Standardized catch rates of small coastal sharks from the Commercial Shark Fishery Longline Observer Program, 1994-2005

John K. Carlson[1], Enric Cortés[1], Alexia Morgan[2], Loraine Hale[1], Dana M. Bethea[1], Ivy E. Baremore[1], and George Burgess[2]

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

[2]Florida Program for Shark Research
Florida Museum of Natural History
University of Florida
Gainesville, FL 32611 USA

Introduction

The shark bottom longline fishery is active in the Atlantic Ocean from about the Mid-Atlantic Bight to south Florida and throughout the Gulf of Mexico. Vessels in the fishery are typically fiberglass and average 50 feet in length. Longline characteristics vary regionally with gear normally consisting of about 5-15 miles of longline and 500-1500 hooks. Gear is set at sunset and allowed to soak overnight before hauling back in the morning. There are currently about 100 active vessels in this fishery out of about 250 vessels that possess directed shark fishing permits. These vessels make between 4000-9000 sets per year. The bottom longline gear targets large coastal sharks, but small coastal sharks, pelagic sharks, and dogfish species are also caught.

Observations of the Atlantic shark directed bottom longline fishery have been conducted since 1994 (Burgess and Morgan, 2003, and references therein). From 1994 through 2001, observer coverage was conducted on a voluntary basis. Beginning with the 2002 fishing season, observer coverage of the Atlantic shark directed bottom longline fishery became mandatory under authority of 50 CFR 635.7. Observer coverage from 1994 through the 1st trimester season of 2005 was coordinated by the Commercial Shark Fishery Observer Program (CSFOP), Florida Museum of Natural History, University of Florida, Gainesville, FL (Burgess and Morgan, 2003). Starting with the 2nd trimester season of 2005, responsibility for the fishery observer program was transferred to National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC), Panama City Laboratory, Panama City, FL.

Nominal relative abundance series from these data were previously presented at the 1998 and 2002 (Cortés 2002) Stock Evaluation Workshops and a standardized series at the 2005 large coastal SEDAR (Cortes et al. 2005). However, data from this observer program have not been used in any small coastal stock assessment. The present study attempts to standardize catch rates for small coastal sharks using data collected by on-board observers from 1994-2005.

Methods

A combined data set was developed based on observer programs from Burgess and Morgan (2003) and Smith et al. (2006). Because observations of the fishery have been conducted using two different non-overlapping sampling strategies (i.e. voluntary and mandatory), catch rates were modeled independently for two time series representing periods of 1994-2001 (voluntary) and 2002-2005 (mandatory). Catch rates were

standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). For the purposes of analysis, several categorical variables were constructed:

-"Year" = 1994-2001, 2002-2005

- "Area": location of set (Figure 1).
North Atlantic Ocean=North of 36°31' N
South Atlantic Ocean=South of 36°31' N to 24°32' N including the straights of Florida
Gulf of Mexico

- "Time of Day": the time of day the set started defined from the time the first hook was set in the water;
Day=0501-1800 hrs
Night=1801-0500 hrs

-"Season"
Winter=Jan-Mar
Spring=Apr-Jun
Summer=Jul-Sep
Fall=Oct-Dec

-"Depth": defined as the mean depth when the first hook was set and the last hook was retrieved.
1-100 ft
101-200 ft
201-300 ft
301-400 ft
401-500 ft
501-600 ft
601-700 ft

-"Hooktype": the hook that was used by the majority of the set
Large hook (type undefined)
Large C hook
Large J hook
Medium hook (type undefined)
Medium C hook
Medium J hook
Small hook (type undefined)
Small C hook
Small J hook
Undefined hook

-"Baitype": the bait that was used by the majority of the set
Clupeid/mullet
Teleost (general)
Shark

Skate/Ray
Tuna
Other (undefined or multiple bait types)

The proportion of sets that caught sharks (when at least one shark was caught) was modeled assuming a binomial distribution with a logit link function. Positive catches were modeled assuming a Poisson distribution with a log link. An offset of effort (number of hooks*soak time) was utilized in the Poisson model.

Initially, a null model was run with no factors entered into the model. Models were then fit in a stepwise forward manner adding one independent variable. 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 providing the effect was significant at $p<0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all final models. After selecting the set of fixed factors and interactions for each error distribution, all interactions that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final model determination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC). Models with smaller AIC and BIC values are preferred to those with larger values. These models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models.

Results and Discussion

A total of 1360 longline sets from 1994-2005 contained essential data necessary to standardize catch rates. Locations of sets made can be found in Figure 1.

Atlantic sharpnose shark

For Atlantic sharpnose sharks, the proportion of positive sets was 54.6 % for the period 1994-2001 and 55.9 % for the period 2002-2005. The stepwise construction of the models is summarized in Table 1. The standardized abundance index is shown in Figure 2. To allow for visual comparison with the nominal values, both series were scaled to their respective means. The index statistics can be found in Table 2.

Blacknose sharks

The proportion of positive sets was 28.7 % for the period 1994-2001 and 37.7 % for 2002-2005 for blacknose shark. The stepwise construction of the models is summarized in Table 3. The standardized abundance index is shown in Figure 2 and the index statistics can be found in Table 4.

Bonnetheads

Due to small sample size and the lack of samples in some years, catch rate series were not constructed for bonnetheads.

Finetooth shark

Due to small sample size and the lack of samples in some years, catch rate series were not constructed for finetooth shark.

Small coastal aggregate

The proportion of positive sets was 66.8 % during 1994-2001 and 69.6 % during 2002-2005 for the small coastal aggregate. The stepwise construction of the models is summarized in Table 5. The standardized abundance index is shown in Figure 2 and index statistics can be found in Table 5.

Acknowledgements

We thank all the observers since inception of the programs for collecting data sometimes during somewhat arduous conditions. Marta Ribera provided assistance with mapping set locations.

Literature cited

Burgess, G.H. and A. Morgan. 2003. Commercial Shark Fishery Observer Program. Renewal of an observer program to monitor the directed commercial shark fishery in the Gulf of Mexico and south Atlantic: 2002(2) and 2003(1) fishing seasons. Final Report, U.S. National Marine Fisheries Service, Highly Migratory Species Management Division Award NA16FM1598, 15p.

Cortés, E., A. Morgan, and G. Burgess. 2005. Standardized catch rates of large coastal sharks from the Commercial Shark Fishery Observer Program, 1994-2004. Shark SEDAR Data Workshop Document. LCS05/06-DW-17_V2

Lo, N.C.H., Jacobson, L.D., Squire, J.L., 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences 49, 2515-1526.

Ortiz, M., Arocha, F., 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fisheries Research 70, 275–294.

Smith, P.C., L.F. Hale, and J.K. Carlson (2006) The Directed Shark Longline Fishery: Catch and Bycatch, 2005. Sustainable Fisheries Division Contribution No. PCB-06/04.

Table 1. Analysis of deviance of explanatory variables for the binomial and Poisson generalized linear and mixed model formulations of the proportion of positive and positive catches for Atlantic sharpnose sharks for (A) 1994-2001 and (B) 2002-2005. Final models selected are in bold.

