SMALL COASTAL SHARK 2007 SEDAR DATA WORKSHOP DOCUMENT

Standardized catch rates for Atlantic sharpnose sharks *Rhizoprionodon terraenovae* from exploratory longline surveys conducted by the Sandy Hook, NJ and Narragansett, RI labs: 1961-1991

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Summary

The United States National Marine Fisheries Service (NMFS), and its predecessor agencies; the Bureau of Commercial Fisheries (BCF) and the Bureau of Sport Fish and Wildlife (BSFW), have conducted periodic longline surveys for swordfish, tuna, and sharks off the east coast of the United States since the early 1950's. While the BCF surveys focused on the development of a tuna fishery, the initiation of shark surveys in1961 at the Sandy Hook Marine Lab (SHML) responded to concerns about shark attacks off the coast of New Jersey and resort owner demands for legislation that would require sport and commercial fishermen to fish further offshore. Surveys predominantly relied on longline gear, although early sampling also used chain bottom gear, gillnets, and sport fishing gear. In subsequent years, monitoring of sport fishing tournaments during summer months complimented dedicated surveys on research vessels and opportunistic trips aboard commercial and sport fishing vessels. Early experimentation with different tag types, ultimately lead to the establishment of the ongoing Cooperative Shark Tagging Program. After the initial coastal surveys were conducted between 1961 and 1965, there was a gradual transition from coastal work to offshore effort along the edge of the continental shelf and associated Gulf Stream waters. The shark research program moved from the Sandy Hook to the Narragansett Lab in the early 1970s.

Catch per set data obtained from the exploratory longline surveys conducted within the U.S. EEZ by the Sandy Hook, NJ and Narragansett, RI labs from 1961-1991 were used to develop standardized indices of abundance for Atlantic sharpnose sharks *Rhizoprionodon terraenovae* for the 2007 Small Coastal Shark SEDAR Data Workshop. Atlantic sharpnose shark catch per unit effort (CPUE) by set in number of sharks/hour were examined. The CPUE was standardized using a modified two-step approach originally proposed by Lo et al (1992) that models the zero catch separately from the positive catch. Standardizing the CPUE data reduced some of the peaks seen in the nominal CPUE data revealing a more stable trend in relative abundance for the Atlantic sharpnose sharks caught during these exploratory longline surveys.

Methods

Data Sources

Data from research cruises and opportunistic deployments were coded as consistently as possible using the database design of the current Pelagic Observer Program (POP). Not all of the gear and operational variables currently recorded by observers were recorded aboard early surveys or on opportunistic trips aboard commercial vessels. Some of these variables reflect new gear innovations. Set specific gear, deployment, retrieval, and species composition data were coded from original cruise reports, field fishing logs maintained by scientific personnel, final grant reports, or published papers. Species counts were initially entered as catch per set totals. For the shark survey data, catch per set totals were subsequently matched against separate morphometric and tagging databases to verify total set counts. While catch per set discrepancies were rare, when they could not be resolved by referring to the original field notes the higher value was accepted for a specific species catch per set estimate.

Species

Scientific observers attempt to identify all animals that are caught or entangled by the gear. Invariably there are animals that are coded as unidentified or unknown, and others that can only be identified to species family groups such as tunas, billfish, sharks, or species groups such as hammerhead, mako, or thresher sharks. This is particularly prevalent in the recent POP data where between 80 and 90 unique codes are recorded for species, species families, species groups, and unclassified records. In the current POP observer time series, 30 to 35 rare codes account for 10 or fewer individuals. To simplify analyses of the Sandy Hook and Narragansett lab exploratory longline survey data and presentation of species catch per set data, the original 80 to 90 POP codes are combined into 34 categories that include the dominant target and incidentally caught (bycatch) species and species groupings. The original POP species codes are maintained in associated animal files for the exploratory longline surveys. The shark records from the exploratory longline surveys are geographically and operationally less diverse than the POP time series, so the number of unique species identified is reduced.

