Small Coastal Shark_Data Workshop Document_xx-xx
SCS_DW_xx-xx

STANDARDIZED CATCH RATES OF BONNETHEADS FROM THE EVERGLADES NATIONAL PARK CREEL SURVEY, 1978-2004

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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 bonnetheads based on the monitoring of the recreational fishery in the Everglades National Park.

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). 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 bonnetheads. We examined the utilization of modeling catch rates for other small coastal sharks but due to small sample sizes, catch rates were not constructed. 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*; 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".

Because of variations in fishing location, depth, bait and gear choice, we believed that many fishing trips that targeted species normally caught had a low probability to capture a bonnethead. In the absence of detailed and reliable data regarding specific fishing location, bait choice, etc., we used an association statistic to attempt to identify trips with a higher probability of catching bonnetheads. Although utilized in the later analysis, species preference was rejected as an overall method to restrict the data because it was believed that very few fishers would report targeting a bonnethead and there is concern that fishers are less likely to report targeting a species if they failed to land that species. The association statistic was developed using the species composition of the catch as described by Cass-Calay and Bahnick (2002) and Cass-Calay and Schmidt (2003):

$$= \frac{\dfrac{\text{Trips with Sawfish + Species X}}{\text{Trips with Sawfish}}}{\dfrac{\text{Trips with Species X}}{\text{Total Trips}}}$$

We calculated the association statistic for all species reported by 100 or more sport fishing trips. After calculating the association statistic, all trips were excluded unless a trip kept or released a bonnethead, or one of the top three species identified as an associate was kept or released (Table 1).

Relative indices of abundance for bonnetheads were estimated by generalized linear modeling (GLM) using the delta method (Lo et al., 1992). This method combines separate generalized linear models of the proportion of positive trips (trips that kept or released a bonnethead) and the positive catch rates on successful trips to construct a single standardized abundance index. A type-3 model with a binomial error distribution and a logit link is assumed for modeling the effects of fixed factors and interactions on the proportion of positive trips (i.e., presence or absence of a bonnethead in a trip).

For each positive trip, we calculated catch per unit effort (CPUE)=bonnethead kept+ bonnethead released/hours fished*number of anglers. A type-3 model and a lognormal error distribution were assumed for modeling the response variable CPUE.

For each generalized linear model, we used a stepwise approach to quantify and eliminate factors (Ortiz and Arocha, 2004). 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. Because of the low sample size and its influence on the ability of the model to converge, we considered only first order interactions. Regardless of its significance, year was kept as a factor in the final model. Parameterization of each model was accomplished using the SAS statistical computer software (PROC GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc.).

After selecting the set of fixed factors for each error distribution, all factors that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final model determination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC) (Littell et al., 1996). Models with smaller AIC and BIC values are preferred to those with larger values. These 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). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models. The standard error of the combined index was estimated with the delta method (Appendix 1 in Lo et al., 1992).

Results and Discussion

The ENP dataset contains 194,535 sport-fishing trips that took place during 1972-2004. However, trips with records of bonnetheads were not found until 1978, thus all years prior to 1978 and trips where essential data were missing were excluded. After refinement using the association statistic (Table 1), the final data set used to estimate the standardized index of abundance contained 12,859 trips. The overall proportion of positive trips was 38.8%.

The stepwise construction of the binomial model of the probability of catching a bonnethead is summarized in Table 2. The final model was *Proportion positive trips=Year + Season + Target.* The stepwise construction of the lognormal model of positive catch is summarized in Table 3.

Single level interactions were significant when modeled within the generalized linear mixed models (Table 4). The final mixed model used to estimate standardized indices was **YEAR SEASON TARGET YEAR*TARGET** for the proportion positive model and **YEAR AREA YEAR*AREA** for the positive catch model.

Diagnostic plots assessing the fit of the lognormal model were deemed acceptable (Figure 2). The standardized abundance indices are reported in Table 5. To allow for visual comparison with the nominal values, the standardized and nominal series were plotted and shown in Figure 3.

Literature cited

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

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Table 1. Species found to be related through the association statistic with the catch of bonnetheads in Everglades National Park during 1978-2004.

