Standardized catch rates of blacktip sharks from the Everglades National Park Creel Survey

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INTRODUCTION

The Everglades National Park was established in 1947 and a fisheries monitoring program by the National Park Service based on sport fisher dock-side interviews began in 1972 (Schmidt et al. 2002). Fisheries data provided by the National Park Service may prove to be a useful long-term time series of relative abundance for monitoring the relative abundance of shark populations, although the area of the survey is limited to south Florida. However, because this data is based on information collected from recreational anglers which normally change fishing tactics, standardization to correct for factors unrelated to abundance such as gear changes, time-of-year, and area are necessary. The present study attempts to standardize an index of abundance for blacktip sharks based on the monitoring of the recreational fishery in the Everglades National Park.

MATERIAL AND METHODS

Field data collection

Recreation sport fishers were interviewed by Everglades National Park personnel at the Flamingo and Chokoloskee-Everglades City boat ramps upon completion of their fishing trip (Figure 1). Data normally recorded includes trip origin, area fished, number of fish kept and released by species, number of anglers, hours fished, species preference, angler residence, and type of fisher (i.e. skilled, family, novice, sustenance) (Figure 2). Further details on the methodology can be found in Davis and Thue (1979), Tilmant et al. (1986), and Schmidt et al. (2002).

Index Development

Standardized catch rates were modeled for blacktip sharks. The factors that were expected to influence the catch of sharks were year, fisher, season, and area. For the purposes of analysis, several categorical variables were constructed from the Everglades National Park data set prior to analysis. The factor "Fisher" refers to the skill level of the fishing party. Based on Cass-Calay and Schmidt (2003), two levels were considered from the data; "Skilled" = fishers identified as "Skilled" by Everglades National Park personnel and "Other" = Fishers identified as "family", "novice" or "sustenance". The factor "Season" was developed from "Month" to create two periods reflective of rainfall in the Everglades National Park. Those periods are "Dry"= December-May and "Wet"= June-November. The factor "Area" where the fisher reported fishing was refined from the Everglades National Park definitions based on similarity in habitat type (Figure 1).

Indices of abundance were estimated following the Delta method (Lo et al., 1992) by modeling the probability of the non-zero catch assuming a type-3 model with a binomial error distribution and a logit link. The distribution of the positive shark catches was modeled assuming a lognormal distribution.

Catch per unit effort= number of blacktip sharks caught/hours reported fishing*number of anglers.

Following Ortiz and Arocha (2004), factors most likely to influence abundance were evaluated in a forward stepwise fashion. Initially, a null model was run with no factors entered into the model. Models were then fit in a stepwise forward manner adding one independent variable. Each factor was ranked from greatest to least reduction in deviance per degree of

freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $p<0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all models. This allows the estimation of the annual indices, which is the main objective of the standardization process, but also accounts for the variability associated with year-interactions. After selecting the set of factors for each error distribution, all factors that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). We applied a Generalized Linear Mixed Modeling (GLMM), approach because these models can predict CPUEs for un-fished fishing cells based on the estimated effects of the explanatory variables as long as these cells were fished in some of the years. The standardized CPUE values for the Delta models were calculated as the product of the expected probability of a non-zero catch and the expected conditional catch rate for sets that had a non- zero catch. The expected probability and expected conditional catch rate were the least square means of the factor year from each of the two analyses that constitute an analysis using the Delta model approach (Lo et al., 1992; Stefansson, 1996). All models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX).

Final models were selected based on Akaike Information Criteria (AIC). Models of positive catches were checked for appropriate fit and diagnostics by examining the residuals plotted against the fitted values to check for systematic departures from the assumptions underlying the error distribution; the absolute values of the residuals plotted against the fitted values as a check of the assumed variance function; and the dependent variable was plotted against the linear predictor function as a check of the assumed link function (McCullagh and Nelder, 1989).

RESULTS AND DISCUSSION

Although data has been collected since 1972, blacktip sharks were not reported until 1976. Trips were excluded if essential fields were missing or unusable. The final ENP dataset analyzed contained 132,361 trips. Of those trips, blacktip sharks were reported caught on 3.9% of trips. The stepwise construction of the model is summarized in Table 1 and the index statistics can be found in Table 2. Table 3 provides a table of the frequency of observations by factor and level. The standardized abundance index is shown in Figure 3 and the diagnostic plots assessing the fit of the models were deemed acceptable (Figure 4). The length distribution (mm TL) of blacktip sharks measured overall and by year is shown in Figure 5.

