

Attacks on Humans by the Blacktip Reef Shark (*Carcharhinus melanopterus*)¹

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ABSTRACT: The blacktip reef shark (*Carcharhinus melanopterus*) occurs in shallow waters throughout most of the tropical Indo-Pacific. Its classification, distribution, and biology are reviewed. Ten attacks by this shark at Palau, Phoenix, Line, and Marshall islands, Caroline Atoll, and Tuamotu Archipelago are summarized. Only three attacks resulted in injuries. Eight of the 10 attacks occurred during the afternoon; nine, in water less than waist deep. All but one victim were wading, and dead or injured fishes were present prior to only three incidents. Contrary to previous reports, the blacktip reef shark should be considered dangerous.

THE BLACKTIP REEF SHARK (*Carcharhinus melanopterus*) (Fig. 1) is a relatively small species of the tropical Indo-Pacific commonly seen in the shallows over reefs and sand flats. The incidents reported below indicate that this shark, although generally regarded as being harmless to man, is in fact capable of inflicting injury. Before discussing the attacks, we will review what is known of the classification, distribution, and biology of this shark.

CLASSIFICATION

The blacktip is one of the most distinctive of the species of *Carcharhinus*, the largest genus of sharks. The genus, in general, is difficult to classify (Garrick, in Gilbert, Mathewson, and Rall 1967); it is still under study by J. A. F. Garrick of the Victoria University of Wellington, New Zealand. As both the scientific and common names imply, this shark's fins are tipped with black. Other sharks may have blackish or dusky areas distally on some fins but none so prominently as *melanopterus*. Its first dorsal fin often has a broad pale zone beneath the jet black apical area which accentuates the dark marking. It lacks a midlongitudinal ridge

on the back between the two dorsal fins. The snout is relatively blunt (tip of snout to front of mouth contained about 1.3 times in the distance between the corners of the mouth). The second dorsal and anal fins are nearly equal in size, the anal being directly under the second dorsal. The nasal opening has a projecting dermal flap. There are 12 or 13 teeth on each half of the jaws (discounting small symphyseal teeth). The teeth, which have been illustrated by Fourmanoir (1961: fig. 23) and Gohar and Mazhar (1964a: text-fig. 49), are finely serrate; the lowers are slender, erect, and symmetrical; the uppers are more broadly triangular and have a large angular notch on the latero-posterior edge, the basal portion of which has large serrations which grade to smaller ones proximally. There are 115 to 122 precaudal vertebrae and 89 to 92 caudal vertebrae (total 202-214, based on counts by Springer and Garrick [1964] of 14 specimens from the Gilbert Islands, Caroline Islands, Philippine Islands, Thailand, and the Red Sea).

Whitley (1934) proposed *Mapolamia* as a genus of sharks, with *melanopterus* as its type species. He based his generic description on a 21-inch male from the Ellice Islands. The blacktip reef shark, however, is the type species of *Carcharhinus*, as recommended by Garrick (1962), and has been accepted by the International Commission on Zoological Nomenclature (1965, Opinion 723, Ruling 2[c]); thus *Mapolamia* is invalid.

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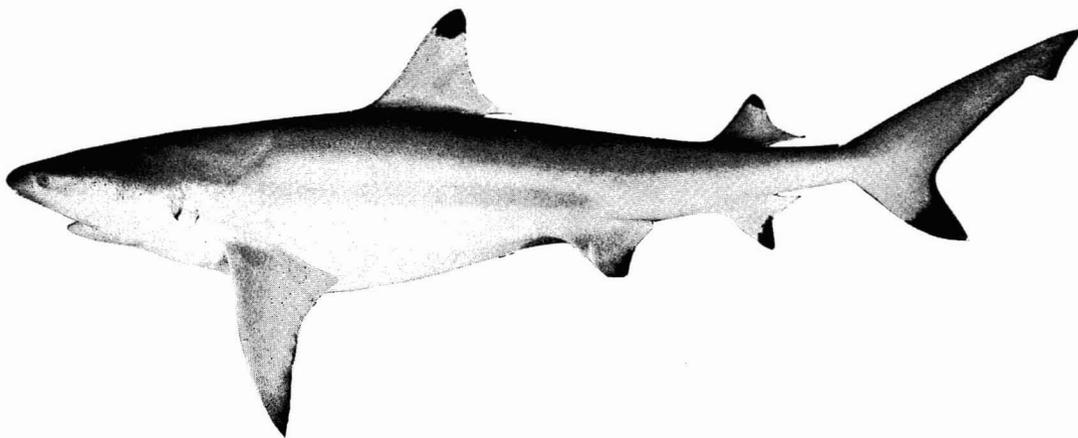


FIG. 1. Blacktip reef shark (*Carcharhinus melanopterus*), female, precaudal length 960 mm, total length 4.5 feet, 28.5 lbs, from Eniwetok, Marshall Islands.

DISTRIBUTION

C. melanopterus was described by Quoy and Gaimard (1824) from "Pile Vaigiou" off the western end of New Guinea. The species has since been recorded from many localities throughout the Pacific and Indian oceans. It is particularly common at atolls. Harry (1953) reported it (as *Eulamia melanopterus*) from Raroia, Tuamotu Archipelago. He stated that it is as abundant as all other sharks combined at the atoll. Schultz in Schultz et al. (1953) wrote in reference to sharks in the Marshall Islands, "The black-tip shark is the commonest species seen, and unlike any other occurs in abundance in shallow water on the reefs, where it can be observed with its back exposed and the black tips of its fins showing." Fig. 2, taken at Eniwetok Atoll, Marshall Islands, by the junior author, shows six blacktips on the lagoon reef flat of Igurin (Glenn) Islet. Randall (1955) noted that *C. melanopterus* was the most common reef shark at Onotoa Atoll, Gilbert Islands, adding that it was rarely troublesome.

