Standardized catch rates of Atlantic sharpnose sharks, *Rhizoprionodon terranovae*, observed by the Northeast Fisheries Observer Program in the gillnet fishery from 1995-2005

Joseph J. Mello[1], Brian J. Gervelis[1], and Camilla T. McCandless[2]

[1]NOAA Fisheries Service
NMFS NEFSC
Northeast Fisheries Observer Program
166 Water Street
Woods Hole, MA 02543

[2]NOAA Fisheries Service
NMFS NEFSC
Apex Predators Investigation
28 Tarzwell Drive
Narragansett, RI 02882

February, 2007

Summary

The Atlantic sharpnose shark, *Rhizoprionodon terranovae*, is a common small coastal shark species of the southern US and Gulf of Mexico waters. The Northeast Fisheries Observer Program has deployed observers on commercial fishing vessels from Maine to North Carolina since 1989. This analysis incorporated data from 1995-2005. Prior to 1995, no Atlantic sharpnose sharks were reported on observed trips. Catch per unit effort (CPUE) in number of sharks per gillnet soak hour was used to estimate the relative abundance of Atlantic sharpnose sharks from observed trips. The CPUE was standardized using the modified two-step approach originally used by Lo et al. (1992). This approach is based on a delta-log-normal model that models the zero catch separately from the positive catch. Both the nominal and standardized CPUE data displayed similar trends in relative abundance except for the following years: 1996, 2003, and 2004. Other factors not included in this analysis that may account for some of the variation seen in this time series are net height, net length, number of nets per string and size and number of the spaces between nets and should be considered in future analyses.

Methods

Sampling and Data Collection

Observers were deployed on commercial gillnet vessels from 1995-2005 in an effort to quantify bycatch and document protected species interactions. Vessels were selected based on the intended target species, mesh size used and the likelihood of protected species interactions. Sampling priorities were determined by the funding source. A majority of the trips were single day trips with gear a configuration of anchored sink gillnets, drift floating gillnets or drift sink gillnets. Observers are tasked with collecting economic data, weather conditions, and gear characteristics as well as biological data for both the catch and bycatch. Only those trips with at least one Atlantic sharpnose caught were used for this study, and of those, the majority of trips were targeting teleosts. The number of gillnet hauls per trip ranged from one to twenty. Each shark was examined for status when brought onboard, end status, kept or discarded status (and discard reason), weight, lengths (fork and total) and sex.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per soak hour was used to examine the relative abundance of Atlantic sharpnose sharks from observed gillnet trips along the US East coast from 1995-2005. CPUE was standardized using the method developed by Lo et al. (1992). This method was originally used in analyzing fish spotter data for northern anchovy, *Engraulis mordax*, from the southern California purse-seine fishery. This approach takes into account highly skewed data with many zeros which is commonly seen in marine data (Pennington 1983, 1996). It is based on a delta-log-normal model and is a two-step approach that models the zero catch separately from the positive catch. This method can also correct the bias that may be introduced into log-normal error models when a substantial number of zero catches in the data may cause zero catches with low effort to appear higher. This method has been used for stock abundance assessment for other shark species (Carlson 2002, McCandless 2005). The data used in this study to develop a relative index of abundance for the Atlantic sharpnose shark from the observed gillnet fishery contains many zero catches. The effort is not distributed evenly across all the sets, therefore, it was determined that this type of model would provide the best estimates of relative abundance for this species.

Factors considered as potential influences on the CPUE for the Lo et al. (1992) analysis were year (1995-2005), month (January-December), statistical area (614, 621, 625, 631, 635, 700, 701, and 707), depth, water temperature, and mesh size (1" intervals). The proportion of sets with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE sets were modeled assuming a Poisson distribution with a log link function. Models were fit in a stepwise manner, adding one potential factor at a time after initially running a null model with no factors included (Gonzalez-Ania et al. 2001, Carlson 2002, McCandless 2005). Each factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model provided the effect was significant at $\alpha = 0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the previous model. This procedure was continued until no additional factors met the criteria for inclusion into the final model. All models in the stepwise method were fitted using SAS GENMOD procedure (SAS Insitute, 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.). Year was incorporated into all models 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 and Discussion

