Catch rates, distribution and size composition of large coastal sharks collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico and U.S. Atlantic Ocean.

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Introduction and Survey Design

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico, Caribbean, and Southern North Atlantic since 1995 (Figure 1). The objective of this shark/snapper/grouper longline survey is to provide fisheries independent data for stock assessment purposes for as many species as possible, and this survey, conducted annually in U.S. waters of the Gulf of Mexico (GOM) and/or the Atlantic Ocean (Table 1), provides an important source of fisheries independent information on large coastal sharks from the GOM and Atlantic.

The primary objective of the initial surveys was assessment of the distribution and abundance of large and small coastal sharks across their known or suspected ranges. The fishing depths were selected based on commercial shark fishing log summaries, which indicated that the primary depths of effort were 18-73m (10 to 40 fm). A random stratified sampling design with three depth strata; 18-36m (10-20 fm), 36-55mm (20-30 fm) and 55-73 (30-40 fm) was used and uniform effort across contiguous 60 nm sampling zones was achieved. Results of the first two years of the survey, including a detailed description of the protocol and gear, are summarized by Grace and Henwood (1997).

Based on analysis of the first two survey years, the 1997 survey was modified by eliminating depth stratification and changing the survey depths to 10-55m (5-30 fm). The depth reduction was at the request of SEFSC to ensure that the full range of several coastal sharks was encompassed by the survey. Elimination of depth stratification was to avoid over-sampling strata which represented the least available habitat (the 30-40 fm strata represented very little of the available bottom, but was receiving 33% of the effort). During 1997, the survey was expanded into Mexican waters in an attempt to cover the full geographic range of some of the more important commercial shark species.

In 1998, the survey was conducted in Mexican waters of the Gulf of Mexico, the circumference of Cuba and the circumference of Navassa Island. Station selection based upon proportional allocation was implemented to ensure that the most abundant habitat received the highest levels of effort. Proportional allocation worked well in Mexican waters, but proved difficult in Cuba due to the narrowness of the continental shelf around most of the island. In many areas finding bottom for a one mile set was a challenge, limiting that set to certain depths was impossible.

A significant event in the evolution of our longline surveys occurred in 1999 when we were requested to implement a longline survey targeting red snapper (*Lutjanus campechanus)*. At the time, red snapper were not specifically targeted as part of the shark surveys; a different hook type (circle hook) was used, and different depth strata were sampled. The snapper work was conducted between 64-146m (35-80 fm) in an area from east of the Mississippi River to south of

Perdido Key, Florida. Random sampling without proportional allocation was used and sampling units were 10 n. mi. blocks given the small geographical area to be covered.

The 1999 shark survey was impacted by the unavailability of the Oregon II. Lack of a larger vessel capable of Gulfwide surveys led to substitution of the 55 ft. shrimp trawler RV Caretta as our survey vessel. The Caretta did not have the range, endurance or capability for 24-hr operations, and it was evident that a full shark survey was not possible. Given the logistical constraints posed by the Caretta, we contracted the survey to an area from the Texas-Louisiana border to Panama City, Florida. By doing this we were able to double and sometimes triple the effort within our 60 nm sampling units (shrimp statistical zones), and to test for optimal sampling levels by species and area. The survey used proportional allocation based on the amount of bottom within each unit. A hook experiment using 25% circle hooks and 75% J hooks was included to allow comparison of catches between the red snapper surveys and the shark surveys.

The year 2000 saw the second red snapper pilot survey conducted off Texas. Stations were randomly selected within 20 nm contiguous sampling blocks in depths of 64-146m (35-80 fm). The hook comparison study was continued with 75% circle hooks and 25% J hooks.

As a result of the two red snapper surveys and the encountering of many important commercial shark species in deeper waters, the 2000 annual shark survey in the Gulf of Mexico was expanded to a depth range of 9-183m (5-100 fms). Proportional allocation was used and the hook comparison study was continued with 75% J hook sets and 25% circle hook sets. A similar survey was conducted in the Atlantic over the same depth ranges and using the same percentages of circle and J hook sets.

In 2001, the shark and red snapper surveys were combined into a single annual survey of the U.S. Gulf of Mexico. Proportional allocation based on shelf width within statistical zones was adopted and the survey was stratified by depth with 50% allocation in 9-55m, 40% allocation from 55-183m and 10% allocation from 188-366m. This allocation provided effort in the 9-55m strata comparable to that achieved in previous shark surveys, thereby preserving the time series back to 1995. The major change in the shark surveys was adoption of the Circle hook as the standard for these surveys. The Gulfwide survey has been completed during FY01, FY02 (with interruption in the eastern Gulf), FY03, and FY04, and was interrupted in FY05 by Hurricane Katrina, with no further changes in sampling methodologies. Also, an Atlantic survey was conducted in FY02 and FY04 with interruption.

Prior to combining the red snapper and shark surveys, we conducted hook comparison studies, sampling density experiments and estimated relative abundance trends for sharks. The following text describes these experiments from a shark stock assessment standpoint.

Sampling Density Experiment

During the first 4 years of survey activities (1995 - 1998), survey effort was allocated based on logistics (time available and coverage area). Often the coverage areas were extensive (i.e., the U.S. Gulf of Mexico and Atlantic seaboard) and allocation of longline sets was determined by available sea days. However, during the 1999 survey vessel constraints prevented a geographically broad-based survey and the survey area was restricted to the north-central U.S. Gulf of Mexico. Based on the allocation of sea days, bottom longline effort within some of the 60-nautical mile statistical zones was increased 2 fold over previous years. This sampling increase allowed statistical analysis useful for determining adequate sampling levels for several important shark management species without having to account for annual variability. The survey area for the 1999 survey extended from south of western Louisiana to south of Cape San Blas of the Florida panhandle (Figure 1). During the 1995 - 1998 surveys this area produced the highest and most species diverse shark catches as compared with other areas.

The coefficient of variation on mean CPUE per species was evaluated at different sample sizes. This was accomplished by first assuming the mean CPUE for each species and its variance was accurate for each population in the sample area. This assumption was considered valid due to the high concentration of sampling effort within the survey area. Due to the zero inflated highly skewed nature of the data, unbiased estimates of mean CPUE and variance were computed using the delta method (Pennington, 1983, 1996). From these statistics, percent standard error (PSE) was calculated for each species for simulated sample sizes ranging from 1 - 200. Line plots were constructed representing the change in PSE with increasing sample size. Sharks encountered during the surveys were not normally distributed and fit the description of low density populations when sampling with passive gear (Murphy and Willis, 1996). The PSE plots (Fig. 2) exhibit a general trend for decreasing PSE with an increase in sampling size; this emulates the slope of the plot presented by Murphy and Willis (1996) for low-density distributions that are not normally distributed (frequency of capture plotted against the number of organisms captured by set with passive gear). Employing the delta method (Pennington, 1983 and 1996) for determining adequate sampling sizes facilitated a more useful and accurate analysis than analytical methods that assume normal distributions.

For the purposes of the sampling density experiment, a sample size that yielded a PSE < 50.0% was considered to have adequate precision for providing reliable statistical information. Based on a PSE of 50.0%, it was possible to determine adequate sampling levels for several important shark management species (e.g., blacknose, blacktip, Atlantic sharpnose, spinner, sandbar, tiger, scalloped hammerhead and finetooth; Fig. 2). The sharks presented are grouped according to their sample size ranges to facilitate graphic representation. For all sharks collectively, a PSE of 50% is achieved with 10 longline sets. For the finetooth shark, the least frequently encountered shark, just under 160 longline sets are required to achieve a PSE of 50%. The PSE values are synoptic within the time frame and survey area for survey CARETTA 99-01.

An associated result to the analysis for the sampling density experiment is the rank in ascending PSE values by species; all sharks combined, blacknose, sharpnose, blacktip, tiger, spinner, scalloped hammerhead, sandbar and finetooth . The PSE ranking closely follows the order for percent composition by species for all surveys combined; the exceptions are the Atlantic sharpnose shark that constitutes a higher percent catch composition than the blacknose shark and the absence of smooth dogfish that are distributed deeper than the depth range for the data set used for the sampling density experiment. This parallel between the 2 rankings may be an indication that the survey area assessed during CARETTA 99-01 (the north-central Gulf of Mexico) may be a unique assessment window representative of shark populations in a broad geographical sense.

The results of the sampling density experiment are important to survey objectives in that it is possible to determine effort levels necessary to sufficiently document species distributions. This can be of particular importance for not only assessing the effectiveness of a survey, but also for designing surveys targeting a specific species. If annual abundance variability is considered not to be a potential source of bias when allocating effort, it is possible to establish adequate sampling levels (based on a past survey or collection of past surveys) for species within specific areas or for broad-based surveys. This is a useful tool for examining not only the more abundant species, but also for assessing cryptic species; surveys can be tailored with effort allocation by area to suit research or management objectives. For some of the rarely captured species achieving adequate sampling would require an unrealistic and logistically challenging amount of effort to gain reliable statistical information on CPUE data.

Hook Comparison Study

For statistical analyses comparing differences between the use of C hook and J hooks, species specific CPUE, mean total length (TL) per hook type, and diversity of catch was compared between hook types for the four cruises during where both hook types were used [i.e., CARETTA 99-01; GU-00-03 (8); OT-00-04 (241); FE-00-12 (2)]. Due to the zero inflated highly skewed nature of the CPUE data, traditional parametric tests (e.g., t-tests) were not appropriate to discern differences in CPUE between hook types for each species. Therefore, a two-group comparison randomization technique was used to test the null hypothesis of no difference in mean CPUE between red snapper captured with C hooks and those with J hooks. This technique was first established by Fisher (1935, 1936) and has recently been updated by Manly (1997). To accomplish this technique, the species specific arithmetic mean difference in CPUE was calculated between C hooks and J hooks (d_{sp}). Next, under the null hypothesis that there is no difference in CPUE between hook types (i.e., the distribution of CPUE data is the same for each hook type), any one of the observed values $c_1, c_2, \ldots, c_m$ and $j_1, j_2, \ldots, j_n$ could equally have occurred in either of the samples. Therefore, a new sample 1 was chosen by randomly selecting m values out of the full set of m + n values, with the remaining n values providing the new sample 2. The mean difference was then calculated for this randomized set of data. This step was repeated 1000 times for a total of 1000 randomized mean differences. These differences were arranged in order from smallest to largest. If the null hypothesis was true, then d_{sp} should tend toward zero, which would be the center of the list of the set of 1000 differences. However, if there was a difference in the distributions of CPUE between C hooks and J hooks, then d_{sp} would tend to be at either end of the list depending on whether the difference is negative or positive. For a positive difference, d_{sp} was said to be sufficiently large ($\alpha = 0.05$) if it occurred among the top 95% of the values in the list. For a negative difference, d_{sp} was said to be significant ($\alpha = 0.05$) if it occurred among the bottom 5% of the values in the list. This type of randomization test has many advantages. First, the test is exact and secondly, it is not necessary to assume any particular type of distribution such as a normal distribution for each sample for a t-test. In addition, unlike a non-parametric test such as the Mann-Whitney U-test, it allows the original data to be used rather than just the ranks of the data.

When examining the comparison data stratified by depths 9 m - 55 m (5 fm - 30 fm), there was a significant difference for CPUE between hook types with the C hook having significantly higher CPUEs for all sharks collectively, blacknose, finetooth, blacktip and Atlantic sharpnose sharks

(Table 2). When data from all depth strata are assessed, the only significantly higher shark CPUE is for all sharks collectively (Table 3) and for all telelosts, red snappers and groupers (Table 4).

To test for differences in mean TL per species per hook type, *t*-tests were employed due to the approximate normality of the data. First, however, equality of variances was tested ($a = 0.05$) per species between hook types using the Folded F method (Steel and Torrie, 1980). If the variances between hook-types were different then a *t*-test for unequal variances was conducted using the Satterthwaite method (1946), and if variances were not significantly different then a *t*-test for equal variances was conducted using the pooled method (Devore and Peck, 1994). Results are shown in Table 5.

To compare species diversity between hook sizes, the diversity of fish communities sampled by each hook size was indexed using the Shannon-Wiener method (Shannon, 1948); data analysis from surveys where both hook sizes were used [i.e., CARETTA 99-01; GU-00-03 (8); OT-00-04 (241); FE-00-12 (2)]. To compare indices from each hook size, a modified *t*-test was used based on methods established by Basharin (1959) and Hutcheson (1970). The results were; $H'_C = 1.41$, $S_{H'C} = 0.068$, and $H'_J = 1.34$, $S_{H'J} = 0.074$, where H'_C and H'_J are the Shannon-Wiener diversity indices for C hooks and J hooks respectively, and $S_{H'C}$ and $S_{H'J}$ are standard deviations of those index values. The *t*-value was 0.703 and the *p*-value for difference in diversity was $p > 0.25$. Therefore, the analysis establishes there was no significant difference in species diversity between hook types (totals; 32 species for C hooks, 28 species for J hooks).

There are several important implications from the hook comparison study; most notably is hook type can affect CPUE. Improving survey efficiency by using a more effective C hook results in catches with generally higher CPUE values. This is an important consideration for better utilization of survey opportunities (getting the most return for survey effort), controlling gear-related biases, and for expanding survey objectives to target a variety of important management species.

Uses of longline data for the LCS SEDAR 2005

For the LCS SEDAR 2005, we used the entire time series of data to develop abundance indices for blacktip shark, sandbar shark and the large coastal shark complex (LCSC) for both the GOM and Atlantic. Before any statistics were employed, the occurrence of stations and stations where blacktip, sandbar and LCSC were caught were plotted by year and all years combined (Figures 3 – 35). Figure 36 shows the species that the make up of LCSC in our data set from the GOM and Atlantic. As described earlier, survey coverage area varied during the time series due to weather, mechanical problems, and mission objectives. Data inclusion in development of annual indices was based on these effort and catch distribution charts (Table 6). If a certain area was not covered or only minimally covered during a given survey year, then that data was not included in the time series for that area. For this study there were five area demarcations: Atlantic (only south of 37° north latitude); Gulfwide (U.S. Gulf of Mexico); Eastern Gulf (east of 88° west longitude); Central Gulf (between 88° and 93° west longitude); and Western Gulf (west of 93° west longitude). Also, as described earlier, hook-type changed over time from J to circle-hooks (C-hooks). Due to the current plan to continue using C-hooks, J-hook catch data were adjusted using an area and species-specific ratio of C-hook CPUE to J-hook CPUE. This allowed for the hook-type effect to be adjusted for before development of annual abundance indices.

In order to develop standardized indices of annual average CPUE for blacktip shark, sandbar shark and LCSC for both the GOM and Atlantic, a delta-lognormal model, as described by Lo et al. (1992), was employed. This index is a mathematical combination of yearly CPUE estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive CPUE values (i.e., presence/absence) and lognormal model which describes variability in only the nonzero CPUE data. The GLMMIX and MIXED procedures (Patetta, 2002) in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. The parameters included in each sub-model were year and depth, and separate covariance structures were developed for each survey year. For the binomial models, a logistic-type mixed model was employed for all areas for LCSC. The fit of each model was evaluated using the fit statistics provided by the GLMMIX macro. For blacktip and sandbar sharks, annual frequencies of occurrence were almost always less than 0.2 and many times less than 0.1, indicating a zero-inflated binomial distribution. Therefore, a zero-inflated binomial regression model was employed instead of a binomial model using the methodology of (Tyre et al., 2003) and the NLMIXED procedure in SAS. Initially, several model types were used to describe the nonzero CPUE data. These included lognormal, Poisson and negative binomial. Based on analyses of residual scatter and QQ plots, the lognormal model was more fitting than the others in describing the variability in the nonzero data in most of the models. Figures 37 – 51 summarize annual abundance indices for blacktip shark, sandbar shark and LCSC by year and area.

We next constructed length frequency histograms for blacktip shark, sandbar shark and LCSC for the Atlantic, GOM and GOM sub-areas (Figures 52 – 63). Also, length frequency histograms for blacktip shark, sandbar shark and LCSC for both estimated and non-estimated lengths (Figures) were constructed, which indicated that lengths of the larger sharks were more likely to be estimated and that fork lengths were less often estimated than total lengths.

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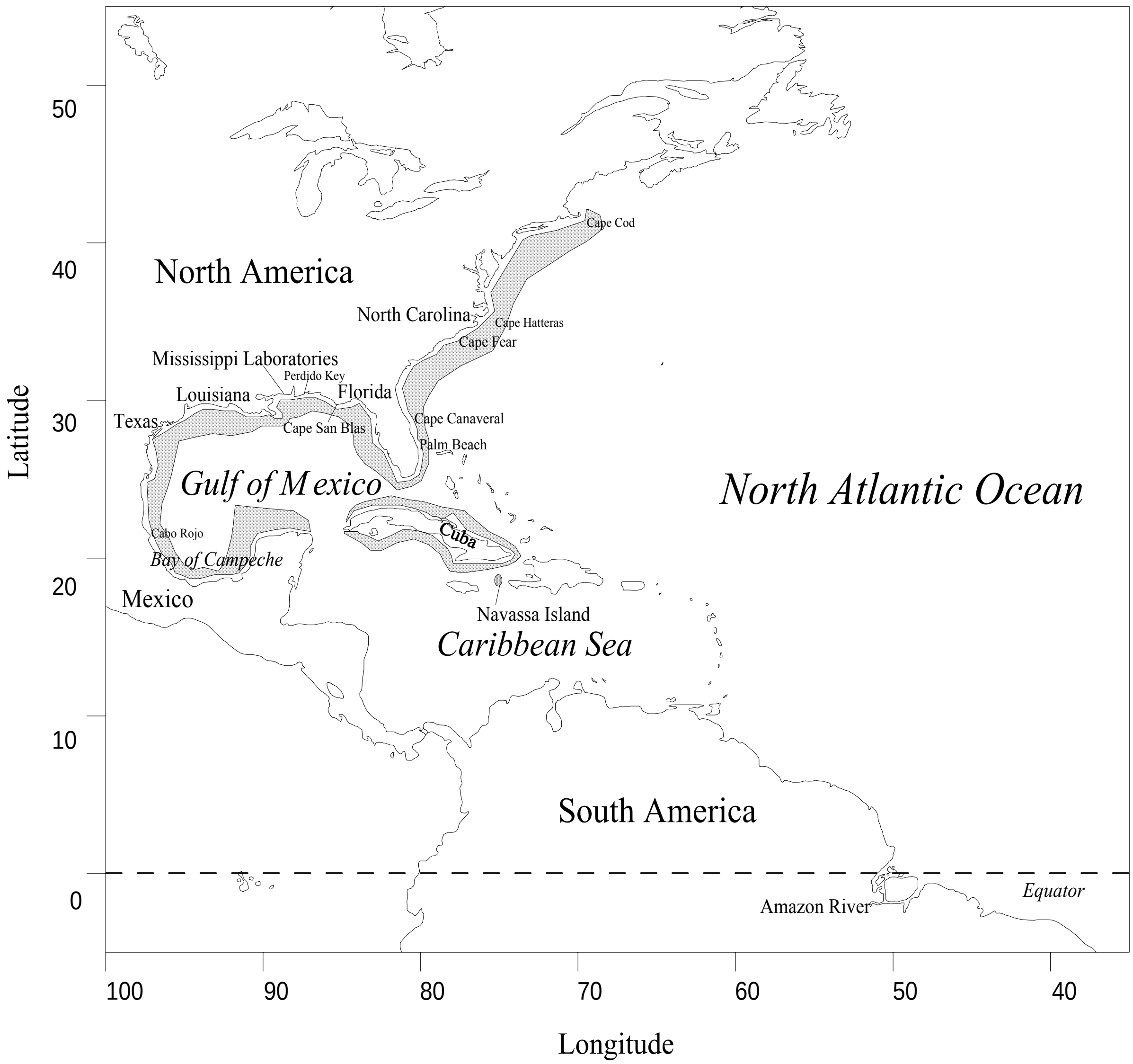


Figure 1. Survey areas for NMFS MS Laboratories longline projects (1995-2001) in the western North Atlantic Ocean.

Table 1. NMFS MS Laboratory longline projects, 1995 - 2003.

Survey	Date	Location	Depth range (m)	Effort (# sets)	Random station selection description.
OT-95-04 (218)	7/23 - 8/17/95	GOM[1]	18 m - 73 m	82	Stations depth stratified and equally allocated within statistical zones; depth strata 18 m - 37 m, 37 m - 55 m, 55 m - 73 m; J hooks.
RS-95-03 (2)	8/10 - 8/24/95	Atlantic[2]	18 m - 73 m	45	Stations depth stratified and equally allocated within statistical zones; depth strata 18 m - 37 m, 37 m - 55 m, 55 m - 73 m; J hooks.
OT-96-04 (222)	7/31 - 9/13/96	GOM and Atlantic	18 m - 73 m	151	Stations depth stratified and equally allocated within statistical zones; depth strata 18 m - 37 m, 37 m - 55 m, 55 m - 73 m; J hooks.
OT-97-04 (227)	7/25 - 9/24/97	Mexican GOM, GOM and Atlantic	9 m - 55 m	259	Stations not depth stratified but equally allocated within 60 linear n. mile zones or statistical zones; J hooks.
OT-98-02 (231)	7/24 - 9/22/98	Mexican GOM, Cuba [3], GOM	9 m - 413 m	216	Stations not depth stratified but equally allocated within 60 linear n. mile zones or statistical zones; J hooks.
OT-99-02 (233)	2/16 - 3/2/99	Atlantic	9 m - 55 m	29	Stations not depth stratified but equally allocated within statistical zones; J hooks.
FE-99-10 SEF	5/6 - 5/19/99	GOM	64 m - 146 m	60	Station coordinates by random longitude and random depth and equally allocated within 10 linear n. mile contiguous sampling blocks; circle hooks.
CARETTA 99-01	8/4 - 9/28/99	GOM	9 m - 55 m	161	Proportional allocation based on continental shelf width within statistical zones; sampling density experiment; hook comparison experiment with 75% J hooks, 25% circle hooks.
GU-00-03 (8)	6/6 - 6/19/00	GOM	64 m - 146 m	59	Station coordinates by random longitude and random depth and equally allocated within 20 linear n. mile contiguous sampling blocks; hook comparison experiment with 75% circle hooks, 25% J hooks.
OT-00-04 (241)	8/3 - 8/28/00	GOM	9 m - 183 m	137	Proportional allocation based on continental shelf width within statistical zones; sampling density experiment; hook comparison experiment with 75% J hooks, 25% circle hooks.
FE-00-12 (2)	9/6 - 10/16/00	Atlantic	9 m - 183 m	105	Proportional allocation based on continental shelf width within statistical zones; sampling density experiment; hook comparison experiment with 75% J hooks, 25% circle hooks.
OT-00-08 (244)	12/6 - 12/12/00	GOM	55 m - 366 m	41	Station coordinates by random longitude and random depth and equally allocated within 10 linear n. mile contiguous sampling blocks; stations depth stratified with 4 stations each block 55 m - 183 m, 2 stations each block 183 m - 366 m; hook comparison experiment with 75% circle hooks, 25% J hooks.
ONJUKU-01	6/1 - 6/20/01	Mexican GOM[4]	9 m - 50 m	38	Proportional allocation based on continental shelf width within 60 linear n. mile sampling zones; circle hooks, Atlantic bonito for bait.
OT-01-04 (247)	7/31 - 9/30/01	GOM	9 m - 366 m	277	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
ONJUKU-01	6/28 - 7/5/02	Mexican GOM[4]	18 m - 217 m	30	Proportional allocation based on continental shelf width within 60 linear n. mile sampling zones; circle hooks, Atlantic bonito for bait
OT-02-04 (251)	7/31 - 9/21/02	GOM and Atlantic	9 m - 366 m	212	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
OT-03-04 (255)	7/29 - 9/29/03	GOM	9 m - 366 m	280	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
GANDY 72-043	07/25 - 08/28/04	Atlantic	8 m – 34 m	40	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
OT-04-04 (260)	7/31 - 9/29/04	GOM	9 m - 366 m	232	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
GANDY 72-044	10/06 - 10/23/04	GOM	7 m – 92 m	17	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.
OT-05-04 (266)	8/5 - 8/25/05	GOM and Atlantic	9 m - 366 m	74	Proportional allocation based on continental shelf width within statistical zones; depth stratified, 50% allocation 9 m - 55 m, 40% allocation 55 m - 183 m, 10% allocation 183 m - 366 m; circle hooks.

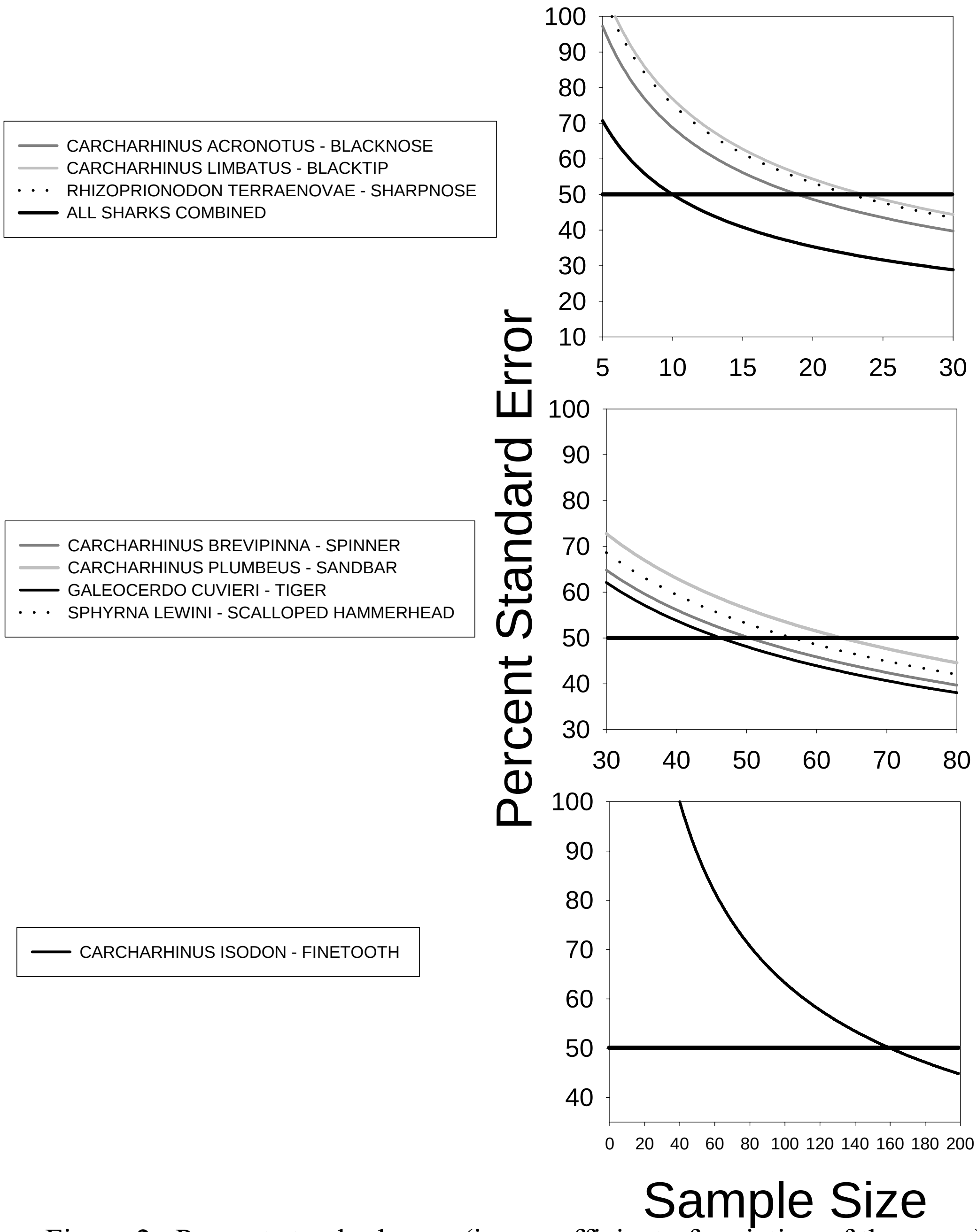


Figure 2. Percent standard error (i.e., coefficient of variation of the mean) shown as a function of sample size for selected species sharks and for all species combined. Dark horizontal line in each graph represents the 50% threshold.

