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Shark evacuation from Mo'orea island in 2002

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Abstract
Reef sharks, including blackfins (*Carcharhinus melanopterus*) reside in the lagoons and on the outer slopes of the barrier reefs of Mo'orea Island, French Polynesia. In general the lagoons are shallow enough to permit underwater observation, while dive clubs hold shark dives at different sites in the lagoons and in the ocean. Thus, the presence of blackfin sharks especially, and other species at times, is confirmed daily. Between about 21 July and 2 August 2002, all blackfin reef sharks under observation, and possibly some of the other species, left their lagoon and ocean ranges and disappeared from human view, a unique evacuation for which no explanation was found. The event suggests an unknown pattern or influence at work which was perceived by sharks, but was not apparent to those investigating.

Keywords
Blackfin reef sharks, *Carcharhinus melanopterus*, Moorea Island, shark behaviour, shark evacuation, shark ethology.

1. Introduction

The community of blackfin reef sharks (*Carcharinus melanopterus*) on the north shore of Mo'orea Island is loosely segregated between the lagoon, occupied by the females, juveniles, and a very few males, and the outer slope of the barrier reef, which is inhabited by the rest of the males (Porcher,

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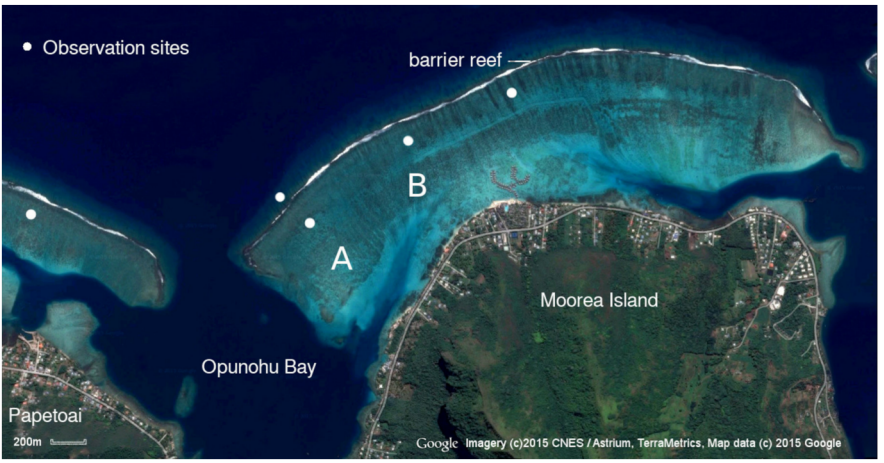

Figure 1. Author's observation sites at the time of the event.

2005; Mourier et al., 2013). I was studying their behaviour as individuals through underwater observation in the Vaihapu region (Galzin & Pointer, 1985) in 2002, and had been doing so for three years. Once a week I held a feeding session at one of the three sites marked in Figure 1 at sunset (a period when they were most active), and between these sessions I visited the western half of the lagoon at random times during the day to observe the members of the community without food. The passes, lagoon borders, and nurseries were monitored to collect complimentary information. Between April 1999 and September 2005, I held 504 sessions totalling 506.95 h, and recorded 11 514 sightings, not counting other shark species. I identified 474 individual blackfins, excluding unconfirmed and partial identifications, and gathered a large amount of information on their movements, ethology, and social biology, including their gestation period (Porcher, 2005).

The observation of sharks at feeding sites, including recreational shark dive sites, has been used successfully to study various aspects of shark behaviour since then (e.g. Sperone et al., 2010, 2012; Mourier et al., 2012; Brena et al., 2018; Thibaut et al., 2021).

2. The event

2.1. Saturday 20 July 2002

I held a feeding session at Site B, trailing scent as I approached it. When I went underwater, two older female sharks who were rarely in that area were

travelling swiftly along the inner edge of the barrier reef. They did not come to the session, though it was unusual for a shark to be present when I arrived and not come to eat when I had trailed scent.

No other sharks were present, but soon a male who was usually found 1 km to the west arrived and during the following half hour, a small group of males and juveniles gathered. This was extremely unusual because the resident females were usually present when I arrived, with more appearing throughout the session. Further, several of the males were from the outer slope of the barrier reef, and I never saw them in the lagoon outside of the reproductive season, when they came to mate with the females. Nearly all of the resident females were absent, which was unprecedented during the dry season when they travelled infrequently. But a young female I had never seen before came into the site, though it was rare for me to encounter a new shark.

