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CATCH RATES FOR BLACKTIP AND OTHER LARGE COASTAL SHARK SPECIES FROM MISSISSIPPI COASTAL WATERS DURING 1998–2005.

Eric R. Hoffmayer[1], Glenn R. Parsons[2], and G. Walter Ingram[3]

SUMMARY

This document examines a catch rate series for the large coastal shark complex (LCS) and blacktip sharks calculated from a gillnet survey which was conducted in the Mississippi coastal waters from 1998 to 2005. As a result of 80 net sets and 354 hours of effort, 446 blacktip and 56 other LCS were collected. Because the work was conducted in a known blacktip nursery area, blacktip shark catch was further divided into young-of-the-young (YOY, age-0) and juvenile catch. Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution and negative binomial regressions. Catch rates did not exhibit a clear pattern because of two years of extremely elevated catch rates in 2000 and 2005. The LCS catch rates exhibited similar patterns to total blacktip catch, primarily because blacktips dominated the LCS catch.

There was some discussion as to what could account for these elevated catch rates. Because both YOY and juvenile catch rates were elevated and not reflected in subsequent years, it was suggested that these elevated catch rates resulted from sharks being concentrated within the study area. It was discussed that other factors should be investigated to help explain these elevated catch rates.

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[1]Department of Coastal Sciences, The University of Southern Mississippi. Gulf Coast Research Laboratory. P.O. Box 7000. Ocean Springs, MS 39566. [2]Department of Biology, The University of Mississippi, University, MS 38677. [3]NOAA, National Marine Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Pascagoula, Mississippi 39567

1. INTRODUCTION

Historically, elasmobranchs have received little attention in the northcentral Gulf of Mexico (GoM), compared to the rest of the GoM, Atlantic or Pacific Oceans. A 7-year fisheries independent shark gillnet dataset was analyzed in this document. The dataset began in 1998 in the northcentral GoM, with a three year study funded by NOAA's Marine Fisheries Initiative (MARFIN). The study focused on identifying and characterizing shark nursery grounds in Mississippi and Alabama waters and established a baseline for shark abundance in these areas (Parsons and Hoffmayer, 2005; Parsons and Hoffmayer, 2006). In 2001, the survey was partially continued (unfunded) in an effort to preserve some of the long-term monitoring of shark numbers. The following year (2002) no effort was put towards continuing the survey. Then in 2003, the Gulfspan Project (headed by J. Carlson) was established, but very limited funds were provided to continue monitoring the local shark species. In 2004, a three year study was funded by the Mississippi Department of Marine Resources through the U.S. Fish and Wildlife Service (Sports Fish Restoration Act), in part to investigate the seasonal abundance and distribution of local shark species in Mississippi waters (Warren and Hoffmayer, 2004). This survey work will hopefully continue in the future.

2. MATERIALS AND METHODS

Sampling Locations

From March 1998 to September 2005 sharks were collected at sites along the Mississippi coast extending from St. Louis Bay to Petit Bois Island. In general, collections were made from March to October with at least two locations sampled each month. Sampling was typically confined to the Mississippi Sound although some sampling was conducted south of the barrier islands. Sampling locations were selected such that a large geographical area and a range of environmental conditions could be covered. However, unless collecting was limited by conditions such as weather, sea state, and shrimp boat activity, we typically selected locations in close proximity to the barrier islands.

From 1998 to 2000 two locations were sampled each month, with one location (Horn Island) established as a long-term sampling location. During 2001, because no funding was available, the long-term Horn Island location was sampled monthly, along with a few other locations when available. With limited funding in 2003, only a few locations were sampled, primarily locations where previous sampling was conducted. From 2004 to 2005, two to three locations were sampled monthly, two of which were long-term sampling locations (Horn and Cat Islands).

Sampling Protocol

Sampling was conducted with a 152.4 meter (500 feet) gill net consisting of five 30.5 meter (100 feet) panels of 4.5, 5.1, 5.7, 6.4, and 7.0 cm (1.75, 2.0, 2.25, 2.5, and 2.75 in) square mesh. The net was typically fished from 1500 until 2000 hours each day. Depending upon the rate of capture and the environmental conditions prevalent, the net was checked every 0.25 to 1.0 hour. Each time the net was checked, the time of day over which those sharks were captured was recorded. As expeditiously as possible, each shark captured was identified and measured (total length, TL) and its sex and, when possible, maturity state recorded. Water temperature, salinity, dissolved oxygen, and depth were measured at the water's surface and near the bottom at each site. We also noted weather conditions, sea state and used a GPS to record latitude and longitude.

