Standardized catch rates of large coastal sharks from the United States bottom longline fishery during 1996-2004

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INTRODUCTION

Bottom longline landings and fishing effort of commercial vessels operating in the Gulf of Mexico and the Atlantic Ocean south of Virginia have been monitored by the National Marine Fisheries Service (NMFS) through the coastal (reef fish) logbook program (conducted by the NMFS Southeast Fisheries Science Center). The program collects data by fishing trip on landings and effort for vessels with permits to fish in a number of fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The reef fish logbook program began in 1990 with a complete census of reef fish fishery permitted vessel activity, with the exception of Florida, where a 20% sample of vessels was targeted. Beginning in 1993, the sampling in Florida was increased to require reports from all vessels permitted in the reef fish fishery. Also in July 1993, reporting requirements began for shark fishing trips.

The available catch per unit effort (CPUE) series, from 1996 - 2004, was used to develop two abundance indices for the large coastal shark species complex. In addition, two indices were developed for blacktip sharks and two indices were calculated for sandbar sharks. The analyses involving the large coastal shark complex included only those species that may currently be landed. Prohibited species (night shark, bignose shark, spinner shark, and sand tiger shark were excluded from the analyses. Unclassified sharks were also excluded from the data set. The prohibited species and the unclassified sharks accounted for a small fraction of the yearly landings of large coastal sharks during the period examined (Figure 1).

METHODS

The logbook data base includes information on trip identifier, landing date, fishing gear, areas fished, number of days at sea, gear specific fishing effort (for longline: number of sets fished, number of hooks per set, length of longline, and estimated total fishing time), species caught and whole weight of the catch. Multiple areas and gear fished may be recorded for a single fishing trip.

Coastal (reef fish) logbook bottom longline data from the period 1996-2004 were used to develop indices of abundance for large coastal sharks. Although fishing effort and landings from 1993-1995 were reported, species identification problems are apparent in those data (Brown, 2002). A large number of the landings are identified as unclassified shark prior to 1996 (Heinemann and Poffenberger, 2002). The proportion of unclassified sharks decreased after 1995 and the proportion of blacktip and sandbar sharks increased coincidentally (Brown, 2002). Data prior to 1995 was excluded from the analyses because of the apparent species identification problem.

Two sets of analyses were performed following the methods used of Brown (2002). The first group of vessels was limited vessels that reported fishing with bottom longline gear for seven years during the 1996-2004 period. That criterion was met by 147 vessels. A second group of vessels which were presumed to actively target large coastal sharks was defined as follows: an average yearly large coastal shark cpue (landings/number of sets fished per trip) was calculated for each of those vessels relative to all other vessels. The highest 20% of vessels by cpue rank were classified as targeting sharks (ST). Separate indices of abundance were calculated for each of those two groups of vessels (all bottom longline vessels that fished in seven of the nine years and all vessels defined as targeting sharks).

For all indices developed, the factors YEAR, QUARTER, ZONE, and VESSEL were examined for inclusion in the catch rate models. The factors YEAR included each year in the time series and the factor VESSEL included each vessel in the data set. The factor QUARTER was constructed for the indices to create four periods generally reflective possible weather associated impacts on the fishery. Those periods were:

January – March,	QUARTER = 1
April – June,	QUARTER = 2
July – September,	QUARTER = 3
October – December,	QUARTER = 4

ZONE defined three regions based upon the distribution of effort. They were:

Northern Gulf of Mexico, north of 26^{o} and west of 82^{o}
Southern Florida, south of 26^{o}
Atlantic, north of 26^{o} and east of 82^{o}

The delta lognormal model approach (Lo et al. 1992) was used to develop the standardized indices of abundance. This method combines separate generalized linear modeling (GLM) analyses of the proportion of successful trips (trips that landed a shark) and the catch rates on successful trips to construct a single standardized CPUE index. For the GLM analysis of the proportion of successful trips, a type-3 model was fit and a binomial error distribution was assumed. The response variable was proportion successful trips. For the analysis of catch rates on successful trips, a type3 model assuming lognormal error distribution was employed and the response variable was ln(CPUE).

RESULTS AND DISCUSSION

For the analyses of the large coastal sharks species complex the final models were ***PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL+QUARTER*** and, for the lognormal model of catch rates on successful trips, ***ln(CPUE)=YEAR+VESSEL+QUARTER***. Identical models were used for developing indices of abundance for blacktip sharks. Final models for the analysis of sandbar sharks were ***PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL+QUARTER*** and ***ln(CPUE)=YEAR+VESSEL+ZONE***. Plots of error distributions from the final models of catch rates on successful trips are provided in Figures 2 and 3. In all cases, those frequency distributions approximated a normal distribution.

The delta-lognormal abundance indices developed for each shark species category (all large coastal sharks, blacktip sharks, and sandbar sharks), with 95% confidence intervals, are shown in Figure 4. Visual comparison between indices developed from vessels categorized as targeting large coastal sharks and vessels fishing bottom longlines in seven of the nine years examined is facilitated by scaling both series to their respective means. The indices and coefficients of variation are provided in Table 1. The standardized abundance indices developed here are similar to those of Brown (2002) for the years 1996-2001. CPUE is essentially flat during the time series for large coastal sharks and for sandbar sharks. Blacktip shark CPUE gradually increased over time before dropping in 2004.

LITERATURE CITED

Brown, C.A. 2002. Bottom longline logbook catch rates for large coastal sharks. SB-02-33R. 5pp.

Heinemann, D. and J. Poffenberger. 2002. Summaries of Gulf of Mexico and southeastern US Atlantic shark catch and fishing effort from coastal fishery logbook reports. Sustainable Fisheries Division Contribution SFD-01/02-168. 19pp.

Lo, N.C., L.D. Jackson, J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models.

Figure 1. Coastal logbook bottom longline landings for large coastal sharks, 1996-2004. Includes prohibited species and unclassified sharks. The category "all other lcs" includes all large coastal shark species that may currently be landed except blacktip and sandbar sharks. Landings for all prohibited species were combined.

