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Standardized catch rates of smooth dogfish from the SEAMAP-South Atlantic Shallow Water Trawl Survey

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Summary

This document presents an analysis of the relative abundance of smooth dogfish (*Mustelus canis*) from the SEAMAP-SA Shallow Water Trawl Survey for 1994-2012. Time series data from this survey were standardized with Generalized Linear Mixed Model (GLMM) procedures. The series showed an increasing trend, followed by a decreasing tendency. Examination of lengths of smooth dogfish over the time period considered revealed no trend. Length compositions revealed that mostly immature individuals of this species are caught in this survey, but adults are also present especially in males.

1. Background

The SEAMAP-South Atlantic Shallow Water Trawl Survey samples nearshore areas where commercial shrimping occurs along the southeastern coast of the U.S. between Cape Hatteras, North Carolina and Cape Canaveral, Florida (ASMFC 2000). This is the first time that data from this survey are analyzed for smooth dogfish (*Mustelus canis*). In this document, we derive an index of relative abundance for this species for the period 1994-2012 for use in the SEDAR 30 stock assessment of smoothhound sharks.

2. Materials and Methods

Data

Methodological details of the SEAMAP survey can be found in various documents that have been made available in previous SEDAR Data Workshops (SEAMAP 2000 and 2005 reports, SEAMAP methods). Briefly, cruises are conducted in spring (early April-mid-May), summer (mid-July-early August), and fall (October-mid-November) in coastal waters between Cape Hatteras, North Carolina, and Cape Canaveral, Florida. Paired trawl nets are towed for 20 minutes during daylight hours only, thus catch rates are expressed on a tow basis. The survey uses a stratified random sampling design, where the strata correspond to different latitudinal areas and depth zones. We used the following variables for this analysis: season (consisting of spring, summer, and fall), region (Florida, Georgia, South Carolina, and North Carolina), and year, as well as interactions between each pair of these factors. Although the survey started in 1989, this species was not recorded until 1994. Data were thus analyzed for the period 1994-2012.

Statistical analysis

Relative abundance indices were estimated using a Generalized Linear Model (GLM) approach assuming a delta lognormal model distribution. A binomial error distribution was used for modeling the proportion of positive sets with a logit function as link between the linear factor component and the binomial error. A lognormal error distribution was used for modeling the catch rates of successful sets, wherein estimated CPUE rates assume a lognormal distribution (lnCPUE) of a linear function of fixed factors. The models were fitted with the SAS GENMOD procedure (SAS Institute Inc. 1999) using a forward stepwise approach in which each potential factor was tested one at a time. Initially, a null model was run with no explanatory variables (factors). Factors were then entered one at a time and the results ranked from smallest to greatest reduction in deviance per degree of freedom when compared to the null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model if two conditions were met: 1) the effect of the factor was significant at least at the 5% level based on the results of a Chi-Square statistic of a Type III likelihood ratio test, and 2) the deviance per degree of freedom was reduced by at least 1% with respect to the less complex model. Single factors were incorporated first, followed by fixed first-level interactions. The year factor was always included because it is required for developing a time series. Results were summarized in the form of deviance analysis tables including the deviance for proportion of positive observations and the deviance for the positive catch rates.

Once the final model was selected, it was run using the SAS GLIMMIX macro (which itself uses iteratively re-weighted likelihoods to fit generalized linear mixed models with the SAS MIXED procedure; Wolfinger and O'Connell 1993, Littell et al. 1996). In this model, any interactions that included the year factor were treated as a random effect. Goodness-of-fit criteria for the final model included Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion, and –2* the residual log likelihood (-2Res L). The significance of each individual factor was tested with a Type III test of fixed effects, which examines the significance of an effect with all the other effects in the model (SAS Institute Inc. 1999). The final mixed model calculated relative indices as the product of the year effect least squares means (LSMeans) from the binomial and lognormal components. LSMeans estimates were weighted proportionally to observed margins in the input data, and for the lognormal estimates, a back-transformed log bias correction was applied (Lo et al. 1992).

We also examined length-frequency distributions for smooth dogfish by sex and tested for trends in length for individuals of this species that were measured.