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for blacktip sharks. Final models selected are in bold.

Proportion positive-Binomial error distribution

FACTOR	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI	AIC
NULL	10.9255					
YEAR	7.1398	34.650	34.65	2063.67	<.0001	4592
YEAR+						
SEASON	4.0188	63.216	28.57	1399.07	<.0001	3195
AREA	5.6687	48.115		685.93	<.0001	3916
FISHER	6.9022	36.825		113.1	<.0001	4481
YEAR+SEASON+						
AREA	2.7464	74.862	11.65	581.25	<.0001	2624
FISHER	3.7973	65.244		102.62	<.0001	3094
YEAR+SEASON+AREA+						
FISHER	2.4875	77.232	2.37	116.68	<.0001	2509
MIXED MODEL	**AIC**					
YEAR+SEASON+AREA+FISHER	**1332.2**					
YEAR+SEASON+AREA+FISHER YEAR*SEASON	Model unable to converge					
YEAR+SEASON+AREA+FISHER YEAR*AREA	Model unable to converge					
YEAR+SEASON+AREA+FISHER YEAR*FISHER	Model unable to converge					

Proportion positive-Lognormal error distribution						
FACTOR	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**	**AIC**
NULL	0.6261					
YEAR	0.6123	2.204	2.204	159.04	<.0001	13270
YEAR+						
AREA	0.6071	3.035	0.831	52.35	<.0001	13227
SEASON	0.6092	2.699		28.84	<.0001	13243
FISHER	0.6115	2.332		7.92	0.0049	13264
MIXED MODEL	**AIC**					
YEAR+AREA	**13283.4**					
YEAR+AREA YEAR*AREA	13283.5					

Table 2. The standardized and nominal index (number of sharks per angler hour) of absolute abundance, and coefficients of variation (CV) for all blacktip sharks. N=number of interviewed trips.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
1976	3613	0.00014	17.41	0.00006	38.55
1977	4317			0.00000	
1978	3358	0.00008	30.92	0.00004	67.44
1979	1925	0.00082	4.27	0.00075	4.68
1980	3009	0.00077	3.44	0.00047	5.66
1981	3746	0.00331	0.84	0.00163	1.71
1982	3864	0.00113	1.90	0.00065	3.32
1983	4423	0.00786	0.34	0.00568	0.47
1984	5583	0.01046	0.29	0.00930	0.32
1985	4660	0.00796	0.36	0.00472	0.60
1986	5342	0.00814	0.33	0.00464	0.59
1987	4703	0.01232	0.28	0.00813	0.42
1988	2849	0.01425	0.29	0.00684	0.61
1989	2859	0.00703	0.45	0.00385	0.83
1990	4248	0.01173	0.25	0.00784	0.38
1991	4909	0.00651	0.36	0.00504	0.46
1992	5391	0.01278	0.21	0.00972	0.28
1993	3915	0.00608	0.39	0.00480	0.49
1994	6589	0.01020	0.21	0.00881	0.24
1995	5030	0.00820	0.27	0.00716	0.31
1996	6666	0.01187	0.18	0.00915	0.23
1997	7402	0.01019	0.19	0.00743	0.26
1998	5468	0.00742	0.25	0.00834	0.22
1999	5010	0.00704	0.27	0.00879	0.22
2000	4624	0.00969	0.22	0.01122	0.19
2001	4415	0.00652	0.30	0.00755	0.26
2002	3616	0.00622	0.31	0.00704	0.27
2003	3306	0.00885	0.26	0.01096	0.21
2004	3347	0.00761	0.29	0.00910	0.24
2005	2757	0.00599	0.36	0.00703	0.31
2006	2814	0.00529	0.39	0.00614	0.33
2007	2863	0.00718	0.31	0.00846	0.27
2008	2475	0.00755	0.33	0.00823	0.30
2009	2307	0.00660	0.37	0.00826	0.30
2010	1798	0.00796	0.35	0.01225	0.23

Table 3. Frequency of observations by factor and level used in the development of the standardized catch rate series.

