

University of York  
Environment Department

# **Investigating Anthropogenic Impacts on the Manta Rays and Whale Sharks of Hanifaru, Maldives**

submitted in partial fulfillment of the  
requirements for the degree of

MSc in Marine Environmental Management

by

Luiza Neves

September 2009

Supervisor: Dr. Julie Hawkins

In-field supervisor: Guy Stevens

Word count: 8,315

# Acknowledgments

My thanks to Guy Stevens for his supervision during fieldwork in Hanifaru, and his continuous support throughout this project. I am grateful to the Four Seasons, Landaa Giraavaru for hosting me throughout the duration of the project and would also like to thank my colleagues at the dive centre for all their help and assistance. Thank you to Steve Lindsay, head of the AEC project and the Ministry of Environment for their contribution to valuable information for this study. Finally I would like to show my appreciation for all of those at the marine biology and recreation departments for their contributions and for making these two months very enjoyable.

# Abstract

The Maldives offers one of the only places on earth where manta rays and whale sharks aggregate in such high numbers to feed. Plankton-rich waters accumulate inside Hanifaru bay, supporting annual mass feeding events for both species. Hanifaru has been declared a marine protected area and is also a proposed core zone for a UNESCO World Biosphere Reserve, where a management plan is being developed. Some of the main issues and concerns identified in this study include inadequate conduct by safari boats, and a number of visitors still touching and chasing manta rays and whale sharks inside Hanifaru bay. This emphasises the need for rules and regulations to be passed into law to help regulate infringements in the face of Hanifaru's growing popularity. Integrated management on a regional level should be conducted to counteract issues of boat collisions with the animals in other areas of the Baa Atoll. The suggested carrying capacity for Hanifaru is 5 boats and 100 visitors at any one time, to avoid overcrowding. Overall, present levels of site use have showed low levels of intrusive or inadequate behaviour toward manta rays and whale sharks of Hanifaru, which is in part awarded to the contributions of staff from the local resorts on self-policing the site.

# Contents

<b>1. Introduction.....</b>	<b>1</b>
1.1. Republic of the Maldives & its marine life.....	1
1.2. Manta rays.....	2
1.2.1. Life-history traits.....	2
1.2.2. Two species.....	3
1.2.3. Major threats.....	4
1.3. Whale sharks ( <i>Rhincodon typus</i> ).....	5
1.3.1. Biology, ecology and movements.....	5
1.3.2. Major threats.....	6
1.4. Purpose of project.....	7
1.5. Useful definitions.....	8
 <b>2. Methods.....</b>	 <b>9</b>
2.1. Site selection & characteristics.....	9
2.2. Site use.....	10
2.3. Boat conduct.....	10
2.4. In-water behaviour of snorkelers & divers.....	11
2.5. Manta ray & whale shark reactions.....	12
 <b>3. Results.....</b>	 <b>12</b>
3.1. Site use (July & August 2009).....	12
3.1.1. Boat operators.....	12

3.1.2. Relationship between manta ray & whale shark sightings and site use.....	15
3.2. Site use over the years (2007-2009).....	18
3.3. Boat conduct.....	20
3.3.1. The problem with safari boats.....	23
3.4. In-water behaviour of snorkelers & divers.....	24
3.5. Manta ray & whale shark reactions.....	26
 <b>4. Discussion.....</b>	<b>29</b>
4.1. Sightings & implications for management.....	29
4.2. Site use: impacts from boats, snorkelers & divers.....	30
4.3. Recommendations and future work.....	35
 <b>5. Conclusions.....</b>	<b>36</b>
 <b>References.....</b>	<b>37</b>
 <b>Appendices.....</b>	<b>42</b>
 <b>Appendix I – Memorandum of Understanding</b>	
<b>2009.....</b>	<b>42</b>
 <b>Appendix II - Participation in additional projects &amp; activities.....</b>	<b>44</b>

# List of tables and figures

Table 1 - Summary of site use at Hanifaru during July and August 2009 .....	15
Table 2 - Sampling effort (=days) by month & year between June 2007 and August 2009, corresponding to figure 8.....	19
Table 3 - Defining ‘adequate’ and ‘inadequate’ behaviour for each of the 3 components of boat conduct, based on the MoU guidelines (2009) for Hanifaru.....	23
Table 4 - Matrix showing the reactions of manta rays and whale sharks to different types of in-water behaviour by snorkelers and divers (2 months observations).....	26
Table 5 - Summarising in-water behaviour of snorkelers and divers at Hanifaru during July and August 2009, according to level of intrusion.....	29
Figure 1 - Map of the Maldives showing the location of Baa Atoll and Hanifaru.....	2
Figure 2 – Distinguishing between the 2 manta ray species: <i>Manta birostris</i> (top) and the newly discovered more migratory specie (bottom), showing the chevron (c) and black (d) color forms. ....	4
Figure 3 - Safari boat (left) and a smaller resort dhoni (right). Safari dhonis, resort dhonis and smaller speedboats are allowed inside Hanifaru bay .....	8

Figure 4 - Detailed map of Hanifaru.....	9
Figure 5 - Codes of conduct for boats operating inside Hanifaru bay, according to the Memorandum of Understanding (2009).....	11
Figure 6 - Site use per operator and purpose of trips to Hanifaru. Data for July and August 09.....	13
Figure 7 - The relationship between peak manta and whale shark sightings and site use during July and August.....	16
Figure 8 - Comparing site use for this year's observations during July and August with past data available on the Manta project database.....	18
Figure 9 - Recording the proportion of boats/ skippers operating inadequately inside Hanifaru bay.....	20
Figure 10 - Boat conduct: anchoring, speed and way of entering and/or leaving Hanifaru bay. Comparing data for July and August 2009.....	22
Figure 11 - People's behaviour toward manta rays and whale sharks at Hanifaru.....	25
Figure 11 - Manta ray scarred and without a cephalic fin due to fishing line and a whale shark with a fresh boat propeller scar seen inside Hanifaru bay.....	32

# 1. Introduction

## 1.1. Republic of the Maldives & its marine life

The Maldives is consists of 1,192 islands in 26 atolls and a total reef area over 3,500km<sup>2</sup> (Emerton *et al*, 2009). Its coral reefs represent as much as 5% of the world's reef area and is by far the largest group of coral reefs in the Indian Ocean, supporting high biodiversity worth approximately US\$1.5 billion to US\$2.7billion to the national economy each year through mainly tourism and fishing (UN, 2007, Emerton *et al*, 2009). A variety of internationally important species are also found including whale sharks *Rhincodon typus*, classed as vulnerable; and the near threatened manta rays *Manta birostris* (IUCN Red list, [www.iucnredlist.org](http://www.iucnredlist.org)). The Maldives offers one of the only places on earth where manta rays and whale sharks aggregate in such high numbers to feed, and one of few places in the world where whale sharks are encountered all year round (Owen, 2009, National Geographic, 2009). Plankton-rich waters accumulate inside Hanifaru bay, supporting annual mass feeding events for both species (Barcott, 2009). Over 1000 manta rays and 30 whale sharks regularly use the site during the SW Monsoon of the Maldives (Stevens, no date).

Due to its significance, Hanifaru has been declared a marine protected area and is also a proposed core zone for a UNESCO World Biosphere Reserve, which will incorporate the Baa Atoll (figure 1), a group of 75 islands with distinctive biodiversity (AEC, 2009a, National Geographic, 2009). This atoll has a history of hunting mantas and whale sharks for their rich oily livers and skins; and several species of sharks have become severely overfished (AEC, 2009). Shark fishing is now banned in Baa Atoll under a moratorium from the government (Emerton *et al*, 2009). Both species are now protected in the Maldives (AEC, 2009a).