Table 2. Mean differences between CPUE of sharks captured with c-hooks (n_c = 99) and those captured with j-hooks (n_j = 274; n_{total} = 373) between 5 and 30 fathoms.

Species	Occurrences	Total number of individuals	Mean CPUE, c-hooks	Mean CPUE, j-hooks	Mean difference	p-value
All Sharks	301	2237	9.38	4.77	4.61	>0.0001**
Carcharhinus acronotus, blacknose	86	178	0.84	0.35	0.49	0.005**
Carcharhinus brevipinna, spinner	29	90	0.41	0.18	0.23	0.123
Carcharhinus falciformis, silky	12	13	0.060	0.026	0.034	0.127
Carcharhinus isodon, finetooth	6	29	0.273	0.007	0.266	0.008**
Carcharhinus limbatus, blacktip	70	156	0.69	0.32	0.37	0.032**
Carcharhinus luecus, bull	14	30	0.0808	0.0803	0.0005	0.464
Carcharhinus plumbeus, sandbar	25	34	0.101	0.088	0.003	0.417
Galeocerdo cuvieri, tiger	77	116	0.39	0.28	0.11	0.183
Rhizoprionodon terraenovae, sharpnose	211	1558	6.44	3.36	3.08	0.001**
Sphyrna lewini, scalloped hammerhead	22	25	0.061	0.069	-0.008	0.492
Sphyrna mokarran, great hammerhead	3	3	0.010	0.007	0.003	0.443

**Significant at $\alpha > 0.05$. *Marginally significant at $\alpha > 0.1$.
(04-241, 55-991, 63-003, 64-012, 04-244) depth 5-30 fathoms

Table 3. Mean differences between CPUE (# per 10,000 hook hours) of sharks captured with c-hooks ($n_c = 166$) and those captured with j-hooks ($n_j = 336$; $n_{total} = 502$).

Species	**Total occurrences**	**Total number of individuals**	**Mean CPUE, c-hooks**	**Mean CPUE, j-hooks**	**Mean difference**	**p-value**
All Sharks	411	3319	836	575	261	0.002**
Carcharhinus acronotus, blacknose	88	182	52	28	24	0.093*
Carcharhinus brevipinna, spinner	39	130	25.90	25.89	0.01	0.479
Carcharhinus falciformis, silky	31	37	12	5	7	0.067*
Carcharhinus isodon, finetooth	6	29	16	1	15	0.414
Carcharhinus limbatus, blacktip	82	217	45	43	2	0.405
Carcharhinus luecus, bull	20	40	7	9	-2	0.411
Carcharhinus plumbeus, sandbar	49	65	14	12	2	0.379
Centrophorus granulose, slimy	4	86	51.2	0.3	50.9	0.062*
Galeocerdo cuvieri, tiger	79	118	23.49	23.51	-0.02	0.513
Ginglymostoma cirratum, nurse	19	25	8	4	4	0.091*
Isurus oxyrinchus, shortfin mako	3	3	60.2	59.5	0.7	0.499
Mustelus canis, smooth dogfish	67	281	84	42	42	0.074*
Mustelus norrisi, Florida smoothhound	8	14	4	2	2	0.255
Rhizoprionodon terraenovae, sharpnose	251	2015	473	366	107	0.141
Sphyrna lewini, scalloped hammerhead	52	65	16	12	4	0.245
Sphyrna mokarran, great hammerhead	3	3	0.602	0.595	0.007	0.504

**Significant at $\alpha > 0.05$. *Marginally significant at $\alpha > 0.1$.
(04-241, 55-991, 63-003, 64-012, 04-244) no depth limits

Table 4. Mean differences between CPUE of groupers and snappers captured with c-hooks ($n_c = 166$) and those captured with j-hooks ($n_j = 336$; $n_{total} = 502$).

Species	**Total occurrences**	**Total number of individuals**	**Mean CPUE, c-hooks**	**Mean CPUE, j-hooks**	**Mean difference**	**p-value**
All Groupers and Snappers	58	174	94	5	89	> 0.0001*
Epinephelus flavolimbatus, yellowedge grouper	20	34	18	1	17	> 0.0001*
Epinephelus morio, red grouper	7	27	15	1	14	0.018*
Epinephelus nigritus, warsaw grouper	3	4	2	0	2	0.036*
Lutjanus campechanus, red snapper	32	101	54	3	51	> 0.0001*
Mycteroperca phenax, scamp	2	3	2	0	2	0.104
Rhomboplites aurorubens, vermilion snapper	3	3	2	0	2	0.034*

*Significant at $\alpha > 0.05$.
(04-241, 55-991, 63-003, 64-012, 04-244) no depth limits

Table 5. Mean differences between total lengths of sharks, groupers and snappers captured with c-hooks and those captured with j-hooks.

Species	Sample size, c-hooks	Sample size, j-hooks	p-value for equal variances	Mean total length, c-hooks (mm)	Mean total length, j-hooks (mm)	Mean difference (mm)	t-value	p-value
All Sharks	1747	1376	<0.0001**	989	1058	-69	-6.14	<0.0001**
Carcharhinus acronotus, blacknose	84	88	0.0123**	1047	1076	-29	-1.40	0.1631
Carcharhinus brevipinna, spinner	77	52	0.3654	1154	1185	-31	-0.90	0.3681
Carcharhinus falciformis, silky	21	16	0.0966*	1094	1259	-166	-1.66	0.1136
Carcharhinus isodon, finetooth	27	2	0.9999	1191	1073	119	1.31	0.2023
Carcharhinus leucus, bull	14	26	0.4077	1918	2326	-408	-2.64	0.0119**
Carcharhinus limbatus, blacktip	114	102	0.0912*	1184	1309	-125	-4.27	<0.0001*
Carcharhinus plumbeus, sandbar	26	36	0.5767	1499	1614	-114	-1.54	0.1297
Galeocerdo cuvieri, tiger	39	78	0.2954	1164	1336	-173	-2.20	0.0301**
Mustelus canis, smooth dogfish	212	64	0.2398	1050	1129	-79	-3.38	0.0008**
Rhizoprionodon terraenovae, sharpnose	971	872	0.0036**	872	894	-22	-3.96	<0.0001**
Sphyrna lewini, scalloped hammerhead	31	33	0.4217	1695	1751	-56	-0.45	0.6516
Epinephelus flavolimbatus, yellowedge grouper	30	2	0.9968	754	949	-195	-1.83	0.0777*
Epinephelus morio, red grouper	24	2	0.3358	528	550	-22	-0.21	0.8340
Lutjanus campechanus, red snapper	88	11	0.5635	756	842	-86	-2.97	0.0037**

**Significant at $\alpha > 0.05$. *Marginally significant at $\alpha > 0.1$.
(04-241, 55-991, 63-003, 64-012, 04-244) no depth limits, estimated lengths included, total lengths

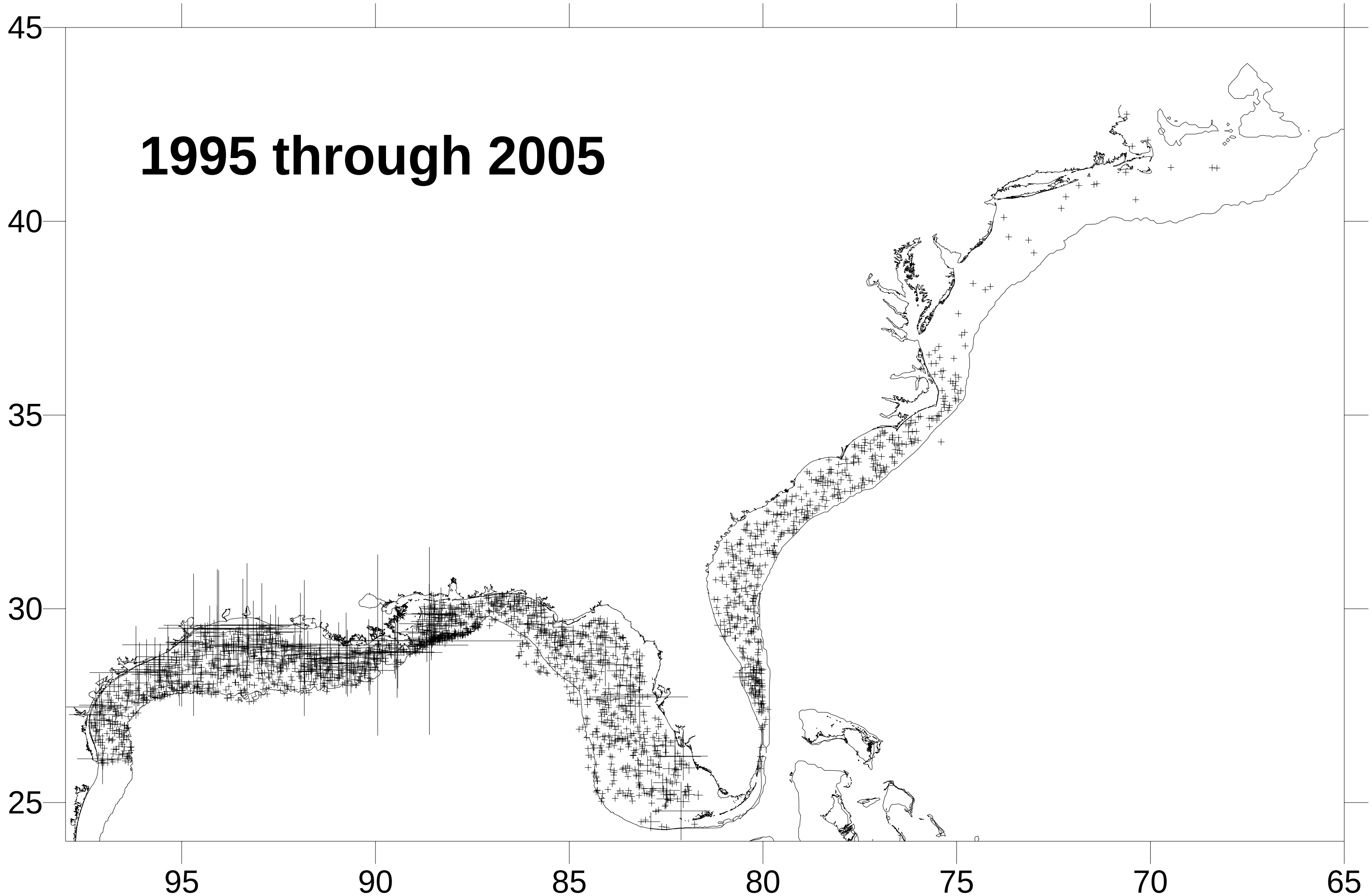


Figure 3. Survey effort and CPUE (range: 0 to 29 sharks per 100 hook hours) of blacktip shark from 1995 through 2005. Small crosses indicate effort with no catch. Size of enlarged crosses are linearly related to CPUE.

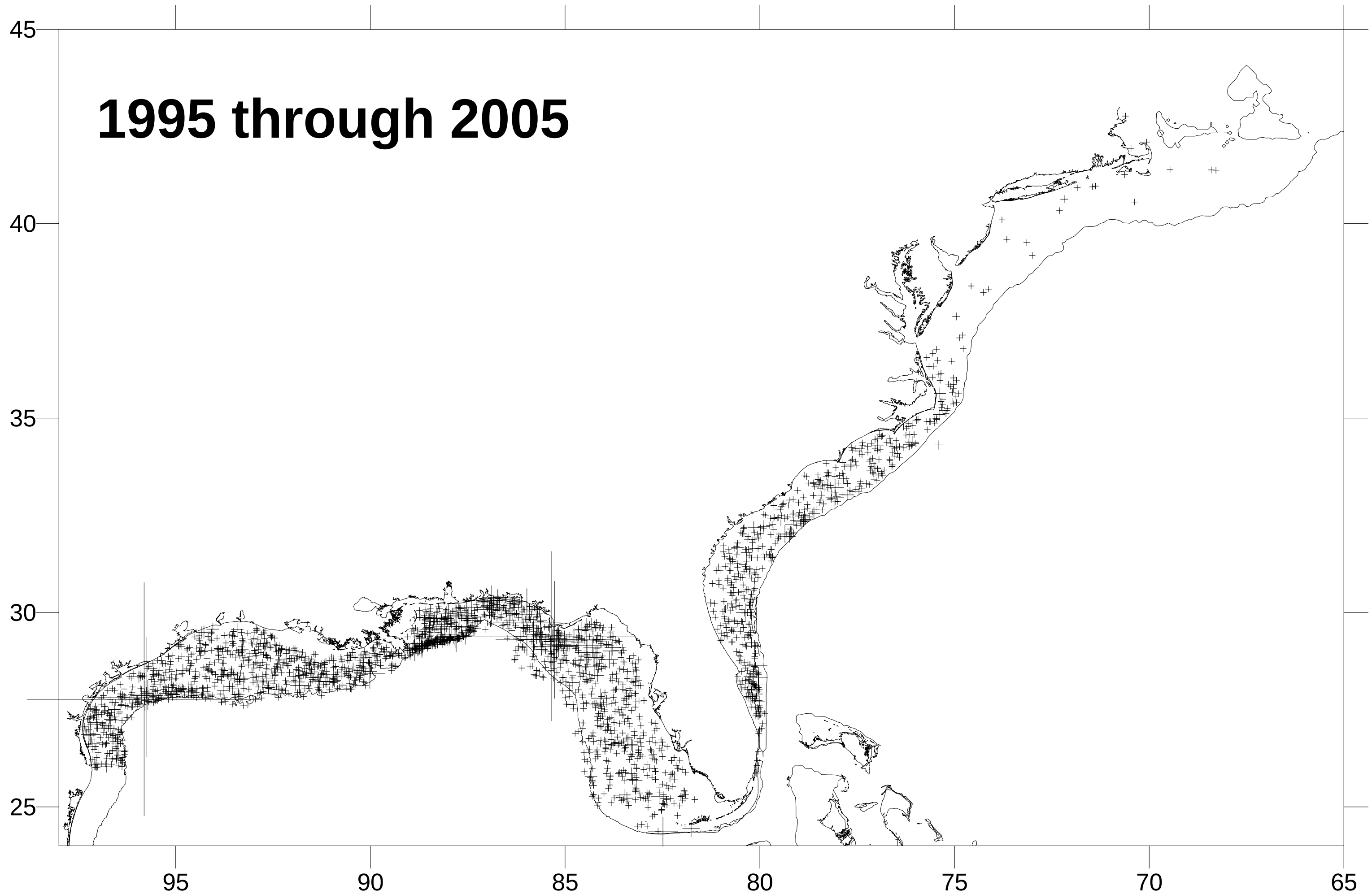


Figure 4. Survey effort and CPUE (range: 0 to 38 sharks per 100 hook hours) of sandbar shark from 1995 through 2005. Small crosses indicate effort with no catch. Size of enlarged crosses are linearly related to CPUE.

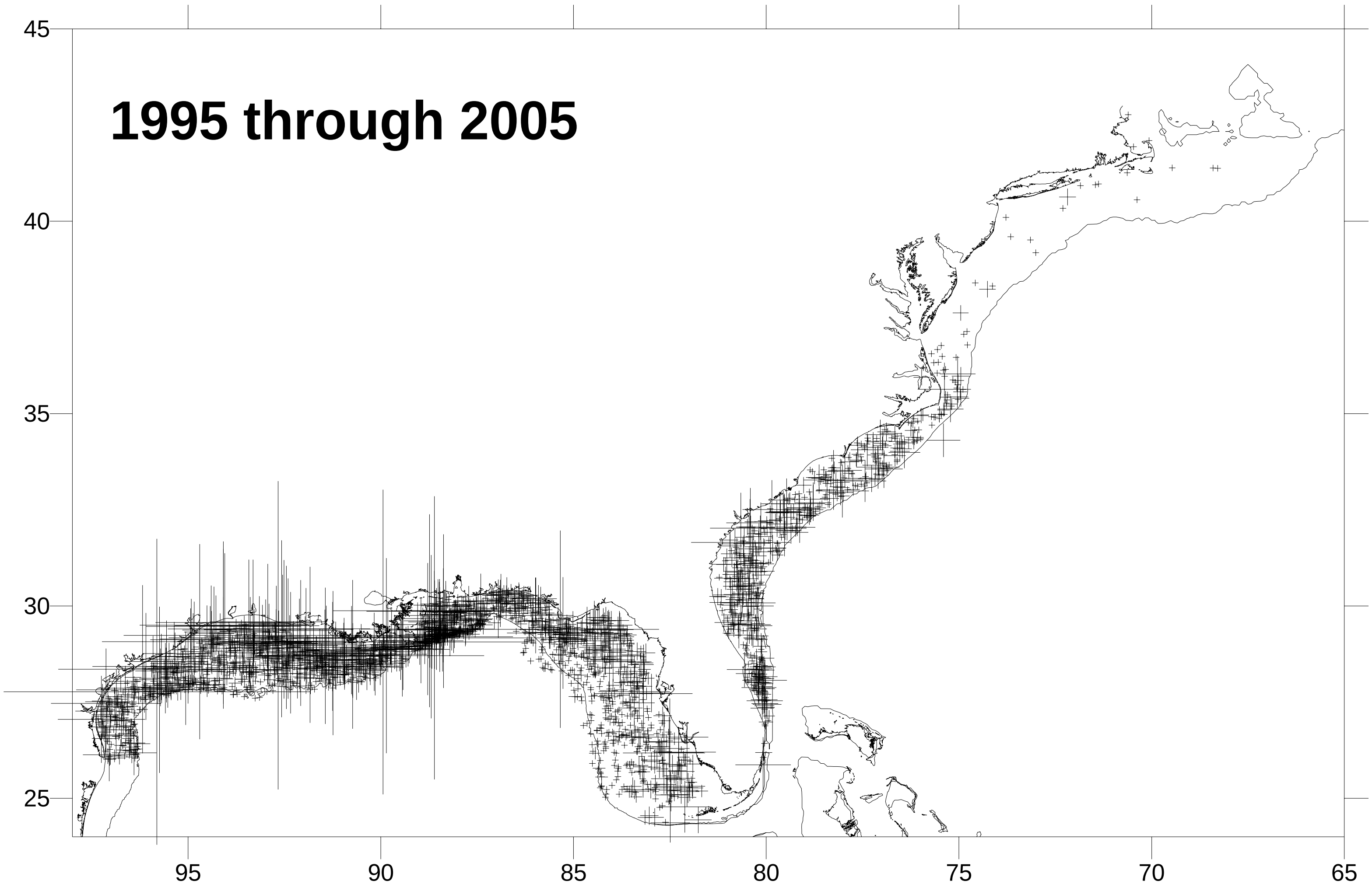


Figure 5. Survey effort and CPUE (range: 0 to 48 sharks per 100 hook hours) of large coastal sharks from 1995 through 2005. Small crosses indicate effort with no catch. Size of enlarged crosses are linearly related to CPUE.

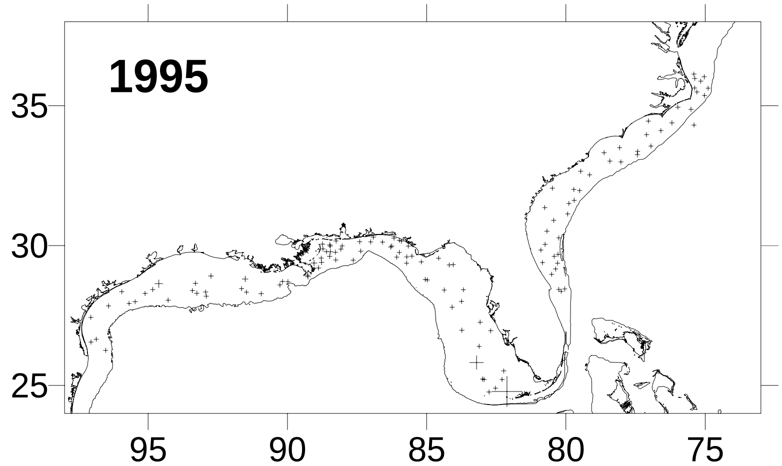


Figure 6. Survey effort and CPUE (range: 0 to 7 sharks per 100 hook hours) of blacktip shark from 1995.

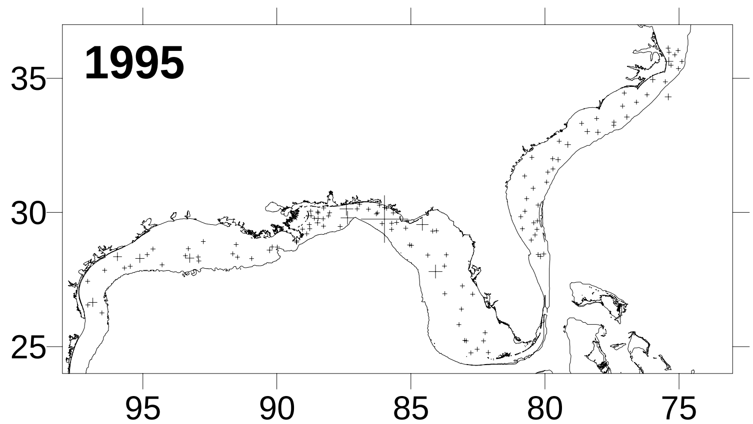


Figure 7. Survey effort and CPUE (range: 0 to 10 sharks per 100 hook hours) of sandbar shark from 1995.

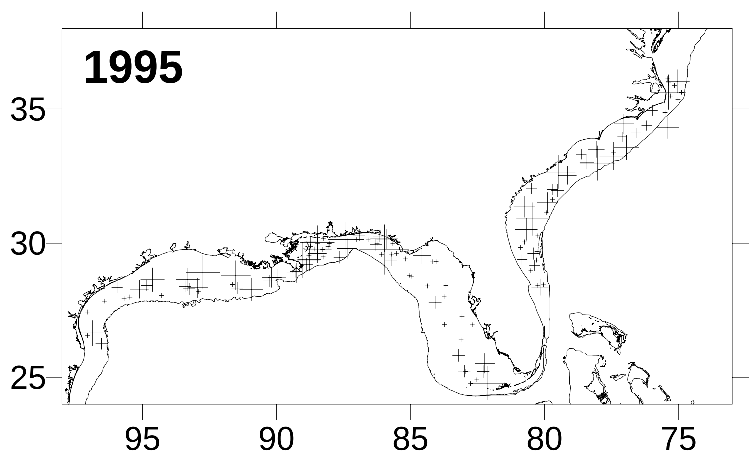


Figure 8. Survey effort and CPUE (range: 0 to 11 sharks per 100 hook hours) of large coastal sharks from 1995.

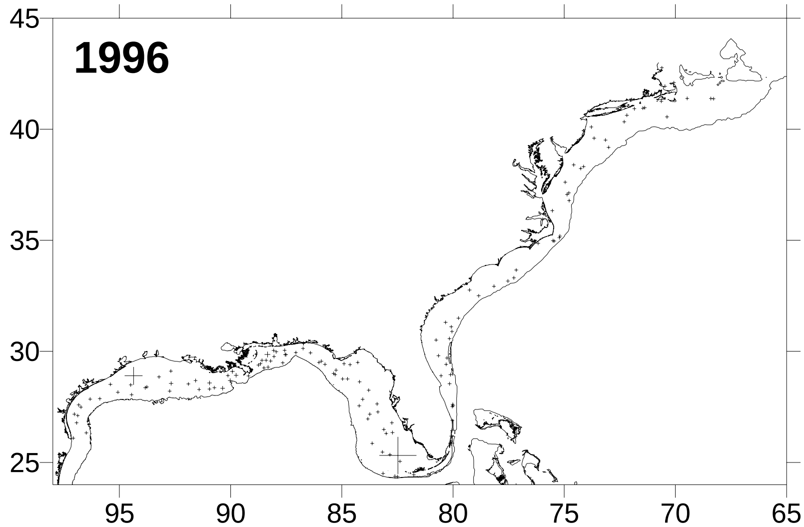


Figure 9. Survey effort and CPUE (range: 0 to 4 sharks per 100 hook hours) of blacktip shark from 1996.

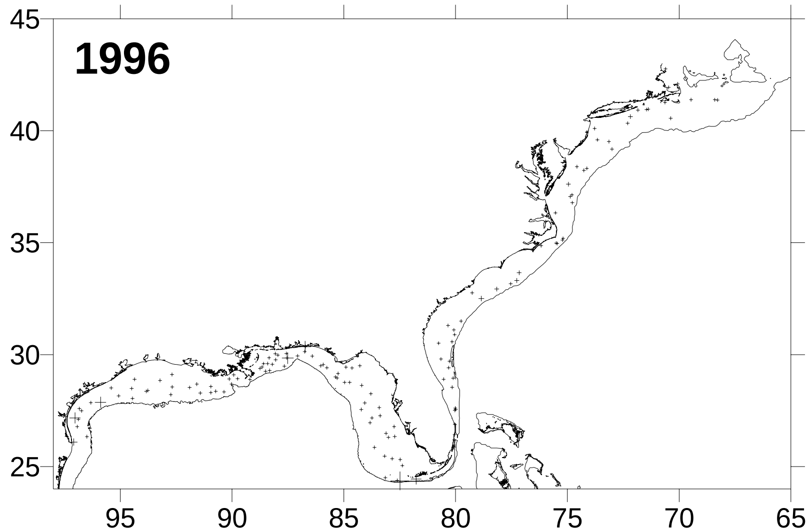


Figure 10. Survey effort and CPUE (range: 0 to 4 sharks per 100 hook hours) of sandbar shark from 1996.