(A) 1994-2001

Proportion positive- Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	819	1129.707	1.379				
AREA	818	1049.474	1.283	6.989	6.99	80.23	<.0001
YEAR	812	1050.668	1.294	6.195		79.04	<.0001
BAITTYPE	814	1079.128	1.326	3.890		50.58	<.0001
HOOKTYPE	818	1097.746	1.342	2.710		31.96	<.0001
TIMEOFDAY	818	1097.746	1.342	2.710		31.96	<.0001
SEASON	816	1116.063	1.368	0.845		13.64	0.0034
DEPTH	815	1119.528	1.374	0.415		10.18	0.0375
AREA+							
YEAR	811	980.449	1.209	12.356	5.37	69.03	<.0001
BAITTYPE	813	983.758	1.210	12.277		65.72	<.0001
HOOKTYPE	813	1014.748	1.248	9.513		34.73	<.0001
TIMEOFDAY	817	1036.435	1.269	8.032		13.04	0.0003
AREA+YEAR+							
BAITTYPE	806	918.503	1.140	17.384	5.03	61.95	<.0001
HOOKTYPE	806	931.171	1.155	16.245		49.28	<.0001
TIMEOFDAY	810	969.250	1.197	13.250		11.20	0.0008
AREA+YEAR+BAITTYPE							
HOOKTYPE	801	893.148	1.115	19.163	1.78	25.36	0.0001
TIMEOFDAY	805	916.458	1.138	17.466		2.04	0.1527
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+AREA+BAITTYPE+HOOKTYPE	**3592.4**	**3597.0**	**3590.4**				
YEAR+AREA+BAITTYPE+ HOOKTYPE YEAR*AREA	4321.4	4322.8	4317.4				
YEAR+AREA+BAITTYPE+ HOOKTYPE YEAR*BAITTYPE	4278.9	4282.2	4274.9				
YEAR+AREA+BAITTYPE+ HOOKTYPE YEAR*HOOKTYPE		Convergence criteria not met.					
Positive catches- Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	447	41720.463	93.334				
BAITTYPE	442	27975.959	63.294	32.186	32.19	13744.50	<.0001
HOOKTYPE	446	33082.056	74.175	20.528		8638.41	<.0001
TIMEOFDAY	446	33082.056	74.175	20.528		8638.41	<.0001
DEPTH	443	37949.086	85.664	8.218		3771.38	<.0001
YEAR	440	38390.775	87.252	6.517		3329.69	<.0001
AREA	446	40100.044	89.910	3.668		1620.42	<.0001
SEASON	444	41543.059	93.565	-0.248		177.40	<.0001

BAITTYPE+							
DEPTH	438	23432.121	53.498	42.681	10.50	4543.84	<.0001
AREA	441	24488.436	55.529	40.505		3487.52	<.0001
TIMEOFDAY	441	24497.836	55.551	40.482		3478.12	<.0001
YEAR	435	24592.949	56.536	39.427		3383.01	<.0001
HOOKTYPE	437	25239.007	57.755	38.120		2736.95	<.0001
BAITTYPE+DEPTH+							
TIMEOFDAY	437	21043.604	48.155	48.406	5.72	2388.52	<.0001
YEAR	431	21006.128	48.738	47.781		2425.99	<.0001
AREA	437	22338.139	51.117	45.232		1093.98	<.0001
HOOKTYPE	433	22173.706	51.209	45.133		1258.41	<.0001
BAITTYPE+DEPTH+TIMEOFDAY							
YEAR	430	17983.917	41.823	55.190	6.78	3059.69	<.0001
HOOKTYPE	432	20035.784	46.379	50.309		1007.82	<.0001
AREA	436	20434.201	46.867	49.785		609.40	<.0001
BAITTYPE+DEPTH+TIMEOFDAY+YEAR							
HOOKTYPE	425	16494.250	38.810	58.418	3.23	1489.67	<.0001
AREA	429	17190.065	40.070	57.068		793.85	<.0001
BAITTYPE+DEPTH+TIMEOFDAY+YEAR+ HOOKTYPE+							
AREA	424	15691.205	37.008	60.349	1.93	803.05	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+BAITTYPE+DEPTH+ TIMEOFDAY+HOOKTYPE+AREA	1913.2	1917.2	1911.2				
YEAR+BAITTYPE+DEPTH+TIMEOFDAY+ HOOKTYPE+AREA YEAR*BAITTYPE	1885.6	1888.8	1881.6				
YEAR+BAITTYPE+DEPTH+TIMEOFDAY+ HOOKTYPE+AREA YEAR*DEPTH	1900.1	1902.6	1896.1				
YEAR+BAITTYPE+DEPTH+TIMEOFDAY+ HOOKTYPE+AREA YEAR*TIMEOFDAY	**1877.9**	**1879.4**	**1873.9**				
YEAR+BAITTYPE+DEPTH+TIMEOFDAY+ HOOKTYPE+AREA YEAR*HOOKTYPE	1901.7	1904.1	1897.7				
YEAR+BAITTYPE+DEPTH+TIMEOFDAY+ HOOKTYPE+AREA YEAR*AREA	1913.2	1913.9	1911.2				

(B) 2002-2005

Proportion positive-Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	539	740.996	1.375				
DEPTH	533	687.686	1.290	6.150	6.15	53.31	<.0001
BAITTYPE	534	714.067	1.337	2.732		26.93	<.0001
HOOKTYPE	530	719.516	1.358	1.250		21.48	0.0107
SEASON	536	733.827	1.369	0.413		7.17	0.0667
YEAR	536	736.478	1.374	0.053		4.52	0.2107
TIMEOFDAY	538	740.383	1.376	-0.103		0.61	0.4336
AREA	538	740.867	1.377	-0.168		0.13	0.7195
DEPTH							

BAITTYPE	528	652.948	1.237	10.047	3.90	34.74	<.0001
HOOKTYPE	524	664.966	1.269	7.692		22.72	0.0069
DEPTH+BAITTYPE+							
HOOKTYPE	519	627.179	1.208	12.098	2.05	25.77	0.0022
YEAR+DEPTH+ BAITTYPE+HOOKTYPE	516	620.243	1.202	12.565	0.47	24.49	0.0036
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+DEPTH+ BAITTYPE+HOOKTYPE	**2424.4**	**2428.700**	**2422.400**				
YEAR+DEPTH+BAITTYPE+ HOOKTYPE YEAR*DEPTH	2443.5	2445.900	2439.500				
YEAR+DEPTH+BAITTYPE+ HOOKTYPE YEAR*BAIT		Convergence criteria not met.					
YEAR+DEPTH+BAITTYPE+ HOOKTYPE YEAR*HOOK		Convergence criteria not met.					
Positive catches-Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	301	17726.525	58.892				
SEASON	298	15280.954	51.278	12.928	12.93	2445.57	<.0001
HOOKTYPE	292	16133.715	55.252	6.180		1592.81	<.0001
BAITTYPE	296	16998.715	57.428	2.486		727.81	<.0001
YEAR	298	17226.785	57.808	1.841		499.74	<.0001
DEPTH	296	17259.467	58.309	0.990		467.06	<.0001
AREA	300	17621.829	58.739	0.259		104.70	<.0001
TIMEOFDAY	300	17725.383	59.085	-0.327		1.14	0.2853
SEASON							
BAITTYPE	293	14538.427	49.619	15.746	2.82	742.53	<.0001
HOOKTYPE	289	14488.596	50.134	14.872		792.36	<.0001
YEAR	295	15233.056	51.637	12.319		47.90	<.0001
SEASON+BAITTYPE+							
HOOKTYPE	284	13742.583	48.389	17.834	2.09	795.84	<.0001
YEAR	290	14455.582	49.847	15.359		82.84	<.0001
SEASON+BAITTYPE+ HOOKTYPE+							
YEAR	281	13568.017	48.285	18.011	0.18	174.57	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+SEASON+ BAITTYPE+HOOKTYPE	1517.5	1521.2	1515.5				
YEAR+SEASON+ BAITTYPE+HOOKTYPE YEAR*SEASON	1517.5	1517.9	1515.5				
YEAR+SEASON+ BAITTYPE+HOOKTYPE YEAR*BAIT	1499.8	1501.4	1495.8				
YEAR+SEASON+ BAITTYPE+HOOKTYPE YEAR*HOOK	**1496.4**	**1498.9**	**1492.4**				

Table 2. The relative standardized index of abundance and coefficients of variation for Atlantic sharpnose shark.

YEAR	ABSOLUTE INDEX	CV
1994	0.0001	38.140
1995	0.0031	3.124
1996	0.0018	4.041
1997	0.0032	3.032
1998	0.0056	1.901
1999	0.0231	0.972
2000	0.0128	1.688
2001	0.0090	1.803
2002	0.0014	0.509
2003	0.0014	0.406
2004	0.0023	0.423
2005	0.0028	0.438

Table 3. Analysis of deviance of explanatory variables for the binomial and Poisson generalized linear and mixed model formulations of the proportion of positive and positive catches for blacknose sharks for 1994-2001 (A) and 2002-2005 (B). Final models selected are in bold.

