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Developing a Code of Conduct for whale shark interactions in Mozambique

SIMON J. PIERCE[a,b,c,*], ADRIANA MÉNDEZ-JIMÉNEZ[b], KYM COLLINS[b], MARCELA ROSERO-CAICEDO[b] and ARA MONADJEM[d]

[a]*Manta Ray and Whale Shark Research Centre, Marine Megafauna Association, Praia do Tofo, Inhambane, Mozambique*
[b]*All Out Africa Research Unit, P.O. Box 153, Lobamba, Swaziland*
[c]*Eyes on the Horizon, Praia do Tofo, Inhambane, Mozambique*
[d]*All Out Africa Research Unit, Department of Biological Sciences, University of Swaziland, Private Bag 4, Kwaluseni, Swaziland*

ABSTRACT

1. The whale shark (*Rhincodon typus*) is a popular focal species within the global marine tourism industry. Although this has contributed to increased protection being granted to the species in several countries, tourism itself can be detrimental to the sharks in the absence of appropriate management. Potential impacts can be mitigated, at least in the short term, by adherence to well-designed interaction guidelines.
2. A burgeoning marine tourism industry based on swimming with whale sharks has developed at Tofo Beach in Mozambique. However, no formal management is currently in place at this site.
3. The behaviour of whale sharks during interactions with boats and swimmers were recorded during 137 commercial snorkelling trips run from Tofo Beach over a 20 month period. Whale sharks were encountered on 87% of trips, which operated year-round.
4. Boat proximity and shark size were significant predictors of avoidance behaviour. No avoidance responses were recorded at >20 m boat distance.
5. The mean in-water interaction time between sharks and swimmers was 8 min 48 s overall. There was a significant decrease in interaction times during encounters where sharks expressed avoidance behaviours, and also in cases where sharks had expressed boat avoidance behaviour before swimmers entered the water.
6. It is suggested that mean encounter times can be extended through adherence to a basic Code of Conduct for operators and swimmers that enforces minimum distances between the sharks, boats and swimmers. Using encounter time as a measure of the 'success' of interactions holds promise, as longer encounters appear to be indicative of lower impacts on sharks while also providing higher customer satisfaction for swimmers.

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KEY WORDS: *Rhincodon typus*; tourism; behavioural ecology; management; conservation

INTRODUCTION

The huge size, placid disposition and planktonic diet of the whale shark, *Rhincodon typus* (Smith), has resulted in the species becoming a popular focus of the global marine tourism industry (Graham, 2004; Compagno *et al*., 2005; Catlin and Jones, 2009). Whale sharks aggregate predictably in certain tropical and sub-tropical locations to target ephemeral bursts in local productivity such as plankton blooms (Clark and Nelson, 1997; Taylor, 2007), fish spawning events (Heyman *et al*., 2001) or crab larval release (Meekan *et al*., 2009). Some of these areas are, in turn, subject to high tourist visitation during these periods as people travel to view and swim with the sharks (Davis *et al*., 1997; Graham, 2004; Cárdenas-Torres *et al*., 2007; Quiros, 2007; Rowat and Engelhardt, 2007; Catlin and Jones, 2009).

Whale shark tourism can give a significant boost to regional economies, with global revenue estimated to be US$47.5 million in 2004 (Graham, 2004). The annual value of each of the 106 individual whale sharks identified in Belize was

*Correspondence to: Simon J. Pierce, Manta Ray and Whale Shark Research Centre, Marine Megafauna Association, Praia do Tofo, Inhambane, Mozambique. E-mail: simon@marinemegafauna.org

estimated to be US$34, 906 in 2002 (Graham, 2004), while whale shark tour participants spent AU$6.0 million (US$4.5 million) in the Ningaloo region of Western Australia in 2006 (Jones *et al*., 2009). A high proportion of whale shark tourism sites are located within developing nations, providing a compelling economic incentive for these countries to protect or manage the species (Graham, 2004). Given that whale sharks have been the subject of large, targeted fisheries in several countries (Pravin, 2000; Alava *et al*., 2002; Chen and Phipps, 2002), the advent of tourism may provide a direct alternative to extractive harvesting in some areas (Topelko and Dearden, 2005; Pine *et al*., 2007).

