STANDARDIZED CATCH RATES FOR BLACKTIP SHARK (*Carcharhinus limbatus*), SANDBAR SHARK (*C. plumbeus*), AND LARGE COASTAL COMPLEX SHARKS FROM THE MARINE RECREATIONAL FISHERIES STATISTICAL SURVEY (MRFSS).

Mauricio Ortiz[1]

SUMMARY

Sharks catch and effort data from the US Marine Recreational Fisheries Statistical Survey of the Atlantic coast and Gulf of Mexico (excluding Texas) were used to update indices of abundance for the blacktip shark, sandbar shark, and the large coastal complex (LCC) (Bull shark, spinner shark, blacktip shark, silky shark, sandbar shark, great hammerhead shark, scalloped hammerhead shark, smooth hammerhead shark, lemon shark, tiger shark and nurse shark) stocks. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution. The explanatory variables considered for standardization included geographical area, seasonal trimesters, fishing target species, and mode a factor that classifies recreational fishing in shore, headboat, charter or private/rental boat.

KEY WORDS

Catch/effort, abundance, recreational fisheries, sharks

[1] U.S. Department of Commerce National Marine Fisheries Service, Southeast Fisheries Science Center
Sustainable Fisheries Division 75 Virginia Beach Drive. Miami, Florida 33149 USA Contribution SFD-2005-0##
Email: Mauricio.ortiz@noaa.gov

Introduction:

Indices of abundance from recreational fisheries have been used to tune stock assessment models (Quinn and Deriso 1999). Data collected and estimated by the Marine Recreational Fisheries Statistical Survey (MRFSS) were used to develop standardized catch per unit effort (CPUE) indices for several shark stocks 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 data base 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 report updates the methods applied to the available US recreational data through 2004 and presents number of sharks standardized indices for the blacktip shark, sandbar shark and the Large Coastal Complex (LCC) sharks [Bull shark, spinner shark, blacktip shark, silky shark, sandbar shark, great hammerhead shark, scalloped hammerhead shark, smooth hammerhead shark, lemon shark, tiger shark and nurse shark] stocks. Standardized catch rates were estimated using the Generalized Linear Mixed Model (GLMM) approach.

Materials and methods:

The MRFSS estimates of catch and effort are base 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, or release alive or death, 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 base on demographic and seasonal (wave) considerations by county from Maine through Louisiana, in the Atlantic and US Gulf of Mexico coast. This report does not include MRFSS estimates from the US Caribbean region.

The MRFSS data include estimates of catch and effort from 1981 through 2004 from Louisiana through Maine. Because of reduce number of records for some states, regional areas were defined and used as spatial factor: Central Gulf (LA, AL, MS), Western Gulf (FLW), Florida (FLE), NC-GE (GE, SC, NC), Mid Atlantic (VA, MD, DE, NJ, NY), and New England (CT, RI, MA, NH, ME). 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 assign to un-classified guild. Fishing effort or angler hours was estimated as the number of anglers times the number of hours fishing, and nominal catch rates were defined as the total catch kept and release (AB1B2, number of fish) per thousand angler hours.

Figure 1 shows a summary of the estimated recreational catch and effort from the MRFSS data. For the recreational fisheries, sharks in general represent less than 2% of the catch, being rather constant through the years. Since 1981 fishing effort and recreational catch has increase, by 2004 total angler hours was about 1.2 million or 6 times the effort in 1984. Catch has also increase, with highest values in the recent years (Fig 1). Within the recreational shark catch, the Large Coastal Complex (LCC) was about 20% until the mid 1990's, however the catch of other sharks has increase substantially while the catch of LCC shark has increase a much lower rate (Fig 2). Blacktip and Sandbar sharks made the bulk of the LCC catch (80% on average), however the proportion of LCC catch to total sharks has decrease to just below 10% in the last years (2003/04) (Fig 3).

Standardized indices of abundance were estimated for sandbar shark and the LCC sharks, for blacktip shark indices were estimated for the Gulf of Mexico area and the Atlantic coast area. Sharks relative indices of abundance were estimated by Generalized Linear Modeling approach assuming a delta lognormal model distribution. The standardization protocols assumed a delta model with a binomial error distribution for modeling the proportion of positive sets, and a lognormal error distribution for modeling the mean catch rate of successful (i.e. positive sharks catch) sets. The lognormal frequency distributions from the MRFSS data are shown in Figure 4. Parameterization of the models used the GLM structure; for the proportion of successful observations per stratum was assume to follow a binomial distribution where the estimated probability is a linear function of fixed factors and interactions. The logit function was used as a link between the linear factor component and the binomial error. For successful sets, estimated CPUE rates assumed a lognormal distribution of a linear function of fixed and random effect interactions when the *year* term was within the interaction.

A step-wise regression procedure was used to determine the set of systematic factors and interactions that significantly explained the observed variability. As the deviance difference between two consecutive nested models follows a chi-square (χ^2) distribution, this statistic was used to test for the significance of an additional factor(s) in the model. Deviance tables are presented for each analysis. Each table includes the deviance for the proportion of positive observations, and the deviance for the positive catch rates. Final selection of the explanatory factors was conditional to: a) the relative percent of deviance explained by adding the factor in consideration, normally factors that explained more than 5% were included in the final model, b) the χ^2 test significance, and c) type III test significance within the final specified model. Once a set of fixed factors was specified, possible first level interactions were evaluated in particular random interactions between the *year* effect and other factors. The significance of random interactions was evaluated between nested models by using the likelihood ratio test (Pinheiro and Bates 2000), the Akaike information criteria (AIC), and the Bayesian information criteria (BIC) (Littell et al 1996), where lower values indicate better model fitting. Analyses were done using GLIMMIX and MIXED procedures from the SAS® statistical computer software (SAS Institute Inc. 1997)

Relative indices were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal components. LSmeans estimates were weighted proportional to observed margins in the positive observations data, and for the lognormal estimates, a log-back transformed bias corrections was applied (Lo et al. 1992).

Results and Discussion

The deviance analyses tables for the Atlantic Blacktip shark CPUE standardization from the MRFSS data are shown in Table 1. Table 3 shows the deviance table for the Gulf of Mexico Blacktip shark biomass index derived from the MRFSS data. The standardization analyses indicated that season, mode, region and guild (or target main habitat group) where the main explanatory factors for the proportion of positive sets models. While for the positive catch sets models, the main explanatory factors were area and guild. Of the interactions evaluated, the year*season, and year*region were also important explanatory factors primarily for the positive catch sets models. Tables 2 and 4 present the evaluation of these interactions as random components in the mixed models.

Tables 9 and 10, and Figure 5 show the nominal and standardized CPUE for Atlantic Blacktip shark and Gulf Mexico Blakctip shark from the MRFSS data, respectively. Reviewing index trends for Blacktip shark they present similar behavior for the Atlantic and Gulf of Mexico area. MRFSS data indicates in general an oscillating trend since 1981 through 2004, with broad estimated 95% confidence intervals for both indices, CV (coefficient of variation) averaging 60% for the Atlantic index and 50% for the Gulf of Mexico index.

The deviance analyses tables for the Sandbar shark CPUE standardization from the MRFSS data are shown in Table 5. The MRFSS index standardization analyses indicated that area, season, mode, region and guild where the main explanatory factors for the proportion of positive observations. While for the positive observations model, the main explanatory factors were area, mode, region and guild. Of the interactions evaluated, the year*Area, and year*season, year*mode and year*guild were also important explanatory factors. Table 6 presents the evaluation of these interactions as random components in the mixed models.

Table 11 and Figure 6 show the nominal and standardized CPUE for Sandbar shark from the MRFSS data. Index trends for Sandbar shark indicate a decline in abundance from the early years 1980-85, reaching low values by mid 1990's and continuing that trend through 2004. Lowest Sandbar shark relative abundance was estimated in 2004. Important to mention, that the estimated 95% confidence intervals are quite broad, particularly for the early period of the series, with CV (coefficient of variation) averaging 65%.

Finally, the deviance analyses tables for the LCC sharks CPUE standardization from the MRFSS data are shown in Table 7. Table 8 presents the evaluation of these interactions as random components in the mixed models.

Table 12 and Figure 7 show the nominal and standardized CPUE for LCC sharks from the MRFSS data. Reviewing index trend for LCC sharks it also shows a decline trend from higher values in 1982-86 until mid 1990's when the trend stabilize a lower levels, trend that continues until 2004.

References

LITTELL, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC:SAS Institute Inc., 1996. 663 pp.

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.

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

Quinn, T.J. and R.B. Deriso. 1999. Quantitative fish dynamics. Oxford University Press. New York.

SAS Institute Inc. 1997, SAS/STAT® Software: Changes and Enhancements through Release 6.12. Cary, NC:Sas Institute Inc., 1997. 1167 pp.

Table 1. Deviance analysis table of explanatory variables in the delta lognormal model for Atlantic Blacktip shark catch rates (number of fish per thousand angler hours) from the MRFSS data. Percent of total deviance refers to the deviance explained by the full model; *p* value refers to the Chi-square probability between consecutive models (alpha = 0.05).

