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Article

Aggression of *Carcharhinus leucas* and *Carcharhinus amblyrhynchos* towards humans

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SUMMARY

An important step in combating shark endangerment is lowering the stigma surrounding the species; one way to do so is to publish data on shark aggression. This paper presents findings on *Carcharhinus leucas* (bull shark) and *Carcharhinus amblyrhynchos* (grey reef shark) aggression towards humans at Beqa Adventure Divers in Shark Reef Marine Reserve, Fiji. We collected data on the number of sharks present and prods delivered - a method to redirect sharks away from tourist divers using a 2.5-meter metal stick by dive masters - during nine shark feeds. We hypothesized that grey reef sharks would receive more prods than bull sharks because grey reef sharks are typically more aggressive than bull sharks. The results supported our hypothesis, as an individual grey reef shark received 2.44 prods on average per feed, while a bull shark had an average of 0.61. Furthermore, grey reef sharks showed signs of aggression, including pectoral depressions and exaggerated swimming, throughout the feeds, while bull sharks showed none. These findings are meaningful not only to the world's general understanding of shark aggression, but also to human protection against grey reef sharks as well as public education on bull sharks and the conservation of the species.

INTRODUCTION

Carcharhinus leucas and *Carcharhinus amblyrhynchos* are species of sharks found worldwide (1). Carcharhiniformes, an order of shark species including grey reef and bull sharks, are speculation-style hunters, which means that they live nearby their prey, in coral reefs and other densely populated areas. As such, both species (especially grey reef sharks) are commonly found near reefs and in coastal areas. Bull sharks are not only able to perform osmoregulation, but their kidneys recycle the salt in their bodies when the shark is in an environment with low saline levels; thus, bull sharks are often found in brackish water and freshwater (2). These sharks are found in the same environments that humans enjoy spending time in; therefore, humans interact with Carcharhiniformes frequently. Additionally, grey reef sharks are known to exhibit more inquisitive and curious behavior towards divers, and being smaller than bull sharks, are more likely to get close to divers without notice (1).

Shark aggression is an often-misinterpreted topic, especially due to the media's portrayal of the species. The media generalizes shark aggression; however, this study questions these generalizations. Different shark species have adaptations that allow them to be closer to humans while others are known to be aggressive; overall, each shark species has a different relationship with human populations. Bull sharks can swim into lakes and rivers, and in doing so have more contact with humans (1). Due to their size, bull shark attacks have the potential to be more harmful than grey reef shark attacks; in fact, bull sharks are among the top three species in serious and fatal attacks (3). Grey reef sharks also are known to exhibit threatening behavior towards fishermen, and often show aggression towards humans through pectoral depressions - where a shark flexes its pectoral fins, arches its back, and displays an exaggerated swimming style (4).

Bull and grey reef sharks pass through the "shark corridor," a pathway between the Fijian islands Viti Levu and Beqa, to feed. Within the shark corridor is the Shark Reef Marine Reserve, or SRMR, which became Fiji's first National Marine Reserve in 2014. A Marine Protected Area (MPA) is an area with restricted human access to preserve the area (5). MPAs have a 'spill over' effect: they benefit both the marine ecosystem and the local community (6). SRMR, as an MPA, has boosted the local economy and preserved the reef (6). We performed the research for this study at SRMR.

Beqa Adventure Divers, an ecotourism company at SRMR, protects its clients using prods. Dive masters hold 2.5-meter-long metal rods to redirect aggressive or curious sharks. In this study, the number of prods given to bull sharks over the course of a feed was compared with the number of prods given to grey reef sharks. Given pre-existing research, we hypothesized that grey reef sharks would exhibit more aggressive behaviors, consequently receiving more prods, than bull sharks over the course of nine feeds. Much is not yet understood about sharks, and more research is vital to understanding and preserving the shark species. This study contributes to public knowledge and perception surrounding shark aggression.

RESULTS

To study the aggressive behaviors of these shark species, we were escorted by Beqa Adventure Divers to a feed site. We recorded the number of both shark species present on each of three days, and the number of prods delivered. Additionally, we knew that from an observational standpoint sharks use clear body language to display their aggression (4). In this study, these signals (pectoral depressions, back arches, and jerky swimming style) were observed and taken into account when drawing conclusions.

