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# HUMAN IMPACT ON THE PRESENCE OF SHARKS AT DIVING SITES OF THE SOUTHERN RED SEA, EGYPT

**Riassunto.** *Impatto della presenza umana sugli squali nei siti d'immersione del Mar Rosso meridionale, Egitto.*
Da giugno a novembre 2008 è stato condotto uno studio in merito all'impatto umano sulla presenza e sul comportamento degli squali nei seguenti siti d'immersione del Mar Rosso: Elphinstone Reef, Daedalus Reef, Big Brother Is., Small Brother Is., Zabargad Is., Rocky Is., and Habili Ali. È stato effettuato un totale di 194 ore di osservazione sul campo; gli squali sono stati incontrati durante 110 immersioni su 138. Sono state registrate 8 specie di squali per un totale di 292 esemplari: squalo balena *Rhincodon typus* (1 esemplare), pesce volpe pelagico *Alopias pelagicus* (12), squalo dalle pinne orlate di bianco *Carcharhinus albimarginatus* (1), squalo grigio di barriera *Carcharhinus amblyrhynchos* (61), squalo sericeo *Carcharhinus falciformis* (2), longimano *Carcharhinus longimanus* (123), squalo dalle pinne bianche di barriera *Triaenodon obesus* (5), pesce martello smerlato *Sphyrna lewini* (87). La frequenza di incontri a Elphinstone Reef è considerevolmente minore che nelle altre aree di studio. La presenza di subacquei ricreativi è stata registrata durante quasi tutte le immersioni: 134 casi su un totale di 138 immersioni, con una presenza in totale di 971 imbarcazioni e 15.601 subacquei. Sia il numero medio di subacquei che il numero medio di imbarcazioni registrate durante ogni immersione sono più elevati a Elphinstone Reef che nelle altre aree di studio. A Elphinstone Reef inoltre l'elevato numero di imbarcazioni è ampiamente distribuito sull'intera area, di conseguenza per gli squali è impossibile evitare la presenza umana. La massiccia presenza umana a Elphinstone Reef sta influenzando negativamente la presenza degli squali e potrebbe anche far aumentare le probabilità che si verifichino attacchi ad esseri umani. Il numero di imbarcazioni e di subacquei che frequentano quest'area e il loro comportamento devono essere regolati da un codice appropriato. È pertanto necessario che Elphinstone Reef sia urgentemente dichiarata area protetta.

**Summary.** A study of human impact on the presence and behavior of sharks was carried out June to November 2008 at these Red Sea diving sites: Elphinstone Reef, Daedalus Reef, Big Brother Is., Small Brother Is., Zabargad Is., Rocky Is., and Habili Ali. A total of 194 hours of field observations was done; sharks were encountered during 110 of 138 dives. Eight species of sharks for a total of 292 specimens were recorded: whale shark *Rhincodon typus* (1 specimen), pelagic thresher shark *Alopias pelagicus* (12), silvertip shark *Carcharhinus albimarginatus* (1), grey reef shark *Carcharhinus amblyrhynchos* (61), silky shark *Carcharhinus falciformis* (2), oceanic whitetip shark *Carcharhinus longimanus* (123), whitetip reef shark *Triaenodon obesus* (5), scalloped hammerhead *Sphyrna lewini* (87). The frequency of encounters in Elphinstone Reef is considerably lower than in the other study areas. Presence of recreational divers was recorded during almost all the dives: 134 cases on the total of 138 dives, with a presence of a total of 971 boats and 15,601 divers. Both the mean number of divers and the mean number of boats recorded for each dive are higher for Elphinstone Reef than in the other study sites. In Elphinstone Reef the high number of boats is also widely distributed for the entire area, making it impossible for the sharks to avoid human presence. The massive human presence in Elphinstone Reef is negatively affecting the presence of sharks and may also increase the probability of attacks on humans occurring. The number and conduct of boats of divers and boats frequenting this site need to be regulated by appropriate rules. It is therefore urgently necessary for Elphinstone Reef to be declared a protected area.

**Keywords:** sharks, oceanic whitetip shark, *Carcharhinus longimanus*, Red Sea, Elphinstone Reef, Daedalus Reef, human impact, divers.