Manta ray excursions in the Maldives generate direct revenue of US \$10,000,000 annually, while whale shark excursions are estimated to generate a similar value each year (Stevens, no date). Hanifaru alone is estimated to contribute US\$200,000 annually, acting as a major contributor to the local resorts and communities (Stevens, no date).



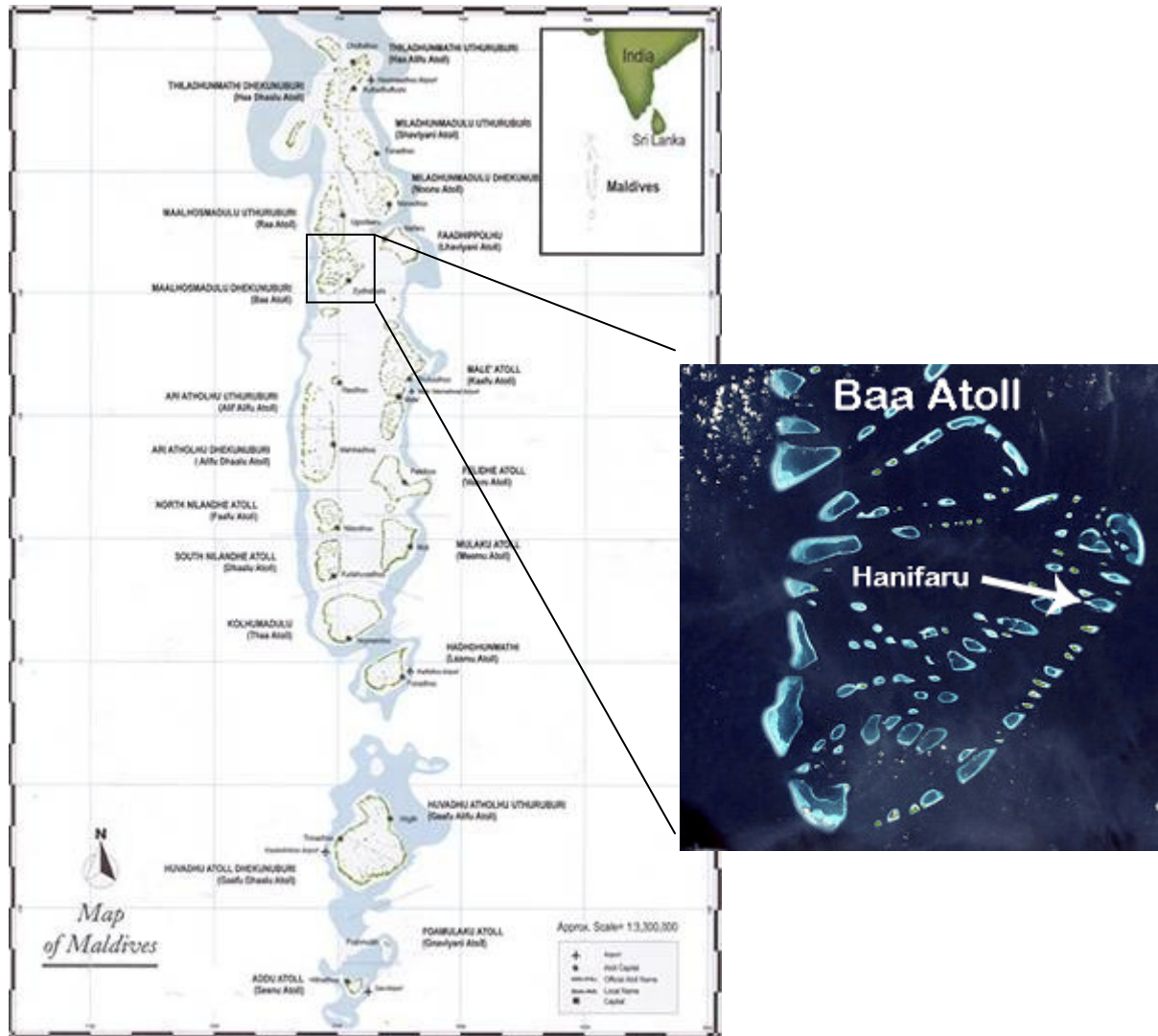


Figure 1 - Map of the Maldives showing the location of Baa Atoll and Hanifaru. Sources: My Maldives Travel Guide ([www.mymaldives.com](http://www.mymaldives.com)) and Stevens (no date).

## 1.2. Manta rays

### 1.2.1. Life-history traits

Manta rays are the largest ray species with a maximum wing-span of 7.01m (females) and 4.08m (males) and weighing up to 2000kg (Duvly *et al*, 2008). They live for about 20 years and give birth to a single pup, typically 1 to 1.5m, after a 9-14 month gestation period (Homma *et al*, 1999, Marshall *et al*, 2006). They possess the largest brain of all

shark and ray species, indicating a highly developed mental function and are also incredibly complex, socially (Stevens and Stevens, no date).

Manta rays aggregate near reef areas where they can be cleaned of parasites by smaller reef fish, which also provides divers some of the best opportunities for seeing these harmless giants (Stevens and Stevens, no date). Mantas are filter feeders, feeding on plankton by unrolling their cephalic fins and channelling water into their mouths (Barcott, 2009). Their natural predators include tiger sharks and orcas (Stevens pers. comm.).

Little is known about their reproduction but studies in Japan from a captive manta ray has shown that male manta rays first chase the females trying to grasp its pectoral fin, and once it does, copulation occurs abdomen-to-abdomen whilst the male keeps hold of the female by biting its fin (Yano *et al*, 2007). Similar behaviour and mating 'trains' have also been observed in the Maldives (Stevens, pers. comm.).

### **1.2.2. Two species**

A new species of manta ray was recently discovered with a wing span of almost 8m occurring across temperate, tropical and subtropical waters worldwide (Owen, 2008). The two species have overlapping distributions, but the newly discovered one is more migratory than its relative, *M. birostris*, which is more residential to particular areas all year-round (Owen, 2008). They can also be distinguished visually as shown in figure 2. *Manta birostris* has been encountered in reef areas of Hawaii, the Maldives, Mozambique, Australia, Japan and the Island of Yap, but may also exist in other parts of the world (Wilson *et al*, 2001a, Clark, 2005, Owen, 2008). Reports of manta ray sightings extend beyond these locations (Duffy and Abbott, 2003, Zeeberg *et al*, 2006, Marshall *et al*, 2006, Luiz Jr *et al*, 2009); but until recently the two manta species were known as one, making it possible that some reports were of the second, newly discovered species.