Shark-related tourism is sometimes viewed as a controversial activity, particularly when the sharks are attracted with bait (Topelko and Dearden, 2005; Laroche *et al*., 2007). However, whale shark tourism usually involves either snorkelling or scuba diving with sharks that have not been actively attracted to observers (Graham and Roberts, 2007; Quiros, 2007) and has thereby largely avoided many of the perceived negative aspects of the broader industry. In practice, whale shark tourism has many similarities to in-water interactions with marine mammals. The latter industry is comparatively well-studied, and research on a number of large and small cetacean species has demonstrated that tourism may have detrimental impacts at an individual, group or population level (e.g. Bejder and Samuels, 2004; Lusseau, 2005; Bejder *et al*., 2006a,b; Stensland and Berggren, 2007). Such impacts can include both short-term behavioural avoidance and longer-term population declines (Bejder and Samuels, 2004; Bejder *et al*., 2006b). The real or potential impacts of whale shark tourism are less understood, although certain in-water swimmer behaviours have been shown to cause short-term disturbance to the sharks (Quiros, 2007). Increasing tourist visitation has anecdotally been linked to declines in whale shark sighting rates in Belize (Graham, 2007) and to other impacts, such as boat strikes (Cárdenas-Torres *et al*., 2007; Rowat *et al*., 2007), in other locations.

Tofo Beach in southern Mozambique has recently emerged as an international hot-spot for whale shark encounters. Although whale sharks have been known to aggregate in the area for some time (Wolfson, 1986), political circumstances within the country and a general lack of infrastructure prevented commercial nature-based marine tourism from developing until the late 1990s. International tourists now travel to the region year-round specifically to swim with the sharks, and at least seven operators currently offer daily snorkelling trips ('ocean safaris'). Whale shark tourism has been identified as a key strategic niche market by the Mozambican government (Ministério do Turismo, 2004). The Mozambican national development plan for tourism aims to safeguard and manage natural assets to create desirable tourism products, while simultaneously monitoring the resources to ensure that tourism itself does not cause damage (Ministédo Turismo, 2004). In most countries where whale shark tourism is now established, it has proven necessary to manage interactions through legislation or voluntary codes of practice to reduce the potential for negative impacts on the sharks (Davis *et al*., 1997; Cárdenas-Torres *et al*., 2007; Quiros, 2007). No legislation pertaining specifically to whale shark encounters is presently in place in Mozambique. The objectives of the present study were to examine the short-term behavioural responses of whale sharks to boat and swimmer interactions. Using this information, we provide explicit recommendations for management of this burgeoning tourism industry through the development of a best-practice Code of Conduct for interactions with the species.

METHODS

Study site and ocean safari procedures

Praia do Tofo (Tofo Beach) (23°51′ S, 35°32′ E) is a small seaside resort town situated in Inhambane province, Mozambique, about 400 km north-east of the nation's capital, Maputo (Figure 1). At the time of writing, November 2009, ocean safaris were offered by four operators at Tofo Beach. Another three operators ran from Barra, which lies slightly to the north of Tofo, yet searched the same geographic area for whale sharks. Generally, two or three operators run ocean safaris on a given day, except during inclement weather. The main attraction of these ocean safaris is swimming with whale sharks, although swimmers will also enter the water opportunistically with bottlenose dolphins (*Tursiops* sp.), humpback dolphins (*Sousa chinensis*) and manta rays (*Manta* spp.).