BLACKTIP SHARK ATLANTIC MRFSS

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	1459.55			
YEAR	23	1377.24	82.3	29.4%	< 0.001
YEAR area	2	1299.41	77.8	27.8%	< 0.001
YEAR area season	3	1294.78	4.6	1.7%	0.201
YEAR area season mode	2	1282.96	11.8	4.2%	0.003
YEAR area season mode region	2	1278.51	4.4	1.6%	0.108
YEAR area season mode region guild	5	1252.77	25.7	9.2%	< 0.001
YEAR area season mode region guild area*season	6	1249.07	3.7	1.3%	0.716
YEAR area season mode region guild area*guild	10	1247.78	5.0	1.8%	0.892
YEAR area season mode region guild area*mode	3	1246.95	5.8	2.1%	0.121
YEAR area season mode region guild YEAR*region	33	1203.54	49.2	17.6%	0.034
YEAR area season mode region guild YEAR*area	45	1203.49	49.3	17.6%	0.306
YEAR area season mode region guild YEAR*season	60	1203.26	49.5	17.7%	0.831
YEAR area season mode region guild YEAR*mode	42	1198.92	53.9	19.2%	0.104
YEAR area season mode region guild YEAR*guild	93	1179.66	73.1	26.1%	0.937

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	9495.46057			
YEAR	23	9200.47394	295.0	6.8%	< 0.001
YEAR area	2	9137.81733	62.7	1.5%	< 0.001
YEAR area season	3	8693.32109	444.5	10.3%	< 0.001
YEAR area season mode	2	8036.92245	656.4	15.2%	< 0.001
YEAR area season mode region	2	6379.75149	1657.2	38.4%	< 0.001
YEAR area season mode region guild	5	5603.37035	776.4	18.0%	< 0.001
YEAR area season mode region guild area*guild	10	5480.2875	123.1	2.8%	< 0.001
YEAR area season mode region guild YEAR*mode	46	5433.78476	169.6	3.9%	< 0.001
YEAR area season mode region guild area*season	6	5404.24477	199.1	4.6%	< 0.001
YEAR area season mode region guild YEAR*area	46	5394.46923	208.9	4.8%	< 0.001
YEAR area season mode region guild YEAR*season	68	5375.39953	228.0	5.3%	< 0.001
YEAR area season mode region guild YEAR*guild	115	5281.2184	322.2	7.5%	< 0.001
YEAR area season mode region guild YEAR*region	46	5251.20609	352.2	8.2%	< 0.001
YEAR area season mode region guild area*mode	3	5176.66855	426.7	9.9%	< 0.001

Table 2. Analysis of mixed model formulations for Atlantic blacktip shark catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Blacktip shark Atlantic	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year season mode region guild	73620.2	73622.2	73629.3		
Year season mode region guild *Year*season*	73515.3	73519.3	73524.4	104.9	0.0000
Year season mode region guild *Year*season Year*guild*	73515.3	73519.3	73524.4	0	1.0000
Year season mode region guild *Year*season Year*guild Year*region*	71989.3	71995.3	72003	1526	0.0000
Positive Catch					
Year season area mode region guild	4596.4	4598.4	4603.9		
Year season area mode region guild *Year*mode*	4582.9	4586.9	4591.3	13.5	0.0002
Year season area mode region guild *Year*mode Year*guild*	4581.1	4587.1	4593.8	1.8	0.1797
Year season area mode region guild *Year*mode Year*guild Year*season*	4581.1	4587.1	4593.8	0	1.0000
Year season area mode region guild *Year*mode Year*guild Year*season Year*area*	4579.3	4587.3	4596.2	1.8	0.1797
Year season area mode region guild *Year*mode Year*guild Year*season Year*area Yea*	4561.4	4571.4	4582.5	17.9	0.0000

Table 3. Deviance analysis table of explanatory variables in the delta lognormal model for Gulf Mexico Blacktip shark catch rates (number of fish per thousand angler hours) from the MRFFS data. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (alpha = 0.05)

BLACKTIP SHARK GULF MRFSS

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	2549.84			
YEAR	23	2515.90	33.9	7.0%	0.066
YEAR area	2	2446.82	69.1	14.2%	< 0.001
YEAR area season	3	2442.57	4.3	0.9%	0.235
YEAR area season mode	2	2249.60	193.0	39.6%	< 0.001
YEAR area season mode region	1	2226.04	23.6	4.8%	< 0.001
YEAR area season mode region guild	5	2199.17	26.9	5.5%	< 0.001
YEAR area season mode region guild area*season	6	2191.10	8.1	1.7%	0.233
YEAR area season mode region guild area*mode	3	2180.25	18.9	3.9%	< 0.001
YEAR area season mode region guild area*guild	10	2179.58	19.6	4.0%	0.033
YEAR area season mode region guild YEAR*region	23	2145.33	53.8	11.1%	< 0.001
YEAR area season mode region guild YEAR*mode	44	2114.24	84.9	17.4%	< 0.001
YEAR area season mode region guild YEAR*area	45	2113.17	86.0	17.7%	< 0.001
YEAR area season mode region guild YEAR*season	64	2111.45	87.7	18.0%	0.026
YEAR area season mode region guild YEAR*guild	110	2062.95	136.2	28.0%	0.046

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	8098.35737			
YEAR	23	7838.00412	260.4	9.6%	< 0.001
YEAR area	2	7484.09156	353.9	13.0%	< 0.001
YEAR area season	3	6684.45748	799.6	29.4%	< 0.001
YEAR area season mode	2	6258.29787	426.2	15.7%	< 0.001
YEAR area season mode region	1	6254.26826	4.0	0.1%	0.045
YEAR area season mode region guild	5	5635.49162	618.8	22.7%	< 0.001
YEAR area season mode region guild area*mode	3	5574.33577	61.2	2.2%	< 0.001
YEAR area season mode region guild area*season	6	5564.42969	71.1	2.6%	< 0.001
YEAR area season mode region guild YEAR*region	23	5557.65867	77.8	2.9%	< 0.001
YEAR area season mode region guild area*guild	10	5505.90967	129.6	4.8%	< 0.001
YEAR area season mode region guild YEAR*area	46	5441.61037	193.9	7.1%	< 0.001
YEAR area season mode region guild YEAR*season	68	5386.82512	248.7	9.1%	< 0.001
YEAR area season mode region guild YEAR*mode	46	5385.56366	249.9	9.2%	< 0.001
YEAR area season mode region guild YEAR*guild	114	5377.43622	258.1	9.5%	< 0.001

Table 4. Analyses of mixed model formulations for Gulf Mexico Blacktip shark catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Blacktip shark Gulf	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year area season mode guild	40573.6	40575.6	40582.4		
Year area season mode guild *Year*season*	40325.6	40329.6	40334.7	248	0.0000
Year area season mode guild *Year*season Year*area*	40148.7	40154.7	40162.3	176.9	0.0000
Year area season mode guild *Year*season Year*area Year*mode*	40020.8	40028.8	40039	127.9	0.0000
Year area season mode guild *Year*season Year*area Year*mode Year*guild*	39928.6	39938.6	39951.4	92.2	0.0000
Positive Catch					
Year season area mode region guild	6791.8	6793.8	6799.6		
Year season area mode region guild *Year*area*	6770.9	6774.9	6779.4	20.9	0.0000
Year season area mode region guild *Year*area Year*region*	6760.1	6766.1	6772.8	10.8	0.0010
Year season area mode region guild *Year*area Year*region Year*mode*	6747.9	6755.9	6765	12.2	0.0005
Year season area mode region guild *Year*area Year*region Year*mode Year*season*	6738.6	6748.6	6759.9	9.3	0.0023
Year season area mode region guild *Year*area Year*region Year*mode Year*season Y€*	6736.3	6748.3	6761.8	2.3	0.1294

Table 5. Deviance analysis table of explanatory variables in the delta lognormal model for Sandbar shark catch rates (number of fish per thousand angler hours) from the MRFSS data. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (alpha = 0.05).

Sandbar SHARK MRFSS

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	2741.58			
YEAR	23	2651.29	90.3	22.2%	< 0.001
YEAR area	2	2620.45	30.8	7.6%	< 0.001
YEAR area season	3	2616.42	4.0	1.0%	0.258
YEAR area season mode	2	2526.64	89.8	22.1%	< 0.001
YEAR area season mode region	5	2495.65	31.0	7.6%	< 0.001
YEAR area season mode region guild	5	2471.39	24.3	6.0%	< 0.001
YEAR area season mode region guild area*season	6	2467.73	3.7	0.9%	0.723
YEAR area season mode region guild area*mode	3	2462.73	8.7	2.1%	0.034
YEAR area season mode region guild area*guild	10	2451.90	19.5	4.8%	0.035
YEAR area season mode region guild YEAR*season	57	2388.78	82.6	20.3%	0.015
YEAR area season mode region guild YEAR*mode	46	2379.40	92.0	22.6%	< 0.001
YEAR area season mode region guild YEAR*area	46	2377.02	94.4	23.2%	< 0.001
YEAR area season mode region guild YEAR*guild	107	2341.62	129.8	31.9%	0.066
YEAR area season mode region guild YEAR*region	98	2334.61	136.8	33.6%	0.006

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	15210.6591			
YEAR	23	14096.9538	1113.7	14.7%	< 0.001
YEAR area	2	13719.2429	377.7	5.0%	< 0.001
YEAR area season	3	12431.8361	1287.4	17.0%	< 0.001
YEAR area season mode	2	11794.6005	637.2	8.4%	< 0.001
YEAR area season mode region	5	9068.68483	2725.9	36.0%	< 0.001
YEAR area season mode region guild	5	8280.65609	788.0	10.4%	< 0.001
YEAR area season mode region guild area*season	6	8158.29806	122.4	1.6%	< 0.001
YEAR area season mode region guild area*mode	3	8135.40466	145.3	1.9%	< 0.001
YEAR area season mode region guild YEAR*mode	46	8080.72449	199.9	2.6%	< 0.001
YEAR area season mode region guild YEAR*season	68	7940.51927	340.1	4.5%	< 0.001
YEAR area season mode region guild area*guild	10	7918.07823	362.6	4.8%	< 0.001
YEAR area season mode region guild YEAR*guild	115	7822.85718	457.8	6.0%	< 0.001
YEAR area season mode region guild YEAR*area	46	7661.33803	619.3	8.2%	< 0.001
YEAR area season mode region guild YEAR*region	115	7630.62705	650.0	8.6%	< 0.001

Table 6. Analysis of mixed model formulations for Sandbar shark catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

Sandbar shark Atlantic	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year area season mode region guild	145448.6	145450.6	145458.3		
Year area season mode region guild *Year*area*	144285.0	144289.0	144293.5	1163.6	0.0000
Year area season mode region guild *Year*area Year*season*	142583.6	142589.6	142596.4	1701.4	0.0000
Year area season mode region guild *Year*area Year*season Year*region*	140796.8	140804.8	140813.9	1786.8	0.0000
Year area season mode region guild *Year*area Year*season Year*region Year*guild*	138638.0	138648.0	138659.4	2158.8	0.0000
Positive Catch					
Year season area mode region guild	8076.1	8078.1	8084.1		
Year season area mode region guild *Year*guild*	8071.2	8075.2	8081	4.9	0.0269
Year season area mode region guild *Year*guild Year*area*	8046.8	8052.8	8061.6	24.4	0.0000
Year season area mode region guild *Year*guild Year*area Year*region*	8035.3	8043.3	8055	11.5	0.0007
Year season area mode region guild *Year*guild Year*area Year*region Year*mode*	8024.1	8034.1	8048.7	11.2	0.0008
Year season area mode region guild *Year*guild Year*area Year*region Year*mode Year*season*	8015.5	8027.5	8045	8.6	0.0034

Table 7. Deviance analysis table of explanatory variables in the delta lognormal model for Large Coastal Complex shark catch rates (number of fish per thousand angler hours) from the MRFSS data. Percent of total deviance refers to the deviance explained by the full model; p value refers to the Chi-square probability between consecutive models (alpha = 0.05).

