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Case report

Features and motivation of a fatal attack by a juvenile white shark, *Carcharodon carcharias*, on a young male surfer in New Caledonia (South Pacific)Eric Clua DVM, PhD State Department Delegate for Research ^{a,b,*},
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ABSTRACT

We present the case of a non provoked fatal shark attack on a 19-year old male surfer in New Caledonia. Several severe bites removed the right arm and all flesh from the right thigh, provoking a quick hypovolemic shock that was fatal. The information provided by a witness and the analysis of a partial bite on the right calf allowed us to identify a 2.7 m TL (est. length) white shark as responsible for this attack. The features of the attack are consistent with a young predator motivated by hunger and the development of its predatory skills.

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1. Introduction

Twelve fatalities worldwide resulted from unprovoked shark attacks in 2011, considerably higher than totals from recent years (the 2001–2010 yearly average was 4.3) and the highest yearly total since 1993.¹ The increased number of shark attacks over the past two decades is consistent with a greater numbers of people in the water.² Amongst all human recreational groups, surfers and others participating in board sports are the most often involved in these incidents, such as in Recife, Pernambuco, Brazil where 47 incidents including 17 fatalities, were recorded within a 14-year period from September 1992 to September 2006.³

The management of shark attacks is a critical issue, and a better understanding of shark motivation and behaviour through forensic analysis should help to avoid adverse outcomes in human encounters with these endangered creatures.^{4,5} If witness descriptions of an attack are available, comparison of display features between the different species of potentially dangerous sharks can help in revealing implications for shark–human interactions and suggest responses which may decrease the likelihood of attack for swimmers or divers faced with a shark showing agonistic display

behaviour.⁶ After the attack, the bite structure of a wound may indicate the motivation and behaviour of the shark.⁷

The three main species involved in fatal attacks around the world are the white shark, *Carcharodon carcharias*, the tiger shark, *Galeocerdo cuvier*, and the bullshark, *Carcharhinus leucas*.¹ The first two are migratory species, and the reliable identification of the species responsible for an attack may have critical consequences in predicting more risky periods of the year, once the local ecology of these large predators is better known.⁸

Here we describe the case of a young male surfer who was attacked and killed in March 2007 by a shark off Bourail, West coast of New Caledonia (South Pacific). The information provided by a witness and forensic analysis of the attack has allowed us to reliably determine the size and species involved and propose a hypothesis for the main features of the attack.

2. Description of the case

On Friday 26 March 2009, a 19-year old male and a friend took a small boat at 7:30 a.m. for a surfing session on the outer slope of the reef barrier, locally known as «Secret», off the city of Bourail on the west coast of New Caledonia (approx. S 21°41'43 and E 165°27'35). The water temperature was around 28 °C, with many jellyfish but clear water. Turbid water linked to recent heavy rains was present at the river mouth (distant by 17 km from the spot) but not on the outer slope. After a short surfing session, the wave height decreased

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and the two surfers then moved some hundreds of meters away for a 40-min spearfishing session. When the wave height increased, they moved back to their surfing spot at 10:30 a.m. At 11:45 a.m, they finished surfing and one of the surfers went back to the small boat that was anchored near the spot to wait for his companion who was «catching a last wave». As the surfer was lying on the surfboard, paddling onto a wave, a shark grabbed him and tore off his right arm. The victim shouted to his companion who jumped from the boat onto his surfboard to join him. The shark however moved in his direction so as the boy moved back to the boat; he then tried to lift the anchor which was stuck. While he was trying to start the boat, the shark attacked the victim again, successively pulling him down and «jumping out of the water around him», both several times, as if «it was playing with him»; «the shark was enormous, probably between 3.5 and 4 m of length» (Witness' statement). After few minutes, the witness cut the anchor rope and retrieved his companion's body onto the boat. The body was motionless and blood flow had ceased. The witness unsuccessfully applied CPR and then proceeded ashore, emergency personnel were contacted and a medical practitioner declared the victim's death at around 12:50 p.m. An autopsy was conducted at a city location during which several photos were taken, subsequently included in the police file (Ref. PV/06930/00444) and used by us for analysing the case (Ref. Parquet AO904702).

Based on the body examination and the witness' declaration, it was evident that the shark attack was violent and sustained, with several strikes (>3). Four main wounds could be distinguished: the right thigh was fleshless from the hip to the knee (with exposed femur), the right arm was missing, the right calf showed a large wound with no loss of tissue and a smaller wound was located on the right ankle which displayed clear cuts on medial and lateral sides that had dislocated the joint (Fig. 1). The autopsy physician determined that death was probably caused by a cardio-pulmonary collapse due to the huge haemorrhage following the cuts of the axial and femoral blood vessels.