Species	Total trips with Species X	Trips with bonnethead + Species X	Ass. Stat.
Bonnethead	5000		
Blacktip shark	4903	473	3.29
Fl. Pompano	1718	130	2.58
Stingray	2248	166	2.52
Gafftop catfish	23658	1645	2.37
Nurse shark	1410	96	2.32
Spanish Mackerel	4574	257	1.92
Pinfish	2847	151	1.81
Bothid flounders	2589	128	1.69
Sea Catfish	50044	2357	1.61
Lizardfish	2188	101	1.57
Pufferfish	7239	309	1.46
Crevalle jack	70960	2992	1.44
Blue runner	1752	73	1.42
Spotted seatrout	76993	3173	1.41
Ladyfish	47503	1948	1.40
Grunts	2999	122	1.39
Gray snapper	52058	1574	1.03
Sheepshead	22270	647	0.99
Blue crab	3080	86	0.95

Tripletail	1606	43	0.91
Black drum	11499	306	0.91
Misc. Serranids	1962	48	0.83
Red drum	49335	1098	0.76
Gag	3920	86	0.75
Goliath grouper	3763	82	0.74
Misc. Snappers	1020	19	0.64
Tarpon	4976	91	0.62
Barracuda	1740	31	0.61
Req. sharks	4114	71	0.59
Requiem shark	4114	71	0.59
Snook	34401	553	0.55
Largemouth bass	1622	7	0.15

Table 2. Results of the stepwise procedure for development of the binomial catch rate model. %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.

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	13000	17179.0142	1.3215				
YEAR	13000	16758.8513	1.2891	2.4458	2.4458	420.16	<.0001
SEASON	13000	16813.4335	1.2933	2.1281		365.58	<.0001
TARGET	13000	16900.8582	1.3001	1.6192		278.16	<.0001
FISHER	13000	17016.6293	1.3090	0.9453		162.38	<.0001
AREA	13000	17055.1240	1.3119	0.7212		123.89	<.0001
YEAR +							
SEASON	13000	16416.8289	1.2628	4.4367	1.9909	342.02	<.0001
TARGET	13000	16458.9565	1.2661	4.1915		299.89	<.0001
YEAR + SEASON +							
TARGET	13000	16126.5236	1.2405	6.1266	1.6899	290.31	<.0001

Table 3. Results of the stepwise procedure for development of the lognormal catch rate model. %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.

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	4992	3073.1604	0.6156				
AREA	4988	3003.8345	0.6022	2.1775	2.1775	113.92	<.0001
YEAR	4966	2997.1022	0.6035	1.9643		125.13	<.0001
TARGET	4988	3024.1456	0.6063	1.5160		80.28	<.0001
SEASON	4991	3050.2996	0.6112	0.7240		37.28	<.0001
FISHER	4991	3057.6795	0.6126	0.4838		25.22	<.0001
AREA+							
YEAR	4962	2928.2117	0.5901	4.1405	1.9631	127.31	<.0001
TARGET	4984	2973.6991	0.5966	3.0811		50.34	<.0001
AREA + YEAR + TARGET	4958	2903.5398	0.5856	4.8715	0.7310	42.25	<.0001

Table 4. Analysis of mixed model formulations for bonnethead catch. The factor year is treated as random within interactions. Final model used for constructing indices is in bold.

Proportion positive

Factor	-2 Res Log Likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion
YEAR SEASON TARGET	56425.9	56427.9	56435.3
YEAR SEASON TARGET YEAR*SEASON	56434.9	56438.9	56442.9
YEAR SEASON TARGET YEAR*TARGET	56414.7	56418.7	56424.5