LCC SHARK MRFSS

Model factors positive catch rates values	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	8505.94			
YEAR	23	8430.35	75.6	5.1%	< 0.001
YEAR area	2	8065.65	364.7	24.5%	< 0.001
YEAR area season	3	8020.59	45.1	3.0%	< 0.001
YEAR area season mode	2	7705.50	315.1	21.1%	< 0.001
YEAR area season mode region	5	7407.16	298.3	20.0%	< 0.001
YEAR area season mode region guild	5	7332.46	74.7	5.0%	< 0.001
YEAR area season mode region guild area*season	6	7322.91	9.6	0.6%	0.145
YEAR area season mode region guild area*mode	3	7290.75	41.7	2.8%	< 0.001
YEAR area season mode region guild area*guild	10	7278.83	53.6	3.6%	< 0.001
YEAR area season mode region guild YEAR*season	68	7228.13	104.3	7.0%	0.003
YEAR area season mode region guild YEAR*area	46	7225.94	106.5	7.1%	< 0.001
YEAR area season mode region guild YEAR*mode	46	7219.86	112.6	7.6%	< 0.001
YEAR area season mode region guild YEAR*guild	114	7164.74	167.7	11.2%	< 0.001
YEAR area season mode region guild YEAR*region	110	7014.87	317.6	21.3%	< 0.001

Model factors proportion of positive / total obs	degrees of freedom	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	29604.1419			
YEAR	23	28793.8354	810.3	7.7%	< 0.001
YEAR area	2	27875.7258	918.1	8.7%	< 0.001
YEAR area season	3	26361.0846	1514.6	14.4%	< 0.001
YEAR area season mode	2	24512.1252	1849.0	17.6%	< 0.001
YEAR area season mode region	5	21984.4239	2527.7	24.0%	< 0.001
YEAR area season mode region guild	5	20060.4904	1923.9	18.3%	< 0.001
YEAR area season mode region guild YEAR*mode	46	19813.8262	246.7	2.3%	< 0.001
YEAR area season mode region guild YEAR*season	68	19750.3222	310.2	2.9%	< 0.001
YEAR area season mode region guild area*season	6	19587.8882	472.6	4.5%	< 0.001
YEAR area season mode region guild area*mode	3	19574.8062	485.7	4.6%	< 0.001
YEAR area season mode region guild YEAR*guild	115	19552.3034	508.2	4.8%	< 0.001
YEAR area season mode region guild YEAR*area	46	19494.7585	565.7	5.4%	< 0.001
YEAR area season mode region guild area*guild	10	19314.5765	745.9	7.1%	< 0.001
YEAR area season mode region guild YEAR*region	115	19083.7552	976.7	9.3%	< 0.001

Table 8. Analysis of mixed model formulations for Large Coastal Complex shark catch rates from the MRFSS data. Likelihood ratio tests the difference of –2 REM log likelihood between two nested models.

LCC sharks	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year area season mode region guild	110968.9	110970.9	110978.6		
Year area season mode region guild *Year*area*	110443.6	110447.6	110452.2	525.3	0.0000
Year area season mode region guild *Year*area Year*season*	110299.1	110305.1	110312.0	144.5	0.0000
Year area season mode region guild *Year*area Year*season Year*region*	109307.0	109315.0	109324.1	992.1	0.0000
Year area season mode region guild *Year*area Year*season Year*region Year*guild*	109097.4	109107.4	109118.8	209.6	0.0000
Positive Catch					
Year season area mode region guild	23300.8	23302.8	23309.9		
Year season area mode region guild *Year*guild*	23283.5	23287.5	23293.4	17.3	0.0000
Year season area mode region guild *Year*guild Year*area*	23257.0	23263.0	23271.9	26.5	0.0000
Year season area mode region guild *Year*guild Year*area Year*region Year*mode*	23229.9	23237.9	23249.8	27.1	0.0000
Year season area mode region guild *Year*guild Year*area Year*region Year*mode Year*season*	23216.2	23226.2	23241.0	13.7	0.0002
Year season area mode region guild *Year*guild Year*area Year*region Year*mode Year*season Year*region*	23091.5	23103.5	23121.3	124.7	0.0000

Table 9. Nominal and standard Atlantic blacktip shark CPUE series (shark/ thousand angler hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	10813	0.430	0.312	102.3%	1.046	0.193	5.686
1982	14591	0.280	0.158	78.7%	0.531	0.132	2.129
1983	18073	0.541	0.354	71.8%	1.186	0.327	4.308
1984	13606	0.646	0.341	74.7%	1.145	0.302	4.339
1985	23432	0.583	0.383	62.1%	1.285	0.410	4.027
1986	23881	0.881	0.425	57.7%	1.427	0.488	4.170
1987	25964	1.143	0.225	63.7%	0.755	0.235	2.424
1988	27465	0.623	0.172	68.1%	0.578	0.168	1.985
1989	37253	0.269	0.169	68.4%	0.567	0.164	1.957
1990	37496	0.184	0.126	75.5%	0.421	0.110	1.613
1991	45441	0.309	0.223	62.7%	0.748	0.237	2.369
1992	49088	0.934	0.370	54.5%	1.243	0.448	3.449
1993	47643	0.330	0.156	68.7%	0.523	0.151	1.814
1994	56305	1.843	0.675	51.1%	2.264	0.863	5.937
1995	51153	0.632	0.310	57.7%	1.039	0.356	3.037
1996	54557	1.142	0.294	57.7%	0.986	0.338	2.878
1997	55428	0.602	0.154	66.0%	0.515	0.155	1.716
1998	54419	1.230	0.353	54.6%	1.183	0.426	3.287
1999	54207	0.540	0.160	63.3%	0.536	0.168	1.711
2000	53246	1.525	0.261	58.3%	0.877	0.298	2.587
2001	65976	2.049	0.516	52.9%	1.730	0.641	4.672
2002	62720	1.495	0.356	55.0%	1.196	0.428	3.344
2003	59168	1.277	0.372	56.0%	1.249	0.440	3.549
2004	52827	1.275	0.289	58.5%	0.969	0.327	2.869

Table 10. Nominal and standard Gulf Mexico blacktip shark CPUE series (shark/ thousand angler hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	4295	1.870	1.848	56.5%	1.358	0.474	3.891
1982	7693	0.675	0.442	55.7%	0.325	0.115	0.918
1983	5111	2.262	1.537	55.5%	1.130	0.401	3.184
1984	6106	0.745	0.915	55.3%	0.673	0.240	1.890
1985	6859	0.992	1.110	50.5%	0.816	0.315	2.119
1986	13900	3.280	1.975	40.6%	1.452	0.664	3.172
1987	13314	2.084	0.865	44.1%	0.636	0.274	1.476
1988	14640	2.627	1.794	40.0%	1.319	0.610	2.852
1989	10662	1.762	1.614	43.6%	1.186	0.515	2.734
1990	9055	3.079	1.793	42.8%	1.318	0.580	2.996
1991	10940	2.226	2.009	41.9%	1.477	0.660	3.304
1992	23531	1.863	1.193	39.1%	0.877	0.412	1.864
1993	20464	1.237	1.051	41.8%	0.772	0.346	1.724
1994	23276	1.131	0.987	40.9%	0.726	0.331	1.593
1995	21138	0.980	1.397	40.9%	1.027	0.467	2.256
1996	21870	1.855	1.576	40.3%	1.159	0.533	2.519
1997	22964	2.042	1.483	40.1%	1.090	0.504	2.359
1998	28996	3.205	2.001	37.2%	1.471	0.716	3.023
1999	40041	1.050	1.003	38.2%	0.737	0.352	1.544
2000	37500	2.400	1.712	37.0%	1.259	0.615	2.576
2001	37313	1.104	0.899	39.0%	0.661	0.312	1.403
2002	38812	1.450	0.979	38.1%	0.719	0.344	1.503
2003	39357	1.537	1.447	37.8%	1.064	0.512	2.208
2004	40865	1.445	1.016	38.7%	0.747	0.354	1.577

Table 11. Nominal and standard Sandbar shark CPUE series (shark/ thousand angler hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	0.973	0.528	64.5%	2.011	0.618	6.540
1982	26893	1.170	0.576	59.2%	2.195	0.734	6.567
1983	28116	3.923	0.726	59.2%	2.766	0.925	8.272
1984	24574	1.758	0.632	61.0%	2.408	0.782	7.416
1985	33371	2.006	0.550	59.1%	2.094	0.701	6.255
1986	41588	3.137	0.556	56.0%	2.119	0.745	6.024
1987	43859	1.393	0.306	59.4%	1.167	0.389	3.504
1988	51559	1.399	0.207	62.1%	0.789	0.252	2.471
1989	58508	0.447	0.187	63.9%	0.714	0.222	2.301
1990	58499	1.369	0.166	67.4%	0.634	0.186	2.153
1991	68303	0.601	0.113	67.9%	0.431	0.126	1.479
1992	84852	0.746	0.229	60.0%	0.874	0.288	2.649
1993	81424	1.040	0.105	67.9%	0.402	0.117	1.377
1994	92037	0.312	0.064	77.6%	0.243	0.061	0.958
1995	86144	0.671	0.129	64.3%	0.492	0.152	1.595
1996	87745	0.639	0.161	61.7%	0.612	0.196	1.907
1997	91863	0.908	0.132	66.3%	0.504	0.151	1.687
1998	97968	0.718	0.241	60.3%	0.917	0.301	2.795
1999	108626	0.520	0.138	63.9%	0.524	0.163	1.689
2000	103608	0.319	0.138	66.0%	0.525	0.158	1.747
2001	118660	0.572	0.132	65.1%	0.503	0.153	1.652
2002	115251	0.844	0.129	65.6%	0.490	0.148	1.619
2003	114031	0.429	0.101	71.4%	0.386	0.107	1.393
2004	106004	0.120	0.053	83.6%	0.201	0.047	0.862