Analysis

Data were divided into two categories; blacktip sharks, *Carcharhinus limbatus*, and large coastal species "aggregrate" (LCS), which includes bull, *C. leucas*, spinner, *C. brevipinna*, sandbar, *C. plumbeus*, scalloped hammerhead sharks, *Sphyrna lewini*, and *C. limbatus*. Data for the LCS minus prohibited species, *C. limbatus,* and *C. plumbeus* was not included because of their low abundance in Mississippi waters.

For the purpose of analysis, blacktip sharks were divided into size classes based on estimates of their growth rates and size at maturity. Blacktip sharks were designated young-of-year (YOY) when between 50 and 75 cm total length (TL), juvenile when between 76 and 134 cm TL (male) and between 76 and 154 cm TL (female), and adult when >135 cm TL (male) and >155 cm TL (female). Analysis of adult catch rates was not performed because of their small number in the collections (n=10). Catch rates were standardized as catch per unit effort (CPUE) in sharks 100 m net $^{-1}$ hour $^{-1}$ for each size class of blacktip sharks, blacktip sharks as a whole, and for LCS as a whole. Length frequency distributions were constructed for blacktip sharks for each year ranging from 50 to 131+ cm using 10 cm increments.

The delta lognormal model approach (Lo et al. 1992) was used to develop the standardized indices of abundance for YOY and juvenile blacktips; however, a negative binomial regression was used for both blacktip and LCS. The Lo Method, a delta-lognormal model, uses 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 fit of each model was evaluated using the fit statistics provided by the GLMMIX macro and analyses of residual scatter and QQ plots.

The loglinear negative binomial regression model closely resembles that of the Poisson regression model except for the dispersion parameter located in the systematic component of the model. The parameters of the log negative binomial are interpreted exactly like those of a Poisson or lognormal regression model (i.e. by taking the inverse natural log of both sides of the regression model and describing the multiplicative effect of each parameter on μ (McCullagh and Nelder, 1989; Agresti, 1996).

There are two primary statistics used in evaluating parameter significance, lack-of-fit, and the significance of each step in the model building process of the aforementioned models: the deviance (likelihood-ratio statistic) and Pearson's chi-square statistics.

For all indices developed, the factors **YEAR, MONTH, SEASON, AREA, DEPTH, SECCHI DEPTH, SURFACE AND BOTTOM TEMP, SAL, and DO** were examined for inclusion in the catch rate models. The factor **YEAR** included each year in the time series, the factor **MONTH** includes the months that sampling was conducted from March to October. The factor **SEASON** was divided into three seasons based on the time of year, as follows: **SPRING** = March to May, **SUMMER** = June to August, **FALL** = September to October. The Mississippi Sound was divided into four zones from east to west (1 to 4) which is represented by factor **AREA**. The factors **DEPTH**, **SECCHI DISK**, **TEMP, SAL**, and **DO** included values present in the data set.

3. RESULTS

From 1998 to 2005, 80 locations in Mississippi were sampled resulting in 354 hours of effort. During this time 446 blacktip and 56 other LCS were collected. The blacktip shark catch consisted primarily of juvenile (n = 248) and YOY (n = 188), with relatively few adults (n = 10). Nominal catch rates for blacktip sharks ranged from 0.283 to 1.977 sharks 100m net^{-1} h^{-1} with a mean CPUE of 0.765 ± 0.350 sharks 100m net^{-1} h^{-1}. Nominal catch rates for blacktip sharks were consistent from 1998 to 2005, except for two relatively high values during 2000 (1.977 ± 0.637 sharks 100m net^{-1} h^{-1}) and 2005 (1.644 ± 0.673 sharks 100m net^{-1} h^{-1}; Table 3). Nominal catch rates for LCS were relatively similar to blacktip catch rates primarily because blacktip shark made up a large majority of the LCS.