During a recent expedition to SE Oceania, the senior author frequently observed this shark in the Society Islands and the Tuamotus but rarely saw it in the Marquesas Islands. None were seen during a month of diving at the four islands of the Pitcairn Group. The species was present at Mangareva and Temoe of the Gambier Group, southern Tuamotus, but seems to be absent from Rapa and Îlots de Bass (Maro-

tiri). None were seen at Raivavae, Tubuai, and Rurutu in the Austral Islands; however, only a few days were spent at each of these islands. Three other Pacific islands where blacktips were not observed by the senior author are Johnston, Marcus, and Easter.

In the western Pacific *C. melanopterus* ranges from Heron Island on the Great Barrier Reef (23° S) (Woodland and Slack-Smith 1963) to Nagasaki, Japan (nearly 33° N) (Kamohara 1967). In the eastern Indian Ocean it is known as far south as North-West Cape, Australia (23° S) (Whitley 1945, recorded as *Mapolamia spallanzani*). On the western side it ranges south to Natal but is not often seen there (Smith 1949). Smith's illustration of the species is not *melanopterus*, however. Also the figure of *melanopterus* from the Seychelles in Smith and Smith (1963) does not appear to be this species, although we do not doubt the occurrence of the blacktip at these islands.

There are several records of *C. melanopterus* from the Red Sea, beginning with Rüppell (1835). Tortonese (1964) reported it as a new arrival in the Mediterranean via the Suez Canal, but one presently restricted to Egypt. Neither Blegvad (1944) in his *Fishes of the Iranian Gulf* nor Khalaf (1961) in his *The Marine and Fresh Water Fishes of Iraq* lists the blacktip from these areas.

At some of the extremes of its range, such as Japan and its southern limits in Australia, *C. melanopterus* may be a migrant during the warm



FIG. 2. A small aggregation of blacktip reef sharks (*Carcharhinus melanopterus*) observed close to shore, lagoon side, of Igurin (Glenn) Islet, Eniwetok Atoll, Marshall Islands, at 1530 hours on 5 January 1972. The six sharks which can be seen in the photo range in length from about 2 to 3 feet. The sharks were swimming slowly and did not appear to be feeding.

months of the year (at these three localities the mean sea surface temperature during the warmest months is about 26° C). In the Hawaiian Islands, a region which would seem somewhat marginal for a tropical shark (monthly sea surface temperatures range from about 24° to 27° C), *C. melanopterus* is resident, although rare.

BIOLOGY

Relatively little is known about the biology of the blacktip reef shark in spite of its broad distribution and its abundance at many localities. Data on food habits are limited (summarized below), little has been reported on reproduction (some information is contradictory), and little or nothing is known about movements, age and growth, predators, para-

sites, etc. Its development was investigated in some detail by Melouk (1957). Tester (1963) used *C. melanopterus* and *C. amblyrhynchos* (*C. menisorrah* of Schultz in Schultz et al. 1953) for research on olfaction, and Tester and Kato (1966) employed the same species for experiments on visual discrimination. Kato (1962) studied the retina of the blacktip. Prasad (1945) conducted research on the structure and function of the nidamental glands of this shark, and Karmarkar and Gazdar (1967) studied the cytology of the blood cells.

Whitley (1945) reported that the stomachs of two specimens of the blacktip reef shark from western Australia contained fragments of fish and the head of a cuttlefish or squid. Chacko (1949) examined the stomach contents of 52 specimens of *melanopterus* from the Gulf of

Manaar, India, which ranged in length from 45 to 152 cm. He stated that this shark feeds on fishes and crustaceans but did not give any indication of the relative amounts. Among the fishes he listed were *Epinephelus* sp., *Therapon jarbua*, *Leiognathus* sp., and *Sillago sibama*, and among the crustaceans, *Penaeus* sp. and *Squilla* sp. Fourmanoir (1961) stated that *C. melanopterus* is abundant in the coral islands of Madagascar where it pursues mullets (*Liza macrolepis*), *Gerres*, *Trachinotus*, etc. in the shallows. Gohar and Mazhar (1964b) concluded from remains found in the stomachs of Red Sea specimens that the food of the blacktip consists principally of fishes.

The senior author has examined the stomach contents of 24 specimens from Tahiti, Fanning, Palmyra, and Eniwetok. These sharks varied from 285 to 1,080 mm in precaudal length (for total length, increase the precaudal length by about 30 percent), and in weight from 220 grams to 2,181 grams. One of these specimens was taken by dip net, six were speared, and the remaining were caught by hook and line. Fourteen of the 24 had empty stomachs or contained bait. One had only a piece of coral rock in its stomach. One had eaten an octopus and another contained about equal amounts of the remains of octopus and fish. Unidentified animal material which appeared to be mollusk in origin was the only thing found in one stomach. The remaining seven blacktips had eaten fishes, most of which were too digested to identify. One fish was *Acanthurus* sp., another was an acanthurid (probably *Acanthurus* or *Ctenochaetus*), and a third was a labrid.

Hobson (1963) studied the feeding behavior of *C. melanopterus*, comparing it with the gray reef shark (*C. amblyrhynchos*) and the whitetip reef shark (*Triaenodon obesus*). He found the blacktip very cautious in approaching a bait, in contrast to the much bolder gray; but, once stimulated to feed, it was capable of a swift and aggressive attack. Both the blacktip and gray sharks displayed a marked increase in excitement when feeding in numbers.

Tester (1963) reported that three small blacktips survived starving in captivity for 2 months while a fourth lasted 3 months (not determined if it fed in part on the three that died).

Of the 24 blacktip reef sharks collected by

the senior author, one (863 mm precaudal length, taken at Palmyra on 9 November 1968) was a female with eggs, and four others, 956 to 1,080 mm precaudal length, contained embryos. Three of the latter were caught in the Line Islands between 25 October and 11 November 1968. Each had four embryos (overall range in precaudal length 57 to 227 mm). The fourth female, which was caught at Eniwetok on 2 December 1968, contained two embryos (one in each uterus, 89 and 91 mm precaudal length). T. A. Clarke (personal communication) captured seven sharks by gill net at Eniwetok during June 1971. Six of these were females that ranged in total length from 770 to 1,270 mm. One 1,150-mm female contained four pups, two of which were females 420 mm and two were males 420 mm and 430 mm total length (approximately 306 and 314 mm precaudal length).

