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Length-Length and Length-Weight Relationships for 13 Shark Species from the Western North Atlantic

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Acronyms

API	=	(NMFS Northeast Fisheries Science Center) Apex Predator Investigation
FL	=	fork length
FMP	=	fishery management plan
HSI	=	hepatosomatic index
NMFS	=	(NOAA) National Marine Fisheries Service
TL	=	total length
WT	=	body weight

Note on Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is to follow the American Fisheries Society's (AFS) lists of scientific and common names for fishes (Robins *et al.* 1991)[a], mollusks (Turgeon *et al.* 1988)[b], and decapod crustaceans (Williams *et al.* 1989)[c], and to follow the American Society of Mammalogists' list of scientific and common names for marine mammals (Wilson and Reeder 1993)[d]. This policy applies to all issues of the *NOAA Technical Memorandum NMFS-NE* series.

[a]*Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed.* Amer. Fish. Soc. Spec. Publ. *20; 183 p.*

[b]*Turgeon, D.D. (chair); Bogan, A.E.; Coan, E.V.; Emerson, W.K.; Lyons, W.G.; Pratt, W.L.; Roper, C.F.E.; Scheltema, A.; Thompson, F.G.; Williams, J.D. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks.* Amer. Fish. Soc. Spec. Publ. *16; 277 p.*

[c]*Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans.* Amer. Fish. Soc. Spec. Publ. *17; 77 p.*

[d]*Wilson, D.E.; Reeder, D.M. 1993. Mammal species of the world: a taxonomic and geographic reference. Washington, DC: Smithsonian Institution Press; 1206 p.*

INTRODUCTION

The rapid expansion of sport and commercial fisheries for sharks in the western North Atlantic has created the need to manage the stocks of several species of large sharks. In response to this need, a fishery management plan (FMP) for sharks within the U.S. Exclusive Economic Zone of the Atlantic Ocean (U.S. Department of Commerce 1992) was implemented in 1993. The 39 shark species included in the FMP are not managed on an individual species basis, but are aggregated into three species groups -- large coastal, small coastal, and pelagic. Basic biological data needed for stock assessment are lacking for many of these Atlantic sharks, including size values (i.e., minimum, maximum, and average) and size relationships/conversions (i.e., length-to-weight and fork length-to-total length). These data are essential for understanding growth rate, age structure, and other aspects of population dynamics.

Size conversions have a practical value in fisheries. One measure currently in practice at nearly all shark tournaments on the Atlantic Coast is the establishment of minimum size limits, usually a minimum weight. Since sizes must be estimated at sea, means for converting lengths to weights are essential to anglers. Moreover, the National Marine Fisheries Service (NMFS) conducts an extensive Atlantic Shark Tagging Program using volunteer assistance of recreational and commercial fishermen. Commercial fishermen generally are more confident in estimating the weight of sharks being released, while recreational fishermen estimate lengths. Conversions are needed to change these estimates into common size units for analysis.

Thus, in response to the immediate needs of tournament officials and fishermen, and for management initiatives, we present length and weight data for 13 species of large Atlantic sharks collected over a 29-yr period by the NMFS Apex Predator Investigation (API) at Narragansett, RI.

MATERIALS AND METHODS

Length and weight data were collected from sharks caught by recreational and commercial fishermen and by biologists along the U.S. Atlantic Coast from the Gulf of Maine to the Florida Keys during 1961-89. Sharks were caught primarily on rod and reel at sport fishing tournaments and on longline gear aboard research vessels and commercial fishing boats. Some data were obtained from sharks that were harpooned or taken in gill nets. Measurements from a white shark captured off Rhode Island in 1991 were also included in the analysis because of the specimen's unusually large size. Data were obtained opportunistically throughout each year, but most (88%) were collected during June-August off the northeastern United States between North Carolina and Massachusetts. Only lengths and weights measured by the authors and other members of the API or by cooperating biologists are included in this report. Measurements of embryos and fish known to be pregnant were excluded from the data set.

All lengths were taken with a metal measuring tape to the nearest centimeter in a straight line along the body axis with the caudal fin placed in a natural position. Fork length (FL) was measured from the tip of the snout to the fork of the tail. Total length (TL) is defined as the distance from the snout to a point on the horizontal axis intersecting a perpendicular line extending downward from the tip of the upper caudal lobe to form a right angle (Figure 1).

Total weight (WT) of each shark was measured to the nearest pound and converted to kilograms. The majority of fish were weighed while hanging by the caudal peduncle which allowed any water in the stomach and, in some cases, stomach contents to drain out prior to weighing. Many fish were examined internally; if unusually large amounts of water or contents were found in the stomach or abdominal cavity, the weights of such were subtracted from the overall weight to obtain a more accurate measurement.

Fork length-to-total length relationships for 13 shark species (n = 5065) were determined by the method of least squares to fit a simple linear regression model. Linear regressions of fork length-to-total length were calculated with their corresponding regression coefficients, sample sizes, and mean lengths. These data are combined into four family groups: Alopiidae (thresher sharks), Lamnidae (mackerel sharks), Carcharhinidae (requiem sharks), and Sphyrnidae (hammerhead sharks). These combined data are then graphed for comparison.

An allometric length-weight equation was calculated using the method of Pienaar and Thomson (1969) for fitting a nonlinear regression model by least squares. The form of the equation is $WT = (a)FL^b$, where WT = total weight (kg), FL = fork length (cm), and a and b are constants for each species. Length-weight relationships, mean lengths and weights, and size ranges were determined for 13 shark species (n = 9512). Literature values for maximum fork length and fork length at maturity were also included. These length-weight relationships were graphed with the size-at-maturity estimates indicated on each figure. Weight (in pounds) was calculated for every 6 inches (15 cm) of length over our size range of each of the 13 shark species to construct a chart that can be used by anglers and tournament officials for setting minimum size limits on their catches.

In addition to metric units (i.e., centimeters and kilograms), figure scales are also shown in English units (i.e., feet and pounds) to make them more useful for U.S. tournament officials, anglers, and commercial fishermen. Regressions of the length-weight equations expressed logarithmically were tested for significant differences ($p<0.05$) between males and females using an analysis-of-covariance test for homogeneity of slopes.

Fork length is used throughout this report as the basis for all conversions and comparisons. We have found fork length to be a more precise measurement. For comparison purposes, all values published elsewhere as total lengths were converted to fork lengths using the species' equations presented in this paper.

Minimum sizes at maturity reported here are from published accounts with their original sources referenced, with the exception of the thresher shark (*Alopias vulpinus*) and white shark (*Carcharodon carcharias*). Minimum size at maturity for the thresher shark and the male white shark were determined by H.L. Pratt, Jr. (pers. comm.; Nat. Mar. Fish. Serv., Narragansett, RI, May 1993), using the following criteria: smallest male with calcified claspers that rotate at the base, and smallest gravid female. When considerable variation occurred among published accounts, traditional sizes at maturity were chosen primarily from Atlantic populations. Maximum sizes and maximum sizes at birth used here are summarized in Pratt and Casey (1990).

RESULTS AND DISCUSSION

Linear regressions of fork length-to-total length for the 13 shark species are presented in Table 1, and linear regressions for the four shark family groups are portrayed in Figure 2. Slopes of the regression lines of the four families decrease with increasing length of the upper caudal lobe (Figure 2). The mackerel sharks (line 1) have lunate tails with the upper and lower caudal lobes almost equal in size. The requiem (line 2), hammerhead (line 3), and thresher (line 4) sharks have heterocercal tails with the upper lobe longer than the lower. The latter group have very long upper caudal lobes with the fork length approximately 60% of the total length. Fork length represents 92%, 84%, and 77% of total length for mackerel, requiem, and hammerhead sharks, respectively.

A total of 9512 sharks representing 13 species were measured, sexed, and weighed. There were no significant differences in slope or intercept of the length-weight relationships between males and females for any of the species. Therefore, one equation, calculated with the sexes combined, was used to represent the data for each species (Figures 3-15; Table 2).

Size at maturity for males and females is difficult to determine for pelagic sharks, and can vary in different parts of the world (Pratt and Casey 1990). The discrepancy is due, in part, to the use of variable criteria in determining a precise length at sexual maturity (Springer 1960; Clark and von Schmidt 1965; Pratt 1979), and thus maturity is often reported as a size range rather than a specific length. An individual author's definition of maturity is sometimes ambiguous or obscure. The sizes at maturity (Table 3) are from multiple reference sources, and therefore may be mixed in definition and criteria. The original published sources should be consulted for the basis for defining sexual maturity among different authors.

An attempt was made to obtain samples representative of the full size range of each species. Minimum, maximum, and mean lengths and weights by species of sharks examined in this study are reported (Tables 1 and 3). A reliable maximum size is difficult to verify. Lengths and/or weights for large fish are often reported inaccurately, and published accounts usually qualify maximum lengths with "probably reach," "possibly to," or "may grow up to." Maximum lengths (FL) reported in Pratt and Casey (1990) are included for comparison with sizes measured in this study (Table 3). With the exception of the porbeagle (*Lamna nasus*) and tiger shark (*Galeocerdo cuvier*), our data are within 62 cm (2.5 ft) of published maximum sizes. The porbeagle is less common in our study area; fewer specimens were examined (< 30), and therefore the full size range of this species is not represented. Although the tiger shark is purported worldwide to grow to 469 cm FL (15.4 ft) (Castro 1983; Compagno 1984; Pratt and Casey 1990), Atlantic specimens may not attain that size. Our longest tiger shark was 339 cm FL (11.1 ft) (Table 3). Maximum reported length examined by Branstetter (1981) in a study of tiger sharks in the north central Gulf of Mexico was 346 cm FL (11.4 ft). Maximum reported length for the U.S. Atlantic Coast is 391 cm FL (12.8 ft) (Bigelow and Schroeder 1948). These lengths are more in agreement with individuals sampled in this study.