All observations in the present study were made from a single operator using 8.2 m rigid-hull inflatable craft. The operational capacity of these vessels was 16–19 people, usually including three or four staff: a skipper, spotter and a divemaster/guide. For commercial reasons, trips were rarely conducted without a minimum of five paying clients. The majority of trips were made in the middle of the day (between 11 am and 2 pm) to fit in between regular scuba dives and to facilitate boat-based visual searching for whale sharks through reduced glare from the sun. Searches were aided on the majority of trips by the use of a removable spotting chair, which raised a single observer to approximately 3 m above sea level to broaden the search corridor. Sharks were sighted by their dark silhouettes or exposed fins as they swam close to the

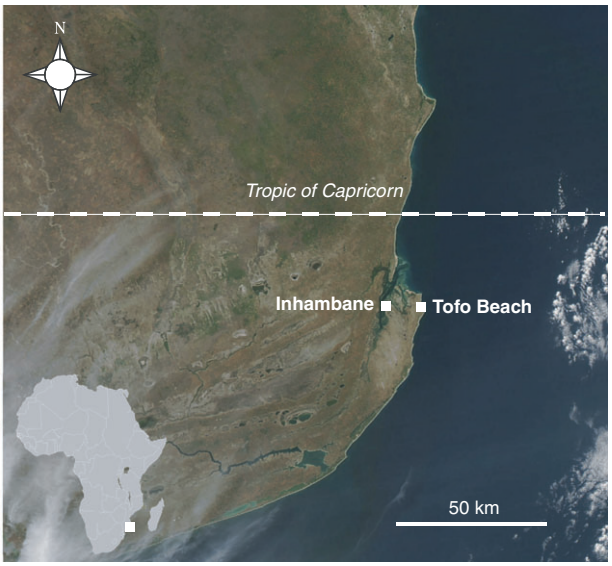

Figure 1. Tofo Beach and surrounding coastline. Inset shows the location of Tofo in Africa.

surface. Search distances were dictated by the number and duration of animal encounters en-route. Normally an S-shaped search pattern was driven along the coast from approximately 100 m past the surf-line to 1000 m from shore, with a one-way travel distance of approximately 6 km. Water depths in this area range from 5 to 30 m over a predominantly sandy substrate. Total trip durations were 90–120 min. Trip characteristics are similar between all the operators working from Tofo.

Before the trip, a briefing was given onshore to cover basic safety aspects, boating and whale shark interaction procedures. A varying amount of environmental interpretation was provided before and during the trip, but swimmers were always specifically told not to touch or otherwise harass the sharks. Upon spotting a shark, the boat was manoeuvred to place it in or near to the anticipated path of the whale shark. Swimmers entered the water and snorkelled with the shark until the encounter was ended by either the shark increasing speed or diving, swimmers due to fatigue, or operator time constraints or safety concerns (i.e. when the shark was close to the surf line).

Data collection and analysis

Observations of whale shark interactions were collected between January 2008 and August 2009, excluding July and August 2008. The location of each shark encountered was noted along with weather conditions and Beaufort sea state. As swimmers entered the water, the proximity of the shark to the boat, number of swimmers in the water, estimated underwater visibility and sea surface temperature (SST) were recorded. The total length of each shark was estimated, sex was distinguished by the presence or absence of claspers on the pelvic fins, and the body surface was examined for wounds or scars.

Behavioural observations for each shark were collected from both above and within the water. The shark's initial response to the boat was categorized as either (a) no reaction; (b) dive; (c) change of direction; or (d) interaction with the boat through purposeful close investigation including occasional 'bumps' to the hull or motors. These reactions were categorized as either avoidance (b) or (c), or no avoidance (a) or (d). A logistic regression was employed to test whether the measured variables (in this case SST, sea state, underwater visibility, sex, size, proximity of boat or scarred/non-scarred) were significant predictors of behaviour. The effect of boat proximity on behavioural response was specifically tested using a Mann–Whitney rank sum test (owing to non-normality of data), and the influence of the number of boats present examined using a chi-squared test (χ^2).

In the water, a basic ethogram of each shark's behaviour in the presence of swimmers was created to record slow swimming (SS), where the shark remained swimming at a slow constant rate, or fast swimming (FS) where the shark was obviously swimming more quickly or accelerated during the encounter. When the shark was obviously feeding, its behaviour was categorized as passive feeding (PF), surface gulping (SG) or underwater gulping (UG). Diving (D) was noted during the encounter, and behavioural responses to swimmers such as avoidance (A), change of direction (CD), banking (B) or interaction (IS), where the shark actively followed swimmers, were also collated. These behaviours were summarized as either (1) avoidance, defined as either A, or two or more of FS, D, CD or B, or (2) no avoidance, comprising all other behavioural observations. Logistic regression was used to test whether this binomial response was influenced by whether the shark was feeding, the number of swimmers in the water, size and sex of the shark, the presence of external scars, SST, visibility or sea state.