3. Results

Catch rates

Factors retained for the proportion of positive tows were region, season, and year; and for the positive catches, the factors years, season, region, and the year*region interaction were retained in that order (Table 1). The standardized index shows an increasing trend from 1994 to 2006 followed by a decreasing tendency from 2006 to 2012. In general, the index was not estimated with precision as denoted by high CVs in some years (Table 1). The nominal series shows the same general trend but less interannual fluctuation than the standardized index (Fig. 1). Catches increased from 1994 to a peak in 2005 and decreased thereafter. Annual effort increased from the beginning to the end of the time series, with 227 tows/yr in 1994-2000, 306 tows/yr in 2001-2008, and 336 tows/yr in 2009-2012 (Fig. 2). The proportion of positive tows fluctuated, with a peak in 2004. The years with the lowest index values (2000 and 2012) coincided with the lowest proportions of positive tows (<3%) (Fig. 1). Diagnostic plots generally showed good agreement with model assumptions and there were no systematic patterns in the residuals, except for a few positively skewed residuals in the proportion of positive sets (Fig. 3). The annual index values with CVs are listed in Table 2.

Trends in size

Examination of length compositions revealed that most animals were immature, although mature animals were also caught, especially males (Fig. 4). There was no trend in length over the time period considered (Fig. 5).

4. Discussion

Overall the index of abundance examined showed no clear trend. It must be noted that sharks became a priority species for SEAMAP-SA in 2001, but that should not have affected catch rates as these species were unofficially sampled in the exact same way since about 1994. The increase in the total number of tows per year starting in 2001 may explain, at least in part, the increase in the time series from 2001 to 2005, but not the subsequent decline. In addition to the increase in the number of stations sampled, the station allocation scheme also changed in 2001 from a fixed number of stations per stratum to an optimal allocation scheme whereby strata with higher variability were allocated more stations, and vice versa. This was an attempt to lower overall variability and it is possible that areas of high variability tend to have higher shark density, although there is no evidence to support this. Outer strata were also abandoned in 2001 to intensify sampling in the inner depth zone. The lack of trend observed in the scatter plots of lengths also suggests that the stock of this species has remained relatively stable over the time period analyzed.

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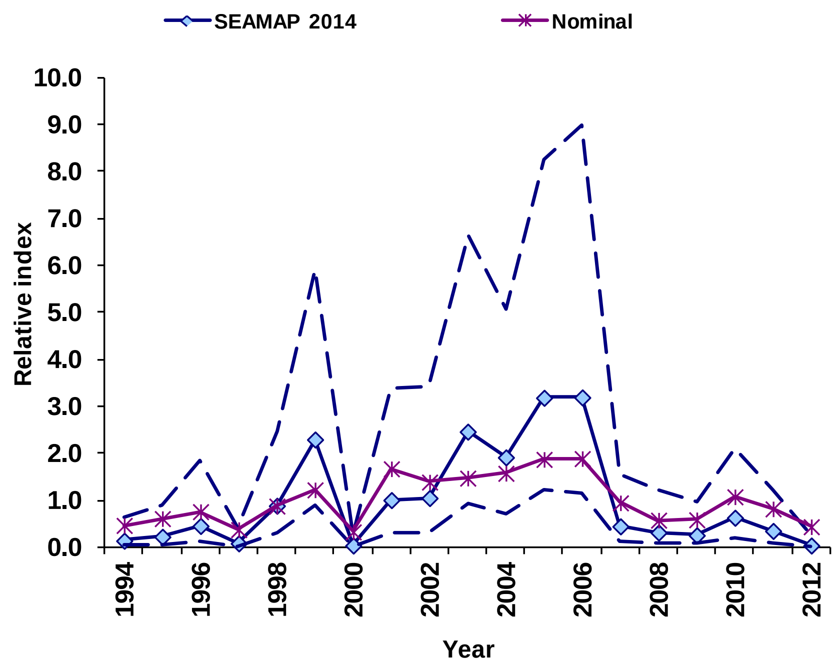
Table 1. Factors retained in the model of proportion of positive sets and positive catch of **smooth dogfish** for SEAMAP-SA trawl data.

Proportion positive	Degrees of freedom	Deviance	Log-likelihood
Null model	5429	2856	-1428
Final model			
REGION SEASON YEAR	5424	1526	-763

Positive catches	Degrees of freedom	Deviance	Log-likelihood
Null model	399	1073	-765
Final model			
YEAR SEASON REGION YEAR*REGION	357	642	-662

Table 2. Estimates of mean annual CPUE (numbers of sharks per 20-minute tow) and coefficients of variation (CV) for **smooth dogfish** for SEAMAP-SA trawl data.