Operational variables

Operating practices generally reflect targeting strategies that can influence catch rates for target and incidental species. POP observers record gear characteristics and operating practices along with location and environmental variables. These include the date, location (latitude and longitude), time, and sea surface temperature at the start and end of setting and hauling operations for each set. For some of the earliest exploratory longline survey data, only one location was recoverable, although for most records the begin set and end haul locations were available. Exploratory longline survey gear information includes number of hooks set, gangion and dropper line lengths, mainline material, number of hooks between floats, hook sizes, types, and bait information. Additional information on the rare use of line throwers, lightsticks, weights, and sets where the gear is tended during the soak period is being recovered.

In comparison to recent POP records, the gear characteristics of the exploratory longline survey records; especially those north of Cape Hatteras, are less variable in terms of component dimensions and rigging patterns (hooks between floats, distances between hooks, etc.). The major change over time relates to the annual proportions of sets deployed in coastal shallow depths versus offshore effort along the edge of the continental shelf and in Gulf Stream waters. The vast majority of exploratory longline survey records described in this report deployed pelagic (free floating) gear similar to Japanese style "basket gear" used by the BCF in tuna surveys and "Yankee Style" swordfish gear. The primary characteristic of these gears is that the major components consist of a multi-filament nylon 3/8" mainline with 1/4" nylon gangions that end with 3/32" stainless steel leaders. When deployed with between 5 and 10 hooks between floats and in depths less than 40 or 50 meters, field notes on bait loss, species composition of the catch and reported hangs, clearly indicate that the gear is fishing on or near-bottom.

Prior to 1966 almost all of the exploratory longline sets occurred in the northern Mid-Atlantic bight in the approaches to New York harbor. Most occurred east and southeast of Sandy Hook with a smaller number of sets off the southern coast of Long Island to Montauk in depths less than 40 meters. A small number of sets occurred in Delaware Bay and three sets occurred in the Baltimore and Hudson canyons. A multi-filament nylon mainline was generally suspended with 5 meter dropper lines, 8 hooks between floats and gangions that were 5 to 6 meters in total length. The major transitional changes that occurred in the exploratory longline surveys occurred after 1966. Most of these cruises occurred between Cape Hatteras and the northeast peak of Georges Bank, where they overlapped BCF and Woods Hole Oceanographic (WHOI) tuna cruises and Canadian DFO swordfish surveys. Effort was primarily concentrated along the edge of the continental shelf and in Gulf Stream waters. Occasional cruises, including cruises with other institutions, extend south of 34° N both along the US continental shelf and in deeper offshore waters north and north east of the Bahamas. While the mainline material remained constant, and hooks between floats rarely exceeded 10, gangion lengths increased slightly to 8 to 12 meters in length. Greater variability occurred in dropper lengths. While dropper lengths exceeding 30 meters were rare, these deep rigs were attempted in offshore waters with depths > 1,000 m especially south of 34 N. During the final three large scale pelagic surveys (Wieczno 86, Del II 89 and Del II 91), a small proportion of monofilament gangions were fished on 55 deep water sets.

Data Analysis

Atlantic sharpnose CPUE for each set is defined as the number of sharks/hooks. The CPUE was standardized using the Lo et al. (2002) method, which models the proportion of positive sets separately from the positive catch. Factors considered as potential influences on Atlantic sharpnose shark CPUE were: year (1961-1991), area (1 = $<34.5^{o}$ latitude, 2 = 34.5 to 37.0^{o} latitude, 3 = 37.1 to 39.0^{o} latitude, and 4 = $> 39.0^{o}$ latitude), season (February and March; April, May and June; July, August and September; October, November and December), depth (< 50 m, 50 to 99 m, 100 to 2499 m and > 2499 m), target (coastal shark, pelagic shark, inshore pelagic shark, swordfish, tuna), and leader type (wire, monofilament, or a combination of both). The proportion of sets with positive catch values was modeled assuming a binomial distribution with a logit link function and the positive catch sets were modeled assuming a Poisson distribution with a log link function. For the positive catch sets an offset of the natural log of the number of hooks was used for the Poisson model.

The models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $\alpha = 0.05$ based on a Chi-Square test, and the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS MIXED procedure (Wolfinger, SAS Institute, Inc). The factor “year” was kept in all final models, regardless of its significance, to allow for calculation of indices. The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and Poisson components.