Specimens from three shark species exceeded the maximum reported lengths (Table 3): sandbar shark (*Carcharhinus plumbeus*), shortfin mako (*Isurus oxyrinchus*), and scalloped hammerhead (*Sphyrna lewini*). The 211 cm FL (6.9 ft) female sandbar shark in this study (Table 1) was measured by one of the authors (J. Casey) and is the largest measured sandbar reported to date. This fish was caught in September 1964 by a sport fisherman approximately 10 mi east of Asbury Park, NJ. Unfortunately, the fish was not weighed. Two shortfin makos measured in this study were longer than the 336 cm FL (11.0 ft) maximum size fish published in the literature. Both of these fish were 338 cm FL (11.1 ft) females caught by sport fishermen south of Montauk Point, NY. One was landed in July 1977 and weighed 471 kg (1039 lb). The other was caught in August 1979 and weighed 382 kg (841 lb). The largest scalloped hammerhead [243 cm (8.0 ft) FL and 166 kg (365 lb)] was measured at a sportfishing tournament in July 1985, and was caught 36 mi southeast of Highlands, NJ.

The lower ends of the length-weight curves also compare well with published estimates of size at birth for each species of shark. Pratt and Casey (1990) give maximum size at birth in TL for 11 of the 13 species of sharks sampled here; all except the thresher shark are within 40 cm (15.7 inches) of those sizes. Our smallest thresher shark is 64 cm (25.2 inches) larger than the reported birth size.

All of the larger fish were female with the exception of the white shark (Figure 5) and blue shark (*Prionace glauca*) (Figure 14). The larger size attained by females is typical of sharks in general (Pratt and Casey 1983; Hoenig and Gruber 1990), and thus larger female blue and white sharks very likely occur outside of our western North Atlantic sampling area which only covers a small portion of their extensive oceanic range.

Factors Affecting Weight

Weights of individual sharks of the same length may differ depending on several factors, including the amount of stomach contents, stage of maturity, liver weight, and body condition. Effects of stomach contents on the weight of the fish were minimal in this study. In many instances, the sharks everted their stomachs prior to being weighed. For the bigger fish, when large amounts of food were present, the contents' weight was subtracted to obtain the total body weight. Since not every shark was examined internally, some pregnant fish may have been inadvertently included in the data base.

Differences in body weight also reflect differences in body condition. Sharks have large livers which store high-energy, fatty acids for buoyancy and use as a food reserve (Bone and Roberts 1969; Oguri 1990). The weight of this organ is thus a good indicator of the health or condition of a shark (Springer 1960; Cliff et al. 1989). The liver is the largest organ by weight in the shark and can vary from 2 to 24% of body weight depending on the species (Cliff et al. 1989; Winner 1990). This variation in liver size accounted for the majority of the weight difference in individuals of the same species with corresponding lengths.

Of the eight largest white sharks, six were measured for liver weight; those liver weights ranged from 14.6 to 22.7% of body weight (hepatosomatic index or HSI) (Table 4). The 458 cm (15.0 ft) FL white shark in this group had the lowest HSI value (14.6%) although it was longer than four heavier fish. The difference in body weight between the 458 cm (15.0 ft) FL and the 463 cm (15.2 ft) FL fish is 360 kg (794 lb). When the body weights of these two fish -- minus their liver weights -- are compared, the difference is reduced to 239 kg (526 lb). Thus, liver weight accounted for 34% of the body weight difference between these two sharks of similar length.

The same is true for large shortfin makos. The HSI for one of the longest makos [338 cm (11.1 ft) FL and 382 kg (841 lb)] was 5.4%, as contrasted with 17.9% for the 323 cm (10.6 ft) FL fish weighing 490 kg (1080 lb). When the body weights of these two fish -- minus their liver weights -- are compared, the difference is reduced from 108 kg (239 lb) to 41 kg (91 lb).

ACKNOWLEDGMENTS

The data for this study could not have been collected without the help and cooperation of thousands of fishermen who allowed us to measure their shark catches over the last 29 yr. The scientists, officers, and crew of several research vessels also assisted in obtaining specimens during sampling cruises. We are particularly grateful to tournament officials and participants from New York, New Jersey, Massachusetts, and Rhode Island from whose catches a large part of the data were collected. Further, we would like to thank the past and present members of the Apex Predator Investigation, including Chuck Stillwell, Lisa J. Natanson, Ruth Briggs, H.L. Pratt, Jr., and Gregg Skomal, for their assistance and support.

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Table 1. Fork length (FL) - total length (TL) relationships for 13 shark species from the western North Atlantic, based on FL = (a)TL + b. (Fork length and total length means and ranges were taken from data presented in this study.)

Species	N	Mean total length (cm)	Total length range (cm)	Mean fork length (cm)	Fork length range (cm)	FL = (a)TL + b		
						a	b	r^2
Bigeye thresher (*Alopias superciliosus*)	56	312	155-371	192	100-228	0.5598	17.6660	0.8944
Thresher shark (*A. vulpinus*)	13	373	291-450	211	168-262	0.5474	7.0262	0.8865
White shark (*Carcharodon carcharias*)	112	204	122-517	187	112-493	0.9442	-5.7441	0.9975
Shortfin mako (*Isurus oxyrinchus*)	199	171	70-368	157	65-338	0.9286	-1.7101	0.9972
Porbeagle (*Lamna nasus*)	13	201	119-247	182	106-227	0.8971	1.7939	0.9877
Bignose shark (*Carcharhinus altimus*)	10	174	132-228	148	112-192	0.8074	7.7694	0.9872
Silky shark (*C. falciformis*)	15	173	90-258	142	73-212	0.8388	-2.6510	0.9972
Dusky shark (*C. obscurus*)	148	153	92-330	125	74-277	0.8396	-3.1902	0.9947
Sandbar shark (*C. plumbeus*)	3734	123	51-249	103	42-211	0.8175	2.5675	0.9933
Night shark (*C. signatus*)	38	154	72-235	130	60-195	0.8390	0.5026	0.9883
Tiger shark (*Galeocerdo cuvier*)	44	247	145-375	203	116-318	0.8761	-13.3535	0.9887
Blue shark (*Prionace glauca*)	572	214	64-337	179	52-282	0.8313	1.3908	0.9932
Scalloped hammerhead (*Sphyrna lewini*)	111	206	82-278	160	64-216	0.7756	-0.3132	0.9868

Table 2. Predicted weight (lb) for various fork lengths (ft) of 13 shark species from the western North Atlantic. (Fork length ranges were taken from data presented in this study.)

FORK LENGTH	BIGEYE THRESHER	COMMON THRESHER	WHITE	MAKO	PORBEAGLE	BIGNOSE	SILKY	DUSKY	SANDBAR	NIGHT	TIGER	BLUE	SCALLOPED HAMMERHEAD	FORK LENGTH
16			3275											16
15.5			2969											15.5
15			2683											15
14.5			2417											14.5
14			2169											14
13.5			1939											13.5
13			1726											13
12.5			1529											12.5
12			1348											12
11.5			1182											11.5
11			1031	987							954			11
10.5			893	853							820			10.5
10			768	732							699			10
9.5			656	623							592			9.5
9			555	526				444			496	303		9
8.5		498	465	439				379			412	253		8.5
8		427	386	363				320			338	209		8
7.5		363	316	297				267			274	171	294	7.5
7	300	305	256	239	262			221			219	138	238	7
6.5	239	253	203	189	210	200	175	179	199	185	172	109	190	6.5
6	186	207	159	147	166	151	138	144	157	143	132	85	149	6
5.5	143	166	121	112	128	112	107	113	120	108	100	65	114	5.5
5	106		91	83	97	81	81	86	90	79	73	48	85	5
4.5	77		65	60	71	56	60	64	66	56	52	35	61	4.5
4	53		45	41	50	37	42	46	46	38	35	24	43	4
3.5	35			27	34	23	29	32	31	25	23	16	28	3.5
3				17			18	21	19	15		10	18	3
2.5				9			11		11	8		5		2.5
2									6	4		3		2
1.5									2					1.5
FORK LENGTH FEET	BIGEYE THRESHER	COMMON THRESHER	WHITE	MAKO	PORBEAGLE	BIGNOSE	SILKY	DUSKY	SANDBAR	NIGHT	TIGER	BLUE	SCALLOPED HAMMERHEAD	FORK LENGTH FEET

Table 3. Fork length (FL) - total weight (WT) relationships for 13 shark species from the western North Atlantic, based on WT = (a)FL^b. (Fork length and weight means and ranges were taken from data presented in this study. Maximum fork lengths and fork lengths at maturity were obtained from the literature.)