The negative binomial regression model was the best fit for both blacktip and LCS data because of the high frequencies of occurrence, residual plots, and other fit statistics (Table 1). The factors that significantly affected catch rates were **YEAR, AREA, DEPTH,** and **BOTTOM TEMP** for all blacktip sharks and **YEAR, AREA,** and **MONTH** for LCS (Table 2). Standardized catch rates for both blacktip and LCS exhibited similar patterns to the nominal catch rates, with peaks in 2000 and 2005 (Table 3, Figure 1).

Standardized catch rates for YOY and JUV blacktip sharks were estimated using the Lo Method. Based on analyses of residual scatter and QQ plots, the lognormal model was more fitting than the other models (Figure 2). **BOTTOM TEMP** was the only factor that significantly affected catch rates in the binomial submodel for YOY sharks; however, for JUV sharks, **DEPTH** was found to have a highly significant affect on catch rates; whereas **YEAR** was only marginally significant in the binomial submodel (Table 4). Both **YEAR** and **BOTTOM SAL** significantly affected catch rates on positive sets for YOY sharks, and **YEAR** and **BOTTOM TEMP** significantly affected catch rates on positive sets for JUV sharks (Table 4). Standardized catch rates for YOY and JUV sharks also exhibited peaks in 2000 and 2005; both YOY and JUV exhibited similar peaks in each year (Table 5, Figure 3).

Blacktip sharks ranged in size from 52.7 to 157.0 cm TL, with a mean TL of 82.3 ± 0.8 cm. The majority of the sharks collected (87%) were between 60 and 100 cm TL (Figure 4).

4. DISCUSSION

Two extremely high catch rates were observed during 2000 and 2005 for blacktip sharks. This phenomenon was also observed with Atlantic sharpnose and finetooth sharks (Parsons and Hoffmayer 2006; Hoffmayer, unpub. data). Both 2000 and 2005 were very similar in regards to water temperature and the amount of rainfall; both years being considered drought years. However, surface and bottom salinity could not account for the differences observed in catch rates during these peak years. During 2000, this trend was not localized to Mississippi waters, but to northern GoM waters; elevated blacktip catch rates were also evident in Alabama state waters (Parsons and Hoffmayer, 2006) and Louisiana state waters (J. Neer, per. comm.). Excluding years 2000 and 2005, catch rates appear to be relatively constant over the seven year time series for Mississippi coastal waters.

Our current data does not explain these increases in catch rates; however, few data sets can actually do this. Increased catch rates of blacktip sharks is not limited to Mississippi waters; the NMFS reported an increase in blacktip catch rates from 2000 to 2004 from longline surveys in the GoM (Ingram et al., 2005). More study is warranted to help elucidate these patterns of blacktip abundance in Mississippi coastal waters.

5. REFERENCES

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Table 1. Negative binomial regression fit statistics for all blacktip and LCS sharks.

Fit Statistics (Blacktip)	
-2 Log Likelihood	148.63
AIC (smaller is better)	174.63
AICC (smaller is better)	180.14
BIC (smaller is better)	205.60
CAIC (smaller is better)	218.60
HQIC (smaller is better)	187.04
Pearson Chi-Square	64.66
Pearson Chi-Square / DF	0.95

Fit Statistics (LCS)	
-2 Log Likelihood	162.35
AIC (smaller is better)	198.35
AICC (smaller is better)	209.56
BIC (smaller is better)	241.23
CAIC (smaller is better)	259.23
HQIC (smaller is better)	215.54
Pearson Chi-Square	75.73
Pearson Chi-Square / DF	1.20

Table 2. Negative binomial regression type III tests of the fixed effects for blacktip and LCS sharks.