Results

A total of 113 Atlantic sharpnose sharks were caught during 1401 sets from exploratory longline surveys conducted within the U.S. EEZ by the Sandy Hook, NJ and and Narragansett, RI labs from 1961-1991 (Table 1). The morphometric data for these sharks is in the process of being recovered and is not available at this time. The nominal CPUE and relative (CPUE/mean) nominal CPUE by year is reported in Table 1.

The percentage of sets with zero Atlantic sharpnose shark catch was 96.7%. The stepwise construction of the binomial model of the probability of catching an Atlantic sharpnose shark and the Poisson model of positive Atlantic sharpnose shark catch sets is in Table 2. The final binomial model was: proportion positive Atlantic sharpnose shark sets = depth + area + year. The final Poisson model was: positive Atlantic sharpnose shark catch = area + year. Year was not a significant factor in both the binomial and Poisson models, but was retained to allow for the calculation of yearly standardized indices of abundance. The model did not produce relative indices of abundance for 1961-1978, 1980-1982, 1984, 1987-1988, and 1990, because of insufficient Atlantic sharpnose shark catch during those years.

The resulting relative indices of abundance based on the standardized year effects obtained from the Lo et al. method for Atlantic sharpnose sharks are reported in Table 3 and illustrated in Figure 2. Standardizing the CPUE data reduced some of the peaks seen in the nominal CPUE data revealing a more stable trend in relative abundance for the Atlantic sharpnose sharks caught during these exploratory longline surveys (Figure 2).

References Cited

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (Thunnus albacares) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Table 1. Catch, nominal CPUE abundance indices, and the nominal relative (CPUE/mean) abundance indices for Atlantic sharpnose sharks. CPUE of a set = sharks/hooks. LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed for the nominal relative abundance indices.

Atlantic sharpnose sharks

YEAR	CATCH	NOM INDEX	REL INDEX	LCL	UCL	CV	N
1961	0	0	0	.	.	.	36
1962	0	0	0	.	.	.	26
1963	0	0	0	.	.	.	52
1964	0	0	0	.	.	.	41
1965	0	0	0	.	.	.	57
1966	0	0	0	.	.	.	15
1967	0	0	0	.	.	.	26
1968	0	0	0	.	.	.	28
1969	0	0	0	.	.	.	34
1970	0	0	0	.	.	.	11
1971	0	0	0	.	.	.	12
1972	0	0	0	.	.	.	14
1973	0	0	0	.	.	.	4
1975	0	0	0	.	.	.	9
1976	0	0	0	.	.	.	19
1977	0	0	0	.	.	.	64
1978	0	0	0	.	.	.	101
1979	2	0.0002	0.6878	-0.2633	1.6390	4.5523	88
1980	0	0	0	.	.	.	82
1981	0	0	0	.	.	.	61
1982	0	0	0	.	.	.	36
1983	5	0.0011	3.0531	-2.9309	9.0371	20.4810	45
1984	0	0	0	.	.	.	33
1985	3	0.0003	0.7462	-0.3362	1.8286	4.2058	58
1986	78	0.0056	16.0747	8.1255	24.0239	47.9889	140
1987	0	0	0	.	.	.	9
1988	0	0	0	.	.	.	16
1989	7	0.0006	1.5903	-0.1187	3.2992	9.8260	127
1990	0	0	0	.	.	.	11
1991	18	0.0012	3.5571	1.2982	5.8160	13.9260	146

Table 2. Results of the stepwise procedure for development of the catch rate model for Atlantic sharpnose sharks. %DIF 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	CHISQ	PR>CHI
NULL	1385	410.4867	0.2964					
DEPTH	1382	349.4649	0.2529	14.6761	14.6761	-174.7324	61.02	<.0001
AREA	1382	350.0887	0.2533	14.5412		-175.0443	60.40	<.0001
SEASON	1382	399.3757	0.2890	2.4966		-199.6879	11.11	0.0111
LEADER	1383	406.6131	0.2940	0.8097		-203.3065	3.87	0.1442
YEAR	1353	298.3794	0.2205	25.6073		-149.1897	Negative of Hessian not positive definite	
TARGET	1379	389.4611	0.2824	4.7233		-194.7306	Negative of Hessian not positive definite	
DEPTH +								
AREA	1379	299.3175	0.2171	26.7544	12.0783	-149.6588	50.15	<.0001
SEASON	1379	343.5405	0.2491	15.9582		-171.7702	5.92	0.1153
YEAR	1350	246.4114	0.1825	38.4278		-123.2057	Negative of Hessian not positive definite	
DEPTH + AREA								
YEAR	1347	260.1488	0.1931	34.8516	8.0972	-130.0744	Negative of Hessian not positive definite	