To conduct the analysis of the wounds, we mainly used the 'inter- dental distance' (IDD) and the 'bite circumference' (BC) for assessing the species and size of the shark.⁹ Accurate calculation of IDD is actually easier with partial bites and there was only one photo that could be effectively used for this calculation, showing at the same time a partial bite and a measuring scale (Fig. 2). The analysis of the pattern of the teeth marks, directly linked to the teeth characteristics of the shark, were also used to discriminate candidate species from each other. Our knowledge and expertise in shark ecology and attacks were also relevant for finalizing conclusions about the case.

The average IDD calculated on the partial bite of the right calf inflicted by teeth of the upper jaw of the shark (see Fig. 2b) was 21.75 mm. Only two shark species have upper jaw features fitting with such an IDD: a 2.65 Total Length (TL) white shark, *C. carcharias*, or a 2.25 TL long fin mako, *Isurus paucus*. The occurrence of a longfin mako off the reef barrier on the west coast of New Caledonia, has an extremely low probability, as the species has a pelagic distribution.¹⁰ Furthermore, the features of the teeth marks on the body do not fit with elongated, thin and smooth-edged teeth (cf. *Isurus* sp.) but rather with large and serrated teeth with broadly triangular cusps, such as those of a white shark (*Carcharodon* sp.). Finally, the assessment of a bite width of 17 cm (Fig. 2b) gives an approximate upper jaw perimeter of 53 cm which corresponds to an estimated 2.675 m TL white shark following an alternative method.¹¹ Both measures indicate a similar sized shark. We therefore concluded that a juvenile white shark of approximately 2.7 m TL was responsible for this fatal attack.

3. Discussion

The described attack resulted in two massive injuries based on severity of the bites, rapid blood loss and induced hypotension; combined with fatal effect, these features directly classify it at level

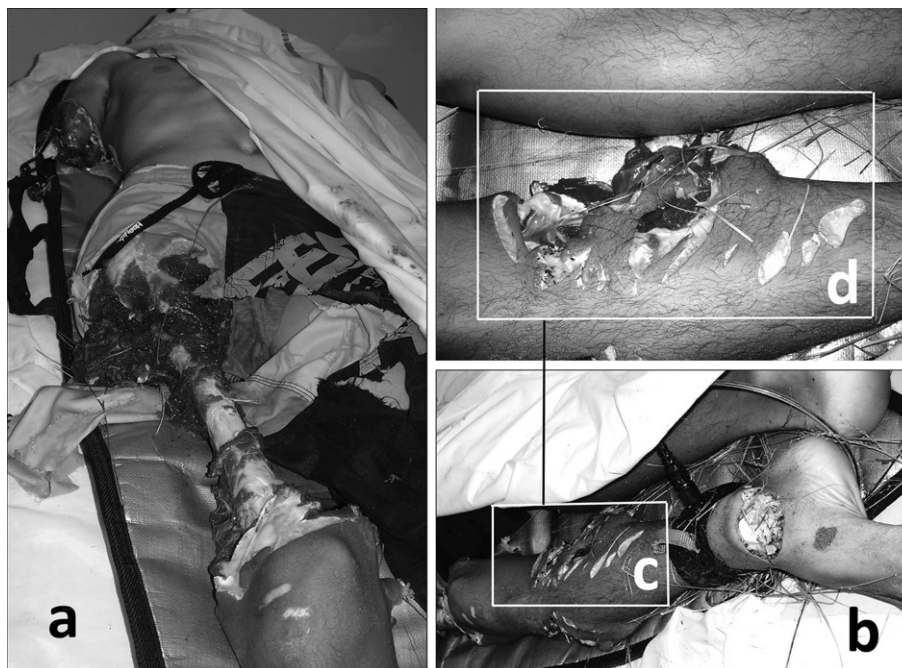


Fig. 1. Body of the 19-year old victim showing the main two wounds in (a): the right arm has been clearly severed 10 cm below the joint of the shoulder (top of the photo); all flesh and muscles have been removed from the right thigh, from the hip down to just above the knee (central and lower part of the photo). (b) Shows the two smaller wounds with a partial bite on the right calf (c) and the internal cut that dislocated the joint of the right ankle (right part of the photo). (d) Displays the partial bite that was used for shark identification and assessment of size (see Fig. 2).

