

# First records of white sharks, *Carcharodon carcharias*, from Mauritius, Zanzibar, Madagascar and Kenya

G. Cliff<sup>a</sup>, L.J.V. Compagno<sup>b</sup>, M.J. Smale<sup>c</sup>, R.P. van der Elst<sup>d</sup> and S.P. Wintner<sup>a</sup>

**D**ISTRIBUTION RECORDS OF WHITE SHARKS in the tropical southwest Indian Ocean are both sparse and speculative. This paper provides the first confirmed records of white sharks from four localities in the region. A male white shark of about 5 m total length was taken by a fisheries vessel off Le Morne on the island of Mauritius in 1971. A white shark over 4 m long was caught at Matemwe Beach, Zanzibar, in 1993. A female white shark, estimated at 3.8 m, was taken in an artisanal net fishery near Antsiranana, in the Baie de Diégo Suarez on the northeastern tip of Madagascar in 1994. A pregnant white shark, reported at 6.4 m, was taken in an artisanal net fishery near Malindi, Kenya, in 1996. At least seven embryos, 1.1 m long and weighing 10–20 kg, were found. White sharks in the tropical Indian Ocean may be predominantly large, possibly mature, specimens. Their occurrence in oceanic island waters may facilitate trans-oceanic movements, which has important consequences for the conservation and management of this species.

White sharks (*Carcharodon carcharias* Linnaeus, 1758) occur in the warm temperate and subtropical waters off the south and east coasts of South Africa.<sup>1,2</sup> This species has been recorded from southern Mozambique and the islands of Seychelles, 5°S, 55°E, (Fig. 1),<sup>3</sup> but there are few records from elsewhere in the tropical southwest Indian Ocean. This paper documents the capture of a large white shark from each of four new localities in the region. All length measurements referred to in the text are total length.

## Results

A large male white shark was caught by a Mauritian fisheries vessel *Investicetier* in about August/September 1971. The vessel was using gill nets, deep-set a few kilo-

metres south of Le Morne, on the southwestern corner of the island of Mauritius (20°17'S, 57°33'E) (Fig. 1). The shark was photographed while suspended vertically by the tail alongside the vessel. One of the photographs shows the shark's tail next to the head of a crew member, which was used to estimate the length of the upper caudal fin. This measurement provided a length estimate of 5.2 m (95% confidence limits 5.1–5.3 m,  $r = 0.99$ ,  $n = 58$ ). On a visit to Mauritius in 1988, one of the authors (M.J.S.) established that this shark was the source of a 'mysterious photograph that purports to show a 30 ft white shark caught in the Maldives'.<sup>4</sup> This photograph was a copy of a copy taken by another of the authors (R.v.d.E.). A tooth from the shark, most likely the third upper lateral tooth, had an enameloid width of 38 mm and a medial enameloid height of 33 mm. Based on the relationship between shark total length and enameloid width, the shark was calculated to be 4.9 m (95% confidence limits 4.7–5.2 m;  $r = 0.99$ ,  $n = 12$ ). Using enameloid height, the calculated length

was 4.8 m (95% confidence limits 4.6–5.1 m;  $r = 0.99$ ,  $n = 12$ ). This shark was therefore close to 5 m in length. Previously it had been acknowledged that the white shark may occasionally occur in the Mascarene Islands (Réunion and Mauritius),<sup>5</sup> but until now there has been no scientific proof of its presence there.

A large white shark was landed in 1993 at Matemwe Beach (05°53'S, 39°23'E) on the northeastern side of the island of Zanzibar, some 20 km off the coast of Tanzania (Fig. 1). The shark was caught in a 30 cm mesh gill net, set in water 15–30 m deep. From four photographs given to one of the authors (L.J.V.C.), the shark was over 4 m long but it is not possible to determine its sex. One or two white sharks are apparently caught annually off Zanzibar (M. Richmond, Institute of Marine Sciences, University of Dar es Salaam, pers. comm.).