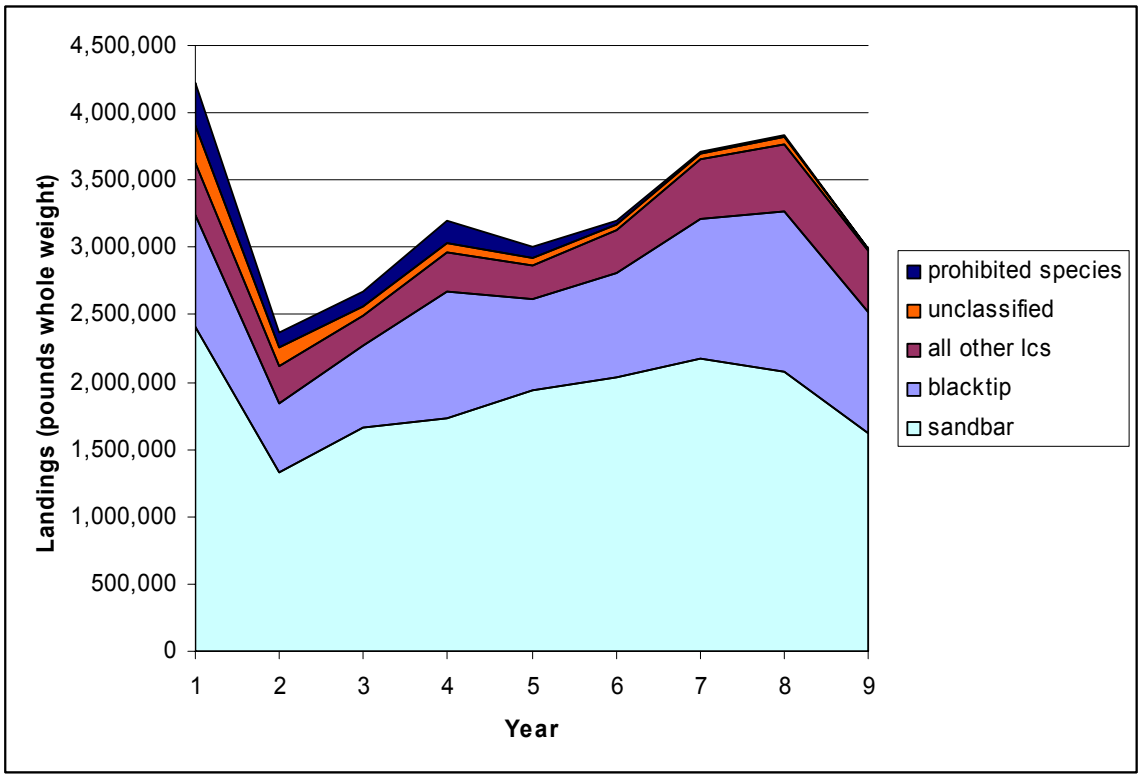
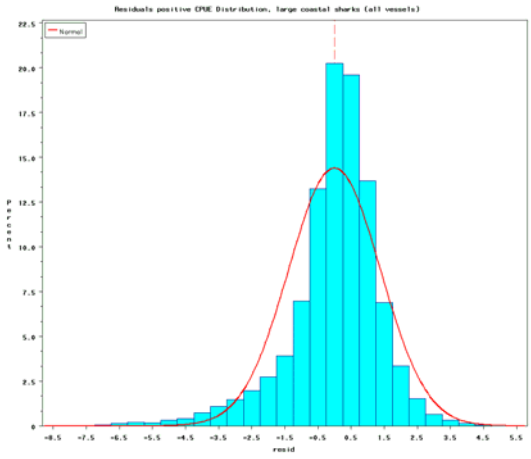


Figure 2. Error distribution of final lognormal models (all vessels). A. Large coastal sharks. B. Blacktip sharks. C. Sandbar sharks. The solid line in each graph is the expected normal distribution.

A.



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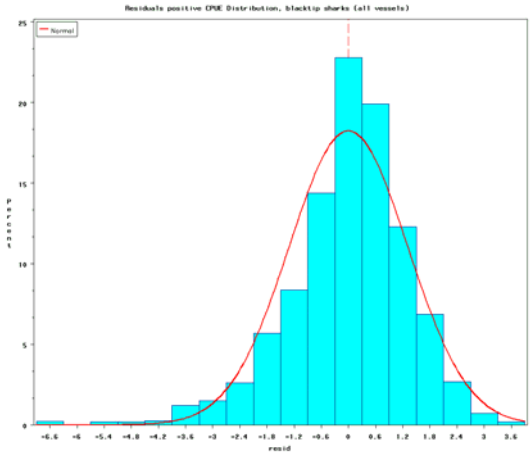

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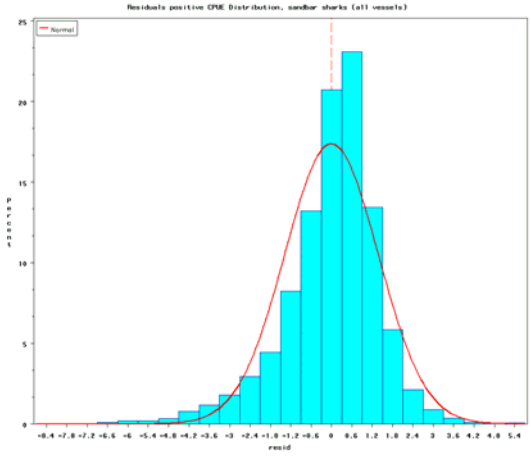
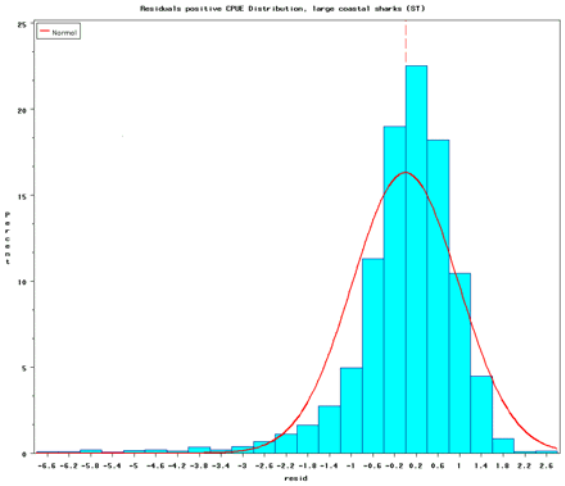


Figure 3. Error distribution of final lognormal models (vessels targeting sharks). A. Large coastal sharks. B. Blacktip sharks. C. Sandbar sharks. The solid line in each graph is the expected normal distribution.

A.



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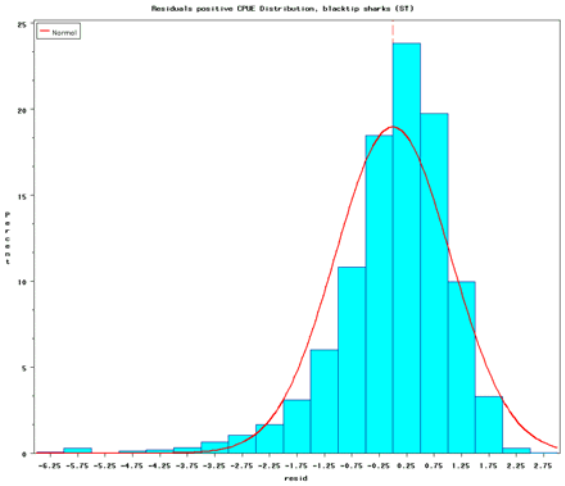