## Introduction

The Red Sea is a well-known area for its conspicuous presence of sharks (Randall, 1986). A total of 49 species of sharks occur in the area encompassing the Red Sea and the Gulf of Aden (Bonfil & Abdallah, 2004). There are no scientific data about the ecological significance of sharks in these areas. Also, the Red Sea has many locations with different environmental conditions and reef structures. All these factors affect the distribution of different species of sharks in the area. Conversely, human impacts negatively affect shark abundance and behavior. A study of human impacts was conducted to create a solid scientific background on the occurrence of sharks in the Southern Red Sea.

We report the results of a program "Shark ecology and its sustainable use in the Southern Red Sea, Egypt", carried out in 2008 thanks to a grant from the PADI Project AWARE Foundation (Europe). The project aims were to assess the presence of sharks and to study shark/human interactions (fishing and diving activities) at different diving sites in the areas of Marsa Alam (Elphinstone Reef) and far southern reefs and islands, Southern Red Sea, Egypt (fig. 1), by means of underwater observations and data collection.

Specific goals of the project were: a) to assess the presence of different species of sharks at different diving sites in the area of Marsa Alam (Elphinstone Reef) and far southern reefs and islands; b) to assess the impacts on sharks, fishing and diving activities; c) to create public awareness of divers at different diving centers along the Red Sea; d) to prepare a Code of Conduct for divers encountering sharks; e) to create a management plan for Elphinstone Reef and the surrounding areas with the view to establishing the first marine park for sharks in the Red Sea.

In this article we focus on the human impact on the presence and behavior of sharks at the diving sites. Results of other aspects of our study will be presented in future reports.

## Materials and methods

The project was conducted over a five and half-month period, beginning on the 1st of June and ending on the 15th of November 2008. The data were collected three times per week during most of the study, and one or two times per week, from September to November. Two dives per day were performed, early morning and afternoon. During the Safari week, there were three dives per day (each month, one week's field work was conducted on the Safari Trip). A total of 194 hours of field observations was carried out. These 194 hours were divided as follows per month: 58 hours in June, 27 in July, 40 in August, 22 in September, 34 in October and 13 in the first half of November.

The operations were conducted aboard a 35-metre Safari Boat supported by full navigational instruments, including GPS map, fish finder, echo-sounder, radar and satellite phone. One researcher collected the data, accompanied by a dive guide of the Safari Trip's team. No chum or bait was used to attract the sharks to the boat. The sharks were instead located by the experience of the diving team, who knows where and when these predators can be found in the study area.