Type III Tests of Fixed Effects (Blacktip)				
Effect	Num DF	Den DF	F Value	Pr > F
Year	6	68	6.53	<.0001
Area	3	68	4.26	0.0081
Depth	1	68	5.05	0.0278
Tempbot	1	68	16.43	0.0001

Type III Tests of Fixed Effects (LCS)				
Effect	Num DF	Den DF	F Value	Pr > F
Year	6	63	6.38	<.0001
Area	3	63	4.38	0.0073
Month	7	63	2.93	0.0103

Table 3. Negative binomial regression indices for all blacktip and LCS sharks

		Blacktip			LCS	
Year	Mu	Std Index	CV	Mu	Std Index	CV
1998	0.1553	0.5837186	0.57172	0.2037	0.5656762	0.52811
1999	0.09374	0.352336	0.5898	0.1213	0.3368509	0.57382
2000	0.7373	2.7712538	0.40414	0.7133	1.9808387	0.42079
2001	0.1504	0.5653012	0.71722	0.2075	0.5762288	0.71679
2003	0.09953	0.3740986	0.75125	0.1435	0.3985004	0.74089
2004	0.11	0.4134517	0.6236	0.17	0.4720911	0.59846
2005	0.5161	1.9398401	0.49067	0.9614	2.6698139	0.45486

Figure 1. Relative indices of abundance for all blacktip and LCS sharks from Mississippi coastal water, 1998-2005.

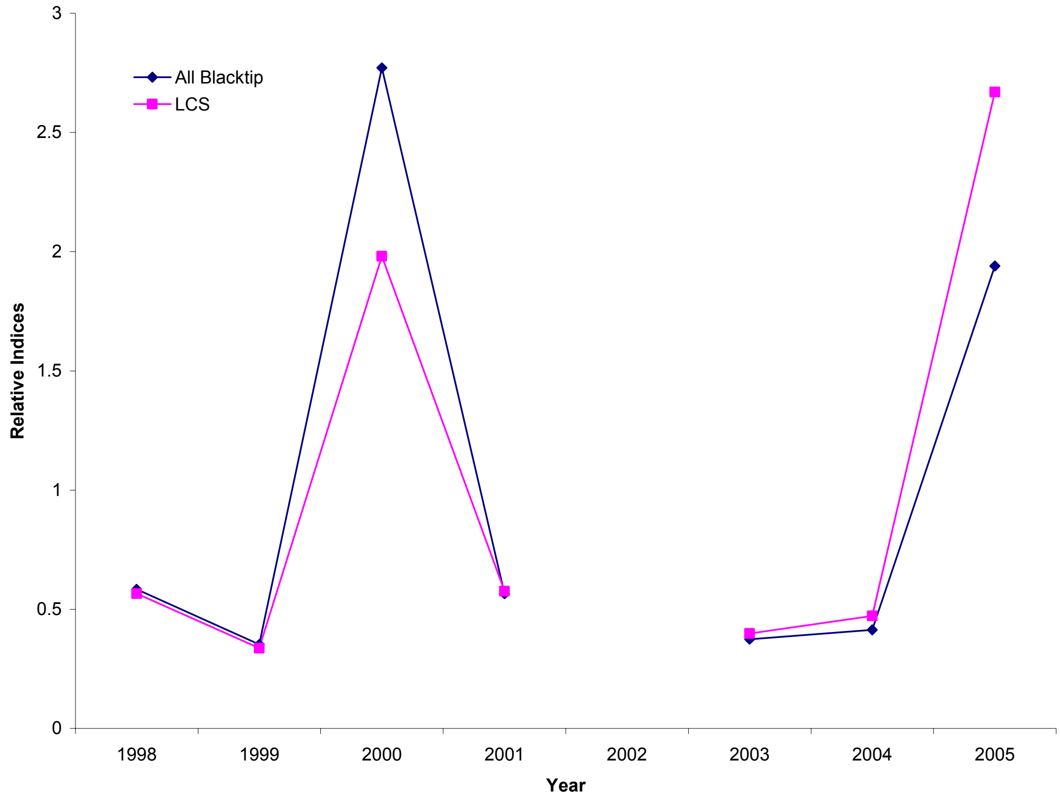


Table 4. The significant effects of the Lo Method for YOY and JUV blacktip sharks.

