Standardized catch rates of Bonnethead, Atlantic sharpnose shark, and the Small Coastal Shark complex from the Marine Recreational Fisheries Statistics Survey (MRFSS)

Enric Cortés

[1] NOAA Fisheries
Southeast Fisheries Science Center
Panama City Laboratory
3500 Delwood Beach Drive,
Panama City, FL 32408, USA

January 2007

Summary

This document presents an analysis of the relative abundance of bonnethead, Atlantic sharpnose shark, and the small coastal shark complex (bonnethead, Atlantic sharpnose, blacknose, and finetooth) using catch and effort data from MRFSS for 1981-2005. Time series data from this survey were standardized using a Generalized Linear Mixed Model approach assuming a delta-lognormal error distribution. The explanatory variables considered for standardization included geographical region, seasonal trimesters, fishing mode (a factor that classifies recreational fishing into shore, headboat, charter, or private/rental boat), area of fishing (according to distance from shore), and fishing target (based on ecological and habitat groups target species were classified into "guilds"). All series showed markedly increasing trends.

1. Introduction

Time series from the MRFSS (Marine Recreational Fisheries Statistics Survey) for small coastal sharks were first used for the 2002 stock assessment of small coastal sharks (Cortés 2002). In that assessment, only a combined recreational series, which was the sum of nominal catch and effort information from the MRFSS, the NMFS Headboat Survey, and the Texas Parks and Wildlife Department Survey (TXPWD), was used. The MRFSS portion of that series used catch (type A+B1) and highly aggregated and non-targeted effort estimates for 1981-1998.

Data collected and estimated by the MRFSS were used to develop standardized catch-per-unit of effort (CPUE) indices for several small coastal sharks in the Western North Atlantic and Gulf of Mexico area. The recreational fisheries survey started in 1979 and its

purpose is to establish a reliable database for estimating the impact of marine recreational fishing on marine resources. More detailed information on the methods and protocols of the survey can be found at http://www.st.nmfs.gov/st1/recreational/overview/overview.html. This document presents standardized indices for the bonnethead, Atlantic sharpnose shark, and the Small Coastal Shark (SCS) complex (consisting of bonnethead, Atlantic sharpnose, blacknose and finetooth sharks). There was an insufficient number of observations to develop separate indices for blacknose or finetooth sharks. Standardized catch rates were estimated using a Generalized Linear Mixed Model (GLMM) approach.

2. Materials and Methods

Data

This document closely followed the methodology used by Ortiz (2005) to develop relative abundance indices for large coastal sharks (Ortiz 2005). The MRFSS estimates of catch and effort are based on intercept (i.e. interview at dock) and telephone surveys. Each record report includes the catch in numbers of all caught species and whether it was retained (type A catch), or released alive (type B1) or dead (type B2), number of participating anglers and number of fishing hours, information on gear used, target species, mode (shore, headboat, charter, or private/rental), area (inshore, ocean < 3 miles, 3 < ocean < 10 miles, ocean > 10 miles), county/state, and date. Frequency and sampling design of interview and telephone surveys are based on demographic and seasonal (wave) considerations by county from Maine through Louisiana, in the Atlantic and U.S. Gulf of Mexico coasts. This report does not include MRFSS estimates from the U.S. Caribbean region or Texas, and the analysis was also restricted to sharks caught on hook and line and excluding the "headboat" mode.

The MRFSS data include estimates of catch and effort for 1981-2005 from Louisiana through Maine. Because of reduced number of records for some states, regional areas were defined and used as a spatial factor: Central Gulf (LA, AL, MS), Western Gulf (FLW), Florida (FLE), North Carolina-Georgia (GA, SC, NC), Mid Atlantic (VA, MD, DE, NJ, NY), and New England (CT, RI, MA, NH, ME). The Mid-Atlantic and New England regions were further excluded form analysis because of very low number of observations. Trimesters were used to account for seasonal fishery distribution through the year (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec). Interviews also collect information on the intended target species for each trip; based on ecological and habitat groups, target species were classified into "guilds": inshore species, reef species, non-reef species, pelagic species, and sharks. When non-primary or secondary target was specified, the record was assigned to an unclassified guild. Fishing effort or angler hours was estimated as the number of anglers times the number of hours fished, and nominal catch rates were defined as the total catch kept and released alive or dead (AB1B2, number of fish) per thousand angler hours.

We thus considered the following variables for this analysis: region, season, fishing mode, fishing area, target species, and year. Because of an insufficient number of observations for blacknose or finetooth sharks, we conducted analyses for the small coastal

shark complex (the sum of the four species) and for Atlantic sharpnose shark and bonnethead separately. Data were available for the period 1981-2005.

Sharks in general represented less than 2% of the estimated catch in MRFSS from 1981 to 2004 (Ortiz 2005). Fishing effort and recreational catch of finfish and sharks have both increased since 1981; by 2005 total angler hours were about 5 times the effort in 1981 and the highest catches of sharks (all species combined) occurred in recent years (**Figure 1** and Fig. 1 in Ortiz [2005]). Atlantic sharpnose and bonnethead sharks make up the bulk of the SCS catch (52% and 40% on average, respectively; **Figure 2**).

Statistical analysis

Relative abundance indices were estimated using a Generalized Linear Modeling (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). The year factor was then added. Subsequently, factors were 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 (or the model explained at least 5% of the total deviance). Only single factors were incorporated for this particular analysis. 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, possible first-level interactions that included the year factor were evaluated and treated as random interactions. 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 random interactions between nested models was evaluated by using the likelihood ratio test (Pinheiro and Bates 2000).

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).

3. Results and Discussion

Bonnethead shark. Factors retained for the proportion of positive sets were year, region, area, mode, guild, and season; and for the positive catches, the factors year, region, mode, and guild were retained in that order (**Table 1**). The final mixed model included the fixed factors listed above and the year*region, year*mode, and year*area random interactions for the proportion positive model and the year*region and year*mode random interactions for the positive catch model (**Table 2**). The index shows a 9-fold increase from beginning to end of the time series, with wide CIs (average annual CV=68%) (**Figure 3**). Diagnostic plots showed good agreement with model assumptions for the positive model, with no systematic patterns in the residuals, but a residual pattern in the proportion positive model as a result of the low proportion of positive sets, which was less than 1% in any year (**Figure 4**). The annual index values with CVs are listed in **Table 3**.

