Environmental Biology of Fishes **33**: 319–325, 1992.

Recurring attacks by white sharks on divers at two Pacific sites off Mexico and California

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Received 7.5.1990 Accepted 26.10.1990

Key words: Microsites, Pinnipeds, Algae, Dentition, Interspace, Precautions

Synopsis

Two pairs of recurring attacks by white sharks on divers are detailed. A free-diving spearfisherman was fatally injured at Isla de Guadalupe, Mexico. Eleven years later, a second free diver was attacked while spearfishing at the same location. The swim fin of a commercial abalone diver was bitten at Point Conception, California, and an abalone sport scuba diver was attacked at the same site only four days later. The possible existence of "attack prone" microsites, perhaps characterized by the presence of pinnipeds and the absence of canopy-forming vegetation, is considered. The use of wound characteristics related to tooth interspace measurements for determining the causal species and approximate shark size is discussed. Diver safety recommendations and precautions are highlighted.

Introduction

Attacks on divers, surfers, and swimmers by white sharks, *Carcharodon carcharias*, occur sporadically in coastal waters worldwide, including along the Pacific coasts of the Americas (Bolin 1954, Fast 1955, Collier 1964, Follett 1966, 1974, Miller & Collier 1981, Engana & McCosker 1984, Lea & Miller 1985).

During the decade 1950–1959, 26% (63 of 256 cases) of documented attacks of all types worldwide were against victims involved in some form of underwater activity (Baldridge 1973). The incidence of diver-victims rose to 30% (116 of 393 cases) during the following decade and was expected to continue rising in concert with the increasing popularity of recreational and vocational diving. Similarly, divers were victims of 64% (30 of 47 cases) of unprovoked attacks in relatively cold waters off California and Oregon during the period 1926–1979, with only 20% (6 cases) of the reported attacks on divers happening prior to 1960 (Miller & Collier 1981).

A pattern in attacks by white sharks against divers appears to be emerging in terms of recurrence at certain locations along the Pacific coast of North America. For example, of 35 confirmed white shark-diver interactions off California, 69% (24 cases) have occurred in only six discrete geographical localities: Bodega Bay-Tomales Point (9), Farallon Islands (6), Pigeon Point (3), Point Conception (2), San Miguel Island (2), and Franklin Point (2) (Miller & Collier 1981, Lea & Miller 1985, Collier unpublished data). These apparently 'attack prone' areas are often characterized by the presence of active populations of pinnipeds and the absence of widespread canopy-forming vegetation.

This report details two pairs of such recurring attacks on divers by white sharks: two free-diving spearfishermen, one abalone sport scuba diver, and one commercial abalone diver tethered to a remote air supply. Two attacks (one fatal) are re-

ported from Isla de Guadalupe, a previously unimplicated island located well off Baja California, Mexico. A temporally proximate pair of attacks off Point Conception, California, noted in Miller & Collier (1981) is treated here in more detail.

Isla de Guadalupe, Mexico

Caleta Melpomene Cove (28° 53.2'N; 118° 16.3'W) is the southern most anchorage off Isla de Guadalupe, about 260 km southwest of Punta Baja, Baja California, Mexico. The sea floor is rocky, partially covered with small stature algae and lacking canopy-forming algae. Three species of pinnipeds frequent the area of the island: elephant seals, *Mirounga angustirostris*, California sea lions, *Zalophus californianus*, and the Guadalupe fur seal, *Arctocephalus townsendi*.

9 September 1973. In late afternoon, the boat HUSTLER was anchored at Caleta Melpomene Cove in about 12 m of water, some 180 m from shore. Water temperature was estimated at 23° C, with about 12 m underwater visibility. The sea surface was calm. Although a large number of pinnipeds were observed lying on the shore, none were noted in the water.

Albert Schneppershoff (caucasian male age 37) entered the water with two other adult male divers at about 1600 hours. Schneppershoff's free-diving equipment was predominantly black in color, consisting of a full neoprene wetsuit with hood and boots, weight belt, face mask with snorkel, and swim fins. He also wore contrasting white gloves and carried a varnished wood spear gun. There was no report of anyone actually spearing fish. In fact, the area was relatively free of fish.