Fourmanoir (1961) also reported the number of embryos of the blacktip reef shark to vary between two and four. His specimens were from islands off Madagascar. He observed the young at term especially during the month of November. They measured between 460 and 520 mm in length. Bonham (1960), on the other hand, reported two juveniles with umbilical scars taken at Rongelap, Marshall Islands, which were 350 and 360 mm in total length. The smallest juvenile blacktip collected by the senior author was 370 mm in total length. It was caught at Eniwetok on 2 December 1968. Another of 490 mm total length that still had an umbilical scar was taken in Tahiti.

Melouk (1957) stated that mating of *C. melanopterus* appears to occur in early summer in the Red Sea. In May embryos vary from about 20 to 400 mm in length. In August stages shorter than 60 to 70 mm are not to be expected, and newly born young occur commonly around the shores of islands in the vicinity of the Biological Station at Al Ghardaqa. He estimated that the complete period of development takes about 16 months. Data for the same area by Gohar and Mazhar (1964a) do not correspond too closely to those of Melouk. They found all females (1,200 to 1,310 mm) in December to be pregnant. There were two embryos 330 to 370 mm in length in each uterus. Gohar and Mazhar stated that the young are born in January as well as June.

C. melanopterus is a small species. Fourmanoir (1961) gave the maximum length as 1,700 mm. Herre (1936) cited the capture of blacktips at Nuku Hiva, Marquesas Islands, of lengths up to 1,275 mm, adding that none seen swimming were more than 1,800 mm long. Gohar and Mazhar (1964a) had 22 specimens from the Red Sea which ranged from 610 to 1,320 mm in length.

Greater lengths have been attributed to the species, but these probably represent misidentifications. Other sharks such as *C. limbatus*, which have blackish tipped fins, attain larger size than *melanopterus*.

Hobson (1963) reported finding an 18-inch blacktip shark in the stomach of an 80-pound grouper at Eniwetok. Blacktips probably also serve as prey to those sharks that often feed on smaller sharks, such as *Galeocerdo cuvier* and *Carcharhinus galapagensis*.

The only information available on the growth of *C. melanopterus* was provided by A. B. Kalawar, Director of Fisheries, Taraporevala Aquarium, Bombay, to whom we are grateful. In a letter dated 16 August 1971 he wrote that *Carcharhinus melanopterus* has been kept on several occasions in the exhibition tanks of the Aquarium. One which lived for 2 years was 19 inches long when brought to the Aquarium. During its 2 years of captivity it attained a length of 37 inches. It was fed once a day, mainly on pieces of sciaenid fish.

HAZARD TO MAN

Because of its abundance and its predilection for shallow water, *C. melanopterus* is encountered by humans more than any other tropical Indo-Pacific shark. Many observers have noticed that it may approach humans in the shallows but is usually frightened away. Herald (1961) wrote, "Although it is not dangerous to man, the blacktip *Carcharhinus melanopterus* is a very inquisitive shark. It is not uncommon for a skin diver to jump into an intertidal pool and instantly be surrounded by several curious blacktips. This is a bit unnerving to the swimmer, even though he may have read all of the books which state emphatically that this species never nibbles at the unwary spear fisherman."

Strasburg (1953) stated, "*C. melanopterus* is

probably a harmless shark, at least at lengths below 6 feet. We were always successful in frightening them away by splashing, beating rocks together underwater, or by swimming directly toward an overly curious individual. It is my belief, however, that a person spearing fish or picking up fish during a poison station, should be alert when these sharks are about. It is possible that odors from dead fish can cause them to become much less timorous than usual."

The senior author has on two occasions been frightened by the proximity and aggressive behavior of blacktip reef sharks while he was collecting fishes with rotenone. The first such incident occurred in 1957 outside the barrier reef at Moorea, Society Islands, east of the pass to Papetoai Bay. While picking up fishes dead or dying from the effect of rotenone at a depth of 80 feet, the senior author was startled when a blacktip not over 2 feet in length entered the collecting area. Its swimming was rapid and erratic, so a decision was made to terminate the collecting sooner than planned. While the grapple that served as an anchor for the collecting boat was being pulled up, the shark was observed through a face mask at the surface to charge and bite the grapple.

The second incident occurred on 7 November 1968 on the south side of Sand Island, Palmyra, Line Islands, in a region of numerous coral heads reaching near the surface from a depth of about 10 feet. Several sharks were feeding on fishes affected by the rotenone. Suddenly one blacktip of about 5 feet in length swam directly and very rapidly toward the senior author's head, veering only inches from his face mask. Possibly a bright reflection from the face mask had attracted the shark.

A similar occurrence took place at Caroline Island (10° S, 150° W) when the senior author was setting a stern anchor by dinghy for his ketch on the western side of the atoll. Watching over the stern of the dinghy with only his head in the water to locate a good place to set the anchor, he perceived a blacktip about 20 inches in length rushing toward him at the surface. The quick removal of his face from the water averted at the last moment what appeared to be certain contact by the shark. As will be noted below, Caroline was later the site for two other blacktip incidents.