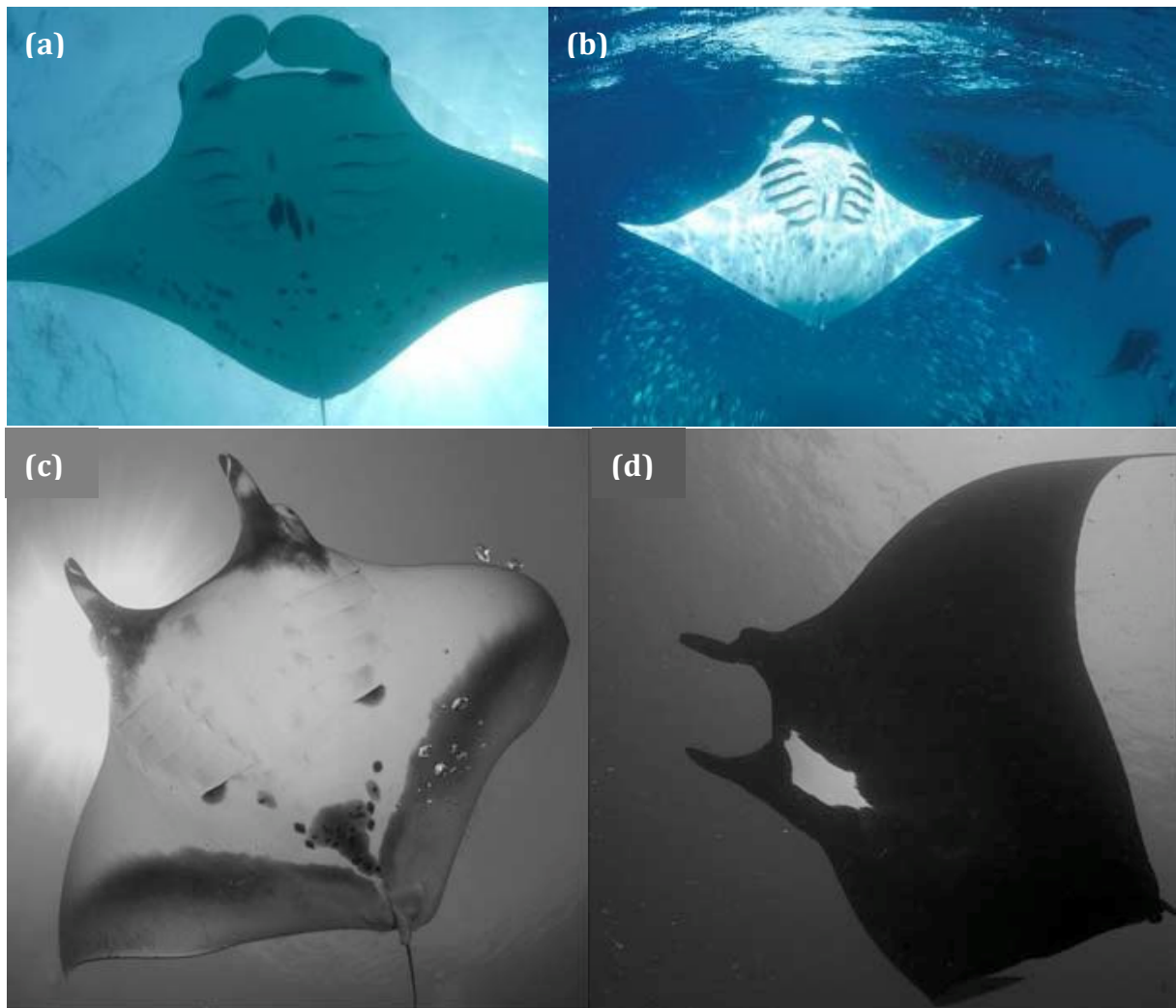


Figure 2 – Distinguishing between the 2 manta ray species: *Manta birostris* (top) and the newly discovered more migratory specie (bottom), showing the chevron (c) and black (d) color forms. Sources: (a) ID shot by Luiza Neves, (b) Thomas Peschak, (c), (d) Luiz Jr *et al*, 2009.

### 1.2.3. Major threats

In the Maldives, the resident population of *M. birostris* is estimated at 5-10,000 individuals (Stevens, no date). They have long been known by local residents, who used to hunt them for their skins, used to make drums (Stevens, no date). Worldwide, fisheries target manta rays (either species) for their branchial filter plates, which are used in traditional Chinese medicines worth as much as US\$30 per kg (dry weight); their cartilage is dried for export as a filler for shark-fin soup; their skins and flesh is used for human consumption and their livers for oil (White *et al*, 2006, Marshall *et al*, 2006). The

high demand for these has led to the decline of manta ray populations in several parts of the world (White *et al*, 2006). The Mexican fishery, for example, has led to such declines in the manta ray population that it prompted formal protection of manta rays in the Philippines (Homma *et al*, 1999, Alava *et al*, 2002).

Further threats to manta rays include habitat degradation, coastal development, pollution, ghost nets, lost fishing lines and hooks, boat traffic and possible harassment from divers who interact with them at critical habitats such as cleaning stations and breeding areas (Marshall *et al*, 2006, Wildlife Extra News, 2008). They are also caught as bycatch in some shark and tuna fisheries (Trent *et al*, 1997, Zeeberg *et al*, 2006, Marshall *et al*, 2006, White *et al*, 2006).

The small population size, limited migration and low fecundity of *M. birostris* increases their risk of local extinction (Marshall *et al*, 2006). Some populations such as in the Hawaiian Islands and the Island of Yap exhibit high site fidelity, with little to no migration from the island groups, increasing their vulnerability (Marshall *et al*, 2006). However, fidelity indicates that marine protected areas created around aggregation sites can effectively increase the protection of the species (Dewar *et al*, 2008). The MPA recently announced for Hanifaru is a big step toward contributing to the protection of manta rays in the Maldives (Save Our Seas website, [www.saveourseas.com](http://www.saveourseas.com)).

### 1.3. Whale sharks (*Rhincodon typus*)

#### 1.3.1. Biology, ecology & movements

Whale sharks have been described since 1828 (Stevens, 2007). They are ovoviparous, suction filter-feeders, feeding on planktonic and nektonic prey including aggregating crustaceans such as euphausiids and copepods, schooling baitfishes such as sardines and anchovies, tropical krill, mysids, small jellyfish, coral spawn and fish spawn (Bauhman, 1955, Norman, 1999, Heyman *et al*, 2001, Wilson, 2002, Graham *et al*, 2006, Stevens, 2007). Whale sharks are the largest fish in world, reaching 18m (possibly 20m)

and weighing up to and over 30 tonnes. (SEMARNAT, 2007, Dearden *et al*, 2008). Males start to mature at *ca* 8m and 50% are mature by the time they reach 8.6m (Norman, 1999). Little information is available on growth rates and reproduction, especially in wild populations (Stevens, 2007).

For several years it has been known that whale sharks are highly migratory species, but still, not much is known about their biology and ecology, distribution and movements, which makes their conservation a difficult task (Norman, 1999, Eckert *et al*, 2002, Rowat and Gore, 2007, Stevens, 2007). However, increases in ecotourism activities around the world has led to discoveries of whale shark aggregations in several regions and there have also been an increase in tagging studies, helping to unravel some of the specie's movement patterns such as diving behaviour (Stevens, 2007). Studies revealed that whale sharks spent the majority of time in waters between 25–35 °C, but they also tolerate short exposures to temperatures below 10 °C during dives (Graham *et al*, 2006, Rowat and Gore, 2007). Depth recordings show a preference of the whale shark for shallower waters (less than 10m) but dives to depths of 750–1000 m were also recorded (Rowat and Gore, 2007). Dive patterns may be related to lunar and light:dark cycles, as well as seasonally predictable food source (Gunn *et al*, 1999, Graham *et al*, 2006). A study by Wilson *et al* (2001b) showed increases in whale shark abundances during La Niña years.

Along with tagging, photo identification studies are increasingly employed to study their populations. Individuals are identified using the spot patterns around their gills and pectoral fins (MWSRP, no date). An estimated population of over 120 whale sharks are resident in the Maldives and can be encountered all year round (National Geographic, 2009).

