



## Comments/Reflections

### Commentary on emotion in sharks

Ila F. Porcher<sup>\*,\*\*</sup>

Independent Researcher, 15161 Cedar Boulevard, Hope, BC, Canada V0X 1L5

\* Author's e-mail address: [ilafranceporcher@protonmail.com](mailto:ilafranceporcher@protonmail.com)

\*\* ORCID: <https://orcid.org/0000-0003-3410-4732>

Received 6 October 2021; initial decision 22 November 2021; revised 1 December 2021;  
accepted 9 December 2021; published online 21 December 2021

---

#### Abstract

While studying the behaviour of a community of blackfin reef sharks, there was a four month long episode during which the entire company of residents and their visitors showed evidence of feeling a negative emotion towards me. They directed a variety of menacing gestures towards me, and their behaviour escalated until they began battering my kayak on my arrival in their range. Underwater, three would have slammed me personally had I not fought them off. Their behaviour suggested that their cognitive functions are complex, for they held their negative attitude in mind long-term. Two years later, under different conditions, they conveyed, via body language, a positive emotion. Social learning, social buffering, and emotional contagion were also displayed in their actions.

#### Keywords

Blackfin reef shark, *Carcharhinus melanopterus*, agonistic display, shark behaviour, shark ethology.

#### 1. Introduction

From April 1999 to September 2005, I studied the behaviour of blackfin reef sharks (*Carcharhinus melanopterus*) in a lagoon on Mo'orea Island (French Polynesia), through underwater observation, following the precepts of cognitive ethology. About once a week, just before sunset, I brought some fish scraps to specific sites in the fringe lagoon. Initially I did this to habituate the sharks to my presence, but found that the feeding sessions also permitted me to see which sharks were in the area and to view their social behaviour. This method has been used successfully to study various aspects of shark

behaviour since then (e.g., Mourier et al., 2011; Mourier & Planes, 2012; Brena et al., 2018). I held 501 sessions totalling 506.20 hours, and recorded 11,514 sightings, not counting other shark species. Between feeding sessions, I visited the lagoon to observe the members of the community without food.

Each individual was identified by the markings on its dorsal fin, general appearance, colour, gender, and age (Porcher, 2005) and over the years I identified 473 individuals. The lagoon was inhabited by the juveniles and females, whose home ranges were in the lagoon. Only a few males attended regularly outside of the mating season. There were about three dozen resident sharks, and many visitors, some who attended frequently, some rarely.

## **2. Negative subjective states**

### *2.1. From April 1999 to January 2002*

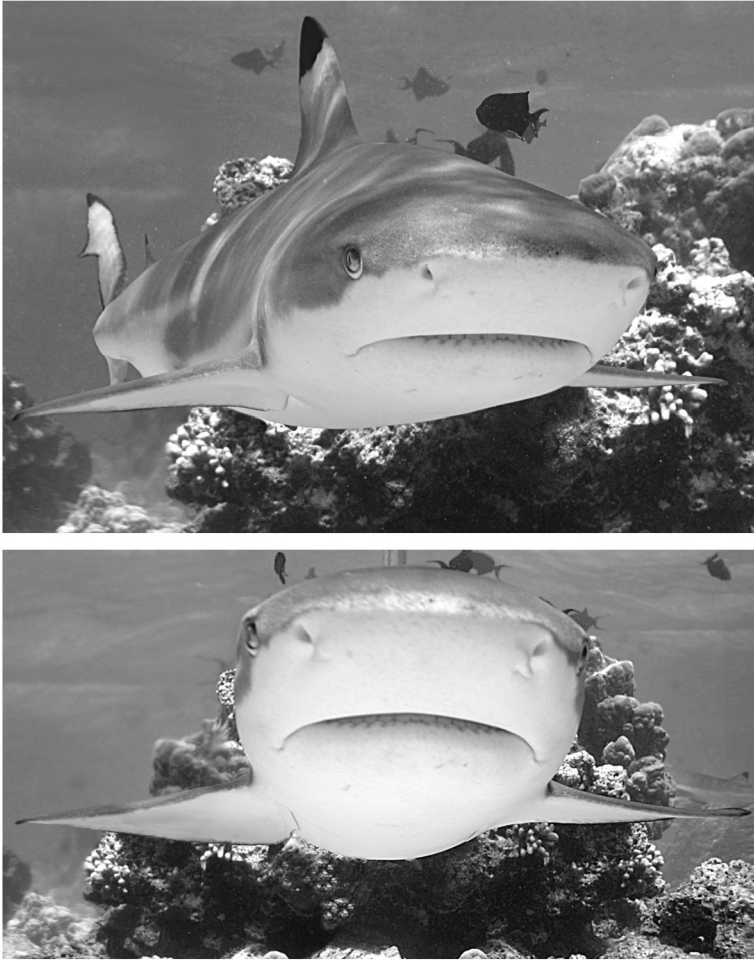
In general the sharks were calm. They would cruise through the coral landscape, picking through the fish scraps, finding those drifting down-current, and socializing. After about half an hour, they would gradually disperse and I could scatter crumbs for the fish. New arrivals coming up the scent flow never harassed me.

