



A catalogue of great white sharks *Carcharodon carcharias* (Linnaeus, 1758) preserved in European museums

Alessandro De Maddalena

Banca Dati Italiana Squalo Bianco (Italian Great White Shark Data Bank), via L. Ariosto 4, I-20145, Milano, Italy; e-mail: a-demaddalena@tiscali.it

ABSTRACT. A catalogue of white sharks preserved in European museums is presented, representing 101 specimens from 42 institutions. Most specimens with known capture locations come from the Mediterranean. The jaws belonging to BAM, Milano, dated from at least 1640–1660, are the oldest white shark material preserved in Europe. The largest specimens of which parts are preserved in any museum may be those of which skeletal parts are preserved in MACR, Roma, and MZF, Firenze: for both these specimens an approximate length of 600 cm is indicated in the literature. The cast of a 565 cm long female, preserved in the MCZL, Lausanne, is the world's largest that has been reconstructed directly from a whole specimen. The largest taxidermied specimen is a 522 cm long female preserved in the MCSNT, Trieste. The 150 cm long female preserved in SFN, Frankfurt/Main is the smallest taxidermied white shark. The data collected reconfirms that the size of teeth and jaws is not a reliable index for estimating the size of large or medium-sized white sharks.

■ **Key words:** great white shark, *Carcharodon carcharias*, museums, Europe

INTRODUCTION

Since 1996 the Italian Great White Shark Data Bank (Banca Dati Italiana Squalo Bianco) has collected a substantial amount of information regarding historical and recent records of the white shark, *Carcharodon carcharias* (Linnaeus, 1758), from the Mediterranean Sea. This data includes information on size, distribution, habitat, behaviour, reproduction, diet, fishery and attacks on humans (De Maddalena 1998, 1999, 2000a,b, 2002, Celona et al. 2001, De Maddalena et al. 2001, 2003, Galaz & De Maddalena 2004). To date, 478 records of white sharks from the Mediterranean have been recorded. This data was obtained by bibliographical research, location and study of material preserved in natural history museums, examination of fish caught in the area and transported to fish markets, collaborations with other researchers, coast guards, and private citizens, especially commercial fishermen, sport fishermen and scuba divers.

The location and the study of white sharks preserved in natural history museum is a fundamental part of this research program. Almost all European museums own at least some sharks in their collections, and some of these institutions hold remarkable specimens (Vanni 1992, Mizzan 1994, Kovačić 1998, Bruni & Würtz 2000, De Maddalena 2000a, Šanda & De Maddalena 2003, 2004). As a first step, a detailed study of 28 white shark specimens preserved in Italian museums has been presented by De Maddalena (2000a). Further studies collected substantial information on many white shark specimens preserved in European museums. Most of the specimens belong to old collections but have never been the object of previous study. Available data and measurements of this material is presented herein.

MATERIAL AND METHODS

A total of 239 museums have been contacted, including museums and institutes of natural history, zoology, biology, anatomy and ichthyology across all of Europe. Material held by private citizens has not been considered; that means that some especially interesting pieces, such as the large jaws of a female white shark captured in Filfla, Malta, on 17 April 1987 and estimated to be 6.68-6.81 m TOT (De Maddalena et al. 2001), are not included in this paper. I preferred to restrict the focus of the catalogue to the material that has been preserved in museums and scientific institutes and is available for research.

The material found includes complete specimens (mounted skins), jaws, teeth, crania, vertebrae, heads, brains, eyes, hearts, and olfactory capsules. Specimens and anatomical parts were preserved by taxidermy, dried, in liquid or as casts. The material has been examined in part directly by the author and in part by the staff of the contacted museums (in the latter case the author has usually checked the proper species identification by examination of photographs).

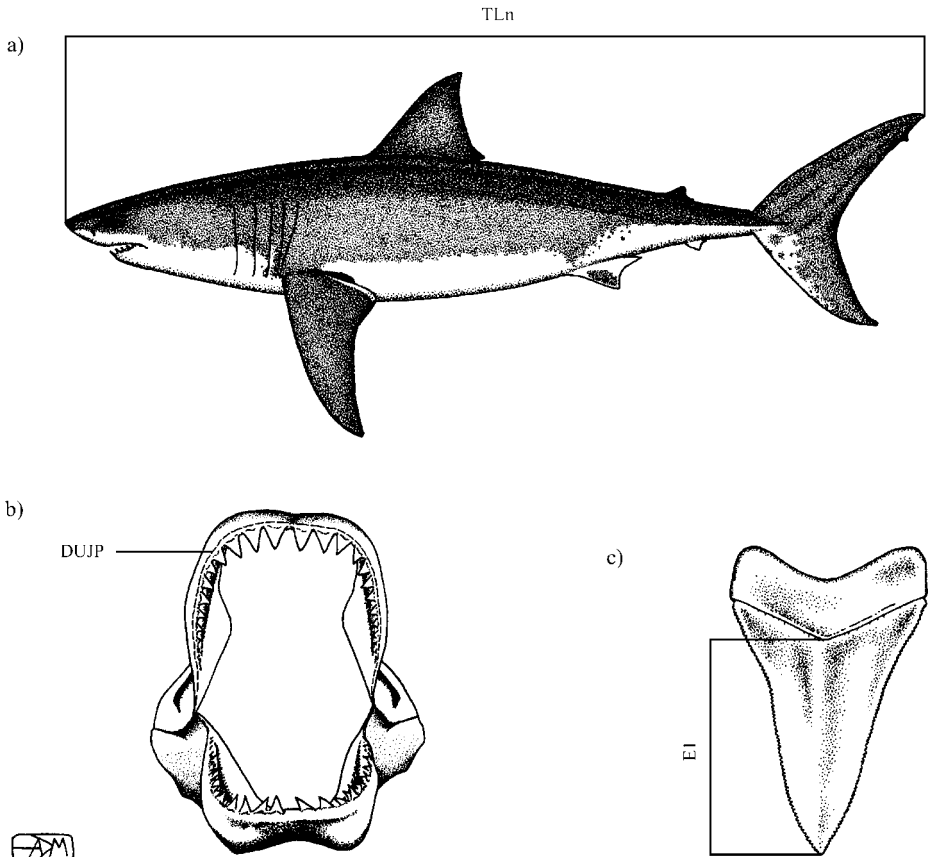


Fig. 1. Measurements used in this work, following the methods of Mollet et al. (1996). a) Measurement of the white shark length: TLn = total length with the caudal fin in a 'natural' position. b) Measurement of the white shark upper jaw: DUJP = dried upper jaw perimeter. c) Measurements of the white shark largest upper anterior tooth: UAE1 = enamel height. Drawing by Alessandro De Maddalena.