Atlantic sharpnose shark. Factors retained for the proportion of positive sets were year, area, region, guild, mode, and season; and for the positive catches, the factors year, mode, area, region, and guild were retained in that order (**Table 4**). The final mixed model included the fixed factors listed above and the year*area and year*area random interactions for the proportion positive model and the year*area, year*region, and year*guild random interactions for the positive catch model (**Table 5**). The index shows a 5-fold increase from beginning to end of the time series, with wide CIs especially in the more recent years (average annual CV=73%) (**Figure 5**). Diagnostic plots showed good agreement with model assumptions for the positive model, with no systematic patterns in the residuals, but a residual pattern in the proportion positive model as a result of the low proportion of positive sets, which was less than 1% in any year (**Figure 6**). The annual index values with CVs are listed in **Table 6**.

Small coastal shark (SCS) complex. Factors retained for the proportion of positive sets were year, guild, mode, season, region, and area; and for the positive catches, the factors year, area, region, mode, and guild were retained in that order (**Table 7**). The final mixed model included the fixed factors listed above and the year*mode, year*season, and year*region random interactions for the proportion positive model and the year*region, year*area, and year*mode random interactions for the positive catch model (**Table 8**). The index shows a 21-fold increase from beginning to end of the time series, with wide CIs especially in the more recent years (average annual CV=52%) (**Figure 7**). Diagnostic plots showed good agreement with model assumptions for the positive model, with no systematic patterns in the residuals, but a residual pattern in the proportion positive model as a result of the low proportion of positive sets, which was less than 1% in any year, except for 2001-2005 when it was between 1-2% (**Figure 8**). The annual index values with CVs are listed in **Table 9**.

In all, the three series examined showed markedly increasing tendencies from 1981 to 2005.

Acknowledgments

I thank M. Ortiz and V. Matter for providing data extractions, files, and code.

References

ASMFC (Atlantic States Marine Fisheries Commission). 2000. SEAMAP-SA 10-year Trawl Report. Results of trawling efforts in the coastal habitat of the South Atlantic Bight, FY 1990-1999. South Carolina Dept. of Nat. Res., Charleston, SC 29422-2559.

Cortés, E. 2002. Stock assessment of small coastal sharks in the U.S. Atlantic and Gulf of Mexico. NOAA Fisheries, SEFSC, Panama City Lab. Sust. Fish. Div. Contrib. SFD-01/02-152. 133 p.

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS System for Mixed Models. Cary, NC, USA.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences 49:2515-2526.

Ortiz, M. 2005. Standardized catch rates for blacktip shark (*Carcharhinus limbatus*), sandbar shark (*C. plumbeus*), and large coastal complex sharks from the Marine Recreational Fisheries Statistical Survey. LCS05/06-DW-36, Panama City, FL, October 2005.

Pinheiro, J.C. and D.M. Bates. 2000. Mixed-effect models in S and S-plus. Statistics and Computing. Springer-Verlag New York, Inc.

SAS Institute, Inc. 1999. SAS/STAT User's Guide, Version 8. Cary, NC, USA.

Wolfinger, R. and M. O'Connell. 1993. Generalized linear mixed models: a pseudo likelihood approach. Journal of Statistical Computation and Simulation 48:233-243.

Table 1. Deviance analysis table of explanatory variables in the delta lognormal model for bonnethead shark catch rates (number of fish per thousand angler hours) from MRFSS. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (i.e., whether the addition of an additional factor is significant).

BONNETHEAD MRFSS

Model factors proportion of positive	Degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	64011			
YEAR	24	62054	1957.0	30.6%	< 0.001
YEAR region	3	60656	1398.0	21.9%	< 0.001
YEAR region area	2	59442	1214.0	19.0%	< 0.001
YEAR region area mode	2	58727	715.0	11.2%	< 0.001
YEAR region area mode guild	5	58160	567.0	8.9%	< 0.001
YEAR region area mode guild season	3	57620	540.0	8.4%	< 0.001

Model factors positive catch rate values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	3271			
YEAR	24	3205	66.0	23.9%	< 0.001
YEAR region	3	3085	120.0	43.5%	< 0.001
YEAR region mode	2	3022	63.0	22.8%	< 0.001
YEAR region mode guild	5	3009	13.0	4.7%	0.023
YEAR region mode guild area	2	3000	9.0	3.3%	0.011
YEAR region mode guild area season	3	2995	5.0	1.8%	0.172

Table 2. Analysis of mixed model formulations for bonnethead shark catch rates from MRFSS. Likelihood ratio tests the difference of -2*the residual log-likelihood between two nested models. Number in second column under Likelihood Ratio Test is the Chi-square probability between consecutive models (i.e., it indicates whether the addition of a factor is significant).

Bonnethead	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives / total obs					
Year region area mode guild season	104583.8	104585.8	104593.3		
Year region area mode guild season *Year*region*	101929.2	101933.3	101938.4	2654.6	000.0E+0
Year region area mode guild season *Year*region Year*mode*	100899.8	100905.8	100913.6	1029.4	0.0000
Year region area mode guild season *Year*region Year*mode Year*area*	100507.4	100515.4	100525.9	392.4	0.0000
Positive Catch					
Year region mode guild	11669.7	11671.7	11678.2		
Year region mode guild *Year*region*	11625.5	11629.5	11634.5	44.2	29.6E-12
Year region mode guild *Year*region Year*mode*	11618.8	11624.8	11632.4	6.7	0.0096

Table 3. Nominal and standardized bonnethead shark CPUE series (sharks per 1000 angler hours from MRFSS.