(A) 1994-2001

Proportion positive- Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	819	984.286	1.202				
DEPTH	815	913.934	1.121	6.692	6.692	70.35	<.0001
BAITTYPE	814	927.707	1.140	5.169		56.58	<.0001
AREA	818	944.305	1.154	3.945		39.98	<.0001
YEAR	812	944.580	1.163	3.207		39.71	<.0001
HOOKTYPE	814	964.644	1.185	1.394		19.64	0.0015
SEASON	816	973.101	1.193	0.773		11.18	0.011
TIMEOFDAY	818	979.770	1.198	0.337		4.52	0.0336
DEPTH+							
AREA	814	843.783	1.037	13.748	7.056	70.15	<.0001
BAITTYPE	810	866.254	1.069	11.014		47.68	<.0001
YEAR	808	889.561	1.101	8.393		24.37	0.001
HOOKTYPE	810	903.033	1.115	7.236		10.90	0.0534
DEPTH+AREA+							
BAITTYPE	809	808.375	0.999	16.857	3.109	35.41	<.0001
YEAR	807	817.658	1.013	15.694		26.13	0.0005
YEAR+DEPTH+AREA+BAIT	802	784.297	0.978	18.629	1.772	33.36	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+DEPTH+AREA+BAIT	3946.3	3951.0	3944.3				
YEAR+DEPTH+ AREA+BAIT YEAR*DEPTH	**3942.2**	**3945.1**	**3938.2**				
YEAR+DEPTH+ AREA+BAIT YEAR*AREA	3994.1	3995.6	3990.1				
YEAR+DEPTH+ AREA+BAIT YEAR*BAIT	3943.1	3946.4	3939.1				
Positive catches-Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	235	3448.7746	14.676				
TIMEOFDAY	234	2465.986	10.538	28.191	28.191	982.79	<.0001
HOOKTYPE	231	2446.643	10.592	27.829		1002.13	<.0001
AREA	234	2659.397	11.365	22.559		789.38	<.0001
BAITTYPE	230	3217.938	13.991	4.665		230.84	<.0001
DEPTH	231	3309.983	14.329	2.362		138.79	<.0001
YEAR	228	3285.996	14.412	1.795		162.78	<.0001
SEASON	233	3437.369	14.753	-0.525		11.41	0.0033
TIMEOFDAY+							
HOOKTYPE	230	2038.9873	8.865	39.593	11.401	427.00	<.0001
AREA	233	2177.9631	9.347	36.306		288.02	<.0001
DEPTH	230	2369.3967	10.302	29.804		96.59	<.0001

YEAR	227	2404.7649	10.594	27.815		61.22	<.0001
BAITTYPE	229	2436.5876	10.640	27.498		29.40	<.0001
TIMEOFDAY+HOOKTYPE+							
AREA	229	1956.1548	8.542	41.794	2.201	82.83	<.0001
DEPTH	226	1941.1032	8.589	41.475		97.88	<.0001
YEAR	223	1876.4271	8.414	42.664		162.56	<.0001
BAITTYPE	225	1992.2041	8.854	39.667		46.78	<.0001
TIMEOFDAY+HOOKTYPE+AREA							
YEAR	222	1846.8541	8.319	43.313	1.520	109.30	<.0001
BAITTYPE	224	1910.9668	8.531	41.869		45.19	<.0001
DEPTH	225	1922.3282	8.544	41.783		33.83	<.0001
YEAR+TIMEOFDAY+HOOKTYPE+AREA	222	1846.8541	8.319	43.313	1.520	29.57	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+TIMEOFDAY+ HOOKTYPE+AREA	890.6	894.0	888.6				
YEAR+TIMEOFDAY+ HOOKTYPE+AREA YEAR*TIME	**885.4**	**886.9**	**881.4**				
YEAR+TIMEOFDAY+ HOOKTYPE+AREA YEAR*HOOK	890.6	891.7	888.6				
YEAR+TIMEOFDAY+ HOOKTYPE+AREA YEAR*AREA	890.6	891.3	888.6				

(B) 2002-2005

Proportion positive- Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	539	716.003	1.328				
AREA	538	589.2121	1.095	17.555	17.555	126.79	<.0001
BAITTYPE	534	647.779	1.213	8.681		68.220	<.0001
DEPTH	533	663.215	1.244	6.330		Negative of Hessian not positive definite.	
SEASON	536	695.867	1.298	2.268		20.140	0.0002
YEAR	536	706.807	1.319	0.732		9.200	0.0268
HOOKTYPE	530	699.560	1.320	0.637		16.440	0.0582
TIMEOFDAY	538	712.998	1.325	0.235		3.010	0.0830
AREA+							
BAITTYPE	533	556.4334	1.044	21.411	3.856	32.78	<.0001
YEAR	535	580.4017	1.085	18.333		8.81	0.0319
SEASON	535	583.3579	1.090	17.917		5.85	0.1189
AREA+BAITTYPE							
YEAR	530	549.9655	1.038	21.885	0.474	30.44	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+AREA+BAITTYPE	**2543.4**	**2547.7**	**2541.4**				
YEAR+AREA+BAITTYPE YEAR*AREA	2566.1	2566.3	2562.1				
YEAR+AREA+BAITTYPE YEAR*BAITTYPE	2579.0	2581.0	2575.0				

Positive catches- Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	203	3463.9670	17.064				
BAITTYPE	198	2828.912	14.287	16.271	16.271	635.06	<.0001
YEAR	200	3189.166	15.946	6.552		274.8	<.0001
AREA	202	3229.881	15.990	6.296		234.09	<.0001
DEPTH	199	3231.315	16.238	4.841		232.65	<.0001
TIMEOFDAY	202	3387.260	16.769	1.730		76.71	<.0001
HOOKTYPE	194	3286.373	16.940	0.726		177.59	<.0001
SEASON	200	3396.052	16.980	0.490		67.92	<.0001
BAITTYPE+							
AREA	197	2639.3708	13.398	21.484	5.213	189.54	<.0001
DEPTH	194	2678.4576	13.806	19.089		150.45	<.0001
YEAR	195	2760.4238	14.156	17.041		68.49	<.0001
TIMEOFDAY	197	2814.544	14.287	16.273		14.37	0.0002
BAITTYPE+AREA+							
DEPTH	193	2478.7351	12.843	24.735	3.250	160.64	<.0001
YEAR	194	2533.5654	13.060	23.466		105.81	<.0001
TIMEOFDAY	196	2607.0142	13.301	22.051		32.36	<.0001
BAITTYPE+AREA+DEPTH							
YEAR	190	2360.4	12.423	27.196	2.462	118.34	<.0001
TIMEOFDAY	192.0	2447.7	12.748	25.291		31.06	<.0001
BAITTYPE+AREA+ DEPTH+YEAR							
TIMEOFDAY	189.0	2284.9	12.089	29.153	1.957	75.53	<.0001
YEAR+BAITTYPE+ AREA+DEPTH+TIMEOFDAY							
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+BAITTYPE+AREA+ DEPTH+TIMEOFDAY	791.8	795.0	789.8				
YEAR+BAITTYPE+AREA+ DEPTH+TIMEOFDAY YEAR*BAIT	791.8	792.5	789.8				
YEAR+BAITTYPE+AREA+ DEPTH+TIMEOFDAY YEAR*AREA	**788.2**	**788.4**	**784.2**				
YEAR+BAITTYPE+AREA+ DEPTH+TIMEOFDAY YEAR*DEPTH	791.2	792.8	787.2				
YEAR+BAITTYPE+AREA+ DEPTH+TIMEOFDAY YEAR*TIME	792.1	792.2	788.1				

Table 4. The relative standardized index of abundance and coefficients of variation for blacknose shark.

YEAR	ABSOLUTE INDEX	CV
1994	0.0075	8.134
1995	0.0094	5.508
1996	0.0110	4.984
1997	0.0025	16.537
1998	0.0094	5.717
1999	0.0162	5.070
2000	0.0162	5.929
2001	0.0079	11.394
2002	0.0008	4.245
2003	0.0004	6.953
2004	0.0004	6.527
2005	0.0012	3.542

Table 5. Analysis of deviance of explanatory variables for the binomial and Poisson generalized linear and mixed model formulations of the proportion of positive and positive catches for the small coastal aggregate for 1994-2001 (A) and 2002-2005 (B). Final models selected are in bold.