When I slid underwater, certain residents would approach my face in a greeting gesture, as shown in Figure 1.

#### *2.1.1. Saturday 20 January 2002 (44 sharks present)*

This time when I arrived underwater, all the blackfins within view were zooming up to my face very fast and a mass of excited sharks was suddenly whipping around me. While I placed their food, many of them circled my body like remoras. Even after they had started nosing through the scraps, they kept leaving the food to swim up to my face in single file as I watched from up-current. Then, one after another, they went to the kayak to sniff the drain-holes in the well where their scraps had been stored. Instead of leaving as they usually did, they circled repeatedly past me. I was unable to turn to swim to my kayak without them zooming over to me. Finally, when they left me a clear passage, I reached the boat and leaped in. The sharks circled and followed me for a distance, something they had never done before.

This was unprecedented behaviour, a change occurring literally from one session to the next. Wild animal behaviour normally evolves over time in



**Figure 1.** This species has a typical gesture in which they closely approach. When done slowly, it is a greeting or inspection. When done fast, it seems to be meant to intimidate (unpublished data).

the absence of sudden changes in the environment. Their actions were not related to food, for they left most of the fish scraps lying on the sand. It was also the period when the black surgeon fish were spawning nearby, so any shark who wished could stuff him- or her- self on any night of the week. The cause of the change was not evident and did not seem to be related to anything in the environment except my presence.

### 2.1.2. Thursday 24 January 2002

After what happened at the previous session, I plugged the drain holes in the well of the kayak, so that no scent would escape as I paddled to the site. The sharks circled close around the craft at the surface as I prepared, and when I slid underwater, they all soared up to me again. I quickly put their food in and they ate. A short time later, I pulled some of the scraps out from under the coral for them, for the current was strong, and many of them began again to stream towards me. Shark No. 3 had always come close, and now she was joined by No. 61, No. 109, No. 174, and No. 254, who were all maturing sharks. They would not leave me alone, so I cruised around the periphery of the site trying to avoid them and eventually climbed into the kayak. After about ten minutes, I returned to have another look. None of them had left, and as soon as I reappeared underwater, a crowd of sharks came soaring towards me just beneath the surface. I grabbed the anchor and got back in the boat. The count for that session of 25 sharks is therefore incomplete.

### 2.1.3. Saturday 26 January 2002 (33 sharks present)

As I prepared in the boat, sharks sped over, but underwater they were calmer. A large fraction of the resident females were absent since it was the period of the full moon, when they often went roaming (unpublished data).

### 2.1.4. Saturday 2 February 2002 (32 sharks present)

On sliding underwater, I saw sharks No. 18, No. 36, and No. 45 coming much too fast with countless others behind them. There was little food this time — they swirled over it and it was gone. A short time later sharks No. 15 and No. 50 (mature females) plus No. 171 and No. 201 (maturing females) came straight to me under the surface and passed close by. They milled around, then a long line of sharks formed and approached me directly. Shark No. 3 did this repeatedly, and others, including sharks No. 68, No. 174, and No. 134 copied her; time after time they accompanied her. Long lines of mature females approached my face, which had never happened before. Shark No. 178, an enormous older shark arrived. She had seemed shy and had never come near, but now she followed No. 3 straight up to my face as I watched. She looked as if she were twice No. 3's volume. After that, she returned every few minutes, with and without No. 3, in concert with the others.

When they began to leave, the fish were agitating around me in a multi-species cloud, so I went to the kayak to get some crumbs for them. But the sharks soared back, so I put in the anchor and left. Many sharks stayed with the boat for about ten minutes as I paddled homewards.

#### 2.1.5. *Thursday 7 February 2002 (35 sharks present)*

I brought a diver friend with me to video tape the behaviour of the sharks, hoping to analyse it more definitely. But the blackfins remained out of visual range for about ten minutes. Then they suddenly appeared, coming through the coral landscape in single file, in two lines led by Sharks No. 3 and No. 109. They zoomed up to the diver's face and he fell over backwards. Then they milled around, fed on the sardines I had brought, and left. Due to the diver's presence, they did not approach me in the way they had been doing in the past few sessions. Their behaviour showed their ability to make swift decisions to come forward, hide behind the visual limit, or leave, depending on the circumstances.