A female white shark, reported to be about 4 m long, was caught on 11 February 1994 in the vicinity of Ilot des Aigrettes (Egret Islet; Nosy Langoro) (12°16'S, 49°19'E) near the town of Antsiranana, in Baie de Diégo Suarez in northeastern Madagascar. The shark was towed back to shore, where it was finned and cut up. One of the authors (G.C.) examined a photograph of the shark's jaw as well as several teeth, including the first upper lateral tooth in the upper jaw, which had an enameloid width of 32.5 mm. Enameloid height could not be measured because the tip of this tooth was missing. From a regression of enameloid width against total length, the shark was 3.8 m (95% confidence limits 3.7–3.9 m;  $r = 0.993$ ;  $n = 12$ ), which was close to the photogra-

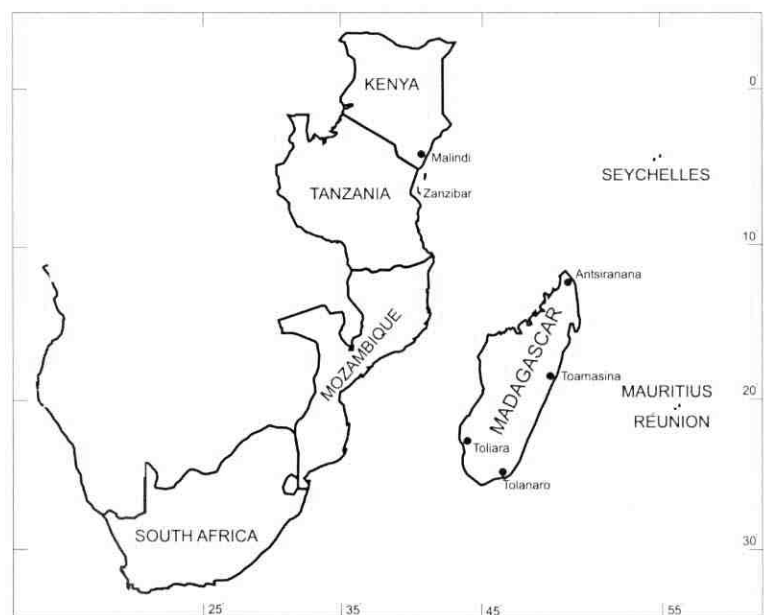


Fig. 1. Southwest Indian Ocean showing localities referred to in the text.

<sup>a</sup>Natal Sharks Board, Private Bag 2, Umhlanga, 4320 South Africa. E-mail: cliff@shark.co.za

<sup>b</sup>Shark Research Centre, Division of Life Sciences, South African Museum, P.O. Box 61, Cape Town, 8000 South Africa.

<sup>c</sup>Port Elizabeth Museum, P.O. Box 13147, Humewood, 6013 South Africa.

<sup>d</sup>Oceanographic Research Institute, P.O. Box 10712, Marine Parade, 4056 South Africa.

\*Author for correspondence.

pher's estimate of 4 m. This appears to be the first record of *C. carcharias* from Madagascar. This species was not recorded in an extensive survey of the island's waters,<sup>6</sup> nor in subsequent accounts covering the Madagascan shark fauna.<sup>7-9</sup>

Subsequent to this capture, several other white sharks have been caught off Madagascar, from the evidence of photographs and material examined by M.J.S. They include two anterior upper jaw teeth from a white shark taken off Toamasina (Tamatave) (18°10'S, 49°23'E), on the northeast coast, with an enameloid height of about 48 mm, which represents a shark of at least 5 m. Two large white sharks were caught in the southwest near Toliara (23°21'S, 43°40'E) and one in the south off Tolano (Fort Dauphin) (25°02'S, 47°00'E). A pregnant white shark of unknown length was taken in a bottom-set gill net in Baie de Diégo Suarez in about 1998. The litter size is not known, but the embryos each weighed about 17 kg.

