

**STANDARDIZED CATCH RATES OF FOUR SHARK SPECIES
IN THE VIRGINIA - MASSACHUSETTS (U.S.) ROD AND REEL FISHERY
1986 - 1998**

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ABSTRACT

*Abundance indices for several shark species off the coast of the United States from Virginia through Massachusetts were developed using data obtained during interviews of anglers in 1986-1998. Subsets of the data were analyzed to assess effects of month, area fished, boat type (private or charter), and interview type (dockside or phone) on catch per unit effort. Standardized catch rates were developed using general linear models for unclassified mako (*Isurus sp.*), sandbar (*Carcharhinus plumbeus*), dusky (*Carcharhinus obscurus*), and blue (*Prionace glauca*) sharks. The nominal catch rate trend is presented for unclassified hammerhead (*Sphyrna sp.*) sharks.*

RÉSUMÉ

*Des indices d'abondance ont été élaborés à partir d'enquêtes menées auprès des pêcheurs sportifs de 1986 à 1998 pour plusieurs espèces de requins au large des côtes américaines, de la Virginie au Massachusetts. Des sous-jeux de données ont été analysés pour évaluer les effets mois, zone de pêche, type de bateau (privé ou en location) et type d'enquête (à quai ou par téléphone) sur la prise par unité d'effort. Des taux de capture standardisés ont été élaborés au moyen de modèles linéaires généralisés pour les requins-taupes (*Isurus sp.*), le requin gris (*Carcharhinus plumbeus*), le requin obscur (*Carcharhinus obscurus*) et le requin peau bleue (*Prionace glauca*). On présente la tendance du taux de capture nominale des requins-marteaux (*Sphyrna sp.*).*

RESUMEN

*Se desarrollaron índices de abundancia de numerosas especies de tiburones frente a la costa de Estados Unidos, desde Virginia hasta Massachusetts, empleando datos obtenidos durante entrevistas a pescadores en 1986-1998. Se analizaron subconjuntos de datos para evaluar los efectos de mes, zona de captura, tipo de barco (privado o alquilado) y tipo de entrevista (a pie de muelle o telefónica) sobre captura por unidad de esfuerzo. Las tasas de captura estandarizadas se desarrollaron por medio de modelos lineales generalizados para el marrajo (*Isurus sp.*), tiburón de Milbert (*Carcharhinus plumbeus*), tiburón arenoso (*Carcharhinus obscurus*), y tintorera (*Prionace glauca*). Se presenta la tasa de captura nominal para pez martillo (*Sphyrna sp.*) sin clasificar.*

Catch per unit effort (CPUE) data on rod and reel (RR) and handline (HL) fisheries off the coast of the United States from Virginia through Massachusetts were collected between 1980 and 1998. Fishermen were interviewed as they returned to the dock and by phone to determine if the trip was directed at large pelagic game fish (sharks, tunas, billfishes). Interviewers recorded the number of fish caught and the methods employed for each trip.

Each trip interview record includes data on: target species, date, boat type, fishing method and state. For this analysis data were restricted to only those trips which targeted sharks and which employed the chumming method. The analysis was also limited to months May through September. Nominal catch rates within these restrictions appeared to be higher than those outside. Observed effort was concentrated during June and July (85% of observations in the restricted data set) and in New Jersey - New York (72%). Observations included charter boat (38%) and private boat (62%) trips; interviews were evenly split between phone (48%) and dockside (52%).

The variation in factors such as area fished, time of year, and boat type (private/charter) make it inappropriate to compare nominal CPUE across years. A general linear model (GLM) approach (Draper and Smith 1966) was used to develop standardized indices of abundance for unclassified mako (*Isurus sp.*), sandbar (*Carcharhinus plumbeus*), dusky (*Carcharhinus obscurus*), blue (*Prionace glauca*) and unclassified hammerhead (*Sphyrna sp.*) sharks in the RR fishery during 1986-1998 (the available time period for which shark targeted effort was covered). The variables chosen for analysis were year, month, boat type, interview type (phone/dockside), state, and region. Region was defined by grouping trips from Virginia - New Jersey into a 'SOUTH' region and trips from New York - Massachusetts into a 'NORTH' region. Nominal catch rates appeared to be similar within these groupings for some species. The Lo method for GLM analysis (Lo *et al.* 1992) was employed using the logged catch per trip (X100) as the CPUE value. This method models the proportion of positive (successful) trips and the catch rate of positive trips separately and then combines the results to yield an index value.