In each case, when possible, the following data was reported: name of the museum or institute where the material is preserved, catalogue number, kind of material, preservation method, capture date, capture location, sex, enamel height (UAE1) of the largest upper tooth, dried upper jaw perimeter (DUJP), total length with the caudal fin in a 'natural' position (TLn). Morphometric measurements were made following the methods of Mollet et al. (1996). Mollet et al. (1996) reported a mean shrinkage of 4% for white shark DUJP. As some set of jaws in this work are several centuries old it is possible that the shrinkage has been significantly greater but that is impossible to determine. Photographs of the specimens have also been collected when possible.

Methods for estimating the length of *C. carcharias* specimens from commonly preserved skeletal parts (teeth, jaws, vertebrae) have been investigated and applied by various authors (Randall 1973, 1987, Gottfried et al. 1996, Mollet et al. 1996, De Maddalena 2000a, Zuffa et al. 2002). However, while Mollet et al. (1996) and De Maddalena (2000a) found out that the size of the largest teeth is a sufficiently reliable index for estimation of the size of a young shark, it cannot reliably indicate the size of large individuals. Consequently these methods have not been used in this work.

Much of this material is preserved in good condition and includes numerous interesting specimens. Unfortunately, the catalogues are sometimes absent or, when present, often lack basic data. The information concerning the size of these specimens is usually not included in the original documentation. The species classification of the white shark specimens found was very often incorrect or obsolete. On the other hand, several other specimens that were identified as *C. carcharias* were actually different species, such as the bull shark *Carcharhinus leucas* (Valenciennes, 1839) and the pigeye shark *Carcharhinus amboinensis* (Müller & Henle, 1839).

MUSEUM ACRONYMS:

BAM - Biblioteca Ambrosiana, Milano	MCSNG - Museo Civico di Storia Naturale "G. Doria", Genova
BMAG - Bristol Museum & Art Gallery	MCSNT - Museo Regionale di Scienze Naturali, Trieste
BMNH - British Museum of Natural History, London,	MCSNV - Museo Civico di Storia Naturale, Venezia
BZL - Biologiezentrum Linz,	MCZL - Musée cantonal de Zoologie, Lausanne
DTRG - Dipartimento del Territorio e delle sue Risorse, Genova	MHNG - Muséum d'histoire naturelle de Grenoble
GLAHM - Hunterian Museum, Glasgow	MHNN - Muséum d'histoire naturelle de Nîmes
HNS - Haus der Natur, Salzburg	MHNP - Muséum National d'Historie Naturelle, Paris
IEND - Inatura–Ergebnis Naturschau Dornbirn,	MNIN - Muzeul National de Istorie Naturala "G. Antipa", București
IIG - Istituto di Idrobiologia, Ganzirri	MNKB - Museum für Naturkunde, Berlin,
KBIN - Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussels	MNSNT - Museo Regionale di Scienze Naturali, Torino
MACB - Museo di Anatomia Comparata, Bologna	MOM - Musée Océanographique, Monaco
MACR - Museo di Anatomia Comparata, Roma	MSNL - Museo di Storia Naturale, Livorno
MCRE - Musei Civici, Reggio Emilia	
MCSN - Museo Civico di Storia Naturale, Ferrara	

MSNM – Museo di Storia Naturale e della Strumentazione Scientifica, Modena
MSNT – Museo di Storia Naturale e del Territorio, Calci
MZB – Museu de Zoologia, Barcelona
MZDP – Museo di Zoologia Doderlein, Palermo
MZF – Museo Zoologico "La Specola", Firenze
MZN – Museo Zoologico, Napoli
MZP – Museo Zoologico, Padova

NHMW – Naturhistorisches Museum Wien
NMBe – Naturhistorisches Museum, Bern
NMP – Národní muzeum, Praha
NRM – Naturhistoriska riksmuseet, Stockholm
PMR – Prirodoslovni muzej Rijeka
SFN – Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main
VMO – Vlastivědné muzeum v Olomouci
ZMBH – Zemaljski muzej Bosne i Hercegovine, ZMK – Zoologisk Museum

RESULTS

Material belonging to a total of 101 great white sharks from 42 institutions of 15 countries has been catalogued. Full available data and measurements of the great white sharks preserved in the European museums are reported in Tab. 1.

DISCUSSION

Most material is represented by taxidermied specimens (22 specimens, or 21.8%) and jaws (55 specimens or 54.5%), in a few cases accompanied by chondrocranium and vertebrae, while internal organs (olfactory capsules, eyes, brain, heart) have rarely been preserved.

Most white shark material is preserved in Italy that hosts 41 specimens or 40.6% of the total 101 specimens preserved in Europe. 36 specimens (35.6% of the total 101 white sharks) come from the Mediterranean Sea, while 4 specimens were captured in the Atlantic Ocean (4.0%), 14 in the Indian Ocean (13.9%), 2 in the Pacific Ocean (2.0%) and 44 are from unknown location (43.6%).

The large majority of specimens preserved in European museums are very old, only 12 specimens (11.9%), having been captured after 1950. The jaws of a great white shark belonging to BAM in Milano, Italy, temporarily held at the MCSNM in Milano, dated from at least 1640-1660, have been identified as the oldest white shark material preserved in any European museum. The set of jaws was originally preserved in the Museo Settala in Milano (17th century). Capture date and location are unknown (De Maddalena 2005).