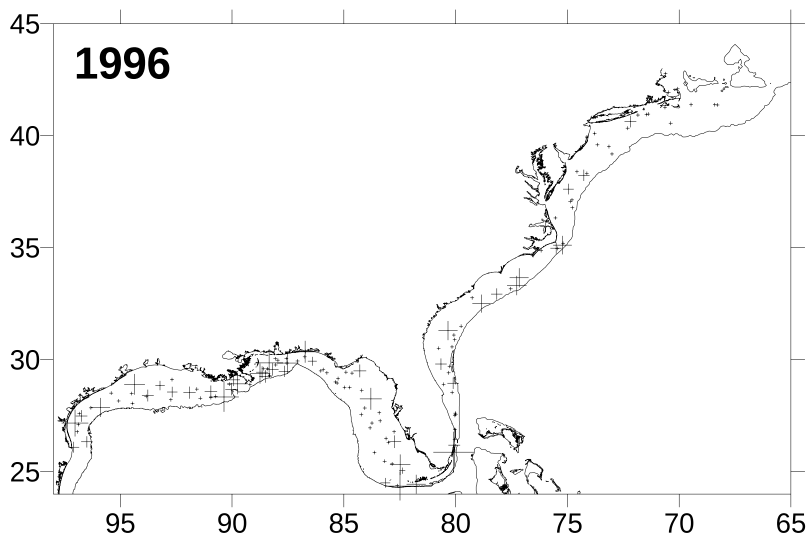


Figure 11. Survey effort and CPUE (range: 0 to 8 sharks per 100 hook hours) of large coastal sharks from 1996.

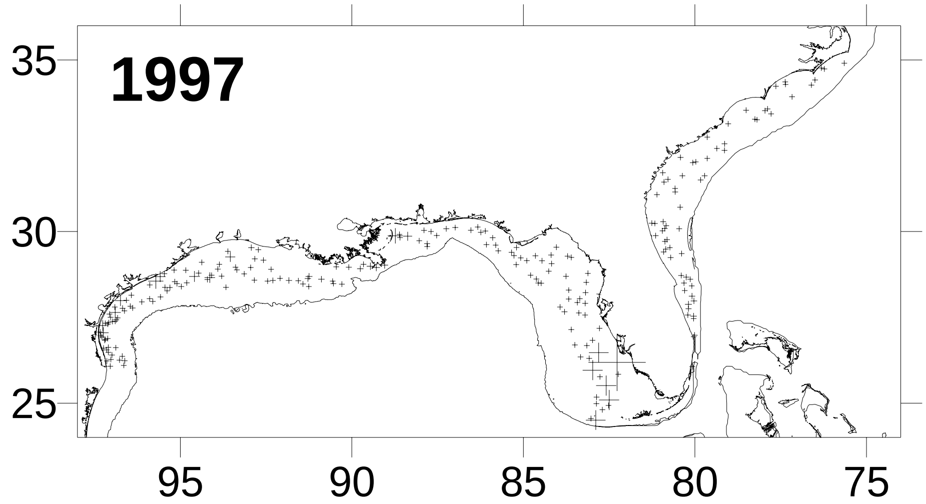


Figure 12. Survey effort and CPUE (range: 0 to 8 sharks per 100 hook hours) of blacktip shark from 1997.

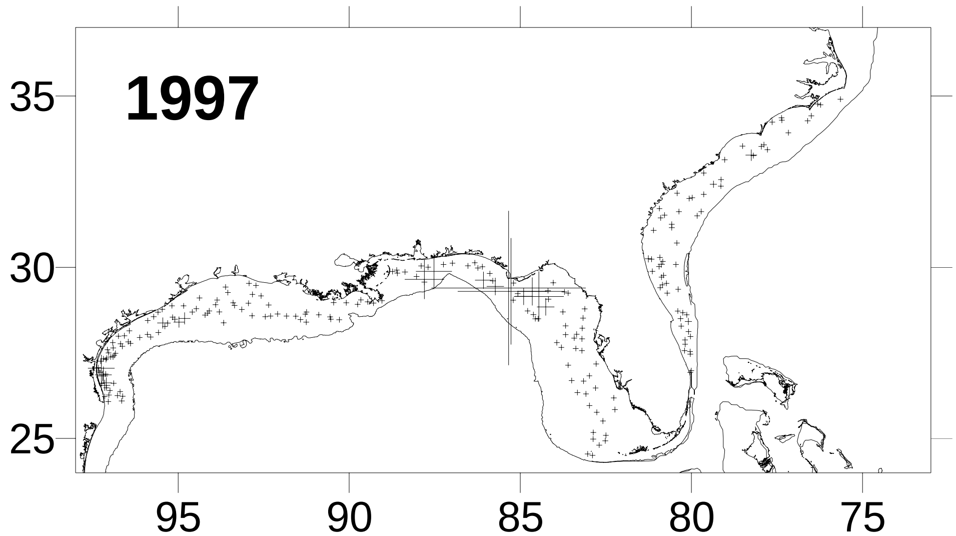


Figure 13. Survey effort and CPUE (range: 0 to 27 sharks per 100 hook hours) of sandbar shark from 1997.

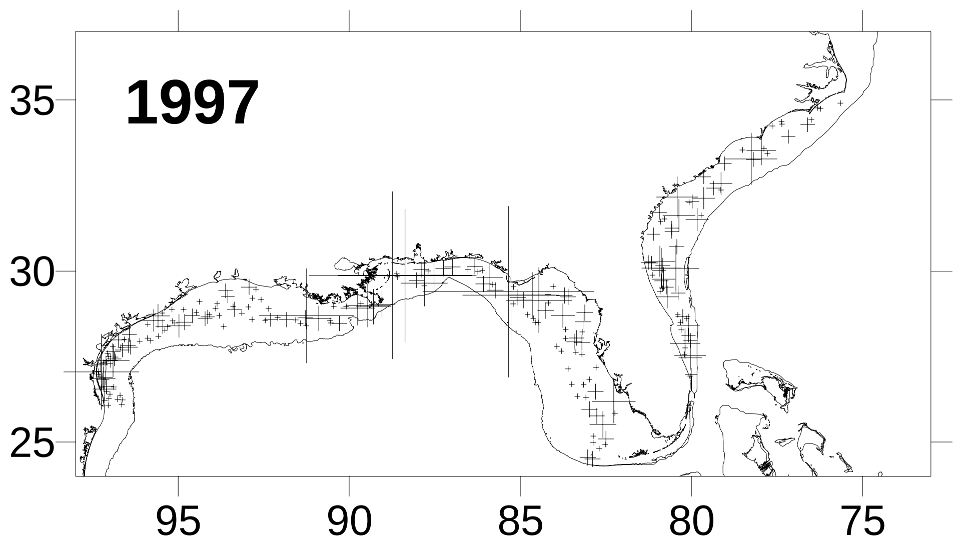


Figure 14. Survey effort and CPUE (range: 0 to 30 sharks per 100 hook hours) of large coastal sharks from 1997.

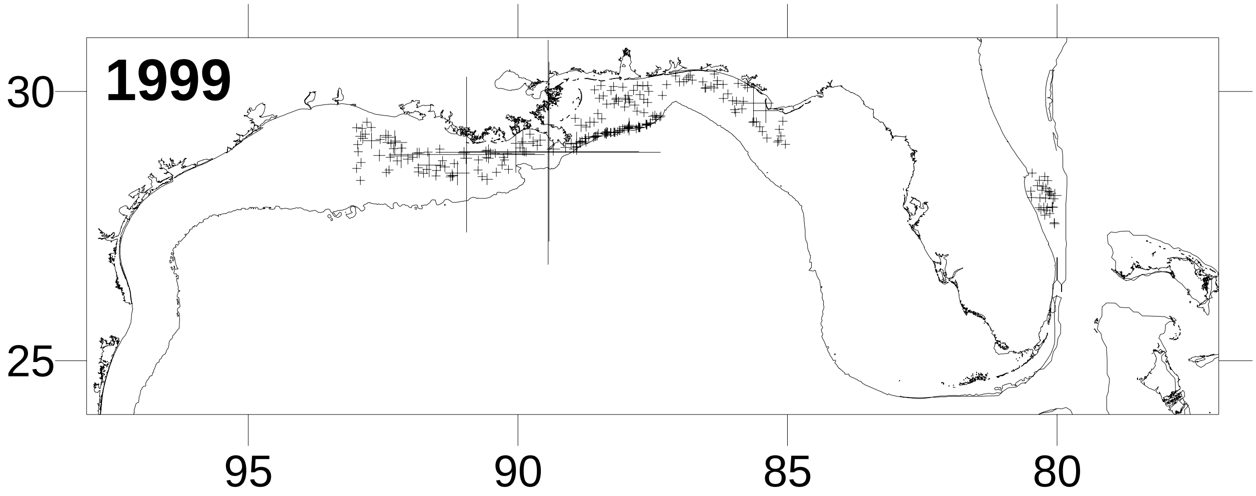


Figure 15. Survey effort and CPUE (range: 0 to 14 sharks per 100 hook hours) of blacktip shark from 1999.

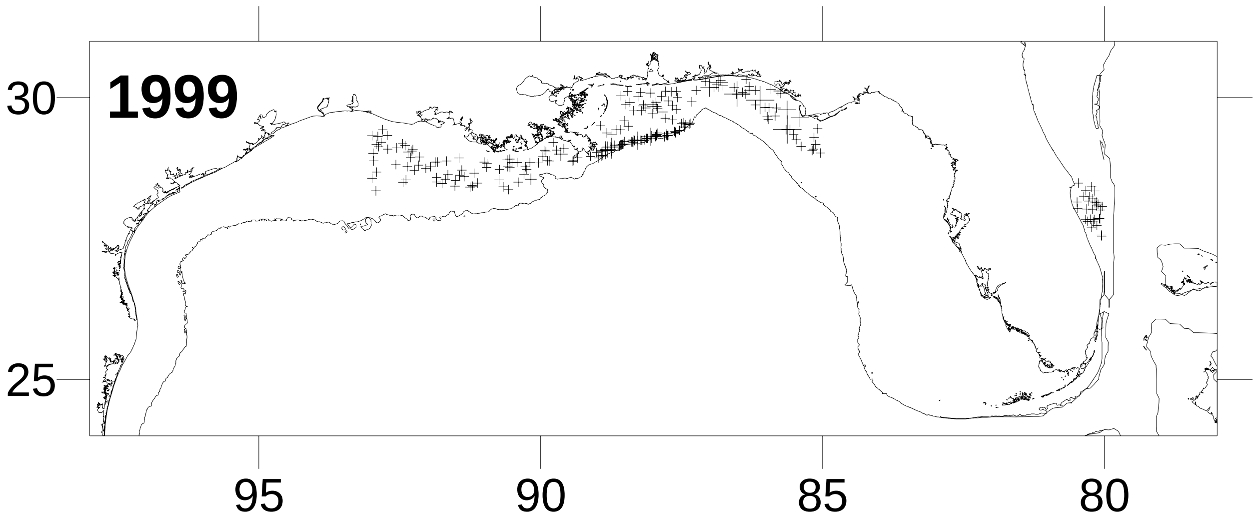


Figure 16. Survey effort and CPUE (range: 0 to 2 sharks per 100 hook hours) of sandbar shark from 1999.

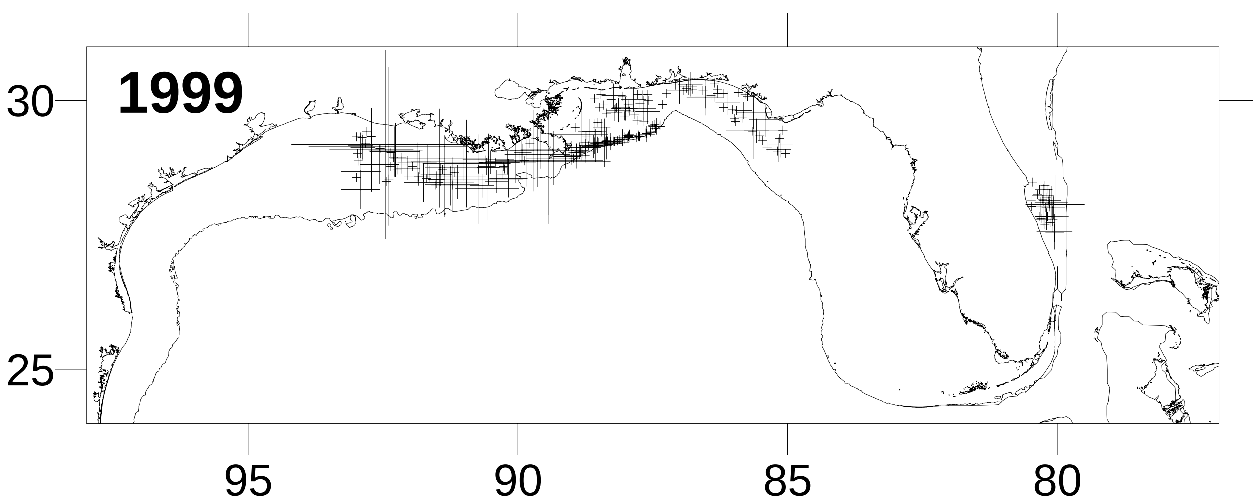


Figure 17. Survey effort and CPUE (range: 0 to 21 sharks per 100 hook hours) of large coastal sharks from 1999.

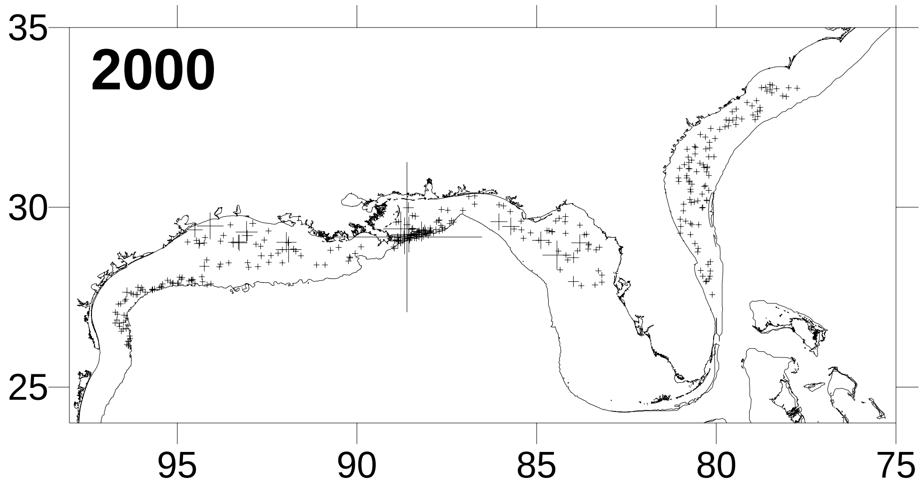


Figure 18. Survey effort and CPUE (range: 0 to 29 sharks per 100 hook hours) of blacktip shark from 2000.

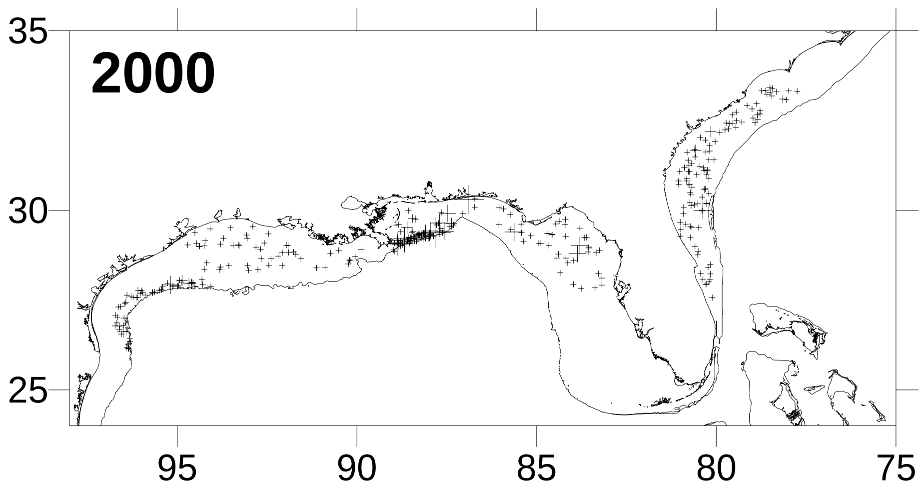


Figure 19. Survey effort and CPUE (range: 0 to 4 sharks per 100 hook hours) of sandbar shark from 2000.

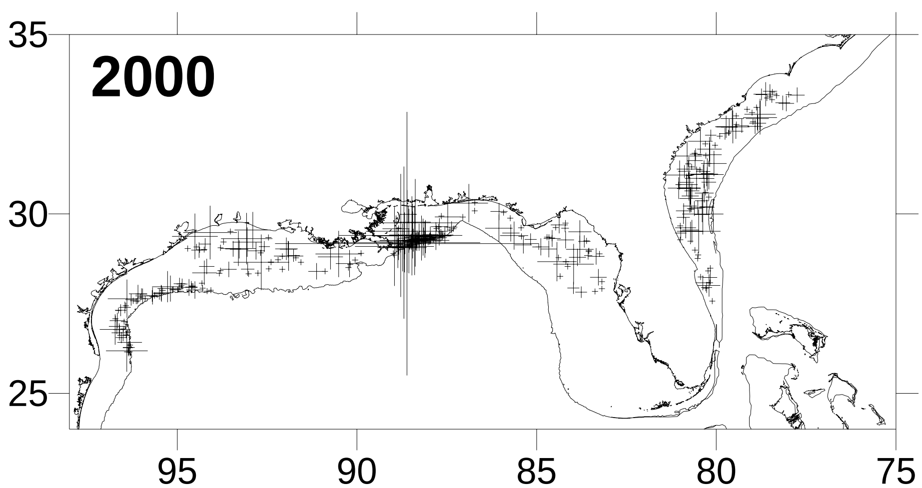


Figure 20. Survey effort and CPUE (range: 0 to 44 sharks per 100 hook hours) of large coastal sharks from 2000.

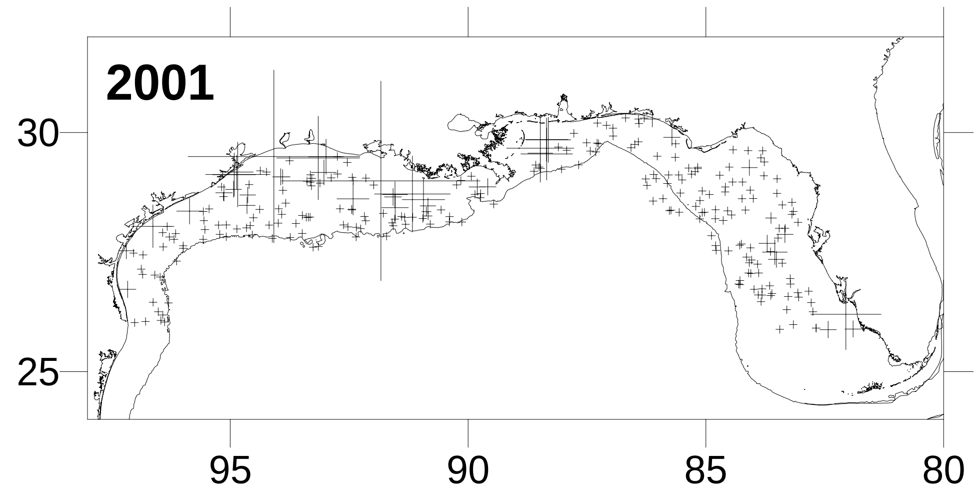


Figure 21. Survey effort and CPUE (range: 0 to 21 sharks per 100 hook hours) of blacktip shark from 2001.

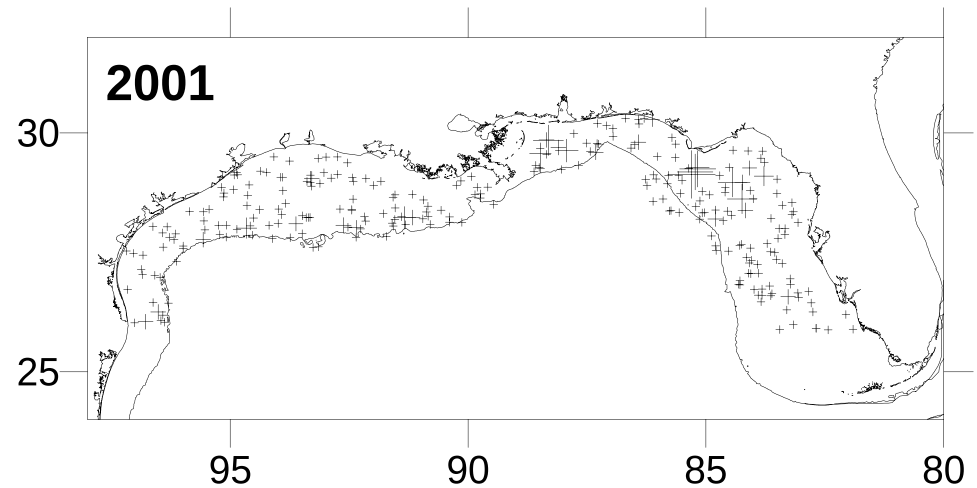


Figure 22. Survey effort and CPUE (range: 0 to 6 sharks per 100 hook hours) of sandbar shark from 2001.

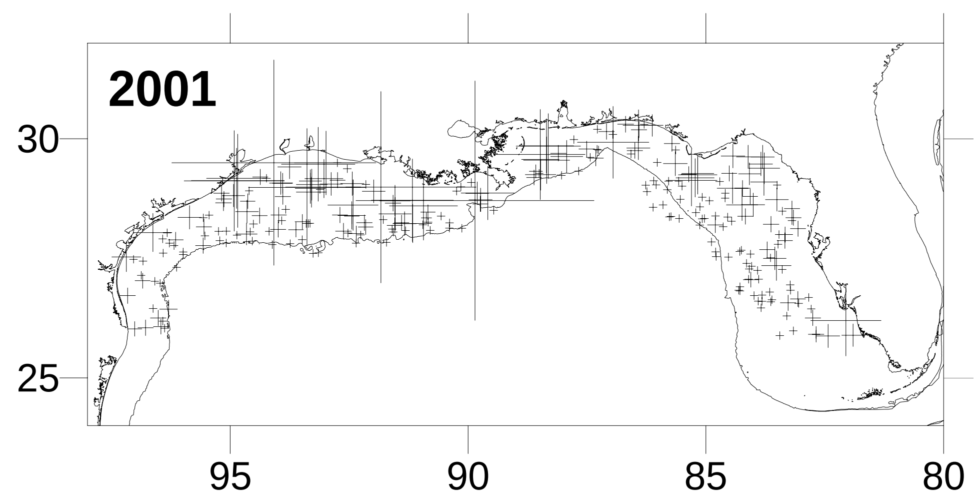


Figure 23. Survey effort and CPUE (range: 0 to 30 sharks per 100 hook hours) of large coastal sharks from 2001.

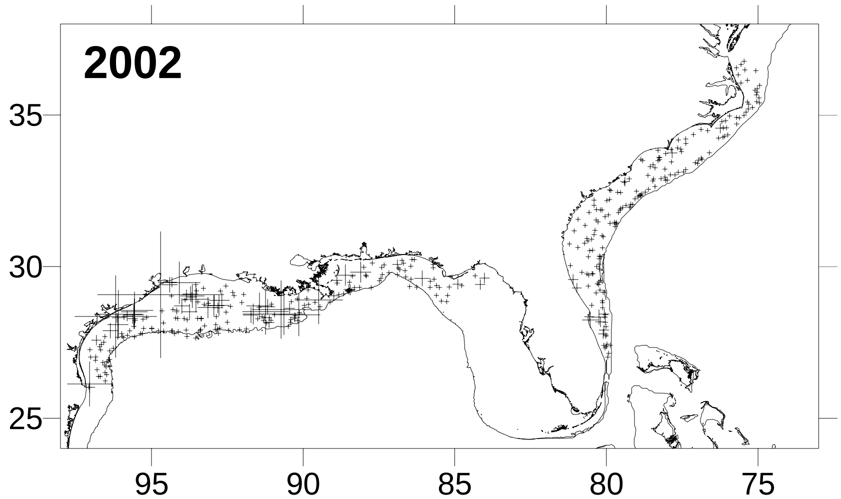


Figure 24. Survey effort and CPUE (range: 0 to 23 sharks per 100 hook hours) of blacktip shark from 2002.

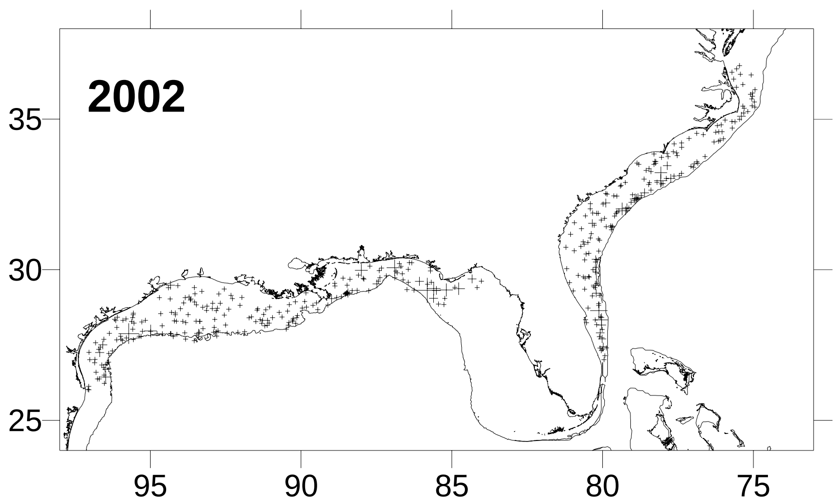


Figure 25. Survey effort and CPUE (range: 0 to 5 sharks per 100 hook hours) of sandbar shark from 2002.

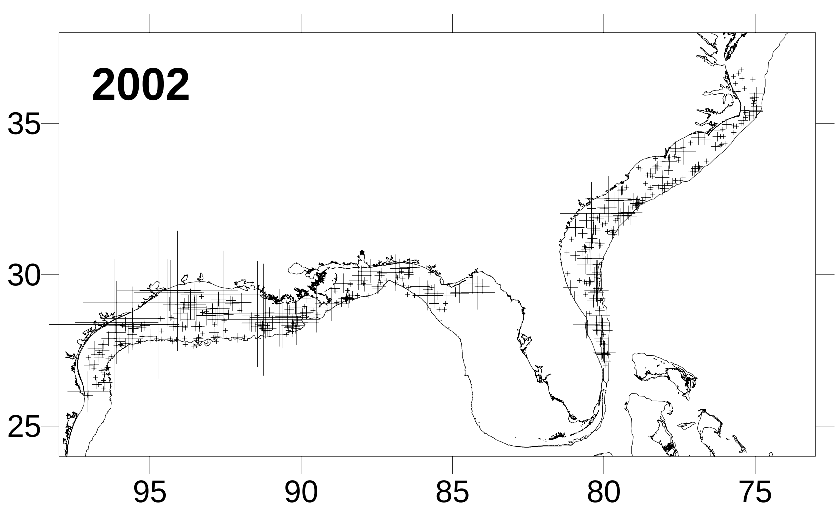


Figure 26. Survey effort and CPUE (range: 0 to 30 sharks per 100 hook hours) of large coastal sharks from 2002.