Species	Sex	N	Mean fork length (cm)	Fork length range (cm)	Maximum fork length (cm)	Fork length at maturity (cm)	Mean weight (kg)	Weight range (kg)	WT = (a)FL^b a	b	r2
Bigeye thresher (*Alopias superciliosus*)	Combined	55	190	100-228	270[a]		99	11-170	9.1069×10^{-6}	3.0802	0.9059
	Male	34	188	100-221		180[a]	92	11-150			
	Female	21	194	123-228		214[a]	110	23-170			
Thresher shark (*A. vulpinus*)	Combined	88	201	154-262	276[d]		122	54-211	1.8821×10^{-4}	2.5188	0.8795
	Male	46	197	154-228		184[b]	116	54-181			
	Female	41	207	155-262		226[b]	129	59-211			
White shark (*Carcharodon carcharias*)	Combined	125	186	112-493	555[c]		141	12-1554	7.5763×10^{-6}	3.0848	0.9802
	Male	65	203	117-493		332[b]	208	16-1554			
	Female	59	168	112-310		454[l]	69	12-297			
Shortfin mako (*Isurus oxyrinchus*)	Combined	2081	172	65-338	336[d]		63	2-531	5.2432×10^{-6}	3.1407	0.9587
	Male	1007	169	70-260		179[e]	59	2-210			
	Female	1054	174	65-338		258[e]	68	3-531			
Porbeagle (*Lamna nasus*)	Combined	15	185	106-227	329[a]		83	19-143	1.4823×10^{-5}	2.9641	0.9437
	Male	13	180	106-216		159[f]	77	19-113			
	Female	2	214	201-227		204[f]	117	91-143			
Bignose shark (*Carcharhinus altimus*)	Combined	38	151	97-210	235[a]		42	6-143	1.0160×10^{-6}	3.4613	0.8958
	Male	12	158	115-205		182[g]	45	14-99			
	Female	26	148	97-210		190[g]	41	6-143			
Silky shark (*C. falciformis*)	Combined	85	118	73-212	253[h]		22	4-88	1.5406×10^{-5}	2.9221	0.9720
	Male	39	117	73-196		178[k]	22	4-88			
	Female	46	119	78-212		186[k]	22	4-88			
Dusky shark (*C. obscurus*)	Combined	247	162	79-287	303[g]		69	5-270	3.2415×10^{-5}	2.7862	0.9649
	Male	103	136	79-276		231[h]	39	5-216			
	Female	144	181	83-287		235[h]	90	6-270			
Sandbar shark (*C. plumbeus*)	Combined	1548	129	44-201	198[g]		30	1-104	1.0885×10^{-5}	3.0124	0.9385
	Male	577	115	45-183		150[h]	20	1-68			
	Female	961	138	44-201		152[h]	36	1-104			
Night shark (*C. signatus*)	Combined	124	111	60-203	235[a]		15	3-102	2.9206×10^{-6}	3.2473	0.9502
	Male	69	112	93-195		-	14	8-64			
	Female	55	111	60-203		150[g]	16	3-102			
Tiger shark (*Galeocerdo cuvier*)	Combined	187	203	92-339	469[a]		110	5-499	2.5281×10^{-6}	3.2603	0.9550
	Male	92	209	95-318		258[i]	113	7-348			
	Female	92	197	92-339		265[i]	107	5-499			
Blue shark (*Prionace glauca*)	Combined	4529	195	52-288	320[a]		52	1-174	3.1841×10^{-6}	3.1313	0.9521
	Male	3095	205	54-288		183[j]	59	1-174			
	Female	1398	172	52-273		185[j]	34	1-140			
Scalloped hammerhead (*Sphyrna lewini*)	Combined	390	158	79-243	239[k]		47	5-166	7.7745×10^{-6}	3.0669	0.9255
	Male	189	166	107-224		139[k]	53	11-126			
	Female	199	151	79-243		194[k]	41	5-166			

[a] Castro (1983).
[b] H.L. Pratt, Jr., personal communication; National Marine Fisheries Service, Narragansett, RI; May 1993.
[c] Randall (1987).
[d] Pratt and Casey (1990).
[e] Stevens (1983).
[f] Aasen (1961).
[g] Compagno (1984).
[h] Springer (1960).
[i] Branstetter et al. (1987).
[j] Pratt (1979).
[k] Branstetter (1987).
[l] Casey and Pratt (1985).

Table 4. Fork lengths, body and liver weights, and hepatosomatic indices for large white sharks from the western North Atlantic

Fork length (cm)	Whole body weight (kg)	Liver weight (kg)	Hepatosomatic index (%)
463	1245	250	20.1
458	885	129	14.6
446	1261	206	16.3
444	1320	232	17.6
437	1084	246	22.7
425	941	179	19.0

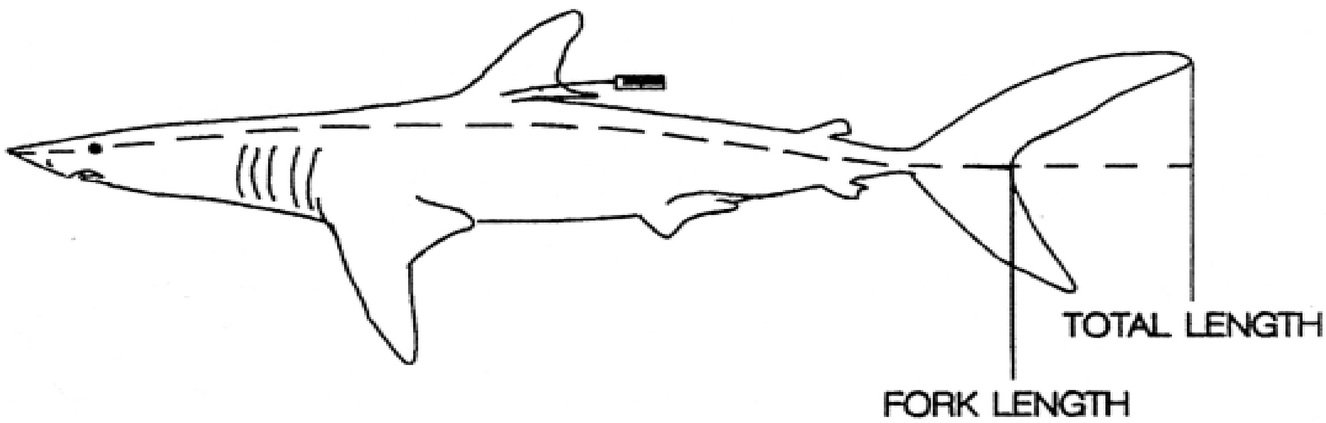

Figure 1. Portrayal of measurements used in this study.

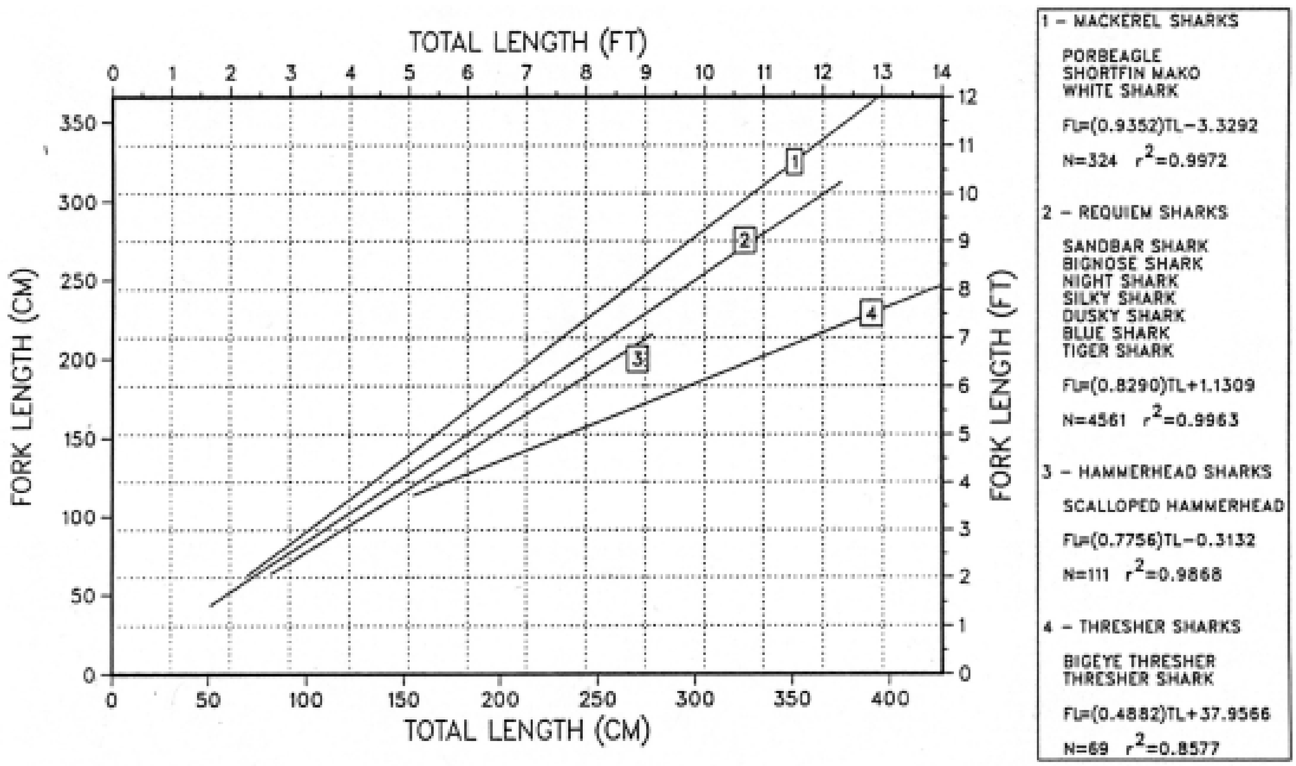

Figure 2. Linear regression lines and equations for fork length - total length relationships by family for 13 shark species from the western North Atlantic.

BIGEYE THRESHER (*Alopias superciliosus*)