European museums hold some specimens that are among the largest white sharks preserved world-wide. The largest specimens of which parts are preserved in any European museum may be those of which skeletal parts are preserved in MACR in Roma, Italy, and MZF in Firenze, Italy. For both these specimens, a probable female caught off Civitanova, Italy, in early February 1839 (Bonaparte 1839, Metaxà 1839, Vinciguerra 1890, Condorelli et al. 1909, De Maddalena 1999, 2000a,b), and a female caught off Monterosso, Italy, on 10 December 1891 (Tortonese 1956, Vanni 1992, De Maddalena 2000a), an approximate length of 600 cm is indicated in the literature. For the specimen of MACR a confirmation of its huge size has been presented by De Maddalena (1999), where a 602 cm total length has been estimated from the size of its largest vertebra.

The cast of a 565 cm TLn (589 cm TOT – total length with caudal fin in depressed position) female great white shark preserved in MCZL in Lausanne, Switzerland, is the largest

Table 1. Data and measurements (terminology and parameters follow Mollet et al. 1996) of the great white sharks *Carcharodon carcharias* preserved in the European museums. All measurements are given in millimetres.

City / Country	Museum ^a	Cat. No.	Material ^b	Capture date ^c	Capture location	Sex	UAEI	DUJP	TLn	References ^d
Austria										
Dornbirn	IEND	Z 105388	complete specimen (T)	20.8.2002	Zinkwazi, South Africa	?	23.0	400	2750	54
Dornbirn	IEND	Z 105389	complete specimen (T)	11.082003	Zinkwazi, South Africa	?	22.0	370	2620	54
Linz /Dornach	BZL	1980/75	jaws (D)	Spring 1980	Albany, Australia	-	36.5	-	-	20, 27
Salzburg	HNS	-	complete specimen (T)	Summer 1989	Malindi, Kenya	?	-	-	5000	60
Salzburg	HNS	-	jaws (D)	~1980s	Perth, Australia	-	32.0	1000	-	1
Wien	NHMW	95054	complete specimen (T)	< 1919	Adriatic Sea	?	~35	-	4380	24
Wien	NHMW	94397	complete specimen (T)	VIII.91	Richards Bay, South Africa	?	~35	-	3600	24
Wien	NHMW	84624	jaws (D)	< 1919?	-	-	13.6	-	-	24
Wien	NHMW	91864	Head (F-D)	-	-	-	11.5	-	-	24
Belgium										
Brussels	KBIN	1385	Teeth (D)	< 09.10.1882	-	-	33.9	-	-	22
Brussels	KBIN	1385 C	chondrocranium, jaws, vertebrae (D)	< 01.05.1900	Mediterranean Sea	-	-	-	-	22
Bosnia and Herzegovina										
Sarajevo	ZMBH	-	complete specimen (T)	10.12.1955	Senj (Sveti Juraj), Croatia	?	-	-	4600	11, 17, 18

City / Country	Museum ^a	Cat. No.	Material ^b	Capture date ^c	Capture location	Sex	UAEI	DUJP	TLn	References ^d
Croatia										
Rijeka	PMR	VP2	complete specimen (T)	29.08.1894	Bakar, Croatia	?	40.0	750	4700	29, 31, 53
Czechia										
Olomouc	VMO	ZO-2354	jaws (D)	< 1925	Atlantic Ocean	-	35.0	920	-	43, 44
Praha	NMP	P6V 5270	jaws (D)	-	-	-	39.0	-	-	52
Praha	NMP	P6V 80544	jaws (D)	-	-	-	39.7	-	-	52
Denmark										
København	ZMK	-	Teeth (3) (D)	-	Malta	-	-	-	-	26
København	ZMK	-	Teeth (2) (D)	-	-	-	-	-	-	26
København	ZMK	-	jaws (D)	1882	Algeri, Algeria	-	-	-	-	26
København	ZMK	-	jaws (D)	1951	Banda Sea, Indonesia	-	-	-	-	26
France										
Grenoble	MHNG	OS.47	jaws (D)	-	-	-	35.6	850	-	46
Nîmes	MHNN	BAC 132	complete specimen (T)	1888	Grau du Roi, France	?	18.4	-	2505	21
Nîmes	MHNN	6	Teeth (3) (D)	11.10.1910	Grau du Roi, France	-	29.0	-	-	21
Nîmes	MHNN	20	jaws (D)	-	-	-	26.0	-	-	21
Paris	MHNP	a-4669	complete specimen (T)	-	-	?	-	-	5000	3
Paris	MHNP	a-7652	complete specimen (T)	-	La Réunion	?	-	-	4950	3, 60
Paris	MHNP	a-9695	complete specimen (T)	-	Algeria	?	-	-	2340	3

Paris	MHNP	a-9922	jaws (D)	-	Algeria	-	-	-	-	3
Paris	MHNP	ab-0002	jaws (D)	-	-	-	-	-	-	3
Paris	MHNP	ab-0003	jaws (D)	-	-	-	-	-	-	3
Paris	MHNP	ab-0004	jaws (D)	-	-	-	-	-	-	3
Paris	MHNP	ab-0143	jaws (D)	-	-	-	-	-	-	3
Paris	MHNP	ab-0185	4 teeth (D)	1889	La Seyne-sur-Mer, France	-	-	-	-	3
Paris	MHNP	ab-0195	rows of teeth (D)	05.1861	Sète, France	-	-	-	-	3
Paris	MHNP	1883-1118	jaws (L)	-	La Réunion	-	-	-	-	3, 60
Paris	MHNP	1900-0246	complete specimen (T)	-	Senegal	-	-	-	-	3
Paris	MHNP	2001-3289	jaws (D)	16.3.1976	Madagascar	-	-	-	-	3
Germany										
Berlin	MNKB	32474	olfactory capsule, rostrum (L)	28.02.1899	Indian Ocean	-	-	-	-	45
Berlin	MNKB	32475	olfactory capsule, rostrum (L)	17.02.1899	Sri Lanka	-	-	-	-	45
Berlin	MNKB	31640	jaws (D)		Atlantic Ocean	-	26.0	530	4100	38, 45
Berlin	MNKB	33662	jaws (D)	-	-	-	34.5	840	-	45
Frankfurt/M.	SFN	-	complete specimen (T)	1822	Napoli, Italy	?	-	-	1500	19, 37
Italy										
Bologna	MACB	ACP 114	jaws (D)	1827	Italy, Adriatic Sea	-	33.0	900	-	14, 36
Bologna	MACB	-	jaws (D)	-	Italy, Adriatic Sea (?)	-	26.0	630	-	32