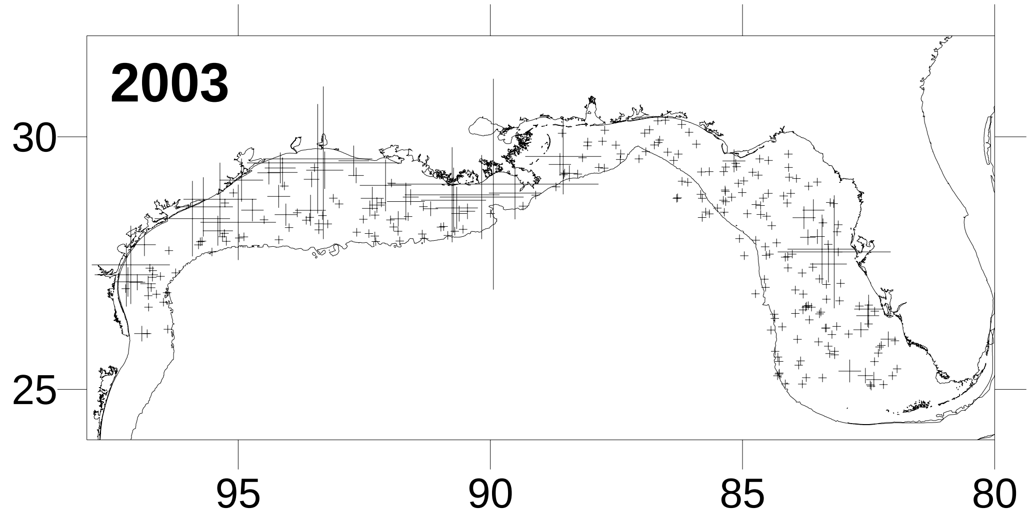


Figure 27. Survey effort and CPUE (range: 0 to 28 sharks per 100 hook hours) of blacktip shark from 2003.

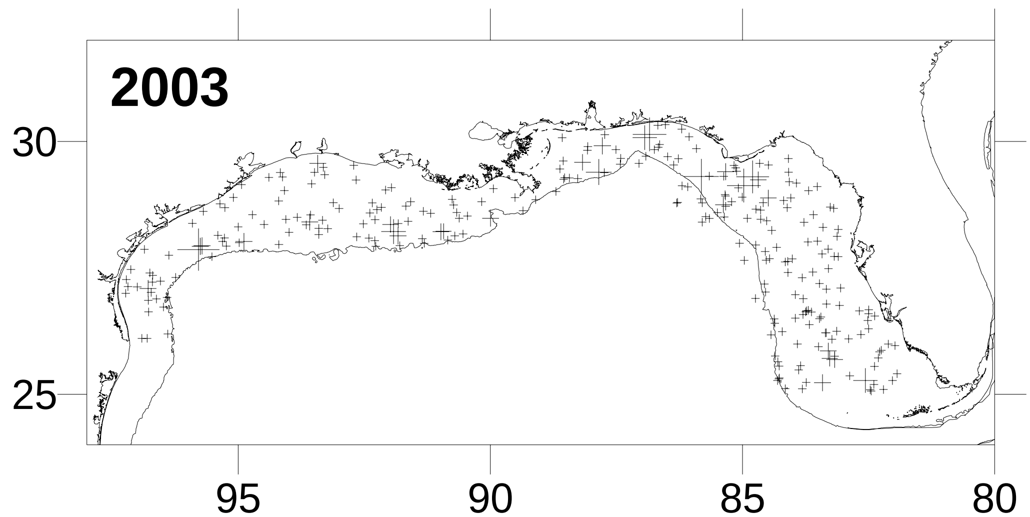


Figure 28. Survey effort and CPUE (range: 0 to 4 sharks per 100 hook hours) of sandbar shark from 2003.

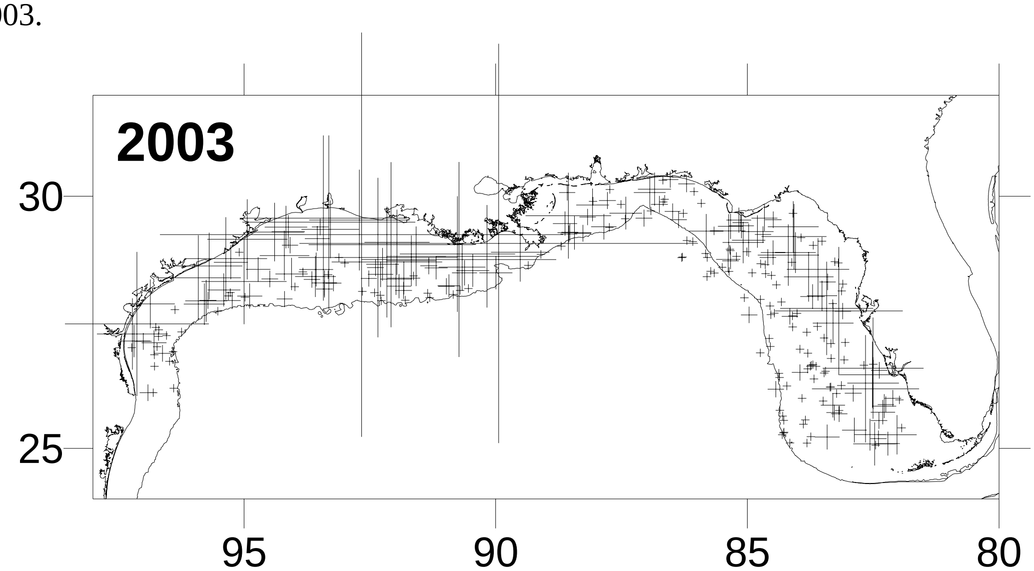


Figure 29. Survey effort and CPUE (range: 0 to 48 sharks per 100 hook hours) of large coastal sharks from 2003.

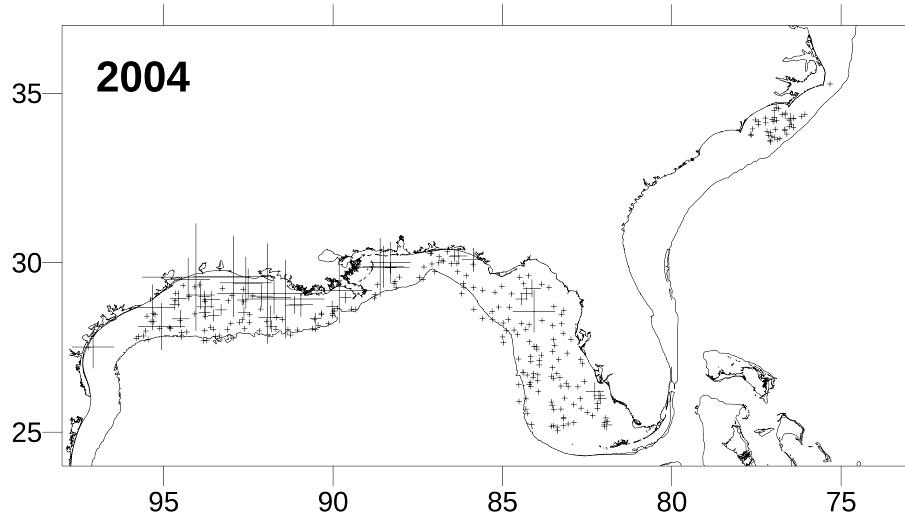


Figure 30. Survey effort and CPUE (range: 0 to 17 sharks per 100 hook hours) of blacktip shark from 2004.

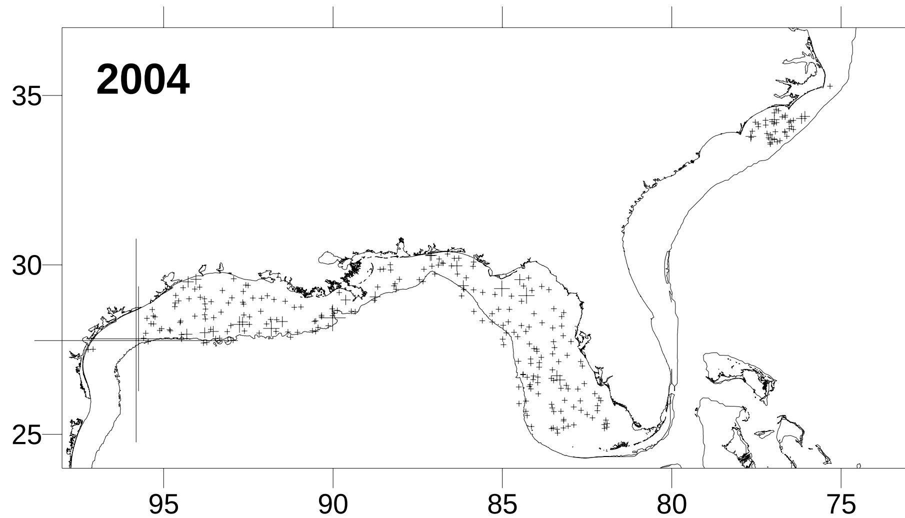


Figure 31. Survey effort and CPUE (range: 0 to 38 sharks per 100 hook hours) of sandbar shark from 2004.

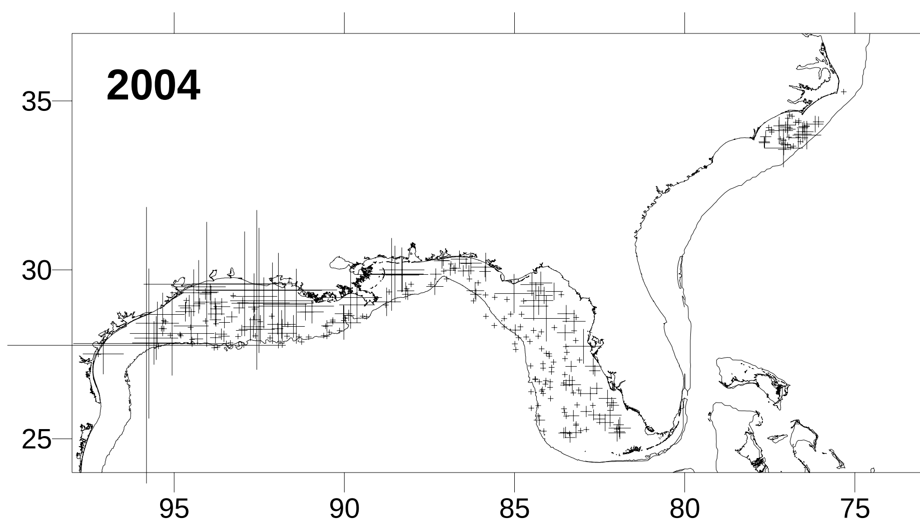


Figure 32. Survey effort and CPUE (range: 0 to 48 sharks per 100 hook hours) of large coastal sharks from 2004.

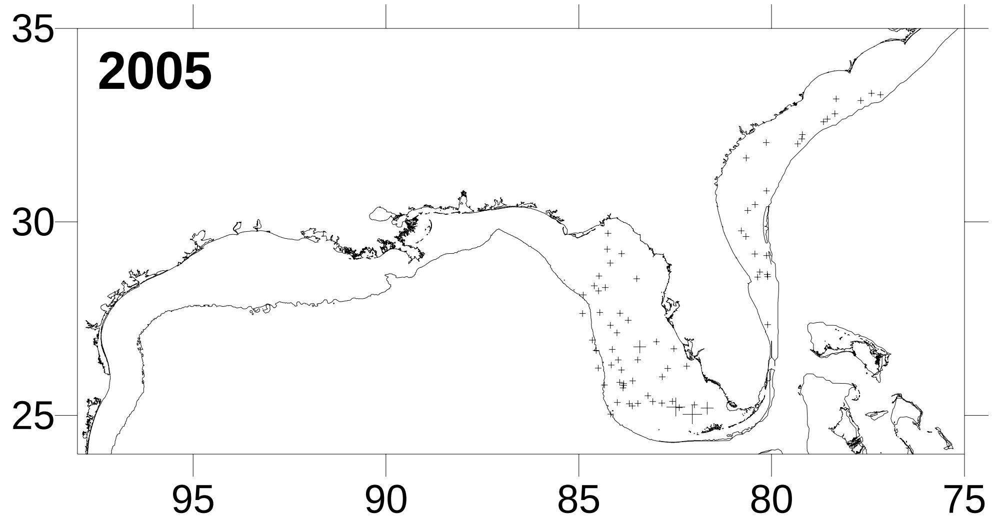


Figure 33. Survey effort and CPUE (range: 0 to 2 sharks per 100 hook hours) of blacktip shark from 2005.

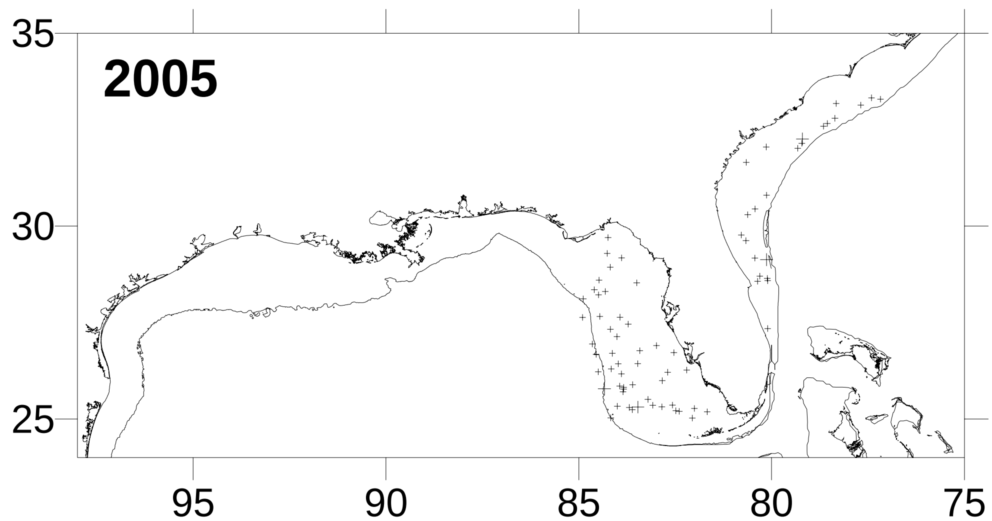


Figure 34. Survey effort and CPUE (range: 0 to 1 sharks per 100 hook hours) of sandbar shark from 2005.

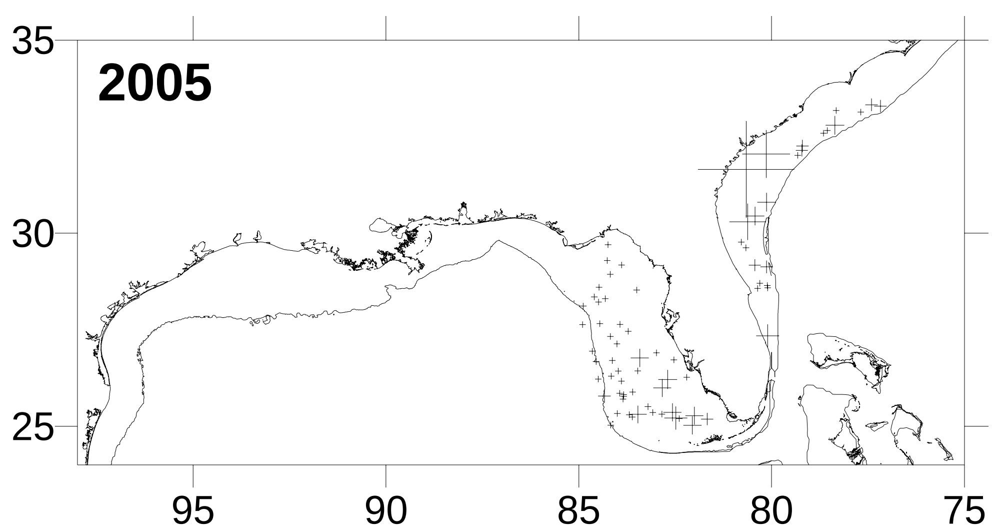
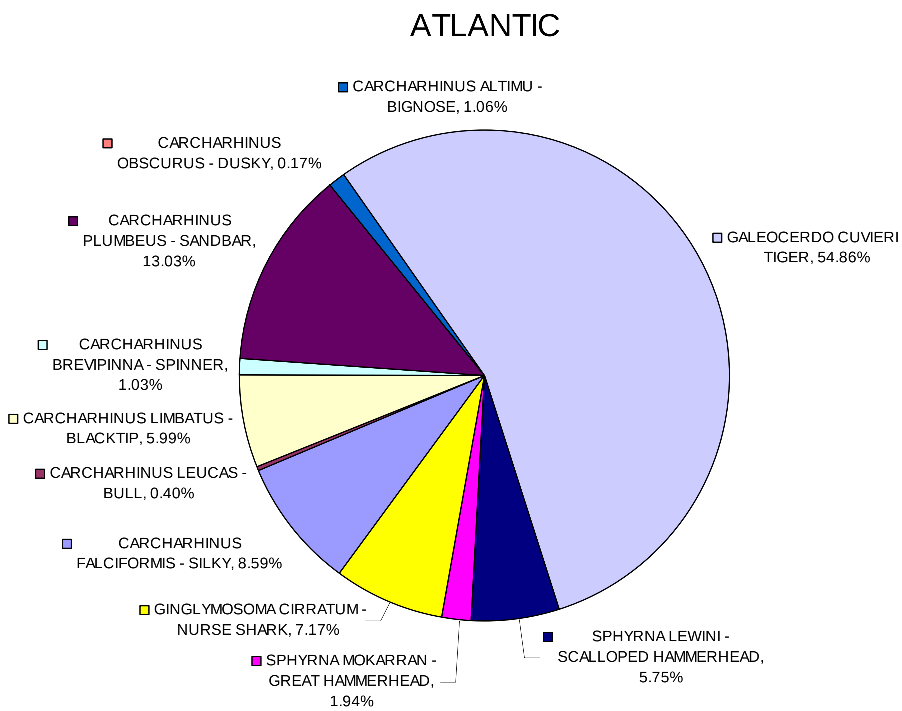


Figure 35. Survey effort and CPUE (range: 0 to 15 sharks per 100 hook hours) of large coastal sharks from 2005.

Table 6. Patterns of data inclusion into indices of various survey areas, based upon yearly distribution of effort.

	Survey Year									
Index Area	**1995**	**1996**	**1997**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Atlantic (only south of 37^o north latitude)	**Yes**	**Yes**	**Yes**	No	**Yes**	No	**Yes**	No	No	**Yes**
Gulfwide (U.S. Gulf of Mexico)	**Yes**	**Yes**	**Yes**	No	No	**Yes**	No	**Yes**	No	No
Eastern Gulf (east of 88^o west longitude)	**Yes**	**Yes**	**Yes**	No	No	**Yes**	No	**Yes**	**Yes**	**Yes**
Central Gulf (between 88^o and 93^o west longitude)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
Western Gulf (west of 93^o west longitude)	**Yes**	**Yes**	**Yes**	No	No	**Yes**	**Yes**	**Yes**	No	No



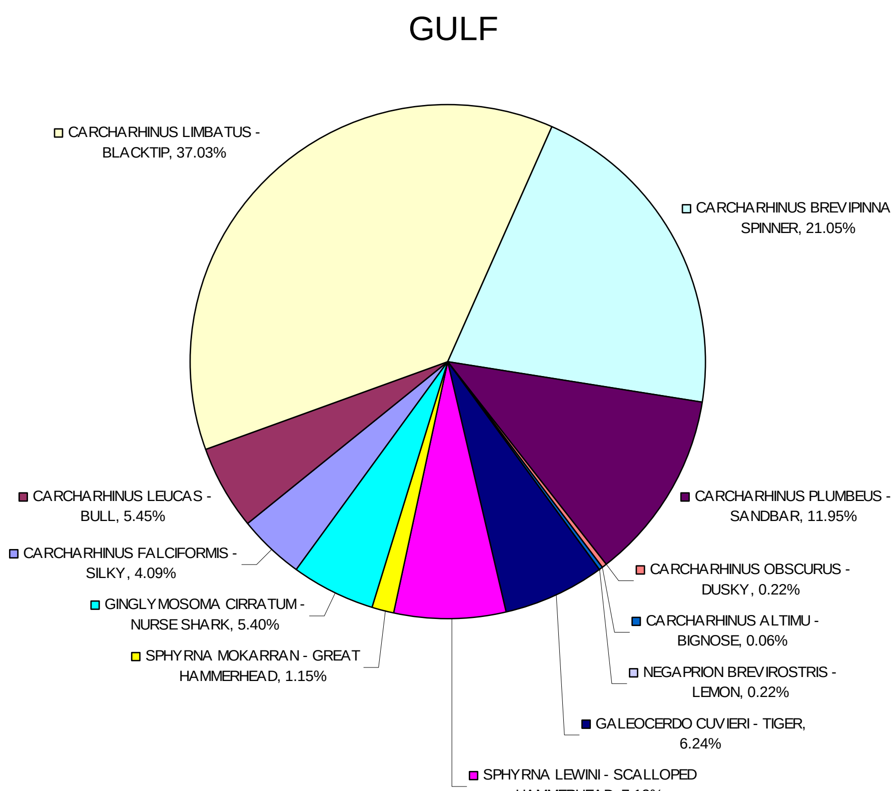
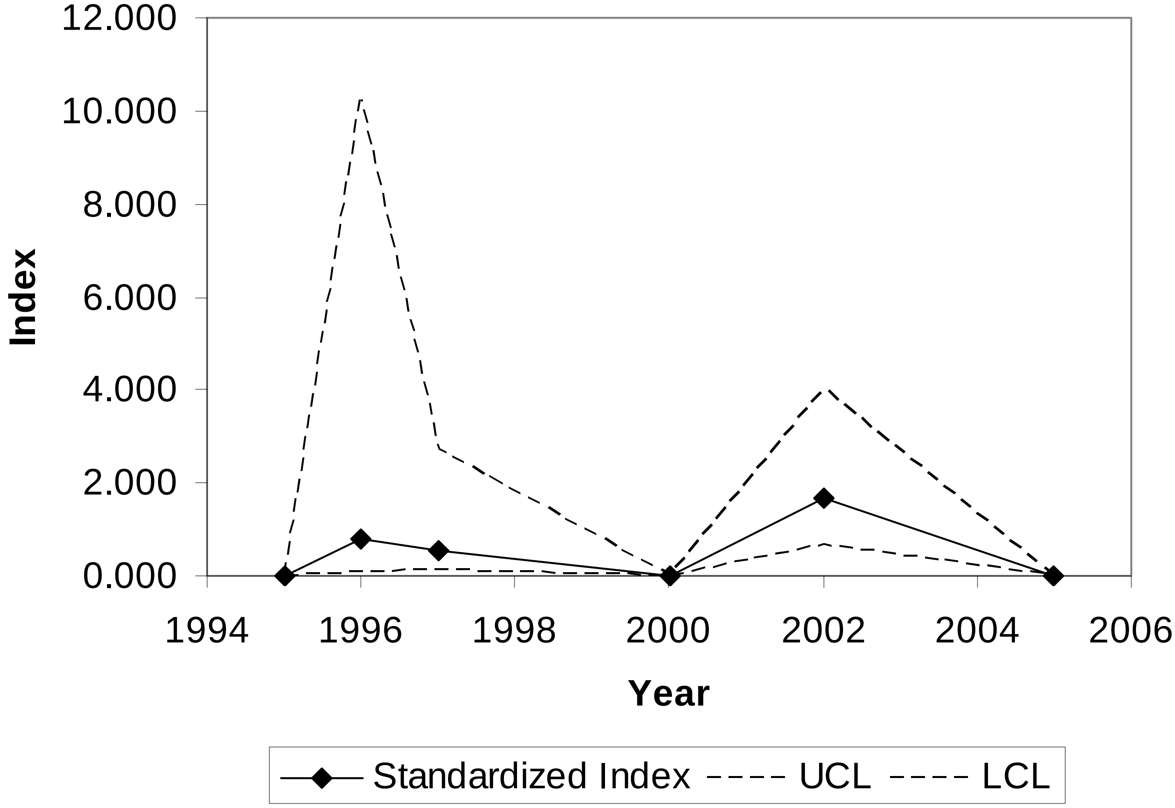
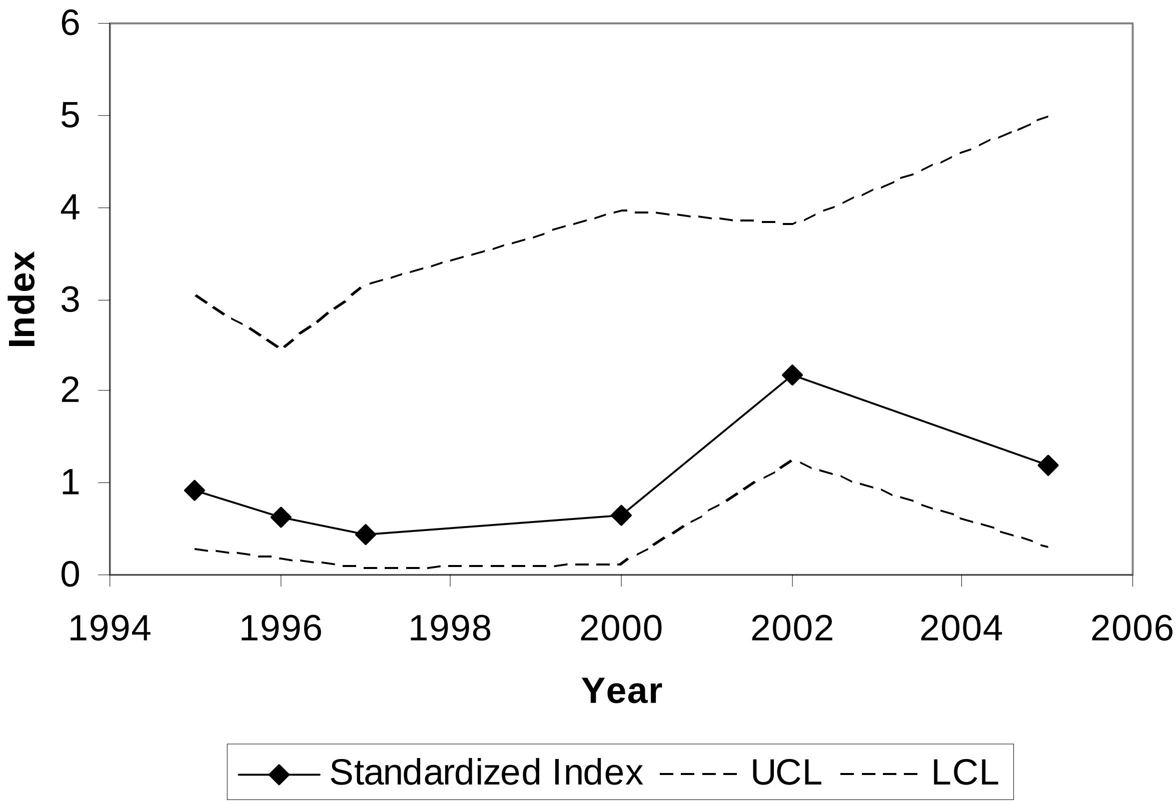


Figure 36. The species that the make up of large coastal shark complex in our data set from the U.S. Gulf of Mexico and U.S. Atlantic Ocean.