Table 12. Nominal and standard Large Coastal Complex (LCC) shark CPUE series (shark/ thousand angler hours) from the MRFSS data.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	1.991	1.714	38.9%	1.266	0.597	2.682
1982	26893	2.275	1.629	35.9%	1.203	0.599	2.414
1983	28116	5.363	2.616	35.1%	1.932	0.977	3.820
1984	24574	2.571	2.122	36.5%	1.567	0.773	3.179
1985	33371	3.192	2.272	34.8%	1.678	0.854	3.298
1986	41588	5.557	2.516	32.9%	1.858	0.978	3.529
1987	43859	3.165	1.525	33.7%	1.127	0.585	2.171
1988	51559	2.617	1.280	34.2%	0.945	0.486	1.840
1989	58508	1.185	1.018	35.2%	0.752	0.379	1.490
1990	58499	2.204	1.109	35.0%	0.819	0.415	1.615
1991	68303	1.278	1.045	34.7%	0.772	0.393	1.514
1992	84852	2.081	1.181	33.3%	0.872	0.456	1.668
1993	81424	1.876	0.938	34.2%	0.693	0.356	1.347
1994	92037	1.902	0.919	34.2%	0.679	0.349	1.320
1995	86144	1.446	1.086	33.9%	0.802	0.415	1.552
1996	87745	2.238	1.108	33.8%	0.818	0.424	1.579
1997	91863	1.892	0.936	34.7%	0.692	0.353	1.357
1998	97968	2.532	1.474	32.8%	1.089	0.574	2.064
1999	108626	1.282	0.899	33.8%	0.664	0.344	1.284
2000	103608	2.119	1.104	33.4%	0.815	0.426	1.561
2001	118660	2.327	1.160	33.3%	0.857	0.448	1.640
2002	115251	2.416	1.120	33.3%	0.828	0.432	1.584
2003	114031	1.743	1.105	33.5%	0.816	0.425	1.567
2004	106004	1.492	0.619	35.3%	0.457	0.230	0.907

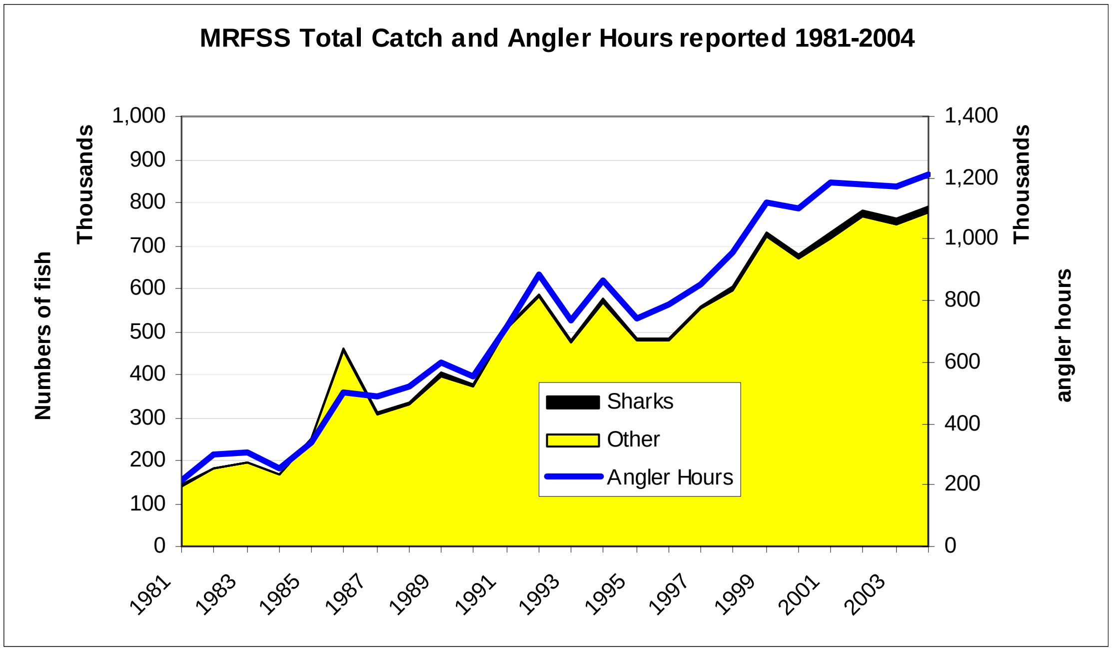


Figure 1. Estimated total annual catch of all finfish species and sharks from the MRFSS data. Solid line represents estimated effort (angler hours) of recreational fishing.

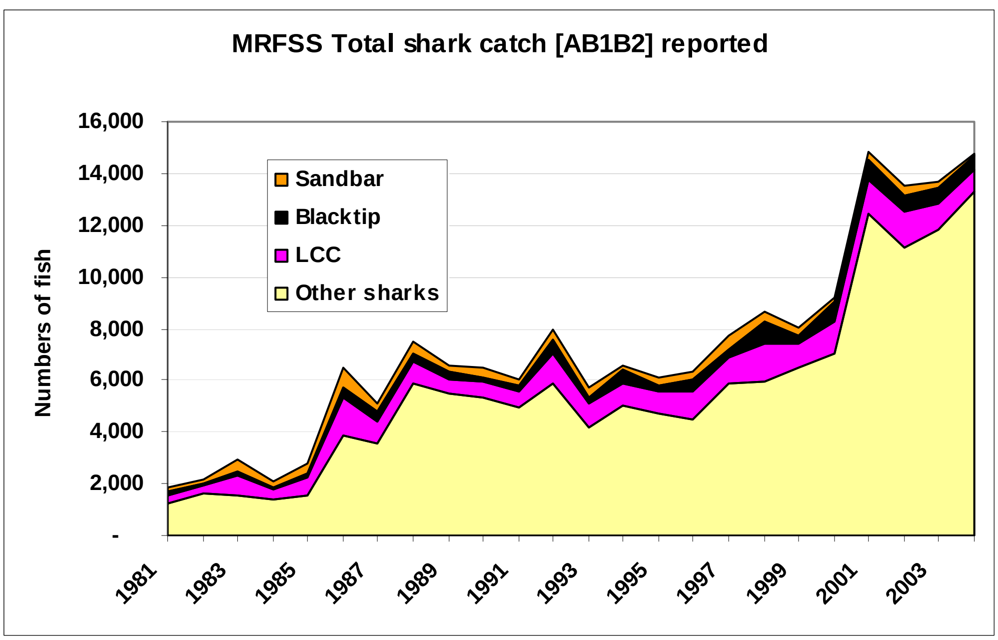


Figure 2. Estimated annual catch distribution of sharks from the MRFSS data by species and group.

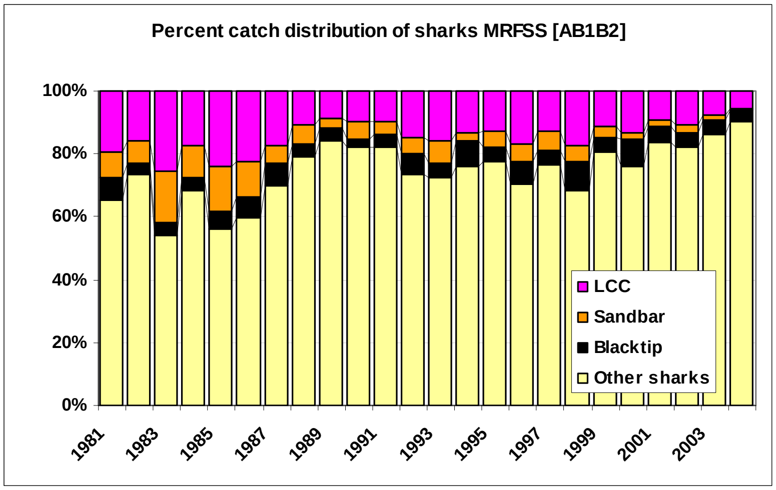


Figure 3. Proportion distribution of shark catches of Blacktip, Sandbar shark and Large Coastal Complex sharks of the total recreational shark catches (MRFSS data).