Year	N obs	Nominal	Standardized	CV	Index	95% confidence intervals	
1981	7679	0.189	0.110	122.3%	0.226	0.033	1.531
1982	15240	0.445	0.178	80.4%	0.366	0.089	1.502
1983	11814	0.133	0.066	170.9%	0.137	0.013	1.416
1984	13963	0.142	0.085	128.9%	0.175	0.024	1.269
1985	16966	0.591	0.215	80.3%	0.442	0.108	1.811
1986	25635	0.590	0.273	67.7%	0.563	0.165	1.923
1987	31449	0.582	0.247	67.5%	0.509	0.150	1.733
1988	33529	0.343	0.142	82.3%	0.292	0.069	1.230
1989	31129	0.464	0.220	70.3%	0.452	0.127	1.607
1990	27311	0.258	0.154	80.1%	0.317	0.077	1.295
1991	34680	0.173	0.101	99.6%	0.207	0.039	1.090
1992	52413	0.862	0.531	48.8%	1.094	0.434	2.757
1993	50731	0.785	0.236	62.9%	0.486	0.153	1.542
1994	60625	0.677	0.269	57.3%	0.554	0.191	1.609
1995	58458	1.105	0.391	51.2%	0.805	0.306	2.113
1996	62338	1.060	0.422	50.2%	0.868	0.336	2.243
1997	62639	0.951	0.366	52.3%	0.754	0.282	2.017
1998	68363	1.533	0.638	44.7%	1.314	0.559	3.087
1999	79438	1.828	0.686	44.5%	1.411	0.603	3.302
2000	76644	2.775	0.904	41.7%	1.860	0.836	4.141
2001	82051	3.381	1.089	40.9%	2.242	1.021	4.925
2002	82179	4.555	1.724	39.2%	3.549	1.666	7.561
2003	78121	2.394	0.958	41.3%	1.972	0.892	4.358
2004	76398	3.036	1.150	40.6%	2.367	1.083	5.174
2005	70095	3.110	0.990	41.6%	2.038	0.917	4.527

Table 4. Deviance analysis table of explanatory variables in the delta lognormal model for Atlantic sharpnose shark catch rates (number of fish per thousand angler hours) from MRFSS. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (i.e., whether the addition of an additional factor is significant).

ATLANTIC SHARPNOSE SHARK MRFSS

Model factors proportion of positive	Degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	46384			
YEAR	24	44989	1395.0	31.5%	< 0.001
YEAR area	2	43306	1683.0	37.9%	< 0.001
YEAR area region	3	42510	796.0	17.9%	< 0.001
YEAR area region guild	5	41595	915.0	20.6%	< 0.001
YEAR area region guild mode	2	40768	827.0	18.6%	< 0.001
YEAR area region guild mode season	5	40554	214.0	4.8%	< 0.001

Model factors positive catch rate values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	3744			
YEAR	24	3650	94.0	32.4%	< 0.001
YEAR mode	2	3540	110.0	37.9%	< 0.001
YEAR mode area	2	3479	61.0	21.0%	< 0.001
YEAR mode area region	3	3407	72.0	24.8%	< 0.001
YEAR mode area region guild	5	3361	46.0	15.9%	< 0.001
YEAR mode area region guild season	3	3360	1.0	0.3%	0.801

Table 5. Analysis of mixed model formulations for Atlantic sharpnose shark catch rates from MRFSS. Likelihood ratio tests the difference of -2*the residual log-likelihood between two nested models. Number in second column under Likelihood Ratio Test is the Chi-square probability between consecutive models (i.e., it indicates whether the addition of a factor is significant).

Atlantic sharpnose shark	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives / total obs					
Year area region guild mode season	101007.3	101009.3	101016.8		
Year area region guild mode season *Year*area*	98284.1	98288.1	98292.6	2723.2	0.0000
Year area region guild mode season *Year*area Year*mode*	95990.5	95996.5	96003.4	2293.6	0.0000
Year area region guild mode season *Year*area Year*mode Year*guild*	95989.1	95997.1	96006	1.4	0.2367
Positive Catch					
Year mode area region guild	9658.6	9660.6	9666.8		
Year mode area region guild *Year*area*	9640.5	9644.5	9649	18.1	0.0000
Year mode area region guild *Year*area Year*region*	9632.3	9638.3	9645	8.2	0.0042
Year mode area region guild *Year*area Year*region Year*guild*	9624	9632	9641	8.3	0.0040

Table 6. Nominal and standardized Atlantic sharpnose shark CPUE series (sharks per 1000 angler hours) from MRFSS

Year	N obs	Nominal	Standardized	CV	Index	95% confidence intervals	
1982	15240	0.450	0.434	82.3%	0.589	0.140	2.481
1983	11814	0.078	0.062	226.3%	0.084	0.006	1.242
1984	13963	0.673	0.433	90.3%	0.587	0.125	2.750
1985	16966	0.473	0.290	88.3%	0.394	0.086	1.799
1986	25635	0.152	0.119	107.2%	0.162	0.028	0.930
1987	31449	0.264	0.184	88.1%	0.250	0.055	1.136
1988	33529	1.226	0.514	66.5%	0.697	0.208	2.339
1989	31129	0.549	0.406	68.7%	0.551	0.159	1.911
1990	27311	0.323	0.320	73.6%	0.434	0.116	1.618
1991	34680	0.398	0.284	71.9%	0.386	0.106	1.403
1992	52413	0.787	0.533	59.6%	0.723	0.240	2.178
1993	50731	0.281	0.307	69.0%	0.417	0.120	1.452
1994	60625	0.708	0.657	58.0%	0.892	0.304	2.617
1995	58458	0.916	0.667	58.0%	0.905	0.308	2.655
1996	62338	0.764	0.681	59.5%	0.924	0.307	2.778
1997	62639	0.529	0.397	64.2%	0.538	0.166	1.743
1998	68363	0.720	0.538	58.9%	0.730	0.245	2.175
1999	79438	1.436	0.847	55.2%	1.149	0.410	3.222
2000	76644	1.656	1.311	51.7%	1.778	0.671	4.708
2001	82051	2.644	1.726	51.1%	2.342	0.893	6.140
2002	82179	2.105	1.659	51.0%	2.250	0.860	5.889
2003	78121	1.978	1.704	51.4%	2.311	0.877	6.090
2004	76398	1.722	1.322	52.4%	1.793	0.670	4.798
2005	70095	3.288	2.298	51.1%	3.117	1.190	8.165

Table 7. Deviance analysis table of explanatory variables in the delta lognormal model for SCS complex catch rates (number of fish per thousand angler hours) from MRFSS. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (i.e., whether the addition of an additional factor is significant).