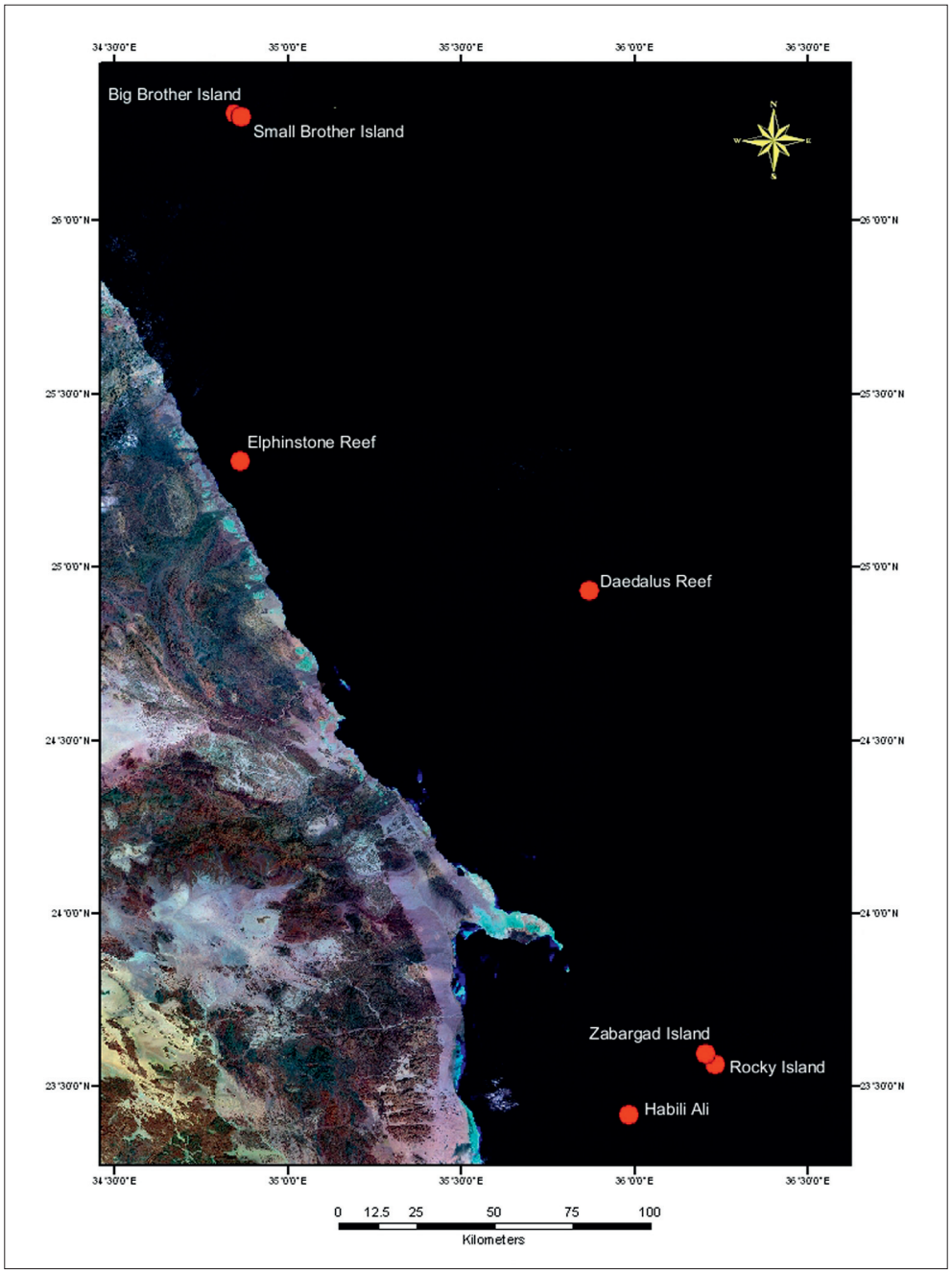


**Fig. 1.** Map of the study area, showing the locations of shark observations.

A form for collecting data in a standardized way was prepared. Data collected include: shark species, number of sharks, date, time, location with latitude and longitude, distance from shore, distance from reef, swimming depth, sea depth, weather conditions, sea state, current direction, current strength, surface water temperature, estimated shark total length, shark sex, shark's distinctive features (such as a particular coloration pattern, scars, deformation, etc.), shark behavior, presence of other animals in the proximity, name of the observer (when different from the first author).

Sharks were photographed or filmed using a CANON Digital PowerShot A630, 8 Megapixel for subsequent analyses of their morphology and, whenever possible, photoidentification of the specimens occurring in the area.

Also, shark/human interactions in the area were studied. Data on the occurrence and number of tourist boats and divers in the area was regularly collected, in order to understand the direct impact that human presence may have on the occurrence of sharks in the study area. For each shark observation, the number of boats and divers present on the site, and the time of each encounter, was recorded. The number of divers includes both those who were diving and those who were on boats at the time of the encounter. Additionally, data on shark fisheries in the area, including direct fisheries for sharks, captures of sharks taken accidentally while fishing for other species, and recreational fishing, were collected.

## Results

A total of 138 dives was done over a five and half-month period. Sharks were encountered during 110 of these dives. The results of these observations are presented.

The species of shark was identified in all encounters. A total of eight species of sharks was recorded: whale shark *Rhincodon typus* Smith, 1828, pelagic thresher shark *Alopias pelagicus* Nakamura, 1935, silvertip shark *Carcharhinus albimarginatus* (Rüppell, 1837), grey reef shark *Carcharhinus amblyrhynchos* (Bleeker, 1856), silky shark *Carcharhinus falciformis* (Müller & Henle, 1839), oceanic whitetip shark *Carcharhinus longimanus* (Poey, 1861), whitetip reef shark *Triaenodon obesus* (Rüppell, 1837), scalloped hammerhead *Sphyrna lewini* (Griffith & Smith, 1834).

