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STANDARDIZED CATCH RATES OF LARGE COASTAL SHARKS FROM THE EVERGLADES NATIONAL PARK CREEL SURVEY, 1972-2002

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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. Based on discussion at the 2005 Shark SEDAR workshop, the present study attempts to standardize catch rates for the large coastal species-aggregate, large coastal species-aggregate minus prohibited species, large coastal species-aggregate minus prohibited species minus blacktip shark minus sandbar shark, and a species-specific catch rate for blacktip sharks in the Gulf of Mexico 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 el at. (1986), and Schmidt et al. (2002).

Index Development

Standardized catch rates were modeled for a large coastal shark aggregate and blacktip sharks. The factors that were expected to influence the catch of sharks were year, fisher, season, target, 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 (Schmidt unpublished). Those periods are "Dry"= December-May and "Wet"= June-November. The factor "Target" was defined using the reported species preference. Species thought to be targeted that used a technique thought to influence the capture a shark included: tarpon, *Megalops atlanticus*; sea trout, *Cynoscion sp*.; grey snapper, *Lutjanus griseus*; crevalle jack, *Caranx hippos*; snook, *Centropomus undecimalis*; red drum, *Sciaenops ocellata*; and shark. All other species were categorized as "Other". The factor "Area" where the fisher reported fishing was refined from the Everglades National Park definitions based on similarity in habitat type (Figure 1). Areas were divided into "Inner Florida Bay"; "Outer Florida Bay"; "Whitewater Bay"; "Ten Thousand Islands" and "Other".

Catch rates were standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). As previously stated, factors considered as potential influences on catch rates included time-area factors: year (31 levels), fisher (2 levels), season (2 levels), target (7 levels), and area (5 levels). One part modeled the proportion of sets that caught any sharks (at least one shark was caught) assuming a binomial distribution with a logit link function while the other part modeled the catch rates of sets with positive catches assuming a Poisson distribution with a log link function. For the Poisson regression, an offset of the natural logarithm of the number of hours fished/number of anglers was employed. Initially, a null model was run with no factors entered into the model. Models were 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. First order interactions were attempted to be modeled but the low sample in some years precluded the final model from converging. The two final delta-lognormal models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX). Relative indices of abundance were calculated as the product of the year effect least square means from the binomial and poisson models. The standard error of the combined index was estimated with the Delta Method (Lo et al. 1992). To facilitate visual comparison, a relative index and relative nominal index were calculated by dividing each value in the series by the mean value of the series.

RESULTS AND DISCUSSION

The ENP dataset contains useful information from 184,203 sport fishing trips that took place during 1972-2002. Trips were excluded if essential fields were missing or unfeasible. Of those trips, large coastal sharks (i.e. any shark reported in the large coastal management group)

were reported to have been caught, or caught and released on 6.7% of trips (Table 1). A requiem shark group was reported in 3.2% of trips and blacktip sharks were reported on 2.4% of trips. The remaining species reported captured in decreasing abundance were nurse shark, great hammerhead shark, lemon shark, bull shark, a hammerhead shark group, spinner shark, and sandbar shark.

Large coastal species-aggregate

Large coastal shark were recorded in 12,130 interviewed trips. The stepwise construction of the binomial model of the probability of catching a large coastal shark is summarized in Table 2. The final model was *Proportion positive trips=Year + Season.* The stepwise construction of the poisson model of positive catch is summarized in Table 3. The final model was *Positive catch = Year + Fisher+ Target.* The frequency distribution of positive trips is in Figure 3 and the distribution of residuals by year is in Figure 4.

The standardized abundance index is shown in Figure 5. To allow for visual comparison with the nominal values, both series were scaled to their respective means. The index statistics can be found in Table 4. The standardized abundance index is similar to the nominal CPUE series. Sharks catches were relatively similar throughout the 1970's, declined beginning around 1982, stabilized in the early 1990's, and have somewhat increased since 1994.

Blacktip Shark

Blacktip sharks were recorded in 4,437 of the 153,458 interviewed trips from 1978-2002. An analysis of the catch rates indicates an increase in blacktip sharks beginning around 1983. However, an increase in reporting rates to species level coincided with an increase in catch rates for blacktip sharks (Figure 6). Thus, it could not be distinguished whether this increase was the result of an increase in species reporting or abundance of blacktip shark. Because of this factor, it was determined that the catch rate series may not be valid for blacktip sharks and was thus eliminated.

