Length and age at maturity of the sandbar shark, *Carcharhinus plumbeus*

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Background

Maturity schedules of female and male sandbar sharks in the western North Atlantic and Gulf of Mexico were reported in Merson (1998) (see LCS05/06-DW-47). These ogives were derived from probit analyses of data collected during that study (1995-1997) combined with sandbar shark data from the NMFS Reproduction Database (1971-1996). The decision to combine the data was made because the 95% fiducial limits of ogives derived separately from each dataset overlapped, indicating there was no significant difference in the maturity schedules. Further, combining the data improved the Chi-square goodness-of-fit from >0.90 to >0.99, thus producing robust maturity schedules. A trend toward increasing proportion mature at smaller lengths in the 1995-1997 dataset suggested the possibility of differences in the length at maturity in sandbar sharks. The objective of this report is to present separate length- and age-at-maturity ogives for each of the two datasets and to explore the possibility of differences in the datasets.

Methods

Maturity status of male and female sandbar sharks from two data sets, sharks examined 1995-1997 (Table 1) and data collected by NMFS fisheries biologists from 1971 to 1996 (Table 2, NMFS Reproduction Database), was determined using anatomical indicators of reproductive maturity (LCS05/06-DW-47; Merson et al in prep.). To compare the length distributions of sandbar sharks in the datasets, length frequency histograms and analysis of variance (ANOVA) were performed using Microsoft Excel. Maturity schedules for males and females were constructed using probit analysis (Finney, 1971) with the SAS computer program (SAS Institute). Lengths were transformed to age using the length-at-age relationships described by Sminkey and Musick (1995) (LCS05/06-DW39).

Results

Maturity status was assigned to 385 female and 154 male sandbar sharks based on anatomical indicators of maturity (Tables 1 and 2). The smallest mature female was 148 cm FL and the largest immature was 175 cm FL. The smallest mature male was 139 cm FL and the largest immature was 153 cm FL. Results of probit analyses of female and male maturity data are presented in Tables 3 and 4, and Figure 1. The L_{50} estimate for female sandbar sharks sampled during 1995-1997 was 156 cm FL and the L_{50} estimate derived from the NMFS Reproduction Database was 158 cm FL, however the 95% lower fiducial limit for the L_{50} estimate using the NMFS data was 155 cm FL, indicating there no significant difference in the length at maturity derived from the two data sources. The trend of smaller length at maturity is probably due to a smaller sample size of small mature female sharks. The lengths of female sandbar sharks sampled 1995-1997 were significantly smaller than the sharks in the NMFS Reproduction Database (ANOVA, $p<0.0001$) (Figure 2A); however, there was no difference in the lengths of the male sharks sampled (Figure 2B). The study of Merson (1998) was a focused effort resulting in a relatively large sample size. Over three decades sandbar shark data have accumulated in the

NMFS Reproduction Database, however the number of samples was not sufficient to conduct a rigorous temporal comparison of length at maturity (see Table 2).

Table 1. Number of sandbar sharks sampled

Year	Females	Males
1995	193	44
1996	38	28
1997	2	0
Total	233	72

Table 2. Number of sandbar sharks in NMFS Reproduction Database used for this study

Year	Females	Males
1971	0	4
1972	5	1
1973	12	7
1974	4	7
1975	9	9
1976	8	4
1977	4	2
1978	6	1
1979	4	0
1980	3	4
1981	5	1
1982	3	4
1983	14	2
1984	5	2
1985	5	4
1986	26	6
1987	10	1
1988	1	0
1989	4	4
1990	3	0
1991	11	9
1992	1	0
1993	3	0
1994	1	6
1995	1	0
1996	4	4
Total	152	82

Table 3. Sandbar shark probability of maturity at length and age derived from probit analysis of data collected from 1995 to 1997 (Merson 1998). Age at length was assigned using Sminkey and Musick (1995) presented in the age-length table on page 11 of NMFS 2006.