Shark No. 109 was an unusual individual (Jacoby et al., 2014) who played a key role in the escalating behaviour of this community of sharks. She had just returned after an absence of eight months. While most of the female residents stayed in their home ranges except for brief excursions, No. 109 attended sessions only from mid-December to April. The most enthusiastic shark to greet me underwater, she was an audacious and energetic animal, who was small and moved very fast. She would swerve up to my face, zoom over my shoulder from behind when I was watching the other sharks, then turn like lightning and orbit my head. No effort to dissuade her, such as pushing her, slapping the surface, or using the kayak as a barrier and banging on it, had any effect on her relentless advances. And now, her actions facilitated the increasingly menacing behaviour of the other sharks, particularly by those females who, like her, had just attained their first year of reproduction. These included sharks No. 36, No. 81, No. 133, No. 171 No. 174, No. 201 and No. 254. Increasingly they accompanied her and acted as she did.

Sharks at that age are nearly full-sized (about 1.8 m), yet, unlike mature females, they are slender, their swimming speed is faster, and they easily accelerate. They are more curious, and have a tendency to be more daring than they are after they mature. By the following year, the shooting torpedo has become an inept and hefty pregnant shark, often without a trace of her former boldness.

During this period, the actions of No. 109 had a profound effect on the entire company of sharks. Shark No. 3, on the other hand, was a resident who had responded to my study by accompanying me on my daytime visits whenever she found me in the lagoon. After three years, she appeared to consider me as a companion (blackfins form companionships) and often glided close to me.

#### 2.1.6. Friday 8 February 2002 (45 sharks present)

Though there were a few swift close approaches, the behaviour of the sharks was calmer. They had eaten the day before when the diver had been with me and many of the residents were absent.

#### 2.1.7. Friday 15 February 2002 (37 sharks present)

There were so many excited sharks present that, for the first time, I put the food in the water from the boat. The fast close approaches and charges continued.

#### 2.1.8. Thursday 21 February 2002 (36 sharks present)

Again the sharks were excited. Instead of leaving or roaming around in the coral as usual, they repeatedly approached, especially No. 109, No. 133, and No. 36. Repeatedly, No. 36 passed centimetres to my right, the others in a loose formation around her. And eventually the repeated approaches became steady circling. None of them left. I began to feel a tension in their persistent watchfulness, focused on me as never before. I sensed that if I moved, it would trigger a mass charge, so I faced each shark motionless, while the night gathered and the sharks circled. Finally, when for a moment they left me the space, I rushed to the boat and flew into it. When I tossed in the fish heads, the water churned, thick with charging sharks, in waters too dim to make out the details beneath. The violence of their movements suggested a release of the tension I had sensed underwater.

#### 2.1.9. Saturday 23 February 2002

A noddy tern (a seabird) I was rehabilitating accompanied me. Sharks were milling around the kayak as I prepared, and the bird was perched on the gunwale, looking down. Suddenly, she flew low across the site, just centimetres above the surface, and the water actually shivered as the thousands of fish startled. And that was the moment that the sharks attacked the boat.

The heavy weight of the loaded craft was bashed with shocking force, first one way and then the other, as the sharks slammed it from multiple directions. The sea surface dissolved into sharks emerging at high speed, then twisting and shooting away together as more replaced them. The powerful blows came mostly from beneath and their upward motion took them through the surface, so that they breached around the kayak. They began leaning towards the compartment behind me and trying to grab a fish scrap, producing clapping sounds all around me as their jaws snapped shut.

Apparently they saw their food when their motion took them through the surface; they did understand that there was a space above it where things exist.

To move the heavy boat with the impact I felt required daunting power—speed and big sharks. Further, there was no pause — for several minutes the slamming was continuous. After the blows from the first sharks, more slammed right behind, and more behind them. The duration of the event suggested that each shark returned to slam again, many times. Shark No. 36, who had been particularly intimidating at the previous session, continued to slam the boat after the food was in the water and I had rinsed out the compartment where it had been.

They had acted in synchrony, though no sign of communication had ever been evident among them. Their attack verified that my sense of a knife-edge tension at the last session had been correct. There was no doubt that their behaviour on my return resulted from their emotion then. Their attitude towards me had lasted though the intervening days, which in itself was evidence of complex cognition.

It was just before the full moon, which suggested a connection with the lunar cycle. Subsequent episodes of slamming, which necessarily involved the sharks being in an aroused state, also occurred during the full moon period.