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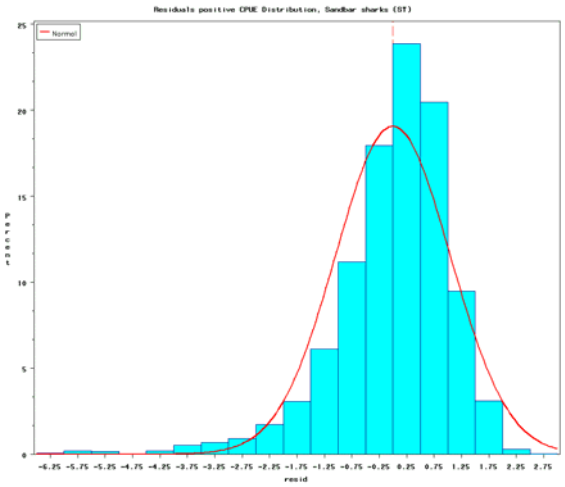
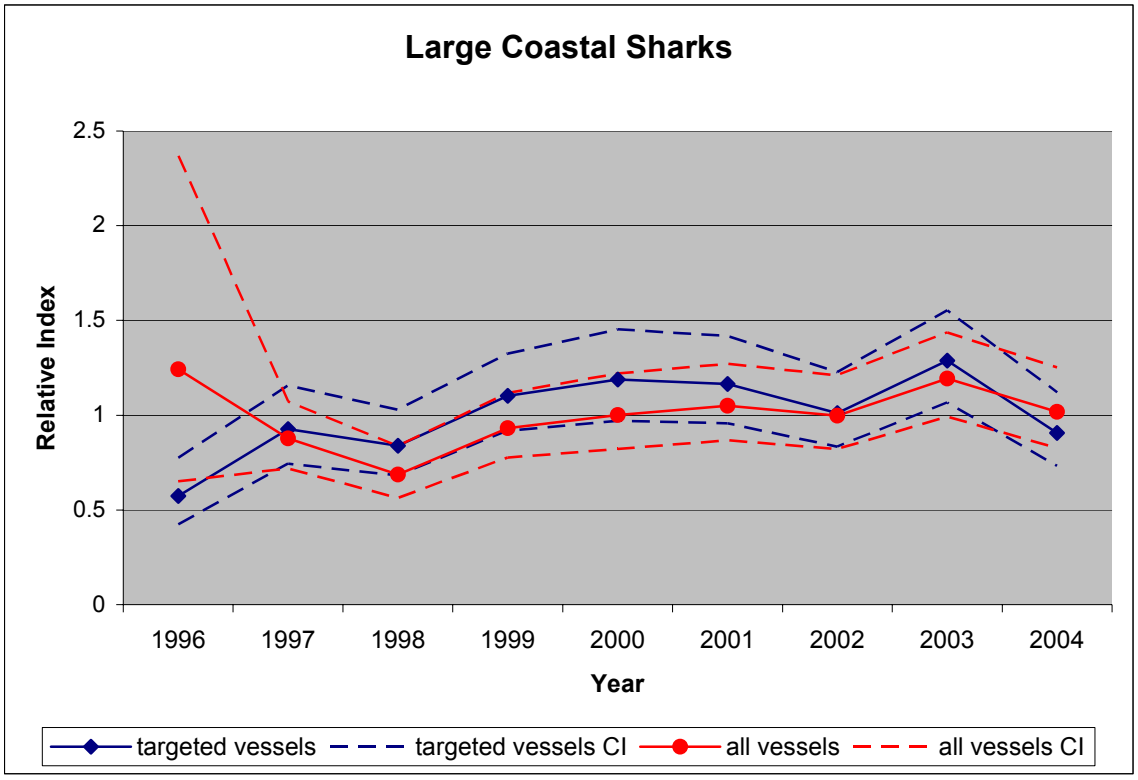


Figure 4. Relative abundance indices by shark species category with 95% confidence intervals. Analyses restricted to vessels categorized as targeting sharks (in blue) and all bottom longline vessels (in red).



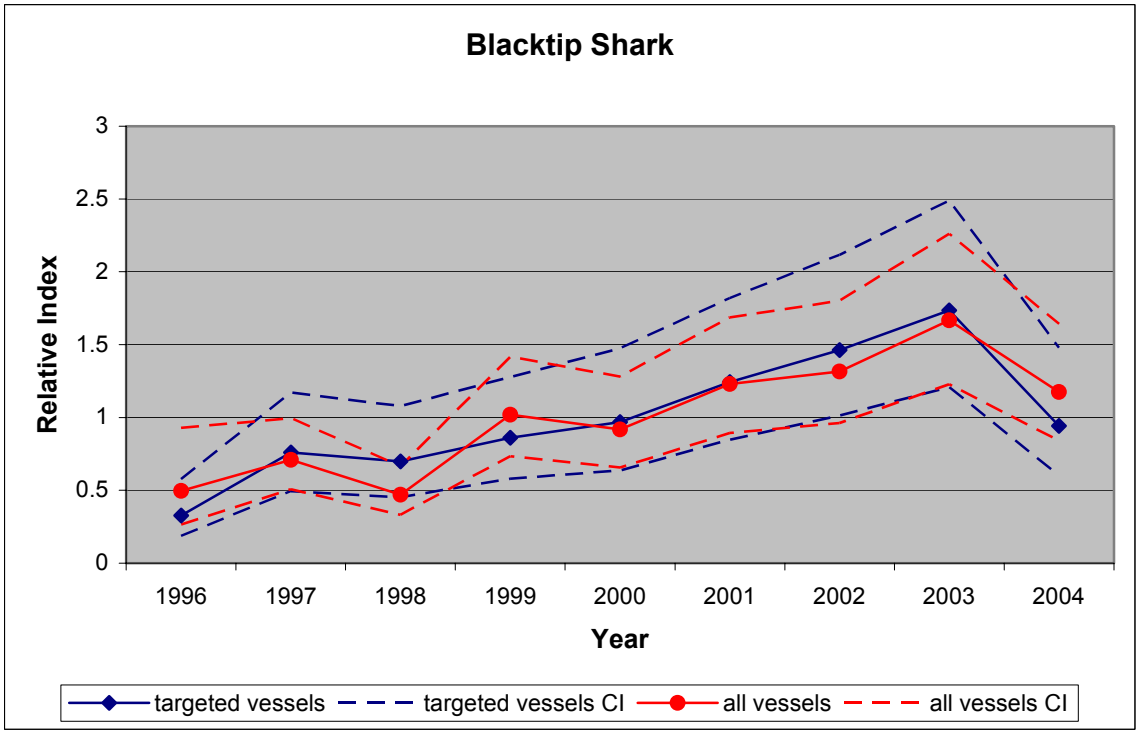


Figure 4. continued.

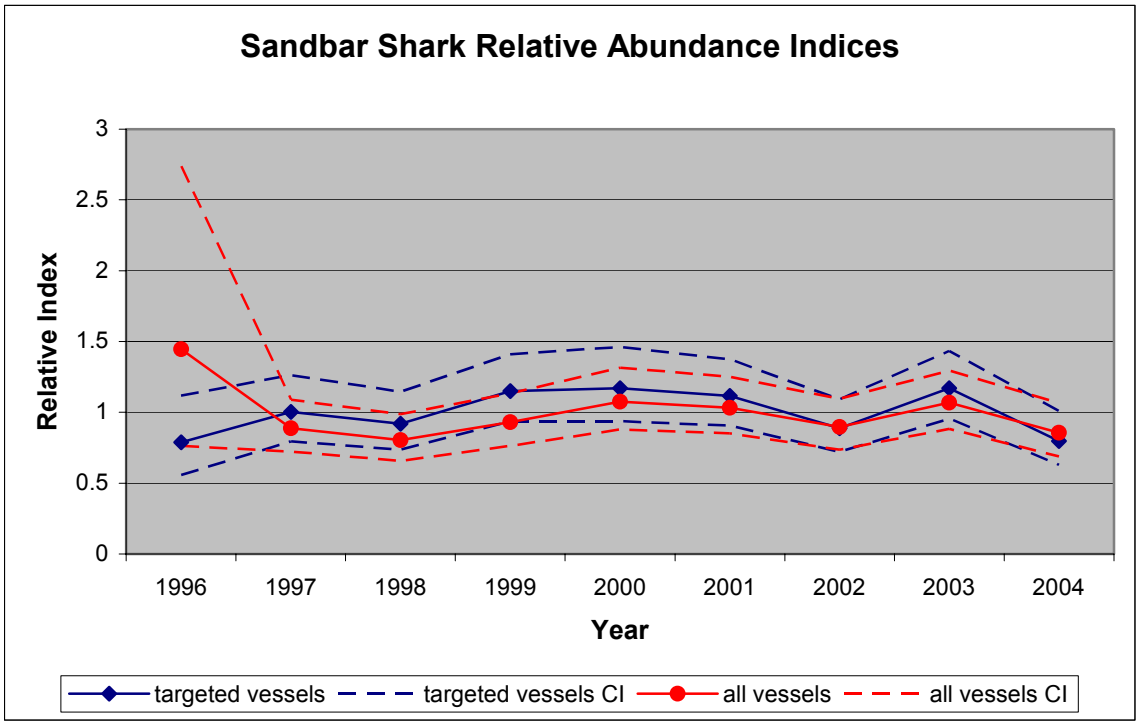


Table 1. Large coastal shark relative abundance indices.