This study represents an update of earlier work conducted on data through 1995. For that study, factors were iteratively removed from the models unless each contributed significantly to the model at the 5% level. There were insufficient observations of trips catching hammerhead sharks to permit the estimation of reliable indices and confidence limits for those species. The final models for each species are shown in Table 1. For the current study, the final models obtained for data through 1995 were retained; these models were rerun using updated data through 1998. All factors in the final models contributed significantly at the 5% (or lower) level.

The nominal CPUE and standardized catch rates are shown in Table 2. Also shown are the relative catch rate indices, calculated by dividing each nominal (or standardized) catch rate by the annual

mean nominal (or standardized catch rate) for each species. These relative trends are shown in Figures 1 - 4.

The increase in relative catch rates of blue sharks (Figure 4) in recent years (peaking in 1996) raised the concern that there may have been increased directed effort toward blue sharks which was not detected by criteria defined in the analysis (shark target, chumming method). The temporal-spatial distribution of nominal effort and catch rate levels were examined for any evidence that effort was shifting offshore. However, there was no evidence of such a trend nor of any clear correlation between distance offshore and blue shark catch rates. Another concern was the unavailability of data from New Jersey in 1988. However, since state was considered as a factor in the analyses for each species group, any significant effect of the (presence or absence of) data from a particular state should be accounted for by the models.

Literature Cited

Draper, N.R., and H. Smith. 1966. *Applied Regression Analysis*. John Wiley and Sons, Inc., New York, 407 p.

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.

SPECIES (common name)	SIGNIFICANT FACTORS	
	PROPORTION OF TRIPS SUCCESSFUL =:	CATCH PER 100 SUCCESSFUL TRIPS =:
MAKO	YEAR + MONTH	YEAR + STATE
SANDBAR	YEAR + STATE	YEAR + MONTH + INTERVIEW TYPE
DUSKY	YEAR + MONTH + REGION + INTERVIEW TYPE	YEAR + BOAT TYPE + MONTH + INTERVIEW TYPE
BLUE	YEAR + MONTH + REGION	YEAR + MONTH + REGION + INTERVIEW TYPE

TABLE 2. Nominal and GLM standardized catch per 100 trips with approximate 95% confidence intervals (upper [UCL] and lower [LCL] confidence limits shown).

YEAR	TRIPS WITH CATCH	NOMINAL CPUE	STANDARD. CPUE	LCL	UCL	TRIPS WITH CATCH	NOMINAL CPUE	STANDARD. CPUE	LCL	UCL
	MAKO					SANDBAR				
1986	369	48.70	40.02	27.85	57.52	119	21.06	15.71	7.81	31.59
1987	273	36.52	26.42	15.78	44.23	67	11.07	15.21	8.68	26.66
1988	71	15.57	11.00	4.27	28.31	59	21.32	28.98	19.58	42.89
1989	160	24.50	17.78	9.07	34.87	170	33.04	25.95	18.12	37.17
1990	201	26.21	20.35	11.10	37.28	87	11.92	8.00	3.49	18.36
1991	193	26.48	32.98	21.88	49.72	67	15.98	7.77	2.69	22.42
1992	188	30.78	31.52	20.37	48.78	66	12.48	13.28	7.25	24.34
1993	101	42.73	32.72	19.51	54.87	7	2.31	2.34	0.30	18.24
1994	93	36.69	29.31	17.85	48.11	11	3.64	2.22	0.28	17.73
1995	120	55.23	27.04	15.94	45.88	7	4.62	4.32	0.61	30.52
1996	57	38.10	31.41	19.14	51.54	6	5.82	2.49	0.23	27.17
1997	86	41.86	41.38	26.77	63.97	10	4.98	9.72	4.05	23.33
1998	55	64.71	49.89	33.59	74.10	3	2.21	1.37	0.11	17.17
	DUSKY					BLUE				
1986	169	32.04	30.93	21.61	44.26	255	87.13	77.92	50.71	119.74
1987	155	27.34	26.04	16.76	40.45	207	74.74	45.41	22.68	90.94
1988	26	8.96	13.78	6.21	30.57	228	187.42	90.38	57.61	141.80
1989	91	17.57	24.27	15.49	38.02	224	103.96	50.72	28.80	89.33
1990	105	16.65	12.21	5.89	25.29	245	73.48	59.08	34.46	101.31
1991	85	17.54	23.48	15.08	36.55	295	162.46	119.02	81.99	172.78
1992	28	5.56	6.28	1.77	22.36	386	234.36	148.65	104.79	210.85
1993	37	16.63	12.01	4.76	30.26	196	247.11	132.80	87.53	201.48
1994	20	8.96	4.83	0.96	24.36	155	242.58	161.00	111.12	233.26
1995	23	9.00	16.11	8.20	31.68	185	375.18	141.68	89.58	224.09
1996	13	12.17	18.71	7.06	49.62	129	613.76	435.01	304.08	622.31
1997	13	10.63	17.58	5.89	52.42	171	393.36	310.52	214.99	448.49
1998	10	11.03	31.62	16.95	58.97	60	213.24	193.70	123.44	303.98