### **1.3.2. Major threats**

Mortality related to human activities occurs through boat strikes and bycatch, but by in large the major threat to whale sharks is the increased demand for their fins and meat (Gudger, 1940, Shark Trust website, [www.sharktrust.org](http://www.sharktrust.org)). Historically, whale sharks were hand-caught using spears and hooks and primarily for their oily livers

(Vivekanandan and Zala, 1994). This form of fishing was carried out in the Baa Atoll, Maldives for hundreds of years before the moratorium (Anderson and Ahmed, 1993). Their main target was the liver – up to 200L of oil would be extracted from a single liver – and their skins were eaten or used in ‘bodabero’ drums. More recently, demand has aimed sharks fins and meat: in the 1970’s and 1980’s, 30-100 sharks were caught per season in SW Taiwan, which soon led to the decrease in population numbers (Joung *et al*, 1996). In the Philippines, increasing fishing effort for whale sharks and manta rays has led to these species becoming threatened in the Bohol Sea (Alava *et al*, 2002). Whale sharks are threatened by overfishing primarily in SE Asia and the Indian Ocean (Stevens 2007). The increased threat of whale sharks and manta rays to human fisheries, including illegal fishing, has raised conservation interest for the species (Stevens, 2007).

#### 1.4. Purpose of project

Apart from the MPA that has been announced for Hanifaru, it is also a proposed core zone for a UNESCO World Biosphere Reserve, which will incorporate the Baa Atoll. The AEC project is working together with the Ministry of the Environment on developing a management plan for the reserve. Amongst the project’s aims are to manage all users and the activities undertaken at Hanifaru, to ensure that manta rays and whale sharks continue to undertake annual feeding at this site. However, to this date, there has been no formal assessment of anthropogenic impacts on the manta rays and whale sharks of Hanifaru.

A Memorandum of Understanding (MoU) was finalized in 2009, detailing specific guidelines and codes of conduct that should be followed by all users (appendix I). This however, is an informal agreement between 6 resorts in the Baa Atoll that visit Hanifaru more frequently and though it has had some success, there is a lack of authoritative power to impose any rules on outside boats also visiting the site (Stevens, no date). Through communication with one another the resort boats help to police the site themselves but there is the need for regulations to become legally established.

This study will help define some of the issues and concerns regarding site use, boat conduct and the behavior of visitors at Hanifaru, which will help to implement official rules and regulations for the site, along with the MoU, and highlight the activities that need greater regulation and enforcement.

## 1.5. Useful definitions

**‘Dhoni’:** Boats approximately 15m in length, owned and crewed by local island residents. Resorts use these for cruises, dive trips, etc. (figure 3).

**‘Safari boat’:** Large live-aboards that cruise around the atolls. They are not allowed to enter Hanifaru bay.

**‘Safari dhoni’:** Smaller boats used by the safari operators to take their guests to dive sites in shallower areas or in places where the large safari boats are not permitted. These look similar to resort dhonis but will have the name of their safari operators written on them.



Figure 3 - Safari boat (left) and a smaller resort dhoni (right). Safari dhonis, resort dhonis and smaller speedboats are allowed inside Hanifaru bay. Photos by Luiza Neves.



## 2. Methods

### 2.1. Site selection & characteristics

Hanifaru is a small island surrounded by reefs that create a bowl-shaped bay where mantas and whale sharks gather to feed. Just south of Hanifaru bay the Indian Ocean's southwestern monsoon current meets the somewhat weaker currents created by lunar tides and in doing so they form eddies, which pulls plankton-rich waters from nearby highly productive areas into the bay (Barcott, 2009). The plankton becomes trapped, sometimes in very thick concentrations, supporting mass feeding events of mantas and whale sharks. Research is being conducted into refining the prediction of feeding events in Hanifaru, but already trends are being seen, namely just after high tide the first few mantas appear (Stevens pers. comm.). This predictability and the accessibility of Hanifaru allows for a unique study location, permitting observations into manta ray and whale shark behavior in response to the behavior of snorkelers, divers and boat skippers.



Figure 4 - Detailed map of Hanifaru. Source: National Geographic, 2009.



## 2.2. Site use

The number of boats, snorkelers and divers visiting Hanifaru were recorded on a daily basis for 2 months, July and August 2009. These months coincide with peak manta ray season and therefore are prone to very high levels of site use (Stevens pers. comm.). Quantifying this is the first step toward defining a carrying capacity for the site. Later this level of use was related to the proportion of people behaving inadequately toward the manta rays and/or whale sharks, and the proportion of boats operating incorrectly inside the bay, according to the Memorandum of Understanding (MoU) guidelines. This information would help to see whether overcrowding of the site is a possible concern for the mantas or whale sharks feeding, cruising or cleaning at Hanifaru. It would also contribute toward advising on a suitable limit for boats and visitor numbers in the bay at any one time to avoid overcrowding of the site and possibly overstressing the animals.

Each vessel entering the bay was logged and the operator identified (resort operators, safari operators or private vessels). The number of snorkelers and divers dropped off in the water were also counted and logged before their in-water behaviour toward the manta rays and/or whale sharks was monitored.

## 2.3. Boat conduct

There are no official rules or regulations for Hanifaru bay yet, however, under the MoU (2009), all vessels larger than a dhoni, as well as jet skis, catamarans and other such small vessels are not permitted to enter the bay (appendix I). The MoU states that Boats should enter and leave the bay according to the red line in figure 5; anchor only in the sandy lagoon at the end of the bay; should reduce their speed whilst looking out for mantas and whale sharks and keep a safe distance of at least 20m away from animals and people; and should instruct all their snorkelers/ divers that they must swim back to the boat rather than being picked up (this prevents unnecessary manoeuvring inside the bay or collision risk). Observations were made for every boat at Hanifaru to see whether or not these codes of conduct were being followed. If they were not, guides from other

resort boats should intervene and kindly instruct them on the correct conduct to follow. The number of interventions during the 2 months was also noted.

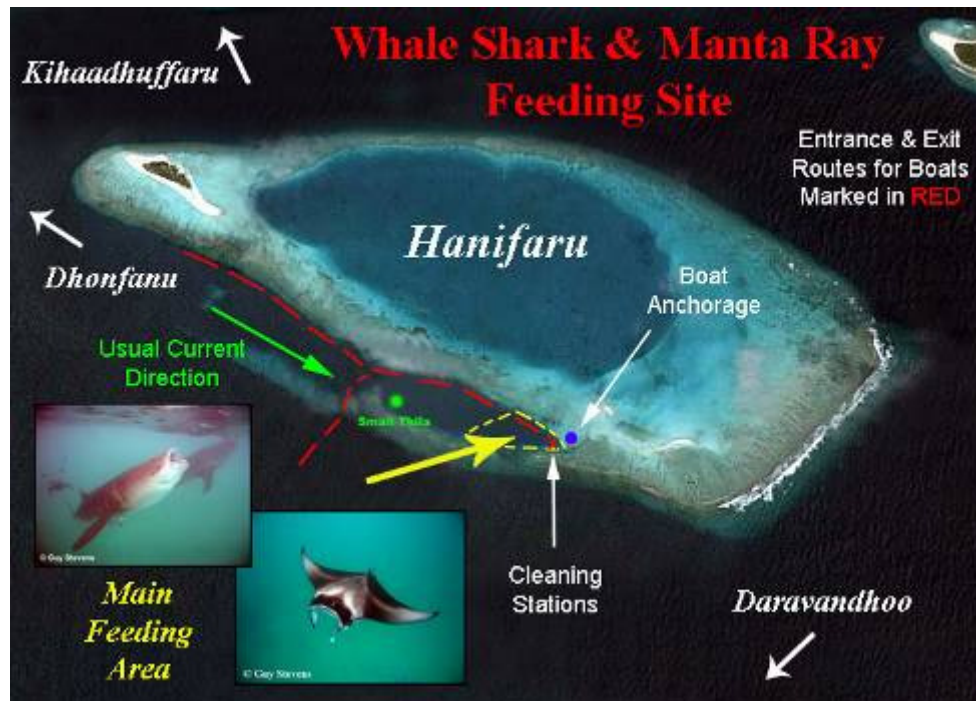


Figure 5 - Codes of conduct for boats operating inside Hanifaru bay, according to the Memorandum of Understanding (2009). Obtained from Guy Stevens, Landaa Giraavaru, Maldives.