FINAL MODEL: DEPTH + AREA + YEAR

Akaike's information criterion 3982.9

Schwartz's Bayesian criterion 3987.3

(-2) Res Log likelihood 3980.9

	Type 3 Test of Fixed Effects		
Significance (Pr>Chi) of Type 3	DEPTH	AREA	YEAR
test of fixed effects for each factor	<.0001	0.0036	<.0001
DF	2	3	6
CHI SQUARE	26.01	13.55	35.22

POSITIVE CATCHES-POISSON ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQ	PR>CHI
NULL	46	76.1319	1.6550					
AREA	43	57.8551	1.3455	18.7009	18.7009	-6.1341	18.28	0.0004
SEASON	44	62.4894	1.4202	14.1873		-8.4512	13.64	0.0011
YEAR	40	58.1264	1.4532	12.1934		-6.2697	18.01	0.0062
DEPTH	44	69.8762	1.5881	4.0423		-12.1447	6.26	0.0438
LEADER	46	76.1319	1.6550	0.0000		-15.2725	0.00	.
TARGET	45	75.6199	1.6804	-1.5347		-15.0165	0.51	0.4742
AREA +								
YEAR	37	43.8418	1.1849	28.4048	9.7039	0.8725	14.01	0.0295
SEASON	41	49.7013	1.2122	26.7553		-2.0572	8.15	0.0170
DEPTH	35	43.5592	1.2445	24.8036		1.0139	0.28	0.8682
AREA + YEAR +								
SEASON	36	43.8279	1.2174	26.4411	-1.9637	0.8795	0.01	0.9060

FINAL MODEL: AREA + YEAR

Akaike's information criterion 98.0

Schwartz's Bayesian criterion 99.6

(-2) Res Log likelihood 98.0

	Type 3 Test of Fixed Effects	
Significance (Pr>Chi) of Type 3	AREA	YEAR
test of fixed effects for each factor	0.0147	0.1303
DF	3	6
CHI SQUARE	10.51	9.87

Table 3. Lo et al. method relative (index/mean) standardized abundance indices for Atlantic sharpnose sharks based on the standardized year effects obtained from the Lo et al. analyses. LCL = lower confidence limit, UCL = upper confidence limit, CV = coefficient of variation, and N = the number of sets observed.

Atlantic sharpnose sharks

YEAR	INDEX	REL INDEX	LCL	UCL	CV	N
1961	.	.	.	.	.	36
1962	.	.	.	.	.	26
1963	.	.	.	.	.	52
1964	.	.	.	.	.	41
1965	.	.	.	.	.	57
1966	.	.	.	.	.	15
1967	.	.	.	.	.	26
1968	.	.	.	.	.	28
1969	.	.	.	.	.	34
1970	.	.	.	.	.	11
1971	.	.	.	.	.	12
1972	.	.	.	.	.	14
1973	.	.	.	.	.	4
1975	.	.	.	.	.	9
1976	.	.	.	.	.	19
1977	.	.	.	.	.	64
1978	.	.	.	.	.	101
1979	0.713	1.109	-8.275	10.493	4.316	88
1980	.	.	.	.	.	82
1981	.	.	.	.	.	61
1982	.	.	.	.	.	36
1983	1.086	1.688	-10.824	14.2	3.781	45
1984	.	.	.	.	.	33
1985	0.115	0.178	-3.518	3.875	10.572	58
1986	0.861	1.339	-1.108	3.786	0.932	140
1987	.	.	.	.	.	9
1988	.	.	.	.	.	16
1989	0.109	0.169	-2.427	2.765	7.822	127
1990	.	.	.	.	.	11
1991	0.273	0.425	-2.132	2.983	3.069	146