Year	Mean CPUE	CV
1994	0.770	0.86
1995	1.224	0.79
1996	2.476	0.80
1997	0.467	0.94
1998	4.809	0.55
1999	12.449	0.50
2000	0.216	1.28
2001	5.460	0.67
2002	5.696	0.65
2003	13.356	0.53
2004	10.390	0.52
2005	17.263	0.51
2006	17.306	0.55
2007	2.431	0.69
2008	1.713	0.75
2009	1.395	0.74
2010	3.422	0.66
2011	1.901	0.68
2012	0.217	1.16



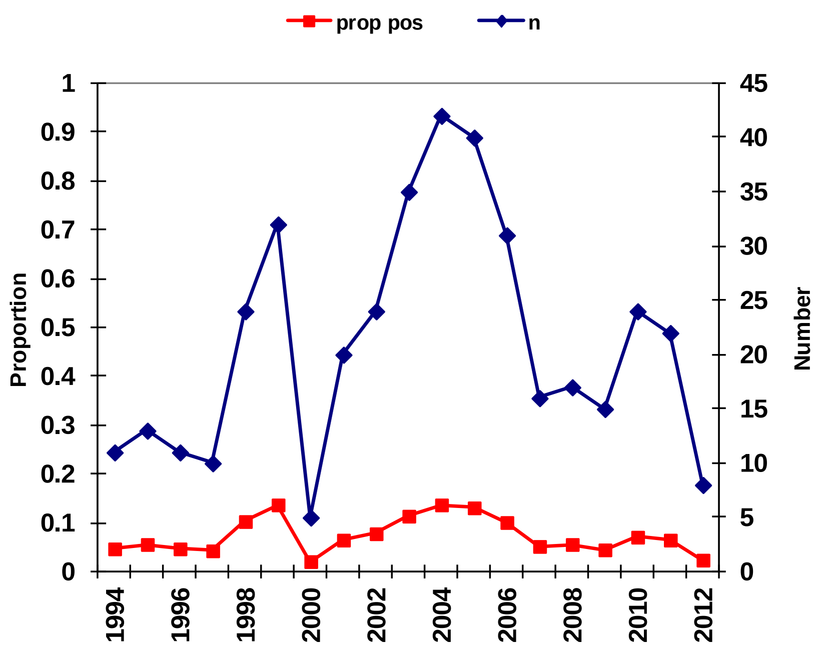


Figure 1. Standardized CPUE (in number) and 95% confidence intervals for smooth dogfish from the SEAMAP trawl survey. The lower panel shows the proportion and number of positive sets by year.

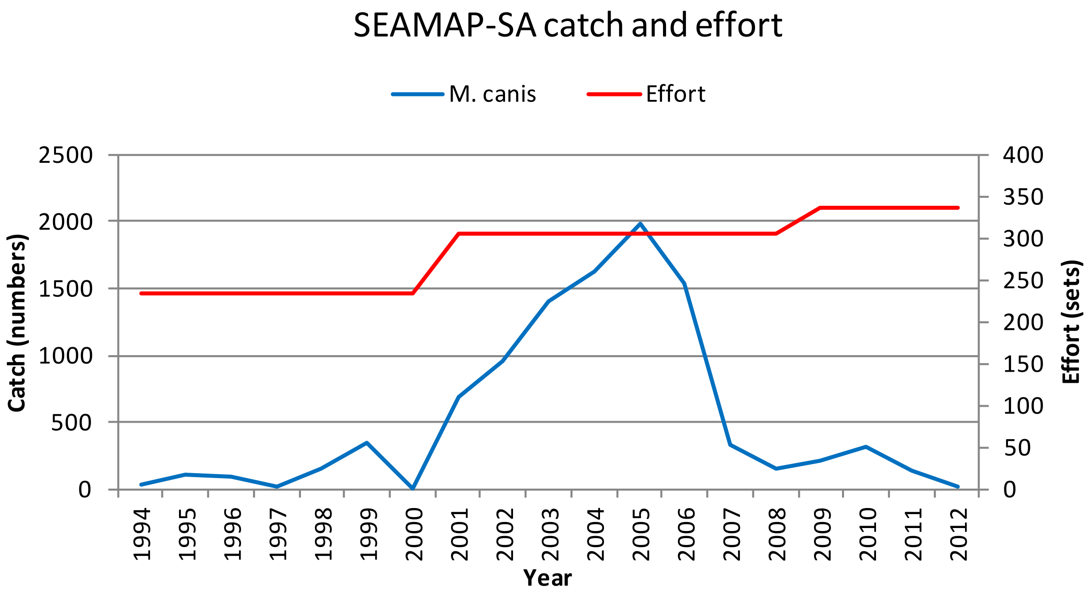


Figure 2. Catch and effort (number of tows) per year in the SEAMAP-SA trawl survey.