## 2.4. In-water behaviour of snorkelers & divers

Observations were made on how individual snorkelers and divers behaved toward the mantas and/or whale sharks present in Hanifaru, for approximately 10 minutes each. When the group was too large (for example over 50 snorkelers at once in the bay) the observations were more generalised. The observer was always in the water along with the groups that were, discretely, being monitored. Records were kept on the total number of snorkelers/ divers seen behaving according to the following categories: 1) people swimming in front of, or directly toward the mantas or whale sharks, interrupting the animal's swimming direction; 2) approaching the animals from behind; 3) approaching the animals from beneath; 4) chasing (noticed particularly through the

level of agitation in the water by snorkelers or the swimming speed of divers); 5) intentional touching or grabbing; 6) accidental touch/ collision; 7) use of flash photography; 8) diver bubbles and 9) the proximity of snorkelers and divers to the mantas and/or whale sharks.

## 2.5. Manta ray & whale shark reactions

Observations were also made on the reactions of the mantas and whale sharks relating to each type of in-water behaviour mentioned above. So for any group of snorkelers or divers visiting Hanifaru, the people's in-water behaviour toward the animals was observed, as well as the manner in which the animals reacted each time. Records were kept on whether or not the behaviour seemed intrusive to the mantas or whale sharks, or whether there was no evidence for intrusion.

## 3. Results

### 3.1. Site use (July & August 2009)

#### 3.1.1. Boat operators

There are six resorts in the Baa Atoll that mainly organise trips for their guests to visit Hanifaru: Four Seasons, Sonevafushi, Valtur Club, Reethi Beach, Royal Island and Coco Palm. From these the latter two visit the site only occasionally, and the other 4 are far more regular (figure 6a, c). The Four Seasons research boat (used by the observer in this study) frequently visited the site to collect data (22 times in July and 25 times in August) and therefore to relieve bias in the observations of site use per operator, it was not included in the analysis that follows. Research conducted from any other boat was considered (figure 6b, d). 'Unknown' corresponds to boats that could not be identified.

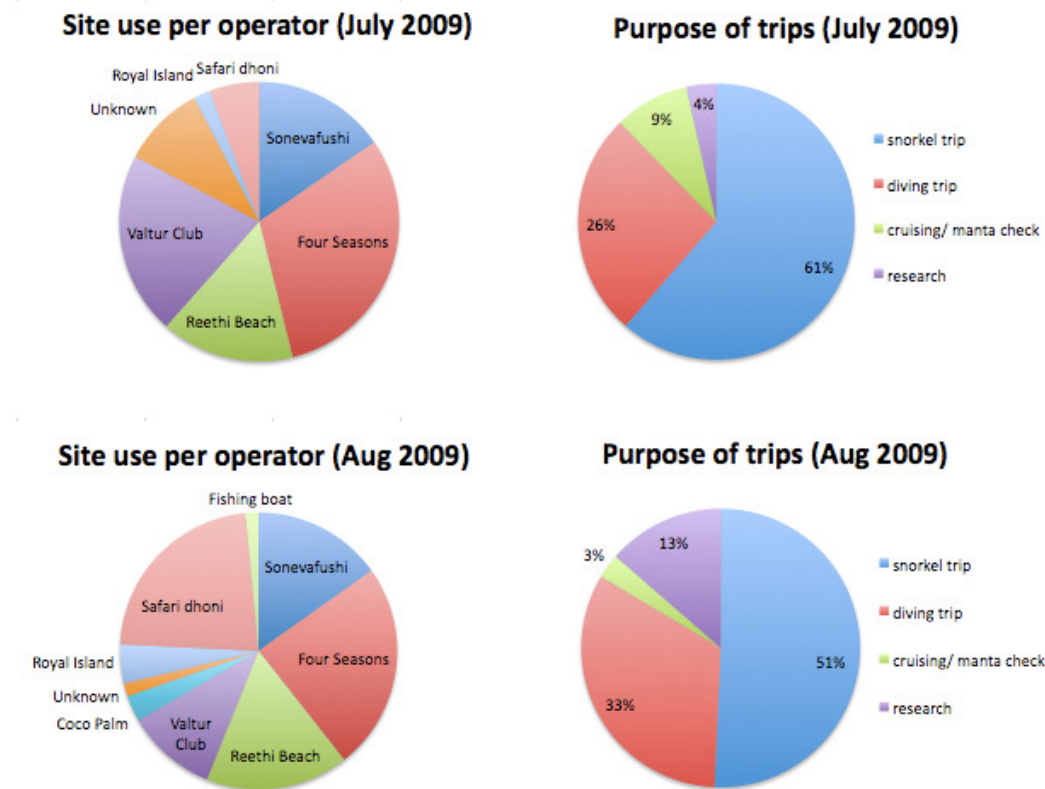


Figure 6 - Site use per operator and purpose of trips to Hanifaru. Data for July and August 09.

Four Seasons' boats visiting Hanifaru consisted of 31% and 24% of the total number of boats observed there in July and August, respectively. The number of Reethi Beach boats at Hanifaru each month remained fairly constant (15% and 17%), and so did Royal Island's (2% and 5%). Sonevafushi's boats consisted of 15% of the total boats present for both months and Valtur Club's site use decreased slightly from July to August (21% to 11%). Coco Palm was not seen at Hanifaru in July, but in August formed 3% of total boats. The number of unknown boats decreased in August (10% to 2%) as the observer's experience with recognising the boats by type, colour or size (or the crew's uniform colours) grew. It is possible that at least a few of the unidentified boats from July were safari dhonis operating to take guests from the large live-aboard boats, and were more difficult to recognise, especially at an early stage in the course of this study. Two fishing boats were seen in August, one of them taking a small film crew to Hanifaru to film the manta and whale shark aggregations, and the other just crossing the bay (fishing inside Hanifaru bay is prohibited as the mantas and whale sharks are protected in the Maldives, as mentioned previously). By far the most significant change seen over

the two months was the percentage of safari dhonis visiting the site, increasing from 6% to 23%.

Most trips to Hanifaru are snorkelling trips (61% and 51%), followed by dive trips (26% and 33%). The corals inside Hanifaru bay are not in very good condition due to storm damage and the mass-bleaching event after the El Nino in 1997/98 (Solandt and Wood, 2005). This makes divers slightly more reluctant to spend a full dive at Hanifaru if the site's main attractions are not there; and makes snorkelling a slightly more attractive option. Some boats, particularly smaller speedboats, are sometimes seen with just one or two crew members performing a quick 'manta check' of the site. More of these were observed in July than in August (9% and 3%). Research was conducted by scientists from one of the safari dhonis visiting the site in August for just over a week, which increased this trip purpose from 4% in July to 13% in August. If the research conducted by the Four Seasons research boat were included here, 'research' would be the 2<sup>nd</sup> major purpose for visiting Hanifaru, but as previously mentioned, it was not included to relieve bias on observations of site use.