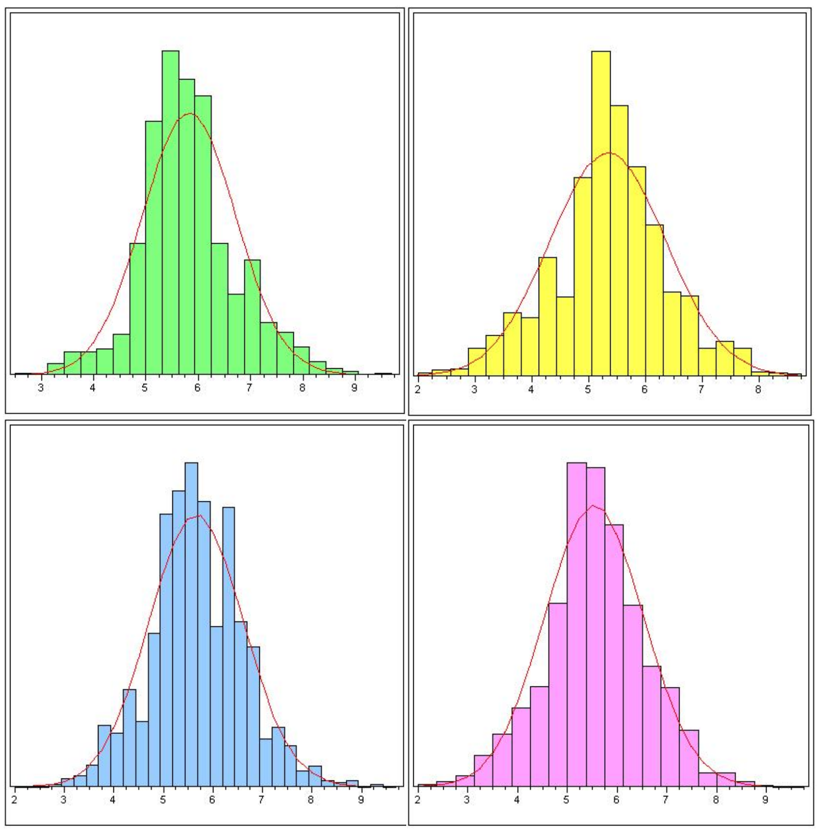
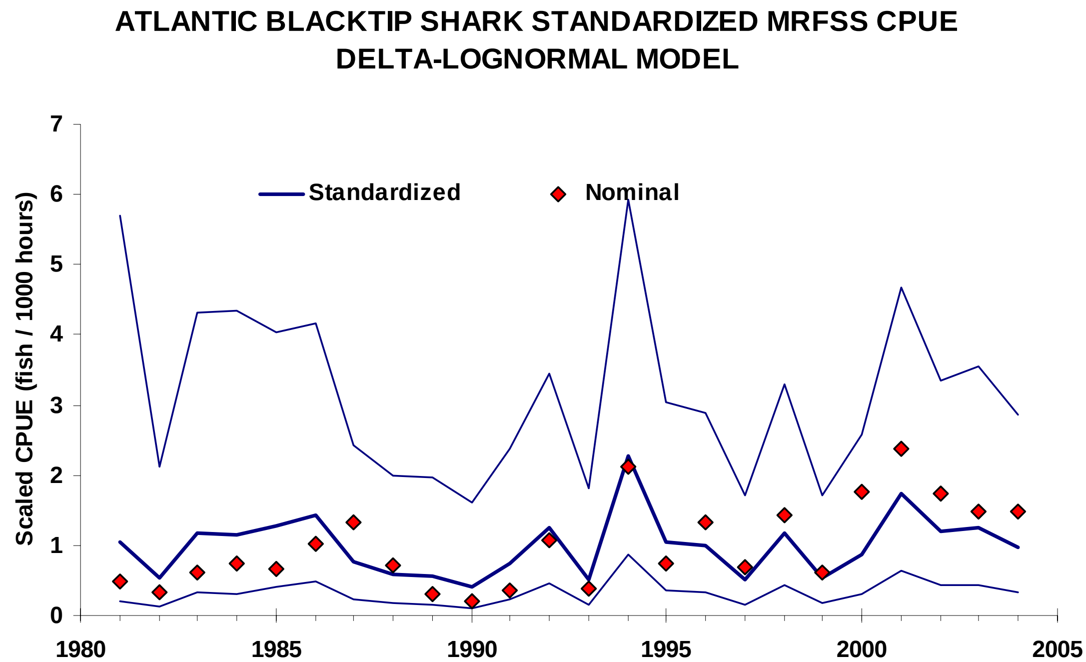


Figure 4. Density frequency distribution of positive catch (logCPUE) for Atlantic Blacktip, Gulf Mexico Blacktip (top), Sandbar shark and Large Coastal Complex sharks (bottom) from the MRFSS data



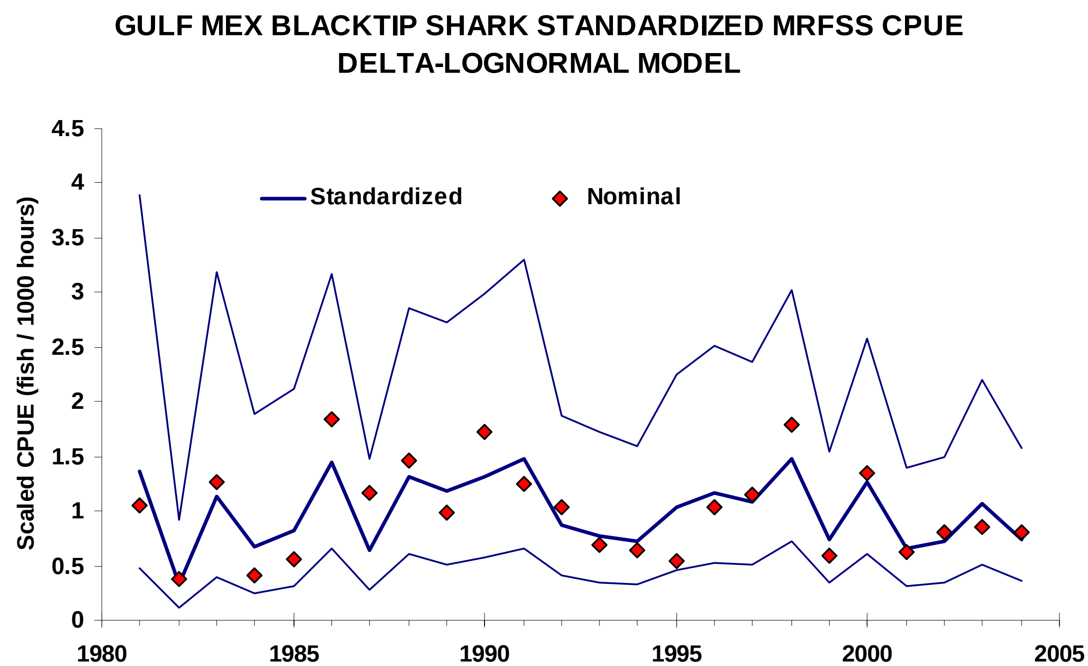


Figure 5 Nominal (solid diamonds) and standard CPUE for Atlantic Blacktip and Gulf Mexico Blacktip shark from the MRFSS data. Outer lines represent upper and lower estimated 95% confidence intervals for the scaled CPUE value**.** Series are scaled to their corresponding mean.

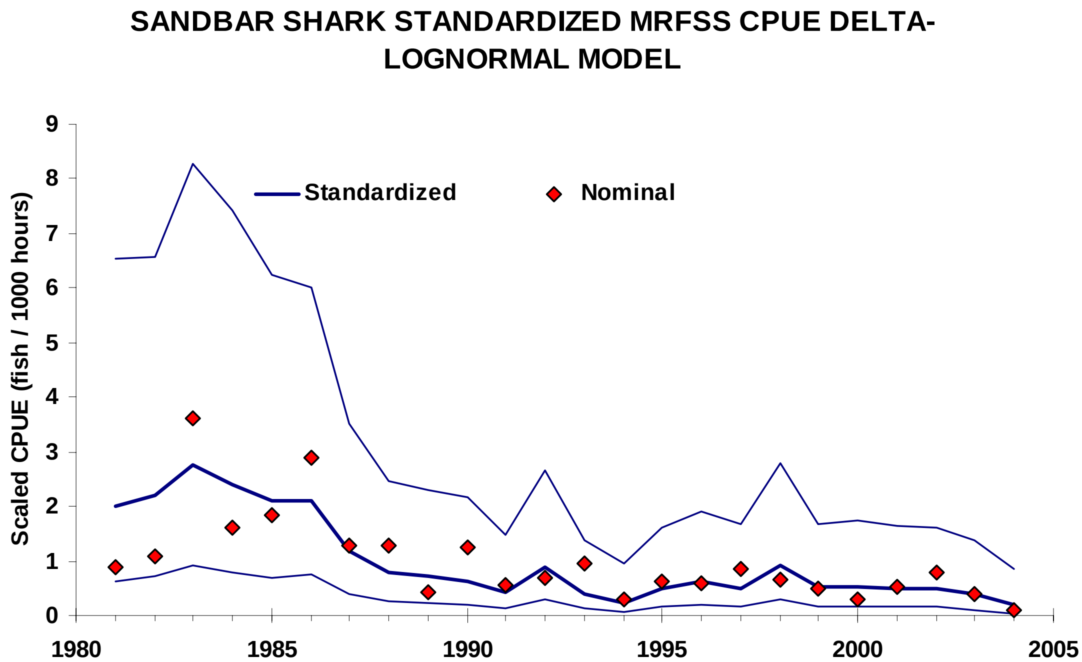


Figure 6. Nominal (solid diamonds) and standard CPUE for Sandbar shark from the MRFSS data. Outer lines represent upper and lower estimated 95% confidence intervals for the scaled CPUE

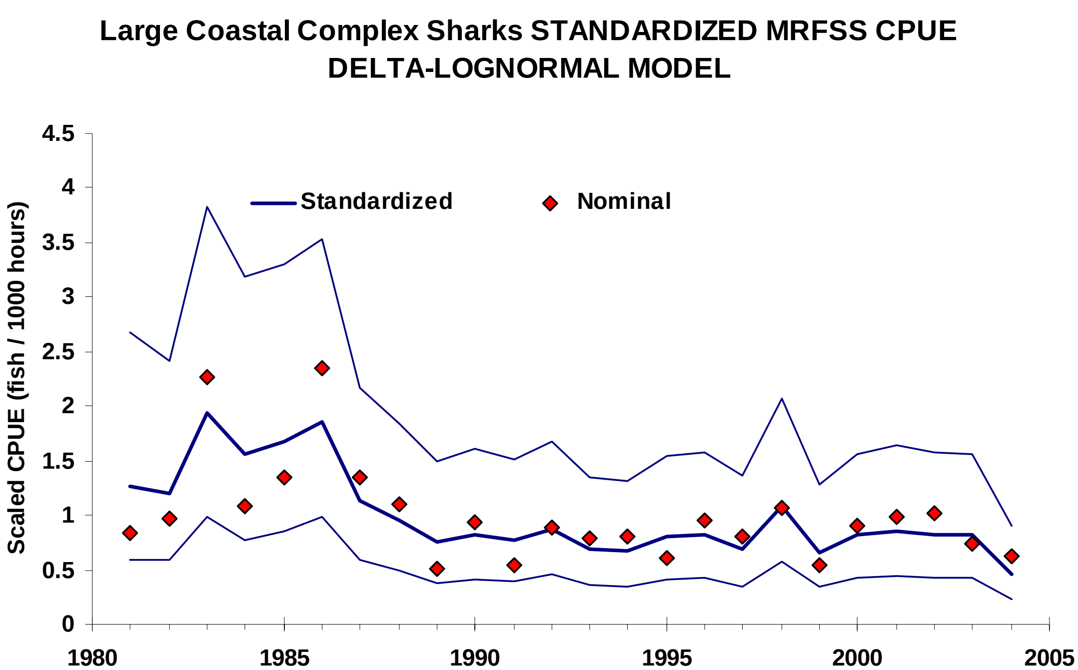


Figure 7. Nominal (solid diamond) and standard CPUE for Large Coastal Complex sharks from the MRFSS data. Outer lines represent upper and lower estimated 95% confidence intervals for the scaled CPUE value. Series are scaled to their corresponding mean.