On 16 July 1996, a pregnant white shark was caught at night in nets set by local fishermen from Malindi, Kenya (03°13'S, 40°07'E), at a depth of about 35 m and about 8–10 km offshore. The shark was towed back to shore where it was cut up, before it could be measured or photographed. The head, which had been removed behind the gills on one side but included the other pectoral fin, weighed 450 kg. At least 2200 kg was weighed in pieces, but this was apparently not the entire shark nor all the embryos. It was estimated to be 21 ft (6.4 m) long. A resident, who saw the shark, stated that 'a few other great whites have been caught at Malindi over the past years, but none approaching this size'.

The only length–weight relationship for white sharks approaching this size is from the western North Atlantic,<sup>10</sup> although the largest shark in this dataset was only 4.97 m (1247 kg). By extrapolation, a 2200 kg white shark would be 6.3 m long, close to the estimated length of 6.4 m.

A section of five vertebrae was removed from the Malindi shark, supposedly from between the pectoral fins, and sent to one of the authors (R.v.d.E.). The centrum diameter was 82 mm, which extrapolates to a shark length of 5.7 m, based on the linear relationship between white shark length and centrum diameter,<sup>11</sup> where the largest vertebra was 67 mm. From the length–weight relationship,<sup>10</sup> a shark of 5.7 m would weigh 1625 kg. The calculated length and weight are far less than the reported values of 6.4 m and at least 2200 kg. Either the reported sizes are

overestimates or the vertebrae may not have been taken from between the pectoral fins, as claimed, but further back in the vertebral column, where the centrum diameter would be far smaller. Measurements made by one of the authors (S.P.W.) on every tenth precaudal vertebra of a 892 kg, 4.7 m white shark indicate that centrum diameter ranges from 62 mm (vertebra 10) to a maximum of 73 mm (vertebra 40) and a minimum of 42 mm (vertebra 100). Given the problems of determining or validating the length of large white sharks from various morphometric measurements,<sup>12</sup> the estimate of 6.4 m cannot be confirmed and should be regarded with caution.

Six to eight embryos, about 3.5 ft (1.1 m) long and estimated to weigh 10–20 kg, were found in the mother. They were described as having 'distended, clear jelly-like sacks attached'. The fishermen indicated that at least 10 were 'released', presumed aborted, while the shark was in the net. The sack is presumably the distended stomach containing a large amount of egg yolk, a feature characteristic of many oophagous lamnoid sharks,<sup>13</sup> including white sharks. Ten embryos, eight from a female from Japan<sup>14</sup> and two from New Zealand,<sup>15</sup> measured 1.3–1.5 m (21–32 kg). This Kenyan litter of possibly as many as 17 embryos would be by far the largest on record. The previous highest was 14 from a female caught off Queensland, Australia,<sup>16</sup> although this was not verified and remains questionable.

### Discussion

The paucity of white shark records from the tropical southwest Indian Ocean undoubtedly reflects the scarcity of this species in the tropics, compared to known 'centres of abundance' such as the temperate waters off the Cape coast of South Africa. Those sharks that do penetrate the tropics tend to be large,<sup>1</sup> a feature of the four specimens detailed above. There are also reports of several large (>3 m) white sharks from the Hawaiian Islands.<sup>17</sup> Records of white sharks around New Caledonia in the Pacific (21°30'S, 165°30'E), from inshore catches as well as deep-set longlines, were also of sharks over 3 m, including two 'of about 7 m'.<sup>18</sup> Several large white sharks have been caught in tropical Brazilian waters, all with lengths ranging from 4–6 m.<sup>19</sup> Younger white sharks, especially newborns, may be restricted to more temperate habitats.