Table 1 provides a summary of site use for the duration of this study and daily records are shown in figure 7.

Table 1 - Summary of site use at Hanifaru during July and August 2009.

	Total no. boats			Total no. of:			
	<b>Resort boats</b>	<b>Safari dhonis</b>	<b>Fishing boats</b>	<b>Snorkelers</b>	<b>Divers</b>	<b>Manta rays</b>	<b>Whale sharks</b>
July	71	3	0	504	120	407	6
August	125	30	2	753	389	796	3

### **3.1.2. Relationship between manta ray & whale shark sightings and site use**

The number of mantas and whale sharks recorded in Hanifaru during July and August is displayed below on a daily basis. The sightings for the manta rays are based on educated estimates. Despite there being large number of mantas inside the bay at one time, through photo-identification and by carefully observing the spot patterns on the ventral side of each manta, one can begin to have an idea of how many different individuals there were based on how many photos were taken and through the recognition of different manta rays, acquired with practice.

The lunar cycle has been super imposed on the graph to show its relevance to peak sightings. The total number of snorkelers, divers and boats observed at Hanifaru each day is also shown alongside the sightings, helping to explain the relationship between site use and 'good manta days'.

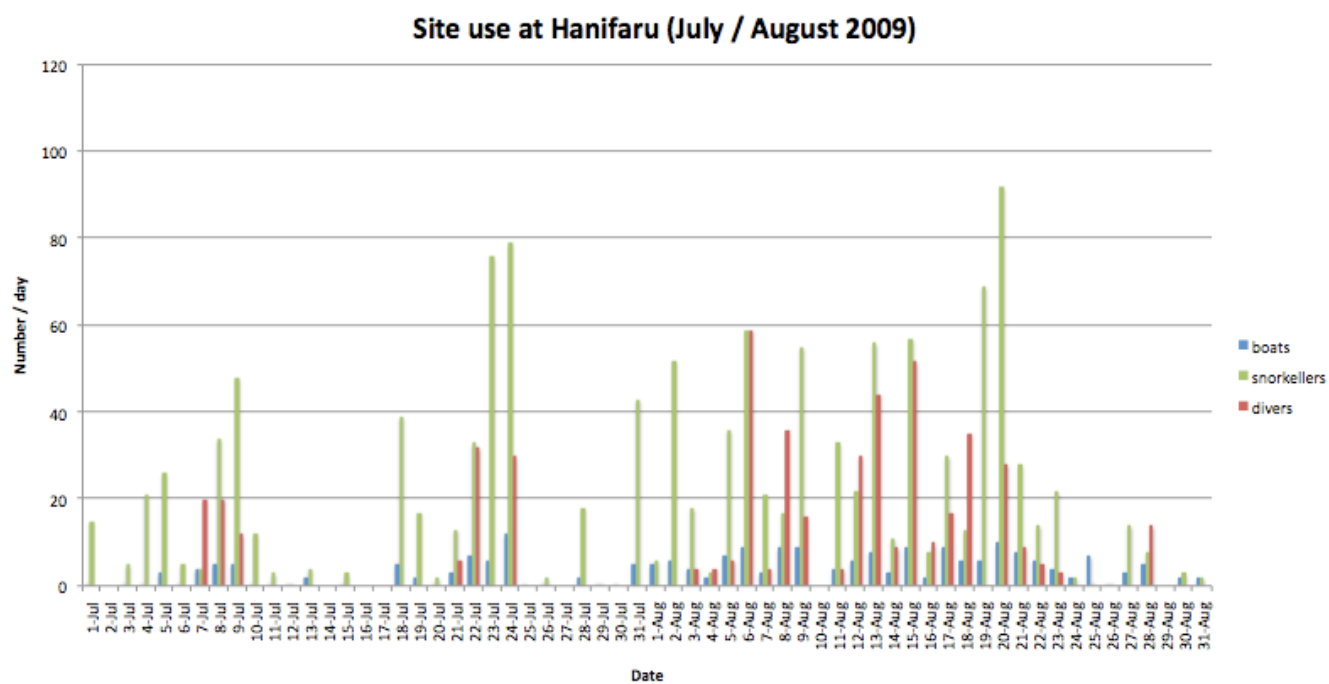
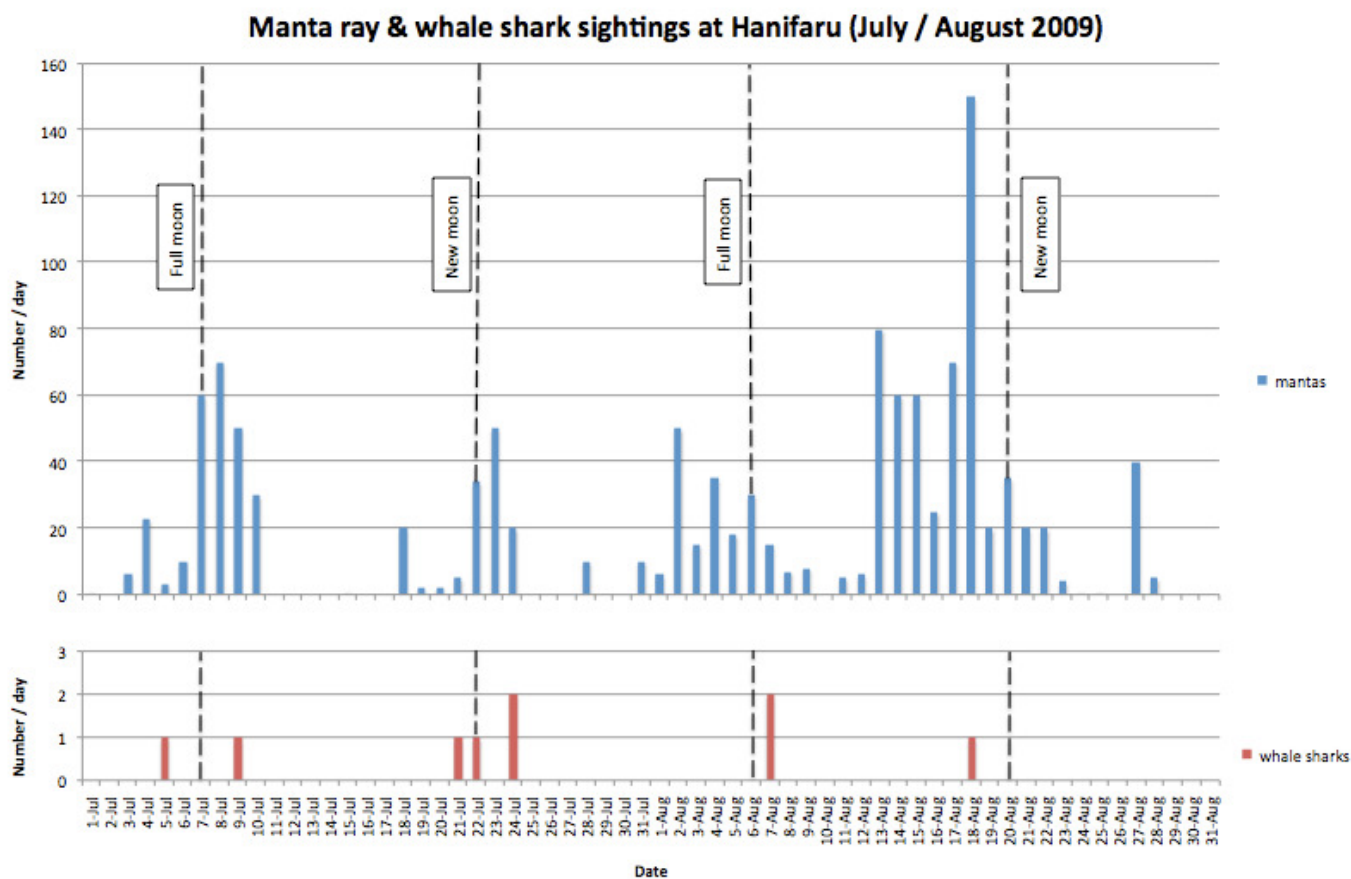