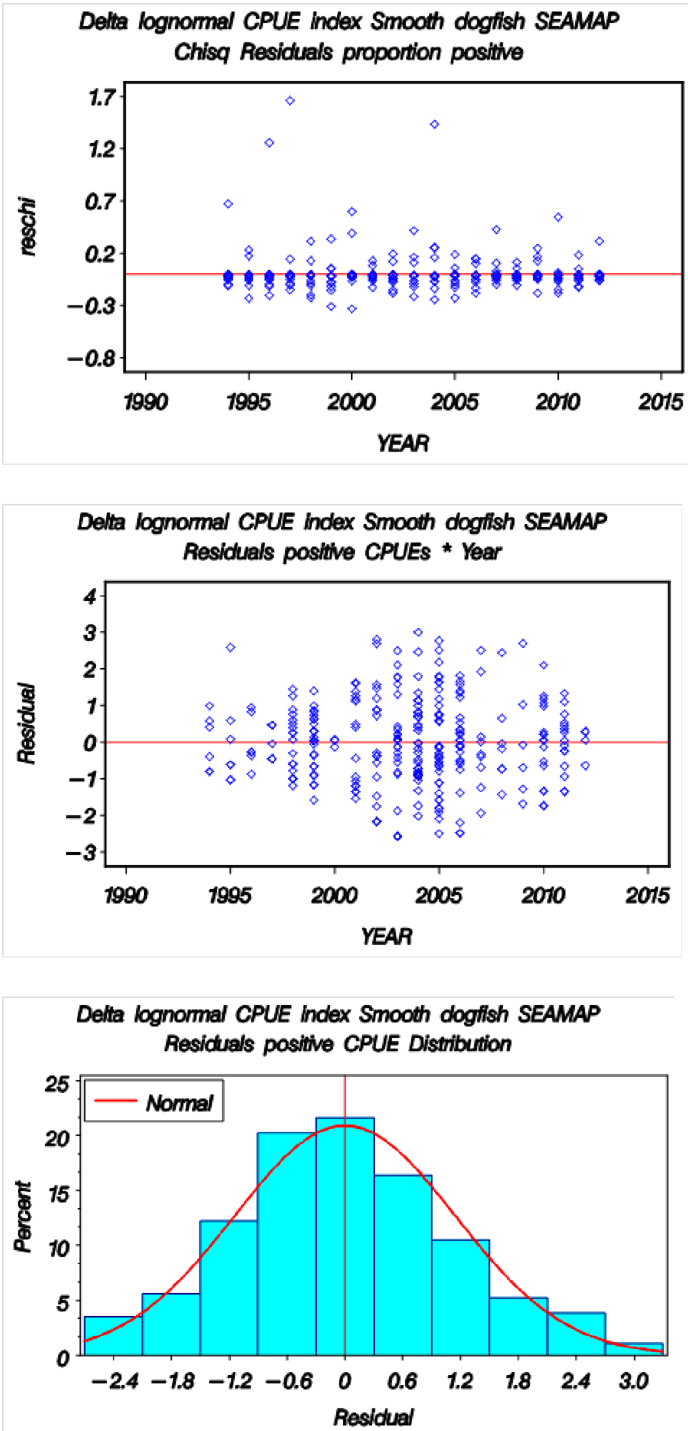


Figure 3. Diagnostic plots of CPUE model from SEAMAP trawl data for smooth dogfish. Top: residuals of proportion positive sets; middle: residuals of positive catch; bottom: residual positive catch distribution.