Binomial submodel

Type 3 Tests of Fixed Effects (YOY)						
Effect	**Num DF**	**Den DF**	**Chi-Square**	**F Value**	**Pr > ChiSq**	**Pr > F**
Year	6	53	0.90	0.15	0.9890	0.9882
Tempbot	1	53	8.20	8.20	0.0042	0.0060

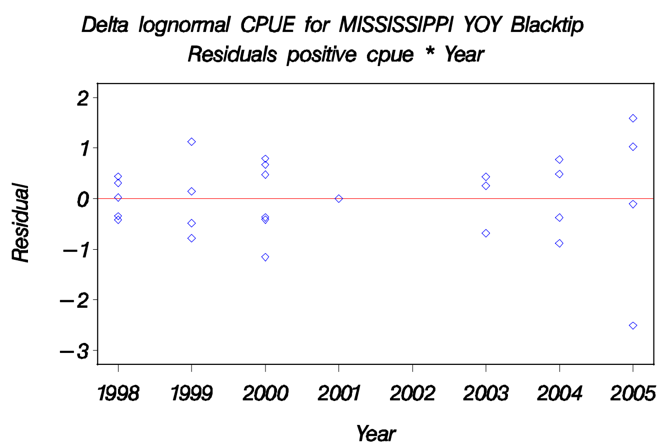
Type 3 Tests of Fixed Effects (JUV)						
Effect	**Num DF**	**Den DF**	**Chi-Square**	**F Value**	**Pr > ChiSq**	**Pr > F**
Year	6	72	11.95	1.99	0.0632	0.0781
Depth	1	72	7.37	7.37	0.0067	0.0083

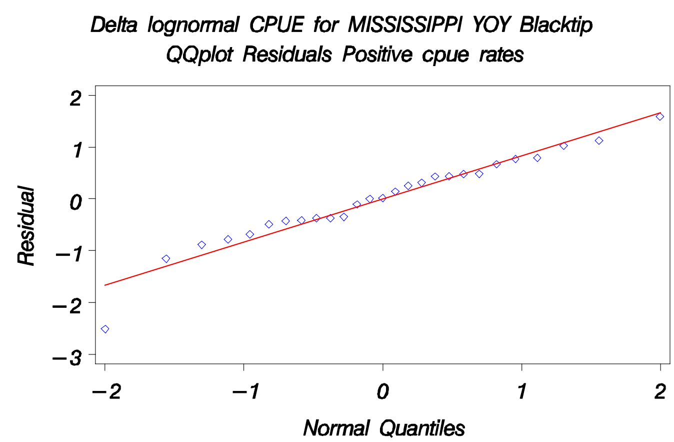
Lognormal submodel

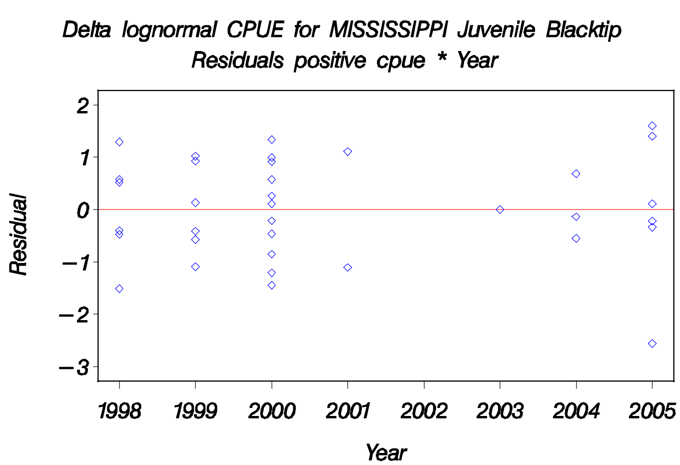
Type 3 Tests of Fixed Effects (YOY)				
Effect	Num DF	Den DF	F Value	Pr > F
Year	6	19	4.78	0.0039
Salbot	1	19	11.37	0.0032

Type 3 Tests of Fixed Effects (JUV)				
Effect	Num DF	Den DF	F Value	Pr > F
Year	6	27	2.86	0.0275
Tempbot	1	27	3.81	0.0613

Figure 2. Residual plots from the Lo Method for YOY and JUV blacktip sharks.