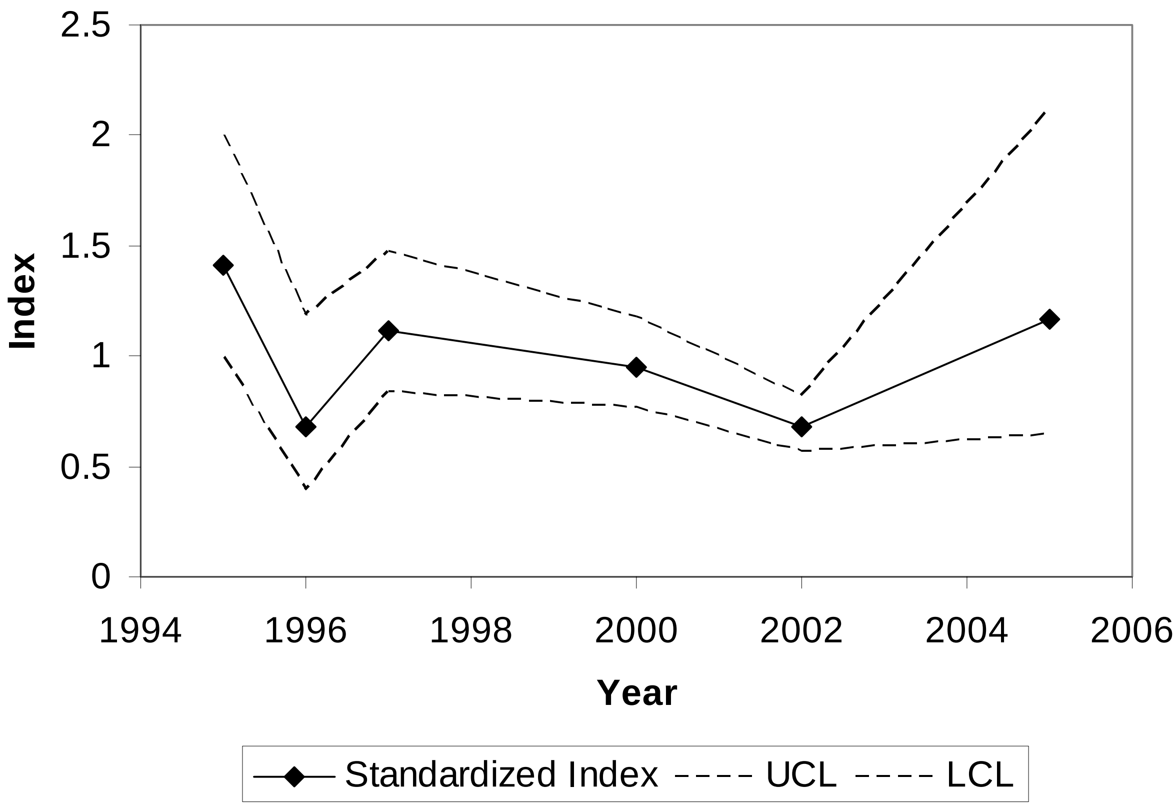
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.000	45	0.000	0.000	.	.	.
1996	0.059	34	0.034	0.805	2.008	0.063	10.228
1997	0.077	65	0.023	0.542	0.951	0.109	2.701
2000	0.000	104	0.000	0.000	.	.	.
2002	0.065	184	0.069	1.653	0.467	0.680	4.020
2005	0.000	24	0.000	0.000	.	.	.

Figure 37. Standardized annual abundance indices for blacktip shark collected during bottom longline surveys from the U.S. Atlantic Ocean south of 37^{o} north latitude. Legend for this and following figures: N = sample size; Lo Index = non-standardized index; Standardized Index = index standardized to the time series mean of one; CV = coefficient of variation on the mean; and LCL and UCL = lower and upper 95% confidence intervals.



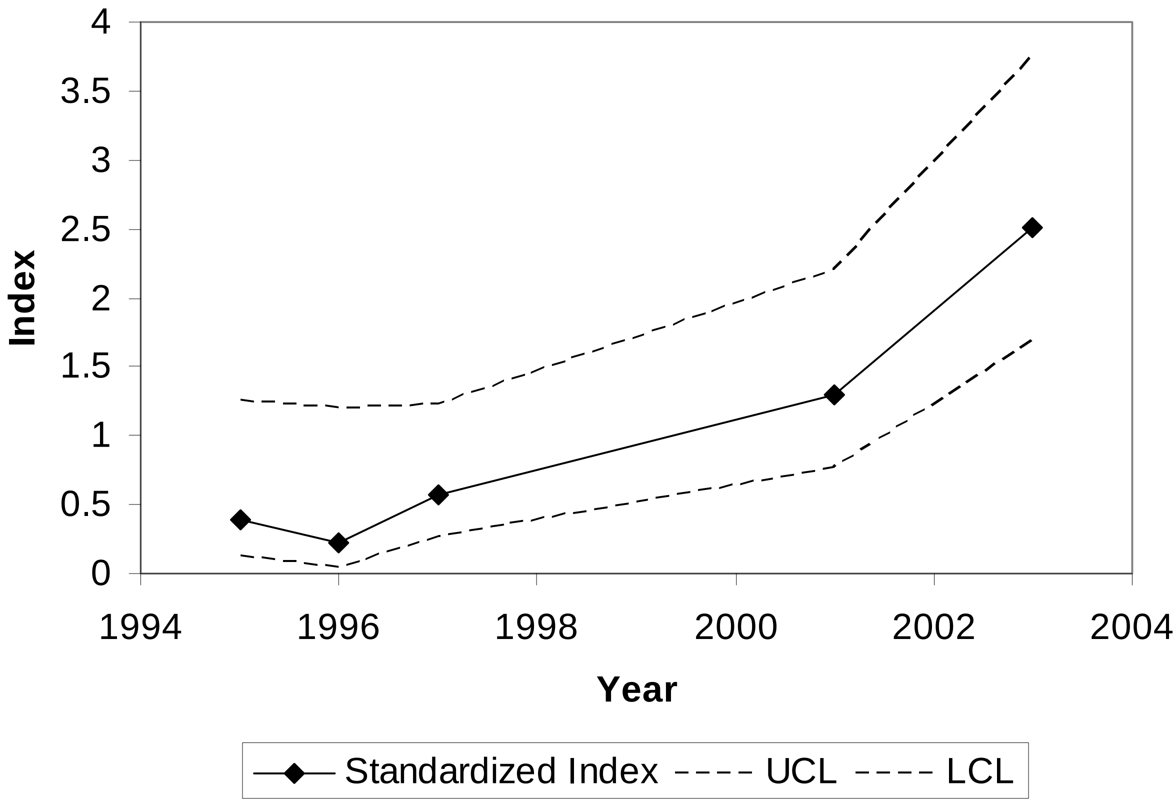
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.200	45	0.063	0.915	0.657	0.276	3.034
1996	0.147	34	0.043	0.625	0.772	0.159	2.455
1997	0.077	65	0.030	0.439	1.275	0.062	3.131
2000	0.067	104	0.045	0.658	1.109	0.110	3.946
2002	0.125	184	0.148	2.169	0.287	1.235	3.810
2005	0.083	24	0.082	1.193	0.815	0.286	4.971

Figure 38. Standardized abundance indices for sandbar shark collected during bottom longline surveys from the U.S. Atlantic Ocean south of 37^{o} north latitude.



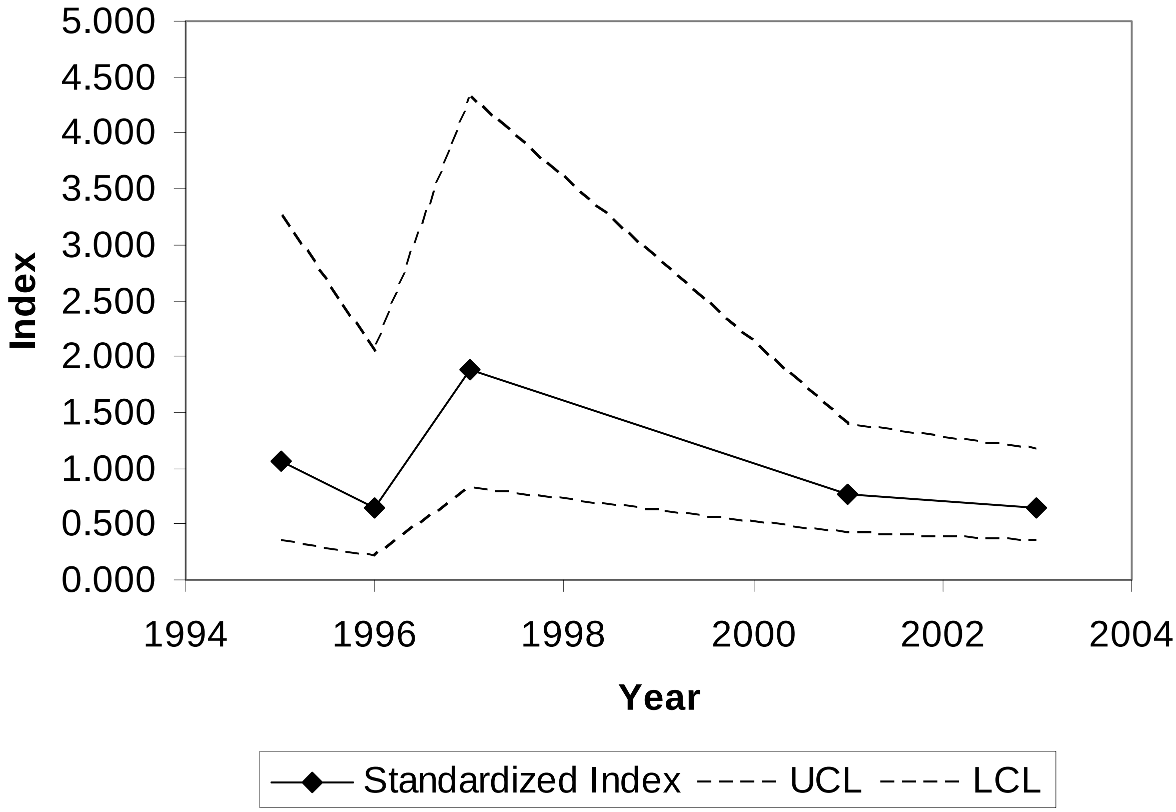
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.600	45	2.021	1.412	0.177	0.995	2.006
1996	0.353	34	0.974	0.681	0.282	0.391	1.183
1997	0.600	65	1.591	1.112	0.142	0.839	1.474
2000	0.615	104	1.359	0.950	0.105	0.770	1.172
2002	0.538	184	0.973	0.680	0.095	0.562	0.822
2005	0.542	24	1.668	1.166	0.306	0.641	2.121

Figure 39. Standardized abundance indices for large coastal sharks collected during bottom longline surveys from the U.S. Atlantic Ocean south of 37^{o} north latitude.



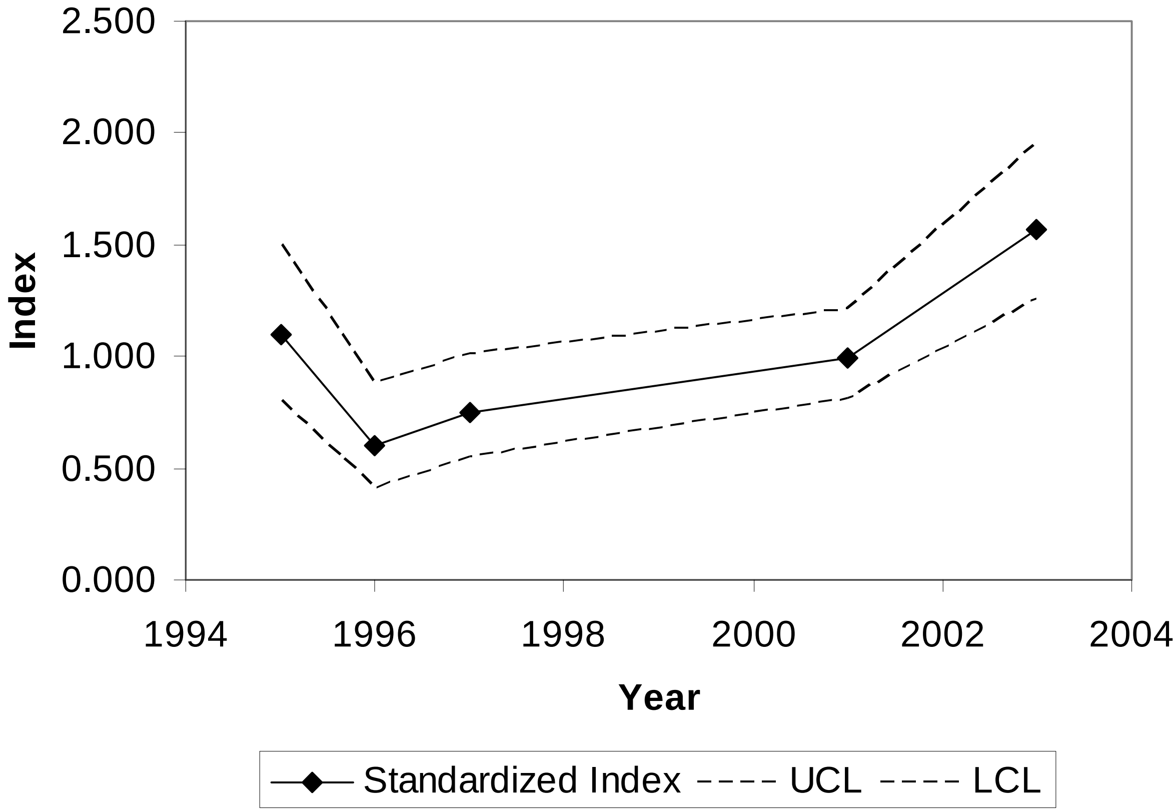
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.171	82	0.148	0.393	0.631	0.124	1.252
1996	0.107	84	0.085	0.224	1.010	0.042	1.200
1997	0.154	169	0.213	0.566	0.401	0.262	1.224
2001	0.159	276	0.492	1.303	0.267	0.771	2.203
2003	0.214	280	0.948	2.514	0.201	1.689	3.742

Figure 40. Standardized abundance indices for blacktip shark collected during bottom longline surveys from the U.S. Gulf of Mexico.



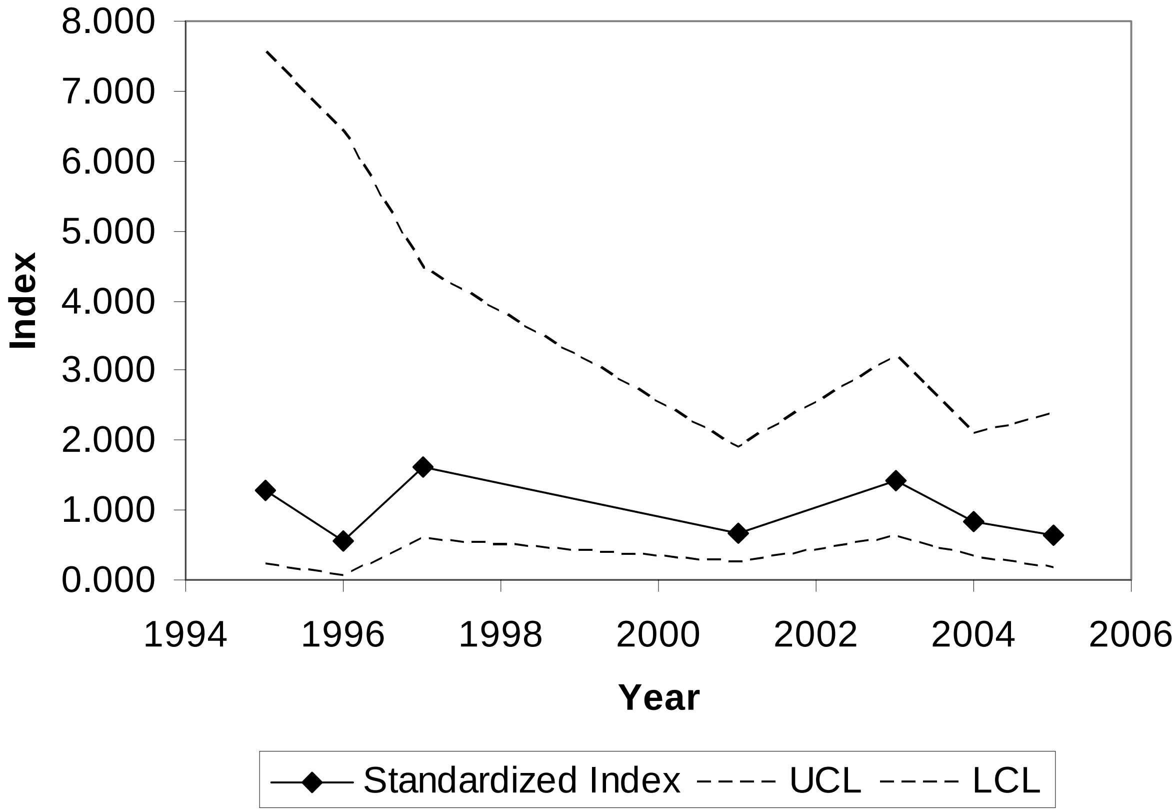
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.146	82	0.264	1.062	0.606	0.347	3.251
1996	0.083	84	0.162	0.651	0.623	0.207	2.044
1997	0.107	169	0.468	1.884	0.433	0.822	4.318
2001	0.109	276	0.189	0.762	0.312	0.414	1.400
2003	0.107	280	0.160	0.642	0.307	0.352	1.171

Figure 41. Standardized abundance indices for sandbar shark collected during bottom longline surveys from the U.S. Gulf of Mexico.



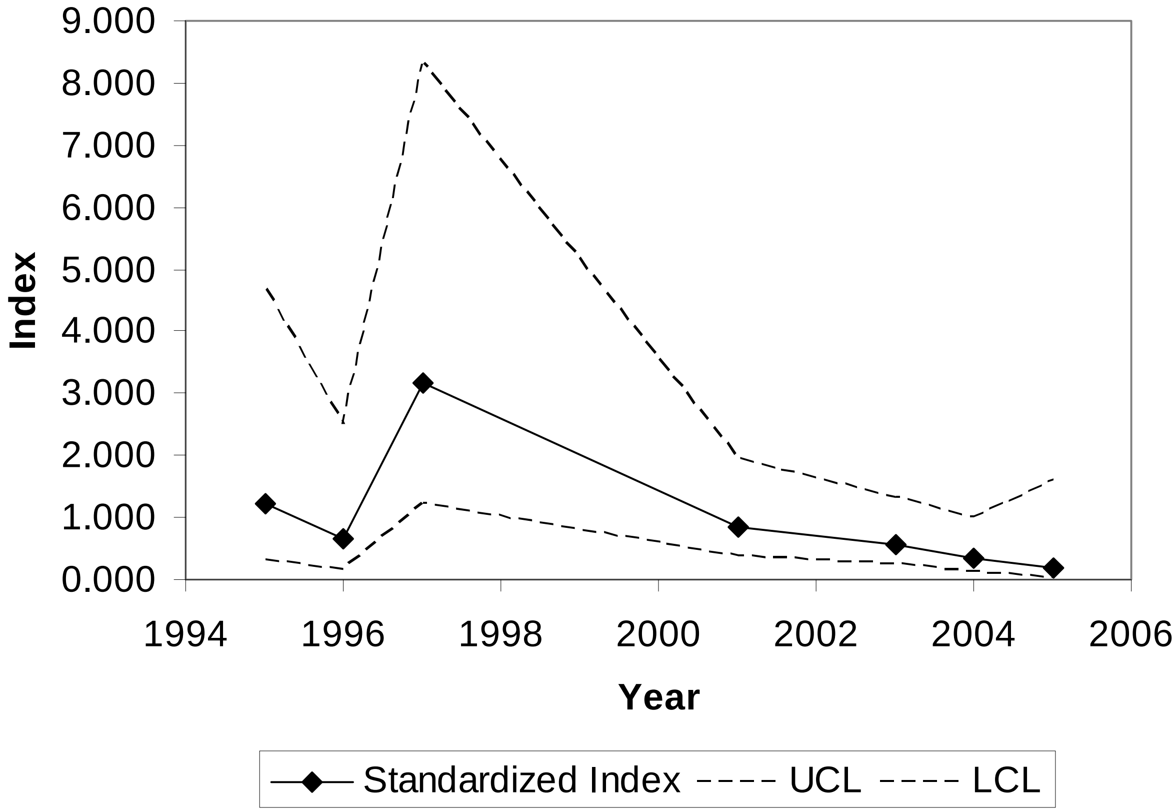
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.524	82	1.524	1.096	0.158	0.800	1.501
1996	0.381	84	0.839	0.603	0.191	0.413	0.881
1997	0.438	169	1.038	0.746	0.150	0.553	1.006
2001	0.478	276	1.377	0.990	0.101	0.810	1.210
2003	0.511	280	2.176	1.565	0.112	1.252	1.955

Figure 42. Standardized abundance indices for large coastal sharks collected during bottom longline surveys from the U.S. Gulf of Mexico.



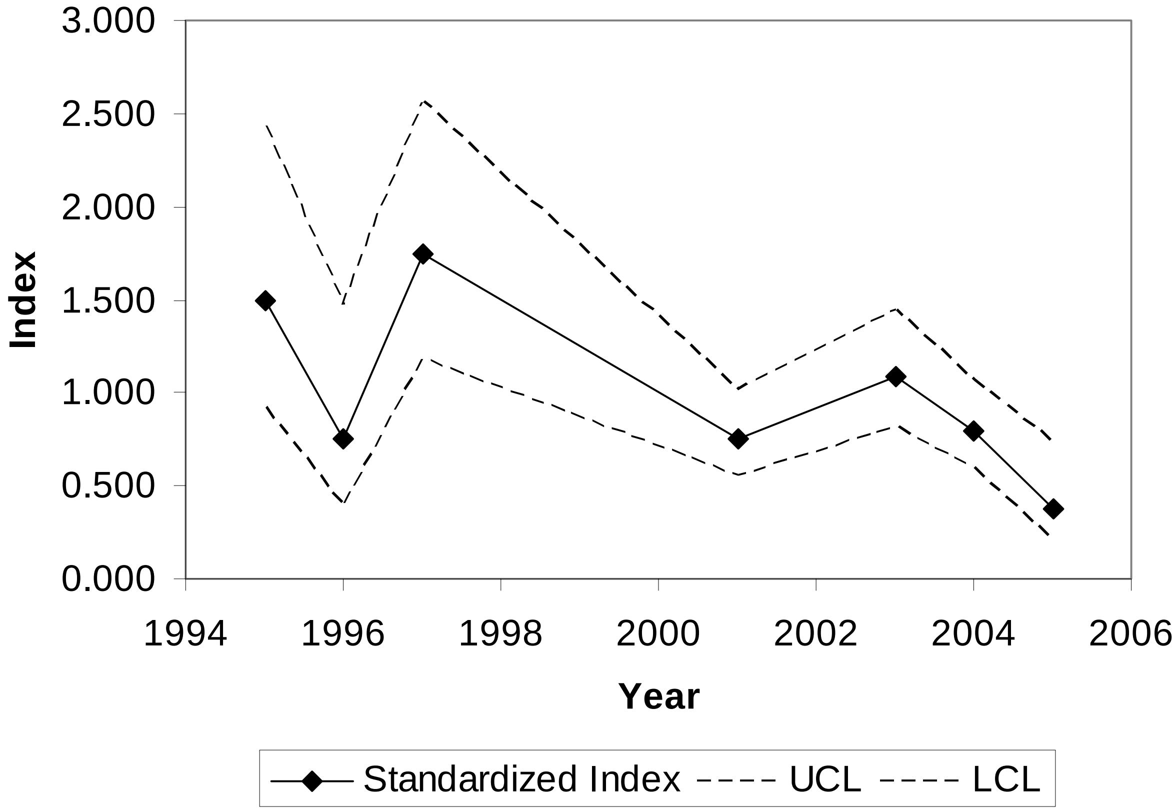
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.051	39	0.229	1.274	1.099	0.215	7.552
1996	0.024	42	0.100	0.557	1.857	0.048	6.414
1997	0.091	66	0.291	1.622	0.540	0.589	4.463
2001	0.085	130	0.121	0.672	0.555	0.238	1.894
2003	0.092	163	0.254	1.414	0.426	0.625	3.201
2004	0.081	134	0.149	0.831	0.490	0.328	2.101
2005	0.080	50	0.113	0.630	0.739	0.168	2.359

Figure 43. Standardized abundance indices for blacktip shark collected during bottom longline surveys from the eastern U.S. Gulf of Mexico.



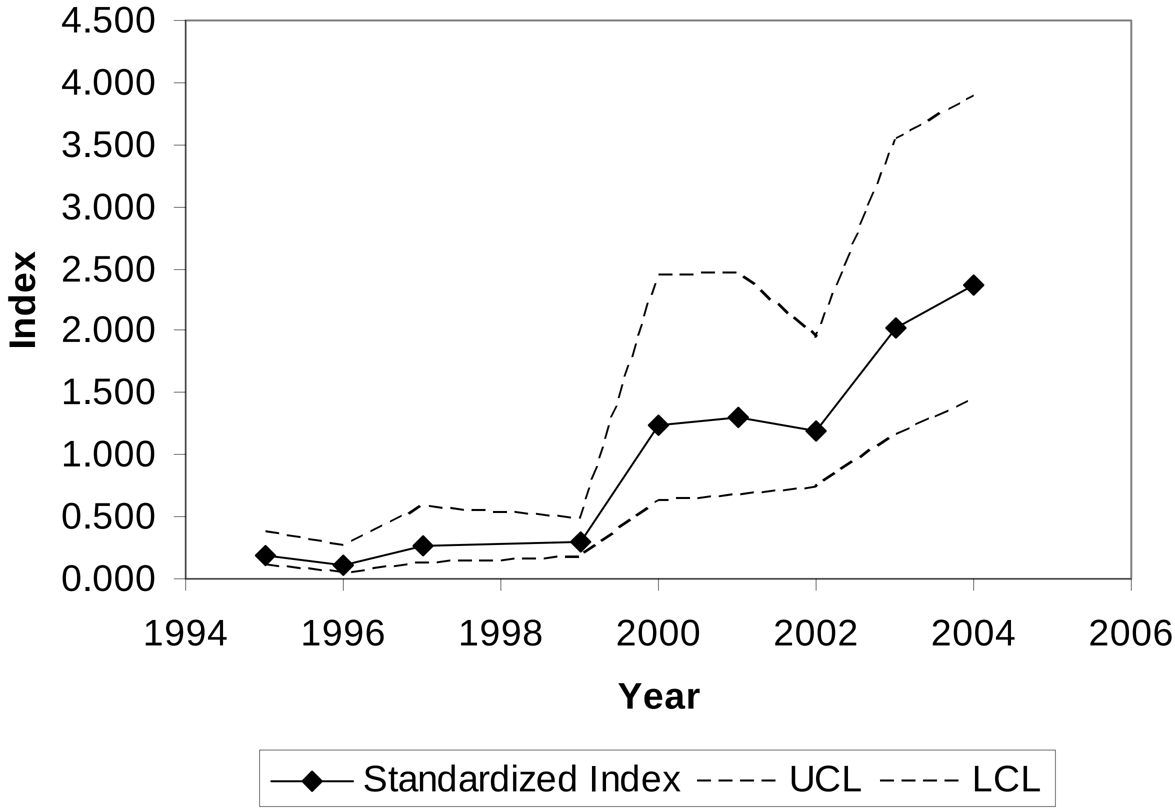
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.128	39	0.343	1.234	0.746	0.326	4.668
1996	0.095	42	0.180	0.647	0.762	0.167	2.506
1997	0.152	66	0.884	3.182	0.508	1.221	8.296
2001	0.123	130	0.239	0.861	0.429	0.379	1.957
2003	0.098	163	0.155	0.557	0.447	0.237	1.308
2004	0.066	134	0.094	0.337	0.587	0.114	1.002
2005	0.040	50	0.050	0.181	1.507	0.021	1.600

Figure 44. Standardized abundance indices for sandbar shark collected during bottom longline surveys from the eastern U.S. Gulf of Mexico.