SMALL COASTAL SHARK COMPLEX MRFSS

Model factors proportion of positive	Degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	101507			
YEAR	24	98429	3078.0	71.8%	< 0.001
YEAR guild	5	97121	1308.0	30.5%	< 0.001
YEAR guild mode	2	95814	1307.0	30.5%	< 0.001
YEAR guild mode season	3	95136	678.0	15.8%	< 0.001
YEAR guild mode season region	3	94454	682.0	15.9%	< 0.001
YEAR guild mode season region area	2	94144	310.0	7.2%	< 0.001

Model factors positive catch rate values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
null	1	7339			
YEAR	24	7229	110.0	19.9%	< 0.001
YEAR area	2	7005	224.0	40.5%	< 0.001
YEAR area region	3	6799	206.0	37.3%	< 0.001
YEAR area region mode	2	6726	73.0	13.2%	< 0.001
YEAR area region mode guild	3	6676	50.0	9.0%	< 0.001

Table 8. Analysis of mixed model formulations for SCS complex catch rates from MRFSS. Likelihood ratio tests the difference of -2*the residual log-likelihood between two nested models. Number in second column under Likelihood Ratio Test is the Chi-square probability between consecutive models (i.e., it indicates whether the addition of a factor is significant).

Small coastal shark complex	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives / total obs					
Year guild mode season region area	86289.6	86291.6	86299.1		
Year guild mode season region area *Year*mode*	84864.5	84868.5	84873.1	1425.1	0.0000
Year guild mode season region area *Year*mode Year*season*	84801	84807	84814	63.5	0.0000
Year guild mode season region area *Year*mode Year*season Year*region*	83539.9	83547.9	83557.2	1261.1	0.0000
Positive Catch					
Year area region mode guild	22263.2	22265.2	22272.2		
Year area region mode guild *Year*region*	22232.6	22232.6	22241.7	30.6	0.0000
Year area region mode guild *Year*region Year*area*	22209.2	22215.2	22223	23.4	0.0000
Year area region mode guild *Year*region Year*area Year*mode*	22205.3	22213.3	22223.6	3.9	0.0483

Table 9. Nominal and standardized Small Coastal Shark complex CPUE series (sharks per 1000 angler hours) from MRFSS

Year	N obs	Nominal	Standardized	CV	Index	95% confidence intervals	
1981	7679	0.189	0.259	101.6%	0.128	0.024	0.688
1982	15240	0.996	0.944	58.0%	0.466	0.159	1.368
1983	11814	0.277	0.298	94.7%	0.147	0.030	0.729
1984	13963	0.825	0.673	66.3%	0.332	0.099	1.111
1985	16966	1.078	0.804	60.0%	0.397	0.131	1.203
1986	25635	0.821	0.702	56.3%	0.347	0.121	0.989
1987	31449	1.046	0.643	56.5%	0.318	0.111	0.910
1988	33529	1.681	1.070	51.2%	0.528	0.201	1.386
1989	31129	1.019	0.796	53.3%	0.393	0.144	1.068
1990	27311	0.618	0.706	54.6%	0.349	0.126	0.968
1991	34680	0.571	0.566	55.5%	0.279	0.099	0.787
1992	52413	1.740	1.259	45.9%	0.622	0.259	1.490
1993	50731	1.228	1.334	46.7%	0.659	0.271	1.600
1994	60625	1.485	1.757	44.3%	0.867	0.372	2.023
1995	58458	2.059	2.356	43.0%	1.163	0.510	2.651
1996	62338	1.917	1.982	44.2%	0.979	0.421	2.277
1997	62639	1.889	1.734	44.2%	0.856	0.368	1.994
1998	68363	2.337	2.549	42.3%	1.259	0.559	2.833
1999	79438	3.335	2.936	42.0%	1.449	0.648	3.244
2000	76644	4.500	3.755	41.1%	1.854	0.841	4.086
2001	82051	6.135	4.442	40.9%	2.193	0.999	4.816
2002	82179	6.746	5.235	40.6%	2.585	1.183	5.645
2003	78121	4.498	3.730	41.3%	1.842	0.833	4.072
2004	76398	4.897	4.655	40.9%	2.298	1.047	5.043
2005	70095	6.521	5.450	40.8%	2.691	1.228	5.896