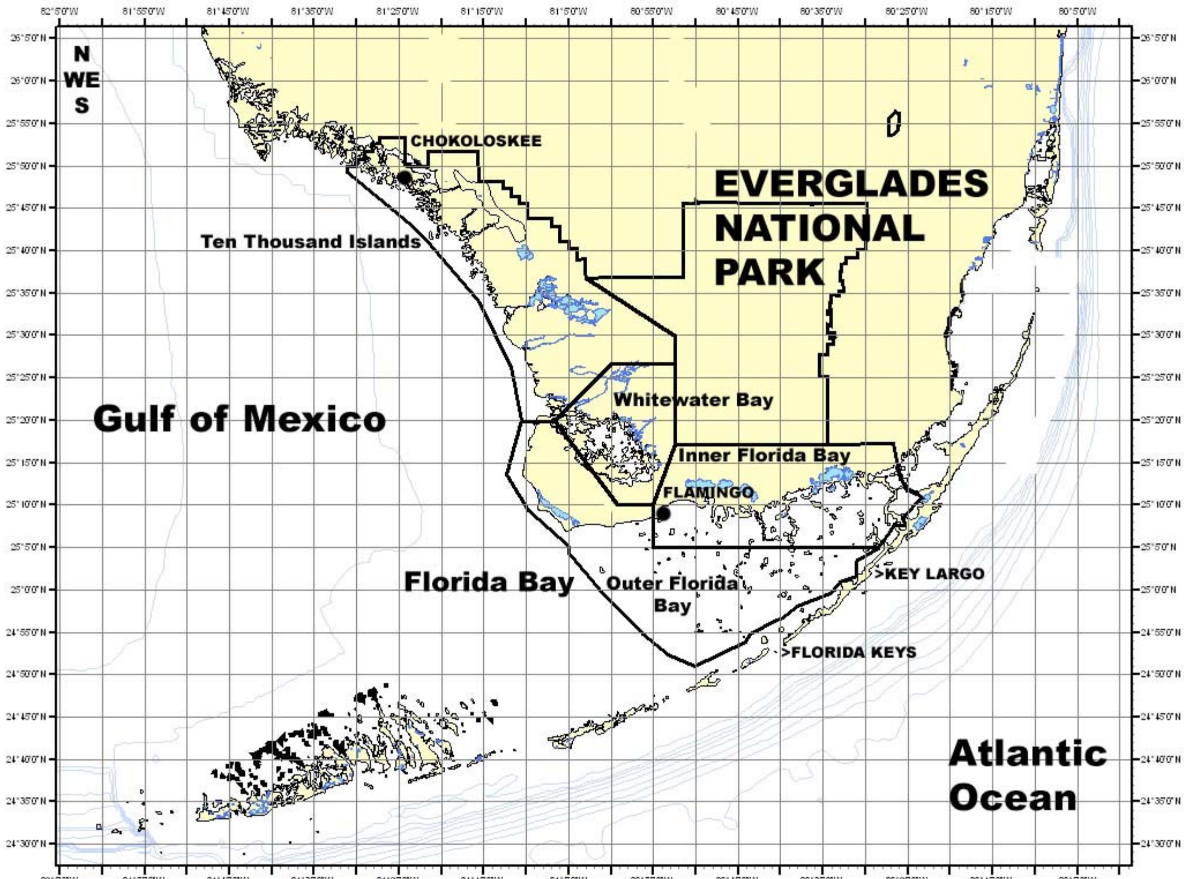
Positive catch rate

Factor	-2 Res Log Likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion
YEAR AREA	11602.2	11604.2	11610.7
YEAR AREA YEAR*AREA	11564.8	11568.8	11574.0

Table 5. The standardized index of abundance and coefficients of variance (CV) associated with the relative abundance index of bonnetheads captured in Everglades National Park, 1978-2004.

Year	**Absolute Index**	**CV**
1978	0.436	0.313
1979	0.545	0.341
1980	0.151	0.443
1981	0.395	0.205
1982	0.285	0.222
1983	0.542	0.137
1984	0.944	0.078
1985	0.627	0.114
1986	0.602	0.115
1987	0.631	0.109
1988	0.708	0.112
1989	0.901	0.104
1990	0.818	0.09
1991	0.498	0.13
1992	0.971	0.077
1993	0.931	0.089
1994	1.026	0.077
1995	1.137	0.075
1996	1.102	0.072
1997	0.879	0.083
1998	0.808	0.094
1999	0.940	0.087
2000	0.888	0.088
2001	0.965	0.087
2002	0.881	0.1
2003	0.803	0.101
2004	0.781	0.119