The total number of shark encounters is 110 and the total number of specimens observed is 292; details for each species are summarized in table 1 and figure 2. Photographic and/or filmed evidence of the shark was taken in 37 encounters.

The size of all sharks encountered was estimated (tab. 1). The size of all the specimens recorded fall within the size range previously known for these species (Compagno, 1984, 2001; Last & Stevens, 2009).

A total of 138 dives with 194 dive hours was made; details for each visited site are summarized in table 2.

The frequency of encounters (encounters/hour) was calculated for Small Brother Is., Daedalus Reef, Big Brother Is., and Elphinstone Reef (tab. 2, fig. 3). We did not calculate the frequency of encounters for the remaining sites because of the scarce amount of time spent at field observations for these locations.

**Tab. 1.** Collected data for each shark species. **A:** Elphinstone Reef; **B:** Daedalus Reef, **C:** Small Brother Is.; **D:** Big Brother Is.; **E:** Zabargad Is.; **F:** Rocky Is.; **G:** Habili Ali.

| Species | Number of encounters (110) | Number of specimens (292) | Estimated size (TL, cm) | Number of encounters per site | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | E | F | G |
| *Rhincodon typus* | 1 | 1 | 600 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Alopias pelagicus* | 10 | 12 | 225-350 | 1 | 4 | 2 | 3 | 0 | 0 | 0 |
| *Carcharhinus albimarginatus* | 1 | 1 | 270 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Carcharhinus amblyrhynchos* | 28 | 61 | 120-250 | 6 | 3 | 12 | 6 | 0 | 0 | 1 |
| *Carcharhinus falciformis* | 2 | 2 | 280-300 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Carcharhinus longimanus* | 35 | 123 | 190-270 | 25 | 9 | 0 | 1 | 0 | 0 | 0 |
| *Triaenodon obesus* | 4 | 5 | 100-180 | 2 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Sphyrna lewini* | 29 | 87 | 190-250 | 15 | 10 | 3 | 1 | 0 | 0 | 0 |

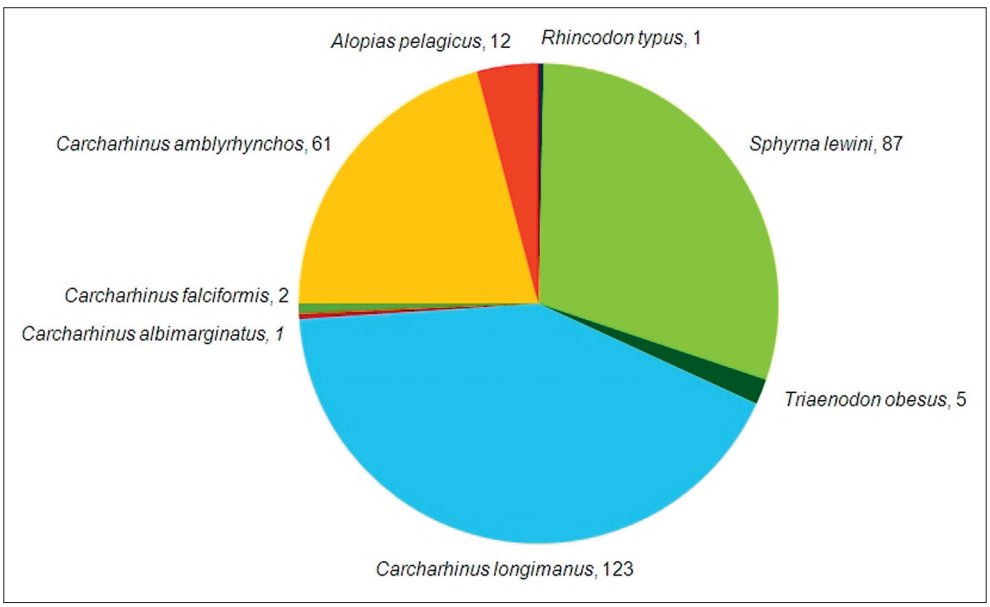


**Fig. 2.** Number of specimens observed for each shark species.

The frequency of specimens for site (specimens/hour) was calculated for Daedalus Reef, Small Brother Is., Elphinstone Reef, and Big Brother Is. We did not calculate the frequency of encounters for the remaining sites because of the scarce amount of time spent at field observation for these locations.