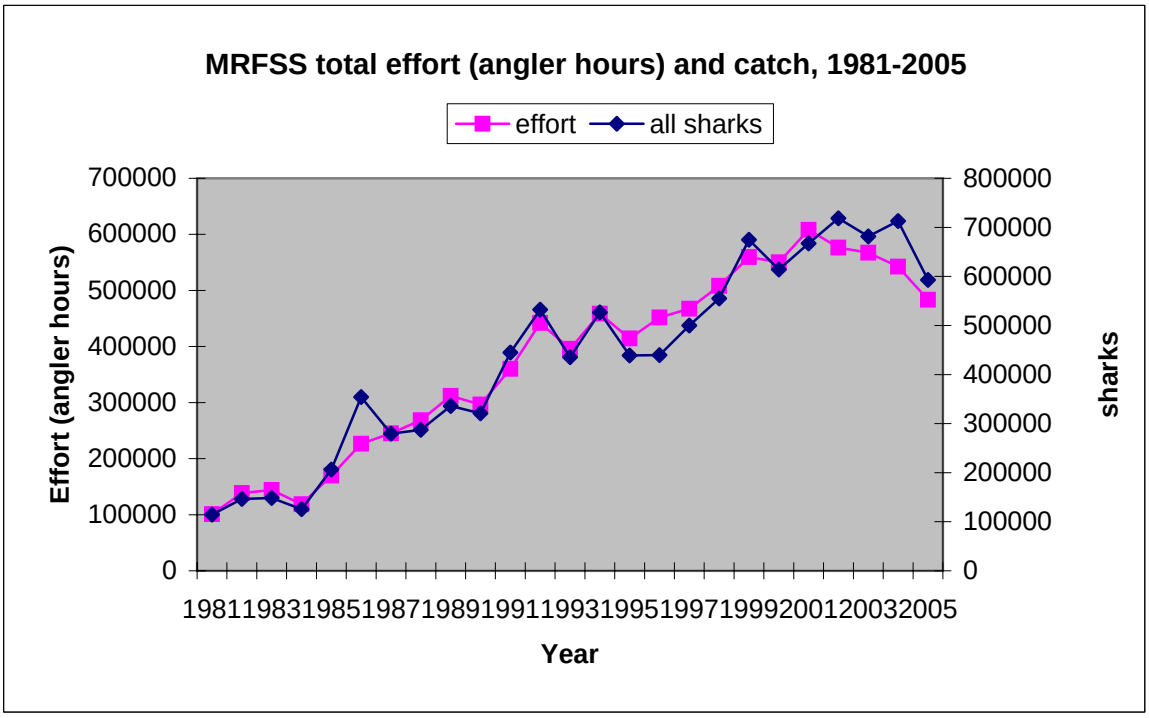

Figure 1. Estimated total annual effort (angler hours) and catch (all sharks) from MRFSS data.

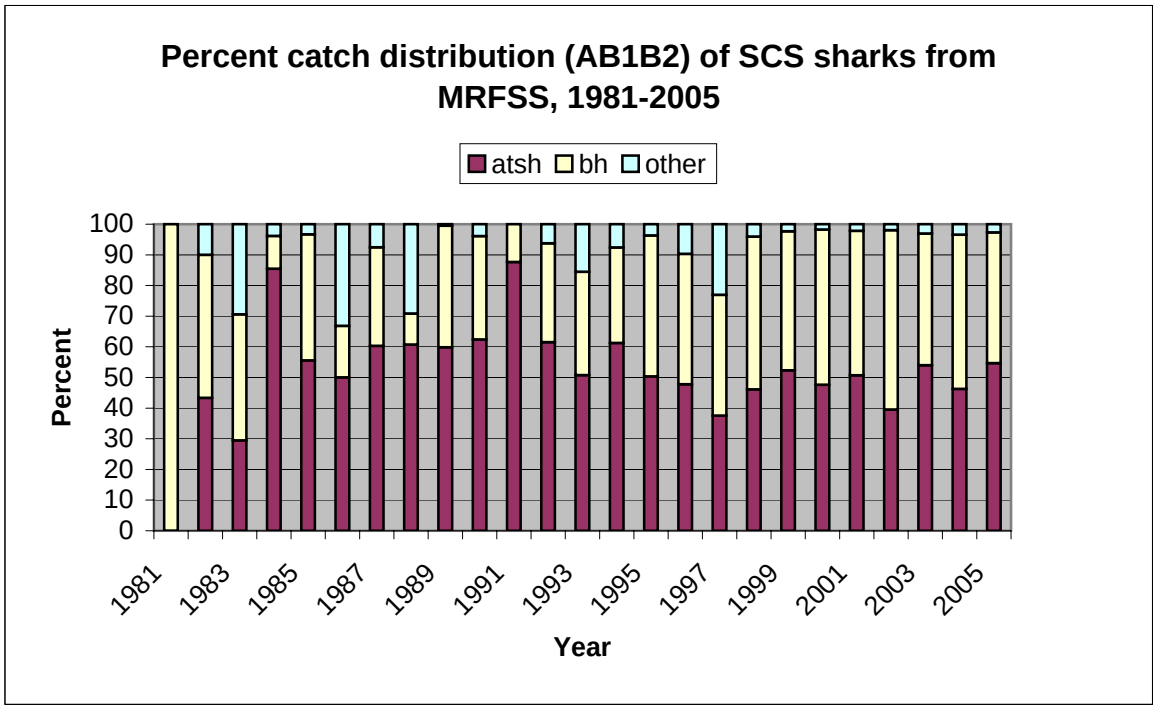

Figure 2. Percent contribution of Atlantic sharpnose shark, bonnethead, and blacknose and finetooth sharks (other) to small coastal shark catches from MRFSS data.

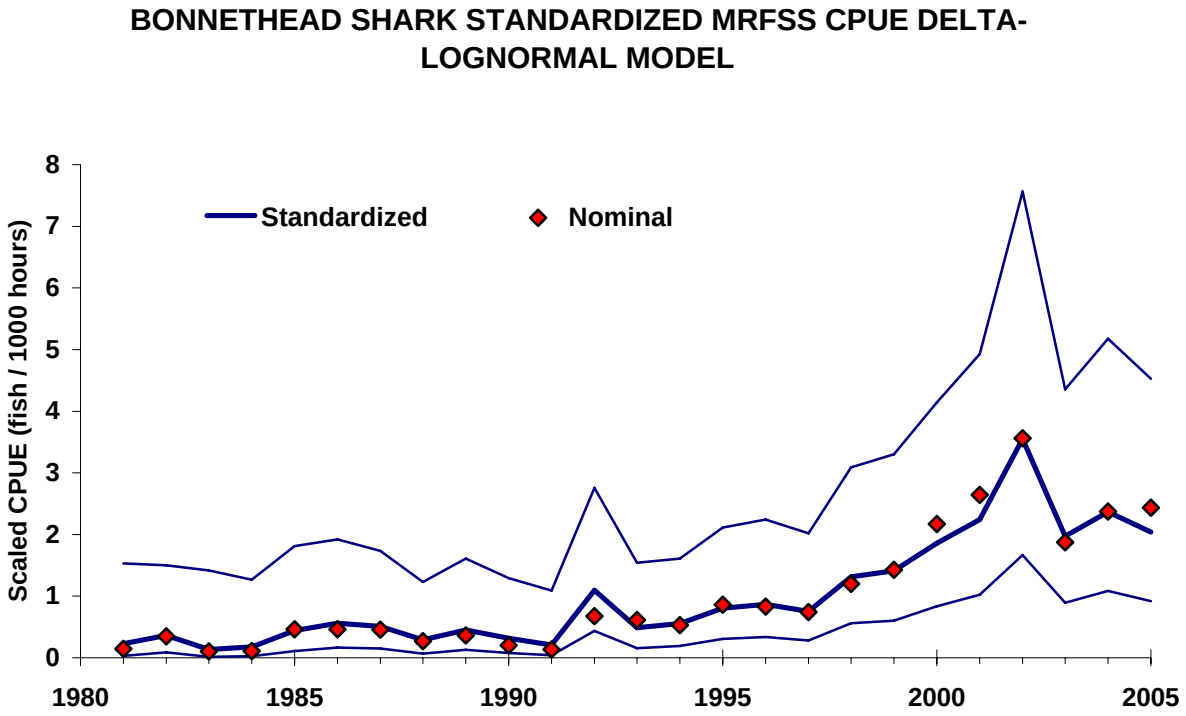

Figure 3. Nominal (solid diamonds) and standardized CPUE for bonnethead shark from MRFSS. Outer lines represent estimated upper and lower 95% confidence limits for the scaled CPUE values. Series are scaled to their corresponding mean.