Year	Species Category											
	Analysis restricted to vessels categorized as targeting sharks (ST)						Analysis not restricted to vessels categorized as targeting sharks (All)					
	Large Coastal		Blacktip		Sandbar		Large Coastal		Blacktip		Sandbar	
	value	c.v.	value	c.v.	value	c.v.	value	c.v.	value	c.v.	value	c.v.
1996	0.5737	0.1515	0.3283	0.2883	0.7891	0.1752	1.2423	0.331	0.497	0.3208	1.4459	0.3275
1997	0.9273	0.1104	0.7599	0.2184	1.002	0.1164	0.8779	0.1002	0.7098	0.1698	0.8877	0.1029
1998	0.8386	0.1032	0.6985	0.2197	0.9187	0.1106	0.6871	0.0996	0.47	0.1745	0.8048	0.1021
1999	1.1026	0.0918	0.8606	0.1995	1.1503	0.102	0.9313	0.0914	1.0199	0.1654	0.9302	0.0989
2000	1.1881	0.1013	0.9696	0.2119	1.171	0.1114	1.0015	0.0989	0.9175	0.1676	1.0747	0.1009
2001	1.165	0.0988	1.2423	0.1922	1.115	0.1042	1.0498	0.0956	1.2289	0.1595	1.0322	0.0968
2002	1.0109	0.0968	1.4632	0.1856	0.8868	0.1043	0.9979	0.097	1.3163	0.1575	0.8979	0.0998
2003	1.2873	0.094	1.7347	0.1821	1.1695	0.1019	1.1937	0.0928	1.6661	0.1533	1.0696	0.0959
2004	0.9065	0.1067	0.9428	0.2275	0.7975	0.119	1.0186	0.104	1.1745	0.169	0.857	0.1096

Standardized catch rates of large coastal sharks from the United States bottom longline fishery during 1996-2004: Addendum

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Additional indices of abundance were requested during the Large Coastal Shark data assessment workshop in Panama City, Florida and are presented here. All indices were developed from coastal logbook data following the methods described in LCS05/06-DW31.

Indices of abundance were developed for three variations of the large coastal shark complex: 1. all prohibited species and the species that may currently be landed; 2. only those species that may currently be landed (this index is reported in LCS05/06-DW31); and 3. only those species that may currently be landed, but excluding blacktip and sandbar shark data from the index. Two additional indices were produced, one for Atlantic blacktip sharks and a second index for blacktip sharks in the Gulf of Mexico. For each of the data sets listed above, indices were produced for vessels reporting bottom longline shark landings in any seven of the nine years (1996-2004) of data examined. Additional indices were produced for vessels that targeted sharks, defined as the 20% of bottom longline vessels with the highest CPUE for sharks.

For the analyses of the large coastal sharks species complex defined as 1 and 3 above (except the proportion positive model for targeted vessels for 1), the final models were

PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL+QUARTER+ZONE

and

ln(CPUE)=YEAR+VESSEL+QUARTER+ZONE

The final proportion positive model for the large coastal shark complex listed above as 1 was

PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL+QUARTER

Plots of error distributions from the final models of catch rates on successful trips are provided in Figure 1. In all cases, those frequency distributions approximated a normal distribution.

The delta-lognormal abundance indices developed for each of the three variations of the large coastal shark complex, with 95% confidence intervals, are shown in Figure 2. Visual comparison between indices developed from vessels categorized as targeting large coastal sharks and all vessels fishing bottom longlines in seven of the nine years examined is facilitated by scaling both series to their respective means. The indices and coefficients of variation are provided in Table 1. CPUE is essentially flat during the time series for all large coastal sharks (including prohibited species) and for large coastal sharks excluding prohibited species. This suggests that prohibited species CPUE has little effect on the indices.

The abundance indices for large coastal sharks excluding prohibited species, blacktip, and sandbar sharks increased through 2002. The index developed for vessels targeting sharks decreased after 2002, but the index developed for all bottom longline vessels was slightly higher in 2004. All of the large coastal shark indices are plotted together in Figure 3.

Final models used to develop indices of abundance for blacktip sharks by all bottom longline vessels in the Atlantic and for all blacktip shark indices developed for the Gulf of Mexico were

PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL+QUARTER

and

ln(CPUE)=YEAR+VESSEL+QUARTER

Final models for blacktip sharks developed from data for vessels targeting sharks in the Atlantic were

PROPORTION SUCCESSFUL TRIPS=YEAR+VESSEL

and

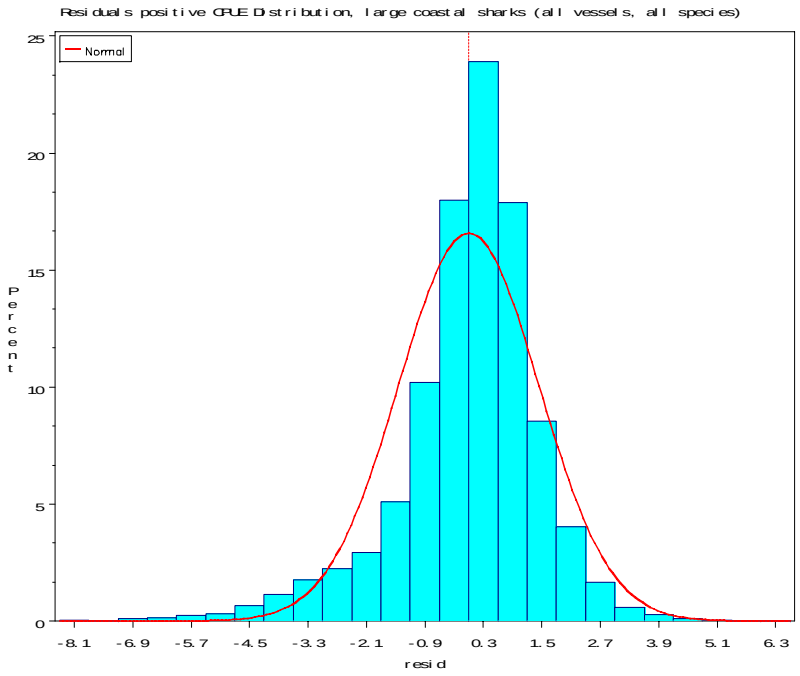
ln(CPUE)=YEAR+VESSEL

Plots of error distributions from the final models of blacktip catch rates on successful trips are provided in Figure 4. In all cases, those frequency distributions approximated a normal distribution.

The delta-lognormal abundance indices developed for blacktip sharks in the Atlantic and Gulf of Mexico, with 95% confidence intervals, are shown in Figure 5. The indices and coefficients of variation are provided in Table 2. Trends in CPUE over time are similar for indices developed for all bottom longline vessels and vessels targeting sharks. In the Atlantic, CPUE is flat during the first four years of the time series, increases through 2002, then decreases. In the Gulf of Mexico, blacktip CPUE increases slightly over the time series with peaks in 1997, 1999, and 2003.

Figure 1. Error distribution of final lognormal models. A. Large coastal sharks, all vessels, all species. B. Large coastal sharks, targeted vessels, all species. C. Large coastal sharks, all vessels, no prohibited species, no blacktip, no sandbar. D. Large coastal sharks, targeted vessels, no prohibited species, no blacktip, no sandbar. The solid line in each graph is the expected normal distribution.

A.



B.