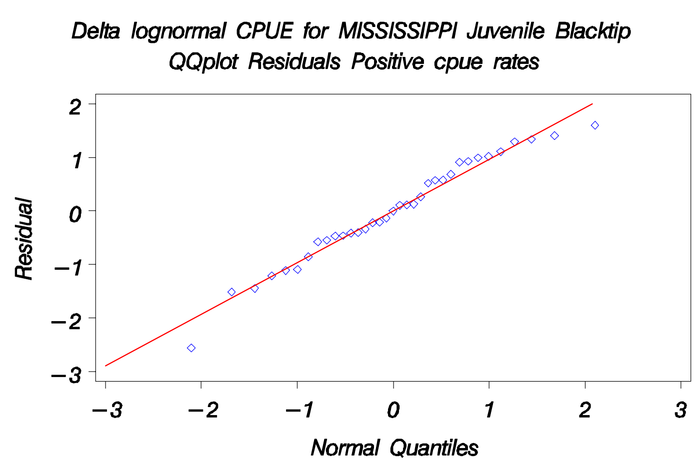
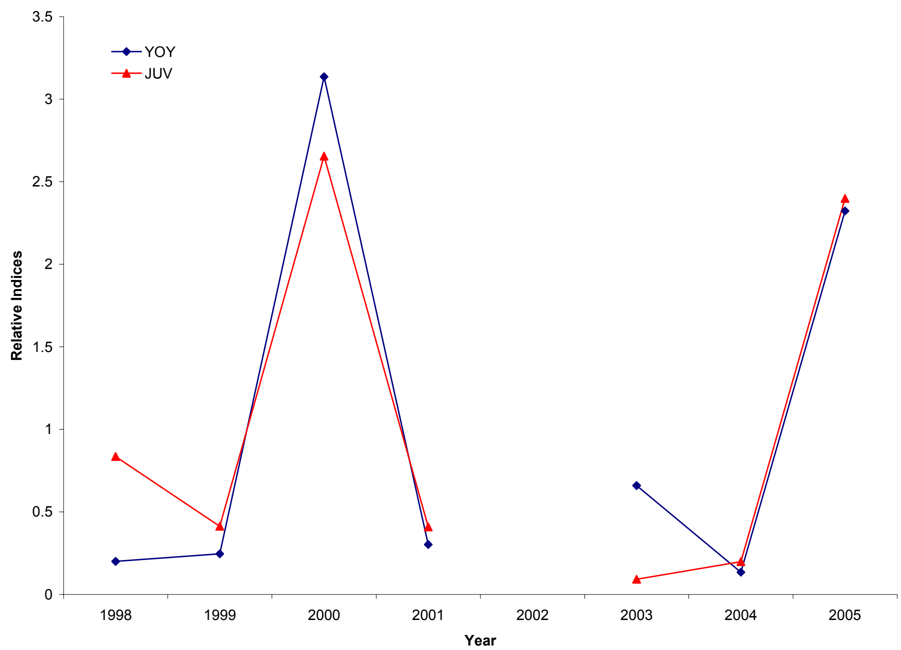


Table 5. Nomimal, Lo, and standardizes indices for YOY and JUV sharks.

YOY SurveyYear	Nominal	LoIndex	StdIndex	CV	LCL	UCL
1998	0.113	0.1098	0.19991	0.68406	0.0579	0.6902
1999	0.143	0.13481	0.24544	1.01147	0.0458	1.3154
2000	0.840	1.72228	3.13565	0.55615	1.11024	8.856
2001	0.000	0.16604	0.30229	1.63323	0.03092	2.9552
2003	0.329	0.36234	0.65969	0.76375	0.17004	2.5594
2004	0.229	0.0737	0.13417	1.17653	0.0208	0.8656
2005	0.673	1.27584	2.32284	0.98188	0.44914	12.0131

JUV SurveyYear	Nominal	LoIndex	StdIndex	CV	LCL	UCL
1998	0.229	0.35114	0.83539	0.68328	0.24225	2.88088
1999	0.200	0.17331	0.41234	0.88665	0.08989	1.89141
2000	1.002	1.11585	2.65475	0.33573	1.3809	5.10371
2001	0.248	0.17179	0.4087	1.8916	0.03468	4.81646
2003	0.047	0.03884	0.0924	1.72164	0.00884	0.96615
2004	0.124	0.08331	0.1982	1.44346	0.02373	1.65511
2005	0.895	1.00803	2.39822	0.79106	0.5948	9.66959

Figure 3. Relative indices of abundance for YOY and JUV sharks from Mississippi coastal water, 1998-2005.