City / Country	Museum ^a	Cat. No.	Material ^b	Capture date ^c	Capture location	Sex	UAEI	DUJP	TLn	References ^d
Calci	MSNT	-	chondrocranium, jaws (D)	< 1900	-	-	18.0	365	-	14
Ferrara	MCSN	-	jaws (D)	-	-	-	-	-	-	14
Firenze	MZF	6032	jaws (D)	10.12.1891	Monterosso, Italy	?	38.0	1040	~6000	14, 56, 58
Firenze	MZF	6361	jaws (D)	-	-	-	20.5	495	-	14, 58
Firenze	MZF	5983	complete specimen (T)	1879	Viareggio, Italy	?	25.5	-	3080	14, 23, 36, 58,
Firenze	MZF	131	complete specimen (T)	06.1885	Port Jackson, Australia	?	-	-	3050 (FOR)	14, 58
Ganzirri	IIG	-	jaws (D)	9.3.1965	Ganzirri, Italy	-	31	-	~5600	8
Genova	DTRG	-	jaws (D)	-	-	-	37.0	980	-	14
Genova	DTRG	-	jaws (D)	-	-	-	33.0	710	-	14
Genova	MCSNG	C.E. 31916	jaws (D)	-	Tyrrhenian Sea	-	38.5	980	-	14
Genova	MCSNG	C.E. 32695	jaws (D)	3.7.1935	Riva Trigoso, Italy	-	32.5	810	-	14
Genova	MCSNG	-	jaws (D)	-	-	-	23.0	540	-	14
Genova	MCSNG	C.E. 27517	complete specimen (T)	1929	Golfo di Genova (Portofino?)	?	33.5	-	4000	14, 36, 56
Genova	MCSNG	C.E. 2056	jaws (D)	08.1857	Gulf of Mexico	-	32.0	780	-	14
Livorno	MSNL	-	jaws (D)	-	-	-	18.5	438	-	14
Milano	BAM	-	jaws (D)	< 1677	-	-	36.2	1000	-	2, 15, 55
Modena	MSNM	PC-035/91	jaws (D)	< 1881	-	-	35.5	980	-	14, 30
Modena	MSNM	-0,53846154	jaws (D)	-	-	-	35.5	-	-	14

Modena	MSNM	-0,53846154	complete specimen (T)	01.1883	Portofino, Italy	?	38.5	-	4300	10, 14
Napoli	MZN	Z6431	jaws (D)	1868 or 1872-78?	-	-	21.4	476	-	33, 40
Napoli	MZN	Z1113	brain (L)	1868	-	-	-	-	-	33
Napoli	MZN	Z1194	eye (L)	1876	-	-	-	-	-	33
Napoli	MZN	Z1244	heart (L)	1876 or 1878	-	-	-	-	-	33
Padova	MZP	-	complete specimen (T)	07.1824	Italy	?	-	-	4900	7, 10, 14, 36
Palermo	MZDP	An-108	jaws (D)	-	Palermo, Italy	-	-	-	-	39
Palermo	MZDP	An-115	jaws (D)	-	Palermo, Italy	-	-	-	-	39
Palermo	MZDP	An-128	jaws (D)	-	Palermo, Italy	-	-	-	-	39
Palermo	MZDP	An-145	jaws (D)	-	Palermo, Italy	-	-	-	-	39
Palermo	MZDP	An-80	jaws (D)	-	Palermo, Italy	-	-	-	-	39
Reggio Emilia		14-4527	jaws (D)	< 1800	-	-	-	-	-	14
Reggio Emilia	MCRE	11-4?4	jaws (D)	<1863	-	-	28.0	600	-	14
Roma	MACR	111-167	jaws (D)	-	-	-	27.5	635	-	14
Roma	MACR	111-95	chondrocranium, jaws, vertebrae (D)	Early 02.1839	Civitanova, Italy	-	38.0	1110	~6000	5, 10, 13, 14, 34, 59
Roma	MACR	...	brain (L)	-	-	-	-	-	-	
Torino	MNSNT	612	chondrocranium, jaws (D)	-	-	-	39.5	940	-	14
Trieste	MCSNT	-	complete specimen (T), vertebrae (D)	29.5.1906	Kvarner, Croatia	?	38.7	-	5220	14

City / Country	Museum ^a	Cat. No.	Material ^b	Capture date ^c	Capture location	Sex	UAEI	DUJP	TLn	References ^d
Trieste	MCSNT	-	jaws (D)	-	Adriatic Sea	-	29.0	790	-	14
Venezia	MCSNV	2039	complete specimen (T)	1902	Trieste, Italy	?	-	-	3750	14, 35
Venezia	MCSNV	4960 Ist. V.S.L.A. 133	jaws (D)	< 1900	-	-	25.0	520	-	14, 35, 57
Monaco										
Monaco	MOM	P0I-4254	jaws (D)	1909	Camargue, France	-	39.0	1070	-	6, 13
Monaco	MOM	P0I-4253	jaws (D)	<1909	Martigues, France	-	29.0	780	-	6, 13, 50
Monaco	MOM	-	teeth	-	-	-	-	-	-	
Romania										
Bucure ^o ti	MNIN	-	complete specimen (T)	-	Zanzibar	?	-	-	3500	60
Spain										
Barcelona	MZB	82-5316	teeth (2)	<16.12.1912	Vilasar de Mar, Spain	-	-	-	4710	4
		82-5317								
Sweden										
Stockolm	NRM	8968	- (L)	<1975	Genova, Italy	-	-	-	-	41
Stockolm	NRM	48416	- (D)	-	-	-	-	-	-	41
Switzerland										
Bern	NMBe	1033139	jaws (D)	-	-	-	38.0	980	-	28
Lausanne	MCZL	-	complete specimen (C)	13.10.1956	Sète, France	?	40.0	-	5650	12, 16, 47
United Kingdom										
Bristol	BMAG	Ad4664	jaws (D)	-	-	-	35.0	673	-	48, 51
Glasgow	GLAHM	116976	jaws (D)	-	-	-	35.0	643	-	25