Much of the nearshore fishing in the tropical southwest Indian Ocean is artisanal and is generally aimed at small fish, using gear that may be incapable of restraining

a large white shark. The sporadic and occasional catches of white sharks by these fishermen may pass unreported. Big-game fishing does occur in the tropics, where large sharks such as the tiger *Galeocerdo cuvier* are often caught, but it is conceivable that the tackle used may not be strong enough to land large white sharks successfully.

Given the scarcity of records from oceanic island groups, white sharks are regarded primarily as inhabitants of continental shelves. However, they may have a broader distribution and therefore occur more frequently in oceanic waters and in the tropics than is currently acknowledged. In addition to the island localities listed above, white sharks have also been recorded from the Marshall Islands,<sup>8</sup> in the catches of squid and tuna driftnet fishing boats in a broad area of the Central North Pacific, north of the Hawaiian chain<sup>20</sup> and from the cold waters near Gough Island (42°S, 8°W) in the South Atlantic (L.J.V.C., unpubl. data).

White sharks appear to be highly mobile, with one individual travelling at least 774 km in 27 days.<sup>21</sup> While their appearance in tropical localities may be highly transient, oceanic islands could constitute important gateways to trans-oceanic movement, thereby reducing the chances of genetic isolation among populations from different regions. If such movements do result in interbreeding, then the protective legislation, that was first introduced in South Africa in 1991,<sup>22</sup> and subsequently in Namibia, Australia and the U.S.A., will have a far more global significance. Such benefits can be quantified only once the genetic structure of white sharks from different regions has been assessed and compared.

The authors are indebted to S. Remuzat, E. Delsaut, E. Nicolay, A. Penny, C. MacKay, J. Roullot, R. Dobbin, M. Richmond, T. van der Ven, C. Harris, J. Robinson, G. Antoni, D. Lebreton, P. Levionois, G. Vangrevelinghe, Y. Lobjoy, J. O'Donnell and I. Fergusson, who provided information or photographs of the sharks.

Received 15 September 1999. Accepted 4 March 2000.

1. Bass A.J., D'Aubrey J.D. and Kistnasamy N. (1975). Sharks of the east coast of southern Africa. IV. The families Odontaspidae, Scapanorhynchidae, Isuridae, Cetorhinidae, Alopiidae, Orectolobidae and Rhinodontidae. *S. Afr. Ass. Mar. Biol. Res., Oceanogr. Res. Inst., Invest. Rep.* 39, 1–102.
2. Cliff G., Dudley S.F.J. and Davis B. (1989). Sharks caught in the protective gill nets off Natal, South Africa. 2. The great white shark *Carcharodon carcharias* (Linnaeus). *S. Afr. J. Mar. Sci.* 8, 131–144.
3. Smith J.L.B. and Smith M.M. (1963). *The Fishes of Seychelles*. Department of Ichthyology, Rhodes University, Grahamstown.
4. Ellis R. and McCosker J.E. (1991). *Great White Shark*. Stanford University Press, Stanford, California.
5. Vangrevelinghe G. (1994). Les requins à la Réunion. Mythes et Réalité. Étude de 12 cas

