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STANDARDIZED CATCH RATES OF SANDBAR SHARKS FROM THE LARGE PELAGICS ROD AND REEL SURVEY 1986-2015

John Walter[1] and Craig A. Brown[1]

SUMMARY

This paper presents a simple update to a relative abundance index for sandbar (Carcharhinus plumbeus) sharks off the coast of the United States from Virginia through Massachusetts were developed using data obtained during interviews of rod and reel anglers in 1986-2015. Subsets of the data were analyzed to assess effects of factors such as month, area fished, boat type (private or charter), interview type (dockside or phone) and fishing method on catch per unit effort. Standardized catch rates were estimated through generalized linear models by applying delta-Poisson error distribution assumptions. Parameters were re-estimated but the same model factors as used in previous iterations of this index are used in this paper. The indices both show a pattern of declines from the 1980s into the 1990s and a recent pattern of increase in the last three years.

KEYWORDS

Catch/effort, Abundance, Sport fishing, Fishery surveys, Multivariate analyses, Stock assessments, Catch rate standardization, Generalized linear model, Shark fisheries, Pelagic fisheries

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1. INTRODUCTION

Data from the United States National Marine Fisheries Service Large Pelagic Survey have typically been used to develop abundance indices for a variety of species, including bluefin tuna (Brown 2002), sharks (Brown 2000), bigeye and yellowfin tuna (Brown 1999, Brown 2004), and sharks (Brown 2000, Brown 2004). This paper describes the development of indices of abundance for sandbar sharks (*Carcharhinus plumbeus*) for the period 1986-2004.

2. MATERIAL AND METHODS

The Large Pelagic Survey (LPS) collects data on the catch and effort of individual fishing trips through interviews with fishermen at the dock and in some years has collected such information over the telephone. Information collected usually includes date, landing area, boat type (charter or private), fishing area, number of anglers fishing, number of lines in the water, hours fished, type of fishing (primarily trolling or chumming), fishing target, sea surface temperature (SST) and catch.

Observations were limited to those on which anglers indicated that they were targeting sharks and were employing the chumming fishing method exclusively. These restrictions are consistent with restrictions imposed for previous shark catch per unit effort (CPUE) standardization analyses for this fishery (Brown 2000, Brown 2004). Trips targeting other species categories (such as tunas) were not included because they were thought to be adding noise rather than information.

Species composition was assumed to have been reported correctly, however, given the close similarity of dusky and sandbar sharks, and prohibitions on retention of large coastal sharks, the species identifications may have become less reliable over time.

Factors which were considered as possible influences on catch rates included YEAR, MONTH, REGION, BOATTYPE, sea surface temperature (TEMP), STATE, MILES offshore, tournament participation (TOURNAMENT, Y=yes and N=no) and interview type (dockside/telephone recall or DOCKRECL). Preliminary analysis indicated that sandbar shark CPUE defined as fish per line*hour (number of lines X number of hours fished) was more independent of effort level than was CPUE defined as fish per hour. Therefore, line*hours was considered to be the preferred measure of fishing effort, in contrast to previous analyses of LPS catch rate data for sharks (Brown 2000, Brown 2004) where fishing effort had been defined as hours fished. The logarithm of the lines*hour was used as an offset term for the positive observation (Poisson) submodel.

The Lo method (Lo *et al.* 1992) was used to develop standardized indices; with that method separate analyses are conducted of the positive catch rates and the proportions of the observed trips which were successful. The error distribution for the proportion positive analysis was assumed to be binomial; for the positive catch rate analyses a Poisson error distribution was assumed, fitting the number of yellowfin tuna per trip with the natural log of the fishing hours as the offset term.

For this analysis, the same models used in the Brown (2004c) paper and a subsequent index developed for dusky sharks were used with updated information. Parameters were re-estimated by model factor selection was not performed.

The indices of relative abundance by year are determined based upon the standardized year effects. The product of the standardized proportion positives and the standardized positive catch rates was used to calculate overall standardized catch rates.