A total of 2,393 Atlantic sharpnose sharks were caught on 1,092 gillnet sets from January - December from 1995 to 2005. The sharks ranged in size from 27 to 114 cm measured fork length (Fig 1.) Water depth for each haul ranged from one to 17 fathoms. Surface water temperatures ranged from 46.2 to 87 degrees Fahrenheit. The number of nets per string ranged from one to thirteen nets. Mesh sizes ranged from two to ten inches. Other gear specific measurements varied from vessel to vessel. Soak durations ranged from 0.1 to 70.0 hours. The nominal relative indices of abundance for Atlantic sharpnose sharks are reported in Table 1 and illustrated in Figure 2.

The percentage of sets with zero catches was 41.3% for Atlantic sharpnose sharks. The stepwise construction of the binomial model of the probability of a positive Atlantic sharpnose shark CPUE for a set and the Poisson model of positive Atlantic sharpnose shark sets is in Table 2. The final binomial model was *Proportion positive Atlantic sharpnose shark CPUE sets = Area + Month + Year*. The final Poisson model was *Positive Atlantic sharpnose shark CPUE = Temp + Mesh Size + Depth + Month + Year + Area*.

The resulting relative indices of abundance based on the standardized year effects obtained from the Lo et al. method for Atlantic sharpnose are reported in Table 3 and Figure 2. For the years 1995, 1997-2002, and 2005 the nominal and standardized relative indices of abundance exhibit similar trends. However, the years 1996, 2003, and 2004 exhibit great variation in relative abundances. Additional factors such as target species, time of day, net height and number of nets were not included in this study but may account for some of the variation seen in this time series.

References

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Table 1. Nominal relative (CPUE/mean) abundance indices for Atlantic sharpnose sharks observed in the gillnet fishery from 1995-2005. N = the number of tows observed.

YEAR	REL INDEX	LCL	UCL	CV	N
1995	0.22113125	-75.7382	101.0675	3.561373	25
1996	0.20851149	-1259.98	2150.455	1.954033	68
1997	1.04665417	-62.3681	84.30995	3.410632	19
1998	0.87821565	-63.8076	237.0233	0.886092	103
1999	1.52955796	-37.70186	254.3773	0.378489	160
2000	1.83611073	-7.32657	424.6968	0.528116	91
2001	0.93061366	-44.9551	202.4310	0.801503	47
2002	0.13787165	-137.637	323.2284	1.266949	20
2003	2.48204623	-17.47568	249.2616	0.443351	156
2004	0.55781167	-114.113	1036.246	0.636478	184
2005	1.17147555	-85.96979	459.9819	0.349523	219

Table 2. Results of the stepwise procedure for development of the catch rate model for Atlantic sharpnose sharks observed in the gillnet fishery from 1995-2005. %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	1049	1420.3022	1.3540					
AREA	1042	1387.9350	1.3320	1.6248	1.624815	-693.9675	32.37	<.0001
YEAR	1039	1385.2424	1.3332	1.5362		-692.6212	35.06	0.0001
MONTH	1039	1389.0406	1.3369	1.2629		-694.5203	31.26	0.0005
DEPTH	1033	1386.3589	1.3421	0.8789		-693.1795	33.94	0.0055
MESH SIZE	1043	1400.5667	1.3428	0.8272		-700.2834	19.74	0.0031
TEMP	874	1163.1195	1.3308	1.7134		-581.5598	Negative of Hessian not positive definite	
AREA +								
MONTH	1032	1347.3049	1.3055	3.5820	1.9572	-673.6524	40.63	<.0001
YEAR	1032	1354.9340	1.3129	3.0355		-677.4670	33.00	0.0003
AREA + MONTH								
YEAR	1022	1328.5165	1.2999	3.995569	0.4136	-664.2583	18.79	0.0430

FINAL MODEL: AREA + MONTH + YEAR

Akaike's information criterion	4590.9
Schwartz's Bayesian criterion	4595.8
(-2) Res Log likelihood	4588.9

	Type 3 Test of Fixed Effects		
Significance (Pr>Chi) of Type 3	AREA	MONTH	YEAR
test of fixed effects for each factor	0.0005	0.0054	0.0594
DF	7	10	10
CHI SQUARE	26.22	24.99	17.74

Table 2. continued.