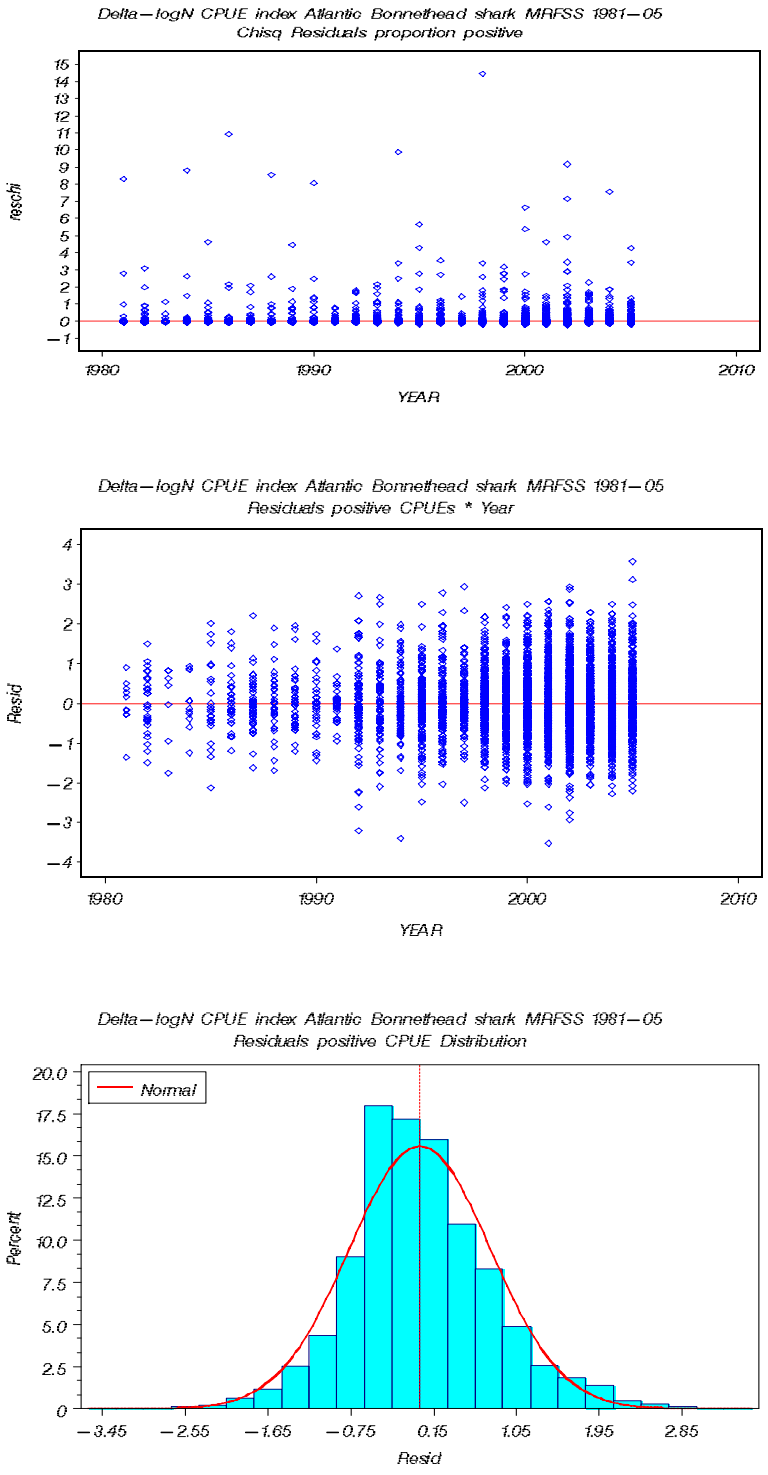

Figure 4. Diagnostic plots of CPUE model from MRFSS data for**bonnethead shark**. Top: residuals of proportion positive sets; middle: residuals of positive catch; bottom: residual positive catch distribution.