Based on recommendations in Lauretta et al., 2016, the variance of the index was estimated using the Goodman (1960) exact estimator assuming that the two components of the delta poisson model were independent.

3. RESULTS

General results

Maps of sample observations of dusky and sandbar sharks by year are shown in **Figure 1**. Nominal catch rate and effort trends for both species are shown in **Tables 1 and 2** and included in **Figures 2**

Model results: sandbar shark

Stepwise construction of the standardization model from Brown 2004c are shown in **tables 4** and **5**. The final models are:

Model: **prop positive = YEAR+TEMP** (for proportion positive)

Model**: cpue = YEAR+ MONTH** (for positive catches)

No two-way interactions, including year interactions, were found to be significant in either proportion positive or positive catch rates in the previous modeling and no interactions were incorporated into these indices. For brevity model factor selection and model diagnostics are not shown in this paper but remain similar to those in Walter and Brown (2010).

4. Discussion

- In the recent three years there appears to be a fairly substantial increase in the catch rate of sandbar sharks as indicated by increasing nominal values, increasing percentage of positive trips and an increasing standardized index.
- Large numbers of missing temperature, miles fished and missing year and state or region combinations appear to create spurious interactions. Filling in these missing cells or condensing over cells could be useful to model interaction effects. The imbalance in the sample distribution makes modeling some of the factors problematic as there are substantial observations with no temperature or miles fished information, resulting in a potentially non-ignorable bias in the sample datasets that could be used to model temperature or miles fished as a factor in the catch rates. It is also possible that temperature could be assigned to the trip position using historical satellite-derived sea-surface temperatures.
- Further improvements in the index could be considered by a more appropriate error distribution assumption. The delta-poisson does not fit the data particularly well as we have removed the zeros, making it a truncated distribution. As single model negative binomial or a single poisson model could be explored in future index construction.

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Table 1. Table of total large pelagic survey trips, selected trips and nominal catch rates of sandbar sharks. Selected trips met the criteria of being 'shark directed' and chumming trips.

year	total offshore trips	Shark Directed	identified as 'shark directed'	total directed, selected trips	Total sandbar kept and released	Total sandbar kept	Prop. positive	Avg per trip	Avg per positive trip
1986	11006	2076	18.86%	971	209	57	12.05%	0.2152	1.79
1987	10060	2206	21.93%	1043	117	58	6.42%	0.1122	1.75
1988	7841	1638	20.89%	458	100	18	12.88%	0.2183	1.71
1989	9689	1712	17.67%	807	267	69	21.07%	0.3309	1.58
1990	11457	2154	18.80%	972	116	21	8.95%	0.1193	1.35
1991	10729	1910	17.80%	882	142	10	7.48%	0.161	2.15
1992	11774	1854	15.75%	799	100	11	8.14%	0.1252	1.55
1993	11398	1156	10.14%	433	10	3	1.62%	0.0231	1
1994	9541	1012	10.61%	354	13	2	3.11%	0.0367	1.33
1995	14314	1252	8.75%	410	19	5	1.71%	0.0463	1.5
1996	4190	474	11.31%	189	11	0	3.17%	0.0582	1.83
1997	8413	816	9.70%	301	15	3	3.32%	0.0498	1.33
1998	8982	392	4.36%	139	3	1	2.16%	0.0216	1
1999	4341	316	7.28%	116	5	0	1.72%	0.0431	2.5
2000	7646	690	9.02%	218	4	0	0.92%	0.0183	2
2001	6414	428	6.67%	147	16	2	2.72%	0.1088	4
2002	7062	564	7.99%	162	5	0	1.85%	0.0309	1.67
2003	10555	1302	12.34%	566	11	0	0.88%	0.0194	2.2
2004	9875	1336	13.53%	579	8	1	1.04%	0.0138	1.33
2005	9371	1056	11.27%	456	24	0	2.19%	0.0526	2.4
2006	7836	1254	16.00%	473	9	0	0.85%	0.019	2.25
2007	11826	1604	13.56%	649	26	2	1.85%	0.0401	2.17
2008	12286	1406	11.44%	508	19	1	1.97%	0.0374	1.9
2009	13140	1526	11.61%	622	37	0	2.09%	0.0595	2.85
2010	11617	1204	10.36%	473	28	0	4.23%	0.0592	1.4
2011	10719	1128	10.52%	461	30	0	2.82%	0.0651	2.31
2012	11721	1156	9.86%	444	10	0	1.13%	0.0225	2
2013	9878	1162	11.76%	437	37	0	4.12%	0.0847	2.06
2014	9461	1152	12.18%	468	60	0	2.99%	0.1282	4.29
2015	12387	1176	9.49%	485	29	0	3.30%	0.0598	1.81