There were many visitors and the sharks socialized with excitement down-current of the session so underwater I was subject to less harassment. I had to leave early to get the seabird home when there was still enough light for her to fly to her sleeping branch, so the count of 56 sharks is incomplete.

#### *2.1.10. Friday 1 March 2002 (44 sharks present)*

As I arrived, converging sharks circled closer and closer until they were swimming against the kayak and under it, particularly No. 174, who lingered beneath the stern. There was a slight bump, then silence. But as I began to put in their food, one after the other, then all at the same time, they began again to slam it. This time it was sharks No. 36 and No. 133 who initiated it. Shark No. 109 was absent. It was not easy to pick out handfuls of the spiny scraps from the kayak's well behind me in the narrow craft, while many of the blackfins were still slamming and leaping from the water, but most of the food was in when No. 3 broke through the surface beside my right elbow and snapped her jaws closed on a scrap trailing from my hand. The power of her action was daunting. The sharks continued to come to the surface even after

the food was in the water and I had rinsed the scent from the place it had been.

Underwater, there was less direct harassment. Eventually they dispersed and I was able to feed the fish and leave in time to get the seabird home before dark.

*2.1.11. Thursday 14 March 2002 (39 sharks present)*

Among the residents, only juvenile males, Shark No. 3, and one other mature female were present when I arrived; they did not slam the kayak. Shark No. 109 and her companions were absent. This supported my conviction that it was the young females who initiated the slamming behaviour, and that the rest of the company followed their lead.

*2.1.12. Wednesday 20 March 2002 (38 sharks present)*

Fast close approaches by several of the young females badly affected my observations. Throughout the session, blackfins darted into my face and lines of sharks repeatedly approached. The scene was complicated by the presence of large nurse sharks (*Ginglymostoma cirratum*) of around three metres in length as well as the usual smaller ones of two metres or less. Though nurse sharks are usually described as being the blimps or slugs of the elasmobranchs, in my experience they regularly made aggressive gestures towards the blackfins, and the blackfins backed down from them and never made such gestures to them. They were also much quicker to locate a food item than the requiem sharks.

*2.1.13. Saturday 23 March 2002 (31 sharks present)*

No scent leaked from the boat, yet many sharks followed it from farther away than ever, and were very excited as I prepared. The session proceeded with less of the intimidating behaviour in spite of the presence of the young females.

*2.1.14. Wednesday 27 March 2002 (45 sharks present)*

Fast approaches and circles around me by certain sharks continued to be a distraction.

*2.1.15. Saturday 30 March 2002 (32 sharks present)*

Except for the resident female No. 4, I found only males and juveniles underwater, the other residents having gone roaming while the moon was full. Shark No. 3 had left to mate. So the session was calm with the exception of some fast approaches by Shark No. 1, who arrived as night fell.

*2.1.16. Friday 5 April 2002 (45 sharks present)*

The sharks were calm, though the marine conditions were very bad and the current was at a maximum. I was sure that their behaviour was returning to normal with the reproductive season ending and the water cooling.

*2.1.17. Tuesday 9 April 2002 (38 sharks present)*

The sharks were excited from the beginning. Sharks No. 3, No. 109, and several of her companions, made repeated close approaches and circled me. The very large visitor No. 178 arrived and joined in. When they dispersed, I scattered some food for the fish but the site filled with blackfins again, who became excited as the nurse sharks tore the fish heads apart. Shark No. 109 continuously harassed me, darting into my face, flying over my shoulder from behind, orbiting my head, and suddenly appearing where I was not expecting her.

*2.1.18. Saturday 20 April 2002 (45 sharks present)*

The sharks were excited, gliding close around the boat as I prepared, especially No. 174. Underwater, Shark No. 3 kept circling me, swimming underneath me, leaving, and doing it again, sometimes joined by others who were roaming in the vicinity. More arrived. After sunset they seemed to be leaving and when I checked down-current no sharks seemed to be around. On the way back, I moved a fish head, that had been swept beneath a coral ledge, 30 cm back out into the open. Shark No. 220, an older female who visited the area only once per year, soared in, grabbed it, and shook it. Instantaneously, several tons of nurse sharks converged on this tiny scrap while forty blackfins shot into the site and dove onto the fish head. They orbited at top speed as the nurse sharks rose vertically, tails thrashing the surface, in their urgent efforts to scrape out a crumb. I was aghast at the turmoil caused by just that one movement of the fish head from under the coral. It had been lying there ignored, all during the session. It was impossible to feed the fish. In the falling night the shadowy green waters were shot through with speeding sharks, orbiting the centre. There were so many present that there was not enough space — multitudes were zooming past me as if I was not there, sharks known and unknown, in front and behind me. I had never seen such a display of animal power, and slowly drifted backwards and away.