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



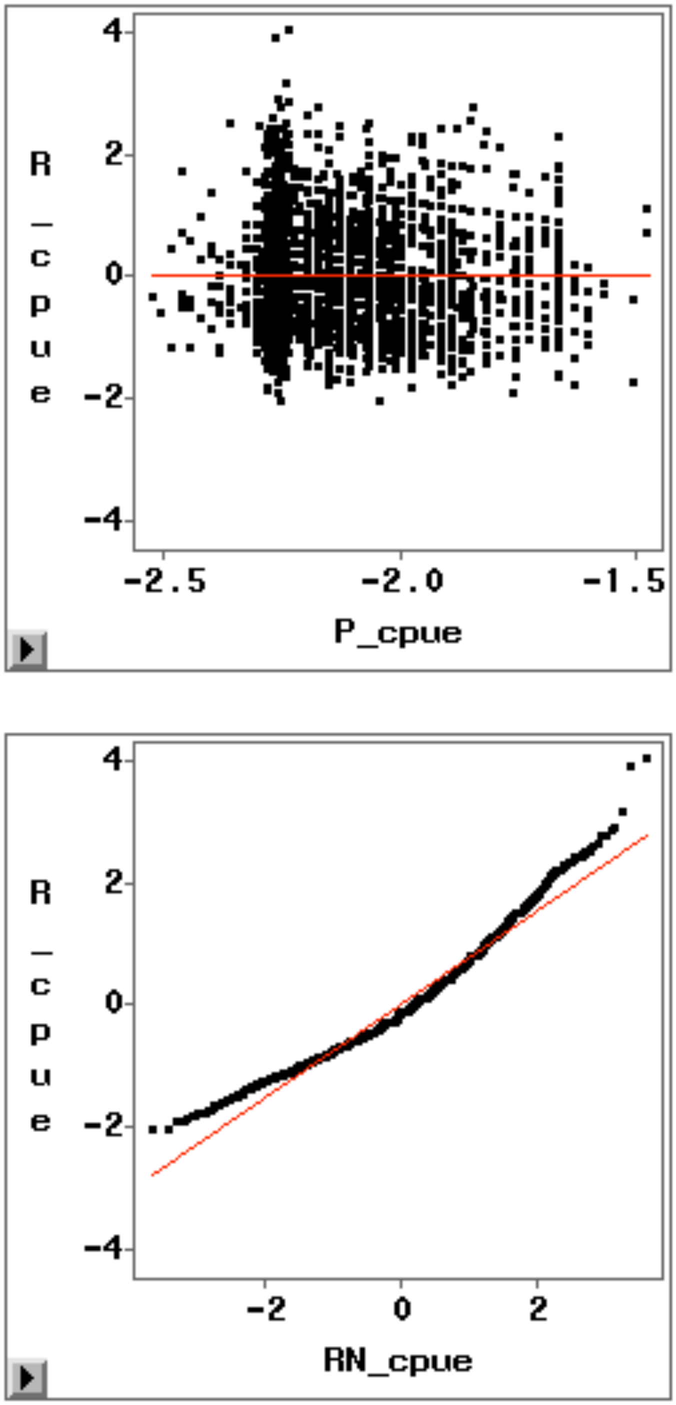


Figure 2. Diagnostic plots of the frequency distribution of residuals and quantile-quantile plots from the lognormal model.

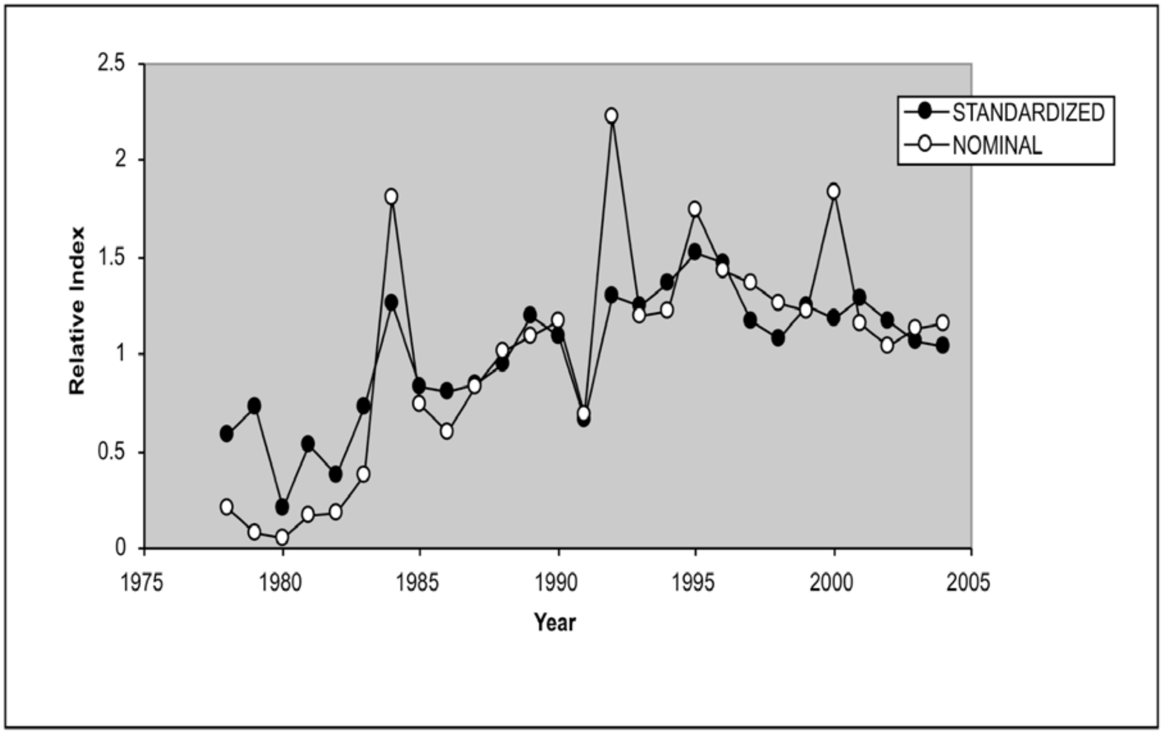


Figure 3. Standardized relative index of abundance for bonnetheads from the Everglades National Park trip interview data based on the final delta model. Nominal relative catch-per-unit effort data is plotted (open circles) for comparison.