One accompanying diver exited the water after about 10 minutes. The second diver returned aboard some 20 minutes later, after casually circling the boat at a distance of about 30 meters. Schneppershoff remained alone in the water.

At about 1645 hours, Schneppershoff, now about 45 m off the bow of the boat and some 135 m from shore, was observed in obvious distress. His head was above the surface, with arms below, and he was seen to be struggling violently. The boat was quickly moved alongside the victim, and he was pulled aboard the swim step, at which time he was heard to say 'shark' before lossing consciousness. The victim had lost his spear gun, face mask and snorkel, weight belt, and swim fins. Efforts to revive the victim were abandoned at about 1830 hours, with death attributed to loss of blood in the absence of any effective attempts by his companions to apply either a tourniquet or a pressure bandage.

Schneppershoff sustained a major injury (17 cm in length) to the medial aspect of the lower right leg, involving all soft tissue, nerves and blood vessels down to the tibia. X-rays revealed two identifiable tooth fragments, 0.4 and 1.2 cm in longest dimensions and with serrae along their margins. Microscopic examination indicated that the fragments were from a white shark (J. Stewart, Scripps Inst. Ocean., pers. comm., 1973).

11 September 1984. Harry Ingram (caucasian male age 37) was among a group of 25 divers aboard the boat SAND DOLLAR when it anchored at about 1700 hours some 300 m offshore in Caleta Melpomene Cove. Water depth of about 12 m increased to near 30 m over an adjacent drop-off. The sky was clear, water temperature was estimated at 21° C, and underwater visibility was about 12 meters. Ingram wore a full black neoprene wetsuit with hood and boots, weight belt, face mask with snorkel, dark green swim fins, and orange life vest, and carried a varnished wood speargun.

Ingram and one of two companion divers returned aboard the boat after some 20 minutes of unsuccessful spearfishing. Water visibility was noted as decreasing along with an increase in currents. There were no reported sightings of pinnipeds either on shore or in the water. Within several minutes, the remaining diver speared a bluefin tuna, *Thunnus thynnus*, of sufficient size to tow the spearfisherman 15–18 m across the surface before the line parted. Ingram and three other divers then entered the water: Ingram paired off with the original spearfisherman and drifted with him 120 m from the boat and the other two divers. They encountered several slow-swimming tuna, and

Ingram's companion speared one at a depth of about 9 meters. After running about 18 m, the spearline suddenly went slack, at which time both divers noted a bubbly upwelling or boiling of water in the region of the expended line. The companion dove to retrieve his spear and during his ascent encountered what appeared to be a cloud of blood, 2–3 m in diameter, where the upwelling had been observed moments earlier. At about 1750 hours, the two divers resumed hunting, separated by a distance of about 12 meters.

Snorkeling at the surface, Ingram observed a large white shark below and slightly behind him, about 3 m off the bottom. After shouting a warning to his partner, Ingram slowly rotated 180° to keep the shark in view. The shark rolled on its left side and 'rotated' its eye in a way indicating to the diver that the shark was also observing him. A second shouted warning followed the first by a few seconds. The shark then turned and rose very rapidly towards Ingram at an angle of about 20°. At a closing distance of about 3 m, the diver discharged his speargun, striking the shark in the head, whereupon it rolled slightly to its right before ramming into him.

Ingram was suddenly thrust about 1 m out of the water and, in the same motion, about 2 m forward. He appeared to be on the back of the shark, which was estimated to have been greater in circumference than 'a large horse'. After reappearing from the turmoil of displaced water, free of the shark, Ingram was joined by his companion, and both divers were quickly brought aboard an inflatable about 60 m from the boat. The orange bouy attached to Ingram's spearline was seen to travel on various headings before disappearing in an easterly direction while paralleling the shoreline.

The white shark was described by Ingram and his companions as about 4.5–5.5 m in length, with a dorsal fin about 0.6 m high, a body about 1.2 m wide, and large black eyes. Witnesses were impressed by the splashing sounds and water displaced by the shark, likening it to disturbances made by a killer whale reentering the water after a jump.