*2.1.19. Thursday 25 April 2002 (41 sharks present)*

The moon was full, and this time the young females had not left — I could identify them from the kayak by their dorsal fins, when they protruded

through the surface. Shark No. 174 was circling closely around the stern as she had done on the former occasion when they had slammed the boat. I put their food in and was still sitting there looking down at them, when just above the sand, several sharks turned all at once, and shot straight up towards my face as if they could see me there above, peering in from the other side of the surface. They slammed the kayak with the same power as ever, though the water was filled with the scent of their food.

When they lost interest in the boat, I slid underwater. Shark No. 109 zoomed over and her close approaches and circles around me made it impossible to pay attention to anything else. She was usually with one of the other young females but they did not approach me as closely as she did. When she cruised away, others came to turn around me. Long lines of sharks rose to the surface behind the boat repeatedly, looking for scent, then they came to me. They seemed suspicious of me when the clouds of fish began waiting around me to be fed, and often darted through them. I threw in the fish heads and the nurse sharks pounced on them.

*2.1.20. Saturday 27 April 2002 (41 sharks present)*

The session passed with less harassment.

*2.1.21. Friday 3 May 2002 (52 sharks present)*

I used a different dead coral structure down-current to hold onto, where it was harder for the blackfins to approach me closely. Sharks No. 3 and No. 109 stayed around me at first but left early, and the harassment by the others was not so extreme. They were distracted by the nurse sharks feeding on the fish heads after the sun set.

*2.1.22. Saturday 4 May 2002 (43 sharks present)*

I went again because so many sharks were in the area. I was hoping to see a particular rare visitor who had been present the night before, and expected that many of the residents would not attend. I threw in the food, splashed my fins on the surface in warning that I was about to descend, and slid in. As I fell through the water, I looked around and saw Sharks No. 1, No. 3, No. 15, No. 22, and No. 133 half a metre away, all rising towards me very close together. In that first second in which I saw them, they closed the distance by half again. To me, that was too many large sharks too close, and, taken by surprise, I kicked out to create a ruckus in the water and make them back off. They did not react at all, but on seeing that it was me and not more food descending, they subtly altered their trajectory to re-descend. The session passed normally with just a few swift charges.

### 2.1.23. *Saturday 11 May 2002 (38 sharks present)*

It was the dark of the moon and there was a bad wind from the south that strengthened as I paddled out to the site near the barrier reef. I lost control of the kayak and threw in the anchor when swept broadside over a deeper region that I occasionally used when the current was strong. It was obvious that I would have to swim, towing the kayak, to the shelter of the island in order to get home.

I threw in the food as wild waters washed over the boat, and slid in, aware of only a few sharks around. As I fell through the water, Shark No. 15 brushed my side, Shark No. 1 against her, and there were many more soaring up between them, obviously assuming that I was more food falling through the surface. The water beyond and behind them was solid with sharks zooming towards me. But again, when they saw that it was me, they all subtly changed direction and descended again.

In the cloudy light, I found myself in a fairly deep region beneath heavy waves. Two large nurse sharks undulated around in mid-water and blackfins were flying everywhere. One of the biggest nurse sharks was vertical, presenting a weird centrepiece as it flung its enormous tail around for balance and flailed its fins — usually the water was not deep enough for such huge fish to balance vertically. The sharks were unnaturally excited. There was no order, and no dead coral structure I could hang onto within view. I drifted up-current, watching several sharks tear a large scrap apart.

Suddenly, Sharks No. 1, No. 2, and No. 3 left the centre of the feeding area and swept up towards me. Their gesture was swift and charged with conviction. They came in triangular formation, as they had in our first moment of meeting more than three years before, with Shark No. 2 in front. Normally in these situations, I quietly faced the shark until she turned away, but No. 2 did not turn, and her approach was far too fast. I could not allow her to slam into my solar plexus, so as she passed under my hands, I hit her on her head.

Like lightning she turned at right angles and shot away, just brushing me, and Shark No. 1 was there. I was already raising my knees between her and my chest, and finned water into her nose, but she just dodged slightly and kept coming! Leaning backwards, I finned harder, and she turned away. Shark No. 3 was simultaneously arriving, so I put my fins on her back in front of her dorsal fin, straightened my knees, and pushed her down and away from me. She went on in the new direction in which I had pointed her, rejoined

No. 1 and No. 2, and, back in triangle formation, the three soared away and disappeared into the whirling sharks.