Table 2. Standardized relative abundance indices for sandbar shark.
Model: **prop positive ~ YEAR+TEMP** (for proportion positive)
Model**: cpue ~ YEAR+ MONTH** (for positive catches). Note that nominal relative mean may differ from the mean per trip in Table 1 due to exclusion of records with missing model factors.

year	index	LCL	UCL	CV	std index	Std LCL	Std UCL	nominal relative mean
1986	1.183	0.825	1.542	0.155	3.723	2.739	5.063	3.750
1987	0.363	0.208	0.519	0.218	1.143	0.743	1.759	1.048
1988	1.184	0.721	1.646	0.199	3.724	2.510	5.527	3.122
1989	1.352	0.999	1.704	0.133	4.253	3.264	5.543	4.336
1990	0.471	0.301	0.640	0.184	1.481	1.029	2.132	1.485
1991	0.762	0.494	1.031	0.180	2.399	1.679	3.428	2.233
1992	0.584	0.363	0.804	0.193	1.836	1.253	2.691	1.657
1993	0.261	-0.028	0.549	0.564	0.821	0.287	2.349	0.320
1994	0.175	0.009	0.340	0.485	0.549	0.219	1.376	0.547
1995	0.138	-0.018	0.294	0.579	0.434	0.148	1.271	0.475
1996	0.164	-0.026	0.355	0.591	0.517	0.173	1.545	0.595
1997	0.198	0.011	0.385	0.483	0.622	0.249	1.553	0.622
1998	0.051	-0.049	0.150	1.001	0.160	0.030	0.844	0.221
1999	0.081	-0.052	0.214	0.841	0.254	0.059	1.099	0.598
2000	0.085	-0.060	0.229	0.870	0.267	0.059	1.198	0.254
2001	0.370	-0.101	0.842	0.650	1.164	0.355	3.817	1.407
2002	0.145	-0.076	0.365	0.778	0.455	0.115	1.803	0.422
2003	0.066	-0.011	0.143	0.592	0.209	0.070	0.625	0.268
2004	0.030	-0.009	0.068	0.666	0.093	0.028	0.313	0.143
2005	0.156	0.013	0.299	0.467	0.492	0.203	1.195	0.468
2006	0.046	-0.025	0.116	0.788	0.144	0.036	0.577	0.058
2007	0.104	0.014	0.195	0.443	0.328	0.141	0.766	0.425
2008	0.135	0.017	0.254	0.447	0.426	0.181	0.999	0.519
2009	0.201	0.048	0.354	0.388	0.633	0.299	1.339	0.447
2010	0.106	0.023	0.189	0.401	0.333	0.154	0.721	0.464
2011	0.086	0.000	0.172	0.509	0.271	0.104	0.708	0.291
2012	0.070	-0.025	0.164	0.690	0.220	0.063	0.765	0.197
2013	0.275	0.090	0.460	0.343	0.865	0.444	1.685	1.033
2014	0.461	0.154	0.769	0.340	1.452	0.750	2.812	1.764
2015	0.232	0.068	0.396	0.360	0.730	0.363	1.469	0.828

Figure 1. Map of sample observations of dusky and sandbar sharks.