Large coastal species-aggregate (minus prohibited species) and large coastal species-aggregate (minus prohibited species minus blacktip shark minus sandbar shark).

For reasons outlined for blacktip shark, further analysis on these series was not conducted.

LITERATURE CITED

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Table 1. Proportion of sharks reported caught from all interviewed trips, 1972-2002.

Species	Percentage of trips reporting
Large coastal aggregate	6.59
Requiem shark	3.16
Blacktip shark	2.39
Nurse shark	0.69
Great hammerhead shark	0.23
Lemon shark	0.21
Bull shark	0.14
Hammerhead shark	0.03
Spinner shark	0.02
Sandbar shark	0.02
Scalloped hammerhead shark	0.00
Silky shark	0.00
Bignose shark	0.00
Tiger shark	0.00
Reef shark	0.00
Dusky shark	0.00

Table 2. Results of the stepwise procedure for development of the binomial catch rate model for the large coastal shark aggregate. %DIFF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model. L is the log likelihood.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQUARE	PR>CHI
NULL	1.80E+05	88445.7213	0.4995			-44222.8607		
SEASON	1.80E+05	86967.7146	0.4912	1.6617	1.6617	-43483.8573	1478.01	<.0001
TARGET	1.80E+05	87206.2986	0.4925	1.4014		-43603.1493	1239.42	<.0001
AREA	1.80E+05	87623.0249	0.4949	0.9209		-43811.5125	822.7	<.0001
YEAR	1.80E+05	87935.4616	0.4967	0.5606		-43967.7308	510.26	<.0001
FISHER	1.80E+05	88434.3675	0.4995	0.0000		-44217.1838	11.35	0.0008
YEAR +								
SEASON	1.80E+05	86459.9286	0.4884	2.2222	0.5606	-43229.9643	1475.53	<.0001
TARGET	1.80E+05	86665.0621	0.4896	1.9820		-43332.5311	1270.4	<.0001

FINAL MODEL: YEAR + SEASON

Akaike's information criterion	1003320.0
Schwartz's Bayesian criterion	1003330
(-2) Res Log Likelihood	1003318

Type 3 Tests of Fixed Effects

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	YEAR	SEASON
	<.0001	<.0001
DF	30	1
CHI SQUARE	482.66	1432.48

Table 3. Results of the stepwise procedure for development of the poisson catch rate model for the large coastal shark aggregate. %DIFF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model. L is the log likelihood.

POSITIVE CATCHES-POISSON ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQUARE	PR>CHI
NULL	1.20E+04	23339.4550	1.9243			-11251.3352		
YEAR	1.20E+04	21750.8757	1.7977	6.5790	6.5790	-10457.0456	1588.58	<.0001
FISHER	1.20E+04	22434.6586	1.8498	3.8715		-10798.9370	904.8	<.0001
TARGET	1.20E+04	22656.1891	1.8689	2.8790		-10909.7023	683.27	<.0001
AREA	1.20E+04	22668.4978	1.8696	2.8426		-10915.8566	670.96	<.0001
SEASON	1.20E+04	23339.3981	1.9244	-0.0052		-11251.3068	0.06	0.8115
YEAR +								
FISHER	1.20E+04	21331.3711	1.7639	8.3355	8.1380	-10247.2933	419.5	<.0001
TARGET	1.20E+04	21386.1128	1.7677	8.1380		-10274.6642	364.76	<.0001
AREA	1.20E+04	21385.6083	1.7681	8.1172		-10274.4119	365.27	<.0001
YEAR + FISHER								
TARGET	1.20E+04	21020.8387	1.7384	9.6607	1.3252	-10092.0271	365.27	<.0001

FINAL MODEL: YEAR + FISHER +TARGET

Akaike's information criterion	42213.1
Schwartz's Bayesian criterion	42220.5
(-2) Res Log Likelihood	42211.1

Type 3 Tests of Fixed Effects

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	YEAR	FISHER	TARGET
DF	30	1	6
CHI SQUARE	282.90	97.00	117.12

Table 4. The relative standardized index of abundance and coefficients of variance (CV) associated with the relative abundance index for large coastal sharks captured in Everglades National Park, 1972-2002.