Appendix

Response to recommendations by the Data workshop Large Coastal Sharks Complex regarding indices of abundance derived from MRFSS databases.

Issue 1. For the MRFSS index of LCC evaluate the following scenarios: i) all large coastals, ii) all LCC minus prohibited species, iii) all LCC minus prohibited species minus sandbar and blacktip sharks.

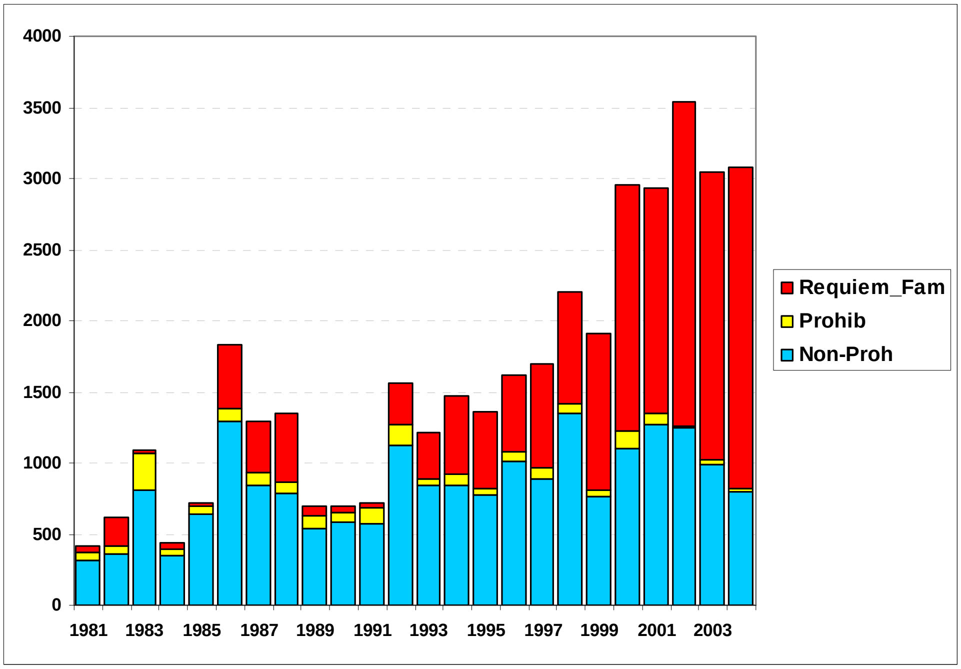
The revision and evaluation of catch rates for large coastal shark complex used the species definition of LCC given in table 4 of LCS05/06-DW-08[1], distinguishing between prohibited and non-prohibited species.

Table 4. List of species that are large coastal sharks (LCC), including those that are prohibited.

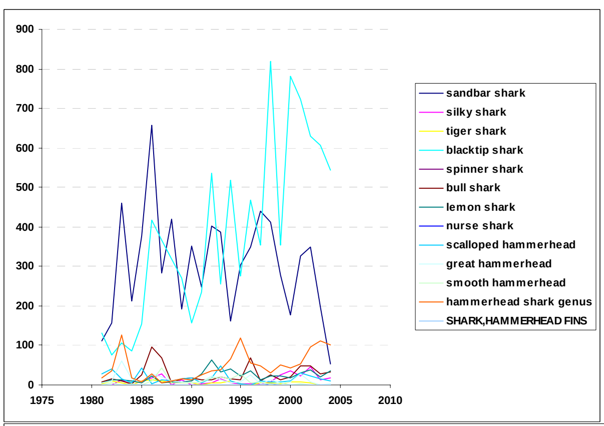
Common name	***Species name***
Non-prohibited species	
Sandbar	*Carcharhinus plumbeus*
Silky	*Carcharhinus falciformis*
Tiger	*Galeocerdo cuvier*
Blacktip	*Cancharhinus limbatus*
Spinner	*Carcharhinus brevipinna*
Bull	*Carcharhinus leucas*
Lemon	*Negaprion brevirostris*
Nurse	*Ginglymostoma cirratum*
Scalloped hammerhead	*Sphyrna lewini*
Great hammerhead	*Sphyrna mokarran*
Smooth hammerhead	*Sphyrna zygaena*
Prohibited Species	
Sand tiger	*Odontaspis taurus*
Bigeye sand tiger	*Odontaspis noronhai*
Whale	*Rhincodon typus*
Basking	*Cetorhinus maximus*
White	*Carcharodon carcharias*
Dusky	*Carcharhinus obscurus*
Bignose	*Carcharhinus altimus*
Galapagos	*Carcharhinus galapagensis*
Night	*Carcharhinus signatus*
Caribbean reef	*Carcharhinus perezi*
Narrowtooth	*Carcharhinus brachyurus*

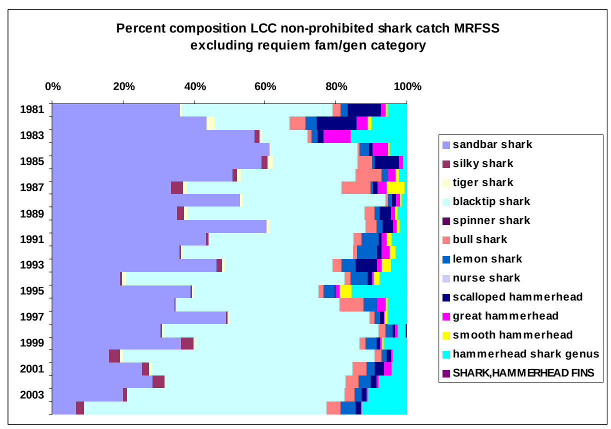
Of the 22 shark species detailed in table 4, the MRFSS data reported only 18 species ever caught. The bigeye sand tiger (*Odontaspis noronhai*), whale (*Rhincodon typus*), Galapagos (*Carcharhinus galapagensis*) and narrowtooth (*Carcharhinus brachyurus*) have been not reported in the MRFSS data ever caught. However, within the MRFSS data there are other categories that can potentially represent catches of LCC sharks. These categories included: hammerhead shark genus, hammerhead shark fins, requiem shark family, and requiem shark genus. In general these additional categories are not problem if total catches are insignificant, or relative consistent through the time period.

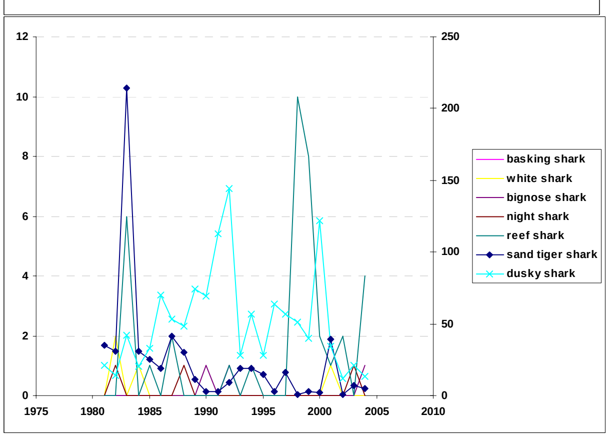
[1] Brewster-Geisz, K. 2005. A summary of the management of Atlantic Large Coastal Sharks. LCS05/06-DW-08.

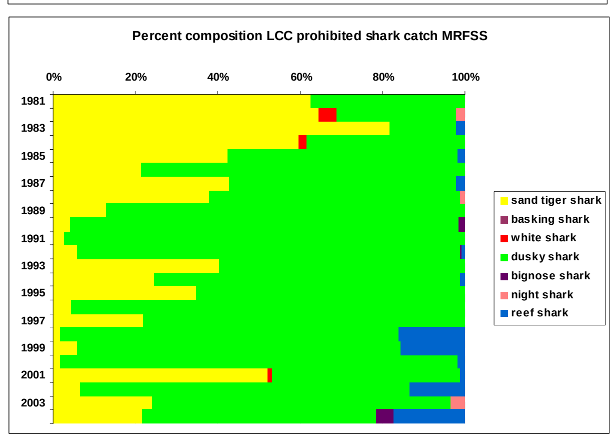


The Figure above show the breakdown of total catch (AB1B2) of MRFSS data by groups of LCC sharks. Unfortunately the catches reported under the categories requiem family/genus is quite large, and increasing in proportion since 1985, by 2004 they represent about 73% of the total LCC catch.









In the case of the hammerheads genus and fins (only reported in one year 2 observations), the catches are very low. The catch of non-prohibited species is dominated by catches of sandbar and blacktip sharks (see following figure, up to 80%), while the remaining of species account for 20%, with hammerheads and silky shark being the predominant species. The recreational catches of prohibited LCC sharks is small, averaging 6% of total LCC catch, the composition catch for prohibited species show that sand tiger and dusky shark are the main prohibited species caught.

The working group request to review standard catch rates for the LCC shark complex broken down by non-prohibited and prohibited species. And catch rates of non-prohibited without the sandbar and blacktip shark catches. The important decision is whether to include or not the requiem family/genus category catches in the LCC shark complex. For comparison, analyses were done for both scenarios; a) including requiem category, and b) excluding the requiem category. For practical purposes, requiem category was assigned to the non-prohibited species groups.