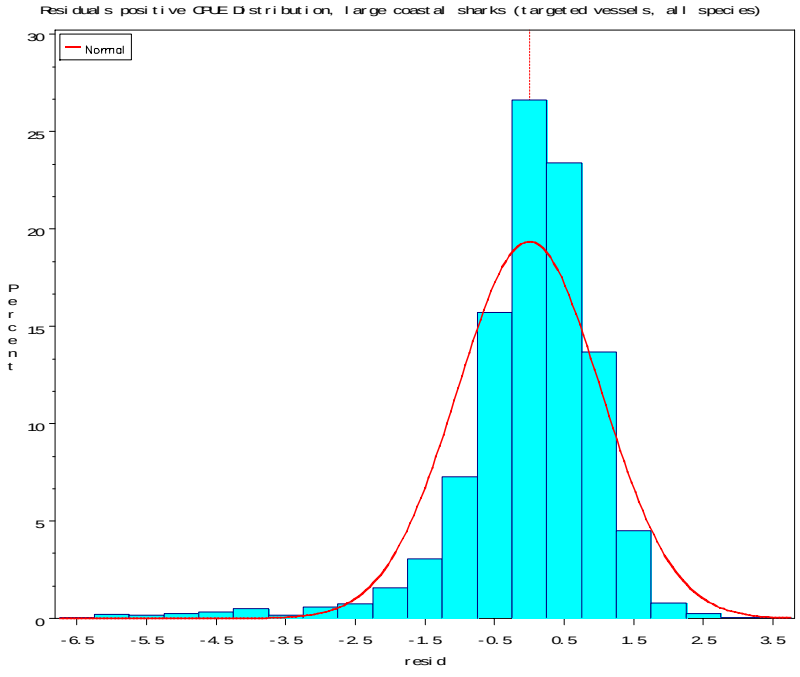
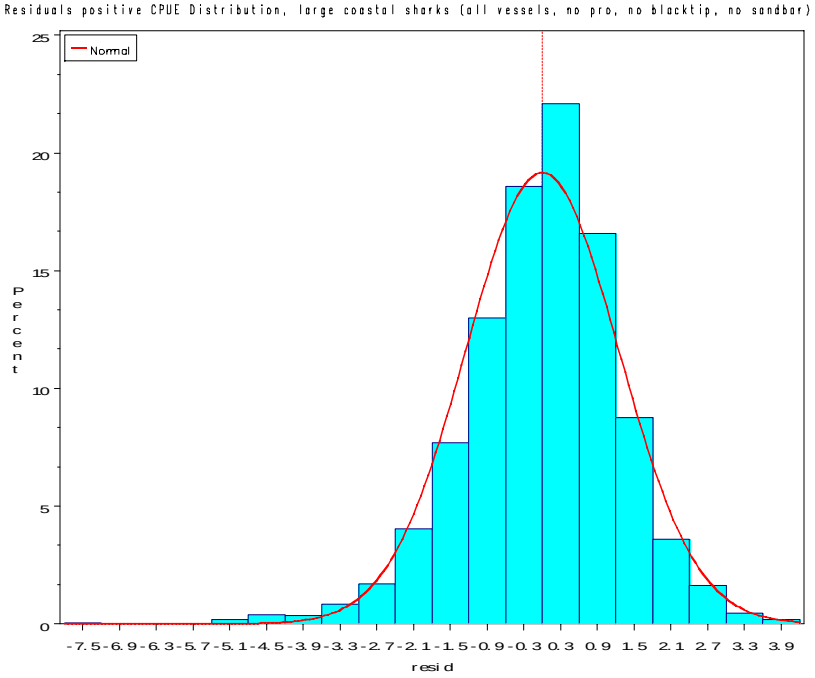


Figure 1. C.


Residuals positive CPUE Distribution, large coastal sharks (all vessels, no pro, no blacktip, no sandbar)
Normal
Percent
25
20
15
10
5
0
-7.5 -6.9 -6.3 -5.7 -5.1 -4.5 -3.9 -3.3 -2.7 -2.1 -1.5 -0.9 -0.3 0.3 0.9 1.5 2.1 2.7 3.3 3.9
resid

D.

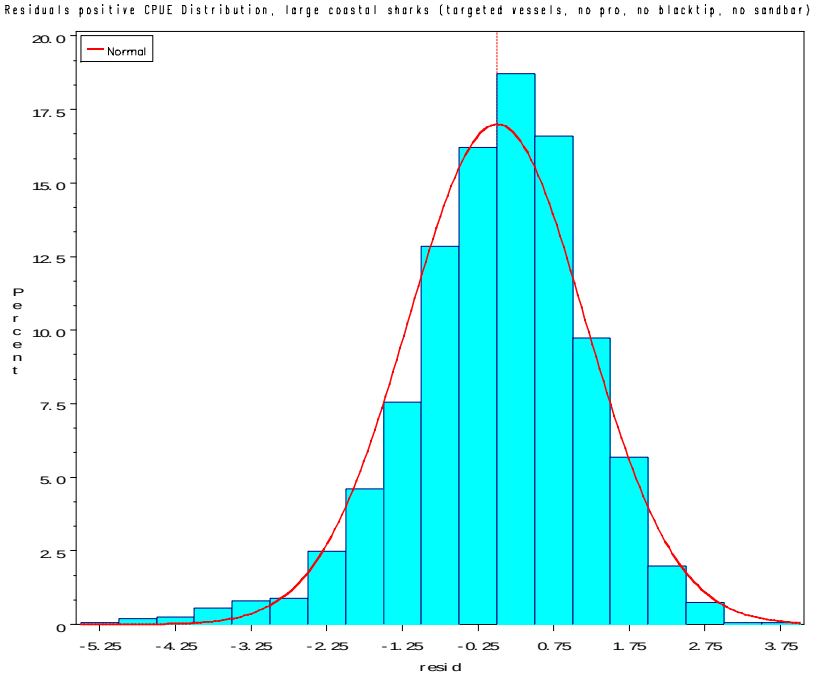
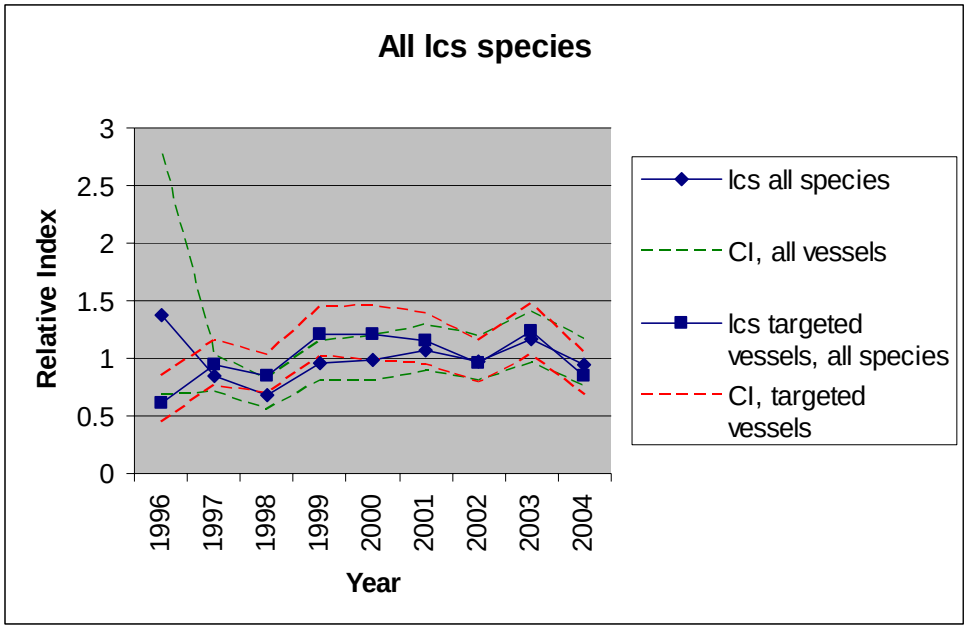
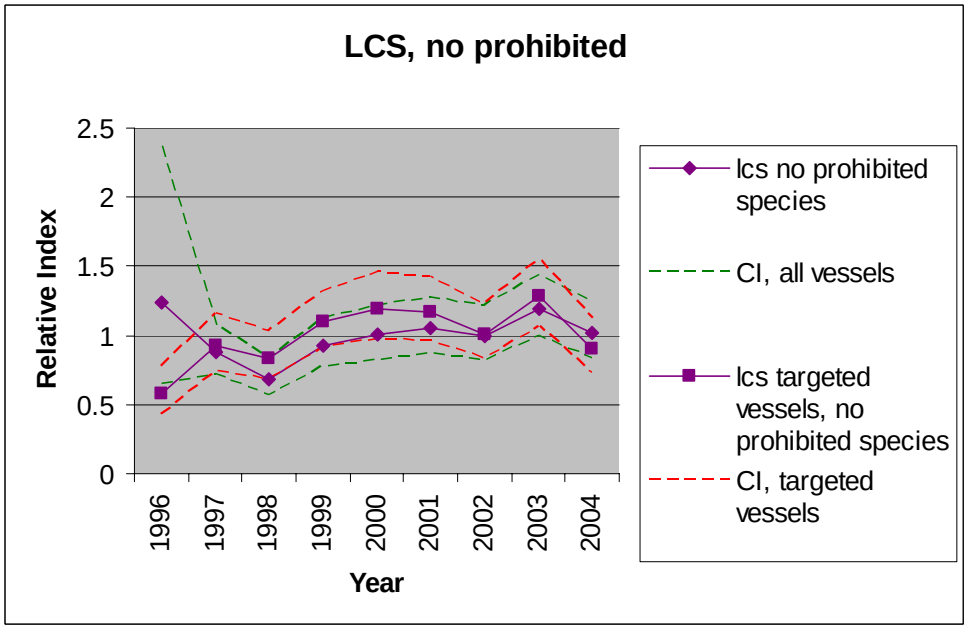