TABLE 2 cont.

YEAR	TRIPS WITH CATCH	NOMINAL CPUE	STAND. CPUE	LCL	UCL	TOTAL OBSERVED TRIPS (shark target, chumming, with and without catch, months May through September)	
	HAMMERHEAD						
1986	50	5.49	NOT ESTIMATED			1002	
1987	34	3.41		1057			
1988	4	0.85		469			
1989	24	3.34		808			
1990	23	2.47		973			
1991	46	6.03		895			
1992	17	2.1		809			
1993	3	0.69		433			
1994	4	1.12		357			
1995	0	0		411			
1996	2	1.06		189			
1997	1	0.33		301			
1998	2	1.47		136			

TABLE 3. Relative nominal and GLM standardized catch per 100 trips with approximate 95% confidence intervals (upper [UCL] and lower [LCL] confidence limits shown).

YEAR	RELATIVE VALUES (yearly value/mean value across years)							
	NOMINAL CPUE	STAND. CPUE	LCL	UCL	NOMINAL CPUE	STAND. CPUE	LCL	UCL
	MAKO				SANDBAR			
1986	1.30	1.33	0.92	1.91	1.82	1.49	0.74	2.99
1987	0.97	0.88	0.52	1.47	0.96	1.44	0.82	2.52
1988	0.41	0.36	0.14	0.94	1.84	2.74	1.85	4.06
1989	0.65	0.59	0.30	1.16	2.85	2.46	1.71	3.52
1990	0.70	0.68	0.37	1.24	1.03	0.76	0.33	1.74
1991	0.71	1.09	0.73	1.65	1.38	0.74	0.25	2.12
1992	0.82	1.05	0.68	1.62	1.08	1.26	0.69	2.30
1993	1.14	1.09	0.65	1.82	0.20	0.22	0.03	1.73
1994	0.98	0.97	0.59	1.60	0.31	0.21	0.03	1.68
1995	1.47	0.90	0.53	1.52	0.40	0.41	0.06	2.89
1996	1.01	1.04	0.63	1.71	0.50	0.24	0.02	2.57
1997	1.11	1.37	0.89	2.12	0.43	0.92	0.38	2.21
1998	1.72	1.66	1.11	2.46	0.19	0.13	0.01	1.62
	DUSKY				BLUE			
1986	2.15	30.93	21.61	44.26	0.38	0.52	0.34	0.79
1987	1.83	26.04	16.76	40.45	0.32	0.30	0.15	0.60
1988	0.60	13.78	6.21	30.57	0.81	0.60	0.38	0.94
1989	1.18	24.27	15.49	38.02	0.45	0.34	0.19	0.59
1990	1.12	12.21	5.89	25.29	0.32	0.39	0.23	0.67
1991	1.17	23.48	15.08	36.55	0.70	0.79	0.54	1.14
1992	0.37	6.28	1.77	22.36	1.01	0.98	0.69	1.39
1993	1.11	12.01	4.76	30.26	1.07	0.88	0.58	1.33
1994	0.60	4.83	0.96	24.36	1.05	1.06	0.73	1.54
1995	0.60	16.11	8.20	31.68	1.62	0.94	0.59	1.48
1996	0.82	18.71	7.06	49.62	2.65	2.88	2.01	4.12
1997	0.71	17.58	5.89	52.42	1.70	2.05	1.42	2.97
1998	0.74	31.62	16.95	58.97	0.92	1.28	0.82	2.01