Figure 7 - The relationship between peak manta and whale shark sightings and site use during July and August.

Peak manta ray and whale shark sightings at Hanifaru appear either on or just before or after full moon and new moon, when spring tides occur. The larger the difference between high and low tides, the greater the force of the tide pushing plankton into the bay, which then accumulates (Stevens, pers.comm.). The highest peak seen was in August 18<sup>th</sup> with 150 mantas (approximately) and 1 whale shark, all feeding together inside the bay, 2 days before new moon (figure 7).

The site use by both boats and people shows a clear correlation with manta and whale shark sightings. During and around the days with higher manta and whale shark abundances, the number of snorkelers, divers and boats is also higher (figure 7). In other words, the peaks for site use correspond, quite closely, to the peaks for sightings. Up to 92 snorkelers, 28 divers and 10 boats were seen at Hanifaru in just one day, Aug 20<sup>th</sup> (at different times), being the busiest day during the 2 months of this study. This day did not correspond with one of the highest peaks in manta ray or whale shark abundance, but had just followed the peak day of 150 mantas and 1 whale shark (figure 7). Between 6 and 10 boats were recorded during 5 consecutive days in August (from the 17<sup>th</sup> to the 21<sup>st</sup>), corresponding to some of the days with greatest abundances of manta rays (figure 7). As word of a 'good manta day' or news of a whale shark inside Hanifaru bay gets out and reaches the resorts, some guests are sent off in speedboats as soon as possible, increasing the number of people and boats at the site that day. Also, for the days that follow a 'good manta day' resorts increase their efforts to sending their guests to Hanifaru (figure 7), hoping that they will have the best chance of observing and/or swimming amongst the animals.

Other very busy days (high site use) were Aug 6<sup>th</sup> and July 24<sup>th</sup> with 59 and 79 snorkelers, 59 and 30 divers, 9 and 12 boats, respectively. Once again, neither of these days were amongst those with the greatest number of observed mantas, but the resorts know that on or around full moon or new moon days is a good time to take the chance to visit Hanifaru bay. However, sometimes a sharp decrease in manta numbers can be seen from one day to the other, for reasons still unknown. The sharpest decrease observed was from 150 to 20 mantas (Aug 18<sup>th</sup> – 19<sup>th</sup>), followed by 50 to 15 (Aug 2<sup>nd</sup> – 3<sup>rd</sup>, respectively) and 40 to 5 (Aug 27<sup>th</sup> – 28<sup>th</sup>). Similarly, for some reason, manta numbers can also increase suddenly such as between Aug 17<sup>th</sup> and 18<sup>th</sup> from 70 to 150 manta



rays, Aug 12<sup>th</sup> – 13<sup>th</sup> from 6 to 80 and July 6<sup>th</sup> – 7<sup>th</sup> from 10 to 60 mantas rays. Whale sharks are much harder to predict, perhaps related to there being mostly juvenile males in and around the bay (Stevens, pers.comm.). The largest whale shark observed during July and August 2009 was a male, 6.5 – 7m in length, the remainder being around 3 to 4m, also males. They do, however, also seem to appear close to new moon and full moon, times where site use also increases due to resorts calling and warning each other.

### 3.2. Site use over the years (2007-2009)

Past data on the number of boats, snorkelers and divers present at Hanifaru was obtained and analysed against this year's observations for July and August, to see how they compared. The data was standardised to take into account sampling effort ie. the number of days per month that data was obtained (table 2). Sampling effort and precision was much smaller for 2007 than it was for 2008 and 2009. Also, during peak season (June – September) there is a greater sampling effort in that data is collected for many more days than during the off-season (December – April).

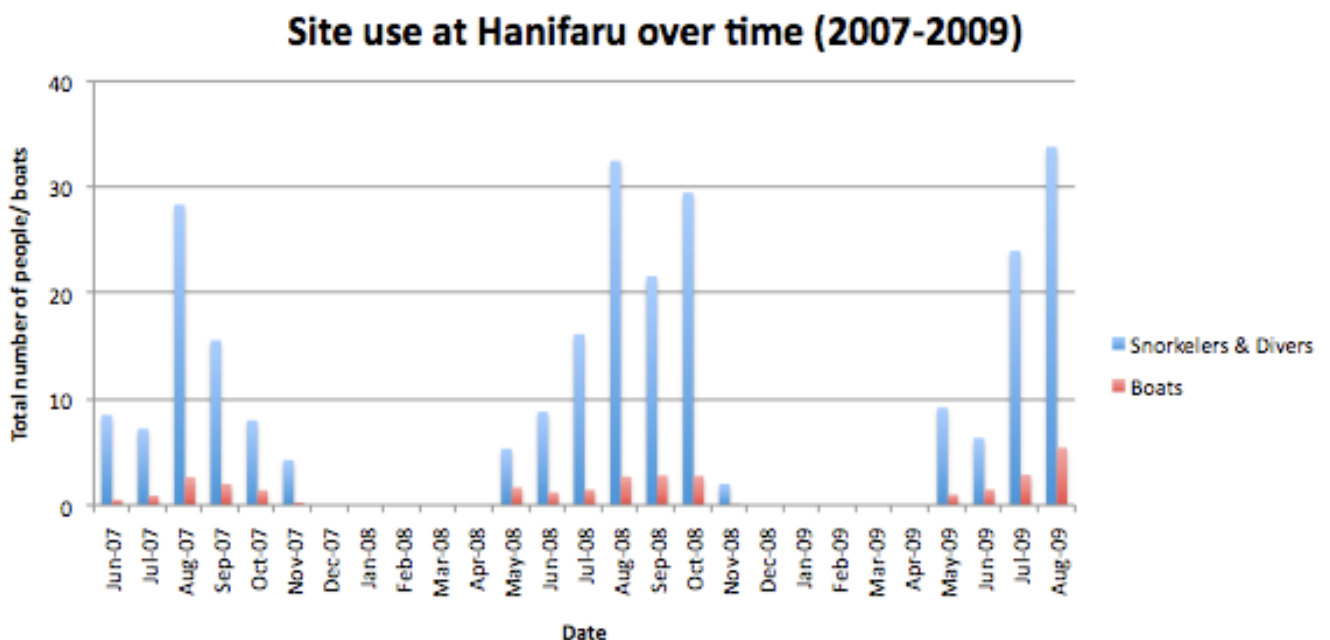


Figure 8 - Comparing site use for this year's observations during July and August with past data available on the Manta project database. Past data obtained from Guy Stevens, Landaa Giraavaru, Maldives and standardised.