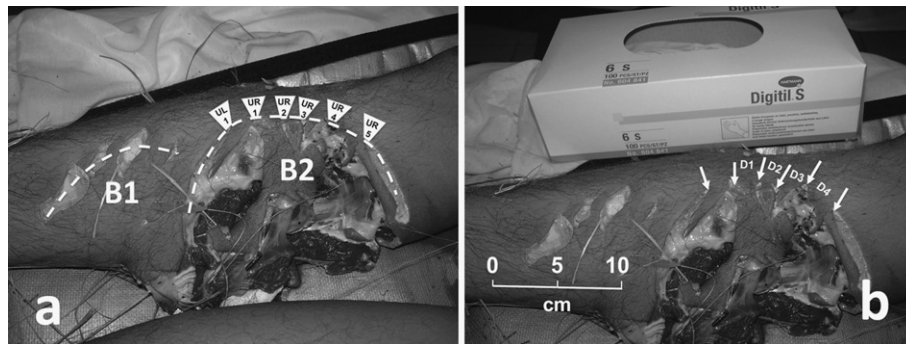


Fig. 2. (a) Arcs B1 and B2 show the two main bites to the right calf, with tooth impression of the top jaw. For the left-hand arc (B1) it appears that the shark held the leg for a very short time, with a shallow holding bite, then eased off before biting down and ripping with full force, just below the labelled marks (B2). On B2, we could define the first isolated tooth mark (top left) as the first Upper Left tooth (UL1), followed then on the right by the Upper Right teeth (UR1 to UR5). (b) The gloves box (24 cm wide) gave us a scale allowing us to calculate bite width as approx. 17 cm, distances between UR1 and UR2 (D1) to be approx. 2.0 cm, and UR2–UR3 as (D2) approx. 1.5 cm, UR3–UR4 (D3) approx. 2.4 cm and UR4–UR5 (D4) approx. 2.8 cm. The average IDD for the left bite arc is approximately 3 cm. The bite width probably represents the jaw width at the 5th tooth from the symphysis.

5 in the Shark Induced Trauma (SIT) Scale (a 1 to 5 scoring system based on the severity of the attack), that was recently set up.¹²

Both the testimony of the witness about the shark behaviour and the analysis of wounds have allowed us to determine with a high confidence a 2.7 m TL (est. length) white shark as responsible for this attack, confirmed by two different measures.^{9,11} This size is less than that estimated by the witness. Compared to other species of shark of the same size, the body of the white shark has proportionately larger girth,¹³ which contributes to its imposing aspect. An overestimate of the shark length by a young non-scientist under extreme circumstances is not surprising. In addition to the features of the wounds, breaching is a putative agonistic behaviour in white sharks⁶ which is much less reported for other shark species; this also supports a reliable species identification.

It is well recognized that hunger is not the main motivation of white shark attacks,^{14,15} but the several strikes and the heavy loss of flesh during this attack support the hypothesis of a feeding behaviour. Young and juvenile white sharks between 1.4 and 2.7 m TL feed preferentially on squid and cartilaginous fishes while the diet of white sharks >3.0 m TL is mainly composed of marine mammals.¹⁶ Other authors¹⁷ postulated that an ontogenetic development in dentition at approximately 3.0 m TL, may account for the shift in predatory behaviour. White sharks are opportunist, generalist predators similar to many large sharks, but show size-based preference for large-bodied, energetically valuable prey.¹⁶ This may have caused the white shark within its dietary shift phase, to target an adult human incidentally crossing its pathway. However, this young shark is still in a learning phase as top predator. The improvement of predatory abilities with experience has been demonstrated in sharks.¹⁸ Studies have quantified the effects of maturation and experience on their predatory efficiency.¹⁹ They concluded that maturation and experience probably act concomitantly to improve the predatory skills. Maturation may allow sharks to utilize more novel and harder-to-eat prey, whereas experience improves foraging efficiency. These facts may have contributed to the motivation for the attack. In line with this experience, it might be relevant to consider that play may help prepare a young predator in the skills that it will need as an adult hunter.²⁰ This would be consistent with the witness' feeling that the shark was displaying a 'playful-like behaviour' during the attack. However, although such behavior was described for mammalian predators,²⁰ it remains speculative for chondrichthyans.

In conclusion, this attack could be summarized as the encounter between a top predator in a specific stage of development (facilitating the attack) and a large-bodied potential prey.

The spearfishing session that the surfers had prior to the attack may have increased the probability of this encounter by attracting the shark around the surfing spot through the noise and distress signals provided by the speared fish. This aquatic activity should be considered as a significant facilitating factor for increasing the risk of potentially harmful shark–human interactions.¹ However, once the two young men were strictly surfing just prior to the incident, we should classify it as a «non provoked» attack.¹ Given the age of the victim, it is a tragic event that should not, however, lead us to forget that fatal shark attacks on humans are extremely rare events.

Ethical approval

It was not necessary.

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Conflict of interest

None.

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