(A) 1994-2001

Proportion positive- Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	819	1042.025	1.272				
BAITTYPE	814	985.568	1.211	4.837	4.837	56.46	<.0001
YEAR	812	992.529	1.222	3.929		49.50	<.0001
DEPTH	815	999.397	1.226	3.620		42.63	<.0001
HOOKTYPE	814	1011.153	1.242	2.367		30.87	<.0001
TIMEOFDAY	818	1024.806	1.253	1.532		17.22	<.0001
AREA	818	1036.041	1.267	0.453		5.98	0.0144
SEASON	816	1039.213	1.274	-0.097		2.81	0.4215
BAITTYPE+							
YEAR	807	939.865	1.165	8.463	3.626	45.70	<.0001
DEPTH	810	946.656	1.169	8.143		38.91	<.0001
HOOKTYPE	809	967.968	1.196	5.959		17.60	0.0035
TIMEOFDAY	813	979.483	1.205	5.308		6.08	0.0136
BAITTYPE+YEAR							
DEPTH	803	894.119	1.113	12.484	4.022	45.75	<.0001
HOOKTYPE	802	917.600	1.144	10.074		22.26	0.0005
BAITTYPE+YEAR+DEPTH							
HOOKTYPE	798	878.849	1.101	13.440	0.956	15.27	0.0093
YEAR+BAITTYPE+DEPTH	803	894.119	1.113	12	4.022	45.75	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+BAITTYPE+DEPTH	**3795.7**	**3800.4**	**3793.7**				
YEAR+BAITTYPE+DEPTH YEAR*BAIT	3797.5	3800.8	3793.5				
YEAR+BAITTYPE+DEPTH YEAR*DEPTH	3807.2	3810.1	3803.2				
Positive catches- Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	547	47551.735	86.932				
BAITTYPE	542	33073.589	61.021	29.806	29.806	14478.10	<.0001
TIMEOFDAY	546	36227.332	66.350	23.675		11324.40	<.0001
HOOKTYPE	542	37849.559	69.833	19.669		9702.18	<.0001
AREA	546	42860.221	78.499	9.701		4691.51	<.0001
YEAR	540	43561.394	80.669	7.204		3990.34	<.0001
DEPTH	543	44610.079	82.155	5.495		2941.66	<.0001
SEASON	544	47112.752	86.604	0.377		438.98	<.0001
BAITTYPE+							
AREA	541	26905.043	49.732	42.792	12.986	6168.55	<.0001

TIMEOFDAY	541	27688.625	51.180	41.126		5384.96	<.0001
HOOKTYPE	537	29294.648	54.552	37.247		3778.94	<.0001
YEAR	535	29261.259	54.694	37.084		3812.33	<.0001
DEPTH	538	29758.018	55.312	36.373		3315.57	<.0001
BAITTYPE+AREA							
TIMEOFDAY	540	24169.026	44.757	48.514	5.722	2736.02	<.0001
YEAR	534	24194.858	45.309	47.880		2710.19	<.0001
HOOKTYPE	536	24698.925	46.080	46.993		2206.12	<.0001
DEPTH	537	24774.462	46.135	46.930		2130.58	<.0001
BAITTYPE+AREA+TIME							
YEAR	533	20832.052	39.085	55.040	6.526	3336.97	<.0001
DEPTH	536	22369.676	41.734	51.992		1799.35	<.0001
HOOKTYPE	535	22396.189	41.862	51.845		1772.84	<.0001
BAITTYPE+AREA+TIME+YEAR							
HOOKTYPE	528	18366.245	34.785	59.986	4.946	2465.81	<.0001
DEPTH	529	19466.538	36.799	57.669		1365.51	<.0001
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE	524.0	17333.081	33.078	61.949	1.963	2133.46	<.0001
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE	2317.1	2321.4	2315.1				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE YEAR*BAIT	2276.8	2280.0	2272.8				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE YEAR*AREA	2317.1	2317.9	2315.1				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE YEAR*TIME	**2272.7**	**2274.2**	**2268.7**				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE YEAR*DEPTH	2299.1	2301.7	2295.1				
YEAR+BAITTYPE+AREA+ TIME+DEPTH+HOOKTYPE YEAR*HOOK	2306.1	2308.6	2302.1				

(B) 2002-2005

Proportion positive- Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	539	663.087	1.230				
DEPTH	533	589.606	1.106	10.081	10.081	73.48	<.0001
BAITTYPE	534	627.264	1.175	4.517		35.82	<.0001
AREA	538	636.386	1.183	3.848		26.70	<.0001
SEASON	536	647.079	1.207	1.868		16.01	0.0011
HOOKTYPE	530	644.871	1.217	1.096		18.22	0.0327
YEAR	536	653.2981	1.219	0.925		9.79	0.0204
TIMEOFDAY	538	663.043	1.232	-0.179		0.04	0.8323
DEPTH							

BAITTYPE	528	544.9557	1.032	16.103	6.022	44.65	<.0001
AREA	532	570.5405	1.072	12.825		19.07	<.0001
YEAR	530	581.5268	1.097	10.811		8.08	0.0444
HOOKTYPE	524	575.5248	1.098	10.721		14.08	0.1195
SEASON	530	584.693	1.103	10.325		4.91	0.1783
DEPTH+BAITTYPE+							
YEAR	525.0	527.4	1.005	18.344	2.241	17.57	0.0005
AREA	527	533.7	1.013	17.681		11.26	0.0008
DEPTH+BAITTYPE+YEAR							
AREA	524.0	517.2	0.987	19.767	1.423	10.18	0.0014
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+DEPTH+BAITTYPE+AREA	2634.7	2639.0	2633				
YEAR+DEPTH+BAITTYPE+ AREA YEAR*DEPTH			Convergence criteria not met.				
YEAR+DEPTH+BAITTYPE+ AREA YEAR*BAIT			Convergence criteria not met.				
YEAR+DEPTH+BAITTYPE+ AREA YEAR*AREA			Convergence criteria not met.				
Positive catches-Poisson error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	375	19673.7306	52.463				
SEASON	372	17477.709	46.983	10.446	10.446	2196.02	<.0001
BAITTYPE	370	18511.780	50.032	4.635		1161.95	<.0001
HOOKTYPE	366	18425.933	50.344	4.039		1247.8	<.0001
YEAR	372	18935.950	50.903	2.974		737.78	<.0001
AREA	374	19389.052	51.842	1.183		284.68	<.0001
DEPTH	370	19342.390	52.277	0.356		331.34	<.0001
TIMEOFDAY	374	19647.923	52.535	-0.136		25.81	<.0001
SEASON							
BAITTYPE	367	16546.2943	45.085	14.063	3.617	931.41	<.0001
HOOKTYPE	363	16691.9512	45.983	12.351		785.76	<.0001
YEAR	369	17385.4402	47.115	10.194		92.27	<.0001
AREA	371	17426.238	46.971	10.469		51.47	<.0001
SEASON+BAITTYPE							
HOOKTYPE	358	15829.2375	44.216	15.721	1.657	717.06	<.0001
AREA	366	16505.1661	45.096	14.043		41.13	<.0001
YEAR	364	16416.5533	45.100	14.034		129.74	<.0001
SEASON+BAITTYPE+HOOKTYPE							
YEAR	355	15632.2	44.034	16.066	0.346	197	<.0001
AREA	357	15818.8	44.310	15.540		10.4	0.0013
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+SEASON+BAITTYPE+HOOKTYPE	1849.5	1853.4	1847.5				
YEAR+SEASON+BAITTYPE+HOOKTYPE	1850.4	1851.2	1846.4				

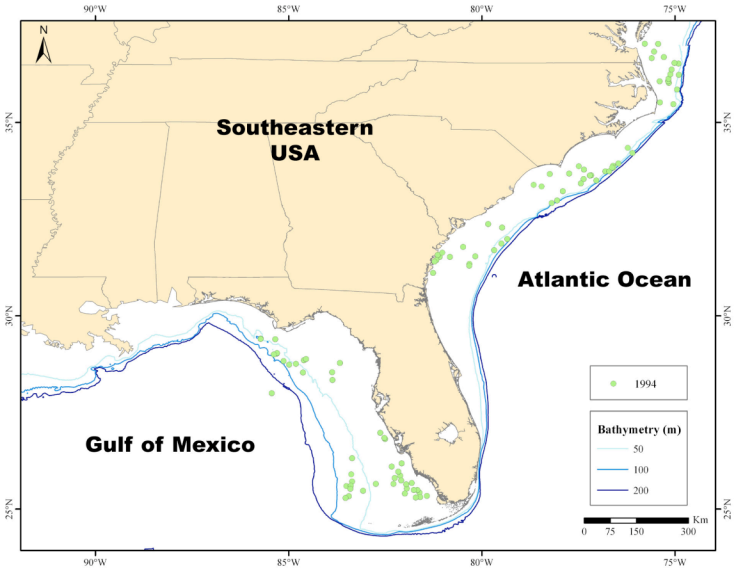
YEAR*SEASON							
YEAR+SEASON+BAITTYPE+HOOKTYPE YEAR*BAIT	1817.2	1819.0	1813.2				
YEAR+SEASON+BAITTYPE+HOOKTYPE YEAR*HOOK	1831.5	1834.0	1827.5				

Table 4. The relative standardized index of abundance and coefficients of variation for the small coastal aggregate shark.