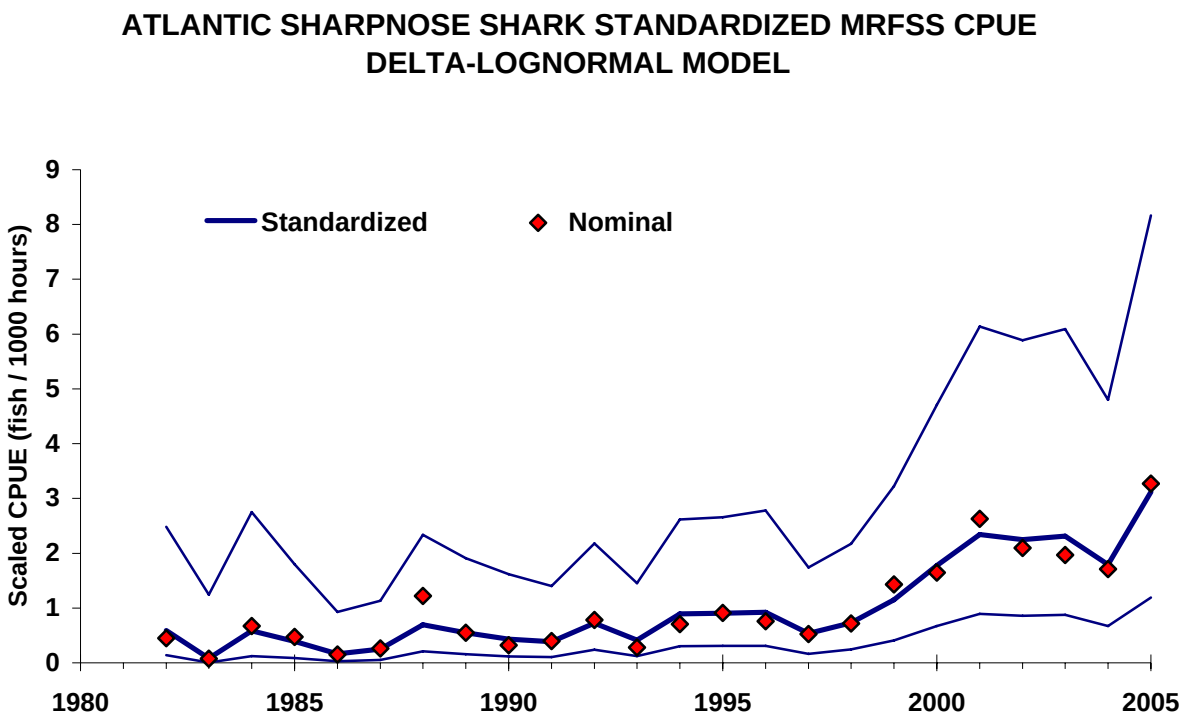

Figure 5. Nominal (solid diamonds) and standardized CPUE for Atlantic sharpnose shark from MRFSS. Outer lines represent estimated upper and lower 95% confidence limits for the scaled CPUE values. Series are scaled to their corresponding mean.

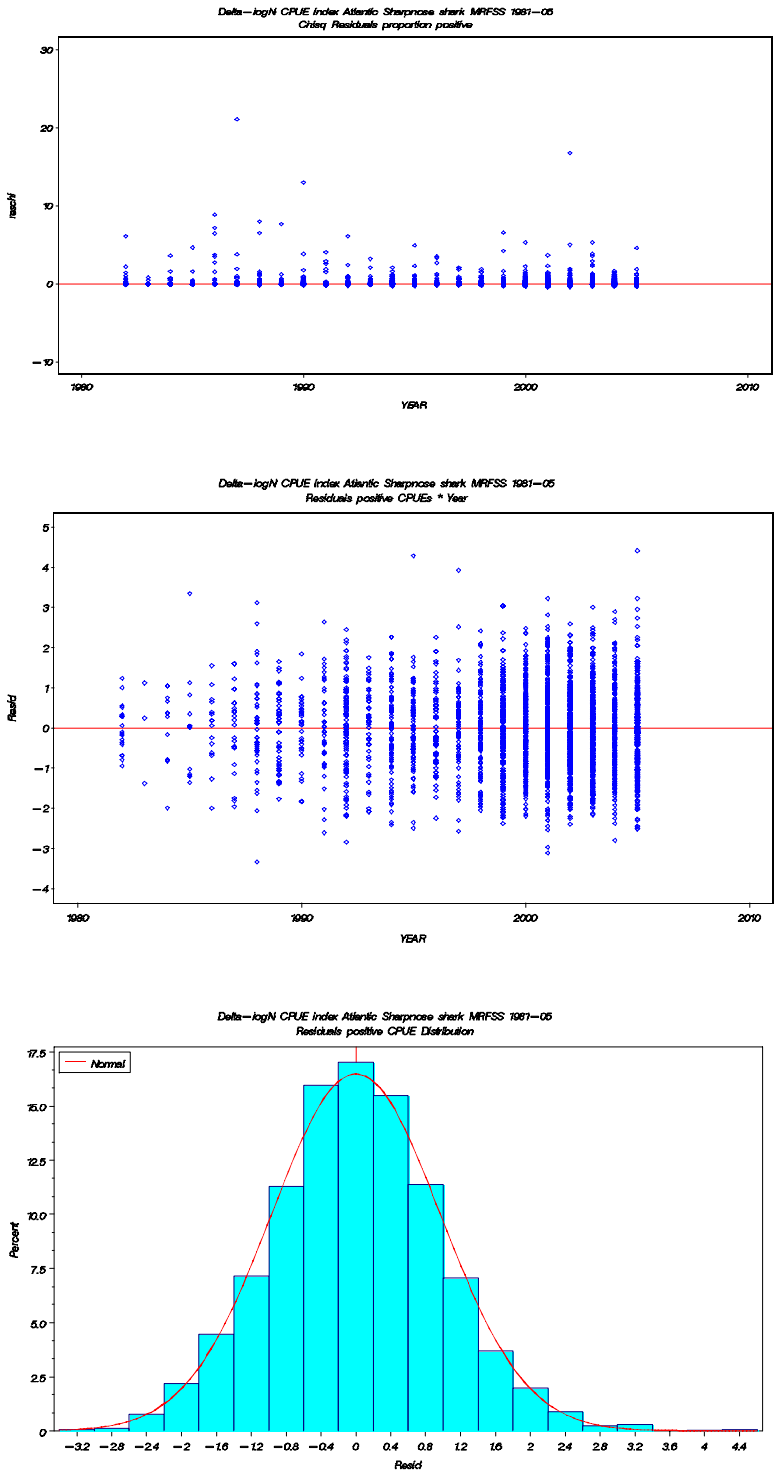

Figure 6. Diagnostic plots of CPUE model from MRFSS data for **Atlantic sharpnose shark.** Top: residuals of proportion positive sets; middle: residuals of positive catch bottom: residual positive catch distribution.