Shortly thereafter, an unknown dark male soared in. He was twitching wildly and displayed successive instantaneous directional changes throughout the period in which he was present — about 20 minutes. Sometimes he performed a series of vertical jerks; other times massive shivers ran through him. Until this episode, I had only seen such a state as a brief startle reaction, usually in juveniles (Porcher, Preprint 2022, 2022080139 doi: 10.20944/preprints202208.0139).

The smallest juveniles — shark pups of less than a year old — were also absent, though there were always many at that site, because the scent flow passed through a region of thick coral beyond, where they habitually sheltered.

This session took place four days before the full moon, so it was already the period in which it was light at night, the apparent reason the sharks tended to choose that time for travelling (Porcher unpublished data). Klimley & Ainley (1996) also noted a correlation with the lunar cycle in the movements of great white sharks as did Pérez-Jiménez et al. (2002) in aggregations of sharpnose sharks (*Rhizoprionodon longurio*). Since the moon was full on 24 July 2002, I kept seeking a reason that would explain their disappearance during this full moon period, but I had never seen any change in the movements of the pups due to the phase of the moon before.

2.2. Tuesday 23 July 2022

The divers conducting daily shark dives outside the barrier reef, and the commercial tours holding shark feedings in separated lagoons on the north

shore, reported that no sharks appeared that day, something that had never happened before. The shark dives were frequented by 20 to 30 male blackfin reef sharks who met the dive boats and moved with the divers during the dive. A few sicklefin lemon sharks (*Negaprion acutidens*) were also regular attendees.

Phillipe Molle, of M.U.S.T. Dive Club, Maharepa, Mo'orea, said that he had been holding shark dives for 17 years and on only one other occasion had no sharks attended — on the day before a hurricane had struck the island. So he was expecting bad weather but none came.

Figure 2 shows the locations where shark dives and feeding sessions were held, so the absence of the sharks was noted. But the actual extent of the evacuation is unknown. It involved the entire populations of blackfins from at least two lagoons, separated by Opunohu Bay, who normally did not interact, as well as all of the males living on the outer slope of the reef along the western two thirds of the north shore.

Daily I called the dive clubs to know whether any sharks had been seen and day after day, none attended the shark dives, though their food was brought as usual. There were only two sightings of 'small sharks' on the outer slope, who passed in the distance and did not approach.

2.3. The search

On Saturday 27 July 2022 I held the usual weekly feeding session at Site B. No sharks met the kayak and I waited. Time passed, but no shark pups flitted from the coral beyond, no blackfins came circling from the veiling light — no sharks appeared. The still lagoon slowly darkened. I drifted down-current but the view was empty in all directions where no shark glided.

The next morning I went early and finned from the border of the lagoon to Site A, creating a strong scent flow and feeding the fish. No sharks came, which was unprecedented, so I continued eastward towards Site B and searched as far as the scent flow would have reached in the hour I had waited the previous night. I took some fish scraps to Site A again that night, and stayed long after the fish went to sleep, until night had fallen. Just as I turned to leave, a small shark drifted by at the limits of visibility, then slowly came close enough to identify. It was a juvenile male who regularly attended the feeding sessions, but he would not come to eat. The scent flow did not interest him and he disappeared into the darkness.

Each morning and evening I trailed a scent flow through the western third of the study lagoon, a region that was home to about four dozen blackfin reef

Figure 2. The sites where shark feedings and dives were held on Mo'orea Island in 2002.

sharks. But not one appeared. The disappearance of the smallest pups from their shelters in the thick coral was especially inexplicable.

2.4. The sharks return

On Tuesday 30 July 2022 one of the resident female blackfins was present when I slid underwater late in the afternoon, and stayed nearby as I searched along the lagoon. She did the same on the following day and on 1 August a second adult female, whose core area was farther to the east, moved with us. The occasional juvenile male also appeared, passing in the distance. It was curious that those two females who returned before the others were the companions of residents who disappeared during the evacuation.

The rest of the community of blackfins suddenly arrived together on Friday, August 2, while I watched at sunset at Site A. Their behaviour was different. They snatched up a fish scrap, swallowed it, and moved on, with neither socializing, casual circling, nor their usual finickiness over the food.

Most were sharks whose core areas were farther east and they travelled fast towards them, widely spread out across the coral landscape. Groups of juvenile males were in the lead, advancing swiftly through the empty lagoon ahead of the big sharks. Those young males of about three years old seemed especially zealous, and were reminiscent of the two reports of a 'small shark' from observers at the dive sites.