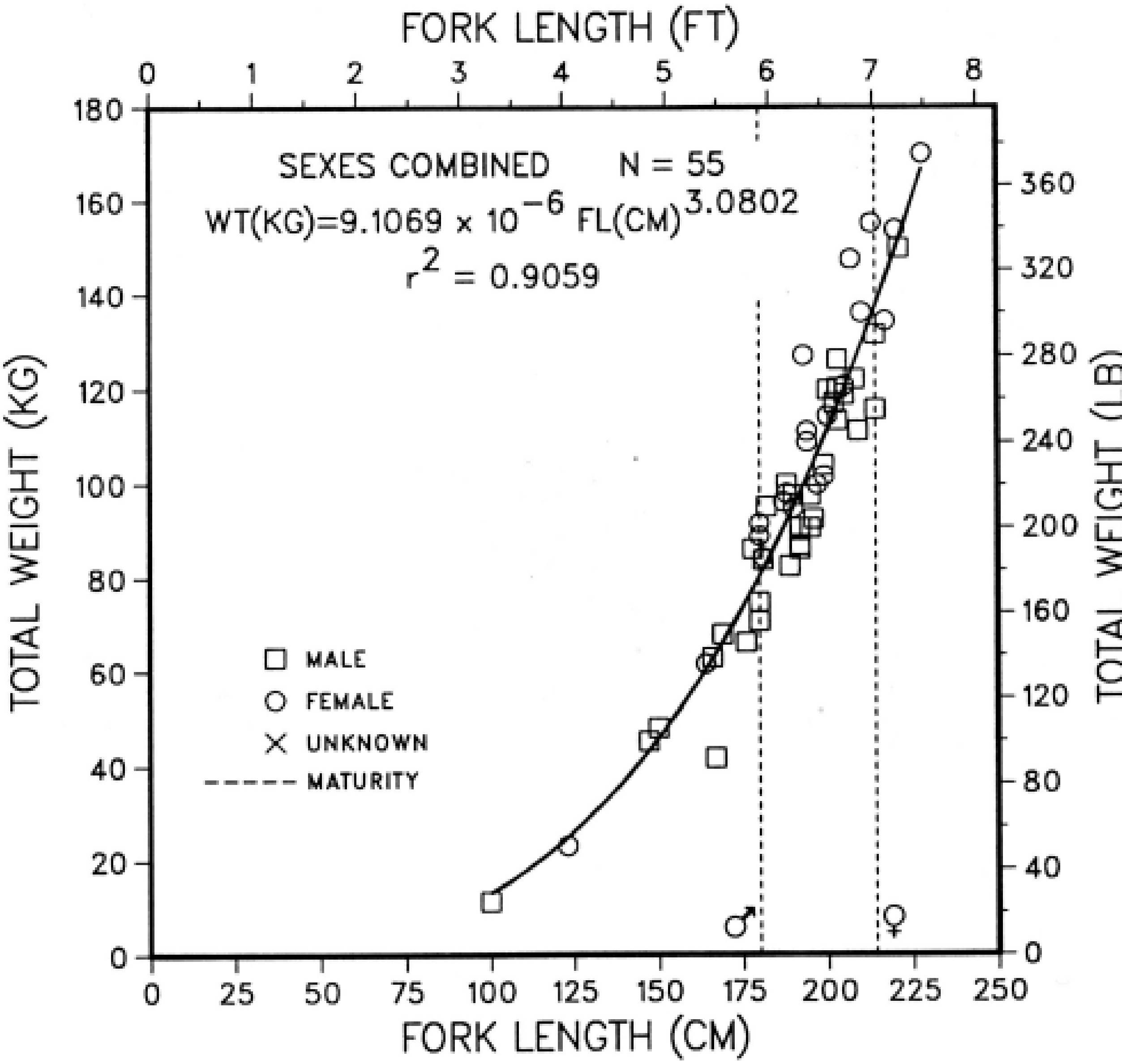

Figure 3. Relationship between fork length and total body weight (sexes combined) for the bigeye thresher (*Alopias superciliosus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

THRESHER SHARK (*Alopias vulpinus*)

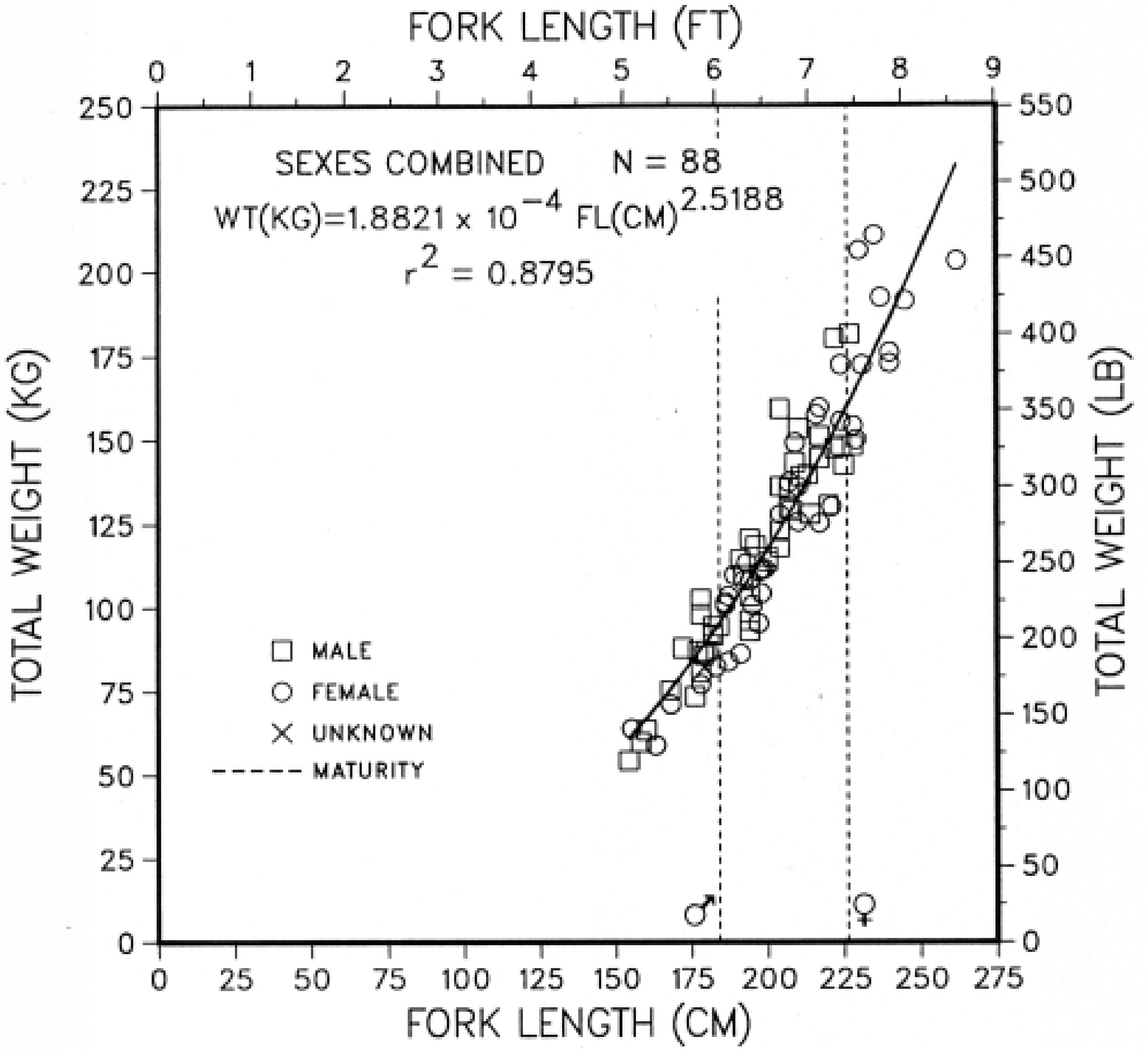

Figure 4. Relationship between fork length and total body weight (sexes combined) for the thresher shark (*Alopias vulpinus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

WHITE SHARK (*Carcharodon carcharias*)

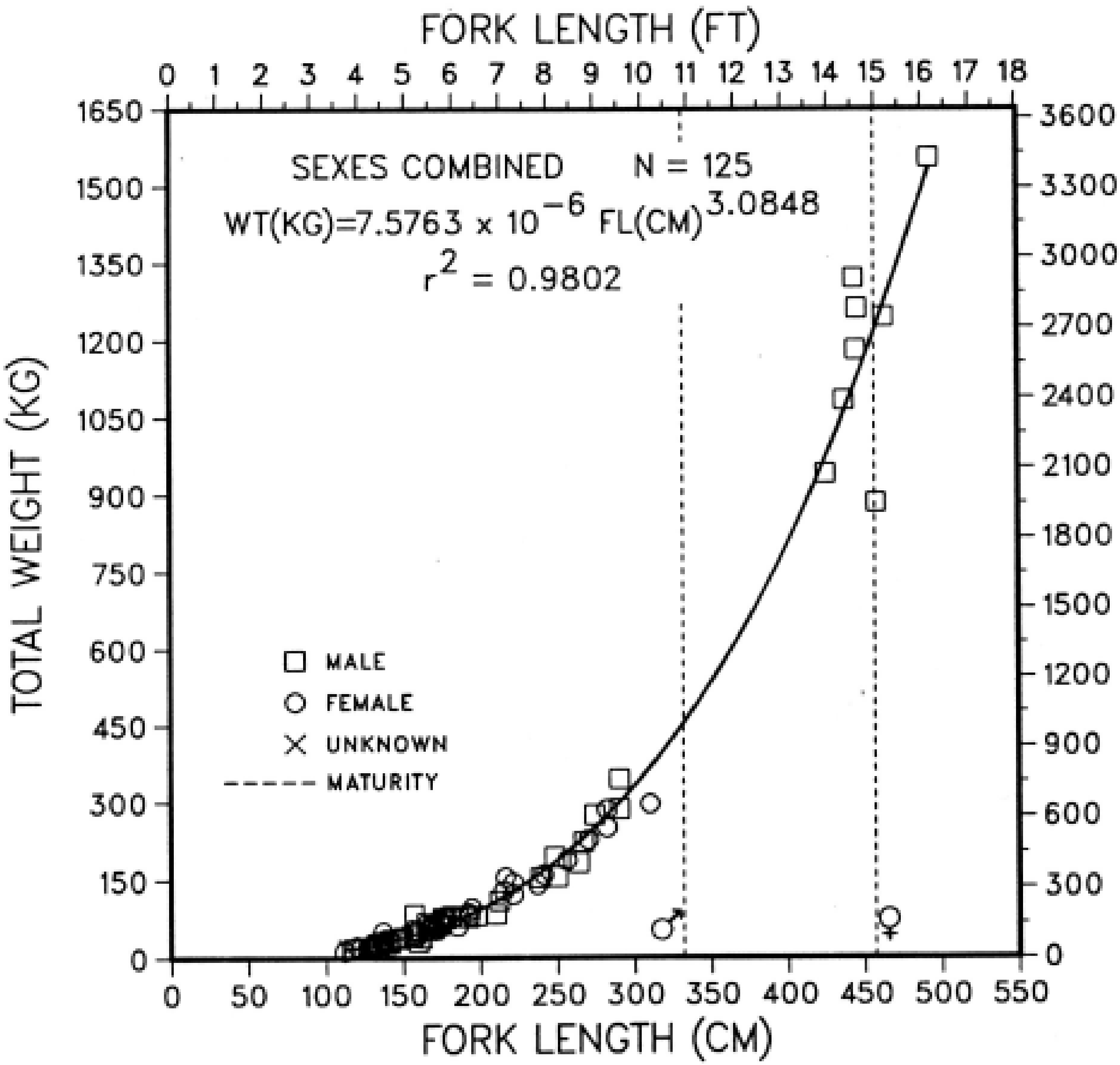

Figure 5. Relationship between fork length and total body weight (sexes combined) for the white shark (*Carcharodon carcharias*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