FACTOR	LEVEL	FREQUENCY OF TOTAL
Year	1976	2.7
	1977	3.3
	1978	2.5
	1979	1.5
	1980	2.3
	1981	2.8
	1982	2.9
	1983	2.6
	1984	4.2
	1985	3.5
	1986	4.0
	1987	3.6
	1988	2.2
	1989	2.2
	1990	3.2
	1991	3.2
	1992	3.7
	1993	2.5
	1994	4.4
	1995	3.5
	1996	4.6
	1997	5.0
	1998	3.6
	1999	3.3
	2000	3.0
	2001	2.8
	2002	2.3
	2003	2.2
	2004	2.2
	2005	1.8
	2006	1.9
	2007	1.9
	2008	1.7
	2009	1.6
	2010	1.2
Area	CS	17.4
	IF	15.0
	NA	19.0
	OF	2.9
	TI	30.6
	WB	14.4
Season	Dry	55.7
	Wet	44.3
Fisher	Skilled	37.9
	Other	62.1

Figure 1. Map of the Everglades National Park illustrating the defined fishing areas and the boat launch ramps where fishers were interviewed.

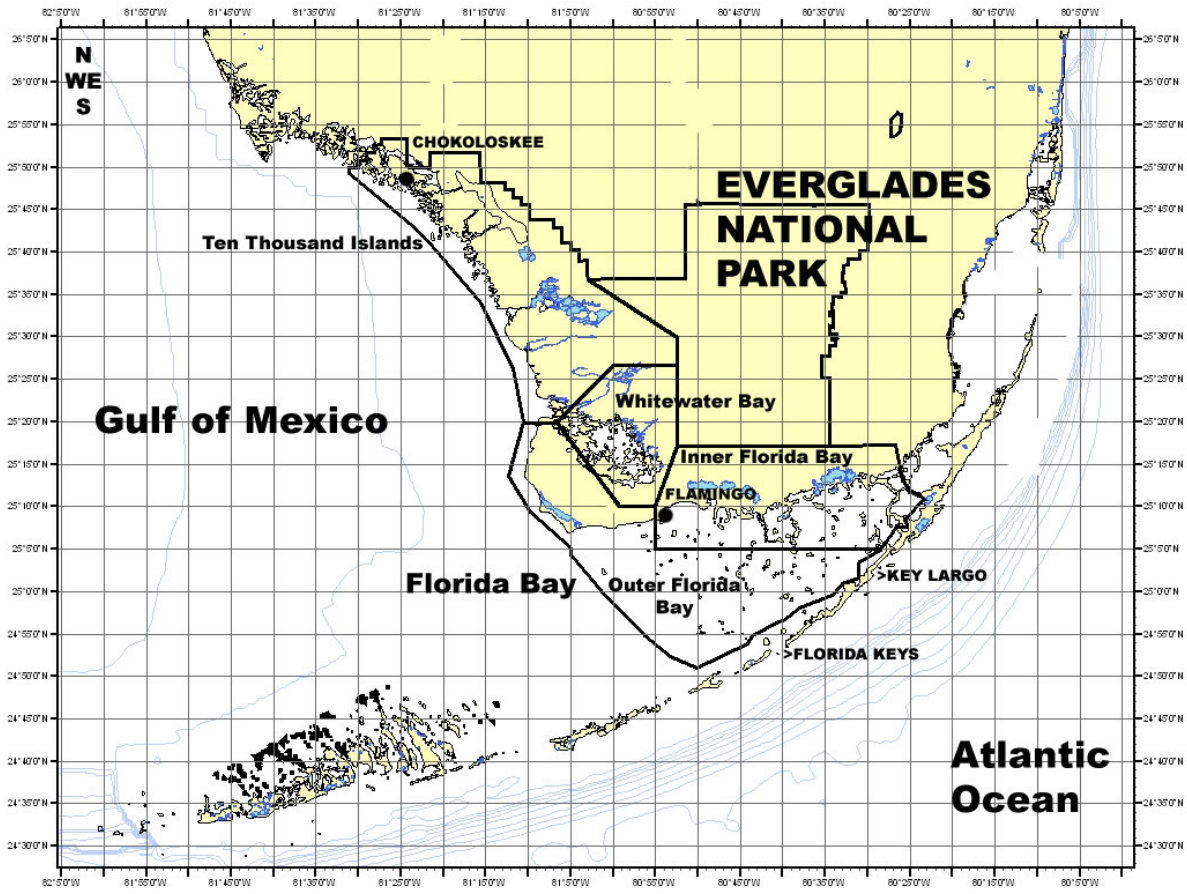


Figure 2. From Davis and Thue (1979), questions asked as part of the sportfishers interview by Everglades Parks personnel.