- d'accidents liés aux requins. Thèse de Diplôme d'État de Docteur en Médecine, Université de Lille.
- Fourmanoir P. (1961). Requins de la côte ouest de Madagascar. *Mém. Inst. scient. Madagascar* 4, 1–81.
  - Bauchot M.L. and Bianchi G. (1984). *Guide des poissons commerciaux de Madagascar (espèces marines et d'eaux saumâtres)*. Food and Agriculture Organization of the United Nations, Rome.
  - Compagno L.J.V. (1984). *FAO Species Catalogue*. Vol. 4 Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. *FAO Fish. Synop.* 125: 1–249.
  - Compagno L.J.V. (1984). Sharks. In *FAO Species Identification Sheets for Fishery Purposes, Western Indian Ocean (Fishing Area 51)*, ed. W. Fischer and G. Bianchi, vol. 5, pp. 1–272. Food and Agriculture Organization of the United Nations, Rome.
  - Casey J.G. and Pratt H.L. (1985). Distribution of the white shark, *Carcharodon carcharias*, in the Western North Atlantic. *South. Calif. Acad. Sci., Mem.* 9, 2–14.
  - Wintner S.P. and Cliff G. (1999). Age and growth determination of the white shark, *Carcharodon carcharias*, from the east coast of South Africa. *Fish. Bull.* 97, 153–169.
  - Mollet H.F., Cailliet G.M., Klimley A.P., Ebert D.A., Testi A.D. and Compagno L.J.V. (1996). A review of length validation methods and protocols to measure large white sharks. In *Great White Sharks, the Biology of Carcharodon carcharias*, ed. A.P. Klimley and D.G. Ainley, chap. 10, pp. 91–108. Academic Press, San Diego.
  - Gilmore R.G. (1993). Reproductive biology of lamnoid sharks. *Environ. Biol. Fishes* 38, 95–114.
  - Uchida S., Toda M., Teshima K. and Yano K. (1996). Pregnant white sharks and full-term embryos from Japan. In *Great White Sharks, the Biology of Carcharodon carcharias*, ed. A.P. Klimley and D.G. Ainley, chap. 14, pp. 139–155. Academic Press, San Diego.
  - Francis M.P. (1996). Observations on a pregnant white shark with a review of reproductive biology. In *Great White Sharks, the Biology of Carcharodon carcharias*, ed. A.P. Klimley and D.G. Ainley, chap. 15, pp. 157–172. Academic Press, San Diego.
  - Paterson R. (1986). Shark prevention measures working well. *Aust. Fish.* 45, 12–18.
  - Taylor L. (1985). White sharks in Hawaii: historical and contemporary records. *South. Calif. Acad. Sci., Mem.* 9, 41–48.
  - Seret B. (1994). Chondrichthyan fishes of New Caledonia. *Chondros* 5(3), 6–9.
  - Gadig O.B.F. and Rosa R.S. (1996). Occurrence of the white shark along the Brazilian coast. In *Great White Sharks, the Biology of Carcharodon carcharias*, ed. A.P. Klimley and D.G. Ainley, chap. 31, pp. 347–350. Academic Press, San Diego.
  - Bonfil R. (1994). Overview of world elasmobranch fisheries. *FAO Fish. Tech. Pap.* 341, 1–119.
  - Cliff G., Van der Elst R.P., Govender A., Witthuhn T.K. and Bullen E.M. (1996). First estimates of mortality and population size of white sharks on the South African coast. In *Great White Sharks, the Biology of Carcharodon carcharias*, ed. A.P. Klimley and D.G. Ainley, chap. 36, pp. 393–400. Academic Press, San Diego.
  - Compagno L.J.V. 1991. Government protection for the great white shark *Carcharodon carcharias* in South Africa. *S. Afr. J. Sci.* 87, 284–285.

## A Middle Pleistocene human tibia from Hoedjiespunt, Western Cape, South Africa

S.E. Churchill<sup>a</sup>, L.R. Berger<sup>b\*</sup> and J.E. Parkington<sup>c</sup>

A 200–350 KYR BP HUMAN TIBIA HAS BEEN recovered in association with cranio-dental remains from the Hoedjiespunt site near Saldhana Bay. The tibia is morphologically similar to other Middle Pleistocene human tibiae from Africa and Europe, indicating a substantial degree of postcranial morphological homogeneity across the western Old World at this time.