The only injury sustained by Ingram was a bruise to the inner surface of his left biceps, caused possibly by the recoil of his speargun when it contacted the head of the charging shark.

Point Conception, Santa Barbara County, California

Two attacks occurred within four days of each other in July 1975, about 400–450 m from shore, just off Perch Rock which stands north northwest of Point Conception, California (34° 26.6′N; 120° 28.5′W) in water about 8 m depth. The ocean floor there is generally rocky, with numerous small ledges and caves, limited growths of short-stature algae and no large canopy-forming vegetation. Water temperature was estimated at about 15–16° C, with underwater visibility limited to about 3–5 meters. There were minimal ground swells and a slight offshore current.

19 July 1975. In early afternoon, Gary Johnson (caucasian male age 34) was diving for abalone off Perch Rock. As a commercial diver, he wore a full black neoprene wetsuit with hood and boots, swim fins, face mask with a stainless steel rim, carried an abalone basket and a grey aluminum abalone iron, and was tethered on an air line (hookah gear). Prior to entering the water, he noticed several harbor seals, *Phoca vitulina*, basking on nearby Perch Rock. His first dive lasted about 15 minutes, and, after a brief rest aboard his boat, he was again prying abalone off the bottom at about 1330 hours. He had been submerged about 5 minutes, working head-down, when he felt something grab his right swim fin. Johnson turned and saw a large white shark, which then released his swim fin, passed closer to the diver, turned and was momentarily lost from view. Tugging on his air line in an effort to attract attention aboard the boat, he spun around to keep sight of the shark. The shark estimated at 5–6 m long, made five fast close passes without making further contact and then departed. Johnson surfaced and was taken aboard the boat. His swim fin bore five individual thin razor-like cuts on the top and bottom.

23 July 1975. In manuevering their boat for a suit-

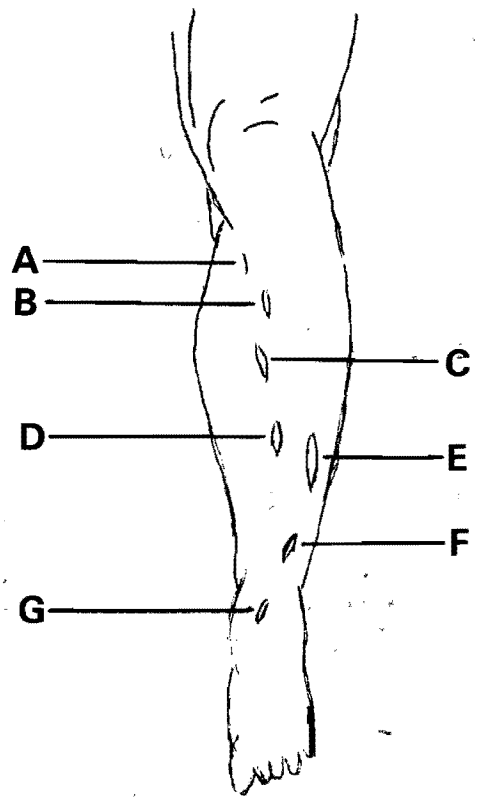

Fig. 1. Locations, individual lengths, and interspaces between the tooth punctures to the lower left leg of Robert Rebstock.

Length of individual tooth punctures (mm)		Interspace measurements (mm)	
A	9.5		
B	19.0	A–B	44.0
C	25.0	B–C	44.0
D	28.5	C–D	75.5
E	50.5	C–E	101.5
F	19.0	E–F	50.5
G	12.5	F–G	63.0

able anchorage about 9 m off Perch Rock at about 1430 hours, Robert Rebstock (caucasian male age 23) and his three companions frightened into the water several harbor seals that had been sunning themselves on the rock. Rebstock then entered the water by rolling backwards out of the boat, equipped with a full black neoprene wetsuit including hood and boots, green swim fins, face mask, weight belt, black flotation vest, yellow pole spear, white game bag, and a black scuba tank with regulator. He surfaced alongside the boat and treaded water while receiving equipment being handed to him. About one minute after Rebstock entered the water, a shark estimated at 4.2–5.5 m in length came from directly beneath him and struck with such tremendous force that he was raised 1.2–1.5 m out of the water. The shark released the man in mid-air, rolled to one side, and arched its back to reenter the water snout first. Rebstock's flight carried him from amidships to the stern of the boat, where within only a few seconds after the attack, he was pulled aboard and given prompt treatment to control bleeding.