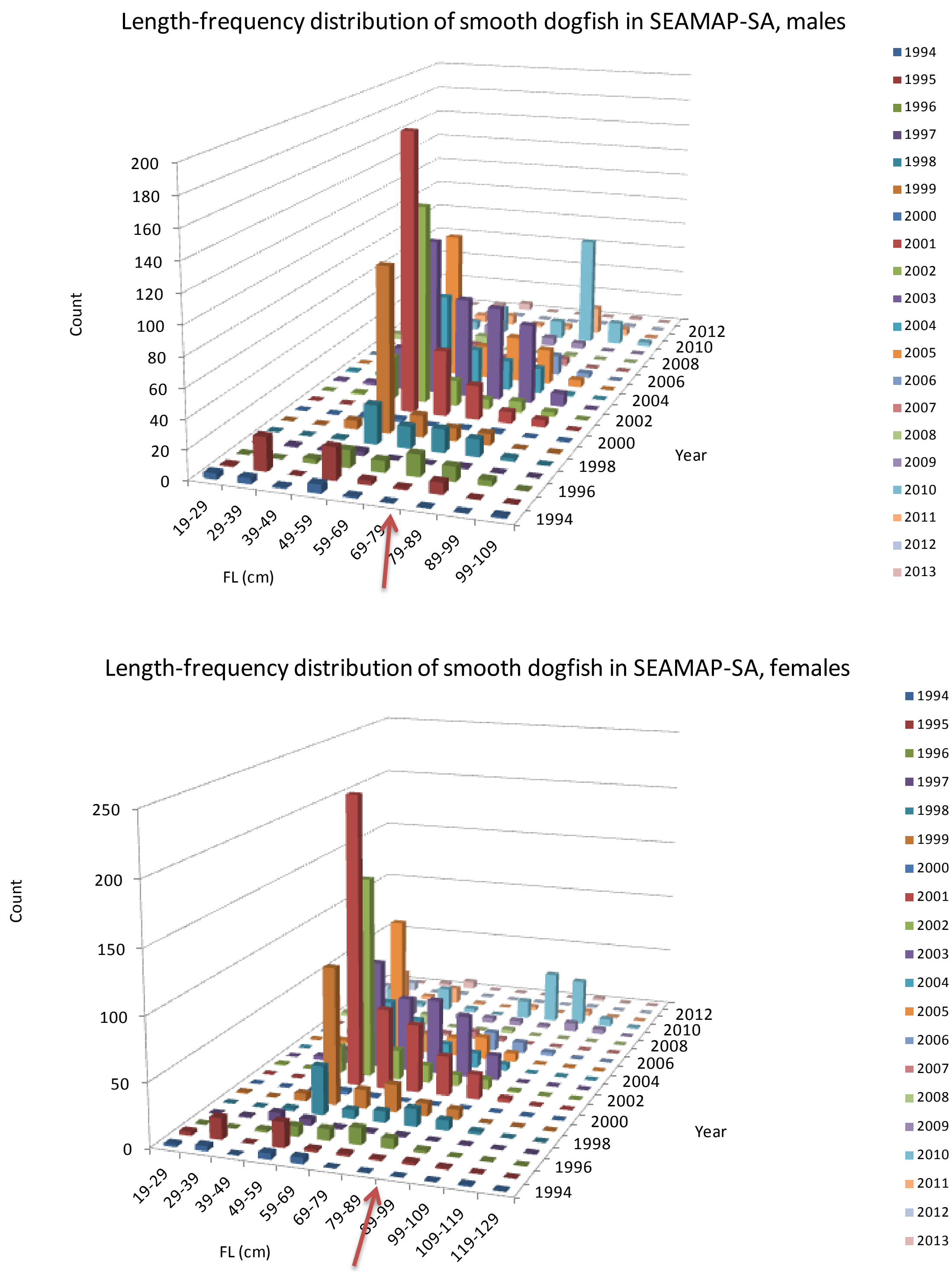


Figure 4. Length frequencies of male (top) and female (bottom) smooth dogfish observed in the SEAMAP-SA trawl survey (1994-2012). The arrows indicate median size at maturity.

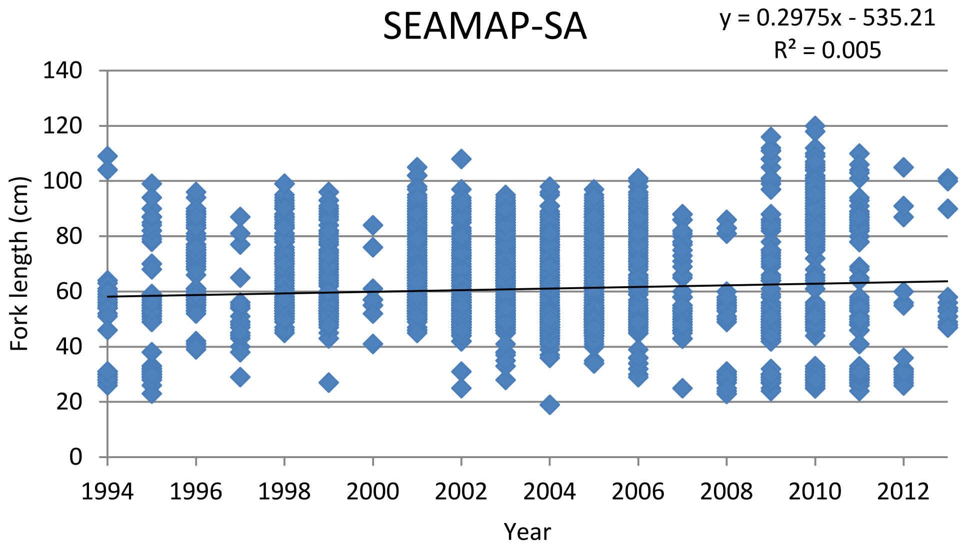


Figure 5. Scatter plot of lengths of smooth dogfish recorded in the SEAMAP-SA trawl survey (1994-2012).