Some whitetip sharks (*Triaenodon obesus*) were travelling with the blackfins. Though a few more blackfins reappeared during the following days, the majority of the lagoon residents returned together that evening. Most of the population had settled back into their core areas by the time a week had passed. Just one resident female returned a month later, after the next full moon.

By mid-August, the blackfins' behaviour and distribution was nearly back to normal but a major disruption had occurred. In some parts of the lagoon, the pattern of sightings I had systematically recorded prior to the disappearance took months to re-establish itself. Some adult residents and many juveniles, especially the smallest pups, never returned. Figure 3 shows the change in attendance at the sessions during this period.

No other shark species were seen during the search for the blackfins, but at that time of year I did not see nurse sharks (*Ginglymostoma cirratum*) and reef whitetips (*Triaenodon obesus*) as often as in the warm season, so whether they had also evacuated was unverifiable. But the presence of whitetips among the returning blackfins does suggest that they too had been affected.

Some dive monitors said that female grey reef sharks (males were never seen there) still appeared off the northwest corner of the island during the disappearance, though others stated that they too, were absent. No sicklefin lemon sharks were seen during this period and the total absence of sharks at the dives during the period in question suggests that other species had been affected by whatever had caused the blackfins to leave.

3. Discussion

Intensive investigation of the shark evacuation revealed no applicable reason for it. Sharks are known to flee before a storm hits (Phillippe Molle, pers. commun. 2002; Heupel et al., 2003), or when some of their numbers are killed by fishermen (Porcher & Darvell, 2022). However, the ocean during

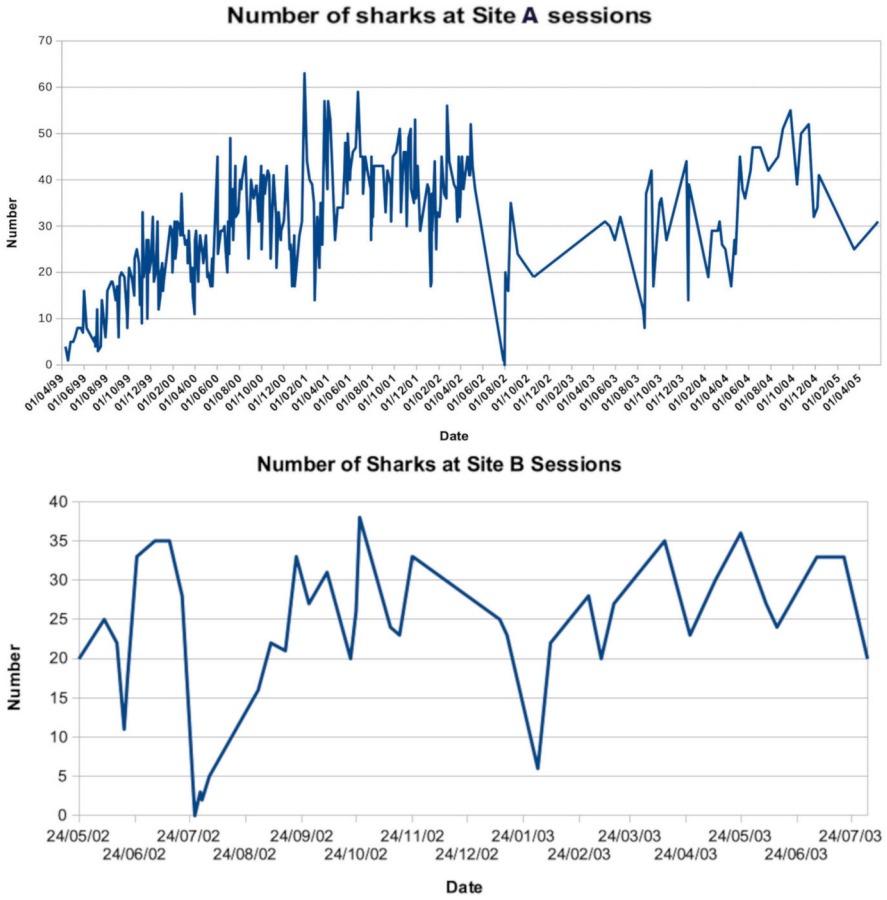

Figure 3. Attendance at the sessions showing the absences during the shark evacuation. Above: Site A attendance from 11 April 1999 to 23 May 2005. Below: Site B attendance, where regular feeding sessions were held at sunset from May, 2002, to August 2003. The second downward spike in January 2003 was caused by such bad conditions that I was instantly swept away and saw only 6 sharks.