Residuals positive CPUE Distribution, large coastal sharks (targeted vessels, no pro, no blacktip, no sandbar)
Normal
Percent
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0
-5.25 -4.25 -3.25 -2.25 -1.25 -0.25 0.75 1.75 2.75 3.75
resid

Figure 2. Relative abundance indices of the large coastal shark complex with 95% confidence intervals. Analyses include all large coastal sharks including prohibited species (all lcs species); only those large coastal sharks that may currently be landed (lcs, no prohibited); and large coastal sharks that may currently be landed, except blacktip and sandbar sharks (lcs, no prohibited no blacktip no sandbar). Indicies developed from data for all bottom longline vessels are indicated by diamonds, indicies for targeted vessels are indicated by squares.





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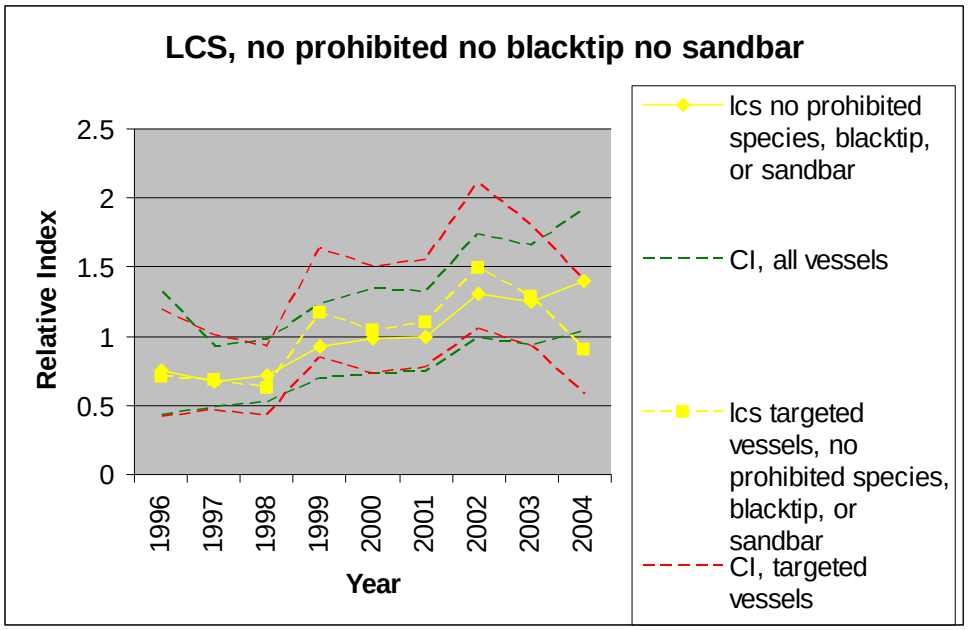


Figure 3. Comparison of indices of abundance for the various large coastal shark complex definitions (all lcs species including the prohibited species, all lcs species that may currently be landed, and all lcs species that my currently be landed except blacktip and sandbar sharks). Indices were developed for all vessels fishing bottom longlines in seven of the nine years examined (solid lines) and for vessels targeting sharks (dashed lines). Line colors for each index match those used in Figure 2.

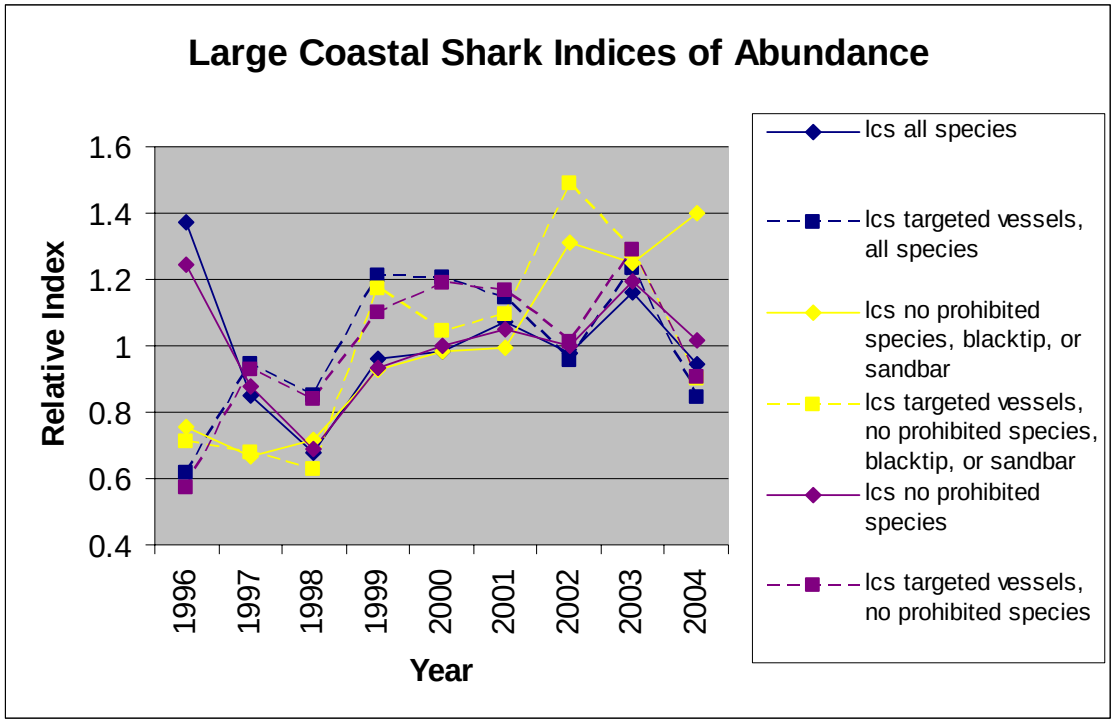
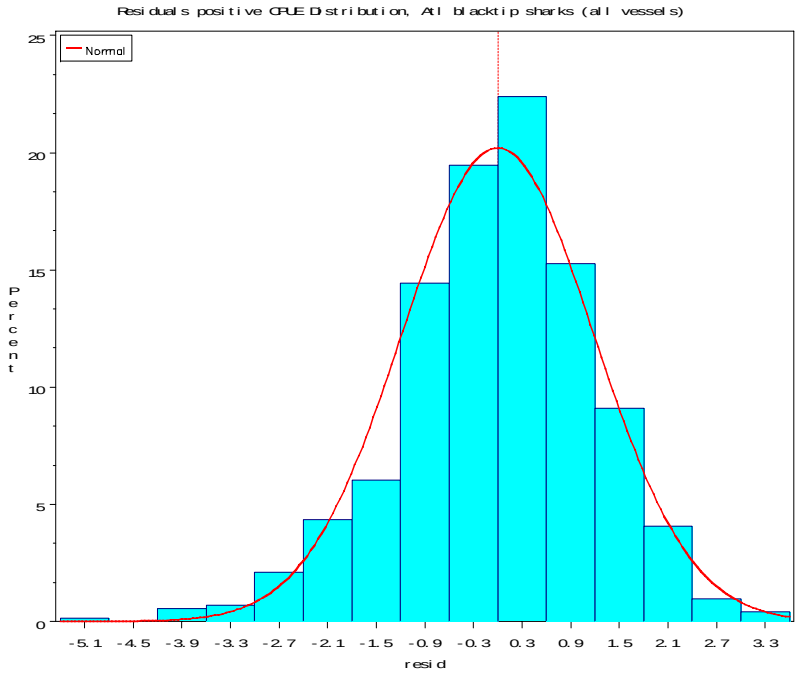