SHORTFIN MAKO (*Isurus oxyrinchus*)

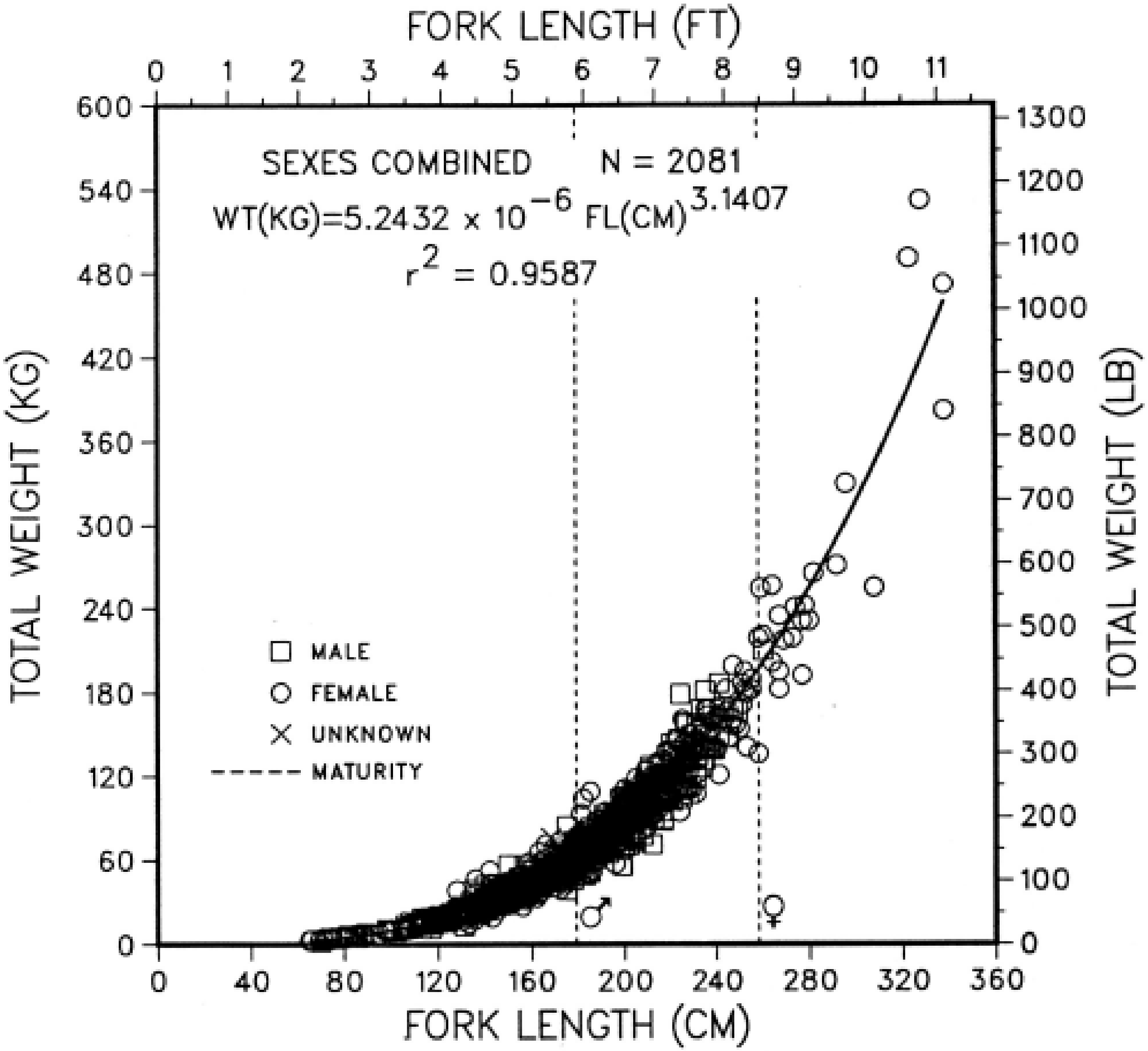

Figure 6. Relationship between fork length and total body weight (sexes combined) for the shortfin mako (*Isurus oxyrinchus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

PORBEAGLE (*Lamna nasus*)

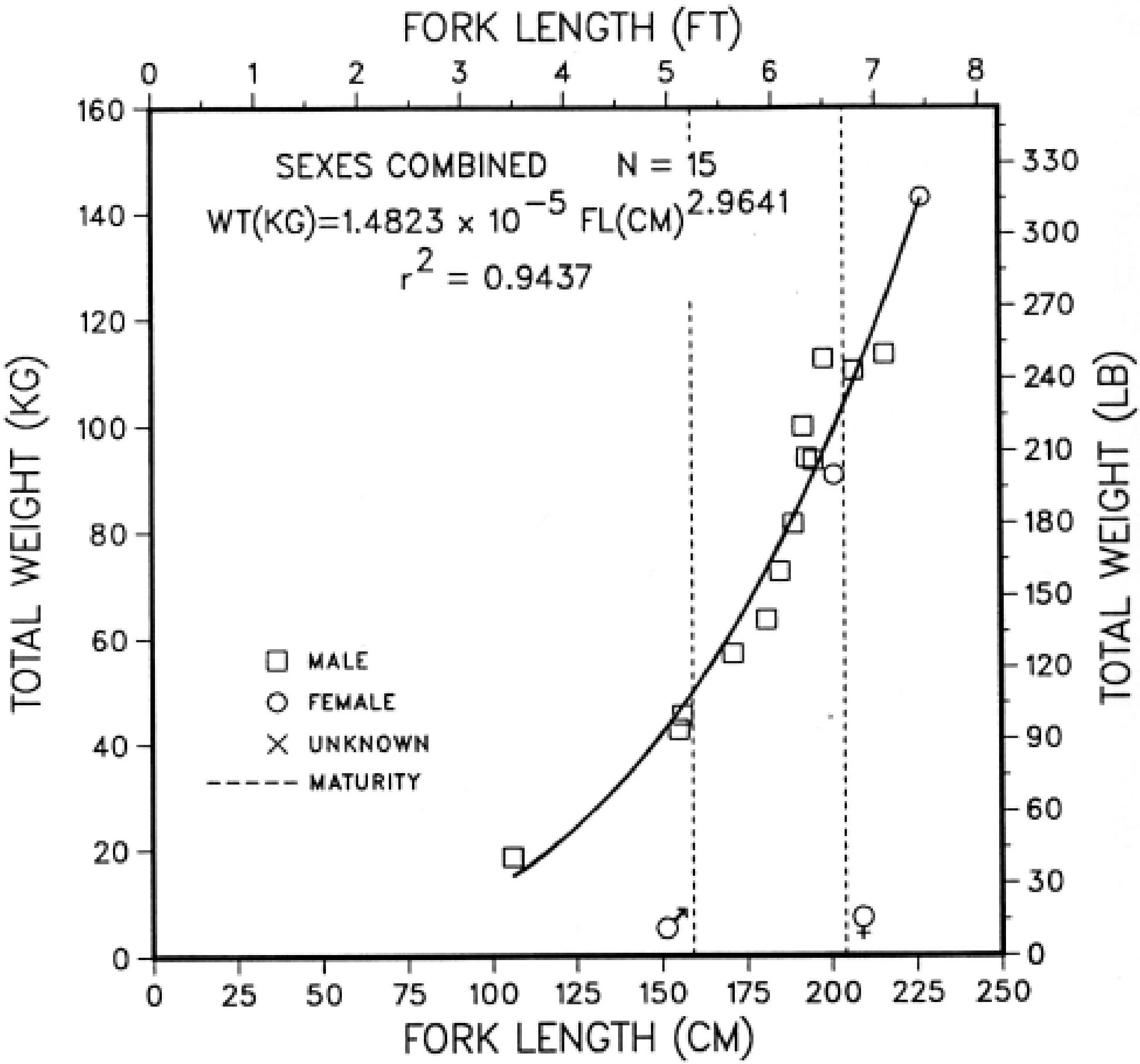

Figure 7. Relationship between fork length and total body weight (sexes combined) for the porbeagle (*Lamna nasus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

BIGNOSE SHARK (*Carcharhinus altimus*)