POSITIVE CATCHES POISSON ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQ	PR>CHI
NULL	426	6924.0904	16.2537					
TEMP	303	2825.4899	9.325	42.6284	42.6253	2056.0730	4098.60	<.0001
AREA	419	5711.6254	13.6316	16.1323		613.0053	1212.46	<.0001
DEPTH	410	5792.2900	14.1275	13.0813		572.6729	1131.80	<.0001
MESH SIZE	420	6278.0721	14.9478	8.0345		329.7819	646.02	<.0001
MONTH	416	6344.7049	15.2517	6.1648		296.4655	579.39	<.0001
YEAR	416	6362.6646	15.2949	5.8990		287.4857	561.43	<.0001
TEMP +								
MESH SIZE	297	2142.5374	7.2139	55.6169	12.9884	2397.5492	682.95	<.0001
YEAR	293	2138.2245	7.2977	55.1013		2399.7057	687.27	<.0001
DEPTH	287	2100.5991	7.3192	54.9690		2418.5184	724.89	<.0001
AREA	296	2179.0986	7.3618	54.7069		2379.2687	646.39	<.0001
MONTH	293	2363.4060	8.0662	50.3731		2287.1149	462.08	<.0001
TEMP + MESH SIZE								
DEPTH	281	1621.5507	5.7706	64.4967	8.8798	2658.0426	520.99	<.0001
YEAR	287	1753.0457	6.1082	62.4196		2592.2951	389.49	<.0001
MONTH	287	1770.3064	6.1683	62.0499		2583.6647	372.23	<.0001
AREA	290	1933.5848	6.6675	58.9786		2502.0255	208.95	<.0001
TEMP + MESH SIZE + DEPTH								
MONTH	271	1255.1500	4.6315	71.5049	7.0083	2841.2430	366.40	<.0001
YEAR	271	1327.6238	4.8990	69.8592		2805.0061	293.93	<.0001
AREA	274	1262.2480	4.6067	71.6575		2837.6939	359.30	<.0001
TEMP + MESH SIZE + DEPTH + MONTH								
YEAR	261	1094.7582	4.1945	74.1936	2.6886	2921.4389	160.39	<.0001
AREA	264	1041.187	3.9439	75.7354		2948.2245	213.96	<.0001
TEMP + MESH SIZE + DEPTH + MONTH + YEAR								
AREA	254	938.1797	3.6936	77.2753	3.0818	2999.7281	156.58	<.0001

FINAL MODEL: TEMP + MESH SIZE + DEPTH + MONTH + YEAR + AREA

Akaike's information criterion 1336.3

Schwartz's Bayesian criterion 1339.8

(-2) Res Log likelihood 1334.3

Type 3 Test of Fixed Effects

	TEMP	MESH	DEPTH	MONTH	YEAR	AREA
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	0.0500	0.3811	0.0536	0.1303	0.5749	0.0574
DF	123	6	16	10	10	7
CHI SQUARE	149.89	6.39	26.03	15.05	8.55	13.67

Table 3. Lo et al. method relative (index/mean) standardized abundances indices for Atlantic sharpnose sharks observed in the gillnet fishery from 1995-2005. CV = coefficient of variation, N = the number of tows observed.

YEAR	INDEX	REL INDEX	LCL	UCL	CV	N
1995	12.66464	0.071473	-0.427428	0.570373	3.561373	25
1996	445.2375	2.512691	-7.11068	12.13606	1.954033	68
1997	10.97095	0.061914	-0.351973	0.475802	3.410632	19
1998	86.60785	0.48877	-0.360097	1.337637	0.886092	103
1999	146.0396	0.824172	0.21277	1.435575	0.378489	160
2000	208.6851	1.177711	-0.041347	2.396770	0.528116	91
2001	78.73794	0.444356	-0.253703	1.142416	0.801503	47
2002	92.79587	0.523692	-0.77675	1.824134	1.266949	20
2003	133.3686	0.752664	0.098624	1.406704	0.443351	156
2004	461.0666	2.602022	-0.643994	5.848038	0.636478	184
2005	272.9758	1.540535	0.485169	2.595901	0.349523	219

Figure 1. Frequency distribution of fork lengths (cm) of Atlantic sharpnose sharks caught in gillnets from 1995-2005.