YEAR	RELATIVE INDEX	CV
1972	0.598	0.255
1973	1.575	0.085
1974	0.985	0.093
1975	1.987	0.066
1976	1.165	0.094
1977	1.409	0.079
1978	1.126	0.094
1979	1.114	0.123
1980	1.469	0.079
1981	1.001	0.080
1982	1.099	0.081
1983	1.368	0.068
1984	1.279	0.066
1985	1.071	0.074
1986	0.921	0.070
1987	0.942	0.080
1988	0.993	0.099
1989	0.604	0.127
1990	0.548	0.098
1991	0.504	0.113
1992	0.910	0.089
1993	0.523	0.105
1994	0.911	0.070
1995	0.762	0.091
1996	0.900	0.070
1997	0.922	0.066
1998	0.855	0.078
1999	0.753	0.085
2000	0.966	0.076
2001	0.838	0.083
2002	0.900	0.087

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

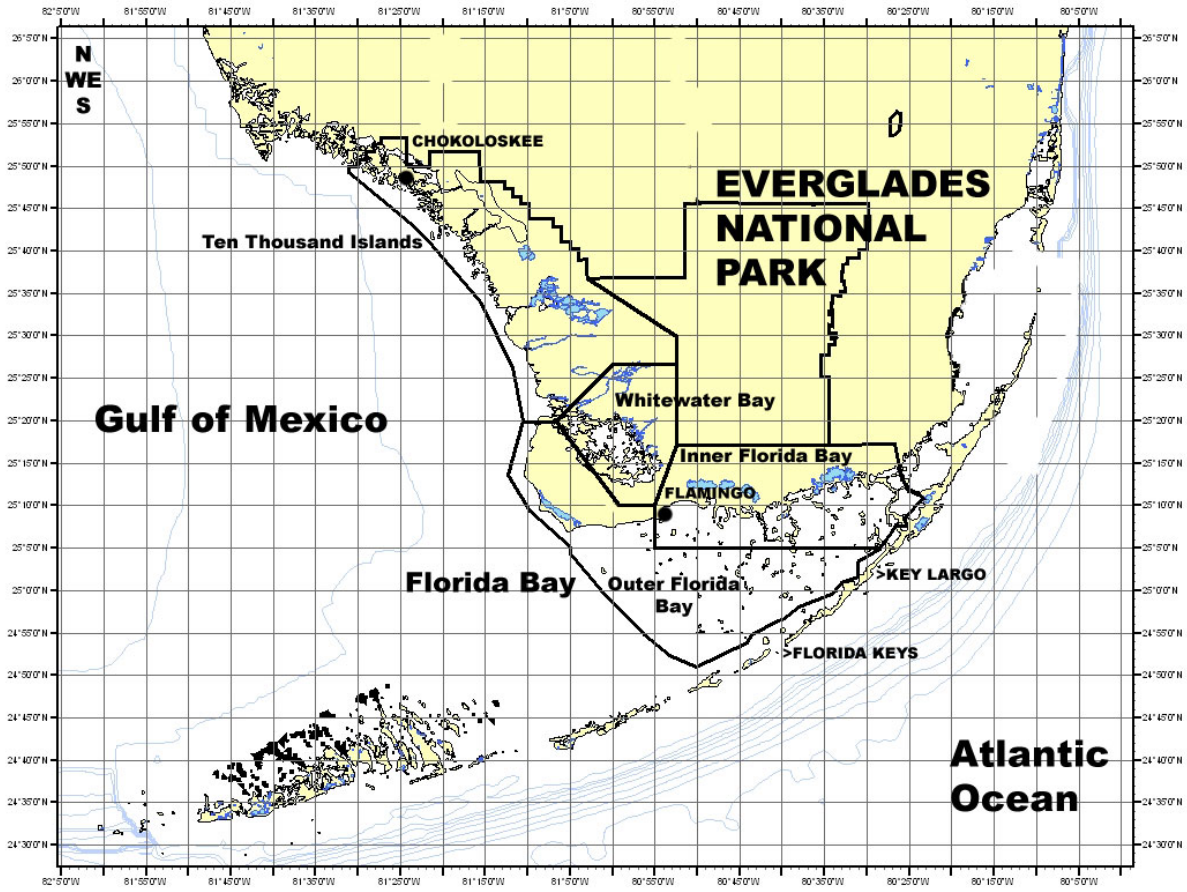

Figure 2. From Davis and Thue (1979), questions asked as part of the sportfishers interview by Everglades Parks personnel.