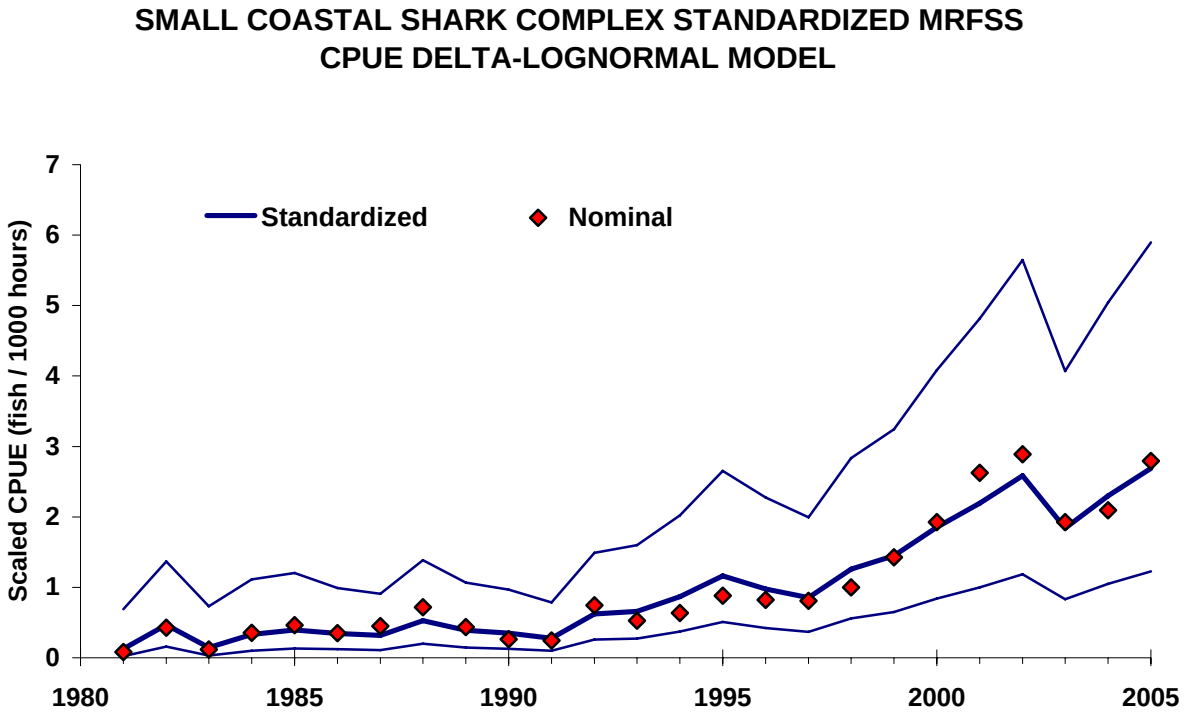

Figure 7. Nominal (solid diamonds) and standardized CPUE for SCS comlpex from MRFSS. Outer lines represent estimated upper and lower 95% confidence limits for the scaled CPUE values. Series are scaled to their corresponding mean.

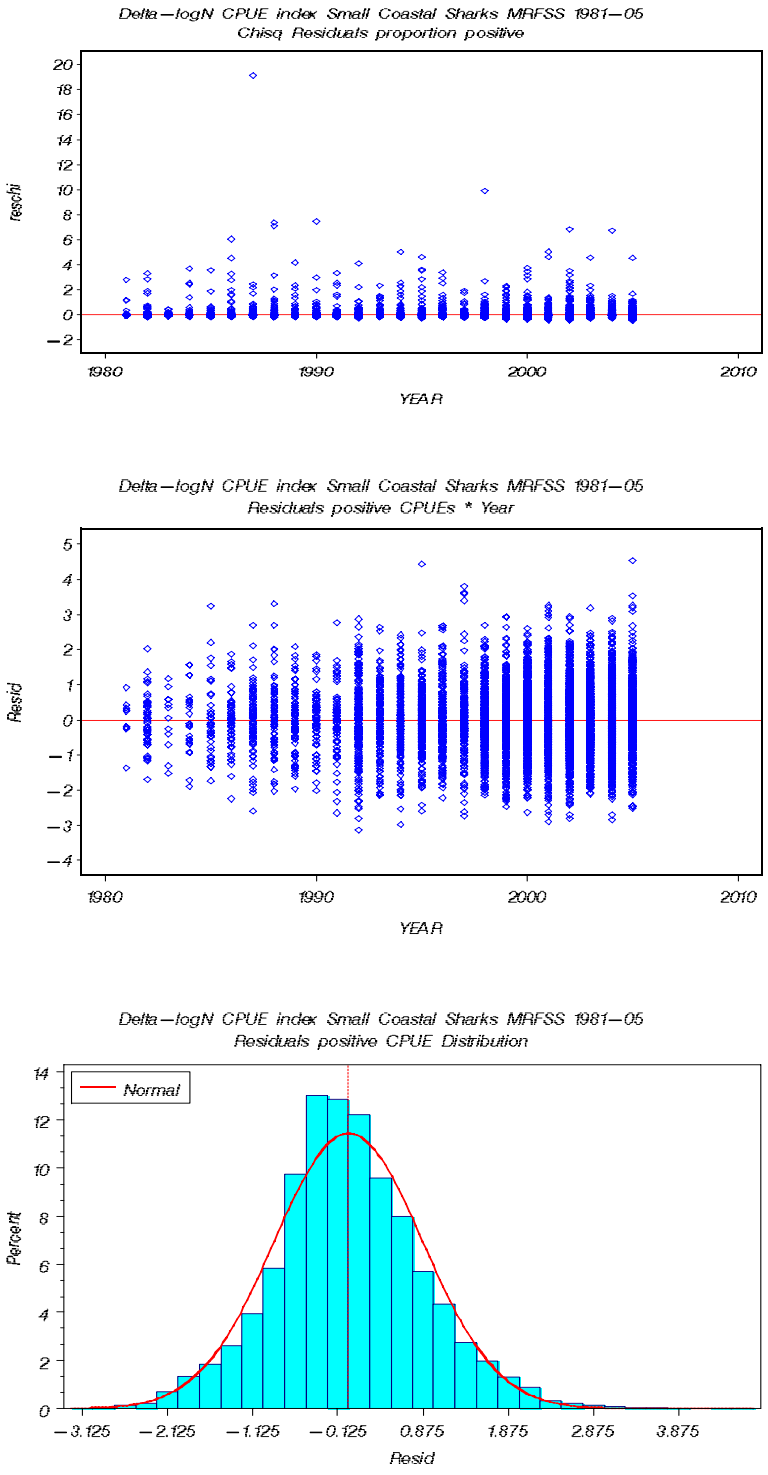

Figure 8. Diagnostic plots of CPUE model from MRFSS data for**small coastal sharks**. Top: residuals of proportion positive sets; middle: residuals of positive catch; bottom: residual positive catch distribution.