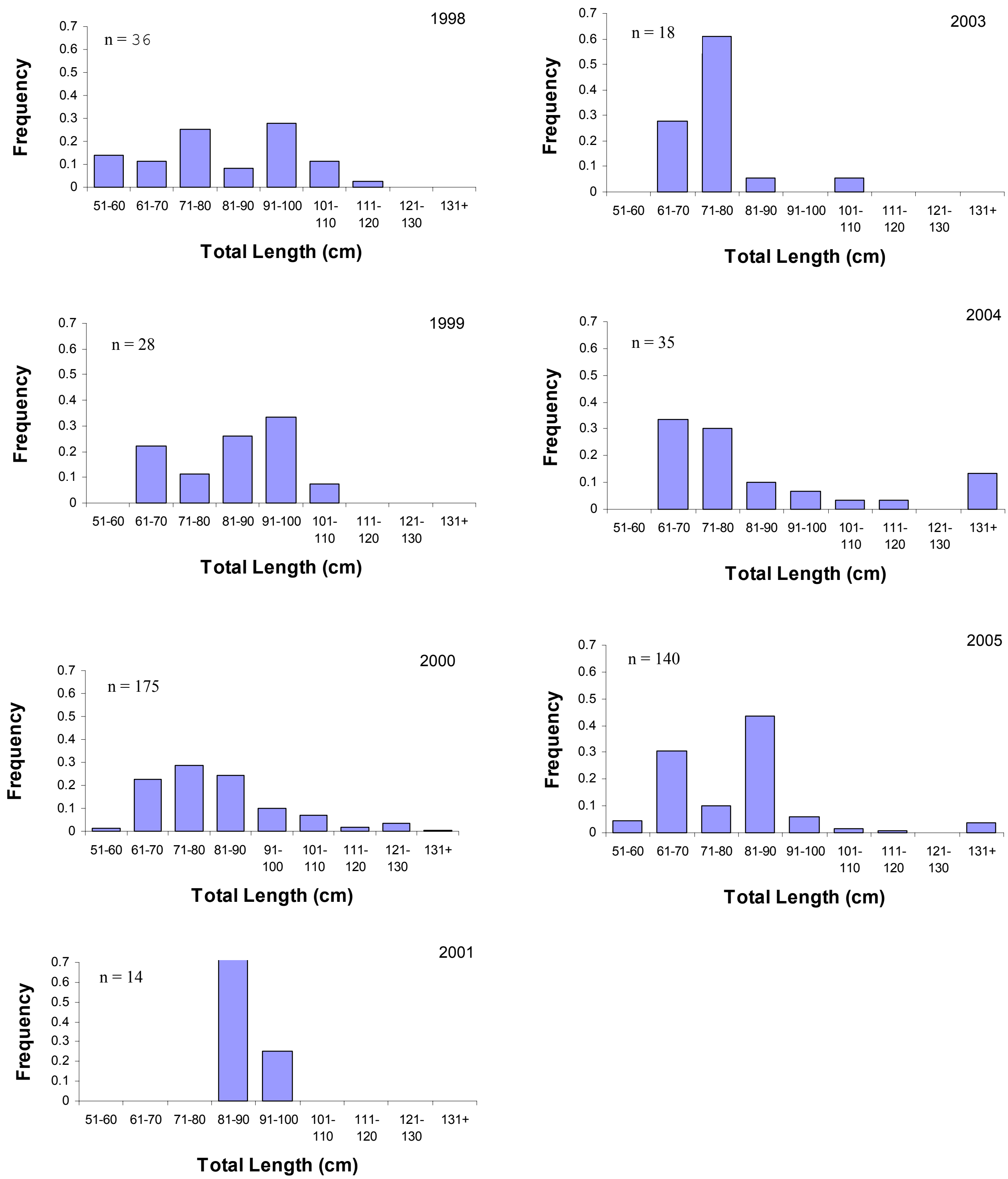


Figure 4. Length frequency distributions of blacktip sharks collected in Mississippi coastal waters from 1998 – 2005. Sample size (n) is indicated for each year.