**Table 2.** Collected data for each site.

| Sites | Dives (138) | Dive hours (194) | Encounters (110) | Encounters/ hour | Specimens (292) | Specimens/ hour | Mean of divers | Mean of boats |
|---|---|---|---|---|---|---|---|---|
| Elphinstone Reef | 73 | 120 | 51 | 0.42 | 159 | 1.32 | 128.42 | 8.53 |
| Daedalus Reef | 27 | 31 | 26 | 0.84 | 73 | 2.35 | 105.74 | 6.11 |
| Small Brother Is. | 20 | 22 | 20 | 0.91 | 34 | 1.54 | 91.6 | 4.8 |
| Big Brother Is. | 13 | 16 | 12 | 0.75 | 21 | 1.31 | 116.38 | 6.61 |
| Zabargad Is. | 2 | 2 | 0 | – | 0 | – | – | – |
| Rocky Is. | 2 | 2 | 0 | – | 0 | – | – | – |
| Habili Ali | 1 | 1 | 1 | – | 5 | – | – | – |

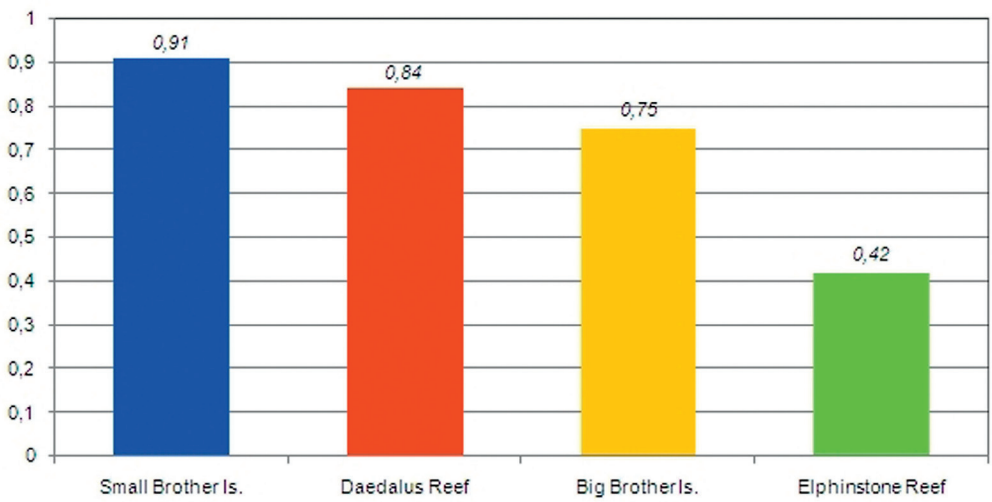


**Fig. 3.** Frequency of shark encounters/hour for each site.

Only one whale shark and one silvertip shark were observed. Pelagic threshers occurred singly or in pairs. Grey reef sharks occurred both singly and in groups of up to 5 individuals. Silky sharks occurred singly. Oceanic whitetip sharks occurred both singly and in groups of up to 11 individuals. Whitetip reef sharks occurred singly or in pairs. Scalloped hammerhead sharks occurred both singly and in groups of up to 10 individuals.

The presence of recreational divers was recorded during almost all the dives: 134 cases on the total of 138 dives. The number of boats on the site, and therefore in the immediate proximity of the sharks, ranged from 1 to 23 boats. The presence of a total of 971 boats and 15,601 divers (mean of 16.07 divers per boat) was recorded during the total of 138 dives, for a mean of 7.04 boats and 113.05 divers per dive. The mean of divers and the mean of boats recorded for each dive were calculated for Elphinstone Reef, Big Brother Island, Daedalus Reef, and Small Brother Island (tab. 2, fig. 4). We did not calculate the frequency of encounters for the remaining sites because of the scarce amount of time spent at field observations for these locations. The maximum human presence was recorded at 10:00 am, on October 22, 2008, in Elphinstone Reef, when 19 boats and 7 speed boats carrying a total of 380 divers, were observed at the same time four *C. longimanus* were seen swimming in the area.