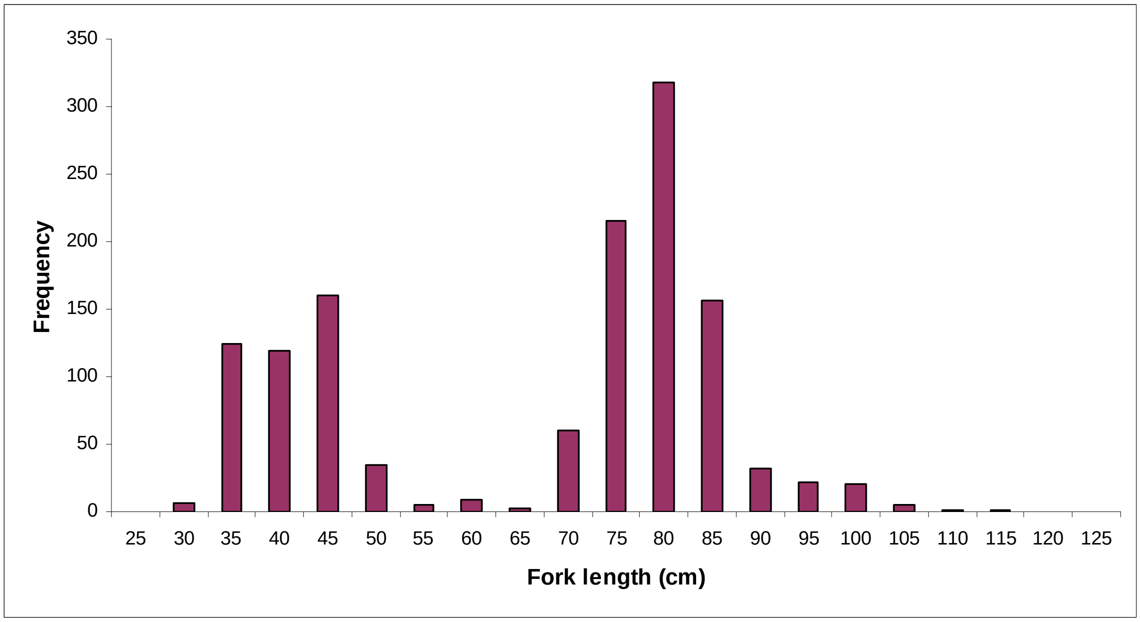
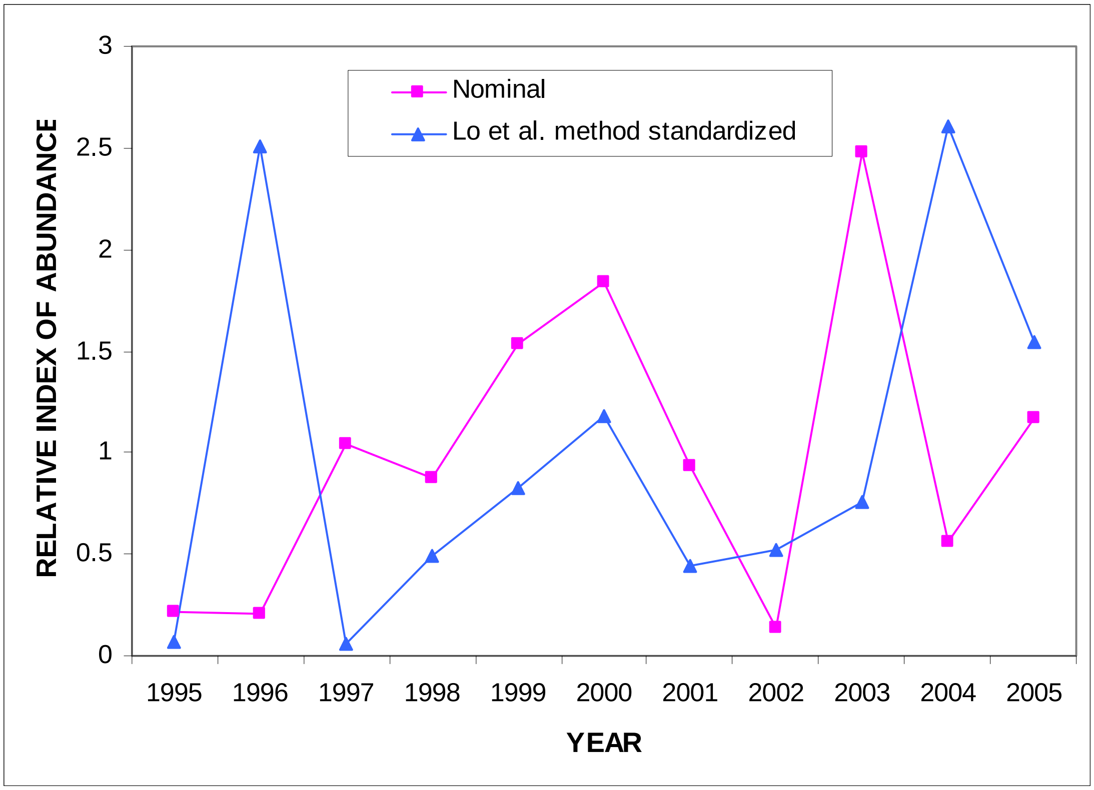