City / Country	Museum ^a	Cat. No.	Material ^b	Capture date ^c	Capture location	Sex	UAEI	DUJP	TLn	References ^d
London	BMNH	1850.9.5.3.	complete specimen (T)	< 1849	Cape Seas, South Africa	?	18.3	360	1980	9, 42
London	BMNH	1851.11.10.79.	jaws (D)	-	-	-	-	1171	-	42
London	BMNH	1905.12.2.2.	jaws (D)	18.9.1902	(Firenze market, Italy)	?	13.2	-	-	42
London	BMNH	2005.11.21.1.	jaws (D)	< 1870	Port Fairy, Australia	-	48.1	1190	-	42, 49
London	BMNH	2005.11.21.2.	jaws (D)	-	-	-	24.0	620	-	42
London	BMNH	2005.11.21.3	jaws (D)	-	Australia (?)	-	-	-	-	42
London	BMNH	2005.11.21.4.	jaws (D)	-	-	-	-	-	-	42

^a See museum acronyms.

^b T = taxidermied, D = dried, F-D = freeze-dried, L = liquid, C = cast.

^c Format: dd.mm.yyyy

^d References: 1 - A. Bryk (pers. comm.), 2 - Anonymous (1640-1660), 3 - B. Séret (pers. comm.), 4 - Barrull (1993-1994), 5 - Bonaparte (1839), 6 - Bruni & Würtz (2002), 7 - Canestrini (1874), 8 - Celona et al. (2001), 9 - Compagno (2001), 10 - Condorelli et al. (1909), 11 - D. Kotrošan (pers. comm.), 12 - de Beaumont (1957), 13 - De Maddalena (1999), 14 - De Maddalena (2000a), 15 - De Maddalena (2005), 16 - De Maddalena et al. (2003), 17 - urović & Obratil (1984), 18 - urović & Obratil (1989), 19 - F. Krupp (pers. comm.), 20 - G. Aubrecht (pers. comm.), 21 - G. Gory (pers. comm.), 22 - G. Lenglet (pers. comm.), 23 - Giglioli (1880), 24 - H. Wellendorf (pers. comm.), 25 - J. Liston (pers. comm.), 26 - J. Nielsen (pers. comm.), 27 - J. Plass (pers. comm.), 28 - K. Grossenbacher (pers. comm.), 29 - Kovačić (1998), 30 - Lawley (1881), 31 - M. Kovačić (pers. comm.), 32 - M. Zuffa (pers. comm.), 33 - Maio et al. (2005), 34 - Metaxà (1839), 35 - Mizzan (1994), 36 - Mojetta et al. (1997), 37 - Müller & Henle (1838), 38 - Müller & Henle (1839), 39 - Museo di Zoologia Doderlein website, 40 - N. Maio (pers. comm.), 41 - Naturhistoriska riksmuseet website, 42 - O. Crimmen (pers. comm.), 43 - Oliva (1959), 44 - P. Adamik (pers. comm.), 45 - P. Bartsch (pers. comm.), 46 - P. Candegabe (pers. comm.), 47 - Quignard et al. (1962), 48 - R. Rowson (pers. comm.), 49 - Randall (1987), 50 - Roule (1912), 51 - S. Trebilcock (pers. comm.), 52 - Šanda & De Maddalena (2004), 53 - Soldo & Jardas (2002), 54 - T. Sohm (pers. comm.), 55 - Terzagò & Scarabelli (1677), 56 - Tortonese (1956), 57 - Trois (1900), 58 - Vanni (1992), 59 - Vinciguerra (1890), 60 - Zuffa et al. (2002).



Fig. 2. 460 cm long, taxidermied female white shark preserved in the Zemaljski muzej Bosne i Hercegovine, in Sarajevo, Bosnia and Herzegovina (without cat. no.). Photo courtesy of the Zemaljski muzej Bosne i Hercegovine.

world-wide that has been reconstructed directly from a whole specimen. The model features the original fins and teeth. This specimen, captured off Sète, France, on 13 October 1956, is one of the three largest white sharks ever measured accurately (De Maddalena et al. 2003).

The largest taxidermied specimen is the 522 cm female preserved in MCSNT in Trieste, Italy, captured on 29 May 1906 in the Kvarner Gulf, Croatia (De Maddalena 2000a,b). This specimen may be the second largest world-wide taxidermied white shark, exceeded only by the 530 cm female preserved in the Victor Sadowsky Museum of Cananéia, Brazil



Fig. 3. 522 cm long, taxidermied female white shark preserved in the Museo Civico di Storia Naturale of Trieste, Italy (without cat. no.). Photo by Alessandro De Maddalena.



Fig. 4. Recently restored 375 cm, taxidermied male white shark preserved in the Museo Civico di Storia Naturale of Venice, Italy (cat. no. 2039). Photo courtesy of the Museo Civico di Storia Naturale of Venezia.

(Arfelli & Amorim 1993). Other two huge taxidermied specimens preserved in Europe reach a 5 m total length: the 500 cm female preserved in MNHN in Paris, France, without capture date and location (B. Séret, pers. comm.), and the 500 cm male preserved in HNS in Salzburg, Austria, captured off Malindi, Kenya, in summer 1989 (Zuffa et al. 2002). The latter is also one of the largest male white sharks ever recorded world-wide.