The behavior of sharks at the diving sites was analyzed. The whale shark swam very slowly and most of the time in one direction. When several of the divers approached the shark, it turned its head slowly at a small angle to change its direction with a little stroke of its caudal fin. With the increasing number of divers around it, the shark dove to a few meters down (10-14 m), keeping its distance from the divers. The shark would then ascend once again to the surface, out from the divers' circle. A zodiac boat approached the whale shark with a load of snorkelers, who then jumped in the water to swim beside the shark.

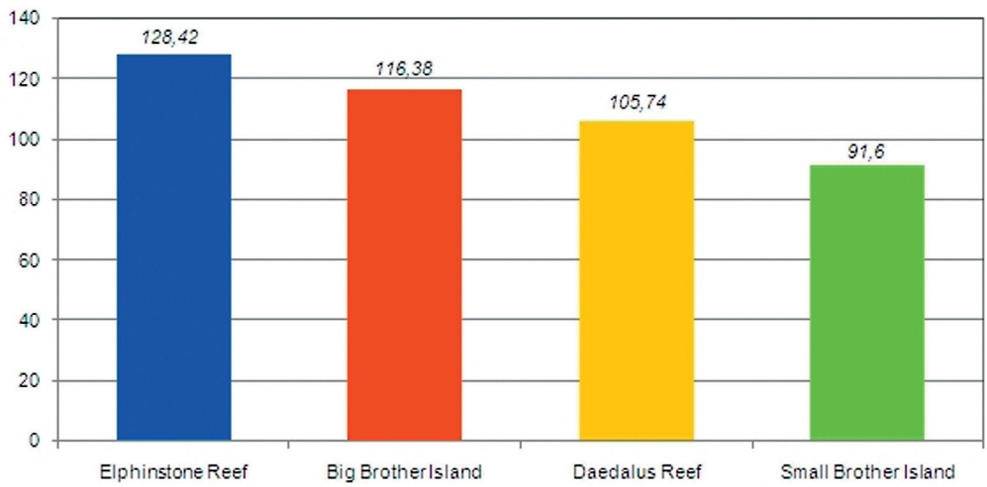


**Fig. 4.** Mean of divers recorded for each site.

The shark then turned to the snorkelers with the mouth slightly open, causing the snorkelers to swim back quickly. As the whale shark approached, a second zodiac boat approached the shark and the animal then found itself caught between the two boats. The whale shark descended once again, then rose again just beneath the zodiac, forcing the small boat to move quickly away. Finally the shark descended once again, this time to return to the surface far from the boats.

When pelagic thresher sharks are encountered in the blue, they swim slowly in the same direction. However, when threshers are encountered near reefs, they tend to swim around given spots, like a Gorgonian coral zone. When a thresher is approached by divers, it swims straight away to the open ocean or parallel to the reef. If a thresher feels threatened or cornered, it will perform a threat behavior with its mouth open to show its teeth. This is followed by the lowering of the shark's pectoral fins and the slight hunching of its back.

Silvertip sharks came up suddenly from the blue and swam in close proximity of divers for about a minute, showing a relaxed behavior and then disappearing.

Grey reef sharks tend to show a more relaxed behavior. Most of the times when they came into contact with divers, however, they became frightened and quickly swam away. This is especially true for small specimens measuring less than 2 m. The bigger specimens were mostly observed sitting still in strong currents.

Silky sharks have been seen coming from the open ocean to circle around a boat. At other times, they have been seen with oceanic whitetip sharks. However, silky sharks tend to avoid divers.

**Fig. 5.** The first author, Ahmed M. Shawky, swims with an oceanic whitetip shark *Carcharhinus longimanus* (Poey, 1861), on October 22, 2008, in Elphinstone Reef. Photo by Mohamed Helmy.