Figure 1. Relative nominal and GLM standardized (with approximate 95% confidence intervals shown) catch per 100 trips for mako sharks. The relative values are obtained by dividing each yearly value by the mean value across years.

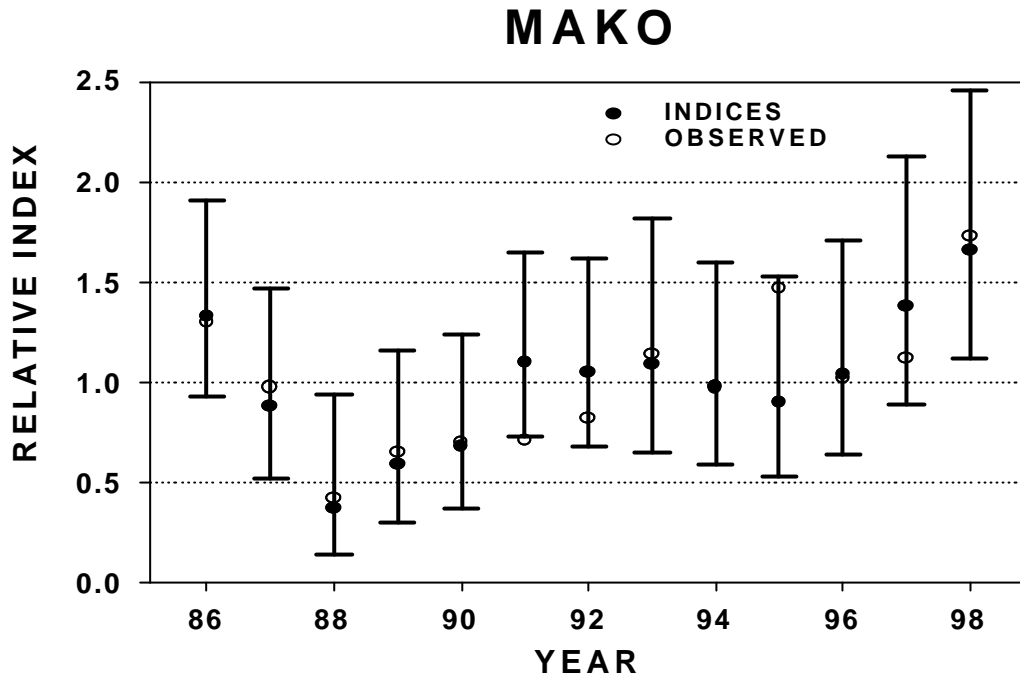


Figure 2. Relative nominal and GLM standardized (with approximate 95% confidence intervals shown) catch per 100 trips for sandbar sharks. The relative values are obtained by dividing each yearly value by the mean value across years.