Total encounter time (in min), defined as the time between the first swimmer entering the water and the last swimmer exiting the water, was recorded for each whale shark interaction. Due to the non-normality of data, the effects of boat avoidance and in-water avoidance behaviours on encounter time were specifically assessed using Mann–Whitney rank sum tests.

RESULTS

In total, 411 interactions with whale sharks were recorded from 137 trips. Between 0 and 14 shark encounters were recorded on each trip, with a mean and standard deviation of 3.0 ± 2.71. At least one shark was sighted on 87.0% of trips. The number of trips per month where data were collected for this study varied from 0 to 15. Sharks were sighted in all months, although there was a significant monthly variation in the number of sharks sighted per trip (ANOVA on ranks, 17 d.f., $P < 0.001$). The highest mean number of sharks was recorded in October 2008 (5.5 ± 2.85 per trip) and the lowest in August 2009 (0.3 ± 0.50 per trip) (Figure 2). In both 2008 and 2009, the mean number of sharks observed declined in the austral winter (Figure 2), indicating that whale sharks move away from the Tofo region during this season. Sharks were feeding during 19.4% of encounters.

Behavioural responses to the boat

The proximity of the boat to the shark when swimmers entered the water ranged from a minimum of <1 m to a maximum of 40 m, with a mean of 7.1 ± 5.98 m. Where both the proximity of the shark and its reaction to the boat was recorded ($n = 264$ occasions), an avoidance response was noted during 32.7% of encounters. Boat proximity ($P = 0.026$) and shark size ($P = 0.015$) were the only two significant predictors of avoidance response among the measured variables (Table 1). The odds ratio for boat proximity shows that for each extra metre between the shark and boat, the shark was 0.882 times less likely to show an avoidance response. Similarly, larger sharks were less likely to avoid the boat, with each metre of length decreasing avoidance responses by 0.620 times. Specific testing of boat proximity effects found mean approach distances of 5.5 ± 4.97 m and 7.6 ± 6.08 m in cases of avoidance and no avoidance, respectively. No avoidance responses were noted at proximities >20 m.

Behavioural responses to swimmers

Total encounter times ranged from <1 to 49 min. Excluding encounters where either the operator ended the encounter prematurely or swimmers from other boats entered the water with the shark ($n = 27$), the overall mean encounter time was 8 min 48 s $\pm$ 8 min 9 s. Swimmers from two or more boats entered the water with an individual shark on 20 occasions. The shark exhibited distinct avoidance behaviour upon the

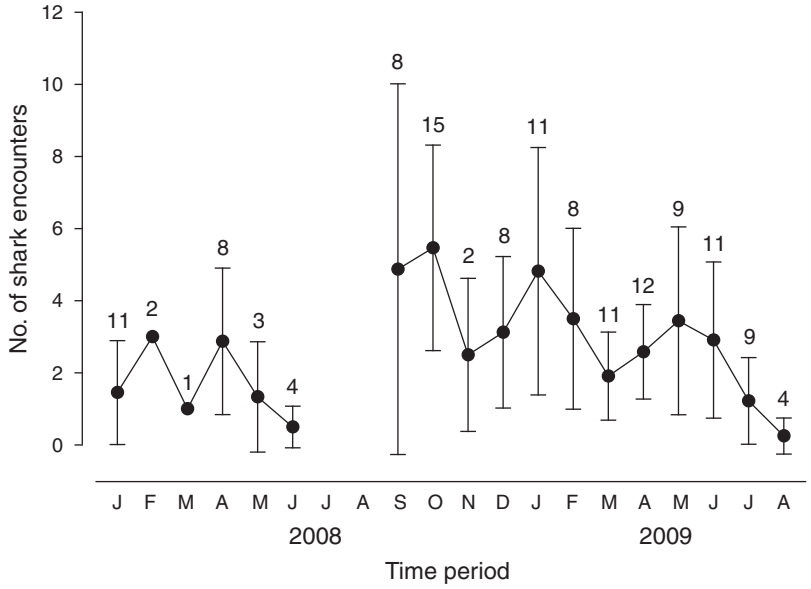

Figure 2. Seasonal variation in shark encounters during 2008 and 2009 (±SD). Numbers above SD lines denote the number of trips undertaken during that month.