Badly shocked by their gesture, I swam away. My heart was pounding so hard I could hear it myself and knew that they could too. And I realized that I could not escape in the boat because of the wind!

Their action was unprecedented. Shark No. 2 had a tendency to circle me, not charge. That was more typical of Sharks No. 1 and No. 3. Their gesture could not have been about food. As well as the usual load, there had been chunks of unsold tuna meat, and half a *saumon des Dieux*. Due to the terrible conditions above the surface I had simply thrown it all in — the resident sharks would have caught all they wanted as it fell through the surface. Indeed, the three sharks had left the food to come to me!

Eventually, I returned, determined that my record be complete. The large nurse sharks were still undulating vertically in the vortex of swirling blackfins. Shark No. 3 came to me at once and began a series of close approaches to my face. Shark No. 2 and several others, including a shy one who had never come near before, closely circled me.

As I watched from up-current, writing down identities, Shark No. 3 continued her nose-to-nose approaches, and sharks continuously came up to me, just under the surface, in waves so big that they were intermittently concealed from my view. Several steadily circled me. Many blackfins were holding onto the *saumon des Dieux*, and chasing around the area with it. One after another they grabbed and tried to shake it while the others changed places as they went. And all the while the oldest shark, from her range 0.5 km to the east, soared above all. Then several male sharks who had never paid attention to me made repeated close passes, and a female made a very swift charge. So I swam away from them again.

Their behaviour was not returning to normal, though the water was markedly colder, and the reproductive season had ended a month before. Sharks who had never approached me had suddenly begun to charge and harass me, and the level of excitement was higher than I had ever seen it. Yet Sharks No. 109, No. 36, and No. 133 were absent. Heightened excitement had always been associated with visits by groups of blackfins from other areas in the past, but here, I saw no visitors. I had written down only thirty-eight identities — those of my best known, my favourite, sharks.

I wanted to leave, but to do that, I had to extricate the anchor chain from beneath several nurse sharks and though I waited, they did not move.

Finally, through repeated dives and manipulations, while being continuously spiralled around by Shark No. 134, I managed to drag the anchor chain out from beneath them. I grabbed the anchor, rose with difficulty to the surface, threw it in the kayak, and swam the kilometre to shore.

The behaviour of Sharks No. 1, No. 2, and No. 3 was troubling. Their charge had felt very much like an attack, just as the violent slamming of the boat had felt like an attack. I had little doubt that their action could have become a general onslaught like the one made on my kayak, given the mood of the sharks, and the speed at which they can suddenly move.

Following this incident, I changed feeding sites, and when those sharks encountered me unexpectedly later, they behaved again in their calm and curious ways.

### **3. Positive subjective states**

Two years later, the sharks were being finned and their community was in upheaval. Due to personal troubles, I was unable to visit them for two months. When I finally entered the lagoon on 18 December 2003, I paused to drink water, and suddenly, there was a blackfin drifting past the boat, with more coming beyond. Several of the resident sharks drifted along the kayak and undulated against it. One slid against the paddle. For many minutes, they placidly glided around me, dorsal fins above the surface, pushing the curves of their bodies against the hull, going underneath and pressing against it, again and again. I reached down and stroked them for the first time as they passed, instinctively responding to what I could only interpret as an affectionate gesture. They seemed to have understood that much more time than usual had passed without me visiting.

The sharks did this each time they met me after that. Shark No. 104 was always the first, and would swim slowly under my hand as I sat in the low craft, so I would stroke her. She would drift while being caressed, then undulate against the kayak and disappear below. One calm evening, through the flawless clarity of the water, I saw the sharks shoot straight upwards from two metres beneath, undulate against the boat, and go straight down again, their tails flashing above the surface, droplets flying. There were several of them on each side. Then they returned to slide against the boat, the paddle, and undulate from one to the other.

On January 24, 2004, a shark slammed the boat hard, and No. 109 appeared at the surface. With the older sharks being finned, a high percentage of the resident females remaining had been her companions during the slamming incidents, but this time, no other shark slammed the kayak. The others undulated against it and descended. After each caress, the shark's tail flicked above the surface as she dove straight down.

They had feelings and their feelings had changed.

#### **4. Discussion**

One could ask why the sharks slammed me and my kayak, when dive clubs are feeding sharks around the world and have reported no similar incidents. However, shark feeding dives are held by different people and there are always many people present, while I was always alone with the blackfins. Far from shore, they likely never met any other people, but over the years, I had become familiar to them.

Locally, I asked all those I knew who had dive clubs if they had noticed a change in the behaviour of the sharks that season, but no one had. The change had occurred in my community alone.