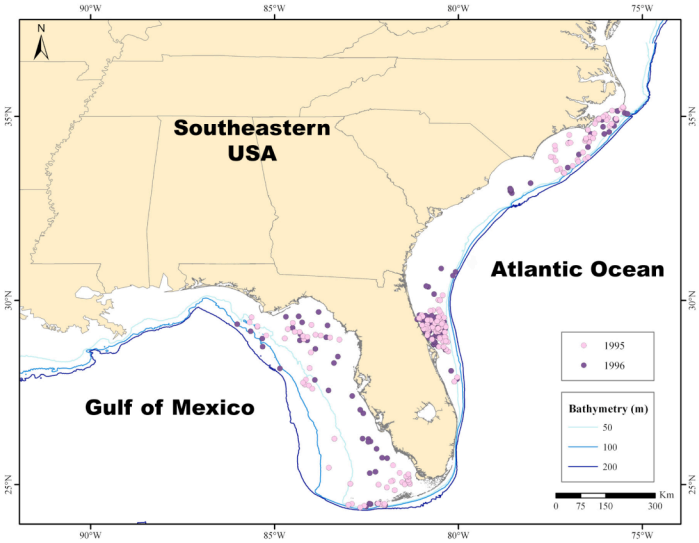
YEAR	ABSOLUTE INDEX	CV
1994	0.0004	11.142
1995	0.0042	1.797
1996	0.0025	2.412
1997	0.0035	2.171
1998	0.0064	1.292
1999	0.0208	0.890
2000	0.0138	1.241
2001	0.0091	1.420
2002	0.0015	2.922
2003	0.0021	2.344
2004	0.0029	2.083
2005	0.0034	1.346

Figure 1. Distribution of longline sets from the bottom longline observer program by year.