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. Frequency distribution of positive trips for the large coastal shark aggregate.

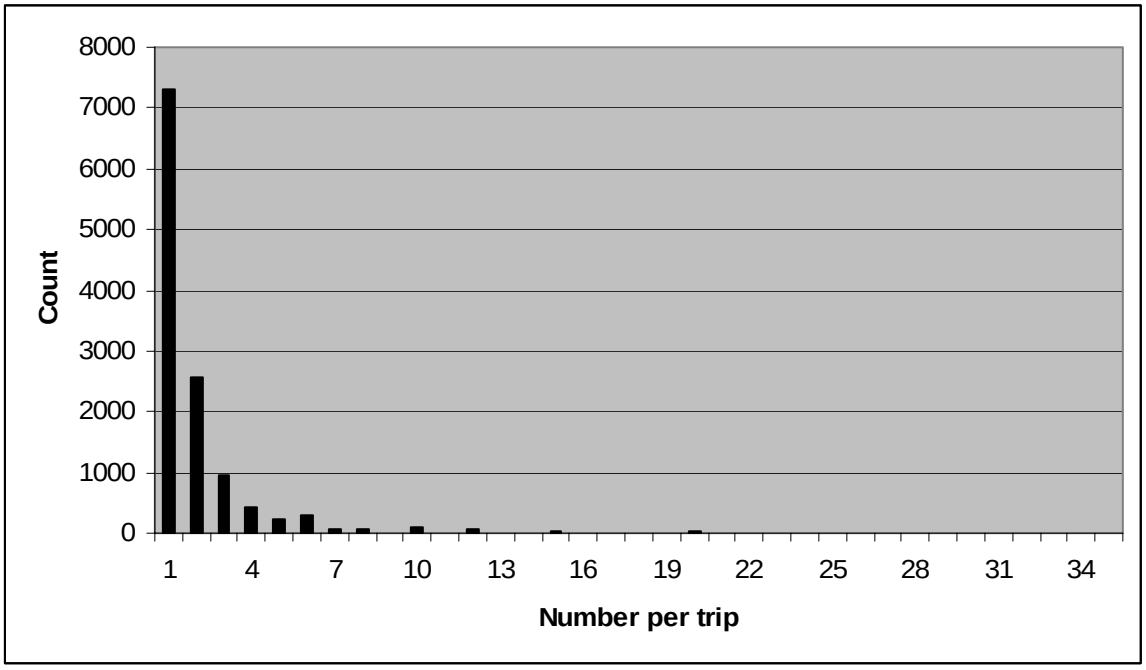

Figure 4. Residuals for the poisson model on positive catch rates by year for the large coastal shark aggregate.