TABLE 1
BLACKTIP REEF SHARK INCIDENTS

INCIDENT	VICTIM	LOCALE	DATE	TIME	DEPTH	TIDE	SHARK LENGTH
1	M. Coburn	Palau (7° N, 134° E)	9 Apr. 1970	1600	2 ft	incoming	4 ft
2	B. Telmetang	Palau (7° N, 134° E)	7 May 1970	1510	2 ft	incoming	3–3.5 ft
3	J. Ichikawa	Canton (3° S, 172° W)	6 Feb. 1972	1600–1700	knee-deep	incoming*	4–4.5 ft
4	P. Helfrich	Palmyra (6° N, 162° W)	Nov. 1959	midafternoon	knee-deep	—	3–4 ft
5	F. Silby	Palmyra (6° N, 162° W)	5–6 June 1965	midday	ankle-knee deep	high-outgoing*	18 in
6	G. Allen	Eniwetok (11° N, 161° E)	Aug. 1968	1430	waist-deep	incoming-high	3.5 ft
7	R. McNair	Caroline (10° S, 150° W)	18 Nov. 1970	late afternoon	knee-deep	incoming*	4 ft
8	R. Costello	Caroline (10° S, 150° W)	18 Nov. 1970	late afternoon	knee-deep	incoming*	< 3 ft
9	A. Sinoto	Anuanuraro (20° S, 143° W)	5 Dec. 1970	1100	8–18 in	outgoing*	33 in
10	R. Nolan	Eniwetok (11° N, 161° E)	27 Jan. 1972	1630	3 ft	outgoing	5 ft

* Tides marked with an asterisk were calculated from U.S. Department of Commerce Tide Tables for the appropriate date and locale.

In addition to our own experiences, several persons have informed us of blacktips rushing at them and turning at the last moment. This type of encounter may not be unusual—the Palauan name for the shark comes from a word that means “to dash at and turn quickly” (Helfman and Randall 1973).

We have found only two shark attacks in the literature attributed to *Carcharhinus melanopterus*. The first was listed as an unprovoked attack on James L. Oetzel at Wake Island by Garrick and Schultz in Gilbert (1963). At our request, Dr. Gilbert kindly provided a copy of an article on shark attacks by Oetzel from *Skin Diver Magazine* (March 1956: 19) in which this incident is discussed, as well as a letter from Oetzel to Gilbert dated 28 December 1961. The attack on Oetzel consisted of being bumped on the right shoulder following an aggressive movement by him toward the shark. It occurred in the lagoon at Wake on 20 November 1954 at 1500. He described the shark in the *Skin Diver* article as being 5 feet in length and “of the type common to these islands, bluish grey with a white belly.” It was not called a blacktip in the article, nor was there any mention of the fins be-

ing black-tipped. In his letter, however, Oetzel once referred to the shark as “this black tipped shark.” We believe, however, that the species responsible for this incident was the gray reef shark (*C. amblyrhynchus*). Although its dorsal fins are not marked with black, the other fins may be edged in blackish, and laymen not infrequently refer to this species as a blacktip. The gray reef shark is common at Wake. The senior author spent a week collecting fishes there in June 1953 and on one occasion was rushed by an individual of this species. Anyone engaged in collecting fishes in the islands of the tropical Indo-Pacific soon learns that the gray reef shark is a threat. It is the species which bit the arm of James Stewart at Wake Island on 9 March 1961 (Garrick and Schultz in Gilbert 1963) and was responsible for the two attacks reported by Hobson, Mautin, and Reese (1961) at Eniwetok, Marshall Islands. In contrast to *C. melanopterus*, which usually retreats when a human swims toward it, *C. amblyrhynchus* may assume a threat posture or attack when pressed by a diver (Donald R. Nelson, Richard H. Johnson, and Walter A. Starck II, personal communications).

The second incident was cited in a popular article concerning balistid fishes by Jonklaas (1972). In the early 1960s while collecting live reef fishes off northeast Ceylon, Mr. Jonklaas was conscious of hundreds of the triggerfish *Odonus niger* around him which were making grunting sounds. As he netted a clownfish (*Amphiprion*) from the vicinity of its anemone, he heard "a frantic rushing and the grunts increased in volume." He looked around and observed that every *Odonus* had vanished from sight into holes in the reef. Then he saw a "hefty blacktip shark (*Carcharhinus melanopterus*)" making straight for him. He just had time to push the net at its snout, which caused it to turn, and he kicked for the surface. He attributed the alarm reaction of the triggerfish to saving him from a probable shark bite.

The senior author has corresponded with Jonklaas for many years and knows him to be an experienced diver very familiar with the fish fauna of Ceylon. Nevertheless, a letter was written to Jonklaas asking for confirmation of the species of shark. He replied, "I can quite emphatically vouch for the fact that it was a *melanopterus* that attacked." He added that he was astonished, for it was the gray reef shark, *C. menisorrhah* (= *amblyrhynchos*) which had usually menaced him in the past. He listed the principal means by which he distinguishes the blacktip: the "very black" fin tips, that of the first dorsal set off by white, the "creamier hue of the body" and the "less chunky" body shape than *menisorrhah*. He stated that the offending shark was very large for the species; he believed it to be a female. He commented on the rapidity of the attack, "She came streaking at me with mouth open, and the whole thing was over in 4-5 seconds."

We have obtained accounts of 10 attacks by blacktip reef sharks on humans which have not been reported previously. Three resulted in wounds, and these are discussed first. The others, all but one of which involved some form of contact with the attacking shark, are presented chronologically. We thank our informants for the data on these incidents. Estimates of the lengths of the sharks, the depth of the water, and various distances were given to us in the English system. We have intentionally not converted these estimates to the metric

system. The 10 incidents are summarized in Table 1.

Incident 1

The victim, Michael Coburn, age 24, a United States Peace Corps volunteer, had been spearfishing approximately 300 yards south of the shoreline of Ngiwal village, Babelthup Island, Palau Islands, on 9 April 1970. At the time of the attack, about 1600, the sky was clear, and the tide, which had been very low, was just beginning to come in. The victim was standing in approximately 2 feet of clear water on the hard algal ridge of the fringing reef near a small channel in the reef 6 feet in depth. In his right hand and trailing about 2 feet off to his right side was a fish stringer made of a 6-foot cord on which there were six small snappers (*Lutjanus* sp.) and a surgeonfish (*Naso lituratus*). The surgeonfish had been speared 10 minutes before the attack and was still alive. The snappers were taken more inshore 40 minutes prior to the attack and were dead. Coburn was facing a small (1-foot) breaking surf when he first saw the shark. It was about 8 feet away, coming from the channel on his left and moving very fast toward him. He yelled, and "by the time the yell came out" the shark had bitten his left leg. The shark left instantly, returning to the channel. The victim described the shark as about a 4-foot-long "matukeyoll," the Palauan name for the blacktip reef shark, *Carcharhinus melanopterus*.