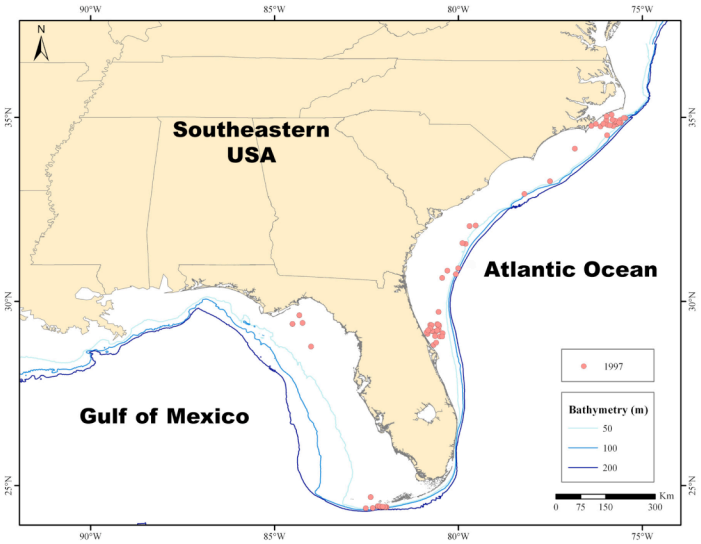
1994



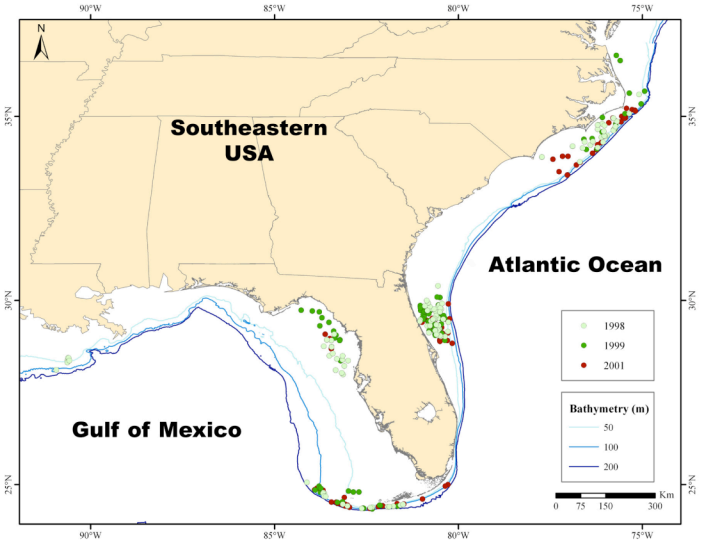
1995 and 1996



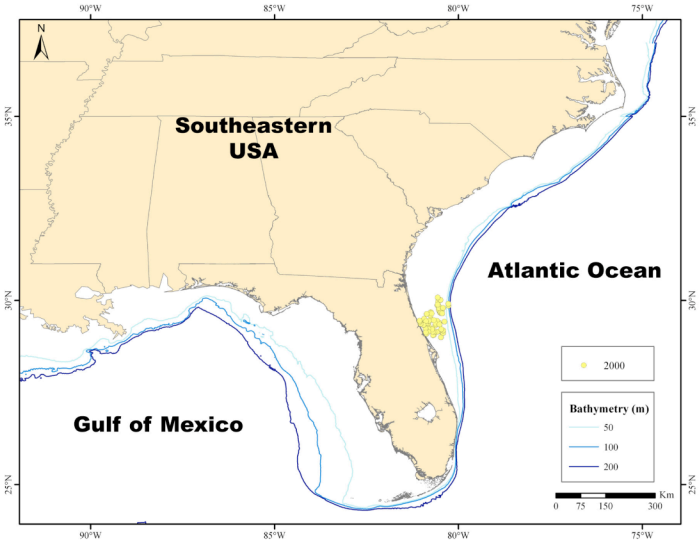
1997



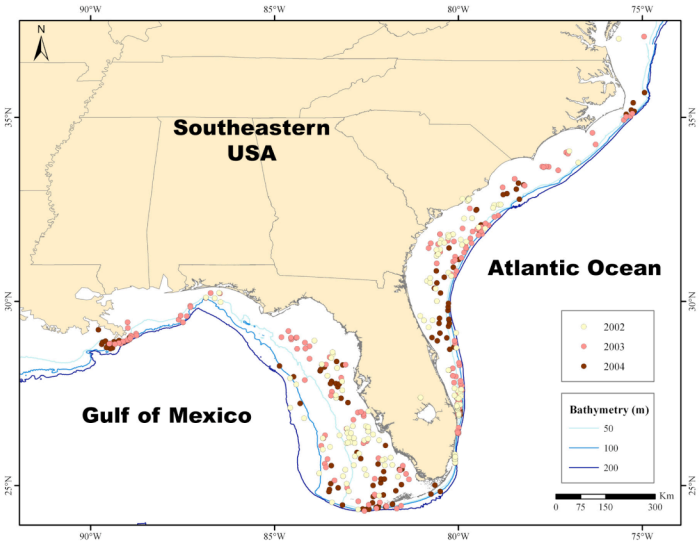
1998, 1999, and 2001



2000



2002, 2003, and 2004



2005

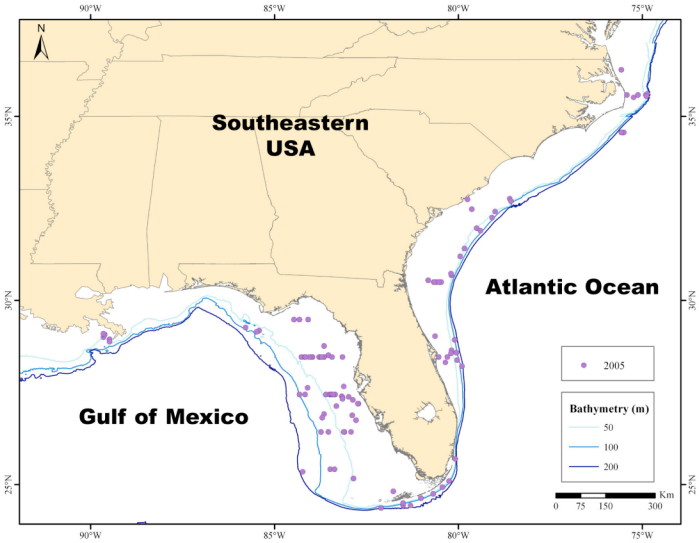
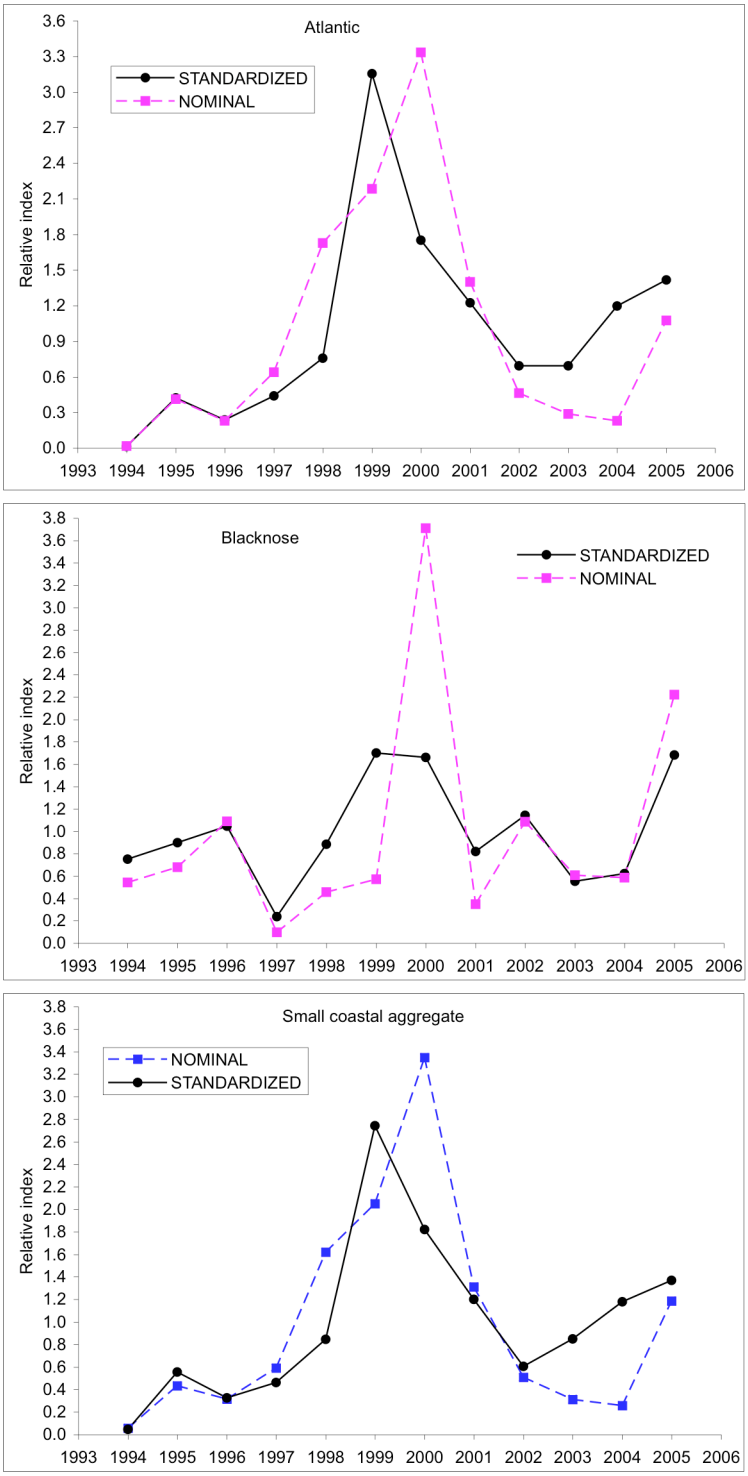

90°W
85°W
80°W
75°W
35°N
30°N
25°N
N
Southeastern USA
Atlantic Ocean
Gulf of Mexico
2005
Bathymetry (m)
50
100
200
0 75 150 300
Km

Figure 2. Nominal and standardized indices of abundance for small coastal sharks. Each index has been divided by its mean.



ADDENDUM TO SEDAR 13-DW-12
(Standardized catch rates of small coastal sharks from the Commercial Shark Fishery Longline Observer Program, 1994-2005)

Introduction

Based on discussion at the 2007 Shark SEDAR 13, the present addendum to document **SEDAR 13-DW-12** revises standardized catch rates for Atlantic sharpnose and blacknose shark and provides a new catch rate series for Atlantic sharpnose shark for the Atlantic Ocean and Gulf of Mexico stock. All analysis followed standardization procedures previously outlined in **SEDAR 13-DW-09** except:

1. The original analysis in **SEDAR 13-DW-12** assumed a Poisson distribution when modeling the positive catch rates. After discussion with stock assessment analysts, CPUE is now expressed as the natural logarithm of the number of sharks caught per 10^{-5} hook hours, i.e.:

CPUE=log [(sharks kept+sharks released)/(number of hooks*soak time/100000)]

2. In **SEDAR 13-DW-12**, catch rates were modeled independently for two time series representing periods of 1994-2001 (voluntary) and 2002-2005 (mandatory) because observations of the fishery had been conducted using two different non-overlapping sampling strategies. However, a closer examination of the data revealed that some vessels (n=6) have been sampled throughout both designs, which will allow for combining the series and utilizing a new factor "program" (i.e. voluntary and mandatory) which will be used to test for any changes in CPUE related to observer program design. Moreover, examination of the data when the series is split by stock would preclude modeling Atlantic sharpnose shark as a separate time series because of low sample in some years in particular areas.

3. High CV's were also noted in the index in **SEDAR 13-DW-09** may have also been caused by few observations in some cells in particular "baittype" (which was highly skewed towards the "other" category). To increase observations per cell, category factors were refined. For example, baittype "shark" and "skate/ray" have been combined to a single category "elasmobranch".

New and revised estimates are listed below:

Table 1. Analysis of mixed model formulations of the proportion of positive and positive catches for Atlantic sharpnose shark. Final models selected are in bold.

A. Areas combined

Proportion positive-Binomial error distribution			
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+HOOK+DEPTH+BAIT+AREA	**6157.8**	**6163.0**	**6155.8**
YEAR+HOOK+DEPTH+BAIT+AREA YEAR*HOOK	6214.2	6218.1	6210.0
YEAR+HOOK+DEPTH+BAIT+AREA YEAR*DEPTH	6201.7	6205.8	6197.7
YEAR+HOOK+DEPTH+BAIT+AREA YEAR*BAIT	6201.9	6206.0	6197.9

YEAR+HOOK+DEPTH+BAIT+AREA YEAR*AREA	6256.0	6258.0	6252.0
Positive catches-Lognormal error distribution	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+BAIT+TIME+SEASON+HOOK+AREA	2738.2	2742.8	2736.2
YEAR+BAIT+TIME+SEASON+HOOK+AREA YEAR*BAIT	2710.3	2714.2	2706.3
YEAR+BAIT+TIME+SEASON+HOOK+AREA YEAR*TIME	**2700.1**	**2702.5**	**2696.1**
YEAR+BAIT+TIME+SEASON+HOOK+AREA YEAR*SEASON	2731.0	2733.9	2727.0
YEAR+BAIT+TIME+SEASON+HOOK+AREA YEAR*HOOK	2725.8	2725.8	2721.0
YEAR+BAIT+TIME+SEASON+HOOK+AREA YEAR*AREA	2739.8	2742.0	2735.8

B. Atlantic Ocean

Proportion positive-Binomial error distribution			
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+BAIT+HOOK	**3683.1**	**3687.7**	**3681.1**
YEAR+BAIT+HOOK YEAR*BAIT	3766.4	3768.4	3764.4
YEAR+BAIT+HOOK YEAR*HOOK	3767.8	3771.6	3763.8
Positive catches-Lognormal error distribution	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+BAIT+TIME+HOOK+DEPTH	1829	1833.2	1827
YEAR+BAIT+TIME+HOOK+DEPTH YEAR*BAIT	1818.3	1822.1	1814.3
YEAR+BAIT+TIME+HOOK+DEPTH YEAR*TIME	**1805.6**	**1807.9**	**1801.6**
YEAR+BAIT+TIME+HOOK+DEPTH YEAR*HOOK	1829.0	1832.0	1825.0
YEAR+BAIT+TIME+HOOK+DEPTH YEAR*DEPTH	1827.0	1830.0	1823.0

C. Gulf of Mexico

Proportion positive-Binomial error distribution			
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+DEPTH+BAIT	**2683.5**	**2687.7**	**2681.5**
YEAR+DEPTH+BAIT YEAR*DEPTH	2659.6	2663.0	2655.6
YEAR+DEPTH+BAIT YEAR*BAIT	2684.8	2687.9	2680.8
Positive catches-Lognormal error distribution	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+DEPTH+HOOK+BAIT	770.3	773.6	768.3
YEAR+DEPTH+HOOK+BAIT YEAR*DEPTH	769.6	772.9	765.6
YEAR+DEPTH+HOOK+BAIT YEAR*HOOK	771.5	774.3	767.5
YEAR+DEPTH+HOOK+BAIT YEAR*BAIT	**765.8**	**768.4**	**761.8**

Table 2. Analysis of mixed model formulations of the proportion of positive and positive catches for blacknose shark. Final models selected are in bold.