Figure 4. Error distribution of final lognormal models. A. Atlantic blacktip sharks, all vessels. B. Gulf of Mexico blacktip sharks, all vessels. C. Atlantic blacktip sharks, directed vessels. D. Gulf of Mexico blacktip sharks, targeted vessels. The solid line in each graph is the expected normal distribution.

A.



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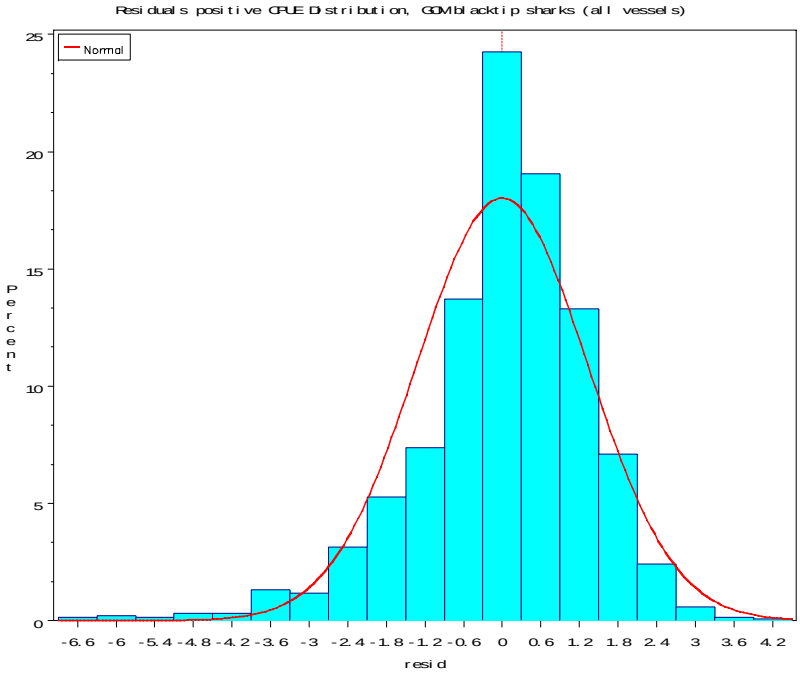
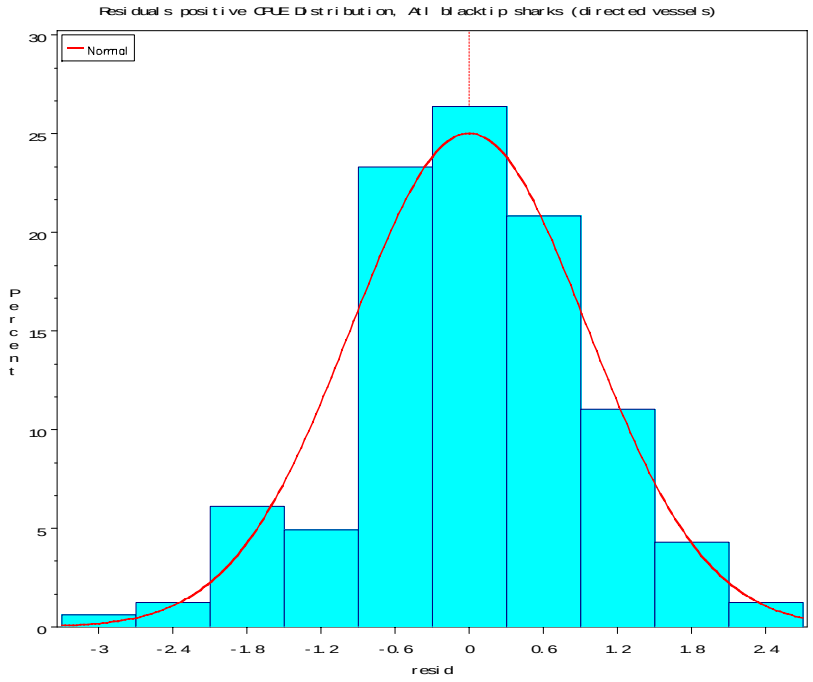


Figure 4. C.


Residuals positive CPUE Distribution, Atl blacktip sharks (directed vessels)
Normal
Percent
resid
30
25
20
15
10
5
0
-3
-2.4
-1.8
-1.2
-0.6
0
0.6
1.2
1.8
2.4

D.