The violent slamming of the boat, and the eventual assault by Sharks No. 1, No. 2 and No. 3, appeared to be the result of a negative emotion, something akin to what passes for rage in sharks, directed towards me. The way violence broke out after four months of increasingly menacing gestures, confirms that it was a negative subjective state that they developed, and which intensified as time passed. Something in my relationship with them had brought it about.

The way their conviction that I was failing to do something they expected, was initiated by one or a few sharks, and then shared among them all, falls into the category of emotional contagion. This indicates that blackfins' emotions are complex, for they involve their social relationships as well as cognition (Hatfield et al., 1993).

The only possible reason that I could discern was that they thought I had food in the boat that I was not giving them, as shown by their repeated trips to sniff it — so they now distrusted me. But desire for food could not have been the motive for their threatening and eventually violent behaviour; they were expressing a strong negative emotion.

Yet, by every measure of animal intelligence, for them to be acting, all together, on an abstract idea about something that is not present, is considered impossible (Vonk & Povinelli, 2006).

A more simple explanation is that they did not want me to be there. But this does not ring true because from the beginning, they came to join me, with and without food, of their own free will. They had always seemed to enjoy the sessions, when they could have ignored them. Shark No. 3 in particular, always came to be with me when she found me in the lagoon. For two and a half years she had seemed to enjoy being with me and swimming close to me.

The blackfins' actions suggest that from their perspective I was wronging them in some way, which indicates a moral sense (Monsó et al., 2018). Given their neuroanatomical complexity (Northcutt, 1978; Montgomery et al., 2012), this is indeed possible; a sense of morals has been identified in a variety of mammal species. The capacity to expect something, and react when it is not forthcoming, requires complex cognition, because the expected outcome must be held in mind while waiting, and then mentally compared with what happens.

Years later I was able to capture a brief video sequence of a shark slamming me, when I found shark No. 123 waiting for me underwater, and I threw her a treat. She took it in her mouth, then shot over and slammed my side with her shoulder, briefly lowering her pectoral fins. Then she swallowed the food. When she returned, she approached just above the sand, then suddenly turned towards me, hunched her back, and rose straight upwards to slam me with the area of her back just behind her head, as shown in Figure 2.

Since slamming involves arching the body and lowering the pectoral fins, there are similarities to the agonistic display of the grey reef shark (Johnson & Nelson, 1973; Nelson et al., 1985). Yet slamming is not a display, but a sudden attack without warning. To the best of my knowledge, no such behaviour has been described in the literature. Aiden Martin's review of agonistic displays (2007) did not identify any in this species, nor has any other researcher (A.A. Myrberg & S.H. Gruber, pers. commun.).

However, the blackfin shark is well known among the Polynesians for the way it dashes up to a person's face and turns away at the last minute, which could be categorized as an agonistic display. Spear fishermen report that they do this, often repeatedly, to intimidate them into relinquishing their catch. The Polynesians are champions underwater, and free-dive to a depth



**Figure 2.** The beginning of No. 123's rise upwards. As she rose, her back arched more and her tail pointed more directly downwards. In such a posture, the powerfully beating tail would propel the shark upwards at great speed. This must have been the way the sharks slammed the boat — by hunching, propelling themselves straight upwards, and striking with the tough region of the back between the head and dorsal fin.

of, 20 m to spear fish, all the while, keeping the sharks away. They consider this species to be the most difficult to manage due to their actions, even more so than the oceanic whitetip shark (*Carcharhinus longimanus*) (but due to the shark fin trade, whitetips are now gone from those waters).

When the sharks undulated against the kayak, they often came straight upwards from beneath, yet what they did bore no resemblance to slamming. Their tails emerging into the air indicated that after their undulation against the hull, they turned one hundred eighty degrees and went straight back down, while slamming brought them through the surface at high speed.

This act was therefore different from simply making a few undulations against the boat while circling it at the surface, yet the circumstances in which sharks might behave in this way in their daily lives is not evident.

#### 4.1. Conclusions

The *chondrichthyan* lineage separated from the *osteichthyan* line (which evolved into fish, amphibians, reptiles, birds, and mammals) at least 440 million years ago (Coates et al., 2018; Andreev et al., 2020), and has been evolving separately ever since, so assumptions about shark intelligence and their subjective states based on comparisons with other animals are unlikely to be correct. Notwithstanding, the blackfins responded rationally to the

reality that I, too, perceive. For example, they seemed to understand my relationship with my kayak very well — that it was an inanimate object that I used. They also displayed social learning when they copied each other in feeding from the back of the kayak, social buffering in the way they arranged themselves in formations, (such as triangular formation and single file lines) for challenging acts, and have been found to be using cognition in a variety of other ways (Schluessel, 2015).