Table 1. Significant predictors of whale shark avoidance behaviours during interactions with boats and with swimmers, derived from logistic regression

	Boat avoidance		**Swimmer avoidance**
Factor	Boat proximity	**Shark size**	Sea surface temperature
P value	0.026	0.015	0.006
Odds ratio	0.882	0.620	0.842
Coefficient	−0.125	−0.478	−0.172

arrival of the second group of swimmers during 60.0% of these encounters, indicating a significantly higher probability of avoidance behaviour compared with single-boat encounters ($\chi^2 = 49.84$, 1 d.f., $P = < 0.001$).

Behavioural observations were collected for 402 normal (single boat per shark) in-water interactions. Avoidance behaviour was noted during 34.6% of these interactions. Instant diving or abrupt directional changes in response to swimmer presence (within 30 s of swimmers sighting the shark) were recorded on 17 occasions (4.8% of in-water interactions), resulting in encounter times of <1 to 5 min. Encounter time was negatively related to the expression of avoidance behaviour by sharks (rank sum test, $P = 0.035$), with average encounter times of 8 min 6 s ± 8 min 2 s, and 9 min 6 s ± 8 min 0 s in cases where sharks did and did not exhibit avoidance behaviour, respectively. The only significant predictor of avoidance behaviour among the measured variables was SST, with each 1°C increase in SST corresponding with a 0.842 time decrease in avoidance responses (Table 1). The number of swimmers per encounter ranged from 1 to 18, with a median of 11 and a mean of 10.8 ± 3.66. There was no obvious relationship between the number of people in the water and encounter time (linear regression, 351 d.f., $P = 0.738$; Figure 3).

In-water interaction times were also significantly related to the prior reaction of the shark to the boat. Mean encounter time was significantly reduced from 8 min 48 s ± 7 min 18 s in cases where the shark had shown no boat avoidance, to 7 min 0 s ± 7 min 39 s when the shark had exhibited an avoidance reaction (rank sum test, $P = 0.007$).

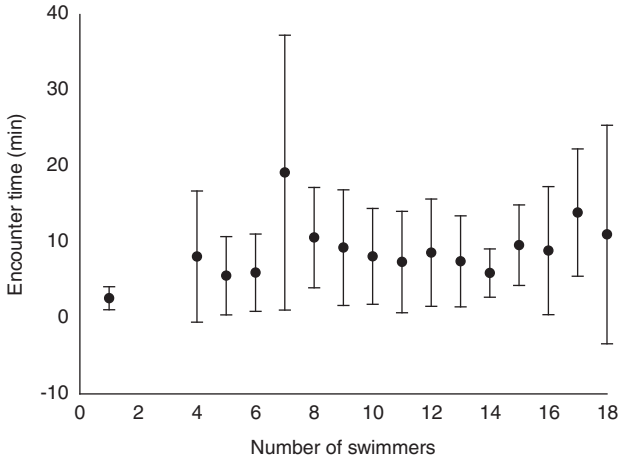

Figure 3. Mean encounter time (±SD) plotted against the number of swimmers present.

DISCUSSION

Whale sharks were sighted in every calendar month, confirming Tofo Beach as having one of the few known year-round aggregations of the species. There was some observational evidence for seasonal variation in shark abundance, with a September/October peak. However, as trip distance and duration – and therefore the total number of whale sharks encountered – varied according to the length of tourist interactions with individual sharks, detailed analysis of seasonal abundance awaits a more standardized approach.