The victim's most severe injury was a single deep laceration on the outer upper part of his right thigh, which formed an upside-down 'J' of overall length about 137 millimeters. Although deep enough to penetrate the primary muscles, this wound did not extend to the femur nor did it involve major blood vessels or nerves. The nature of the wound indicates penetration of the thigh by only one or two upper anterior teeth of the shark. Other injury consisted of multiple tooth punctures, 9.5–50 mm in length and 12–37 mm deep, on the anterior surface of the lower left leg (Fig. 1). The arrangement of these punctures is consistent with the victim's left leg having been bent at the knee when the shark struck from below, causing the anterior surface of the leg to be impinged upon the shark's lower teeth. The smooth-edge, razor-like cuts indicated further that there was minimal relative movement during the short time that the man was in contact with the shark's teeth.

Discussion

Dentition patterns and shark size

Dentition patterns seen in wounded victims and damaged equipment have been used for size estimation and identification of causal species, most recently by Randall & Levy (1976), Wallett (1978), Miller & Collier (1981), Engana & McCosker (1984), and Lea & Miller (1985). For example, white sharks and bonito sharks, *Isurus oxyrinchus*,

often occupy the same habitats in Pacific waters off Mexico and California, and are somewhat similar in appearance, particularly during the fleeting observations associated with most shark attacks. However, they produce readily differentiable dentition patterns and wound characteristics. The flat serrated teeth of white sharks most often give rise to long, narrow, razor-like cuts. On the other hand, the more rounded unserrated teeth of the bonito shark are more likely to produce circular punctures with ragged edges (Randall & Levy 1976).

Measurements of punctures made by individual teeth are of questionable worth in determining shark size. Some level of relative movement between victim and attacker is all but guaranteed, thereby causing wound dimensions to exceed tooth dimensions to an unknown degree. Of greater diagnostic value is the interspace between punctures; i.e., the distance between the center of one puncture to the center of an adjacent puncture. Such measurements relate well to corresponding distance between involved shark teeth, which in turn are functions of shark size within a species.

The overall configuration and interspace measurements of leg wounds received by Robert Rebstock (Fig. 1) confirmed the causal species as a white shark. Size of this shark was estimated by W.I. Follett, California Academy of Sciences, San Francisco, after comparison of wound interspace measurements with those from the largest (5.1 m) white shark jaw in the Academy's collection (Table 1). Although subjective, such a comparison indicated that the shark that attacked Rebstock was longer than the reference specimen, thus supporting the consensus estimate by witnesses of 4.2–5.5 meters.

Table 1. Lower jaw tooth interspace measurements for *Carcharodon carcharias* (CAS 26245), female, 5.1 m. Measurements (mm) are from tooth tip to adjacent tooth tip. It is 29 mm between the first lower right and left anteriors. Tooth terminology follows that of Applegate (1965).

Interspace measured	Left	Right
First anterior to second anterior	50	48
Second anterior to third anterior	49	40
Third anterior to first lateral	34	33
First lateral to second lateral	33	36
Second lateral to third lateral	35	34
Third lateral to fourth lateral	26	29
Fourth lateral to fifth lateral	22	23
Fifth lateral to sixth lateral	19	23
Sixth lateral to first posterior	12	12
First posterior to second posterior	8	9
Second posterior to third posterior	5	7
Third posterior to fourth posterior	3	4

Although no direct evidence exists, the short 4-day period between the attacks on Rebstock and Johnson at Point Conception, suggests that a single white shark may have been involved.