Figure 1. Set locations

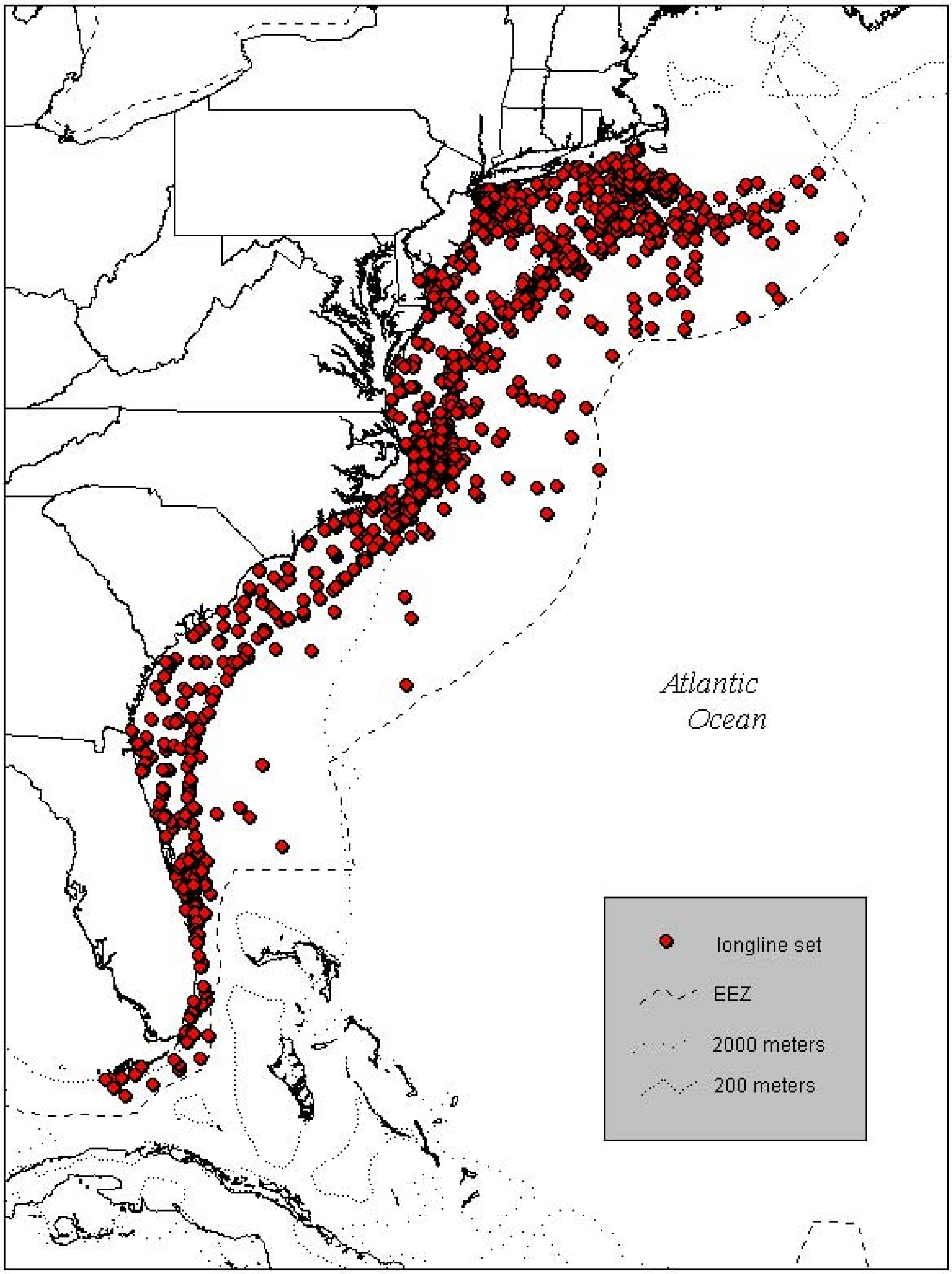

Figure 2. Relative (index/mean) indices of abundance by year for Atlantic sharpnose sharks.