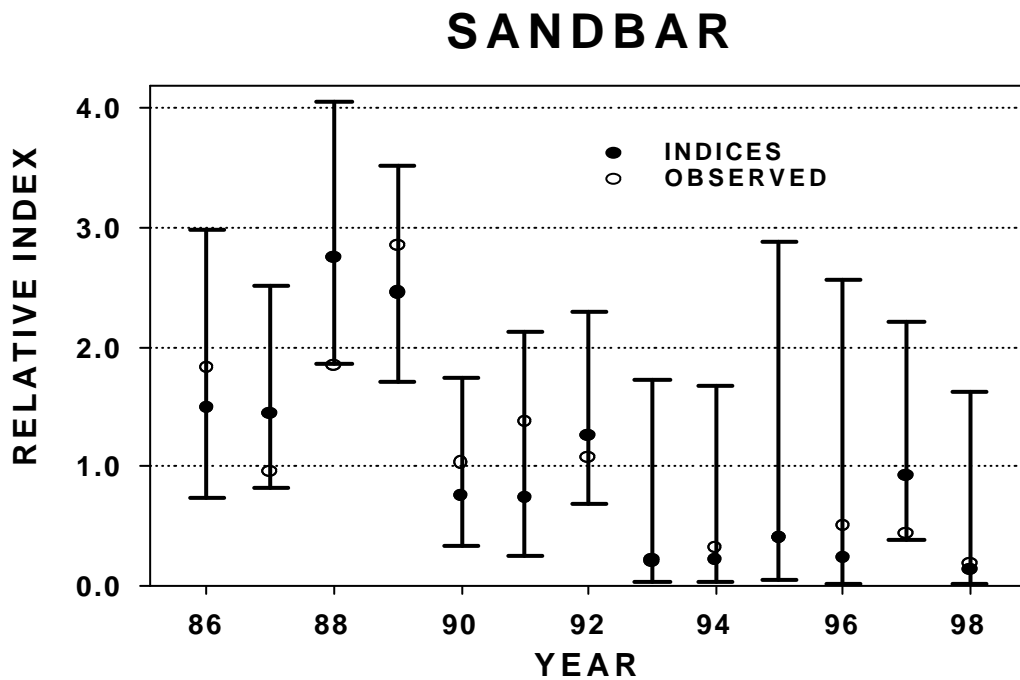


Figure 3. Relative nominal and GLM standardized (with approximate 95% confidence intervals shown) catch per 100 trips for dusky sharks. The relative values are obtained by dividing each yearly value by the mean value across years.

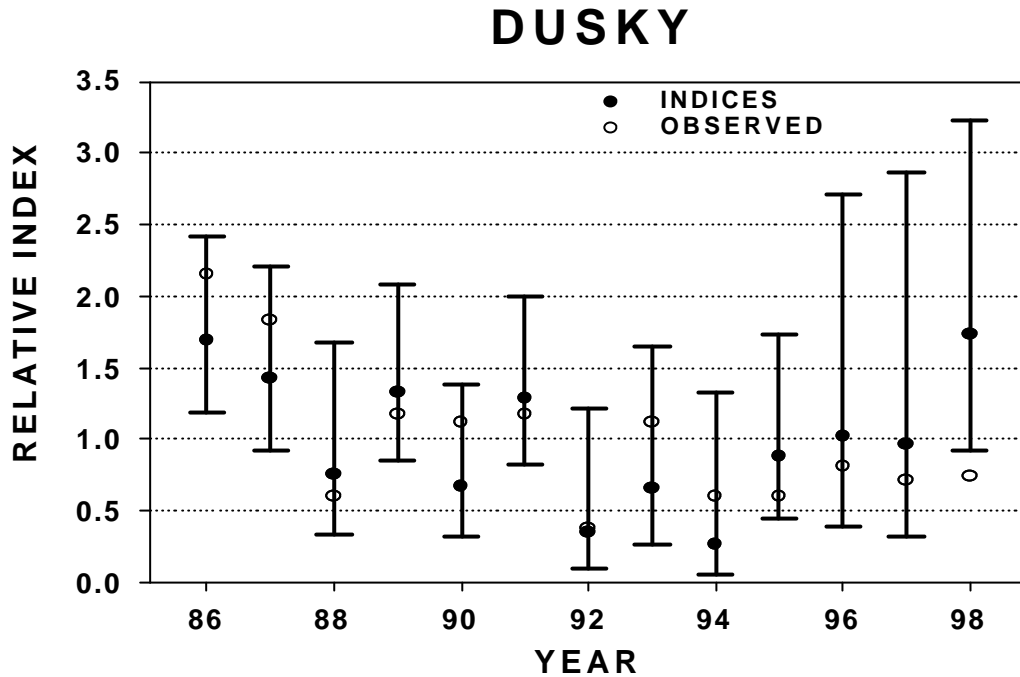


Figure 4. Relative nominal and GLM standardized (with approximate 95% confidence intervals shown) catch per 100 trips for blue sharks. The relative values are obtained by dividing each yearly value by the mean value across years.