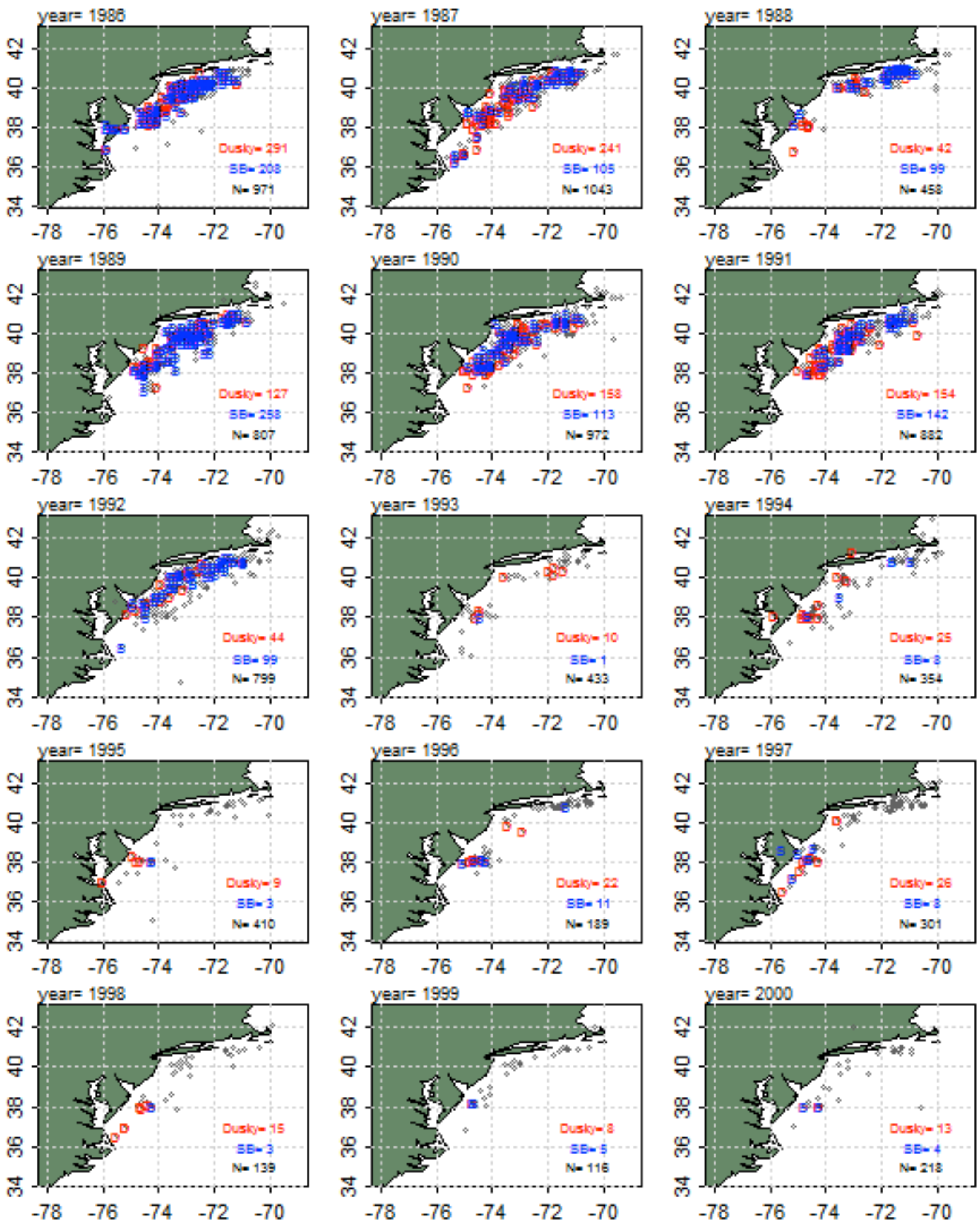

Figure 1. Continued.