Coburn was wearing full length blue denim jeans and black ankle-high canvas reef shoes (*tabi*). The shark bit through the jeans of his left leg in the region of his shin, leaving a 1.25-inch curving wound on the front inside of the leg, some bruises just in front of this area, and a series of scratches 2.25 inches down and slightly anterior to the larger wound (Fig. 3). The shark hit with considerable force, and the victim was surprised that he had not been knocked down by the impact.

While spearfishing outside the reef in 20 feet of water about 10 minutes prior to the attack, Coburn had seen a blacktip shark of similar size to the one that attacked him. This shark came within about 20 feet of him along the surface. The victim shouted twice underwater, and the shark swam away.

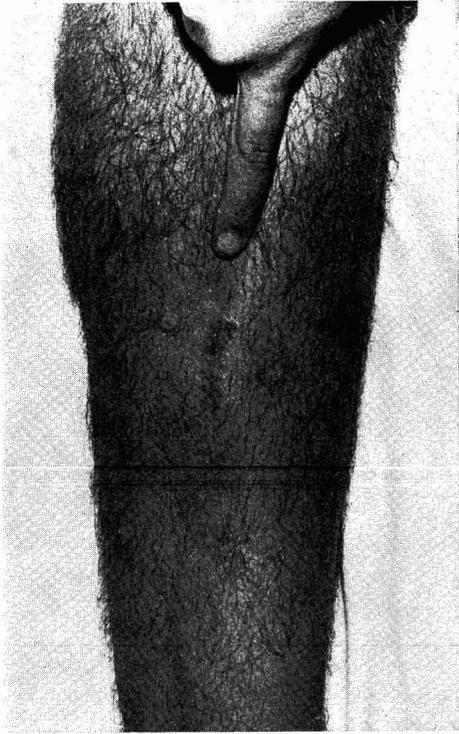


FIG. 3. Wound on the left leg of Michael Coburn inflicted by a blacktip reef shark (*Carcharhinus melanopterus*) in the Palau Islands.

The only other person in the area, Paulus Mad, was about 25 yards away at the time of the attack in the deeper water on the ocean side of the reef. He had not speared any fish as of that time, nor did he see the shark before or after the attack.

Following the attack, the victim and Mad walked quickly back to the village of Ngiwal, where the victim's wound was treated at the village dispensary. The wound was closed with eight stitches and has healed normally.

Incident 2

This attack occurred on 7 May 1970 when Belesoch Telmetang, a 37-year-old Palauan, and his brother Hirosak Telmetang were walking slowly in clear water about 2 feet deep in the lagoon of Palau on a sand-rubble bottom about 75 yards east of Ngerobelobang Island (hence about 30 miles from the site of the attack on

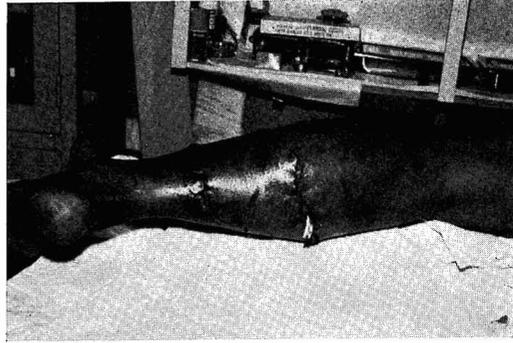


FIG. 4. Wounds on the left leg of Belesoch Telmetang inflicted by a shark believed to be the blacktip reef shark (*Carcharhinus melanopterus*) in the Palau Islands.

Coburn). They were carrying a gill net between them and were separated by approximately 4 feet. The net was not open and they had not yet caught any fish. They had been searching for fish for half an hour before the attack, which took place at 1510. At this time there was a small surf (1 to 2 feet) 10 yards behind them; the waves were breaking over the lagoon reef that drops off into 20 feet of water at its edge. The tide was beginning to come in. Neither man saw the shark just before it attacked; it apparently came out of the deeper water and through the waves to their rear. The shark struck the victim on his left leg, knocking him down. The victim said that he felt the shark shake when it bit him, and it then swam away. The witness heard the victim shout and then turned and saw his brother holding up his bleeding leg. The witness saw a small (approximately 3- to 3.5-foot) shark disappearing through the breaking waves into the deeper water just beyond the surf. The witness could not be certain what kind of shark it was, but said that it was brown and he thought it was "matukeyoll" (*C. melanopterus*).

About 20 minutes prior to the attack, both men had seen a blacktip reef shark of similar size to the one that attacked. This shark had been swimming on the lagoon side of the waves and moving parallel to the men. It approached to within 7 yards of them but did not come into the shallow water.

Both men were wearing short pants (boxer shorts) and black canvas *iabi*, leaving their legs exposed. The shark bit the victim above the

tabi, resulting in two severe wounds to the mid and lower portions of the calf (Fig. 4). The medical report states, "The shark severed both the deep and superficial layers of the calf muscle and the deep blood vessels and nerves of the leg, removing a portion of the calf muscle. A similar laceration was located about 4 inches below the calf injury, severing the superficial muscles above the achilles tendon."

Following the attack, the witness bandaged the victim's leg with a pair of pants and a fish stringer and carried him to a nearby area that was not yet covered by the incoming tide. He then sought a third brother, Yehelu Dismas, who was handline fishing in the party's outboard motor boat about 400 yards west of the scene of the attack. The two brothers brought the boat to the victim over the shallow reef flat, adjusted the bandages, and motored for 2 hours to Koror, where the victim was admitted to MacDonal Memorial Hospital. A medical team, headed by Yuji Mesubed, M.O., took 2 hours to debridge and suture the injuries. Three sets of 20 sutures, including one internal set, were required to close the wound. Prior to surgery, the victim was unable to perform a plantar flexion movement. Anthony H. Polloi, M.O., informed us in a letter dated 18 December 1972 that Telmetang has recovered except for a limp.