The 150 cm long taxidermied female preserved in SFN in Frankfurt am Main, Germany, caught in 1822 off Napoli, Italy (Müller & Henle 1838, F. Krupp, pers. comm.), has been identified as the smallest white shark preserved in any European museum. Other very young specimens are a 198 cm taxidermied female preserved in BMNH in London, United Kingdom, caught off the Cape, South Africa, before 1849 (Compagno 2001, O. Crimmen, pers. comm.), and a similar-sized specimen caught before 20th century in an unknown location, of which the chondrocranium and the jaws are preserved in MSNT in Calci, Italy (De Maddalena 2000a).

The measurements of white shark teeth and jaws collected in this work reconfirmed what emerged from the data presented by Mollet et al. (1996) and De Maddalena (2000a), that the size of teeth and jaws is not a reliable index for estimation of the size of large or medium-sized white sharks. That can be clearly seen taking into consideration for

example the 565 cm female preserved in MCZL in Lausanne, Switzerland, and the 470 cm female preserved in PMR in Rijeka, Croatia, both having a 4,0 cm UAE1 despite their notable difference in total length.

CONCLUSIONS

Populations of great white sharks are decreasing in all oceans because of human activities. Therefore the numerous white sharks preserved in European museums represent precious material for researchers studying sharks worldwide, and may be of noticeable importance for future studies. It is hoped that the material now in an inadequate preservation state will be properly restored. It is also important that the material is very attentively stored, in order to avoid cases of theft, such as those occurred in the museums of Firenze, Venezia and Lausanne, where in the past teeth have been stolen with the consequence of great damage to the specimens. The danger is that these kinds of episodes may increase as *C. carcharias* becomes more and more rare and its jaws and teeth reach higher prices on the market.

ACKNOWLEDGMENTS

Very special thanks to all the people that offered their help in collecting data and general information for this work: Peter Adamik, Luca Altichieri, Ivano Anzalani, Gerhard Aubrecht, Enrico Banfi, Peter Bartsch, Emilio Balletto, David C. Bernvi Andrea Bryk, Michèle Bruni, Philippe Candegabe, Ernesto Capanna, Silvia Chicchi, Oliver Crimmen, Pascal Deynat, Luciano De Nicolao, Sergio Dolce, Giuliano Doria, Donatella Foddai, Nicola Franzese, Elena Gavetti, Olivier Glaizot, Gérard Gory, Kurt Grossenbacher, Ernst Hofinger, Drazen Kotrošan,



Fig. 5. 150 cm long, taxidermied female white shark preserved in the Senckenberg Forschungsinstitut und Naturmuseum of Frankfurt am Main, Germany (without cat. no.). Photo courtesy of the Senckenberg Forschungsinstitut und Naturmuseum of Frankfurt am Main.



Fig. 6. White shark jaws preserved in the Haus der Natur of Salzburg, Austria (without cat. no.). Photo by Alessandro De Maddalena.

Marcelo Kovačić, Friedhelm Krupp, Boris Krystufek, Georges Lenglet, Jeff Liston, Nicola Maio, Riccardo Manni, Gianni Marangoni, Mario Marconi, Adelaide Mastandrea, Mario Mazza, Alessandro Minelli, Daniela Minelli, Luca Mizzan, Jiří Moravec, Alessandro Morescalchi, Marco Maria Navoni, Jørgen Nielsen, Guy Oliver, Peter Psomadakis, Lidia Orsi Relini, Carlo Pesarini, Jürgen Plass, Michela Podestà, Marta Poggesi, Roberto Poggi, Alberto Luca Recchi, Giulio Relini, Carlotta Rindone, Rhian Rowson, Radek Šanda, Maurizio Sarà, Fabrizio Serena, Bernard Séret, Paolo Sibille, Thomas Sohm, Tiziano Storai, Paolo Tongiorgi, Sam Trebilcock, Stefano Vanni, Helmut Wellendorf, Marco Zuffa and Marco Zuffi. Special thanks to Bill Heim, who kindly edited the English text of the manuscript. I also thank the referees for their helpful comments. Particular thanks go to my wife Alessandra and my son Antonio.

REFERENCES

- Anonymous, 1640-1660: Volume a disegni colorati rappresentanti oggetti del Museo Settala ceduto dalla Biblioteca di Brera alla Biblioteca Ambrosiana dietro convenuto compenso come da atti. Il 6 Luglio 1907. [Illustrated catalogue of the Settala Museum given from the Brera Library to the Ambrosiana Library observing the terms of payment agreed. On 6 July 1907.] [In Italian.]
- Arfelli C.A. & Amorim A.F., 1993: Notes on the white shark (*Carcharodon carcharias*) caught off Cananéia, São Paulo-Brazil. Abstract American Elasmobranch Society Meeting, The University of Texas at Austin, 27 May-2 June 1993.
- Barrull J., 1993-1994: Cita histórica de tiburón blanco *Carcharodon carcharias* (Linnaeus, 1758), en el Mar Catalán (Mar Mediterráneo), documentada con dientes de la mandíbula. [Historical record of the great white shark *Carcharodon carcharias* (Linnaeus, 1758) in the Catalan Sea (Mediterranean Sea) testified by teeth.] – *Miscellfñia Zoològica* 17: 283-285. [In Spanish.]
- Bonaparte C., 1839: Iconografia della fauna italia per le quattro classi degli animali vertebrati. Tomo III. Pesci. [Iconography of the Italian fauna for the four classes of the vertebrate animals.] – Roma: Tipografia Salviucci. [In Italian.]
- Bruni M. & Würtz M., 2002: The Chondrichthyan fish collection of the Oceanographic Museum of Monaco: history and present status. – In: Vacchi M., La Mesa G., Serena F. & Séret B. (eds.): Proc. 4th European Elasmobranch Association Meeting, Livorno (Italy), 2000. 49-63. Rome: ICRAM, ARPAT & SFI.
- Canestrini G., 1874: Fauna d'Italia. Parte terza. Pesci. [Fauna of Italy. Part 3. Fishes.] – Milano: Vallardi, 208 pp. [In Italian.]
- Celona A., Donato N. & De Maddalena A., 2001: In relation to the captures of a great white shark *Carcharodon carcharias* (Linnaeus, 1758) and a shortfin mako, *Isurus oxyrinchus* Rafinesque, 1809 in the Messina Strait. – *Annales, Series Historia Naturalis* 11(1): 13-16.
- Compagno L.J.V., 2001: Sharks of the World. Volume 2. FAO Species Catalogue for Fishery Purposes 1(2): 100 pp.