On the first day of this study, 29 bull sharks and 11 grey reef sharks were present in the first dive. The second dive, which was specifically a feeding for bull sharks, there were 21 bull sharks present. We observed during the dive that all bull sharks turned away after one prod, while many grey reef sharks were prodded two to three times before retreating.

On the second day of data collection, there were 21 bull sharks, and 12 grey reef sharks present during the first dive. The second dive, there were 22 bull sharks present.

During the third and final day of data collection a strong current was present during the dives.

Divers from Beqa Adventure Divers stated that in most cases, more prods occur when there is a stronger current. There were 30 bull sharks, and 12 grey reef sharks present during the first dive and 45 bull sharks present during the second dive.

Across all dives, we noted that bull sharks showed no tell-tale signs of aggression (back arch, etc.), while grey reef sharks often swam jerkily and exhibited aerial gaping, back arches, and pectoral depressions throughout the dives.

Across all dives, bull sharks received an average of 102.5 prods and grey reef sharks received 85.5 prods. Bull sharks received an average of 17.08 prods per dive, in contrast to grey reef sharks, which received an average of 28.5 prods per dive (**Figure 1**). Within a feeding session, an individual bull shark received 0.61 prods and an individual grey reef shark 2.44 prods (**Figure 2**). While there were fewer grey reef sharks than bull sharks in the sample area, dive masters gave more prods to the grey reef sharks (**Figure 1**).

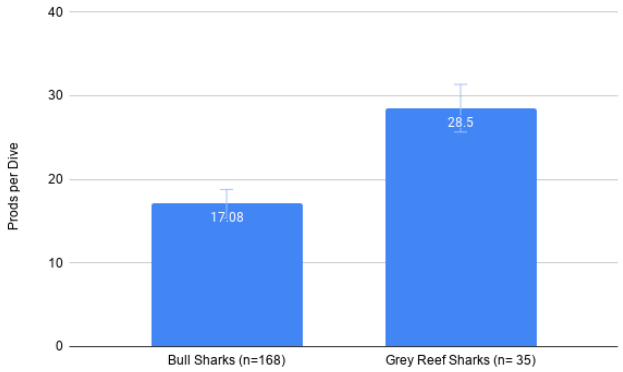

Figure 1. Grey reef sharks received more prods than bull sharks in one dive. The average number of prods given to bull sharks (n = 168, across 6 feeds) and grey reef sharks (n = 35, across 3 feeds) in one dive was measured. Data is shown as average ± standard deviation.

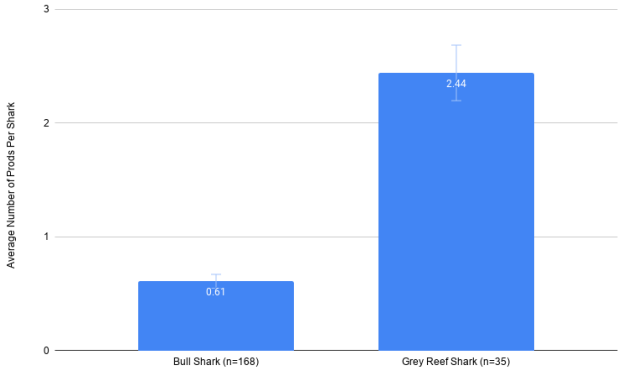

Figure 2. The average individual grey reef shark received more prods than the average individual bull shark. The average individual grey reef shark received 2.44 prods per dive ± SD 0.354. The average individual bull shark received 0.61 prods per dive ± standard deviation 0.117. Data is shown as average ± standard deviation.

DISCUSSION

We hypothesized that grey reef sharks would receive more prods on average than bull sharks during a feed. The results from this study supported our hypothesis, as on average, an individual bull shark would receive 0.61 prods per feed, while an individual grey reef shark would receive 2.44 prods per feed. These data show that grey reef sharks received more prods than bull sharks and support the idea that grey reef sharks are bolder towards the human ecotourists. Furthermore, grey reef sharks showed signs of aggression during each feed, swimming jerkily and lowering their pectoral fins, while bull sharks showed none. Grey reef sharks did not turn away after one prod, while the bull sharks did. These data and observations support that grey reef sharks are more aggressive around humans.

Grey reef sharks may feel more comfortable when there are more grey reef sharks present, as there were fewer prods during feeds with more sharks (**Figure 2**). While an increased quantity of bull sharks may agitate the individual bull shark. However, all shark feeds were high-stress environments which may have influenced the bull shark behavior.