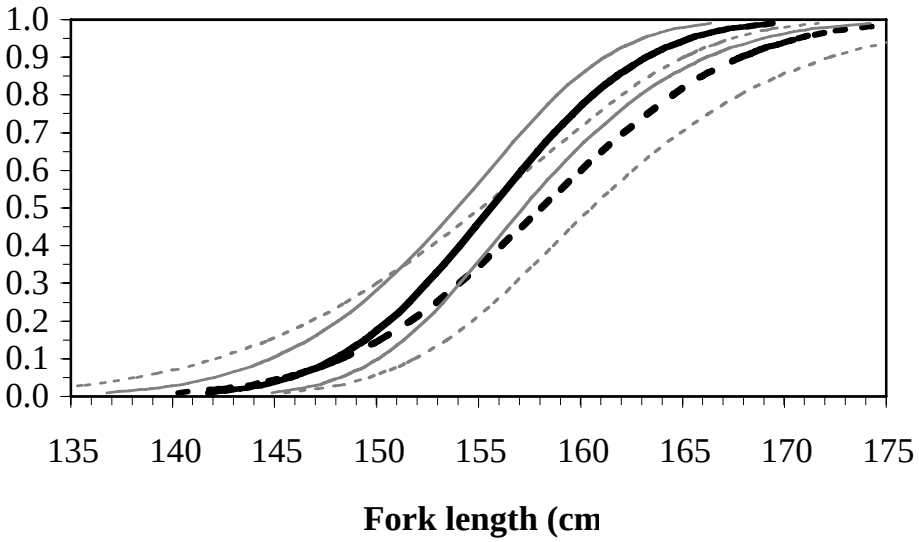
	Females				Males			
		Fiducial limits				Fiducial limits		
Probability of maturity	Length (cm FL)	Lower 95%	Upper 95%	Age	Length (cm FL)	Lower 95%	Upper 95%	Age
0.01	142	137	145	13	135	123	139	12
0.05	146	142	148	14	138	130	142	12
0.10	148	145	150	15	140	133	144	13
0.15	149	147	151	15	142	136	145	13
0.20	151	148	152	16	143	137	146	13
0.25	152	149	153	16	144	139	147	14
0.30	152	150	154	16	145	140	148	14
0.35	153	151	155	16	145	141	148	14
0.40	154	152	156	17	146	142	149	14
0.45	155	153	156	17	147	143	150	15
0.50	156	154	157	18	147	144	151	15
0.55	156	155	158	18	148	145	152	15
0.60	157	156	159	18	149	146	153	15
0.65	158	156	160	19	150	147	154	16
0.70	159	157	161	19	150	147	155	16
0.75	160	158	162	19	151	148	156	16
0.80	161	159	163	20	152	149	158	16
0.85	162	160	164	20	153	150	160	17
0.90	163	161	166	21	155	151	162	18
0.95	165	163	169	22	157	153	166	19
0.99	169	166	174	25	160	155	172	20

Table 4. Sandbar shark probability of maturity at length and age derived from probit analysis of data collected from 1971 to 1996 (NMFS Reproduction Database). Age at length was assigned using Sminkey and Musick (1995) presented in the age-length table on page 11 of NMFS 2006.

	Females				Males			
		Fiducial limits				Fiducial limits		
Probability of maturity	Length (cm FL)	Lower 95%	Upper 95%	Age	Length (cm FL)	Lower 95%	Upper 95%	Age
0.01	140	131	145	12	141	129	145	13
0.05	145	138	150	14	144	135	147	14
0.10	148	142	152	15	145	138	148	14
0.15	150	145	153	15	146	140	149	14
0.20	152	147	155	16	147	141	149	15
0.25	153	148	156	16	148	143	150	15
0.30	154	150	157	17	148	144	150	15
0.35	155	151	158	17	149	145	151	15
0.40	156	153	159	18	149	146	151	15
0.45	157	154	160	18	150	147	152	16
0.50	158	155	161	19	150	148	153	16
0.55	159	156	162	19	151	148	153	16
0.60	160	157	163	19	151	149	154	16
0.65	161	159	164	20	152	150	155	16
0.70	162	160	165	20	152	150	156	16
0.75	163	161	166	21	153	151	157	17
0.80	165	162	168	22	154	152	158	17
0.85	166	163	170	23	155	152	160	18
0.90	168	165	172	24	155	153	162	18
0.95	171	167	176	25	157	154	165	19
0.99	176	172	183	26	160	156	171	20

Figure 1. Probability of maturity-at-length from probit analyses of A) female sandbar sharks, and B) male sandbar sharks. Solid lines are sharks examined during this study, dashed lines are sharks recorded in the NMFS Reproduction Database. Black lines are probability estimates, gray lines are 95% lower and 95% upper fiducial limits. All probit analyses have Chi-square goodness-of-fit >0.90. Fiducial limits were calculated using a t-value of 1.96.