Incident 3

On 6 February 1972, at 1600 to 1700 hours, Jack C. Ichikawa, age 52, finished cleaning a string of fishes on the outer reef flat, ocean side, at Canton Island, Phoenix Islands. He then waded into the water about knee-deep to wash his hands. With the periodic surge, the water rose to his thighs. He saw a blacktip reef shark about 4 to 4.5 feet long swimming rapidly toward him. Realizing that he could not reach the safety of the exposed reef behind him, though this was only a few steps away, he held his right arm outstretched toward the oncoming shark to ward it off. As it passed by, he grabbed it by the tail with the objective of flinging it away from him. Before he could succeed in this he was bitten below the right knee. Fortunately, the wound was minor and required no sutures. He also received an abrasion on one

finger as a result of his initial contact with the shark. He believes this may have occurred from striking one of the fins.

Our informant for the above was Dr. Louis C. Spillman, the medical officer on Canton. He was asked to be certain that the victim could positively identify the shark as a blacktip. He replied that there was no question of this. Ichikawa had spent 5 years as a boat operator at Kwajalein Atoll in the Marshall Islands. In this capacity and as a fisherman he was very familiar with the island fishes and could readily distinguish the blacktip from the few other sharks that occur inshore in Oceania.

Incident 4

This incident occurred in November 1959 in midafternoon when three men were wading side by side about 10 feet apart in knee-deep water while crossing a broad channel west of the easternmost islet of Palmyra, Line Islands. A blacktip shark of about 3 to 4 feet in length swam directly toward the seaward member of the trio (Mr. Leslie Fullard-Leo, the owner of the atoll). Although he slashed at the shark with a long cane knife, it was not ascertained if he struck the shark. The shark then swam in a broad arc and rapidly approached the individual on the lagoon side (Dr. Philip Helfrich of the Hawaii Institute of Marine Biology) who was carrying a large glass ball (float for Japanese longline). Dr. Helfrich submerged the ball at arm's length in front of the onrushing shark. The shark bumped into the ball, then veered toward the lagoon and departed. About an hour earlier when the group had been walking toward the islet (at which time the water in the channel was more shallow), a fourth member of the party had cut his leg on coral in about the same area. He had been advised by the others to turn back.

Incident 5

This attack also occurred at Palmyra. On 5 or 6 June 1965, toward midday, Fred C. Silby was wading in water that varied from ankle to knee depth. He saw a blacktip reef shark about 18 inches long swim toward him. He expected it to approach merely "to investigate" the disturbance he had created by walking in the

shallows. He had experienced a number of such approaches during the course of birdbanding activity at the atoll, and the sharks had always turned away. This one, however, swam directly to him "without slackening its pace" and bit the end of his tennis shoe. The shark's teeth "did not hit flesh."

Incident 6

The following account was prepared at our request by Dr. Gerald R. Allen, age 26, who was serving as the laboratory manager at the Eniwetok Marine Biological Laboratory when the incident occurred.

During the latter part of August, 1968, I was rushed by a 3 1/2-foot black-tip shark (*Carcharhinus melanopterus*) while wading in shallow water on the lee side of Eniwetok Atoll. During late morning I had crossed a half mile stretch between two of the islands for the purpose of gathering glass fishing floats. At this time much of the reef was exposed or the water was only about ankle-deep; however, upon my return a few hours later, the tide had risen and it was necessary to wade in waist-deep water much of the way. I encountered approximately six blacktips on the return crossing. All of these approached from the lagoon side (*i.e.* deeper water) at great rates of speed and without any preliminary circling. All but one veered away when they were within 10 to 20 feet of me. One shark, however, did not veer until the last moment before reaching me, perhaps only 2 feet away, and then only after I had struck it with a large bag of glass floats which I was carrying.

After spending ten months at Eniwetok, I am convinced that *C. melanopterus* does not pose a threat to divers who are totally submerged and who are not spearfishing. It can be dangerous to waders as the above incident points out. At the time of my encounter (about 2:30 p.m.) I was wearing light-colored bermuda shorts and white tennis shoes and was creating a great deal of unavoidable splashing as I walked over the reef flat.

Incident 7

During a 6 months' expedition to SE Oceania on the schooner *Westward* (led by the senior author and supported by the National Geographic Society and the Oceanic Foundation), three shark episodes took place involving crew members of the vessel, two of whom are students of marine biology at the University of Hawaii. The third, Rhett McNair, age 46, a keen enthusiast about sharks and their danger to man, had developed his own front-loading powerhead (explosive device for killing sharks)

and was anxious to test it at every opportunity. With the powerhead in hand, he was wading in water nearly knee-deep on the outer reef at Caroline Island (then uninhabited), returning in the late afternoon of 8 November 1970 to hail a boat from the *Westward* which was hove to off the western side of the atoll. The sun was in front of him, and there was so much glare on the water that he did not see the approach of a shark from the direction of the sun. The nose of the shark struck the lower shin of his left leg just above the ankle, and its teeth penetrated the laces and tongue of the low-cut white tennis shoe he was wearing. He fell in the water and the shark splashed around him briefly, seemingly disoriented, before it departed in haste. McNair could then see clearly that it was a blacktip about 4 feet long. There were no cuts or abrasions from the teeth but a small bruise on the lower shin resulted from the initial contact with the shark's snout. After this incident another blacktip made a direct approach and McNair fired the powerhead but missed. The explosion frightened the shark away. McNair succeeded in killing two blacktips at Caroline by luring them close to him by kicking one foot in the water to cause splashing.