Characteristics of attack-prone locales

As at Point Conception and Isla de Guadalupe, nearby pinniped activity and the absence of abundant, canopy-forming underwater vegetation have characterized other locales where white shark attacks on divers have occurred. Underwater visibility, however, appears to be a more random variable in such cases. For example, Miller & Collier (1981) noted several white shark attacks in very clear water (visibility of at least 6.5 m) but no attacks directly within beds (canopies) of *Macrocystis* kelp. They speculated that the recognized increase in white shark attacks in the cold-temperate waters north of Point Conception, California, might be associated with an increase in pinniped populations along the same coast over the past 20 years. All white shark attacks on divers reported by Lea & Miller (1985) for Pacific waters north of Point Conception during the period 1980–1984 occurred in the vicinity of pinniped rookeries or haulout sites and in areas essentially free of canopy-forming kelp. Engana & McCosker (1984) described three white shark attacks on divers in waters off the coast of Chile. Pinnipeds were present and abundant macroalgae absent in each instance. Location and topography may therefore be more important than activity, (e.g. spearfishing) in determining likelihood of attack by a white shark.

The possible existence of such 'attack prone' sites of relatively limited area is further suggested by the recurrence of attacks by white sharks in such discrete waters over time periods of varying lengths;

e.g. Isla de Guadalupe, Mexico, and Point Conception, California. Of 40 unprovoked shark attacks in waters north of Point Conception, from 1926–1979, 55% (22 cases) took place at recurring locations (Miller & Collier 1981). Of 12 attacks described by Lea & Miller (1985) for California and Oregon during 1980–1984, 58% (7 cases) took place at locations where attacks had occurred previously.

Shark attack prevention

Much advice has been given in both scientific and popular literature on the matter of avoiding shark attack, most notably by Gilbert (1963), Baldridge (1973, 1974), and Moss (1984). Recent white shark/diver encounters justify reaffirmation and expansion of those recommendations which pertain specifically to divers operating in waters known to be frequented by white sharks:

(1) Avoid diving in the immediate vicinity of pinniped rookeries or haulout sites.
(2) Never dive alone for numerous, increasingly obvious reasons.
(3) Seek certification in advanced CPR/first aid techniques.
(4) Always have readily available an effective means for controlling bleeding; for example, a 1-meter length of surgical tubing for use as a tourniquet.
(5) If collecting marine animals of any type, remove them from the water immediately following capture.
(6) During ascent from a dive, continually check the depths for the possibility of attack from below and behind.
(7) Be alert to any unusual activity in the immediate area. An abnormal absence of fish or marine life could indicate impending danger.
(8) In preparing to exit the water, make a submerged close approach to the dive step, etc., and thereby avoid swimming at the surface.
(9) Never dive in areas divers have encountered or been attacked by white sharks.

In the continuing absence of any meaningful level of understanding of predation or attack behavior by sharks generally, and white sharks in particular, such recommendation, heavily tempered with common sense, should provide divers with a higher margin of safety when either exploring or exploiting the marine environment.

Acknowledgements

The following contributors made this report possible: Wes Andrew, Tom Blanford, Peter Howorth (Howorth & Associates, Santa Barbara), Gordon Hubbell (Director, Metro Zoo, Miami), Berney LeBoeuf, J.E. Michaels, Dan Miller, Scott Rebstock, Robert Stanbery, Dave Stark (Coroner, San Diego County), Jim Stewart (Scripps Institute of Oceanography), Steve Vukas (Coast Chandlery, Santa Barbara), and Doc White (White Water Enterprises, San Diego). Phillip Buttolph, Diving Safety Officer, Humboldt State University, greatly enhanced the diver safety and precaution suggestions. Special thanks to Harry Ingram, Gary Johnson, Linda (Schneppershoff) McWhorter and Robert Rebstock for their insight and permission to publish their incidents. H. David Baldridge graciously gave of his time and talents in the preparation and writing of the manuscript. Gene Helfman (University of Georgia, Athens) read the manuscript and offered valuable suggestions.

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