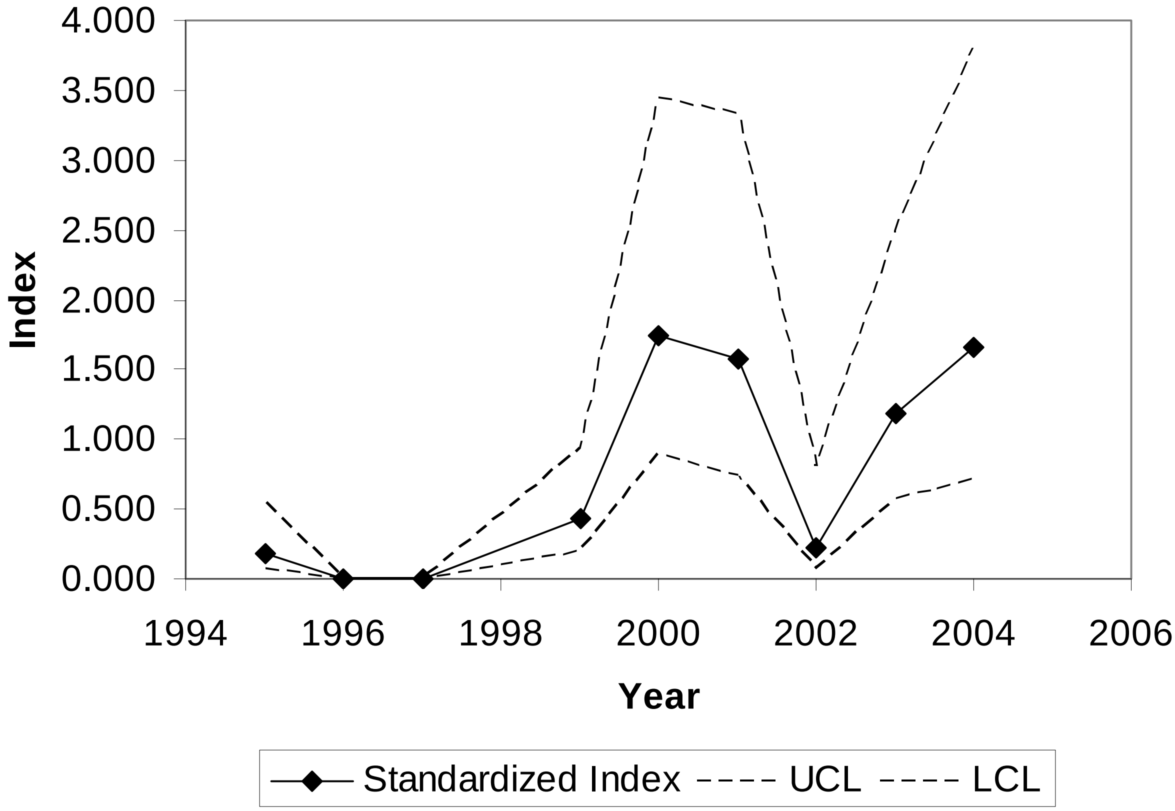
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.436	39	1.510	1.498	0.247	0.921	2.438
1996	0.286	42	0.757	0.751	0.348	0.382	1.477
1997	0.485	66	1.754	1.741	0.195	1.183	2.560
2001	0.392	130	0.755	0.749	0.154	0.552	1.017
2003	0.399	163	1.092	1.084	0.145	0.812	1.447
2004	0.404	134	0.805	0.799	0.144	0.600	1.064
2005	0.200	50	0.381	0.378	0.339	0.196	0.731

Figure 45. Standardized abundance indices for large coastal sharks collected during bottom longline surveys from the eastern U.S. Gulf of Mexico.



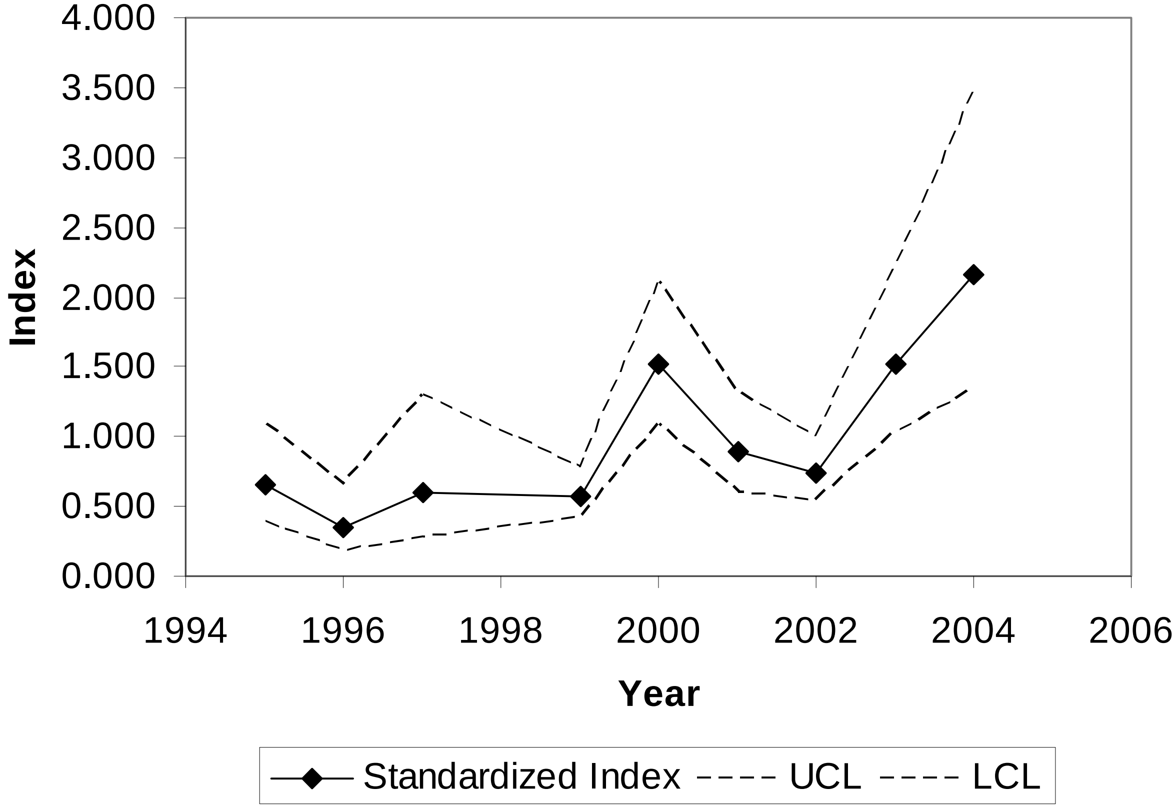
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.393	28	0.153	0.196	0.326	0.104	0.369
1996	0.280	25	0.088	0.112	0.445	0.048	0.262
1997	0.344	32	0.213	0.271	0.402	0.125	0.588
1999	0.266	139	0.232	0.296	0.258	0.178	0.491
2000	0.310	87	0.970	1.237	0.351	0.625	2.449
2001	0.266	64	1.015	1.294	0.329	0.681	2.458
2002	0.288	80	0.939	1.198	0.246	0.737	1.945
2003	0.389	54	1.591	2.029	0.284	1.163	3.541
2004	0.350	60	1.857	2.367	0.252	1.441	3.888

Figure 46. Standardized abundance indices for blacktip shark collected during bottom longline surveys from the central U.S. Gulf of Mexico.



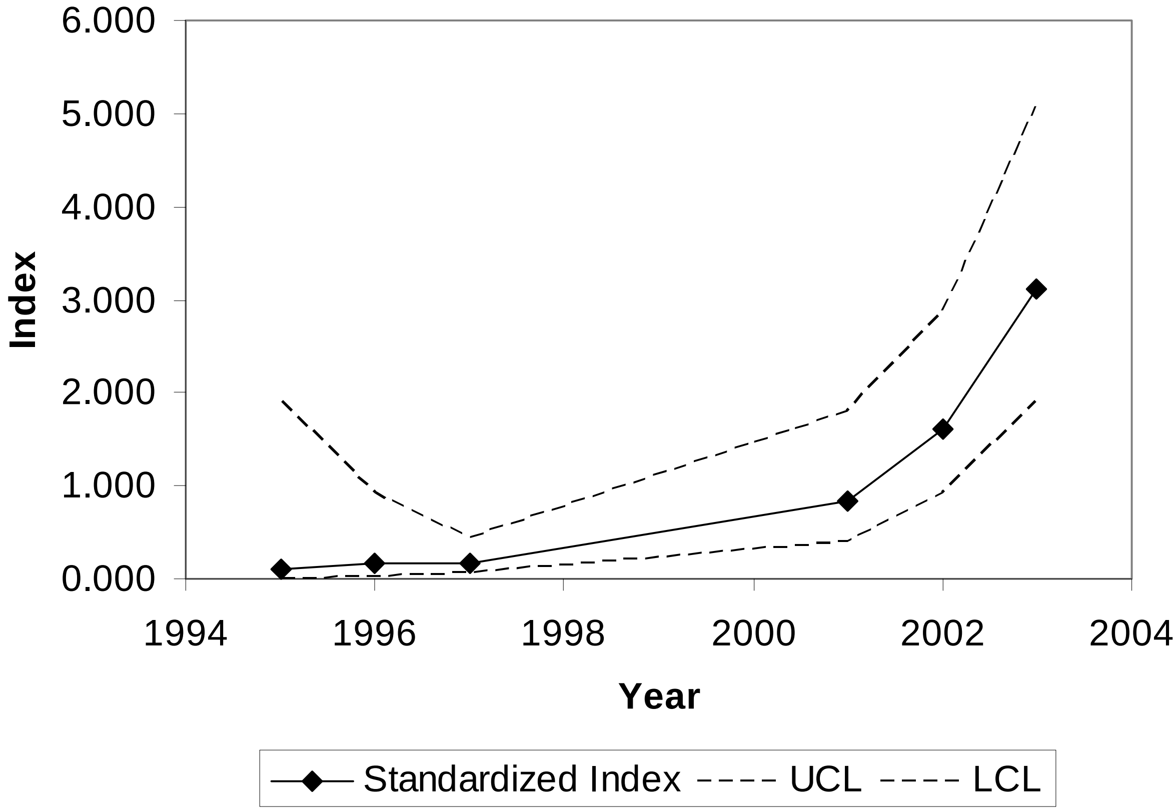
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.107	28	0.022	0.188	0.570	0.065	0.541
1996	0.000	25	0.000	0.000	.	.	.
1997	0.000	32	0.000	0.000	.	.	.
1999	0.079	139	0.051	0.425	0.408	0.194	0.933
2000	0.184	87	0.208	1.747	0.350	0.886	3.446
2001	0.125	64	0.187	1.573	0.388	0.744	3.324
2002	0.025	80	0.027	0.226	0.705	0.063	0.804
2003	0.130	54	0.142	1.189	0.383	0.567	2.494
2004	0.117	60	0.197	1.652	0.436	0.717	3.808

Figure 47. Standardized abundance indices for sandbar shark collected during bottom longline surveys from the central U.S. Gulf of Mexico.



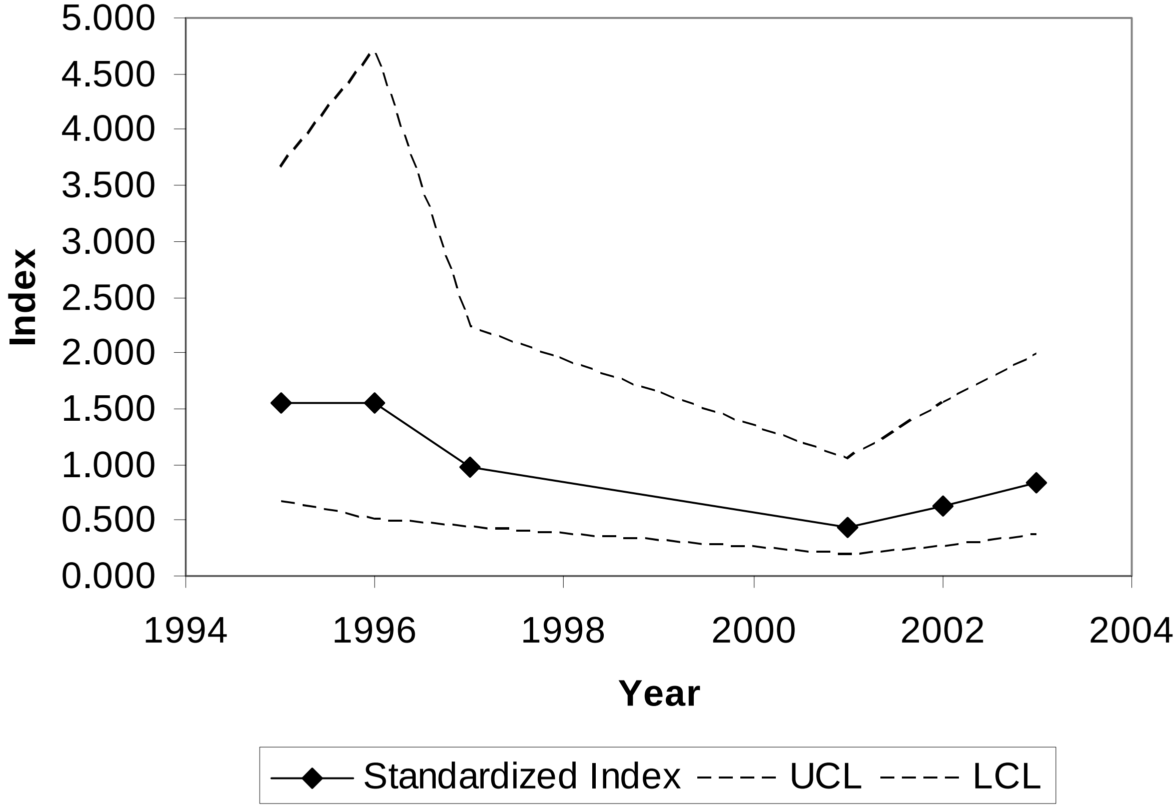
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.607	28	1.750	0.652	0.260	0.390	1.088
1996	0.480	25	0.934	0.348	0.321	0.186	0.650
1997	0.438	32	1.627	0.606	0.396	0.283	1.300
1999	0.532	139	1.542	0.574	0.157	0.421	0.784
2000	0.598	87	4.065	1.514	0.165	1.090	2.103
2001	0.625	64	2.395	0.892	0.195	0.606	1.313
2002	0.625	80	1.985	0.739	0.155	0.543	1.006
2003	0.704	54	4.084	1.521	0.194	1.036	2.233
2004	0.567	60	5.785	2.154	0.242	1.336	3.474

Figure 48. Standardized abundance indices for large coastal sharks collected during bottom longline surveys from the central U.S. Gulf of Mexico.



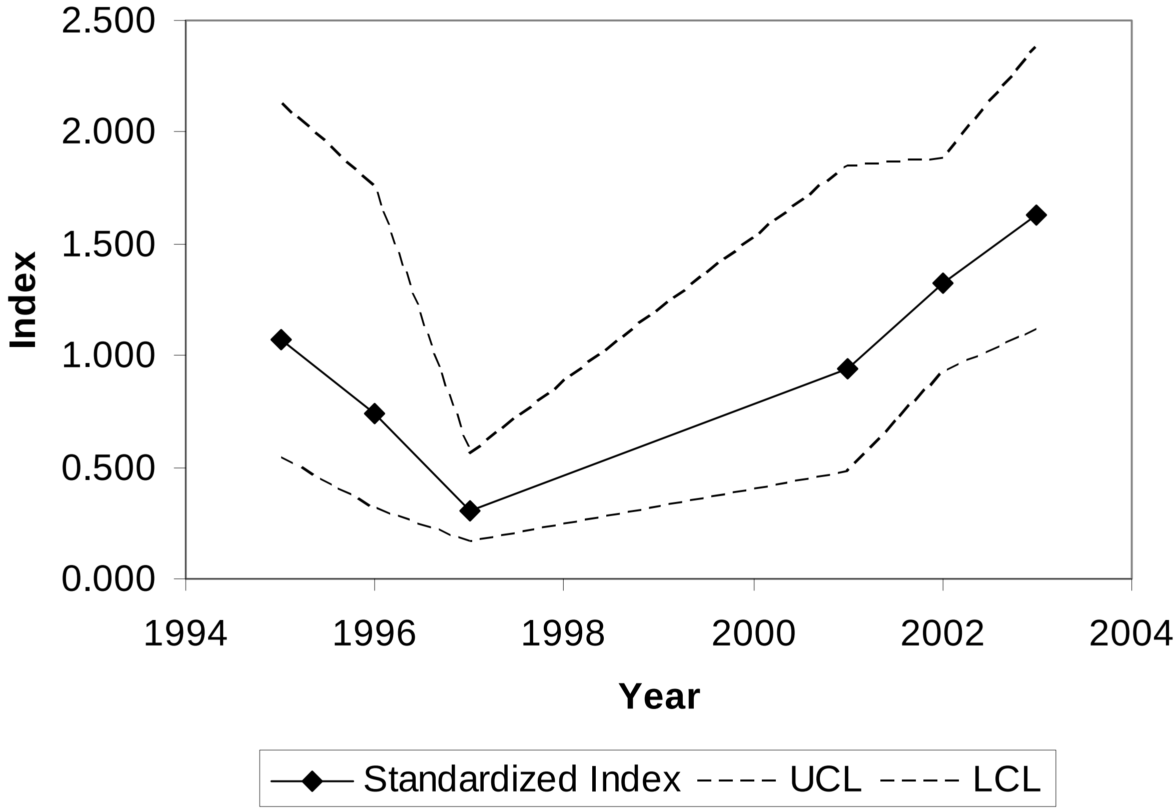
Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.067	15	0.061	0.098	2.836	0.005	1.902
1996	0.059	17	0.103	0.166	1.036	0.030	0.917
1997	0.127	71	0.105	0.169	0.506	0.065	0.441
2001	0.195	82	0.520	0.837	0.399	0.388	1.806
2002	0.255	98	1.006	1.619	0.290	0.917	2.860
2003	0.381	63	1.932	3.110	0.249	1.904	5.080

Figure 49. Standardized abundance indices for blacktip shark collected during bottom longline surveys from the western U.S. Gulf of Mexico.



Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.267	15	0.276	1.555	0.447	0.663	3.651
1996	0.176	17	0.275	1.551	0.601	0.511	4.708
1997	0.113	71	0.173	0.978	0.428	0.431	2.221
2001	0.073	82	0.078	0.442	0.450	0.187	1.044
2002	0.071	98	0.111	0.629	0.473	0.256	1.545
2003	0.111	63	0.150	0.845	0.447	0.360	1.983

Figure 50. Standardized abundance indices for sandbar shark collected during bottom longline surveys from the western U.S. Gulf of Mexico.



Survey Year	Frequency of Occurrence	N	Lo Index	Standardized Index	CV	LCL	UCL
1995	0.600	15	1.581	1.074	0.352	0.543	2.126
1996	0.471	17	1.084	0.736	0.453	0.310	1.748
1997	0.394	71	0.444	0.301	0.317	0.162	0.559
2001	0.500	82	1.380	0.938	0.349	0.476	1.849
2002	0.510	98	1.943	1.320	0.179	0.926	1.882
2003	0.635	63	2.400	1.630	0.190	1.118	2.378

Figure 51. Standardized abundance indices for large coastal sharks collected during bottom longline surveys from the western U.S. Gulf of Mexico.

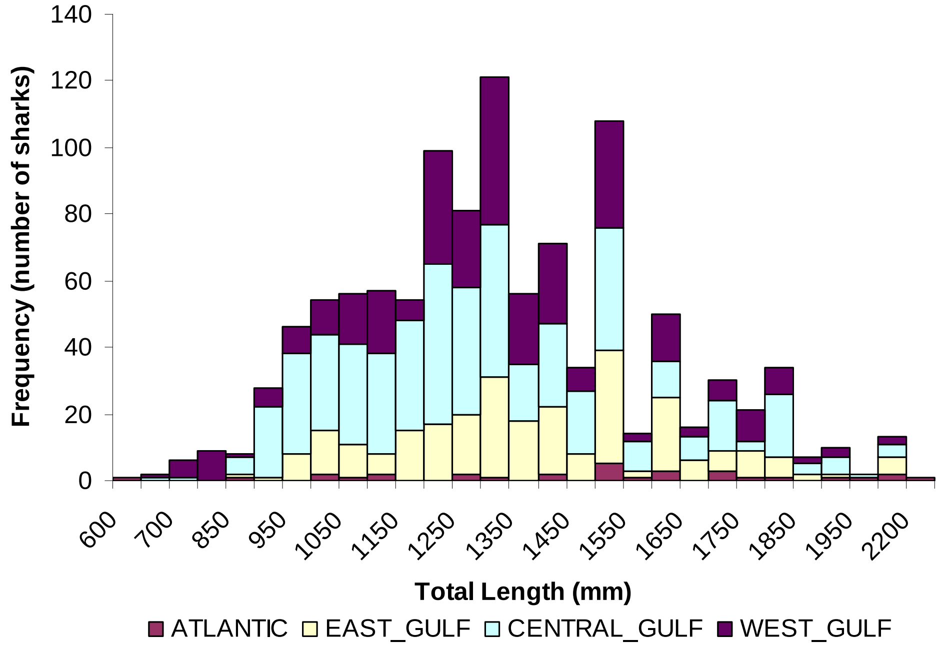


Figure 52. Length frequency histogram of blacktip shark total lengths designated by area collected during bottom longline surveys (N = 1089).

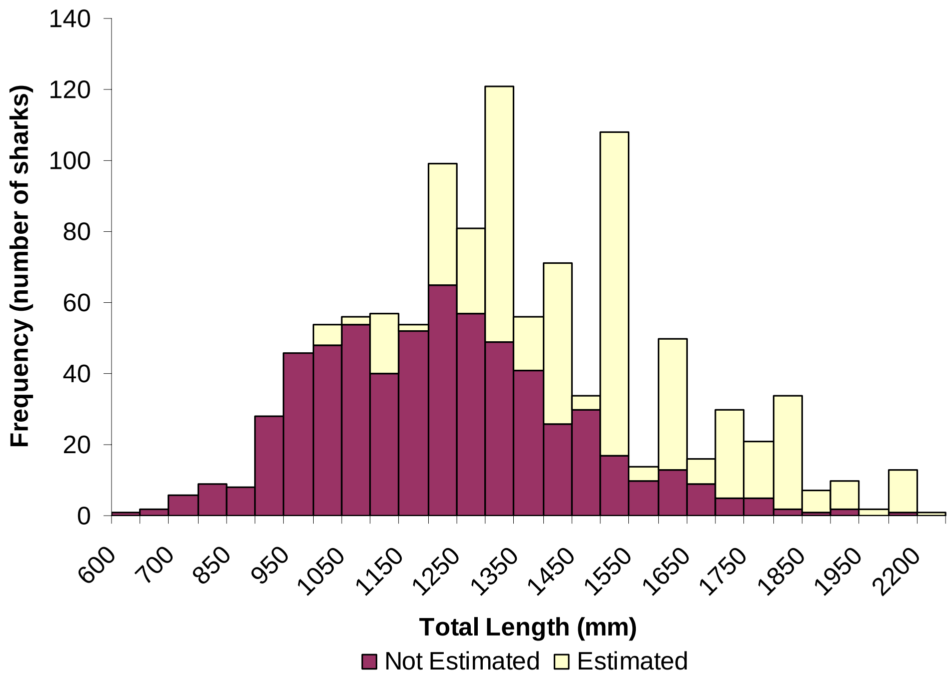


Figure 53. Length frequency histogram of estimated and non-estimated blacktip shark total lengths collected during bottom longline surveys (N = 1089).

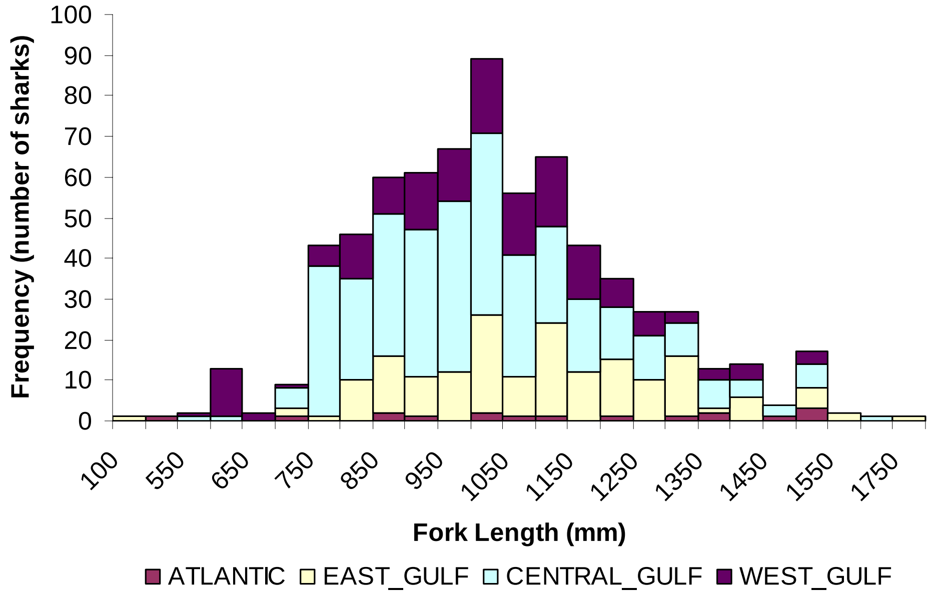


Figure 54. Length frequency histogram of blacktip shark fork lengths designated by area collected during bottom longline surveys (N = 699).