The overall success rate of tours, i.e. where one or more sharks were sighted, was 87.0% over the study period. This figure is higher than the seasonal sighting rates at Ningaloo Reef in Western Australia (81.6% between 1996 and 2004) (Mau and Wilson, 2007) and Gladden Spit in Belize (69% between 1998 and 2003) (Graham and Roberts, 2007). The mean number of whale sharks encountered per trip at Tofo (3.0) was higher than the mean number of interactions recorded per trip at Ningaloo between 1996 and 2004, which was 2.6 initially, declining to 1.2 during the period of that study (Mau and Wilson, 2007). This is a notable point, considering that snorkelling trips at Tofo utilize boat-based searches along a relatively small length of coast, whereas in Ningaloo spotter planes are employed to locate the sharks over a broader area (Mau and Wilson, 2007). The number of sharks encountered per trip during September and October at Tofo were similar to in-season rates at Donsol in the Philippines (6.6 and 8.15 interactions per trip in 2004 and 2005, respectively) (Quiros, 2007) and Gladden Spit (2 to 6 sharks per trip between 1998 and 2003) (Graham and Roberts, 2007). The high trip success rate and mean number of interactions observed over the period of the present study suggest that Mozambique has considerable potential as a whale shark tourism destination, with a 'product' that rivals or exceeds more established whale shark tourism destinations. These results also support aerial survey data from the South African and southern Mozambican coasts that had previously recorded relatively high numbers of whale sharks close to Tofo (Cliff *et al*., 2007).

Customer satisfaction with in-water interactions with dwarf minke whales (*Balaenoptera acutorostrata*) in Australia was significantly associated with the duration of the encounter (Valentine *et al*., 2004), and the same appears to be true for swimmers with whale sharks (Catlin and Jones, 2009). In the present study, the expression of short-term avoidance behaviour by individual whale sharks was linked to a reduction in encounter time. Therefore, encounter time appears to have potential as a crude measure of the overall 'success' of interactions. For the purposes of the following discussion, it is explicitly assumed that the primary aim of any management intervention will be to maximize encounter times, which is most easily achievable through the minimization of avoidance behaviour.

A significant link was found between the expression of avoidance behaviour by sharks and the proximity at which swimmers entered the water from the vessel. Boat avoidance behaviour was also associated with shorter encounter times during ensuing in-water interactions with individual sharks. This suggests that disturbed sharks either have a heightened stress response, or in some cases dived before a close interaction with swimmers could take place. Martin (2007) suggested that boat avoidance behaviour in whale sharks may be related to either the low-frequency noise signature of the motors or to a perceived potential for boat strikes. Scars from small boat strikes have previously been recorded from Mozambican whale sharks (Speed *et al*., 2008), although the observed frequency of occurrence at Tofo was considerably lower than that reported from other aggregation sites (Cárdenas-Torres *et al*., 2007; Rowat *et al*., 2007). The presence of scarring was not identified as a significant predictor of avoidance behaviour in the present study, although this analysis did not specifically examine injuries from boats.

Boat avoidance behaviour was not observed at (estimated) distances >20 m in the present study. These data suggest that this distance represents a useful initial value for a boat exclusion radius around sharks. This recommended distance considerably exceeds the present mean swimmer discharge distance of slightly over 7 m, suggesting that training programmes will need to be implemented for skippers and guides to ensure changes in current behaviour. Given that a reduction in boat avoidance behaviour is likely to significantly increase mean in-water encounter times overall, the application of this new exclusion distance should be emphasized in training. There is no internationally-applied boat exclusion radius in use at present, as the situations and practical realities differ between sites. Code of Conduct recommendations around the world vary from 5 m in Bahia de los Angeles, Mexico (Cárdenas-Torres *et al*., 2007), to 10 m in Yum Balam, Mexico (Remolina *et al*., 2007) and 30 m in Western Australia (DEH, 2005). Furthermore, the high frequency of avoidance behaviour exhibited by sharks when interacting with more than one boatload of swimmers clearly suggests that, as laid out in most national Codes of Conduct, only one boat should be 'in contact' with a shark at one time, whilst any others maintain a reasonable distance (i.e. outside the proposed 20 m exclusion radius).