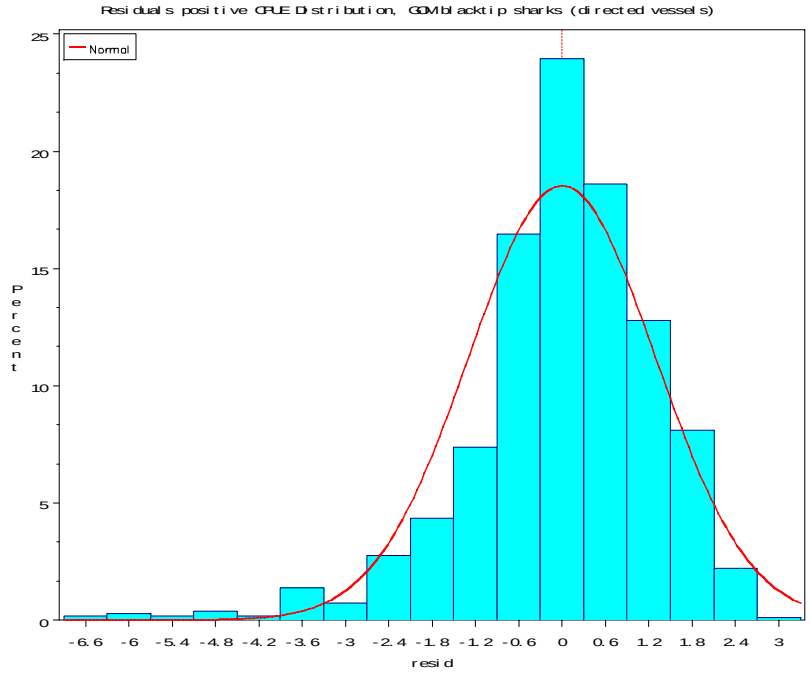
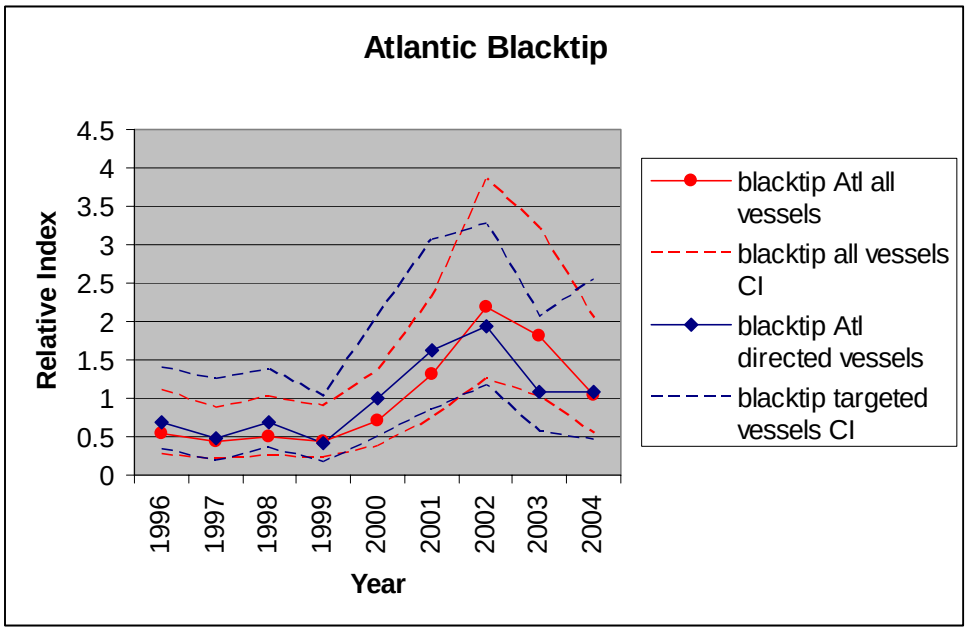

Residuals positive CPUE Distribution, GOM blacktip sharks (directed vessels)
Normal
Percent
resid
25
20
15
10
5
0
-6.6
-6
-5.4
-4.8
-4.2
-3.6
-3
-2.4
-1.8
-1.2
-0.6
0
0.6
1.2
1.8
2.4
3

Figure 5. Relative abundance indices of blacktip sharks in the Atlantic and Gulf of Mexico with 95% confidence intervals. Analyses restricted to vessels categorized as targeting sharks (in blue) and all bottom longline vessels (in red).



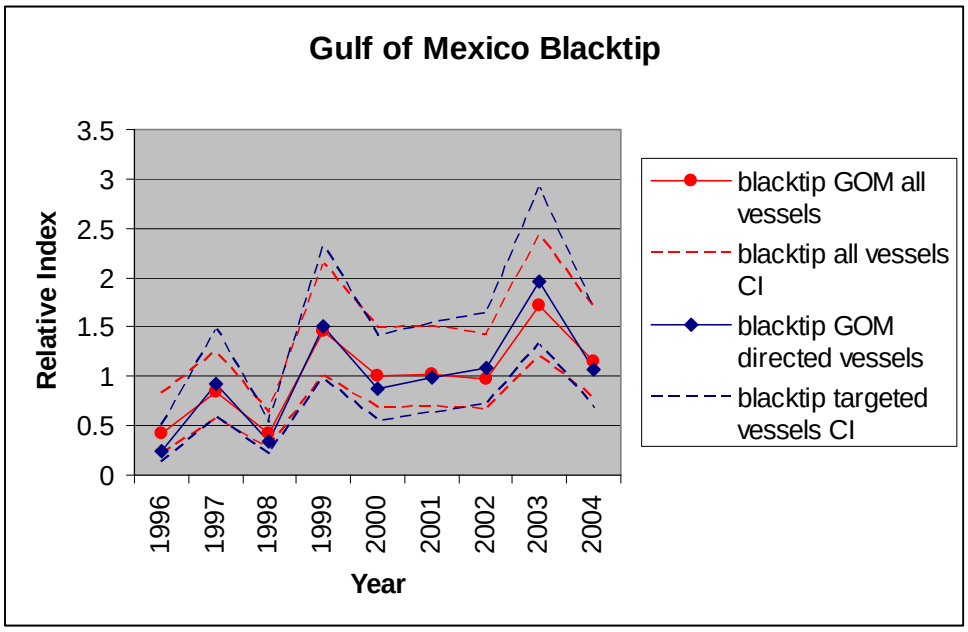


Table 1. Large coastal shark (LCS) relative abundance indices.

Year	LCS: all species		LCS: targeted vessels, all species		LCS: no prohibited species, blacktip, or sandbar		LCS: targeted vessels, no prohibited species, blacktip, or sandbar	
	relative index	CV	relative index	CV	relative index	CV	relative index	CV
1996	1.3738	0.3634	0.6146	0.164	0.7557	0.2841	0.709	0.2662
1997	0.8473	0.0946	0.9448	0.1028	0.6672	0.1651	0.6803	0.1991
1998	0.6753	0.097	0.8477	0.0988	0.7142	0.1554	0.6263	0.1987
1999	0.9634	0.0921	1.2099	0.0899	0.927	0.1411	1.1702	0.1667
2000	0.9839	0.0975	1.2035	0.0977	0.985	0.1548	1.0441	0.1835
2001	1.0707	0.0965	1.1462	0.0953	0.9938	0.1441	1.0946	0.1762
2002	0.9777	0.0978	0.9582	0.0921	1.309	0.1416	1.4901	0.1747
2003	1.161	0.0939	1.2313	0.0888	1.2495	0.1418	1.2856	0.1665
2004	0.947	0.1063	0.8439	0.1027	1.3986	0.1565	0.8998	0.2247

Table 2. Blacktip shark relative abundance indices developed for the Atlantic and Gulf of Mexico (GOM) separately.

Year	Blacktip Atlantic all vessels		Blacktip Atlantic directed vessels		Blacktip GOM all vessels		Blacktip GOM directed vessels	
	relative index	CV	relative index	CV	relative index	CV	relative index	CV
1996	0.5443	0.367	0.6775	0.3697	0.4203	0.3527	0.2493	0.3615
1997	0.4377	0.358	0.474	0.5117	0.8379	0.1992	0.9306	0.2356
1998	0.5101	0.3548	0.6886	0.3522	0.4234	0.2044	0.3336	0.2469
1999	0.4475	0.3538	0.4234	0.459	1.4594	0.1909	1.5061	0.2187
2000	0.7041	0.3321	1.005	0.3713	1.0024	0.1978	0.8825	0.2398
2001	1.3044	0.2899	1.6203	0.3273	1.023	0.1938	0.9853	0.2246
2002	2.1931	0.2886	1.9476	0.2637	0.9742	0.1898	1.0783	0.2099
2003	1.816	0.2889	1.0806	0.3329	1.7095	0.177	1.9667	0.1994
2004	1.0428	0.3451	1.083	0.4465	1.1497	0.1951	1.0677	0.232