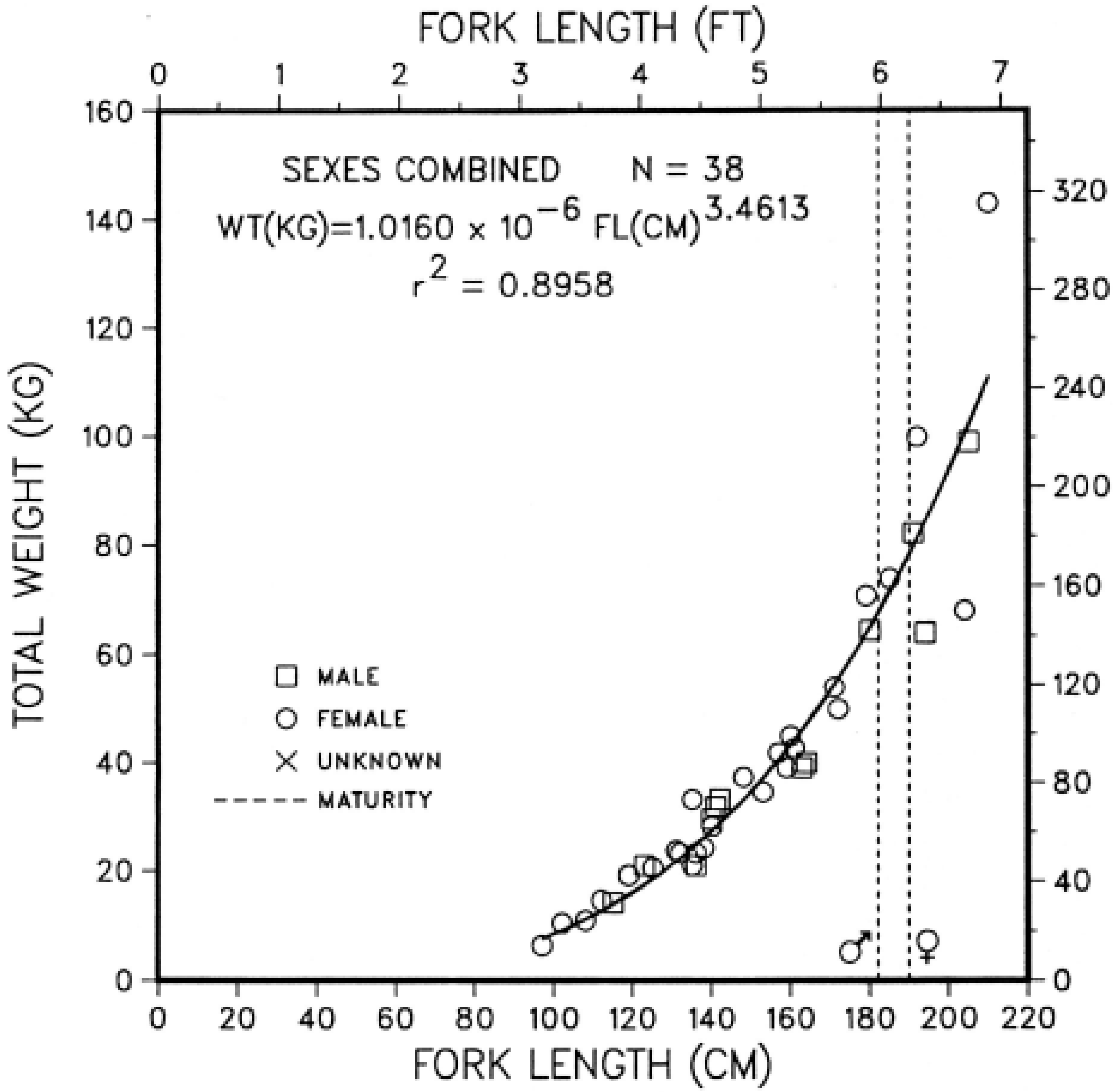

Figure 8. Relationship between fork length and total body weight (sexes combined) for the bignose shark (*Carcharhinus altimus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

SILKY SHARK (*Carcharhinus falciformis*)

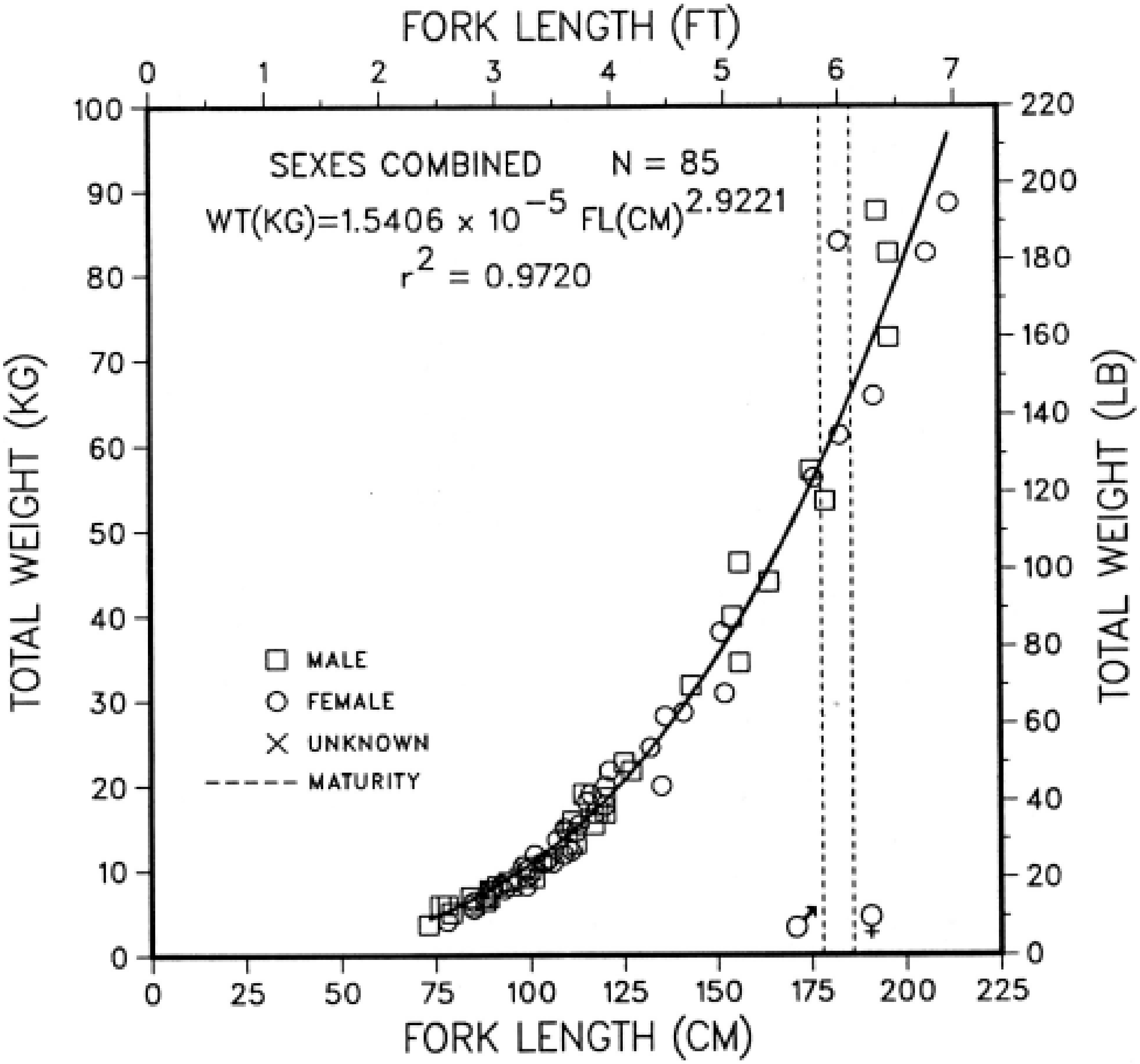

Figure 9. Relationship between fork length and total body weight (sexes combined) for the silky shark (*Carcharhinus falciformis*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

DUSKY SHARK (*Carcharhinus obscurus*)

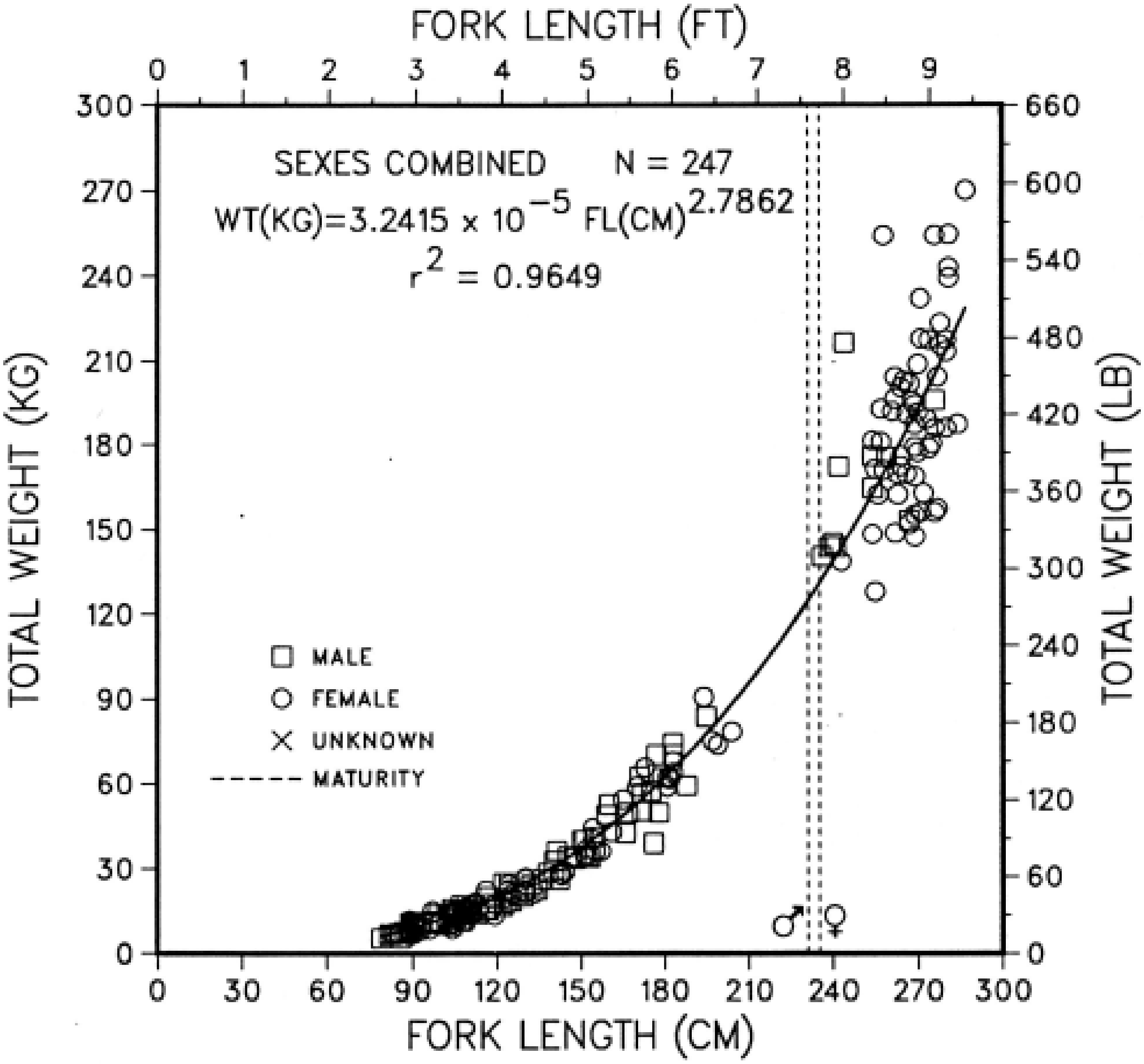

Figure 10. Relationship between fork length and total body weight (sexes combined) for the dusky shark (*Carcharhinus obscurus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