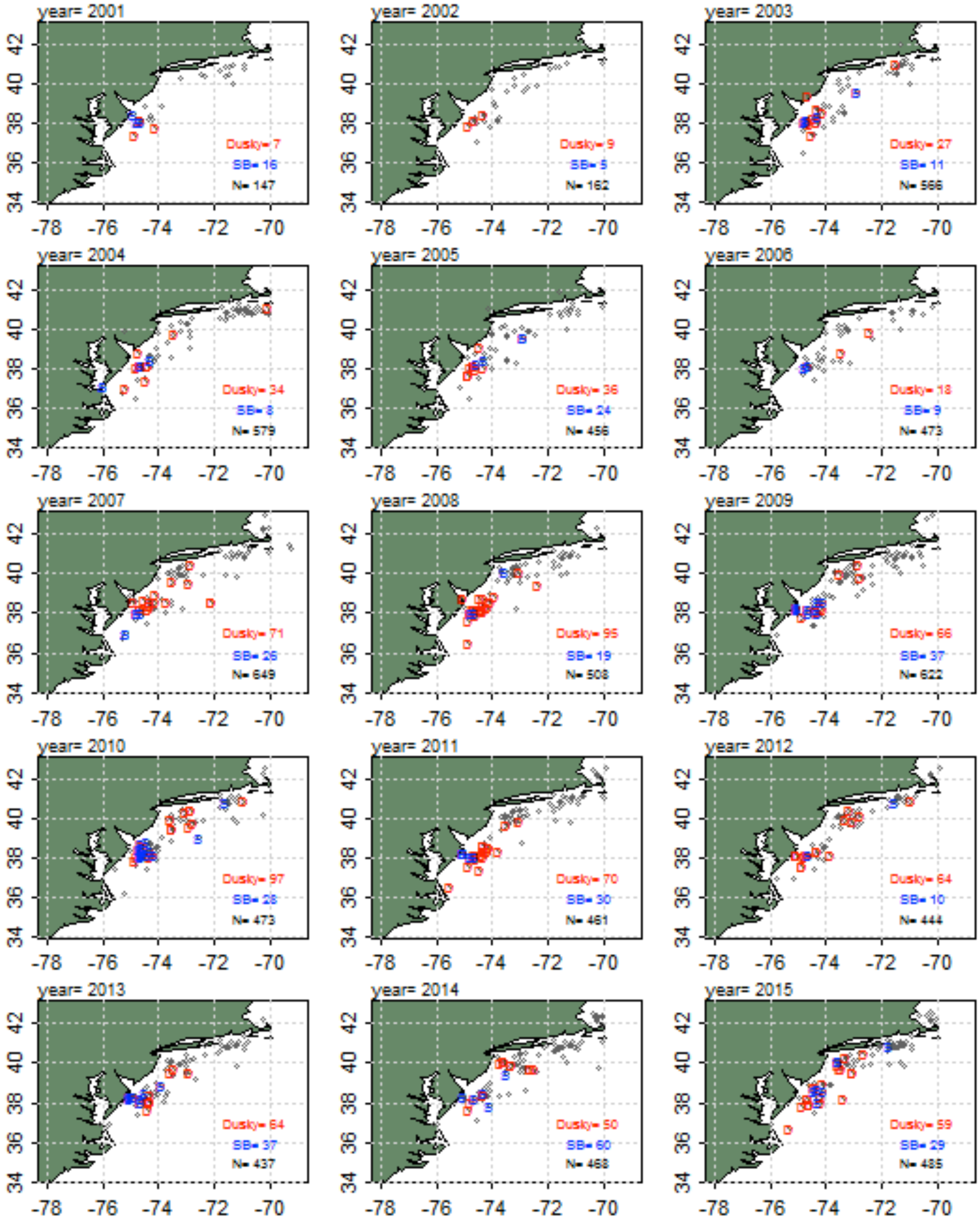

Figure 2. Relative abundance indices for SANDBAR SHARKS with approximate 95% confidence intervals.(Proportion positive error distribution: binomial; Positive error distribution: Poisson)

Model = **YEAR+TEMP** (for proportion positive)

Model = **YEAR+MONTH** (for positive catches)