Proportion positive-Binomial error distribution			
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+DEPTH+AREA+BAIT	**6571.5**	**6576.7**	**6569.6**

YEAR+DEPTH+AREA+BAIT YEAR*DEPTH	6601.8	6605.8	6597.8
YEAR+DEPTH+AREA+BAIT YEAR*AREA	6809.7	6811.9	6805.7
YEAR+DEPTH+AREA+BAIT YEAR*BAIT	6602.6	6606.6	6598.6
Positive catches-Lognormal error distribution	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**
YEAR+TIME+HOOKTYPE	1462.9	1466.9	1460.9
YEAR+TIME+HOOKTYPE YEAR*TIME	1464.8	1467.1	1460.8
YEAR+TIME+HOOKTYPE YEAR*HOOK	**1454.2**	**1457.9**	**1450.2**

Table 3. The standardized index of abundance, coefficients of variation (CV), lower (LCI) and upper (UCI) 95% confidence intervals and number of sets observed (N) for Atlantic sharpnose shark by area.

A. Atlantic sharpnose shark, area combined.

YEAR	INDEX	CV	LCI	UCI	N
1994	10.534	0.654	0.004	0.042	102
1995	118.473	0.561	0.050	0.407	162
1996	107.619	0.558	0.046	0.368	126
1997	157.065	0.563	0.066	0.541	80
1998	245.823	0.543	0.107	0.819	110
1999	760.861	0.547	0.330	2.553	99
2000	828.940	0.567	0.348	2.872	64
2001	292.945	0.551	0.126	0.990	77
2002	272.197	0.548	0.118	0.916	132
2003	167.911	0.547	0.073	0.564	171
2004	133.011	0.558	0.057	0.455	120
2005	148.218	0.558	0.063	0.507	128

B. Atlantic sharpnose shark, Atlantic Ocean.

YEAR	INDEX	CV	LCI	UCI	N
1994	36.151	0.620	0.012	0.116	55
1995	203.128	0.552	0.074	0.583	109
1996	146.506	0.550	0.054	0.419	86
1997	177.954	0.571	0.063	0.527	54
1998	400.443	0.549	0.147	1.144	72
1999	674.209	0.582	0.234	2.032	68
2000	977.488	0.569	0.347	2.882	64
2001	498.290	0.567	0.177	1.465	54
2002	395.279	0.573	0.139	1.174	68
2003	98.901	0.594	0.034	0.304	91
2004	75.067	0.653	0.023	0.253	51
2005	216.165	0.597	0.073	0.667	53

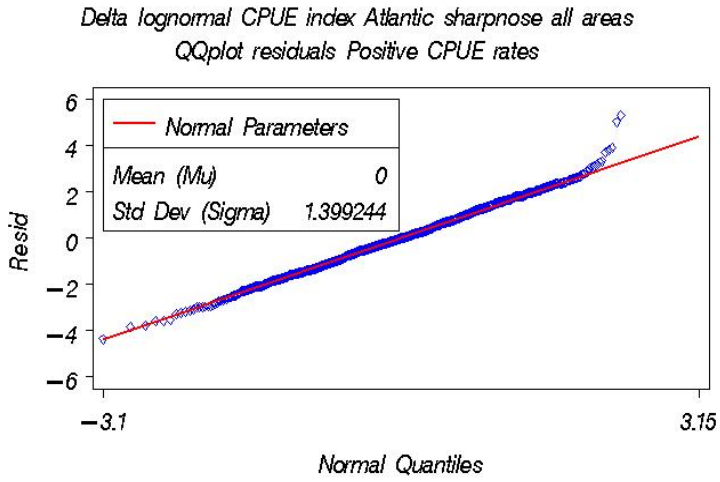
C. Atlantic sharpnose shark, Gulf of Mexico

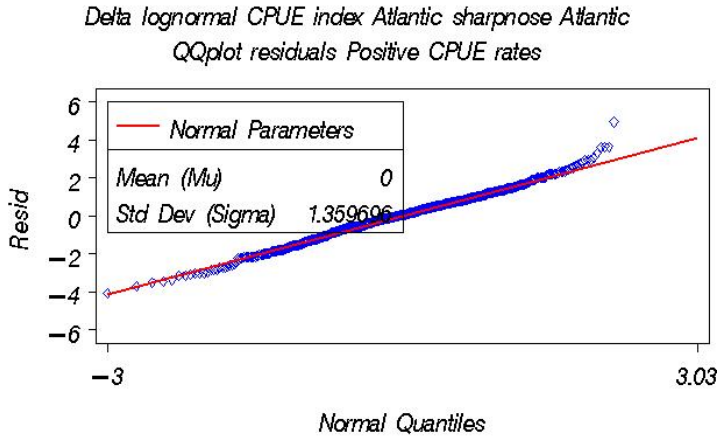
YEAR	INDEX	CV	LCI	UCI	N
1994	0.036	4.355	0.000	0.004	47
1995	1.533	0.909	0.001	0.023	53
1996	6.081	0.828	0.005	0.082	40
1997	167.410	0.575	0.184	1.555	26
1998	82.080	0.617	0.084	0.816	38
1999	102.412	0.526	0.122	0.878	31
2000					
2001	41.426	0.677	0.039	0.452	23
2002	92.860	0.498	0.116	0.760	64
2003	108.793	0.460	0.145	0.834	80
2004	170.670	0.463	0.226	1.316	69
2005	313.232	0.453	0.421	2.375	75

Table 4. The standardized index of abundance, coefficients of variation (CV), lower (LCI) and upper (UCI) 95% confidence intervals and number of sets observed (N) for blacknose shark.

YEAR	INDEX	CV	LCI	UCI	N
1994	17.126	0.615	0.042	0.407	102
1995	41.156	0.450	0.133	0.744	162
1996	35.776	0.459	0.114	0.657	126
1997	13.373	0.600	0.034	0.311	80
1998	37.706	0.465	0.119	0.700	110
1999	44.055	0.582	0.114	0.994	99
2000	130.194	0.522	0.373	2.663	64
2001	14.477	0.649	0.034	0.363	77
2002	67.202	0.368	0.252	1.049	132
2003	34.630	0.407	0.121	0.581	171
2004	28.780	0.501	0.085	0.568	120
2005	130.604	0.468	0.411	2.435	128

Figure 1. Quantile-quantile plots assessing the fits of the delta model for Atlantic sharpnose shark.





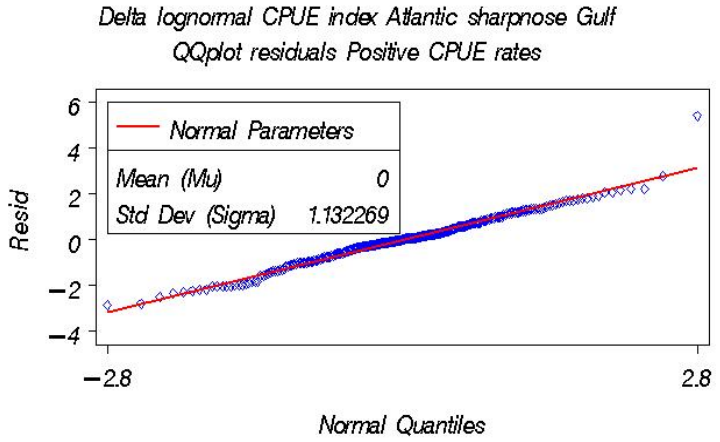


Figure 2. Quantile-quantile plots assessing the fits of the delta model for blacknose shark.

