |
| 1998 | 19 | 1.778E-04 | 0.428 | 0.303 | 0.554 | 1.036 | 68 |
| 2001 | 55 | 4.881E-04 | 1.176 | 0.872 | 1.480 | 2.504 | 68 |
| 2004 | 93 | 9.699E-04 | 2.336 | 1.686 | 2.987 | 4.952 | 58 |

Table 2. Relative (index/mean) standardized abundance indices for Atlantic sharpnose sharks based on the standardized year effects obtained from the Lo et al. analyses. LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed.

**Atlantic sharpnose sharks**

| YEAR | INDEX | REL INDEX | LCL | UCL | CV | N |
|---|---|---|---|---|---|---|
| 1996 | 0.002 | 0.056 | -13.607 | 13.720 | 123.969 | 74 |
| 1998 | 0.017 | 0.399 | -17.262 | 18.059 | 22.607 | 68 |
| 2001 | 0.046 | 1.063 | -17.927 | 20.053 | 9.113 | 68 |
| 2004 | 0.108 | 2.482 | -21.120 | 26.084 | 4.852 | 58 |

Table 3. Results of the stepwise procedure for development of the catch rate model for Atlantic sharpnose sharks. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model. L is the log likelihood.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% | L | CHISQ | PR>CHI |
|---|---|---|---|---|---|---|---|---|
| NULL | 267 | 289.9194 | 1.0858 | | | | | |
| YEAR | 264 | 260.2212 | 0.9857 | 9.2190 | | -130.1106 | 29.70 | <.0001 |
| AREA | 266 | 288.4922 | 1.0846 | 0.1105 | 9.4442 | -144.2461 | 1.43 | 0.2322 |

**FINAL MODEL: YEAR**

| | |
|---|---|
| **Akaike's information criterion** | 1298.3 |
| **Schwartz's Bayesian criterion** | 1301.9 |
| **(-2) Res Log likelihood** | 1296.3 |

**Type 3 Test of Fixed Effects**

| | YEAR |
|---|---|
| **Significance (Pr>Chi) of Type 3 test of fixed effects for each factor** | <.0001 |
| **DF** | 3 |
| **CHI SQUARE** | 21.38 |

POSITIVE CATCHES-POISSON ERROR DISTRIBUTION

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% | L | CHISQ | PR>CHI |
|---|---|---|---|---|---|---|---|---|
| NULL | 61 | 156.0781 | 2.5587 | | | | | |
| YEAR | 58 | 127.7587 | 2.2027 | 13.9133 | 13.9133 | 14.0730 | 28.32 | <.0001 |
| AREA | 60 | 146.8476 | 2.4475 | 4.3460 | | 4.5286 | 9.23 | 0.0024 |
| YEAR + AREA | 57 | 111.2140 | 1.9511 | 23.7464 | 9.8331 | 22.3454 | 16.54 | <.0001 |

**FINAL MODEL: YEAR + AREA**

| | |
|---|---|
| **Akaike's information criterion** | 174.0 |
| **Schwartz's Bayesian criterion** | 176.0 |
| **(-2) Res Log likelihood** | 172.0 |

**Type 3 Test of Fixed Effects**

| | YEAR | AREA |
|---|---|---|
| **Significance (Pr>Chi) of Type 3 test of fixed effects for each factor** | 0.0051 | 0.0164 |
| **DF** | 3 | 1 |
| **CHI SQUARE** | 12.80 | 5.76 |

Figure 1. Relative (index/mean) indices of abundance by survey year for Atlantic sharpnose sharks.