A



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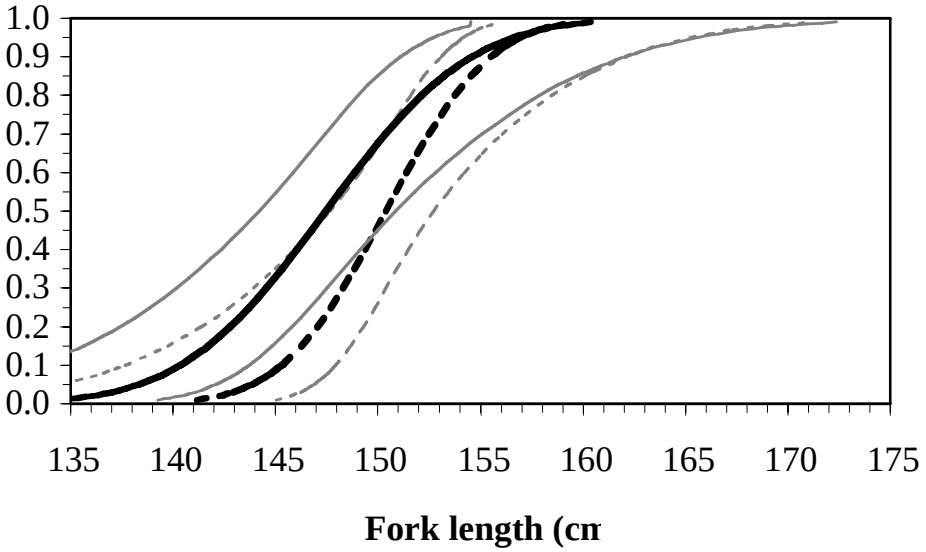
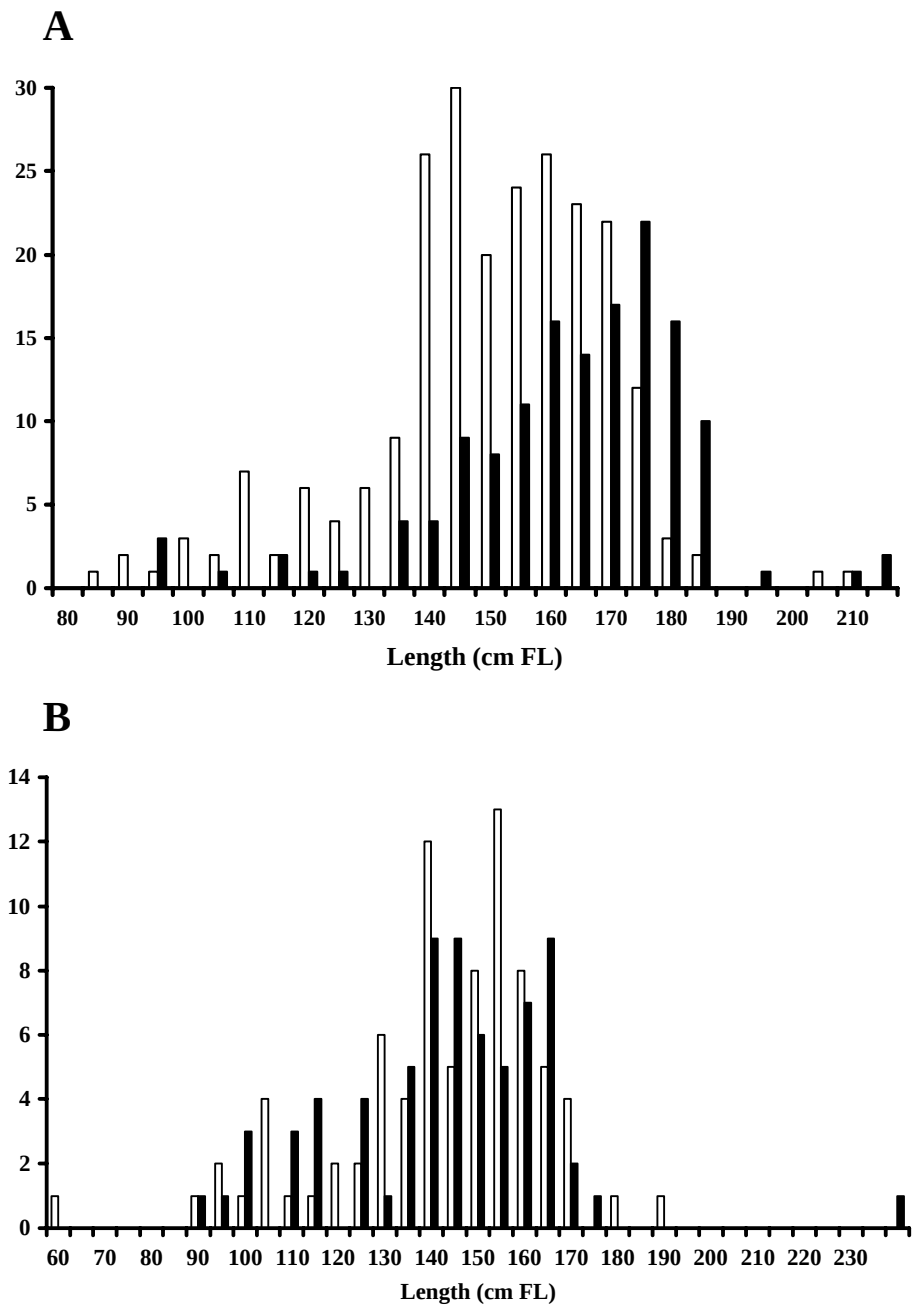


Figure 2. Length frequencies of A) female sandbar sharks and B) male sandbar sharks sampled by Merson (1998) open bars, and sharks from the NMFS Reproduction Database solid bars. Shown are lengths in 5 cm bins.



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