SANDBAR SHARK (*Carcharhinus plumbeus*)

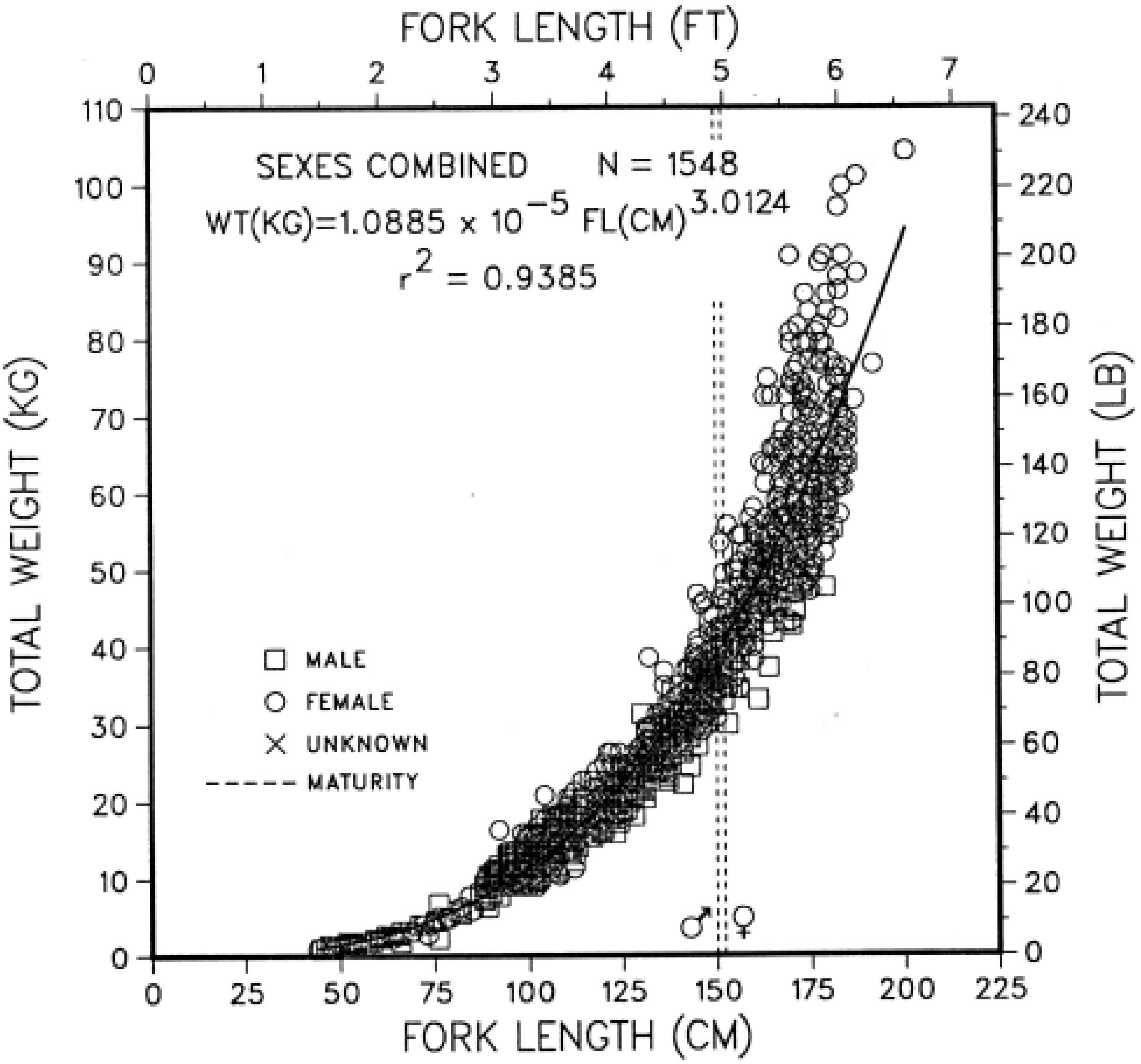

Figure 11. Relationship between fork length and total body weight (sexes combined) for the sandbar shark (*Carcharhinus plumbeus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

NIGHT SHARK (*Carcharhinus signatus*)

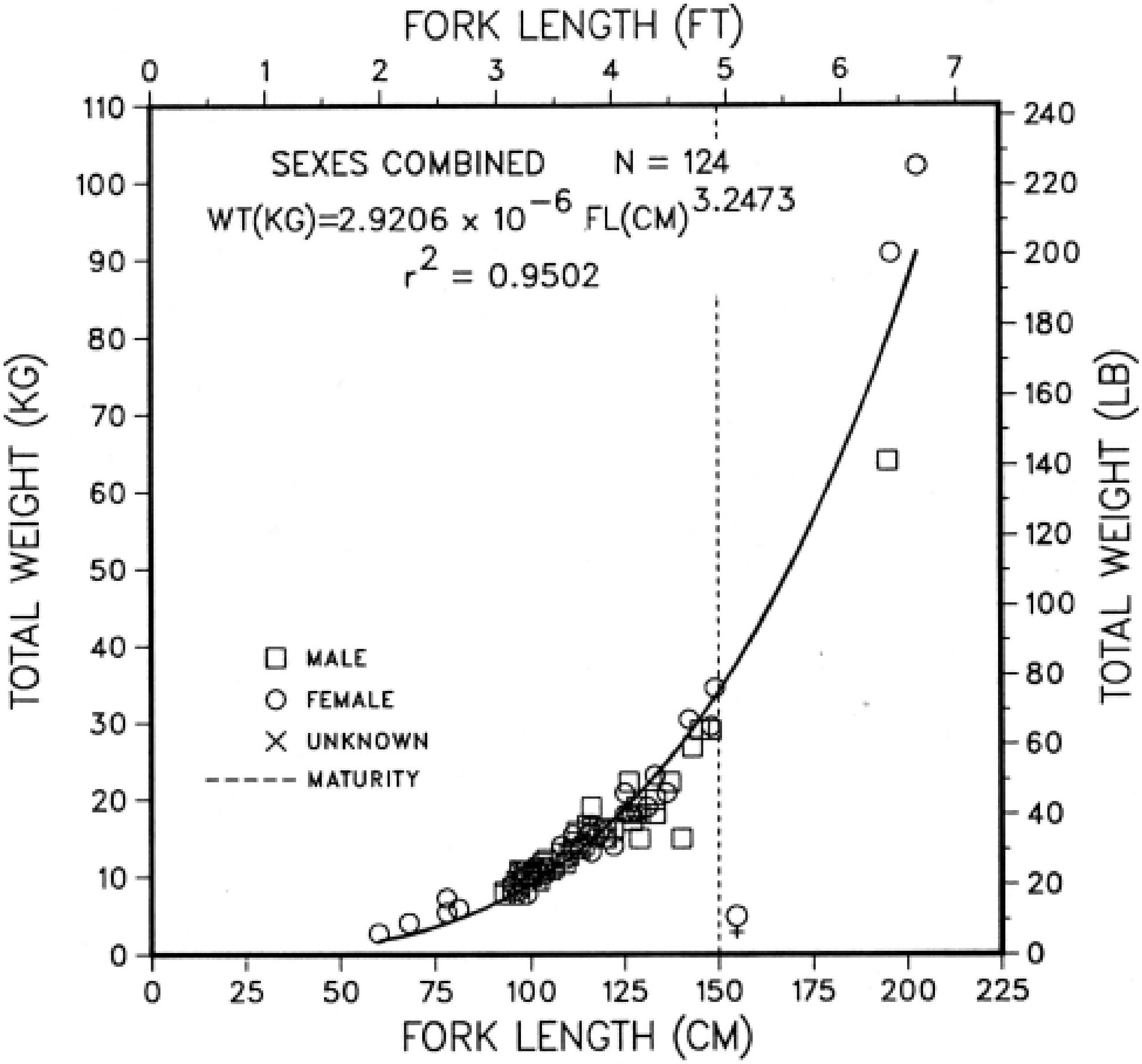

Figure 12. Relationship between fork length and total body weight (sexes combined) for the night shark (*Carcharhinus signatus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

TIGER SHARK (*Galeocerdo cuvier*)