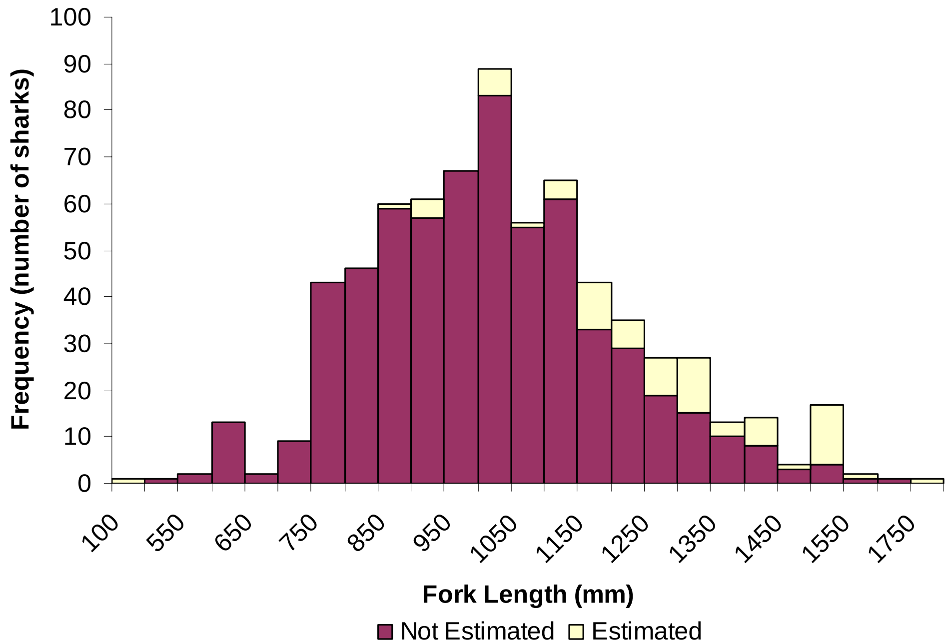


Figure 55. Length frequency histogram of estimated and non-estimated blacktip shark fork lengths collected during bottom longline surveys (N = 699).

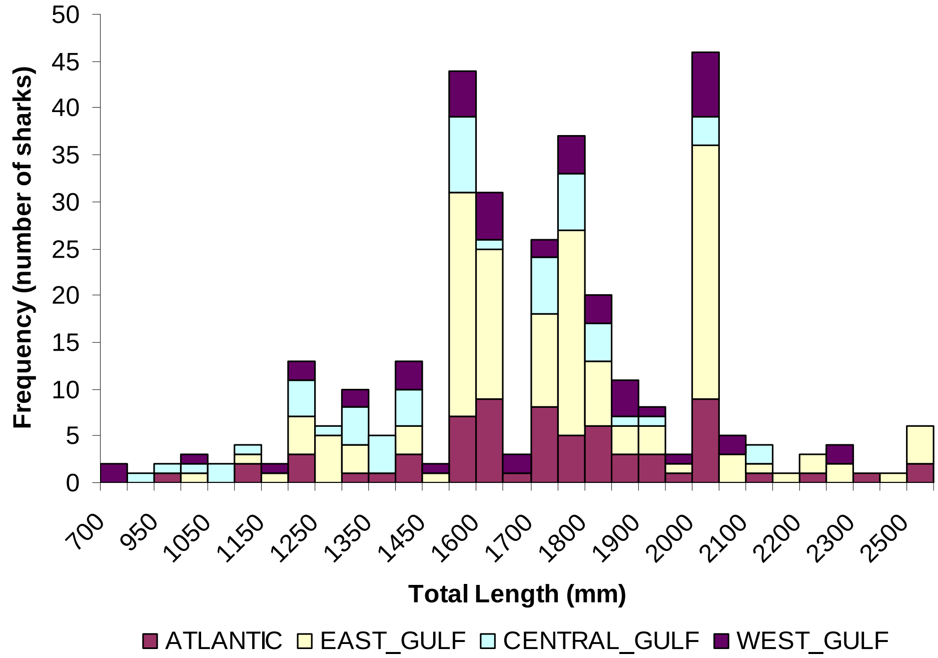


Figure 56. Length frequency histogram of sandbar shark total lengths designated by area collected during bottom longline surveys (N = 319).

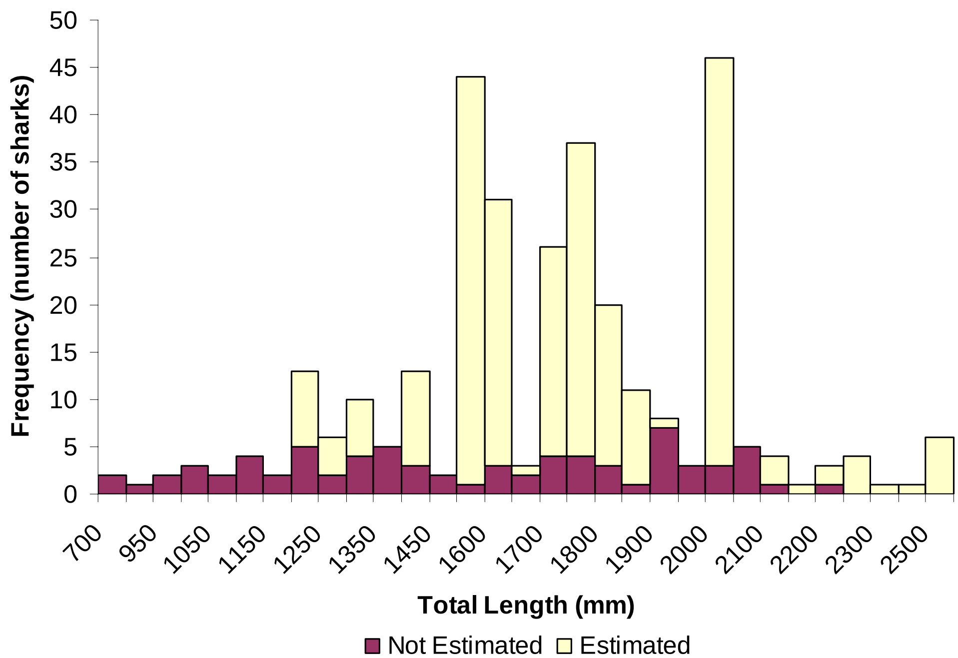


Figure 57. Length frequency histogram of estimated and non-estimated sandbar shark total lengths collected during bottom longline surveys (N = 319).

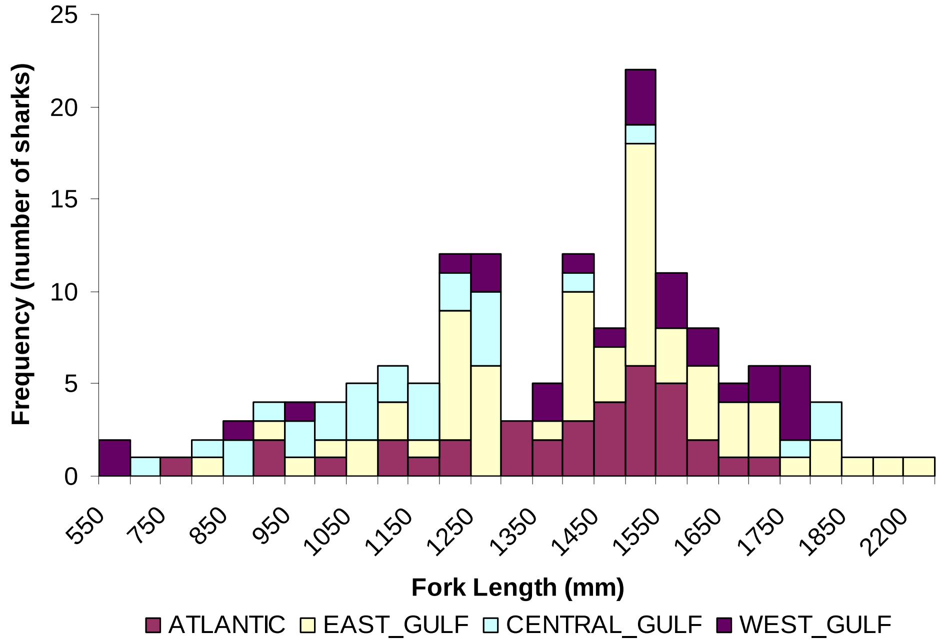


Figure 58. Length frequency histogram of sandbar shark fork lengths designated by area collected during bottom longline surveys (N = 154).

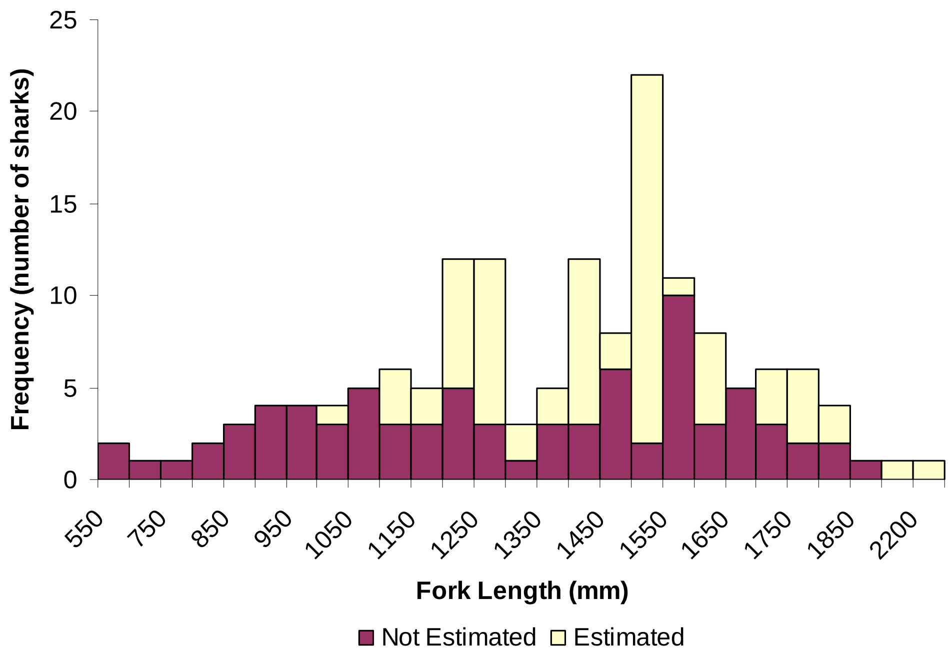


Figure 59. Length frequency histogram of estimated and non-estimated sandbar shark fork lengths collected during bottom longline surveys (N = 154).

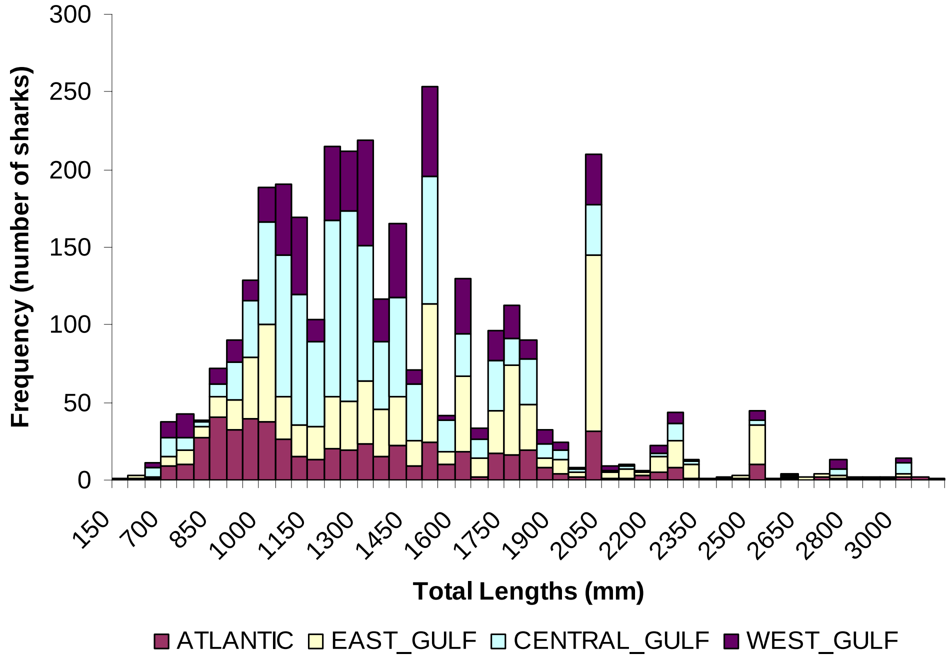


Figure 60. Length frequency histogram of total lengths designated by area of large coastal sharks collected during bottom longline surveys (N = 3309).

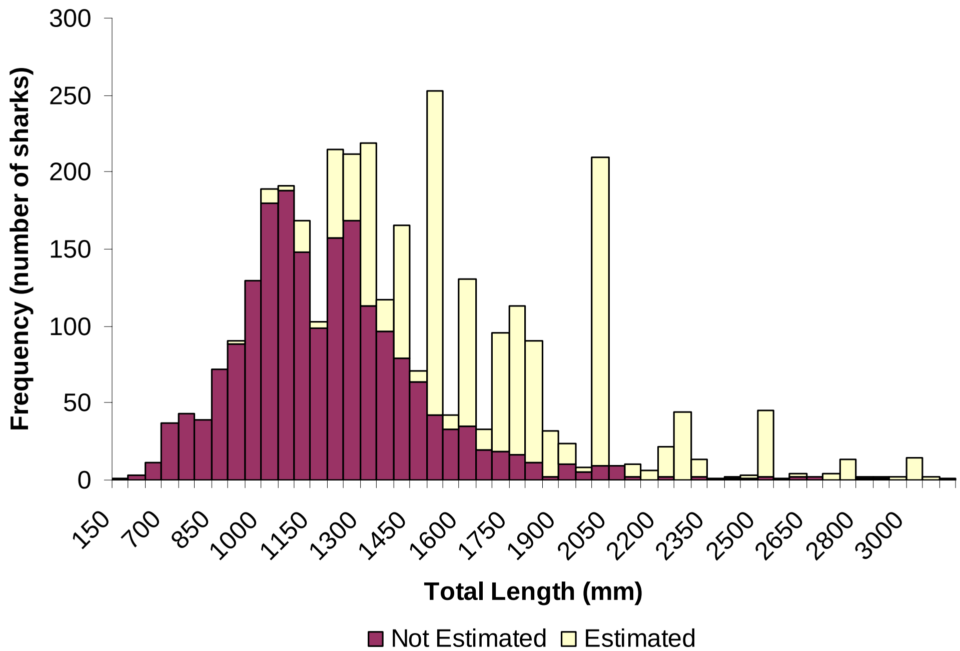


Figure 61. Length frequency histogram of estimated and non-estimated total lengths of large coastal sharks collected during bottom longline surveys (N =).

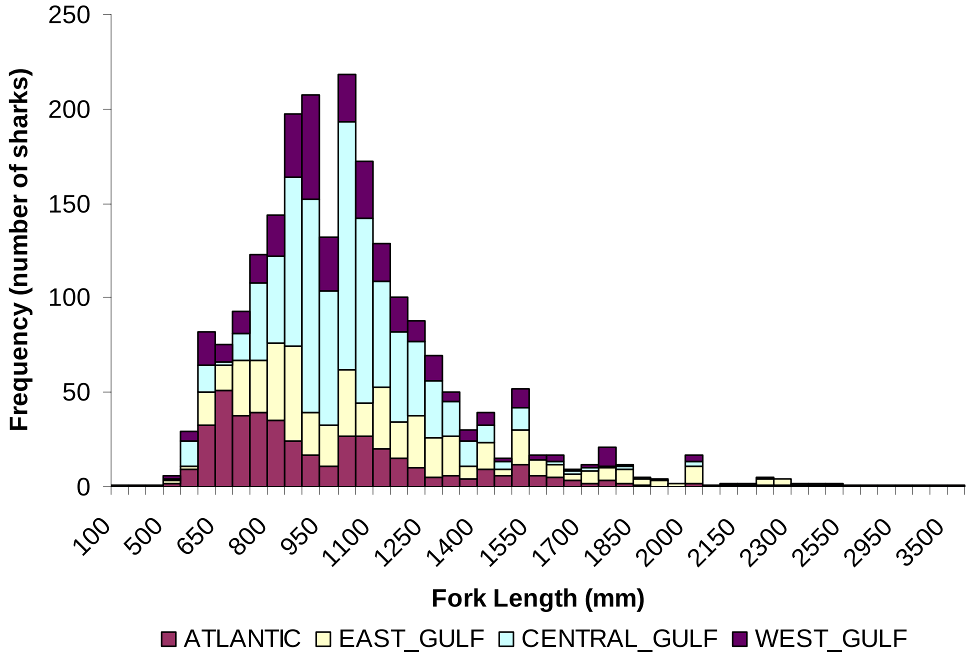


Figure 62. Length frequency histogram of fork lengths designated by area of large coastal sharks collected during bottom longline surveys (N = 2196).

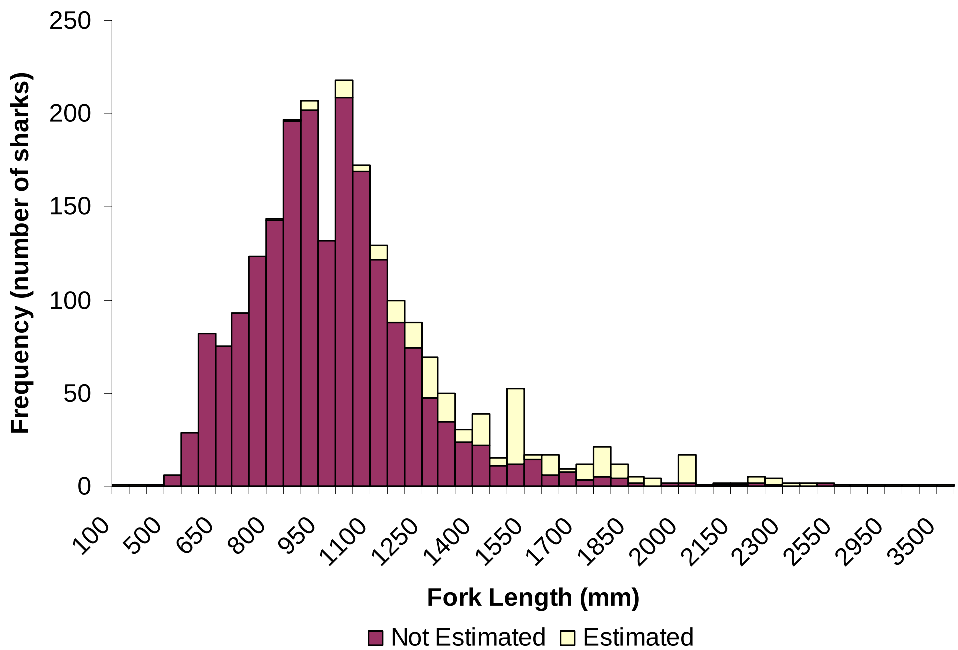


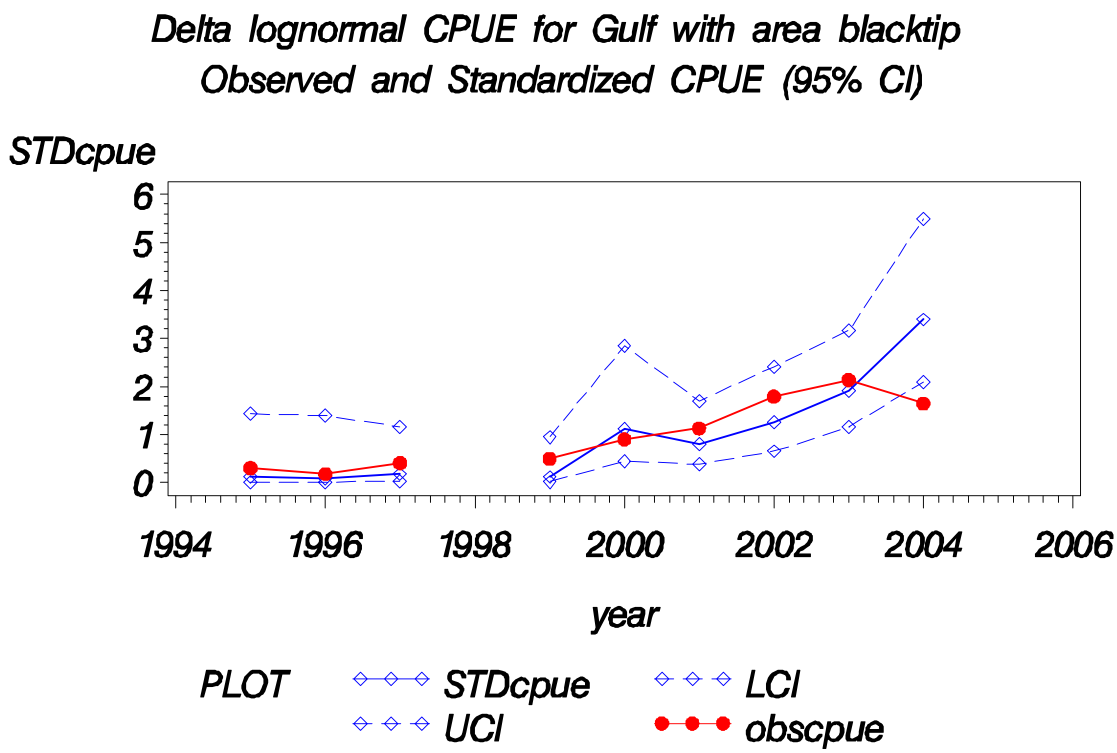
Figure 63. Length frequency histogram of estimated and non-estimated fork lengths of large coastal sharks collected during bottom longline surveys (N = 2196).

ADDENDUM to
Ingram et al. SEDAR05/06-DW-27

After review by the Indices Workgroup I was asked to create six indices using the Lo method:

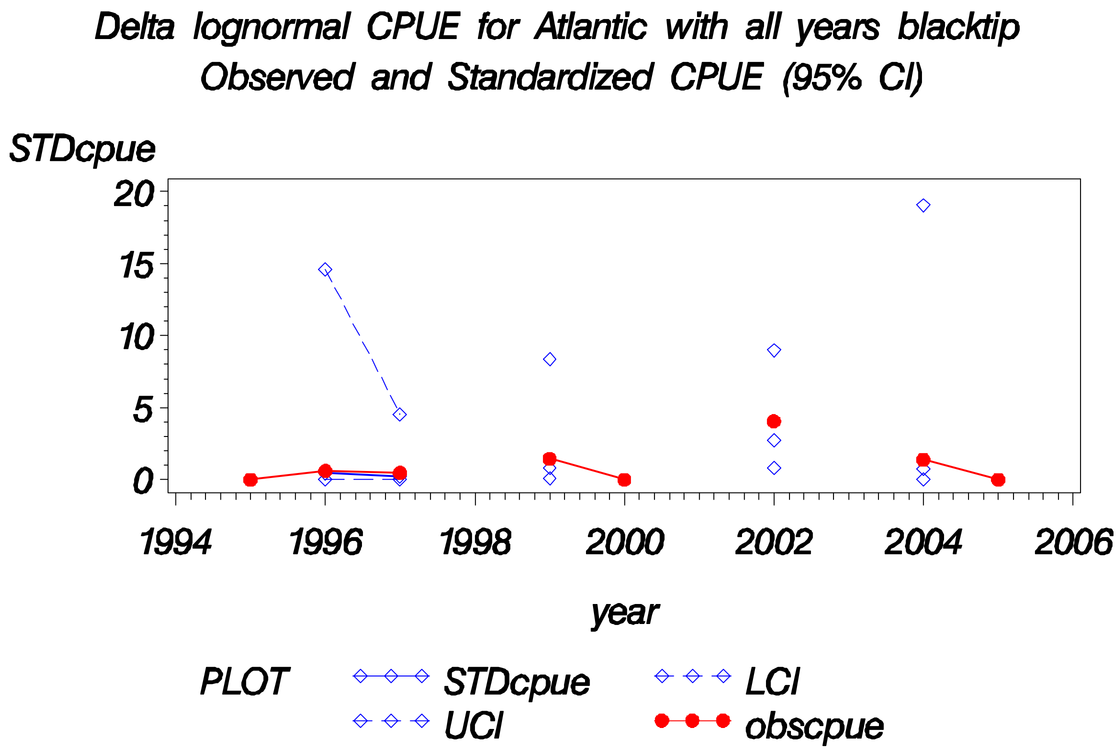
1. Blacktip for Gulf of Mexico with year, area and depth as variables;
2. Blacktip for Atlantic south of 37^{o} with year and depth as variables;
3. Sandbar for Gulf of Mexico and Atlantic combined with year, area and depth as variables;
4. Large coastal sharks for Gulf of Mexico and Atlantic combined with year, area and depth as variables;
5. Large coastal sharks excluding prohibited species for Gulf of Mexico and Atlantic combined with year, area and depth as variables;
6. Large coastal sharks excluding prohibited species, blacktip and sandbar for Gulf of Mexico and Atlantic combined with year, area and depth as variables.

The following figures and tables illustrate results to the above models in the order indicated above.



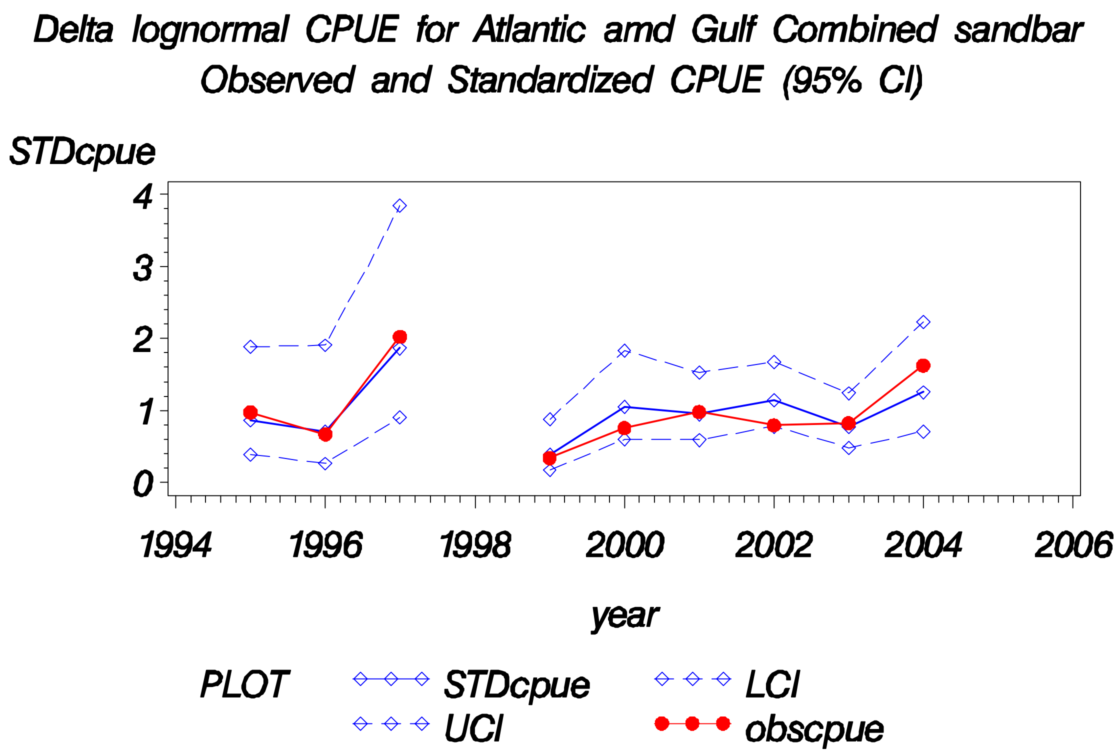
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.17073	82	0.02864	0.12412	1.86279	0.01074	1.43453
1996	0.10714	84	0.01992	0.08630	2.43419	0.00534	1.39422
1997	0.15385	169	0.04089	0.17718	1.18770	0.02714	1.15659
1999	0.18100	221	0.02701	0.11704	1.41017	0.01444	0.94873
2000	0.18565	237	0.25909	1.12277	0.49123	0.44305	2.84531
2001	0.15942	276	0.18549	0.80384	0.38859	0.37970	1.70176
2002	0.23982	221	0.29038	1.25837	0.33527	0.65511	2.41714
2003	0.21429	280	0.44137	1.91273	0.25613	1.15534	3.16663
2004	0.18876	247	0.78403	3.39765	0.24407	2.10010	5.49690

Figure A1. Blacktip for Gulf of Mexico with year, area and depth as variables. For above graph: Graph of nominal index (obscpue) and standardized index (STDcpue) with lower and upper confidence limits (LCI and UCI, respectively). For below table: Frequency = frequency of positive catches. N = number of sampling stations. LoIndex = annual CPUE index (number per 100 hook hours). StdIndex = LoIndex adjusted to a time series mean of 1. CV = coefficient of variation on the mean. LCL and UCL = lower and upper 95% confidence limits. All the following figures follow the same legend.