There are 116 recorded unprovoked bull shark attacks and 9 recorded grey reef shark attacks to date; however, bull sharks are more easily identified than grey reef sharks. Grey reef sharks bear resemblance to several different shark species of Carcharhiniformes, and therefore, it is possible that while reporting a grey reef shark attack, the reporter misidentified the shark as another member of the *Carcharhinus* genus of similar size (3). Furthermore, bull shark attacks are more likely to be fatal due to their size; still, 22% of unprovoked bull shark attacks were fatal, compared to 11% of grey reef shark attacks, constituting only an 11% difference (3).

It is possible that sharks and prod numbers were counted

inaccurately. The values used in this study were an average of two data points, therefore, the values are less accurate than if more data points were collected. The shark feeds occurred at spaces designated for such dives, thus, creating an artificial behavioral environment with higher shark densities than would normally occur. Additionally, it was a high-stress environment from the presence of food and from humans being intentionally in proximity to the sharks and food. Data was collected from just six bull shark feeds and three grey reef shark feeds. In the future, an equal number of bull shark and grey reef shark feeds should be observed, and more feeds should be recorded. More data points are necessary to ensure the accuracy of the hypothesis and conclusions.

The results of this study suggest that grey reef sharks are bolder around humans. This has several implications regarding diver safety and shark preservation. Regarding diver safety: divers may feel more comfortable around a smaller shark, which may be misguided. Divers should be cautious and respectful no matter the shark species to ensure safety for both the diver and the shark at hand. Divers should be cautious of bull sharks in larger groups (**Figure 3**). As to shark preservation, industry kills millions of sharks each year (2). Unlike turtles or other sea animals, sharks lack the protection of the 'charismatic megafauna.' Movies such as *JAWS* eroded public relationships with sharks, and therefore, people are less inclined to protect them (7). The media misrepresents shark populations through hyperbolistic characterizations. Grey reef sharks and bull sharks display different levels of aggression towards humans. Marine conservation depends upon public participation; as such, public perception of the shark species plays a role in the success of shark conservation. The knowledge that sharks are likely to steer clear of divers despite already being in a high-stress environment may encourage the public to be more sympathetic towards the shark species during a time of growing endangerment.

METHODS

We collected data during six shark dives (nine feeds) at Shark Reef Marine Reserve, a marine park in Fiji, from July 29 to August 3, 2019. Beqa Adventure Divers, an ecotourism company, is located on the reserve, and the dive company holds shark feeds and organizes tourist dives. There were two dives each day: a 9 AM bull shark and grey reef shark dive, and a 12 PM bull shark dive. The reef has five shark dive sites, at 33, 25, 15, 10, and 5 meters deep, in which tourists and researchers observe a shark feeding. Bull sharks are fed at 33, 25, and 15 meters, and grey reef sharks are fed at 10 meters.

Five Beqa Adventure Diver divemasters held prods, metal rods 2.5 meters in length with rounded edges, that they used to deflect sharks away from the tourists. Prodding was instigated if the shark charged towards a tourist or touched a tourist. The number of sharks and the number of prods given to the sharks were counted using a dive slate. The number of prods given to bull sharks was compared with the number of prods given to grey reef sharks. After collecting all data, we averaged the prod numbers across six bull shark and three grey reef shark dives. We observed 28 bull sharks and 16 grey reef sharks on average per dive. We graphed and compared data in Microsoft Excel. Observations on shark behavior was also noted: pectoral depressions, jerky swimming style, and back arches, throughout the dives.

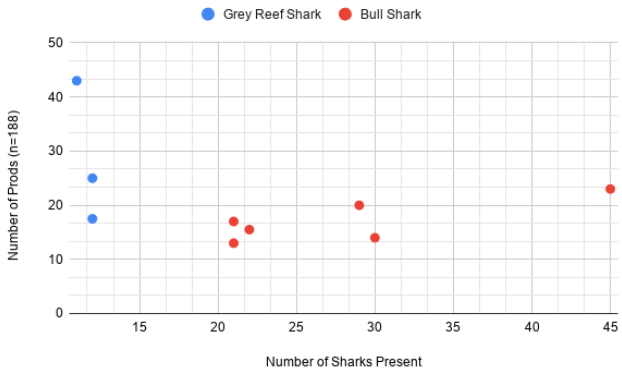

Figure 3. Grey reef sharks received more prods than bull sharks. The 203 sharks studied received 188 prods across 9 total feeds.

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