Swimmer interaction times recorded in the present study represent an intra-site baseline value for future adaptive management measures. Inter-site interaction times are likely to be less useful to the formulation of Mozambican management procedures, as shark behaviour is likely to change according to feeding strategy and the specific characteristics of each location. For example, the average length of interactions in the Philippines, where a higher proportion of sharks were feeding while observed (in 2005), was only 3 min (Quiros, 2007). Conversely, mean interaction times at Ningaloo Reef declined from 27 min in 1996 to 7 min in 2004, although some interim years remained high, with the decline possibly influenced by changes in operator procedures (Mau and Wilson, 2007). Although data on swimmer behaviours were not collected in the present study, other studies have shown that maintaining a distance of 3 m from the body of the shark and 4 m from the tail result in a reduction of avoidance by sharks. These distances minimize the potential for accidental touching and also reduce swimmer perceptions of crowding, thereby improving the quality of the encounter. Underwater visibility is generally high enough at Tofo to make these distances practical, unlike in Mexico and the Philippines where visibility is often poor. In the current study, however, the physical number of swimmers in the water had no apparent effect on encounter length, although the mean number of swimmers was higher than that recommended by most Codes of Conduct (Quiros, 2007; Remolina *et al*., 2007; Catlin and Jones, 2009). It seems likely that, rather than the sheer presence of swimmers, their behaviour and proximity to the shark is the important factor to consider in future studies and management assessments. Sea surface temperature was a significant predictor of avoidance response, with higher temperatures associated with decreased encounter times. As the metabolic rate of ectothermic sharks are strongly affected by ambient water temperatures (Carlson *et al*., 2004), this result may suggest that whale sharks swim faster or are more responsive to swimmer approach under warmer conditions.

Although the results of the present study show that an unmanaged tourism industry in Mozambique could have the potential to cause short-term behavioural modification in

whale sharks, basic mitigation measures should be relatively simple to implement. The results as shown can reasonably be taken to approximate the natural behaviour of skippers and guides, as no formal interaction guidelines were in place during the study. An increased effort to educate front-line operators in appropriate interaction techniques is therefore integral to the success of any new management strategies. Experience from other countries has shown that instituting accountability procedures for these staff members is also an important element, as even relatively low levels of non-compliance can lead to negative short-term behavioural impacts (Quiros, 2007). Recent studies from Ningaloo Reef in Australia (Meekan *et al*., 2006; Holmberg *et al*., 2008, 2009), Mahe in the Seychelles (Rowat *et al*., 2009) and Gladden Spit in Belize (Graham and Roberts, 2007) have demonstrated that whale sharks can be temporarily resident or show fidelity to feeding sites. This suggests the potential for sharks to be repeatedly exposed to tourist operators, which could result in cumulative impacts. Quiros (2007) found that sharks sighted for the first time at Donsol were significantly more likely to exhibit avoidance behaviour when interacting with swimmers than sharks encountered repeatedly, which suggests that some degree of habituation may occur. However, results from long-term studies on bottlenose dolphins suggest that in some cases, rather than becoming habituated, sensitive individuals may simply leave the area (Bejder *et al*., 2006a,b). This can lead to long-term population declines even in the absence of obvious short-term behavioural modification (Bejder *et al*., 2006a,b). Given that the length of coast where tours are conducted in Mozambique is relatively small, a large proportion of sharks utilizing this area are likely to be exposed to tourism. This could exacerbate the potential for negative impacts on Mozambican sharks and highlights the importance of ongoing monitoring to assess the medium- to long-term impacts of tourism on whale sharks in this area.

Mozambique plans to attract 4 million tourists annually by 2020 (Ministério do Turismo, 2004). Such increasing tourist numbers make it vital to introduce active management for Mozambique's whale shark tourism industry to ensure high quality experiences for swimmers while minimizing detrimental impacts on the sharks. The Mozambican government is presently focused on poverty reduction rather than environmental sustainability. Consequently, realizing the potential non-consumptive economic value of whale sharks is likely to be an important management consideration. However, if this vision of sustainable growth is to be achieved, iconic tourist species such as whale sharks require enhanced protection and a dedicated management strategy.

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