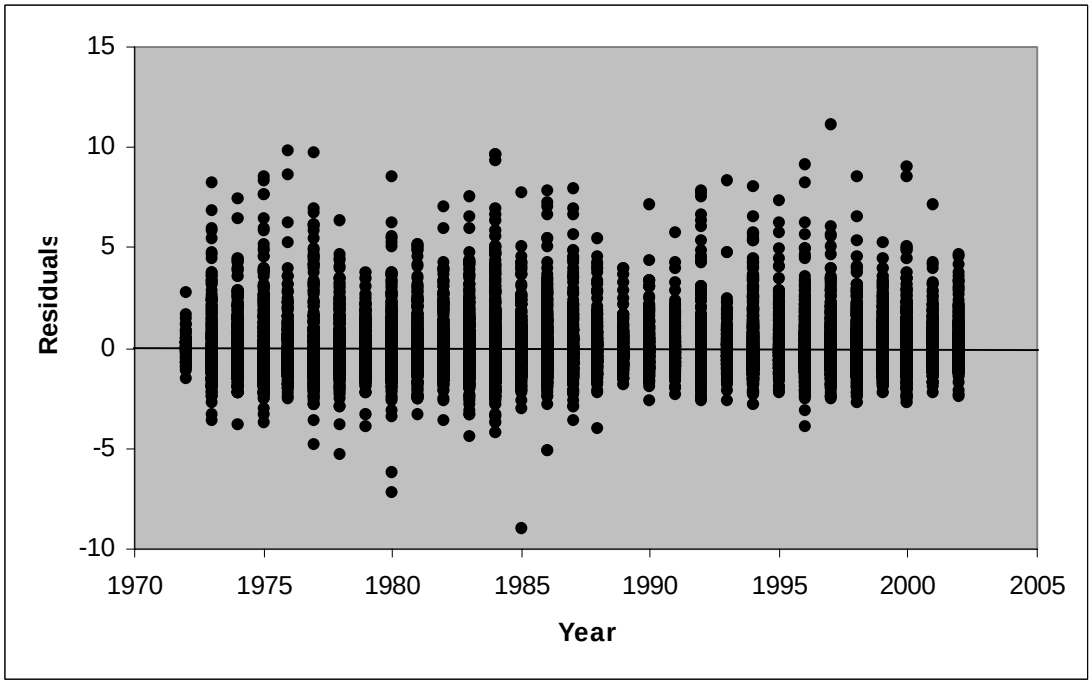

Figure 5. Standardized and nominal relative abundance trends for the large coastal shark aggregate.

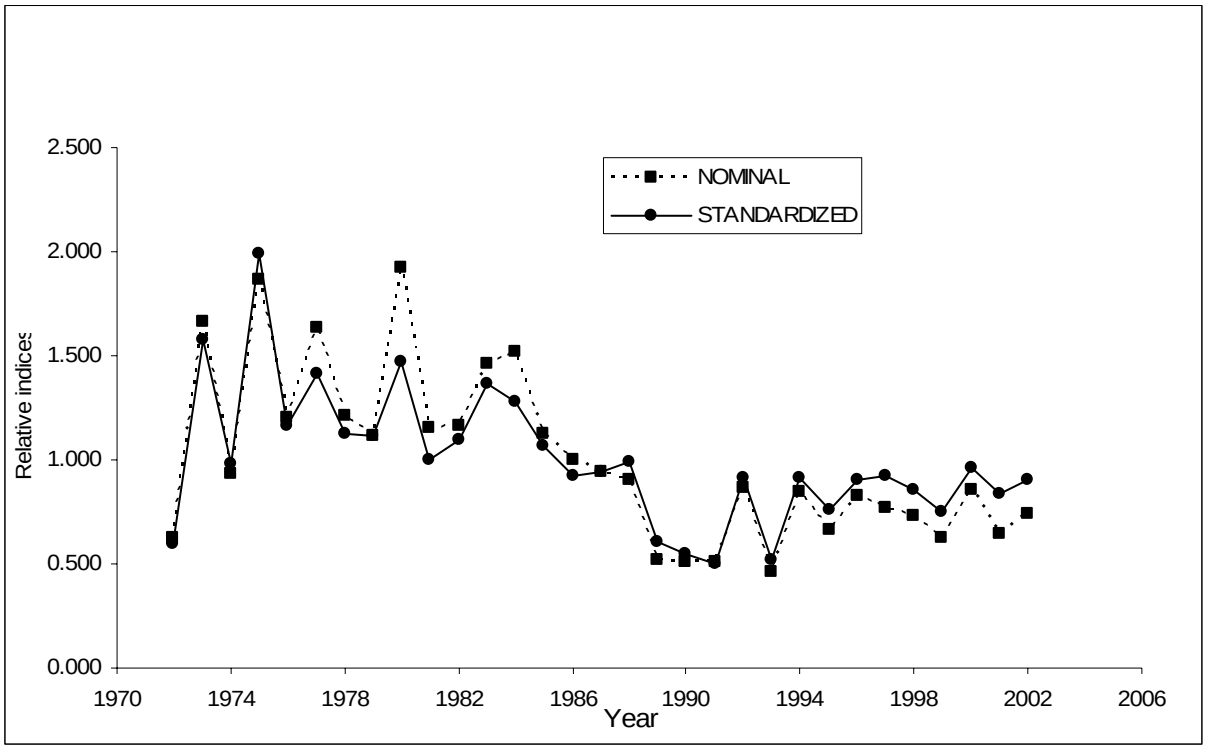

Figure 6. Standardized abundance trends for blacktip shark and the proportion of trips reporting blacktip sharks to species-level..