Incident 8

On the same day and at nearly the same location, shortly after the incident involving McNair, Rich Costello, age 24, was wading across the outer reef in knee-deep water to be picked up by the *Westward's* boat. He was wearing black *tabi* and also carried a powerhead. He saw a small blacktip approaching from about 20 feet away. When it came to within 3 feet of him, he shook the powerhead in front of the shark and it turned away. At this point he shook his foot at the shark, whereupon three other sharks of the approximate size range of 2.5 to 3 feet swam at him from different directions. He splashed the end of the powerhead in front of each just before they reached him. Observers in the boat saw him turning rapidly one way and then the other to frighten off the three sharks. After a brief respite, a fourth shark of similar size came in from about 35 feet away. Then Costello had time to fire the powerhead. As a result of the explosion the shark was seen

to come partly out of water, and it swam away. Costello did not know if he had injured the shark.

Incident 9

On 5 December 1970 on the northwest side of Anuanuraro Atoll, Duke of Gloucester Group, Tuamotu Archipelago, Akihiko Sinoto, age 20, was the first to jump ashore on the outer reef from the *Westward's* boat. He was armed with a machete. While waiting for the others he was standing in about 8 inches of water, which increased to about 1.5 feet with each surge. He saw a blacktip which he estimated to be 33 inches in length approaching him from the side about 10 feet away. He turned to face the shark and took one step in its direction. The shark moved in a wide arc nearly 180 degrees around him and then came for him with its first dorsal fin out of water. Sinoto had again faced the shark, machete in readiness. The shark swam at medium speed directly toward Sinoto's right foot (clad in a low-cut light blue tennis shoe with white sole). When the shark was only 2 feet away, but still heading straight for his foot, Sinoto struck it with the machete and cut a slice into the snout to the right of the midline (he could see a flap of partially separated tissue showing later). The shark then swam in a tight circle counterclockwise and struck Sinoto's left foot at the front of his shoe but did not engage its jaws. With the contact of the shark, Sinoto lifted his left foot out of water, and the shark followed it with its mouth open until nearly two-thirds of its length was out of water in an apparent effort to bite the foot, but it did not reach it. The shark circled closely again to rush several times at Sinoto's feet, who was jumping to avoid the charges and slashing with his machete. One slash cut off most of the right pectoral fin, and another inflicted a deep gash in the tail. The shark then circled more widely and finally swam off in an irregular way. The time was 1100, the water was clear, and there was full sunlight. The incident was observed by four others in the boat nearby.

Incident 10

On 27 January 1972, at 1630 hours, Ronald S. Nolan of the Scripps Institution of Oceanog-

raphy was working a gill net in LaCrosse Crater (the result of an experimental H-bomb explosion in 1958) on Runit (Yvonne) Islet, Eniwetok Atoll, Marshall Islands, with two other divers when he was menaced by a blacktip reef shark about 5 feet in length. The net, of 1.25-inch stretch mesh, was set at an angle of about 30 degrees to the northern edge of the crater at a depth varying from 6 to 14 feet. The tide had started to ebb from a high of 4.5 feet at 1514 hours. About 18 inches of water separated the crater from the outer reef and the open sea on the north side. The two associates were herding schools of goatfishes (*Mulloidichthys* spp.) into the gill net while Nolan held a station near the outer edge to frighten those fishes that might try to escape around the free end of the net. All had SCUBA. He saw a school of large mullet (*Crenimugil crenilabis*) approaching and left his post to try to drive them into the inner area set off by the net. As he neared the edge of the crater he saw the shark coming toward him. He retreated to the edge of the crater and backed into an area of cover beneath a small ledge in about 3 feet of water. For a period of about 20 seconds the shark swam back and forth very close to him. For protection he held a clipboard at arm's length when the shark came particularly near, and on two occasions the shark bumped the end of the board. Nolan stated that the shark swam relatively slowly during this time. There were no rushes toward him or any display of agitated or rapid swimming that one might expect prior to an attack. The men had been working the gill net for about an hour. They had caught a number of fishes and tagged them, a process which generally means the loss of some scales by the fishes. Four smaller blacktips had been seen in the crater during this period.

DISCUSSION

The 10 incidents reported above clearly demonstrate that the blacktip reef shark is not to be regarded as a harmless species. There is no question that it is less dangerous than the gray reef shark and some of the larger species of carcharhinid sharks, but with adequate stimulation it can inflict serious wounds. Even when

only a small blacktip is present, the potential exists for a serious mishap. At Fanning Island in early November 1970, the schoolteacher informed the *Westward's* personnel that a Gilbertese copra worker who was pushing a small canoe in the shallows had been found dead in the lagoon in water only knee-deep. He had numerous bites from small sharks over his body. Although the man was not young and could have died from some cause other than the shark bites, it is also possible that several blacktips may have been responsible for the fatality. An initial bite from one could have led to a fall into the water which could have been followed by repeated attacks from the same and other sharks.

Of the 10 incidents, eight of them occurred from mid to late afternoon, and the remaining two from 1100 to midday. There are two possible explanations for this. First, winds tend to increase in the afternoon, making it more difficult for a shark in the shallows to see an entire human being. The flickering light from the wind effect on the surface and possibly greater turbidity might obscure the view of a man's limbs in the water.

The second explanation concerns the feeding habits of sharks. In general, sharks feed principally at night. The junior author was informed that Palauans who spear fishes at night occasionally have their catch stolen by blacktip sharks from the fish stringer they trail in the water. If *C. melanopterus* is mainly nocturnal, its appetite may increase as the day passes, and the shark would be progressively bolder later in the day.

All 10 incidents occurred in shallow water varying from 8 inches to waist deep. We have tidal information for nine of the 10 attacks; six took place during a high or rising tide. All but one incident involved persons who were wading. Depending on the conditions of light and wind, the shark probably did not observe that portion of the victim which was out of water. It is possible that the shark mistook a man's foot or calf for a fish. Because of the splashing caused by walking, the lower limbs may have simulated fish in distress. It is our belief that a person who sees a blacktip approaching him in shallow water and has no means of fending off the shark should consider submerging as much

of his body as possible. We have been informed that Marshallese swim rather than wade their canoes when crossing shallow atoll passes because they fear blacktip attacks on their legs.