Sportfishing data are collected by interviewing sportfishermen at the completion of their trips. Fishermen volunteer their information. The interviewer explains that the reason for the interview is to collect data for the purpose of estimating total harvest and monitoring fishery resources. The following questions are suggested to gather the necessary information.

1. What time did you leave the dock to go fishing?

2. How many people on your boat fished? If the answer is none, fill in Column 1-18 and Columns 26-38. The element area fished will be understood to be boating area.

3. How much time did your party spend fishing?

4. Did you prefer to catch a particular species?

5. Where did you fish? If resistance is encountered to this question show them the map of the six areas (Fig. 3) used to record locations, and explain that you only need an answer as to the area fished, not their particular 'fishing hole.'

6. Why did you go fishing? This question will help determine the type fisherman. The skilled fisherman shows his expertise in many ways, such as knowledge of the park waters, fishing experience, fishing rods rigged with appropriate artificial lures or fishing in a specialized manner for particular fish. The family designation is applied to groups of adults and children, or to groups of adults whose primary interest is other than fishing. The novice fisherman has little experience fishing, or little experience in the park. The sustenance fisherman is primarily fishing for food and usually keeps everything caught.

7. Where did you launch your boat?

8. Where are you from? If party members are from different areas, use the residence of the boat owner.

9. What species of fish did you catch? If the answer is more than four species, additional lines may be used for a total of 20 species (five lines). Additional lines are coded only with interview number, date, and species repeats.

10. How many fish of each species did you keep? For confirmation, interviewer must see and count the catch.

Figure 3. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for all blacktip sharks for both surveys. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index

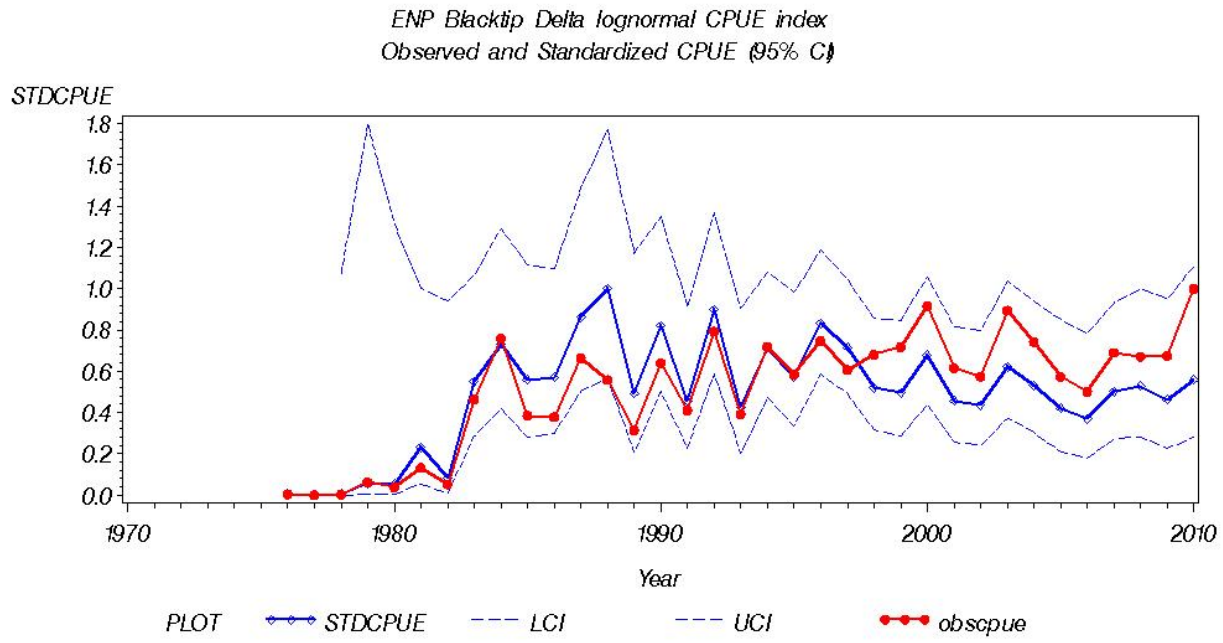


Figure 4. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year.