With the discovery of human dental remains in 1993,<sup>1</sup> the site of Hoedjiespunt (Western Cape, South Africa) joined the small but growing list of southern African Middle/Late Pleistocene sites that have produced fossil hominids. Excavations since then have recovered additional cranio-dental remains, and most of a human tibia was recovered in 1998. The

hominid remains from Hoedjiespunt thus increase the sample of Middle Pleistocene human fossils at or close to the time of the emergence of modern *Homo sapiens* and the disappearance of more archaic forms, and provide additional postcranial evidence important to our understanding of human body size and shape and locomotor patterns during this important transition. We provide here a preliminary description of the specimen. The tibia was recovered from the shelly sands<sup>1</sup> of a cavity fill at Hoedjiespunt during continuing excavations. The sediments and fossils from the sands were dated using a variety of methods that have consistently given results between 200 000 and 350 000 years before present (kyr BP). Foraminifera and fauna indicate a regressive sea level, possibly corresponding to the cold conditions of oxygen isotope stage 8 (303–245 kyr BP). Dental and cranial remains of a juvenile hominid were recovered from the same level.

The Hoedjiespunt specimen comprises a right human tibial diaphysis (Fig. 1). It is

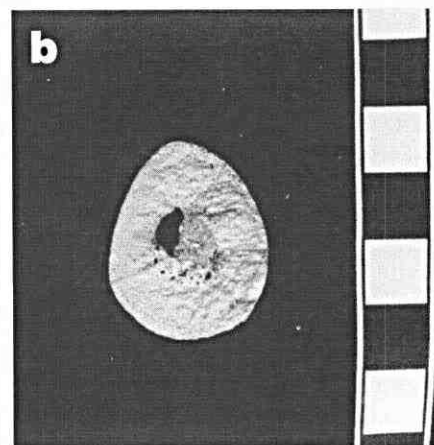
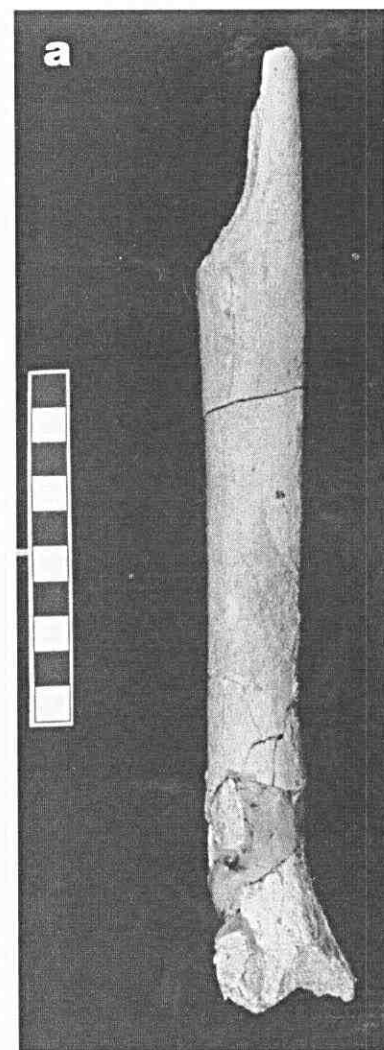


Fig. 1. a, Lateral view of the Hoedjiespunt tibia; b, cross-section of Hoedjiespunt tibia at the midshaft break. Viewed from distal, anterior top. Note that the medullary cavity is partially filled with matrix. Scale bars = 1 cm.

preserved from immediately below the tibial tuberosity to the distal metaphyseal region. Maximum preserved length of the specimen is 275 mm. The specimen is broken near mid-shaft, revealing a slightly amygdaloid shape in cross-section. The cortical bone in the exposed

<sup>a</sup>Department of Biological Anthropology and Anatomy, Duke University, Durham, North Carolina 27708, U.S.A.

<sup>b</sup>Palaeo-Anthropology Unit for Research and Exploration, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Private Bag 3, WITS, 2050 South Africa.

<sup>c</sup>Spatial Archaeology Research Unit, Department of Archaeology, University of Cape Town, Rondebosch, 7701 South Africa.

\*Author for correspondence. E-mail: berger@icon.co.za

Copyright of South African Journal of Science is the property of South African Assn. for the Advancement of Science and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.