Oceanic whitetip sharks, at Elphinstone Reef were observed most often at the surface, near boats parking at the South end of the reef. The oceanics have also been seen congregating outside of the boat where the kitchen and toilets were located. Oceanic whitetip sharks seemed to be used to the presence of divers (fig. 5), but were frightened by divers bubbles. Occasionally, a diver tried to touch an oceanic whitetip shark as it passed by. The shark quickly swam away from the offending diver for a few meters before slowing down. Some oceanic whitetip sharks were observed keeping a vertical position while divers were finishing their safety stop just before leaving the water to get back to an inflatable boat. Sometimes an oceanic whitetip bit a diver's fin or ruined a SMB (surface marker buoy). Some divers had to push an oceanic whitetip on its nose to keep it at a distance. This caused the shark to change its direction but only to soon return, appearing more nervous. At Daedalus Reef, oceanic whitetip sharks were observed closely investigating people SCUBA diving at 25 meters by swimming straight down from the surface to the divers near the reef. When divers tried to keep the oceanic whitetips at bay, the sharks showed no fear towards the divers. This behavior was also reported by dive tour guides at different Southern sites like Satayh.

Whitetip reef sharks were recorded mostly at coral gardens swimming over the reef. The whitetip reef sharks were also seen resting over the sandy bottom within a reef garden or under a coral head. When divers approached, the startled sharks swam quickly away in a wide circle to deeper water, coming back near the same place only after the divers left the area.

Scalloped hammerheads were mostly recorded in current swept, deeper waters, far from the reef. Firstly one or two hammerheads came near the reef facing the divers, then they disappeared for 2-3 minutes before reappearing again with many other sharks, providing that there was no noise or the divers left the area. However, if a diver used a signal device such as a dive shaker, the shark went into deeper water at Daedalus Reef, or moved far from Elphinstone Reef if the hammerhead was located there. At Brother Island, scalloped hammerheads were sometimes recorded at a 15 m depth near the reef. If the divers made no attempt to touch the sharks, the sharks swam in a relaxed fashion around the divers for 15 minutes or more. But when divers disturbed the hammerhead by producing noise or swimming suddenly up to the shark, the hammerhead swam in a wide circle before continuing on in its usual way after it left the divers far behind.

The sharks that showed less fear towards divers were oceanic whitetip sharks. These animals approached the divers very closely during five encounters. In one case at Daedalus Reef, on June 4, 2008, two oceanic whitetip sharks became aggressive to divers, gaping their jaws in front of them and making circles around them. In one case at Elphinstone Reef on August 20, 2008, three oceanic whitetip sharks became aggressive to snorkelers at the surface. In another case on September 17, 2008, at Daedalus Reef, three oceanic whitetip sharks became aggressive to divers and made circles around them, and a shark swam down and then up going directly to the divers, catching the fins of one of them. During all other 107 encounters with sharks in this study, no aggressive behavior was observed.

The fearsome reputation of sharks is exaggerated: the human attack rate is very low, usually the attack ends after the initial contact, and the shark does not eat or kill the victim (De Maddalena, 2008). Of the eight shark species observed during this study, six are among those usually considered dangerous or potentially dangerous, and the most abun-

dant in the area is also the most dangerous of them, the oceanic whitetip shark. On safari trips some seamen use food attached to a fishing line in order to attract sharks close to the boat so to allow their guests to take photos of them, and at night cooks often throw food remains in order to keep sharks around the boats all night long. In this case, the sharks can become nervous and may be more inclined to attack humans, as already happened in 2008 when a guest swimming south of Daedalus Reef was attacked by an oceanic whitetip shark that bit her leg after a seaman gave food to the sharks. Luckily, the victim was quickly picked out of the water by the seaman and survived. Another attack occurred just a few months ago at Elphinstone Reef, when a tourist diving with an oceanic whitetip shark tried to touch the head of the animal, and it bit his leg. Luckily, even in this case, the victim survived.

One of the oceanic whitetip sharks encountered during this study had a hook with line in its mouth. The fishermen use lines that are fixed vertically by weight and end with a balloon at the surface. The fishermen fix this line at night and the sharks are easily attracted to it. When the shark take the bait, it tries to escape by swimming deeper, but the balloon at the surface prevents the shark's escape. So, the shark keeps on trying until it dies, and the fishermen catch it at early morning when no one can see them. Sharks have also been reported being killed by collision with boat propellers, as happened to a 236 cm TL male shortfin mako *Isurus oxyrinchus* found dead on the coast in Ras Hankorab on May 1, 2008, after being hit on the dorsal surface of its head by a boat propeller (Mohamed H. Besar, pers. comm. 2009).