- Condorelli M. & Perrando G.G., 1909: Notizie sul *Carcharodon carcharias* L., catturato nelle acque di Augusta e considerazioni medico-legali sui resti umani trovati nel tubo digerente. [On the *Carcharodon carcharias* L. caught off Augusta and medic-legal considerations on the human remains found in its digestive system.] – Bollettino della Società Zoologica Italiana 1909: 164-183. [In Italian.]
- De Beaumont J., 1957: Rapport des conservateurs pour l'année 1956. Musées d'histoire naturelle de Lausanne. [Report of the curators for the year 1956. Natural History Museum of Lausanne.] - Lausanne: Musées d'Historie Naturelle de Lausanne, 6 pp. [In French.]
- De Maddalena A., 1998: Il più grande esemplare italiano di squalo bianco, *Carcharodon carcharias* (Linnaeus, 1758) individuato nei reperti conservati presso il Museo di Anatomia Comparata dell'Università "La Sapienza" di Roma. [The largest Italian white shark, *Carcharodon carcharias* (Linnaeus, 1758) preserved in the Comparative Anatomy Museum of the "La Sapienza" University in Rome] – *Museologia Scientifica* 15(2): 195-198. [In Italian.]
- De Maddalena A., 1999: Records of the great white shark in the Mediterranean Sea. – Milan: privately published, 54 pp.
- De Maddalena A., 2000a: Sui reperti di 28 esemplari di squalo bianco, *Carcharodon carcharias* (Linnaeus, 1758), conservati in musei italiani. [On 28 great white sharks, *Carcharodon carcharias* (Linnaeus, 1758), preserved in Italian museums.] – *Annali del Museo Civico di Storia Naturale "G. Doria"*, (Genova) 93: 565-605. [In Italian.]
- De Maddalena A., 2000b: Historical and contemporary presence of the great white shark *Carcharodon carcharias* (Linnaeus, 1758), in the Northern and Central Adriatic Sea. – *Annales, Series Historia Naturalis* 10(1): 3-18.
- De Maddalena A., 2002: Lo squalo bianco nei mari d'Italia. [The great white shark in Italian waters.] – Formello: Ireco, 144 pp. [In Italian.]
- De Maddalena A., 2005: The great white shark, *Carcharodon carcharias* (Linnaeus, 1758) of the Settala Museum in Milan. – *Bollettino del Museo civico di Storia naturale di Venezia* 57: 149-154.
- De Maddalena A., Glaizot O. & Oliver G., 2003: On the great white shark, *Carcharodon carcharias* (Linnaeus, 1758), preserved in the Museum of Zoology in Lausanne. – *Marine Life* 13(1/2): 53-59.
- De Maddalena A., Zuffa M., Lipej L. & Celona A., 2001: An analysis of the photographic evidences of the largest great white sharks, *Carcharodon carcharias* (Linnaeus, 1758), captured in the Mediterranean Sea with considerations about the maximum size of the species. – *Annales, Series Historia Naturalis* 11(2): 193-206.
- urović E. & Obratil S., 1984: The living world of aquatic and swampy environments (fish, birds, mammals and reptiles). – In: Guide to collections of the regional museum of Bosnia and Herzegovina. 97-101. Sarajevo: National Museum SRBiH.
- urović E. & Obratil S., 1989: Živi svijet vodenih i močvarnih staništa (ribe, ptice, sisari) i gmizavci [The living world of aquatic and swampy environments (fish, birds, mammals) and insects]. – In: Vodič kroz zbirke zemaljskog muzeja Bosne i Hercegovine [Guide to collections of the Regional museum of Bosnia and Herzegovina]: 97-100. Sarajevo: Zemaljski muzej Bosne i Hercegovine. [In Bosnian.]
- Galaz T. & De Maddalena A., 2004: On a great white shark, *Carcharodon carcharias* (Linnaeus, 1758), trapped in a tuna cage off Libya, Mediterranean Sea. – *Annales, Series Historia Naturalis* 14(2): 159-164.
- Giglioli E.H., 1880: Elenco dei Mammiferi, degli Uccelli e dei Rettili ittiofagi od interessanti per la Pesca, appartenenti alla Fauna italiana, e Catalogo degli Anfibi e dei Pesci italiani. [List of Italian Mammals, Birds, Reptiles that feed on fish or of some interest for fisheries, and Catalogue of Italian Amphibians and Fish.] – In: Esposizione internazionale di Pesca in Berlino 1880. Sezione italiana. Catalogo degli Espositori e delle cose esposte. N. 11: 63-117. Firenze: Stamperia Reale. [In Italian.]
- Gottfried M.D., Compagno L.J.V. & Bowman S.C., 1996: Size and skeletal anatomy of the giant megatooth shark *Carcharodon megalodon*. – In: Klimley A.P. & Ainley D.G. (eds): Great white sharks. The biology of *Carcharodon carcharias*: 55–66. San Diego: Academic Press.
- Kovačić M., 1998: Ihtioloska zirka (Cyclostomata, Selachii, Osteichthyes). Prirodoslovnog muzeja u Rijeci. – In: Arko-Pijevac M., Kovacic M. & Crnkovic D. (eds.): Prirodoslovna istracivanja rijeckog područja. 685-698. Rijeka.
- Lawley R., 1881: Studi comparativi sui pesci fossili coi viventi dei generi *Carcharodon*, *Oxyrhina* e *Galeocерdo*. [Comparative studies of fossil fish with living species of the genera *Carcharodon*, *Oxyrhina* and *Galeocерdo*.] – Pisa: Nistri, 151 pp. [In Italian.]
- Maio N., Psoadakis P.N. & Vacchi M., 2005: I Condritti del Museo Zoologico dell'Università di Napoli Federico II. Catalogo degli Elasmobranchi Pleurotremata con note storiche (Pisces, Chondrichthyes, Elasmobranchii). [Chondrichthyes in the Zoology Museum of the "Federico II" University in Naples.