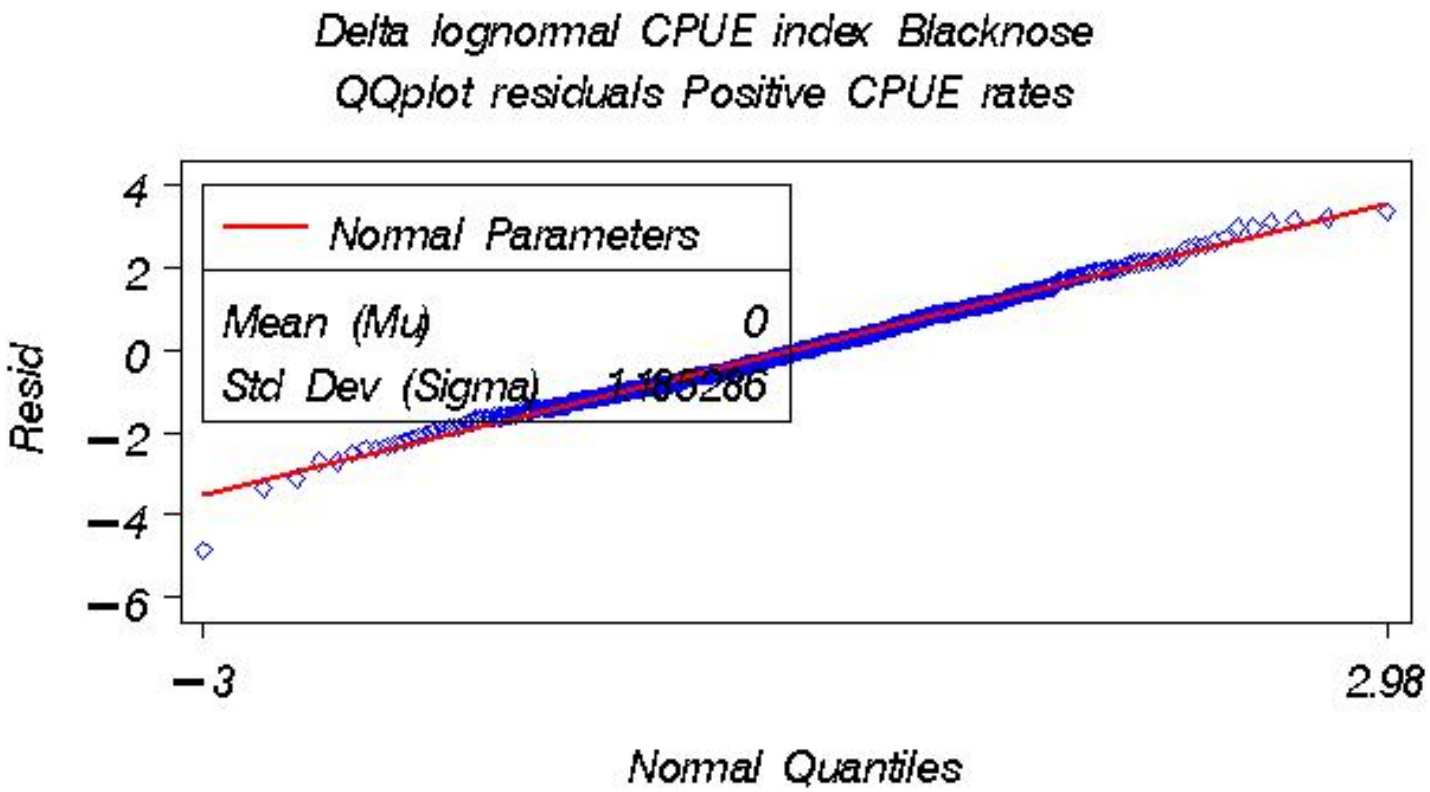
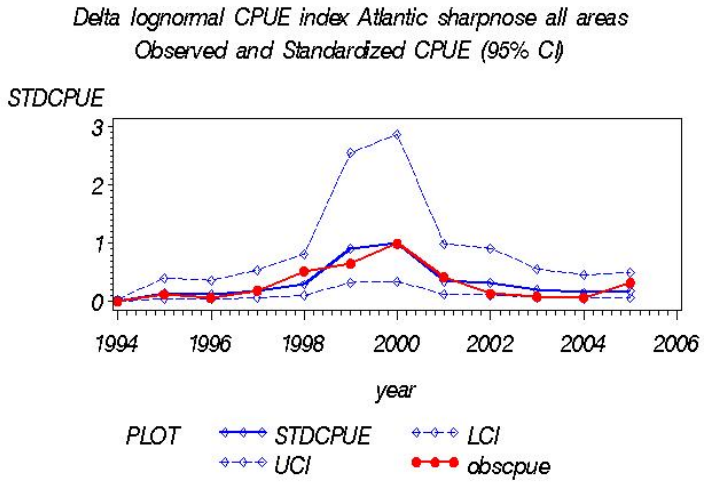
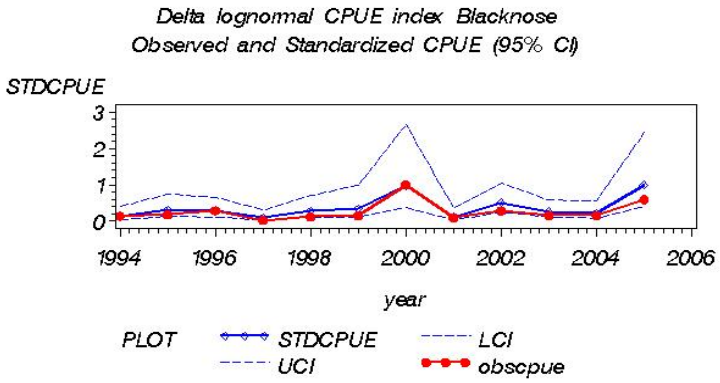
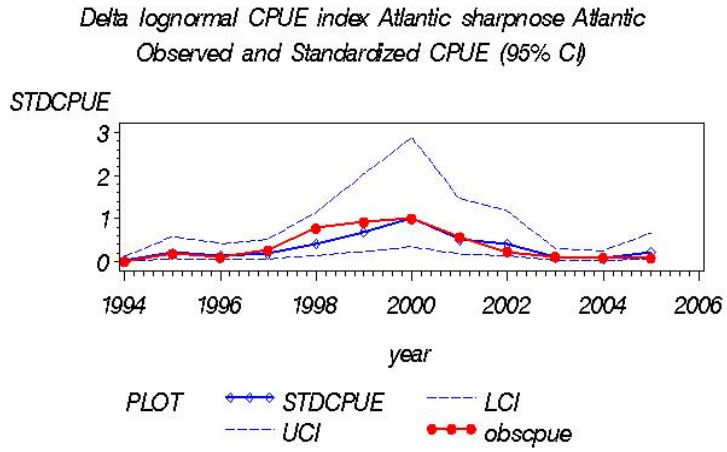
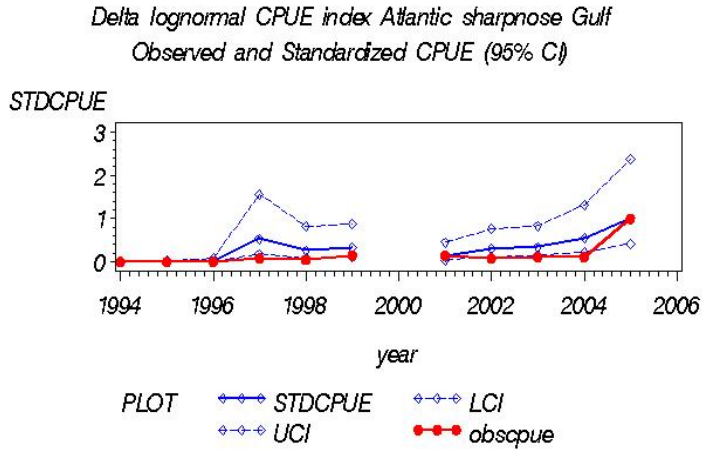



Figure 3. Standardized relative index (STDCPUE= index/maximum index) of abundance for Atlantic sharpnose and blacknose shark based on the final delta model. Nominal relative index (obscpue) are provided for comparison.