## Discussion

The species recorded in the area during our study are the same encountered by the first author during 170 dives in the 2005-2006 period. Therefore, their presence in the area is clearly constant in time and they can be considered as usual inhabitants of these waters.

Humans create different kinds of interferences with shark behavior, through sound of boat propellers, zodiac (inflatable boat) movements, bubbles produced by divers, divers directly interacting with sharks such as when they follow the animals, sound signals among diver buddies, waste products from diving boats (especially the Safari boats, that throw a large amount of food remains into the sea at the end of the day), and fishing activities of fishermen.

The oceanic whitetip sharks are easily attracted to the diving boats due to the waste products of these boats. Other sharks, like scalloped hammerheads, especially at Daedalus Reef, are scared by sounds. Park rangers have to act as dive guides to the divers, by asking the guests to not use sound signals under water. Therefore the park rangers need to be in the water first, before any other divers. Other common species like grey reef sharks, are easily scared by the bubbles produced by the divers when they are abundant. Most sharks turn and change direction when they meet a diver. This avoidance behavior was observed especially in pelagic threshers, scalloped hammerheads and grey reef sharks. It has been noticed that, once scalloped hammerhead sharks have been seen by divers, at Elphinstone Reef they go into the blue far from the reef and come back after 3-5 minutes, but at Daedalus Reef the schools of hammerheads stay together and dive deep rather than go far from the reef.

The frequency of specimens per site is higher at Daedalus Reef, then followed by Small Brother Is., Elphinstone Reef, and Big Brother Is. The frequency of encounters per site is higher in Small Brother Is., followed by Daedalus Reef, Big Brother Is., and Elphinstone Reef. We need to point out that the frequency of encounters at Elphinstone Reef is considerably lower than in the other study areas. We suggest that the reason for this lowest frequency of encounters at Elphinstone Reef is due to the fact that this is the only unprotected area. Both the mean of divers and the mean of boats recorded for each dive are higher at Elphinstone Reef than at the other study sites. The highest peak in human presence was recorded at Elphinstone Reef. We believe that the massive human presence at this particular site is negatively affecting the presence of sharks.

Comparing the situation of Elphinstone Reef with the one we observed at Daedalus Reef, we note another relevant aspect. Daedalus Reef is well known for the presence of scalloped hammerhead sharks. While boats are parked at the south of Daedalus Reef, hammerheads tend to stay at the north, far from the disturbance caused by human presence. The situation is different at Elphinstone Reef: the high number of boats is widely distributed over the entire area, making it impossible for the sharks to avoid human presence.

We also note that one of the very rare cases in which sharks showed an aggressive behavior against humans was observed in Elphinstone Reef, when there were present 13 boats (9 boats and 4 speed boats) and 204 divers, a considerably higher number than the mean recorded both in general and at this particular site. We infer that a massive human presence may negatively affect the behavior of sharks, especially of oceanic whitetip sharks (the most dangerous species among those that have been recorded during our study), therefore increasing the probability of attacks on humans, an event exceptionally rare under normal circumstances. The attack that occurred a few months ago at Elphinstone Reef shows the importance for the people frequenting the diving sites to adopt an adequate behavior in the presence of sharks. They should avoid touching sharks, especially those belonging to dangerous species such as oceanic whitetip sharks.

In the end, taking into account all the considerations expressed above, we suggest that the number of divers and boats frequenting Elphinstone Reef should urgently be regulated by appropriate rules. Also, a mode of conduct for those frequenting this area needs to be established. It is therefore necessary that Elphinstone Reef be declared a protected area.

## Conclusions

We strongly hope that this work will have a direct specific environmental benefit on the shark populations inhabiting the Red Sea. The study sites of this work are already protected areas, with the exception of Elphinstone Reef. The management plan for Elphinstone Reef will now be presented to the Egyptian Environmental Affairs Agency (EEAA), of which the project curator and first author is an employee, as an Environmental Researcher or Park Ranger, in order to allow the Red Sea National Park authorities to declare Marsa Alam (Elphinstone Reef) a marine park, as has already been done for the other study sites.

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