Figure 2. Relative (index/mean) indices of abundance by year for Atlantic sharpnose sharks caught in gillnets from 1995-02005.



Addendum to SEDAR 13-DW-25, by J. Mello, B. Gervelis and C. McCandless

After initial review it was requested to rerun the analyses by gear type and incorporate the net length, net depth, and the number of nets per string into the catch per unit effort. Only the anchored sink net had enough records to analyze separately, excluding the years 1997, 2001 and 2002, for which there was not sufficient data available containing the appropriate variables for calculation of catch per unit effort. The geographic range of these sets is from New Jersey to North Carolina. The results are presented here:

Table 1. Nominal relative (CPUE/mean) abundance indices for Atlantic sharpnose sharks observed in the anchored sink gillnet fishery from 1995-2005. N = the number of tows observed. [CPUE = # Sharpnose / (Soak Duration * Number of nets * Net Length * Net Height)]

YEAR	NOMINAL CPUE	REL INDEX	LCL	UCL	CV	N
1995	2.04E-05	0.2630	-0.0242	0.5502	2.7292	24
1996	3.09E-05	0.3985	0.1948	0.6022	2.1509	68
1997						
1998	1.55E-04	1.9982	0.3091	3.6873	3.1397	53
1999	1.66E-04	2.1441	0.1833	4.1048	3.6442	61
2000	1.30E-04	1.6709	0.3015	3.0402	2.9567	50
2001						
2002						
2003	4.21E-06	0.0543	-0.0091	0.1176	1.9774	11
2004	6.90E-05	0.8895	0.3168	1.4621	3.1163	90
2005	4.51E-05	0.5816	-0.0693	1.2325	4.4959	62

Table 2. Results of the stepwise procedure for development of the catch rate model for Atlantic sharpnose sharks observed in the anchored sink gillnet fishery from 1995-2005. %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	418	526.6943	1.2600					
AREA	413	507.3655	1.2285	2.5000	2.5000	-253.6828	19.33	0.0017
MONTH	408	507.7437	1.2445	1.2302		-253.8718	18.95	0.0409
TEMP	411	514.6837	1.2523	0.6111		-257.3418	12.01	0.1002
DEPTH	403	506.8273	1.2576	0.1905		-253.4136	19.87	0.1771
MESH SIZE	413	522.5282	1.2652	-0.4127		-261.2641	4.17	0.5258
YEAR	411	523.2186	1.2730	-1.0317		-261.6093	3.48	0.8378
AREA +								
MONTH	403	486.4805	1.2071			-243.2402	20.89	0.0219
AREA + MONTH								
YEAR	396	476.6919	1.2038			-238.3460	9.79	0.2009

FINAL MODEL: AREA + MONTH + YEAR

Akaike's information criterion 1904.9

Schwartz's Bayesian criterion 1908.9

(-2) Res Log likelihood 1902.9

Type 3 Test of Fixed Effects

	AREA	MONTH	YEAR
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	0.0015	0.0349	0.3007
DF	5	10	7
CHI SQUARE	19.57	19.45	8.38

Table 2 continued.