Tables 1-2 and Figure 1 presents the standardized catch series for the LCC shark complex, all species (non-prohibited + prohibited) including or not the requiem category catches. It is clear that the inclusion of the requiem category has a significant impact in the trend of the standard catch rates, particularly after 1990. If the LCC category include catch recorded as requiem category, the trend indicates increase of abundance in latest years, compare to 1990. As expected, this effect was also important in the case of non-prohibited shark species (Tables 3-4, Figure 2), this scenario address the request of the working group of catch trends without prohibited species. For comparison, catch trend of prohibited species is shown in Table 5 and Figure 3. It was attempt to standardized catch rates of non-prohibited shark species excluding the sandbar and blakctip shark catches, however the proportion of positive catch for the remaining species is very low (below 0.1%) in all years, and the model did not converge to a solution.

The important clarification deals with the requiem category catches, first what species or non-identified species most likely are counted/reported under this category, and why has increased in proportion compared to identified-species in the latest years. It is recommended that this issue be further clarify if indices of abundance from the MRFSS data would be used.

Table 1. Standard catch rates of LCC all species (excluding the requiem category) from the MRFSS db.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	2.816	2.475	35.7%	1.505	0.752	3.010
1982	26893	2.813	2.136	33.7%	1.298	0.674	2.501
1983	28116	6.963	3.205	33.2%	1.948	1.020	3.721
1984	24574	3.104	2.628	34.5%	1.597	0.817	3.121
1985	33371	3.617	2.646	33.1%	1.608	0.844	3.064
1986	41588	6.087	2.833	31.5%	1.722	0.931	3.185
1987	43859	3.637	1.813	32.1%	1.102	0.589	2.062
1988	51559	2.968	1.566	32.5%	0.952	0.505	1.795
1989	58508	1.489	1.228	33.4%	0.747	0.390	1.430
1990	58499	2.417	1.253	33.3%	0.762	0.399	1.456
1991	68303	1.584	1.332	32.7%	0.810	0.428	1.531
1992	84852	2.391	1.459	31.6%	0.887	0.478	1.645
1993	81424	2.058	1.106	32.6%	0.672	0.356	1.269
1994	92037	2.210	1.163	32.4%	0.707	0.376	1.329
1995	86144	1.854	1.396	32.1%	0.848	0.454	1.586
1996	87745	2.513	1.321	32.2%	0.803	0.428	1.505
1997	91863	2.172	1.195	32.7%	0.726	0.384	1.373
1998	97968	2.773	1.649	31.4%	1.003	0.542	1.853
1999	108626	1.431	1.090	32.2%	0.663	0.353	1.243
2000	103608	2.335	1.324	31.8%	0.805	0.432	1.498
2001	118660	2.582	1.307	31.9%	0.794	0.426	1.480
2002	115251	2.656	1.286	31.9%	0.782	0.420	1.456
2003	114031	2.068	1.337	31.9%	0.813	0.436	1.515
2004	106004	1.733	0.738	33.6%	0.448	0.233	0.862

Table 2. Standard catch rates of LCC all species (including the requiem category) from the MRFSS db.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	3.140	2.226	35.0%	1.002	0.508	1.976
1982	26893	4.002	2.530	31.6%	1.139	0.614	2.111
1983	28116	7.060	3.021	31.9%	1.359	0.730	2.531
1984	24574	3.303	2.477	33.2%	1.115	0.584	2.127
1985	33371	3.754	2.412	31.9%	1.086	0.582	2.024
1986	41588	6.874	2.758	29.9%	1.241	0.691	2.229
1987	43859	5.186	2.088	30.5%	0.940	0.518	1.706
1988	51559	4.676	1.804	31.1%	0.812	0.443	1.489
1989	58508	1.730	1.177	32.8%	0.530	0.279	1.005
1990	58499	2.585	1.153	32.8%	0.519	0.274	0.984
1991	68303	1.639	1.172	32.2%	0.528	0.281	0.990
1992	84852	2.916	1.479	30.4%	0.665	0.367	1.207
1993	81424	2.890	1.521	30.7%	0.685	0.376	1.247
1994	92037	3.393	1.962	29.8%	0.883	0.492	1.583
1995	86144	3.031	2.218	29.6%	0.998	0.559	1.782
1996	87745	3.796	1.999	30.0%	0.900	0.501	1.617
1997	91863	3.773	1.997	30.1%	0.899	0.498	1.620
1998	97968	4.506	2.394	29.2%	1.077	0.608	1.910
1999	108626	3.501	2.065	29.5%	0.929	0.522	1.656

2000	103608	5.597	2.524	29.1%	1.136	0.642	2.009
2001	118660	5.444	2.750	28.9%	1.238	0.702	2.181
2002	115251	6.900	2.995	28.6%	1.348	0.769	2.363
2003	114031	6.176	3.361	28.6%	1.513	0.863	2.650
2004	106004	6.366	3.250	28.8%	1.462	0.832	2.570

Table 3. Standard catch rates of LCC non-prohibited shark species excluding the requiem category from the MRFSS db.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	0.973	0.457	60.0%	1.807	0.596	5.477
1982	26893	1.170	0.461	54.3%	1.820	0.658	5.034
1983	28116	3.923	0.651	54.7%	2.571	0.924	7.154
1984	24574	1.758	0.625	55.8%	2.468	0.871	6.994
1985	33371	2.006	0.479	54.4%	1.895	0.684	5.248
1986	41588	3.137	0.621	51.0%	2.453	0.937	6.421
1987	43859	1.393	0.295	53.6%	1.165	0.427	3.183
1988	51559	1.399	0.241	54.0%	0.953	0.347	2.621
1989	58508	0.447	0.188	56.3%	0.742	0.260	2.119
1990	58499	1.369	0.140	60.0%	0.552	0.182	1.672
1991	68303	0.601	0.142	57.4%	0.563	0.194	1.637
1992	84852	0.746	0.231	53.2%	0.913	0.337	2.476
1993	81424	1.040	0.097	57.3%	0.384	0.132	1.115
1994	92037	0.312	0.056	63.3%	0.220	0.069	0.702
1995	86144	0.671	0.147	54.5%	0.581	0.210	1.610
1996	87745	0.639	0.183	53.5%	0.721	0.265	1.967
1997	91863	0.908	0.166	56.3%	0.656	0.229	1.874
1998	97968	0.722	0.222	53.8%	0.876	0.320	2.399
1999	108626	0.520	0.140	54.8%	0.553	0.199	1.541
2000	103608	0.319	0.126	56.8%	0.498	0.173	1.436
2001	118660	0.572	0.132	55.8%	0.520	0.184	1.474
2002	115251	0.844	0.125	56.1%	0.493	0.173	1.402
2003	114031	0.429	0.103	59.7%	0.407	0.135	1.229
2004	106004	0.120	0.048	66.3%	0.189	0.056	0.631

Table 4. Standard catch rates of LCC non-prohibited species including the requiem category from the MRFSS db.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	2.567	1.779	37.0%	0.884	0.432	1.809
1982	26893	3.709	2.208	32.5%	1.097	0.582	2.066
1983	28116	5.728	2.619	32.8%	1.301	0.687	2.464
1984	24574	2.940	2.156	34.1%	1.071	0.552	2.081
1985	33371	3.383	2.139	32.7%	1.063	0.561	2.012
1986	41588	6.463	2.529	30.5%	1.256	0.692	2.281
1987	43859	4.729	1.828	31.2%	0.908	0.493	1.672
1988	51559	4.376	1.589	31.8%	0.789	0.424	1.470
1989	58508	1.460	1.003	34.0%	0.498	0.257	0.965
1990	58499	2.418	1.072	33.6%	0.533	0.277	1.024
1991	68303	1.401	0.994	33.4%	0.494	0.258	0.947
1992	84852	2.717	1.289	31.2%	0.641	0.348	1.179
1993	81424	2.814	1.407	31.2%	0.699	0.380	1.286

1994	92037	3.255	1.769	30.4%	0.879	0.484	1.594
1995	86144	2.930	2.080	30.1%	1.033	0.573	1.863
1996	87745	3.676	1.817	30.5%	0.903	0.497	1.640
1997	91863	3.624	1.828	30.7%	0.908	0.498	1.656
1998	97968	4.355	2.219	29.7%	1.102	0.616	1.973
1999	108626	3.431	1.919	30.0%	0.953	0.530	1.715
2000	103608	5.457	2.312	29.6%	1.149	0.643	2.053
2001	118660	5.296	2.610	29.3%	1.297	0.730	2.304
2002	115251	6.864	2.865	29.1%	1.423	0.805	2.516
2003	114031	6.074	3.178	29.0%	1.579	0.894	2.789
2004	106004	6.325	3.102	29.2%	1.541	0.870	2.730

Table 5. Standard catch rates of LCC Prohibited shark species from the MRFSS db.

Year	N obs	Nominal	Standardized	Coeff Var	Index	95% confidence intervals	
1981	18572	0.573	0.397	60.3%	2.954	0.970	9.000
1982	26893	0.293	0.203	64.8%	1.513	0.463	4.944
1983	28116	1.331	0.273	63.2%	2.031	0.637	6.479
1984	24574	0.363	0.201	70.7%	1.497	0.419	5.349
1985	33371	0.371	0.272	60.9%	2.023	0.657	6.224
1986	41588	0.411	0.193	61.9%	1.436	0.459	4.489
1987	43859	0.456	0.217	60.0%	1.611	0.532	4.884
1988	51559	0.300	0.209	61.1%	1.556	0.504	4.800
1989	58508	0.270	0.099	74.0%	0.734	0.196	2.752
1990	58499	0.167	0.081	80.1%	0.604	0.148	2.467
1991	68303	0.238	0.123	66.0%	0.915	0.275	3.045
1992	84852	0.199	0.135	62.6%	1.004	0.318	3.168
1993	81424	0.075	0.056	90.8%	0.414	0.088	1.953
1994	92037	0.138	0.099	70.6%	0.734	0.206	2.617
1995	86144	0.101	0.070	80.4%	0.522	0.127	2.144
1996	87745	0.120	0.081	76.4%	0.600	0.155	2.330
1997	91863	0.148	0.114	66.5%	0.847	0.253	2.841
1998	97968	0.151	0.102	72.3%	0.762	0.208	2.786
1999	108626	0.070	0.061	86.4%	0.455	0.102	2.025
2000	103608	0.140	0.061	89.4%	0.450	0.097	2.085
2001	118660	0.148	0.069	79.1%	0.512	0.127	2.062
2002	115251	0.037	0.029	131.1%	0.218	0.030	1.612
2003	114031	0.101	0.050	103.9%	0.372	0.067	2.060
2004	106004	0.041	0.031	128.6%	0.234	0.032	1.690