But given the vast evolutionary gulf between us, no human mind can ever know how a shark might view, and feel about, an event. I had to accept that in spite of my human need to understand and categorize everything, when it came to the reason why the sharks had treated me as they had, it was simply impossible for me, ever, to know what it was.

## References

- Andreev, P., Zhao, W., Wang, N., Smith, M., Li, Q., Cui, X., Zhu, M. & Sansom, I. (2020). Early Silurian chondrichthyans from the Tarim Basin (Xinjiang, China). — PLoS ONE 15: e0228589. <https://doi.org/10.1371/journal.pone.0228589>.
- Brena, P.F., Mourier, J., Planes, S. & Clua, E.E. (2018). Concede or clash? Solitary sharks competing for food assess rivals to decide. — Proc. Roy. Soc. Lomd. B: Biol. Sci. 285: 20180006. DOI:10.1098/rspb.2018.0006.
- Coates, M.I., Finarelli, J.A., Sansom, I.J., Andreev, P.S., Criswell, K.E., Tietjen, K., Rivers, M.L. & La Riviere, P.J. (2018). An early chondrichthyan and the evolutionary assembly of a shark body plan. — Proc. Roy. Soc. Lomd. B: Biol. Sci. 285: 20172418. DOI:10.1098/rspb.2017.2418.
- Hatfield, E., Cacioppo, J. & Rapson, R.L. (1993). Emotional contagion. — Curr. Dir. Psychol. Sci. 2: 96-99.
- Jacoby, D.M.P., Fear, L.N., Sims, D.W., David, M.P. & Croft, D.P. (2014). Shark personalities? Repeatability of social network traits in a widely distributed predatory fish. — Behav. Ecol. Sociobiol. 68: 1995-2003. DOI:10.1007/s00265-014-1805-9.
- Johnson, R.H. & Nelson, D.R. (1973). Agonistic display in the gray reef shark, *Carcharhinus menisorrhah*, and its relationship to attacks on man. — Copeia: 76-84.
- Martin, R.A. (2007). A review of shark agonistic displays: comparison of display features and implications for shark-human interactions. — Mar. Freshw. Behav. Physiol. 40: 3-34.
- Monsó, S., Benz-Schwarzburg, J. & Bremhorst, A. (2018). Animal morality: what it means and why it matters. — J. Ethics 22: 283-310. DOI:10.1007/s10892-018-9275-3.
- Montgomery, J.C., Bodznick, D. & Yopak, K.E. (2012). The cerebellum and cerebellum-like structures of cartilaginous fishes. — Brain Behav. Evol. 80: 152-165. DOI:10.1159/000339868.
- Mourier, J. & Planes, S. (2012). Inferring social behaviour and mating patterns in a reef shark from social network and molecular analyses. — In: Book of abstracts. 12th international Coral Reef symposium, 9–13 July 2012, Cairns, Queensland, Australia, p. 306-307.

- Mourier, J., Vercelloni, J. & Planes, S. (2012). Evidence of social communities in a spatially structured network of a free-ranging shark species. — *Anim. Behav.* 83: 389-401. DOI:10.1016/j.anbehav.2011.11.008.
- Nelson, D.R., Johnson, R.R., McKibben, J.N. & Pittenger, G.G. (1985). Agonistic attacks on divers and submersibles by gray reef sharks, *Carcharhinus amblyrhynchos*: anti-predatory or competitive? — *Bull. Mar. Sci. Miami* 38: 68-88.
- Northcutt, R. (1978). Brain organization in the cartilaginous fishes. — In: *Sensory biology of sharks, skates and rays* (Hodgson, E.S. & Mathewson, R.F., eds). Office of Naval Research, Arlington, VA, p. 117-193.
- Porcher, I.F. (2005). On the gestation period of the blackfin reef shark, *Carcharhinus melanopterus* in waters off Mo'orea, French Polynesia. — *Mar. Biol.* 146: 1207-1211.
- Schluessel, V. (2015). Who would have thought that 'Jaws' also has brains? Cognitive functions in elasmobranchs. — *Anim. Cogn.* 18: 19-37. DOI:10.1007/s10071-014-0762-z.
- Vonk, J. & Povinelli, D.J. (2006). Similarity and difference in the conceptual systems of primates: the unobservability hypothesis. — In: *Oxford handbook of comparative cognition: experimental explorations of animal intelligence* (Wasserman, E. & Zentall, T., eds). Oxford University Press, Oxford, p. 363-387.