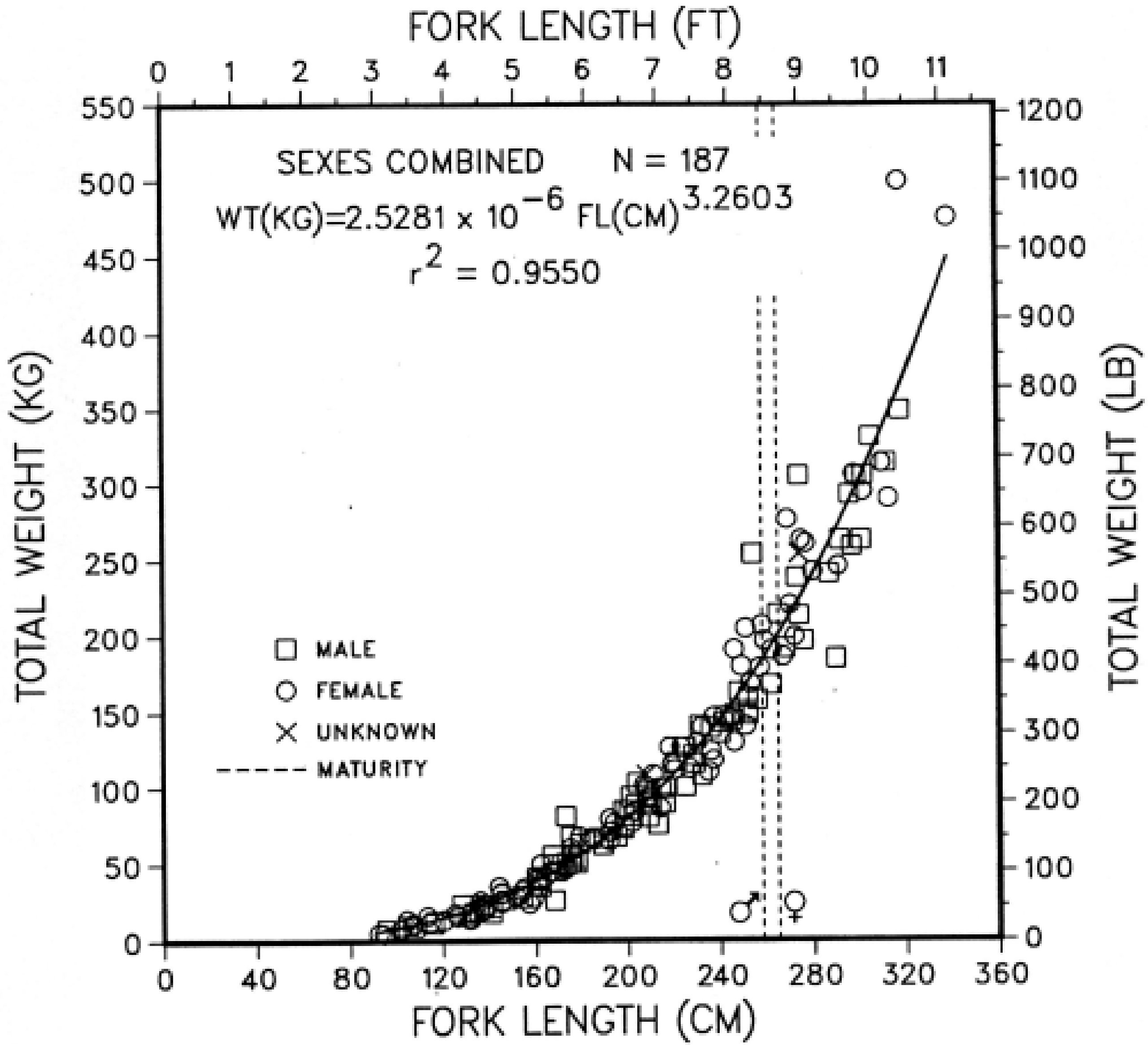

Figure 13. Relationship between fork length and total body weight (sexes combined) for the tiger shark (*Galeocerdo cuvier*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂= male, ♀ = female).

BLUE SHARK (*Prionace glauca*)

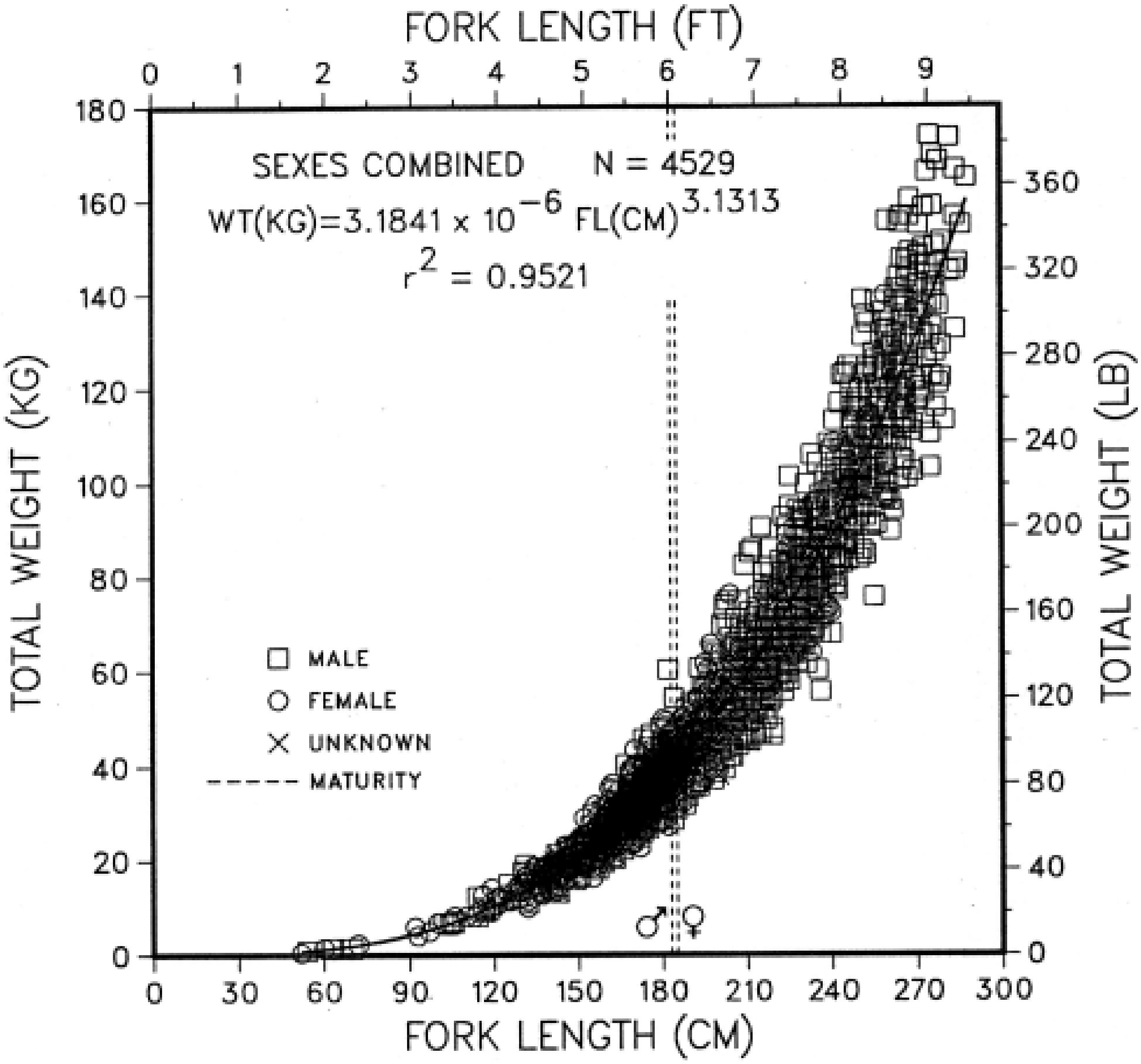

Figure 14. Relationship between fork length and total body weight (sexes combined) for the blue shark (*Prionace glauca*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂= male, ♀ = female).

SCALLOPED HAMMERHEAD (*Sphyrna lewini*)

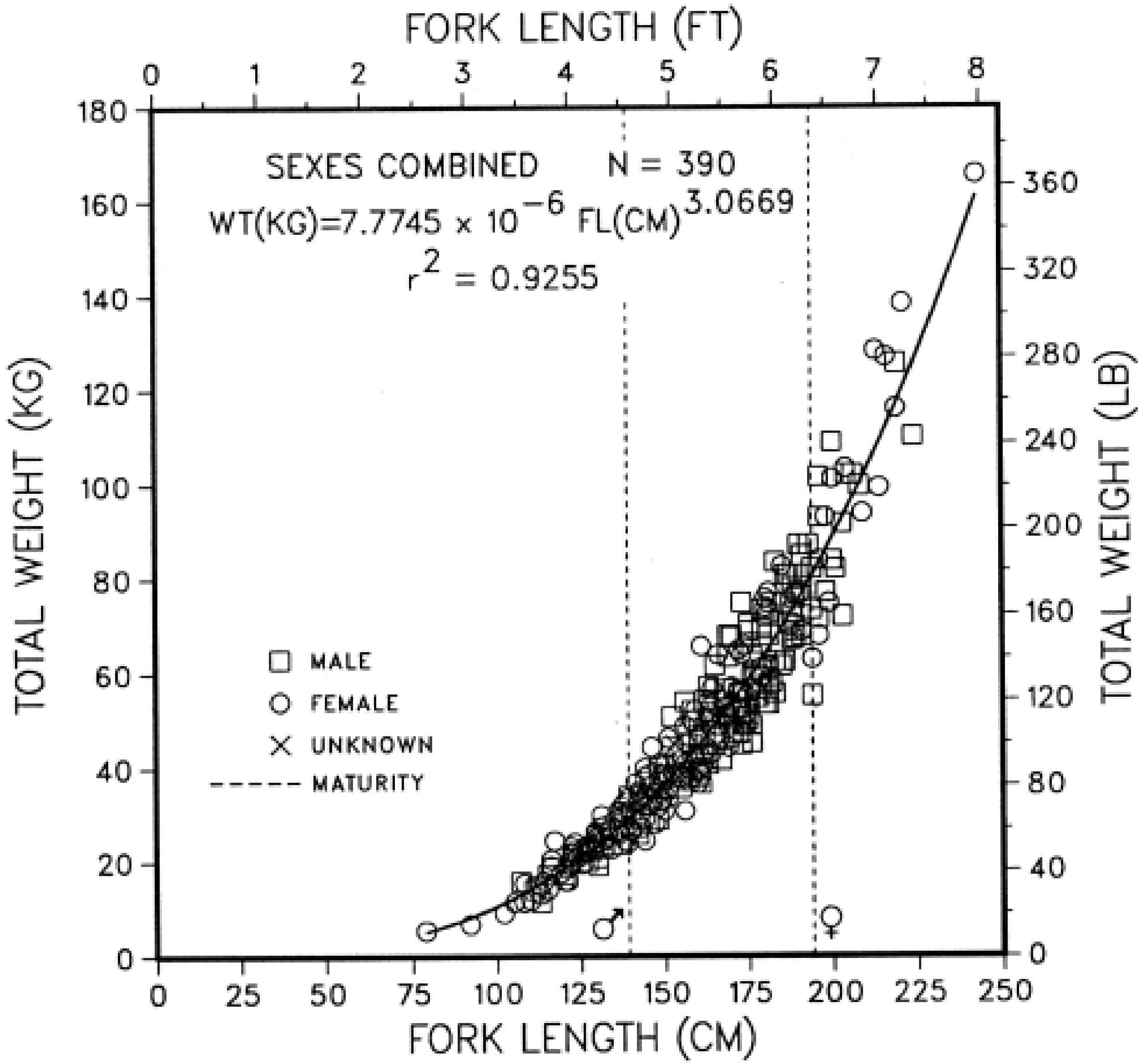

Figure 15. Relationship between fork length and total body weight (sexes combined) for the scalloped hammerhead (*Sphyrna lewini*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female).

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