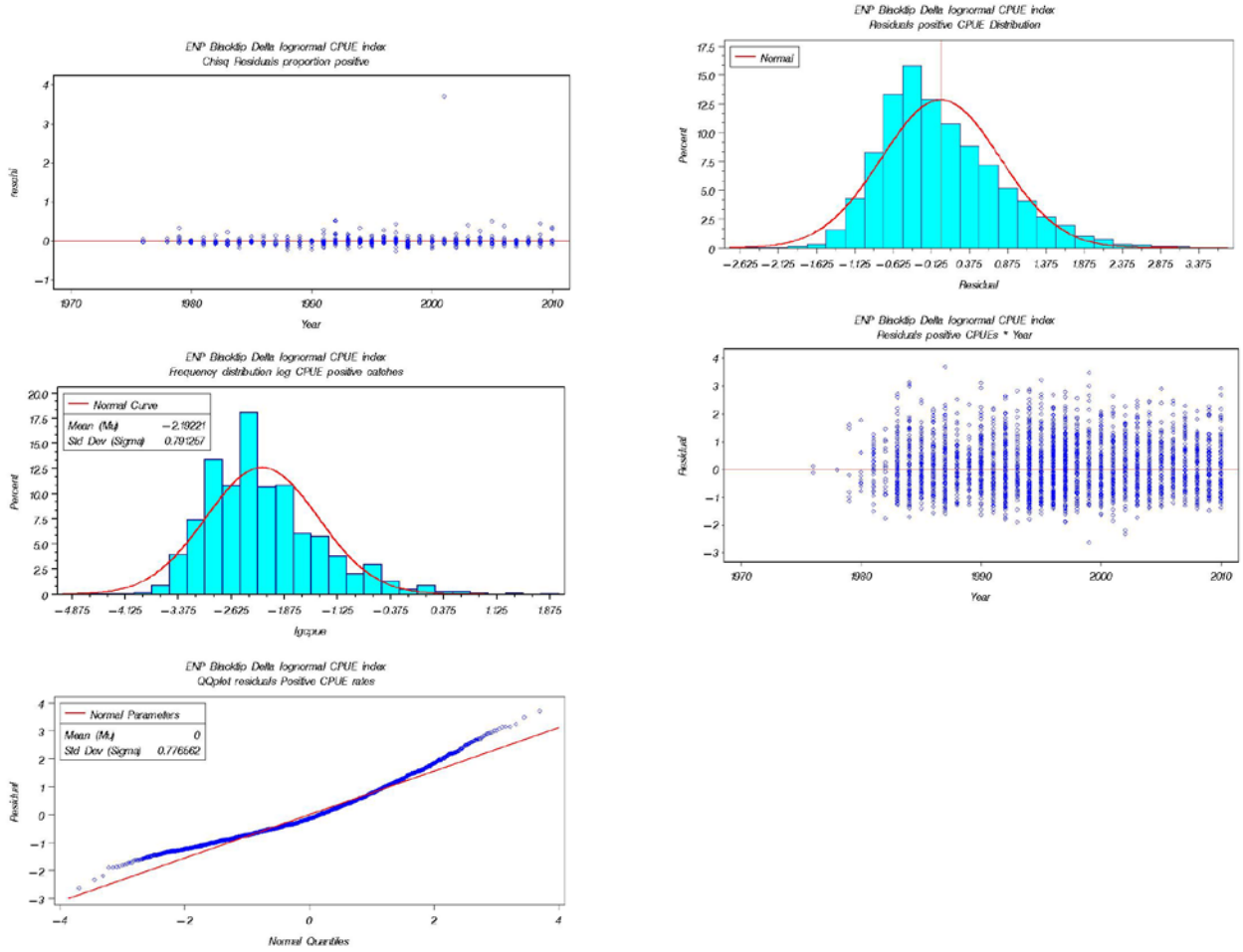
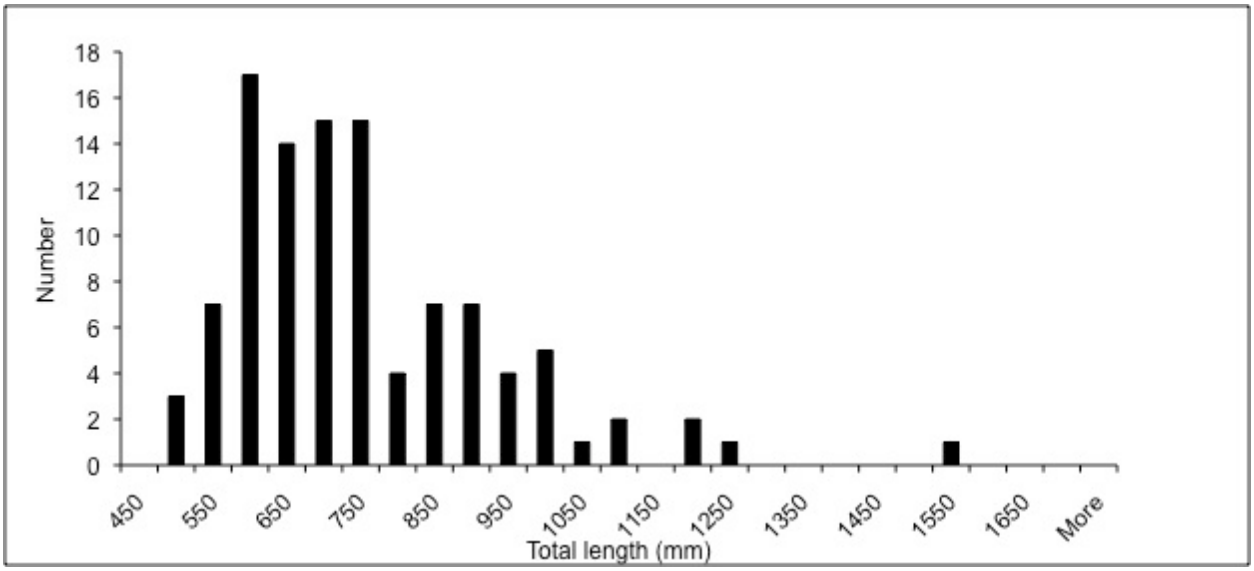
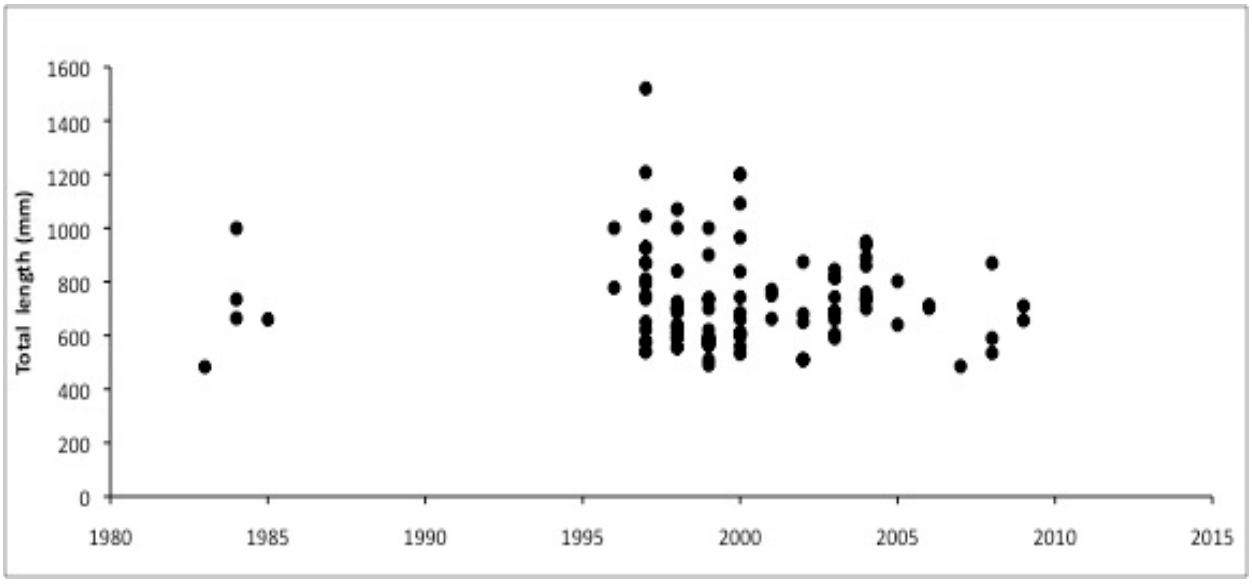


Figure 5. Length frequency distribution and lengths by year of blacktip sharks caught in the Everglades National Park.





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