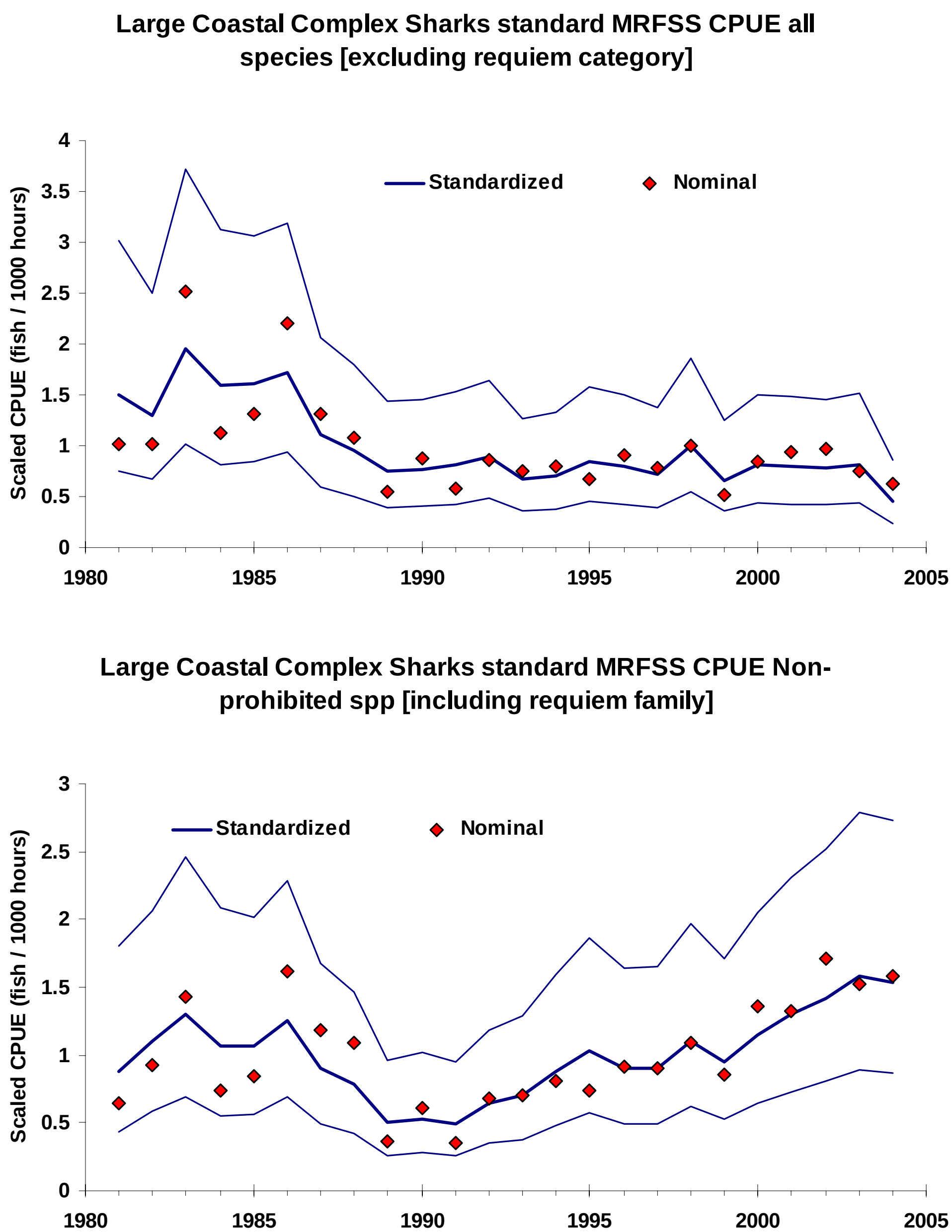
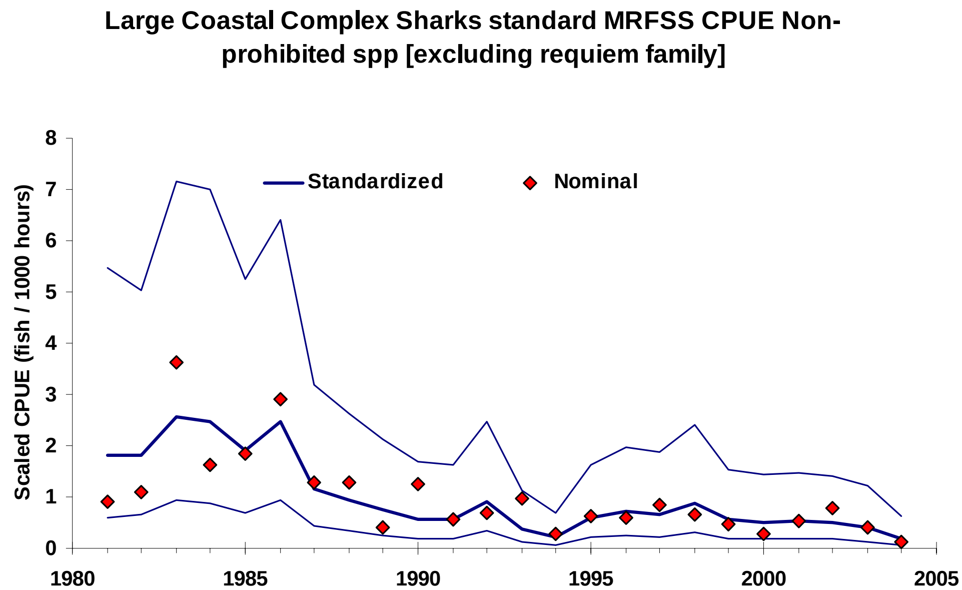


Figure 1. Nominal (solid diamonds) and standard catch rates of large coastal shark complex all species excluding the requiem category (top) or including the requiem category (bottom) from the MRFSS data. Outer lines indicated estimated 95% confidence intervals.



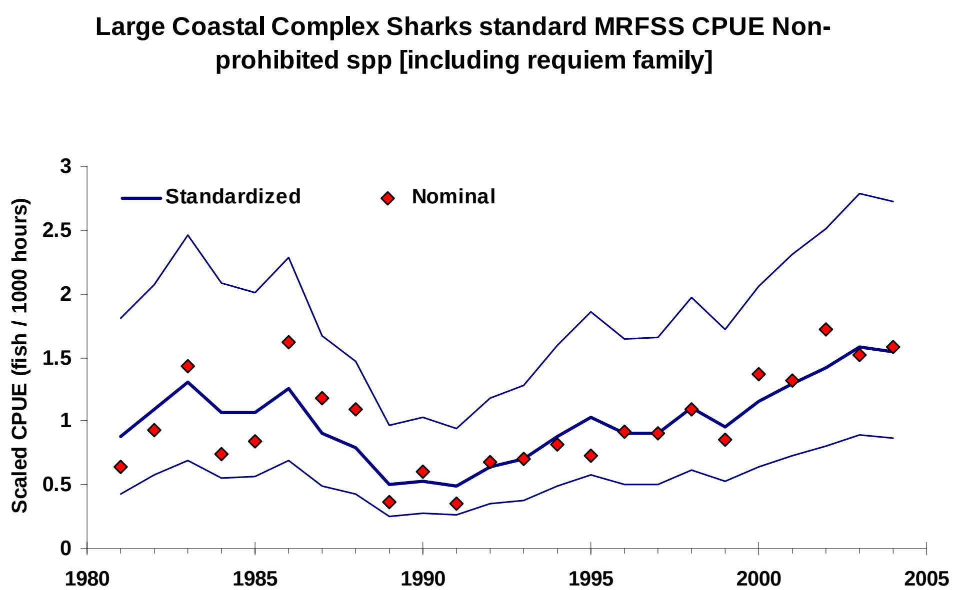


Figure 2. Nominal (solid diamonds) and standard catch rates of large coastal shark complex non-prohibited species excluding the requiem category (top) or including the requiem category (bottom) from the MRFSS data. Outer lines indicated estimated 95% confidence intervals.

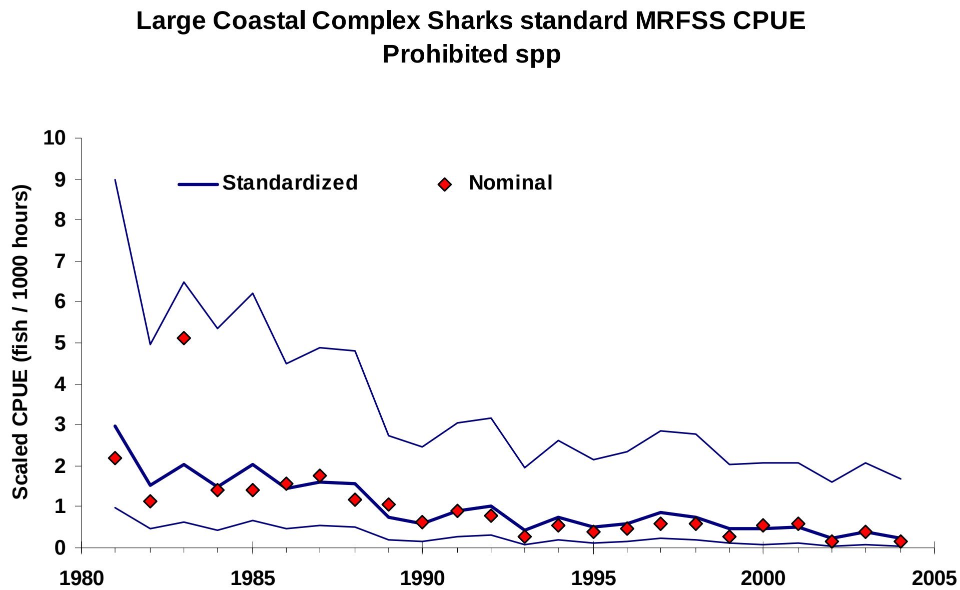


Figure 3. Nominal (solid diamonds) and standard catch rates of LCC prohibited shark species from the MRFSS data.