that period of time was undisturbed. There was no sudden fishing effort, the weather was settled, and the water temperature was normal. Intensive discussion among those who spent their days on the seas around the island revealed no shark fishing or any other unusual factor that could affect the sharks. The divers assured me that no one could have massacred a lot of sharks without someone hearing about it. Though they were not yet protected by the government at that time (Animal Welfare Institute, 2022), the Polynesians had never

wanted their sharks either fished nor disturbed and though some tourists did enjoy killing them, no shark fishing was being done off that coast. Even if a long-liner had killed some of them along the coast at night and the others had fled, the smallest shark pups would not have left their refuges of thick coral as a result.

The same was true if some unusual predator had visited those shores. Towner et al. (2022) reported that great white sharks (*Carcharodon carcharias*) fled from their usual ranges when two killer whales (*Orcinus orca*) began hunting them and killed some of their numbers. A similar event could certainly disrupt the patterns of the adult blackfins, though since there are neither killer whales nor white sharks in those waters, it is unknown what novel predator could suddenly appear. However, the juveniles remain in shallow waters specifically to protect themselves from large predators, so this possible explanation does not account for the disappearance of the lagoon residents, especially the shark pups from their shallow-water coral refuges.

The circle-island tours moving daily around the island reported nothing unusual, such as an incidental food source which could have attracted the sharks into the ocean. Such a food source would be visible from far away due to the vast multi-species congregation of seabirds circling above it. No construction work had been under way and there had been no oil or pollution spills. If there had been pollution from a point source, the sharks would have presented movements reasonably correlated with dispersal from it. The laws of chemical diffusion would not predict large numbers of individuals leaving rapidly from such a large region without some indication of differential spread. There were no military events in the area and no earth tremors. On one of the days in which the sharks were absent, humpback whales were resting in Opunohu Bay with a group of spinner dolphins. Whatever had affected the sharks was not troubling the marine mammals. Dr Michael Poole, a marine biologist observing the whales and dolphins daily along the north shore, and frequently down the west coast and around the entire perimeter of the island, reported no change in the patterns of their movements, and nothing unusual in the ocean during the period in question. The oceanic current does not move fast enough to explain the return of the sharks in such a short period if oceanic conditions were responsible for the evacuation (Prof Arthur A. Myrberg, pers. commun. 2002).

Dive clubs on neighbouring islands informed me that they had noticed no change in the numbers of sharks attending their dives, suggesting that whatever the cause was, it had only affected Mo'orea Island.

The appearance of a solitary juvenile shark at the visual limit, as reported by two dive monitors, suggested that the sharks might be in deeper water. The reluctance to approach to eat is typical of a shark alone. It is conceivable that the larger sharks had gone much deeper, while the juveniles prefer shallower water, so were the ones who came into the visual range of divers at about 22 m in depth.

I contacted every shark scientist I knew and posted an inquiry on the different Internet shark discussion lists, including the elasmo-list of the American Elasmobranch Society (a society of shark researchers), to report the event and see if others had seen something similar and knew of an explanation. But although I received many interested replies from shark researchers around the world, no one reported having seen or heard of any similar event, nor did anyone have a plausible explanation. It was not in the category of a migration; it could not be related to reproduction since it was not the reproductive season and all the females were pregnant; it could not have been caused by a food source elsewhere, because that would not have caused the tiny shark pups to leave.

One clue is presented by the disruption of the blackfin communities prior to the evacuation, including the appearance in the lagoon of males from the outer slope, and the extreme behaviour of the disturbed shark. The unusual displacement of the male sharks in concert with the disappearance argued against the idea that the entire north shore shark population had simply fled the island to deep water. Perhaps they had bolted from some disturbance, some to the protection of the lagoons. Then they had gone on and vanished from human view — most likely in deep water.

Animals are known to display changed behaviour prior to earthquakes, and in other ways, too, sometimes show that they are aware of certain things that humans ignore. Whatever it was that alarmed Mo'orea's sharks, it must have presented as something very dire to force the smallest shark pups from their shelters of thick coral, for most of them never came back.

Professor Arthur A. Myrberg's final comment on the subject was, "Animals often do remarkable things that have no answer. Perhaps we'll understand someday, when we can ask them and they can provide us with an answer that makes sense."

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