- Catalogue of Elasmobranchii Pleurotremata with historical notes (Pisces, Chondrichthyes, Elasmobranchii). – *Annali del Museo Civico di Storia naturale “G. Doria”*, Genova 96: 453-481. [In Italian.]
- Metaxà L., 1839: Smisurato pesce del peso di 4000 libre. [Huge fish weighing 4000 lbs.] – *Annali della Società Medico-Chirurgica Metaxà* 1839: 35-38. [In Italian.]
- Mizzan L., 1994: I Leptocardi, Ciclostomi e Selaci delle collezioni del Museo Civico di Storia Naturale di Venezia - 1) Leptocardia, Agnatha, Gnathostomata - Chondrichthyes (esclusi Rajiformes). [Leptocardia, Cyclostomes and Selachians in the collections of the Natural History Museum in Venice. - 1) Leptocardia, Agnatha, Gnathostomata - Chondrichthyes (excluding Rajiformes).] – *Bollettino del Museo Civico di Storia Naturale di Venezia* 45: 123-137. [In Italian.]
- Mojetta A., Storai T., Zuffa M., 1997: Segnalazioni di squalo bianco *Carcharodon carcharias* in acque italiane. [Records of the great white shark *Carcharodon carcharias* in Italian waters.] – *Quaderni della Civica Stazione Idrobiologica di Milano* 22: 23-38. [In Italian.]
- Mollet H.F., Cailliet G.M., Klimley A.P., Ebert D.A., Testi A.D. & Compagno L.J.V., 1996: A review of length validation methods and protocols to measure large white sharks. – In: Klimley A.P. & Ainley D.G. (eds.): *Great white sharks. The biology of Carcharodon carcharias*: 91-108. San Diego: Academic Press.
- Müller J. & Henle F.G.J., 1838: Systematische Beschreibung der Plagiostomen. [Systematic Description of the Plagiostomi.] – Berlin: Veit. [In German.]
- Oliva O., 1959: Zajímavé čelisti žraloků (Selachii) z muzea v Olomouci [Interesting jaws of sharks (Selachii) from the museum in Olomouc]. – *Zprávy Krajského Vlastivědného Střediska v Olomouci* 80: 32-34. [In Czech.]
- Quignard J.-P., Raibaut A. & Trilles J.-P., 1962: Contribution à la faune ichthyologique sétoise. [Contribution to the ichthyological fauna of Sète.] – *Naturalia Monspeliensia., Série Zoologie* 3: 61-85. [In French.]
- Randall J.E., 1973: Size of the great white shark (*Carcharodon*). – *Science* 181(4095): 169-170.
- Randall J.E., 1987: Refutation of lengths of 11.3, 9.0, and 6.4 m. attributed to the white shark, *Carcharodon carcharias*. – *California Fish and Game* 73(3): 163-168.
- Roule L., 1912: Notice sur les Sélaciens conservés dans les collections du Musée Océanographique. [Note on the Selachians preserved in the collections of the Oceanographic Museum.] – *Bulletin de l'Institut Océanographique* 243: 1-36. [In French.]
- Šanda R. & De Maddalena A., 2003: Collection of the sharks of the National Museum in Prague - Part 1. Complete taxiderms and liquid preservations. – *Journal of the National Museum (Praha), Natural History Series* 172: 61-70.
- Šanda R. & De Maddalena A., 2004: Collection of the sharks of the National Museum in Prague - Part 2. Skeletal preservations. – *Journal of the National Museum (Praha), Natural History Series* 173: 51-58.
- Soldo A. & Jardas I., 2002: Large sharks in the Eastern Adriatic. – In: Vacchi M., La Mesa G., Serena F. & Séret B. (eds.): *Proc. 4th European Elasmobranch Association Meeting, Livorno (Italy), 2000*. 141-155. Rome: ICRAM, ARPAT & SFI.
- Terzago P.M. & Scarabelli P.F., 1677: Museo o galeria adunata dal sapere, e dallo studio del Sig. Canonico Manfredo Settala nobile Milanese. Terza edizione. [Museum or gallery realized by Manfredo Settala, nobleman of Milan. Third edition.] – Tortona: Nicolò e Fratelli Viola. [In Italian.]
- Tortonese E., 1956: Fauna d'Italia vol.II. Leptocardia, Ciclostomata, Selachii. [Fauna of Italy. vol.II. Leptocardia, Cyclostomata, Selachii.] – Bologna: Calderini, 334 pp. [In Italian.]
- Trois F., 1900: Catalogo delle collezioni d'anatomia comparata del Regio Istituto Veneto di Scienze Lettere ed Arti dalla fondazione (Gennaio 1867 all'Aprile 1900). [Catalogue of the comparative anatomy collections of the Royal Venetian Institute of Sciences, Letters and Arts from the foundation (from January 1867 to April 1900).] – Venezia: Tipografia Carlo Ferrari. [In Italian.]
- Vanni S., 1992: Cataloghi del Museo di Storia Naturale dell'Università di Firenze, Sezione di Zoologia “La Specola”. XI. Chondrichthyes. [Catalogue of the Natural History Museum of the Florence University, Zoology Section «La Specola». 11. Chondrichthyes.] – *Atti della Società Toscana di Scienze Naturali, Memorie (B)* 99: 85-114. [In Italian.]
- Vinciguerra D., 1890: Guida del Museo di Zoologia della R. Università di Roma - Fauna locale - Specie animali della provincia di Roma esistenti nella nuova collezione. Parte III - Pesci. [Guide to the Zoology Museum of the Royal University in Rome - Local fauna – Animal species of the Rome district in the new collection. Part 3 – Fishes.] – Roma: Istituto di Zoologia della Reale Università di Roma. [In Italian.]
- Zuffa M., Van Grevelynge G., De Maddalena A. & Storai T., 2002: Records of the white shark, *Carcharodon carcharias* (Linnaeus, 1758), from the western Indian Ocean. – *South African Journal of Science* 98(7-8): 347-349.