LITERATURE CITED

- BLEGVAD, H. 1944. Fishes of the Iranian Gulf. Einar Munksgaard, Copenhagen. 247 pp.
- BONHAM, K. 1960. Note on sharks from Rongelap Atoll, Marshall Islands. *Copeia*, no. 3: 257.
- CHACKO, P. I. 1949. Food and feeding habits of the fishes of the Gulf of Manaar. *Proc. Indian Acad. Sci.* 28B: 83-97.
- FOURMANOIR, P. 1961. Requins de la côte ouest de Madagascar. *Mém. Inst. sci. Madagascar*, F, 4: 1-81.
- GARRICK, J. A. F. 1962. Reasons in favor of retaining the generic name *Carcharbinus* Blainville, and a proposal for identifying its type species as the Indo-Pacific black-tipped shark, *C. melanopterus*. *Proc. Biol. Soc. Wash.* 75: 89-96.
- GILBERT, P. W. 1963. Sharks and survival. D. C. Heath and Company, Boston. 578 pp.
- GILBERT, P. W., R. F. MATHEWSON, and D. P. RALL. 1967. Sharks, skates, and rays. Johns Hopkins Press, Baltimore. 624 pp.
- GOHAR, H. A. F., and F. M. MAZHAR. 1964a. The elasmobranchs of the north-western Red Sea. *Publs. Mar. Biol. Stn. Ghardaqa*, no. 13: 1-144.
- . 1964b. Keeping elasmobranchs in vivaria. *Publs. Mar. Biol. Stn. Ghardaqa*, no. 13: 241-250.
- HARRY, R. R. 1953. Ichthyological field data of Raroia Atoll, Tuamotu Archipelago. *Atoll Res. Bull.* 18. 190 pp.
- HELFMAN, GENE S., and JOHN E. RANDALL. 1973. Palauan fish names. *Pacif. Sci.* 27: 136-153.
- HERALD, E. S. 1961. Living fishes of the world. Doubleday & Co., Garden City, New York. 304 pp.
- HERRE, A. W. 1936. Fishes of the Crane Pacific Expedition. *Publ. Field Mus. Nat. Hist. zoological series*, 353. 472 pp.
- HOBSON, E. S. 1963. Feeding behavior in three species of sharks. *Pacif. Sci.* 17: 171-194.

- HOBSON, E. S., F. MAUTIN, and E. S. REESE. 1961. Two shark incidents at Eniwetok Atoll, Marshall Islands. *Pacif. Sci.* 15: 605-609.
- JONKLAAS, R. 1972. Those terrific triggers! *Trop. Fish Hobby.* 20(12): 88-94.
- KAMOHARA, T. 1967. *Fishes of Japan in color.* Hoikusha Publishing Co. Osaka. 135 pp.
- KARMARKAR, S. P., and G. S. GAZDAR. 1967. Study on the cytology of blood cells of *Carcharbinus melanopterus*. *J. Biol. Sci.* 10: 1-6.
- KATO, S. 1962. Histology of the retinas of the Pacific sharks *Carcharbinus melanopterus* and *Triaenodon obesus*. M.S. Thesis. University of Hawaii, Honolulu.
- KHALAF, K. T. 1961. *The marine and fresh water fishes of Iraq.* Ar-Rabitta Press, Baghdad. 164 pp.
- MELOUK, M. A. 1957. On the development of *Carcharbinus melanopterus* (Q. & G.). *Publ. Mar. Biol. Stn. Ghardaqa*, no. 9: 229-251.
- PRASAD, R. R. 1945. The structure, phylogenetic significance, and function of the nidamental glands of some elasmobranchs of the Madras coast. *Proc. Nat. Inst. Sci. India* 11: 282-302.
- QUOY, J. R. C., and P. GAIMARD. 1824. Poissons. Chapter 9, pages 192-401 in L. C. D. Freycinet, *Voyage autour du monde... exécuté sur les corvettes de S. M. l'Uranie et la Physicenne, pendant les années 1817-1820.* Imprimerie royale, Paris.
- RANDALL, J. E. 1955. *Fishes of the Gilbert Islands.* Atoll Res. Bull. 47. 243 pp.
- RÜPPELL, W. P. E. S. 1835. *Neue Wirbelthiere zu der Fauna von Abyssinien gehörig.* 2 vols. Frankfurt-am-Main.
- SCHULTZ, L. P., ET AL. 1953. *Fishes of the Marshall and Marianas islands.* Bull. U.S. Nat. Mus. 202. xxxii + 685 pp.
- SMITH, J. L. B. 1949. *The sea fishes of southern Africa.* Central News Agency, South Africa. 550 pp.
- SMITH, J. L. B., and M. M. SMITH. 1963. *The fishes of Seychelles.* Dep. Ichthyology, Rhodes University, Grahamstown. 215 pp.
- SPRINGER, V. G., and J. A. F. GARRICK. 1964. A survey of vertebral numbers in sharks. *Proc. U.S. Nat. Mus.* 116: 73-96.
- STRASBURG, D. W. 1953. *Fishes of the southern Marshall Islands.* Rep. U.S. Off. Nav. Res., Contract 695(00). 267 pp.
- TESTER, A. L. 1963. The role of olfaction in shark predation. *Pacif. Sci.* 17: 145-170.
- TESTER, A. L., and S. KATO. 1966. Visual target discrimination in blacktip sharks (*Carcharbinus melanopterus*) and grey sharks (*C. menisorab*). *Pacif. Sci.* 20: 461-471.
- TORTONESE, E. 1964. The main biogeographical features and problems of the Mediterranean fish fauna. *Copeia*, no. 1: 98-107.
- WHITLEY, G. 1934. Notes on some Australian sharks. *Mem. Qd. Mus.* 10: 180-200.
- . 1945. New sharks and fishes from western Australia. *Aust. Zool.* 11: 1-42.
- WOODLAND, D. J., and R. J. SLACK-SMITH. 1963. *Fishes of Heron Island, Capricorn Group, Great Barrier Reef.* University of Queensland Press, St. Lucia. 69 pp.