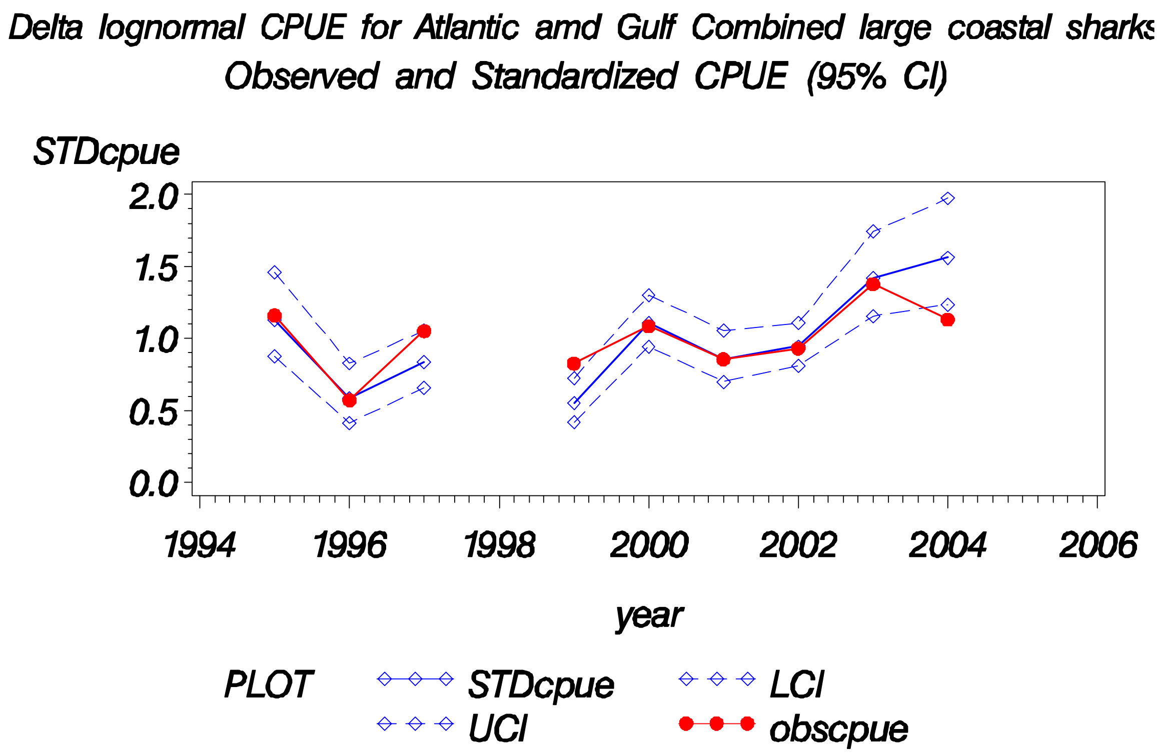
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.00000	45	0.00000	0.00000	.	.	.
1996	0.05882	34	0.008401	0.45308	4.40255	0.01406	14.5978
1997	0.07692	65	0.004521	0.24381	2.72460	0.01315	4.5188
1999	0.24138	29	0.015029	0.81054	1.70567	0.07845	8.3746
2000	0.00000	104	0.00000	0.00000	.	.	.
2002	0.06522	184	0.050951	2.74794	0.64921	0.83927	8.9973
2004	0.02500	40	0.013807	0.74464	3.58571	0.02908	19.0653
2005	0.00000	24	0.00000	0.00000	.	.	.

Figure A2. Blacktip for Atlantic south of 37^{o} with year and depth as variables. Due to low frequencies of positive catches a zero-inflated binomial model was used to describe proportion of positive catch instead of binomial.



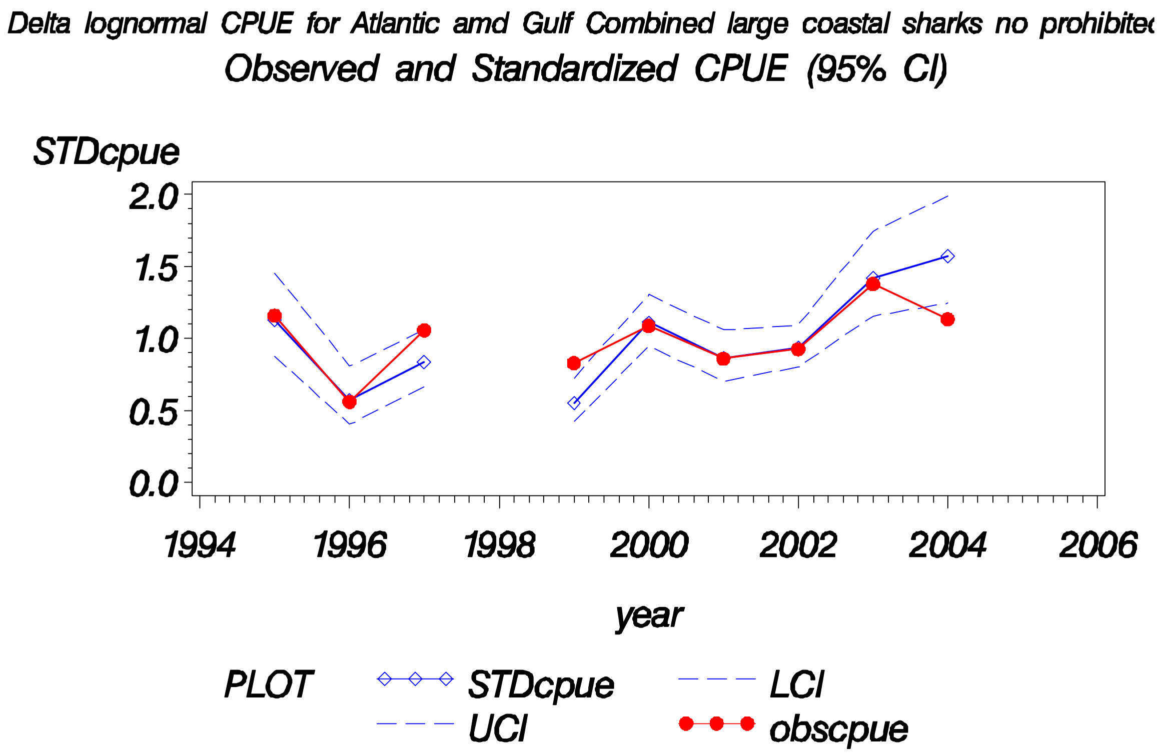
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.16535	127	0.13736	0.86097	0.40693	0.39353	1.88363
1996	0.10169	118	0.11341	0.71089	0.52532	0.26486	1.90806
1997	0.09829	234	0.29771	1.86606	0.37359	0.90567	3.84487
1999	0.07200	250	0.06177	0.38719	0.42745	0.17065	0.87848
2000	0.11437	341	0.16752	1.05001	0.28416	0.60139	1.83332
2001	0.10870	276	0.15184	0.95174	0.23966	0.59327	1.52682
2002	0.10617	405	0.18201	1.14090	0.19280	0.77859	1.67179
2003	0.10714	280	0.12369	0.77532	0.23913	0.48378	1.24253
2004	0.09689	287	0.20053	1.25693	0.29264	0.70849	2.22992

Figure A3. Sandbar for Gulf of Mexico and Atlantic combined with year, area and depth as variables.



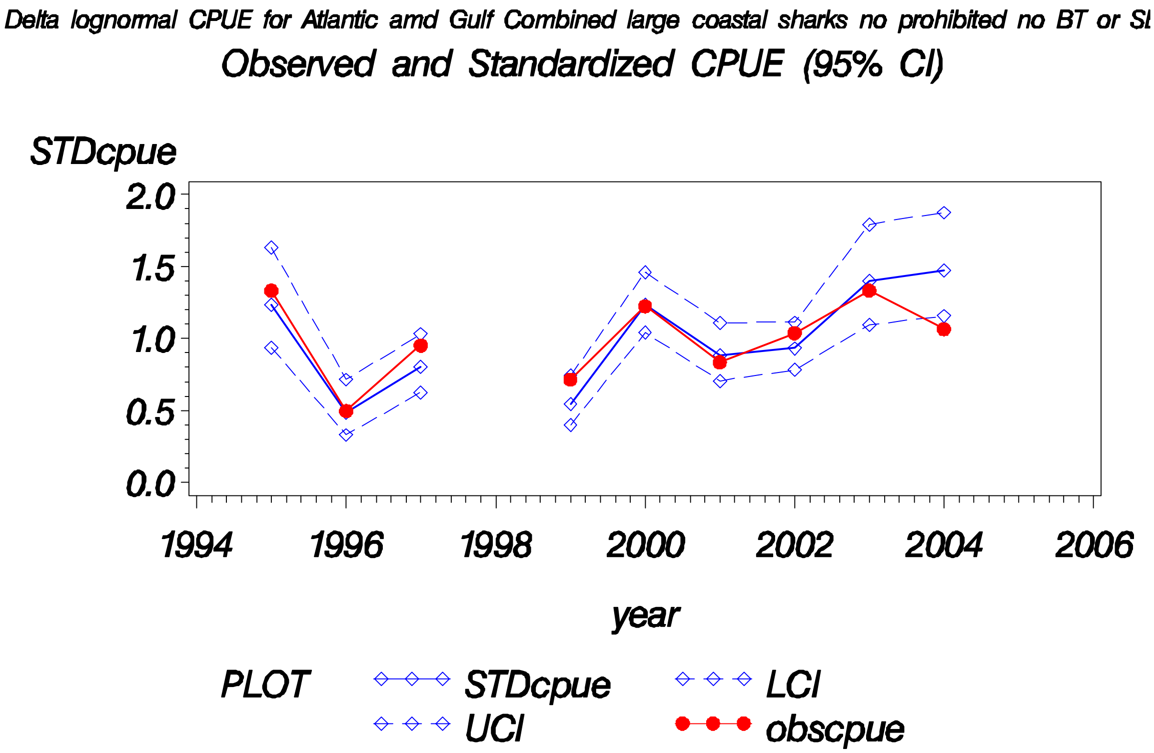
SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.55118	127	1.62909	1.13066	0.12810	0.87604	1.45930
1996	0.37288	118	0.84261	0.58481	0.17552	0.41277	0.82854
1997	0.48291	234	1.20371	0.83543	0.11811	0.66021	1.05716
1999	0.42000	250	0.79581	0.55233	0.13784	0.41979	0.72670
2000	0.56891	341	1.59763	1.10883	0.08007	0.94500	1.30106
2001	0.47826	276	1.23730	0.85874	0.10315	0.69904	1.05493
2002	0.55062	405	1.36484	0.94726	0.07819	0.81033	1.10734
2003	0.51071	280	2.04541	1.41961	0.10302	1.15592	1.74346
2004	0.48443	287	2.25103	1.56232	0.11739	1.23639	1.97417

Figure A4. Large coastal sharks for Gulf of Mexico and Atlantic combined with year, area and depth as variables



SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.55118	127	1.61758	1.12926	0.12697	0.87690	1.45423
1996	0.36441	118	0.81691	0.57029	0.17503	0.40292	0.80720
1997	0.48291	234	1.20171	0.83893	0.11714	0.66424	1.05957
1999	0.42000	250	0.79326	0.55379	0.13619	0.42227	0.72627
2000	0.56598	341	1.59236	1.11165	0.07984	0.94783	1.30378
2001	0.47826	276	1.23721	0.86371	0.10219	0.70443	1.05901
2002	0.54815	405	1.34184	0.93676	0.07761	0.80226	1.09381
2003	0.50714	280	2.03663	1.42180	0.10309	1.15752	1.74642
2004	0.48443	287	2.25438	1.57381	0.11770	1.24472	1.98990

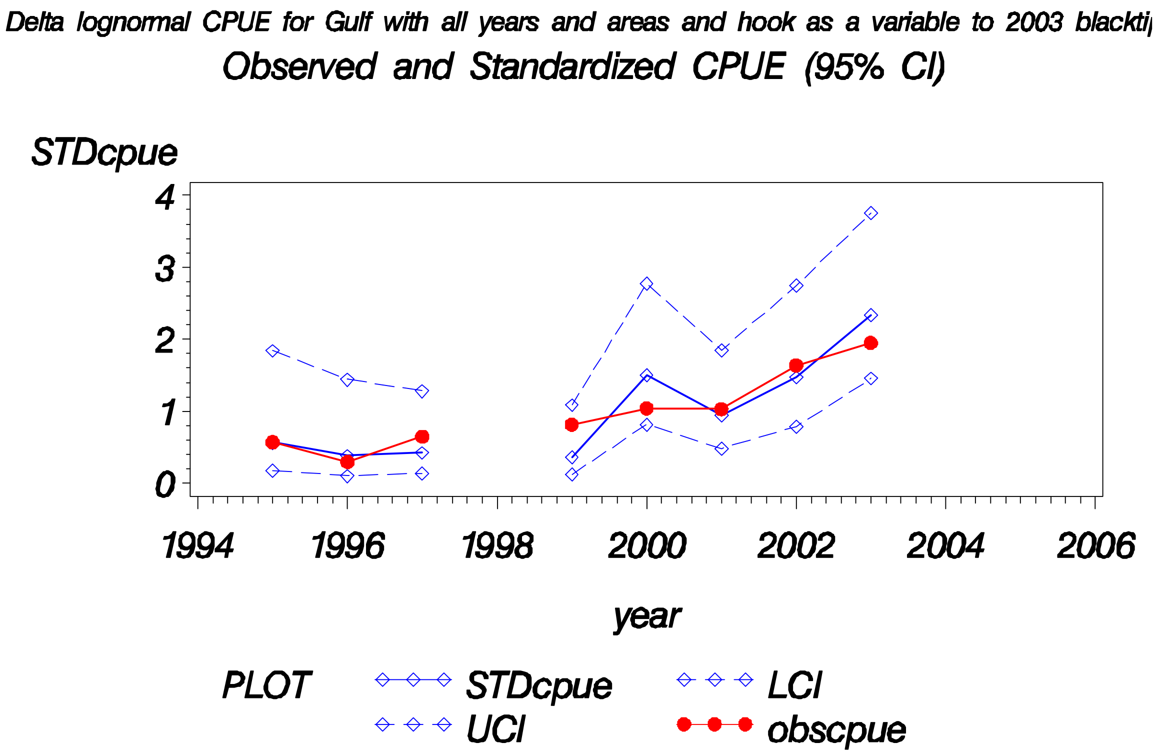
Figure A5. Large coastal sharks excluding prohibited species for Gulf of Mexico and Atlantic combined with year, area and depth as variables.



SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.44882	127	0.96947	1.23684	0.13891	0.93806	1.63079
1996	0.25424	118	0.38113	0.48624	0.19460	0.33067	0.71500
1997	0.33761	234	0.63053	0.80442	0.12529	0.62674	1.03249
1999	0.26000	250	0.42692	0.54466	0.15617	0.39929	0.74295
2000	0.46334	341	0.96724	1.23400	0.08465	1.04212	1.46120
2001	0.34783	276	0.69420	0.88566	0.11365	0.70611	1.11086
2002	0.42469	405	0.73138	0.93308	0.08779	0.78308	1.11181
2003	0.36071	280	1.09854	1.40150	0.12383	1.09507	1.79368
2004	0.37370	287	1.15506	1.47361	0.12105	1.15777	1.87561

Figure A6. Large coastal sharks excluding prohibited species, blacktip and sandbar for Gulf of Mexico and Atlantic combined with year, area and depth as variables.

Delta lognormal CPUE for Gulf with all years and areas and hook as a variable to 2003 blacktip Index Output



SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.17073	82	0.12130	0.56731	0.64336	0.17484	1.84081
1996	0.10714	84	0.08218	0.38435	0.74002	0.10250	1.44124
1997	0.15385	169	0.09063	0.42385	0.59851	0.14015	1.28182
1999	0.18100	221	0.07816	0.36552	0.58800	0.12291	1.08701
2000	0.18565	237	0.32133	1.50276	0.31316	0.81512	2.77052
2001	0.15942	276	0.20241	0.94661	0.34455	0.48445	1.84966
2002	0.23982	221	0.31448	1.47075	0.32024	0.78731	2.74747
2003	0.21429	280	0.50010	2.33883	0.24027	1.45621	3.75643

A large increase was observed in latter years of the time series of indices for Gulf of Mexico blacktip collected during NMFS bottom longline surveys. This increase was deemed biologically impossible for this species. Also, the nominal index fell below the 95% confidence interval for the standardized index for the 2004 survey year. Therefore, the index workgroup deemed it necessary to drop this year from the analysis, and a the above index was developed. This still resulted in a substantial increase, but not as an extreme an increase as seen in the previous analysis on this time series.

Delta lognormal CPUE for Atlantic and Gulf Combined Blacktip Index Output

Type 3 analysis results of variables included into binomial sub-model.

Type 3 Tests of Fixed Effects						
Effect	**Num DF**	**Den DF**	**Chi-Square**	**F Value**	**Pr > ChiSq**	**Pr > F**
YEAR	8	794	49.51	6.15	<.0001	<.0001
AREA	3	1667	231.33	77.10	<.0001	<.0001
sta_dpth	1	1678	160.31	160.31	<.0001	<.0001

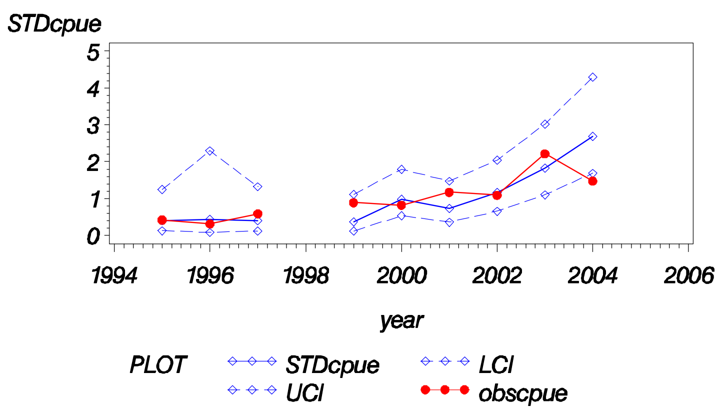
Type 3 analysis results of variables included into log-normal sub-model.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
YEAR	8	350	2.13	0.0329
AREA	3	350	9.52	<.0001
hook	1	350	8.55	0.0037
sta_dpth	1	350	35.27	<.0001

Table of resulting indices from Lo method.

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.11024	127	0.06538	0.40008	0.61726	0.12842	1.24638
1996	0.09322	118	0.07141	0.43701	0.99566	0.08310	2.29810
1997	0.13248	234	0.06583	0.40285	0.65188	0.12253	1.32445
1999	0.18800	250	0.06006	0.36756	0.60036	0.12118	1.11488
2000	0.12903	341	0.16010	0.97975	0.30926	0.53531	1.79320
2001	0.15942	276	0.11935	0.73041	0.36225	0.36188	1.47423
2002	0.16049	405	0.18987	1.16194	0.28867	0.65985	2.04606
2003	0.21429	280	0.29890	1.82918	0.25528	1.10665	3.02346
2004	0.16609	287	0.43976	2.69121	0.23670	1.68713	4.29286

Delta lognormal CPUE for Atlantic amd Gulf Combined Blacktip
Observed and Standardized CPUE (95% CI)



Lo method was used to developed annual abundance indices for blacktip shark for Gulf and Atlantic combined. These indices were developed to aid in sensitivity analyses due to separate stock assessments being conducted for Atlantic and Gulf blacktip.

Addendum 4 to LCS-DW-27 Walter Ingram

Due to a past change in data acquisition methodology that I was not informed of before the data workshop, all indices were ran again. Previously, station depth data was collected automatically by ship systems in units of fathoms. Recently (i.e., 2004), new data acquisition technology was added to ship systems and now records station depth data in units of meters. Therefore, depth data from 2004 and 2005 survey years have been transformed accordingly, and the models redeveloped. After the models for each species and species group were ran, it was found that all have the same significant variables as reported in earlier versions of the same models, reported in earlier sections of this document. Therefore, only new tables of indices are provided below for each species and species group in question.

Delta lognormal CPUE for Atlantic and Gulf Combined Sandbar – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.16535	127	0.20449	1.29263	0.28096	0.74483	2.24330
1996	0.10169	118	0.13145	0.83095	0.37893	0.39941	1.72878
1997	0.09829	234	0.20577	1.30075	0.31563	0.70231	2.40914
1999	0.07200	250	0.06174	0.39025	0.38434	0.18575	0.81988
2000	0.11437	341	0.15361	0.97104	0.21043	0.64038	1.47244
2001	0.10870	276	0.16471	1.04119	0.25598	0.62908	1.72327
2002	0.10644	404	0.16955	1.07180	0.20688	0.71170	1.61410
2003	0.10714	280	0.13927	0.88034	0.26052	0.52732	1.46971
2004	0.09689	287	0.19316	1.22104	0.32242	0.65099	2.29028

Delta lognormal CPUE for Gulf of Mexico Blacktip – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.17073	82	0.11806	0.55388	0.68234	0.16084	1.90737
1996	0.10714	84	0.08104	0.38021	0.78812	0.09469	1.52670
1997	0.15385	169	0.08720	0.40907	0.63383	0.12795	1.30788
1999	0.18100	221	0.07262	0.34069	0.62964	0.10726	1.08215
2000	0.18565	237	0.32346	1.51749	0.32704	0.80213	2.87082
2001	0.15942	276	0.19131	0.89753	0.35327	0.45204	1.78206
2002	0.23982	221	0.30610	1.43605	0.32704	0.75908	2.71675
2003	0.21429	280	0.47684	2.23707	0.24242	1.38712	3.60783
2004	0.18876	247	0.26176	1.22801	0.30735	0.67334	2.23956

Delta lognormal CPUE for Atlantic and Gulf Combined Blacktip – Index Output

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.11024	127	0.07513	0.49258	0.48698	0.19579	1.23929
1996	0.09322	118	0.08401	0.55085	0.82628	0.13015	2.33149
1997	0.13248	234	0.07243	0.47491	0.53302	0.17469	1.29112
1999	0.18800	250	0.06767	0.44368	0.49999	0.17249	1.14122
2000	0.12903	341	0.18794	1.23226	0.26468	0.73229	2.07359
2001	0.15942	276	0.13763	0.90243	0.29522	0.50621	1.60881
2002	0.16089	404	0.22097	1.44887	0.25159	0.88277	2.37799
2003	0.21429	280	0.34550	2.26536	0.22508	1.45227	3.53370
2004	0.16609	287	0.18135	1.18905	0.25917	0.71406	1.97999

Delta lognormal CPUE for Atlantic and Gulf Combined, All Large Coastal Sharks

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.55118	127	1.02919	0.84923	0.13517	0.64887	1.11148
1996	0.37288	118	0.54366	0.44860	0.20010	0.30183	0.66674
1997	0.48291	234	0.75809	0.62553	0.12819	0.48457	0.80750
1999	0.42000	250	0.60513	0.49932	0.14977	0.37069	0.67259
2000	0.56891	341	1.26236	1.04163	0.08255	0.88336	1.22826
2001	0.47826	276	1.35791	1.12047	0.10589	0.90716	1.38394
2002	0.55198	404	1.47821	1.21974	0.07971	1.04027	1.43018
2003	0.51071	280	2.23737	1.84616	0.10451	1.49878	2.27404
2004	0.48443	287	1.63525	1.34932	0.10734	1.08930	1.67141

Delta lognormal CPUE for Atlantic and Gulf Combined, All Large Coastal Sharks with No Prohibited Species

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.55118	127	1.02267	0.84831	0.13486	0.64856	1.10958
1996	0.36441	118	0.52856	0.43844	0.20274	0.29348	0.65499
1997	0.48291	234	0.75763	0.62846	0.12833	0.48670	0.81150
1999	0.42000	250	0.60405	0.50106	0.15010	0.37174	0.67536
2000	0.56598	341	1.25874	1.04413	0.08299	0.88469	1.23230
2001	0.47826	276	1.35879	1.12711	0.10593	0.91247	1.39225
2002	0.54950	404	1.45486	1.20681	0.07985	1.02894	1.41543
2003	0.50714	280	2.23014	1.84990	0.10530	1.49947	2.28222
2004	0.48443	287	1.63447	1.35579	0.10745	1.09429	1.67978

Delta lognormal CPUE for Atlantic and Gulf Combined,
All Large Coastal Sharks with No Prohibited Species, Blacktip or Sandbar

SurveyYear	Frequency	N	LoIndex	StdIndex	CV	LCL	UCL
1995	0.44882	127	0.63772	0.94634	0.15159	0.70005	1.27929
1996	0.25424	118	0.25661	0.38079	0.23566	0.23920	0.60620
1997	0.33761	234	0.40969	0.60797	0.14460	0.45597	0.81063
1999	0.26000	250	0.34223	0.50786	0.18636	0.35095	0.73491
2000	0.46334	341	0.79214	1.17550	0.09210	0.97812	1.41271
2001	0.34783	276	0.74696	1.10846	0.12456	0.86486	1.42067
2002	0.42574	404	0.79982	1.18690	0.09511	0.98172	1.43496
2003	0.36071	280	1.17625	1.74551	0.13193	1.34221	2.26998
2004	0.37370	287	0.90345	1.34068	0.11996	1.05559	1.70275