POSITIVE CATCHES POISSON ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQ	PR>CHI
NULL	134	1990.9552	14.8579					
AREA	129	1278.8671	9.9137	33.2766	33.2766	905.2432	712.09	<0.0001
MESH SIZE	129	1459.6652	11.3152	23.8439		814.8442	531.29	<0.0001
DEPTH	119	1470.3130	12.3556	16.8415		809.5203	520.64	<0.0001
MONTH	124	1523.8221	12.2889	17.2905		782.7657	467.13	<0.0001
YEAR	127	1644.5167	12.9490	12.8477		722.4184	346.44	<0.0001
TEMP	127	1675.6238	13.1939	11.1994		706.8648	315.33	<0.0001
AREA +								
MONTH	119	866.6785	7.2830	50.9823	17.7057	1111.3375	412.19	<0.0001
MESH SIZE	124	1094.3951	8.8258	40.5986		997.4792	184.47	<0.0001
TEMP	122	1150.2868	9.4286	36.5415		969.5334	128.58	<0.0001
DEPTH	114	1114.6133	9.7773	34.1946		987.3701	164.25	<0.0001
YEAR	122	1205.3329	9.8798	33.5047		942.0103	73.53	<0.0001
AREA + MONTH +								
MESH SIZE	114	658.8645	5.7795	61.1015	10.1192	1215.2445	207.81	<0.0001
YEAR	112	683.6061	6.1036	58.9202		1202.8737	183.07	<0.0001
DEPTH	104	717.4539	6.8986	53.5695		1185.9498	149.22	<0.0001
TEMP	112	806.1798	7.1980	51.5544		1141.5869	60.50	<0.0001
AREA + MONTH + MESH SIZE +								
YEAR	107	591.7453	5.5303	62.7787	1.6772	1248.8041	67.12	<0.0001
TEMP	107	619.6417	5.7910	61.0241		1234.8559	39.22	<0.0001
DEPTH	99	597.0799	6.0311	59.4081		1246.1368	61.78	<0.0001
AREA + MONTH + MESH SIZE + DEPTH +								
YEAR	92	506.4076	5.5044	62.9530	0.1743	1291.4730	90.67	<0.0001
TEMP	92	562.0822	6.1096	58.8798		1263.6357	35.00	<0.0001
AREA + MONTH + MESH SIZE + DEPTH + YEAR +								
TEMP	85	458.2629	5.3913	63.7143	0.7612	1315.5453	48.14	<0.0001

FINAL MODEL: AREA + MONTH + MESH SIZE + DEPTH + YEAR + TEMP

Akaike's information criterion	427.1
Schwartz's Bayesian criterion	429.5
(-2) Res Log likelihood	425.1

Type 3 Test of Fixed Effects

	AREA	MONTH	MESH SIZE	DEPTH	YEAR	TEMP
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	0.1836	0.0437	0.6561	0.5668	0.0758	0.4690
DF	5	10	5	15	7	7
CHI SQUARE	7.54	18.74	3.29	13.46	12.85	6.62

Table 3. Lo et al. method relative (index/mean) standardized abundances indices for Atlantic sharpnose sharks observed in the anchored sink gillnet fishery from 1995-2005. CV = coefficient of variation, N = the number of tows observed.

YEAR	INDEX	REL INDEX	LCL	UCL	CV	N
1995	0.0045	0.2113	-12.3969	12.8194	30.4500	24
1996	0.0878	4.0947	-52.1105	60.2999	7.0033	68
1997						
1998	0.0014	0.0645	-7.2502	7.3792	57.8530	53
1999	0.0015	0.0708	-5.9930	6.1346	43.6915	61
2000	0.0286	1.3312	-13.9942	16.6566	5.8736	50
2001						
2002						
2003	0.0051	0.2371	-23.0405	23.5146	50.0960	11
2004	0.0291	1.3546	-19.8947	22.6039	8.0035	90
2005	0.0136	0.6359	-18.5368	19.8086	15.3837	62

Figure 1. Relative (index/mean) indices of abundance by year for Atlantic sharpnose shark observed in the anchored sink gillnet fishery from 1995-2005.