Table 2 - Sampling effort (=days) by month & year between  
June 2007 and August 2009, corresponding to figure 8.

2007		2008		2009	
		Jan-08	3	Jan-09	4
		Feb-08	5	Feb-09	2
		Mar-08	4	Mar-09	3
		Apr-08	3	Apr-09	3
		May-08	3	May-09	10
Jun-07	8	Jun-08	10	Jun-09	15
Jul-07	9	Jul-08	22	Jul-09	26
Aug-07	11	Aug-08	26	Aug-09	29
Sep-07	9	Sep-08	10		
Oct-07	5	Oct-08	4		
Nov-07	4	Nov-08	10		
Dec-07	4	Dec-08	4		

Figure 8 seems to indicate that site use was higher for this year's months of July and August than in the same months in 2008 or 2007. Though the data was standardised, there is still a remarkable difference between some of the days in which data was collected. During some days, particularly during peak manta season, the research boat would spend several hours at Hanifaru, increasing the possibilities of observing boats entering the bay in contrast with the mere 5 to 10 minutes spent some days during the off-season (during which time the researchers would visit Hanifaru just to check that there were no mantas around). Furthermore, data recorded during this study was more precise than that collected between June 2007 and June 2009, which were based on rough estimates. These factors add some bias to figure 8. In reality, Guy Stevens, an active researcher at Hanifaru for the past 5 years, has observed the trends in the bay and tells that July and August of this year was far less busy than in 2008, which is not apparent in figure 8. What is certain is that there is seasonality in site use at Hanifaru, which corresponds to the peak manta seasons and off-seasons. The number of trips to the bay during December to April are greatly reduced, despite it being a busy time for the resorts. For all 3 years, July and August have been the busiest months, subject to greater boat activity and more people in the water interacting with the mantas and whale sharks in the bay (figure 8).

### 3.3. Boat conduct

It is very important to monitor and record boat conduct in Hanifaru bay, particularly during the months of July and August that experience the heaviest site use and far greater numbers of mantas and whale sharks. Observations on boat conduct, following the guidelines described in the MoU (2009), are given in figure 9.

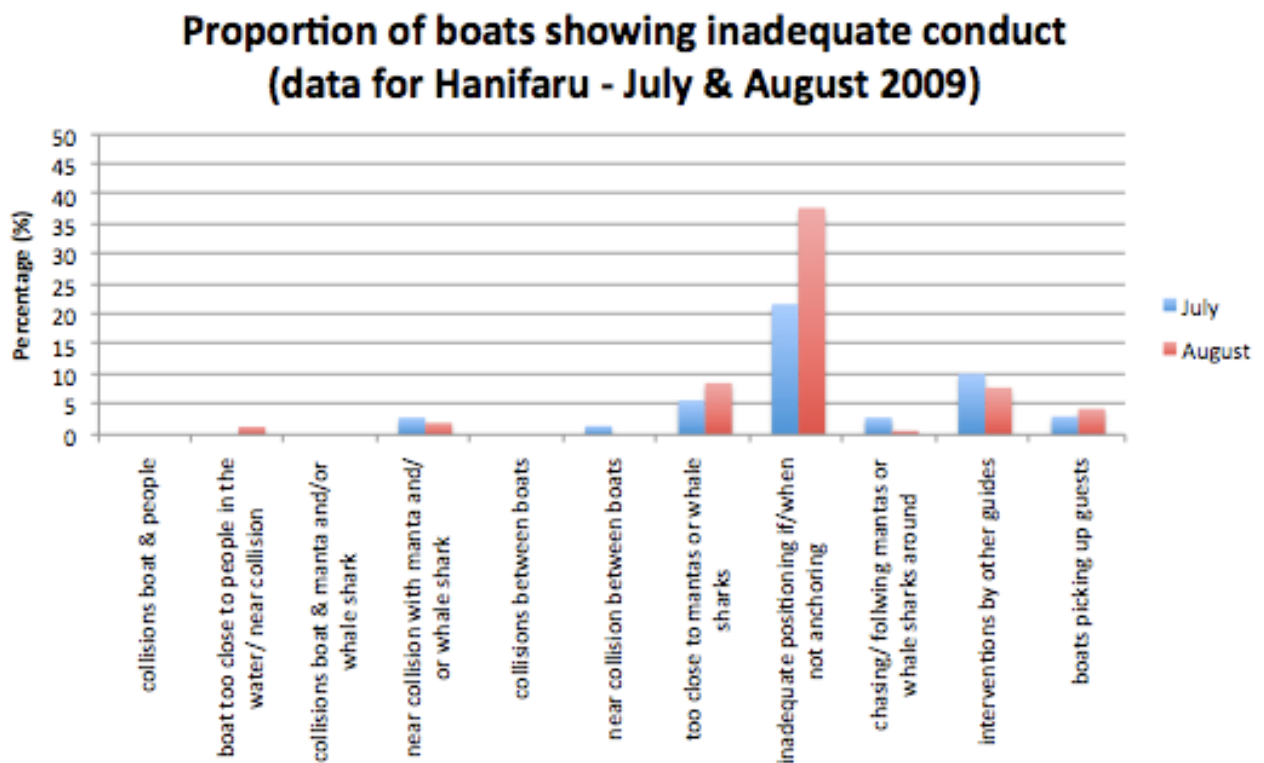


Figure 9 - Recording the proportion of boats/ skippers operating inadequately inside Hanifaru bay. Note: the scale reaches only 50% so that the smaller values for some of the categories may be observed. Values are standardised against the total number of data points (or data entries) for each category.

Generally, majority of the boats visiting Hanifaru operate adequately, following the MoU (2009) guidelines. There were no collisions between boats and people in the water, between boats and animals or between different boats (figure 9). 94% (July) and 91% (August) of boats kept their distance to whale sharks and manta rays aggregating inside the bay. A total of 231 boats were seen during the 2 months combined and only 2 (1%)

came a bit too close to people in the water (in August); only one boat nearly collided with another (1%); and 5 had near collisions with the mantas and/or whale sharks (5%). Out of these 5 near collisions with the animals, 4 were from safari dhonis. Throughout the 2 months there were 3 incidences of smaller speedboats chasing the mantas around the bay so that a guest could try to take pictures from the boat. All of these were being driven by safari boats' crew members.

There is a more concerning number of boats positioning themselves inappropriately in the bay whilst not anchoring. The MoU guidelines state that boats may drop their divers/ snorkelers in the water at a safe distance from the animals, then the boat must move to the anchoring site. 22% (July) and 38% (August) of boats were not following this and were just hovering over deeper water after dropping off their guests, sometimes too close to the mantas' cleaning stations, and not moving to the sandy area for anchoring. 3% and 4% of boats were still picking up their guests from the water, instead of waiting for them to swim back to the boat, as recommended in the MoU (2009). This guideline is in place to avoid unnecessary manoeuvring in the bay when there are mantas and/or whale sharks around, as it may disturb them or risk collisions. In total, 7 and 12 interventions on 'bad' behaviour were made by other guides during July and August, respectively.

The greater proportion of incorrect boat conduct was seen in August and mostly by the safari dhonis, which increased significantly from July. Their crew are generally unaware of the MoU guidelines and once told by guides from other resort or research boats, most safari dhonis then proceed to act correctly; yet, some of these still repeat their mistakes on a later occasion. The most common example is anchoring (figure 10).

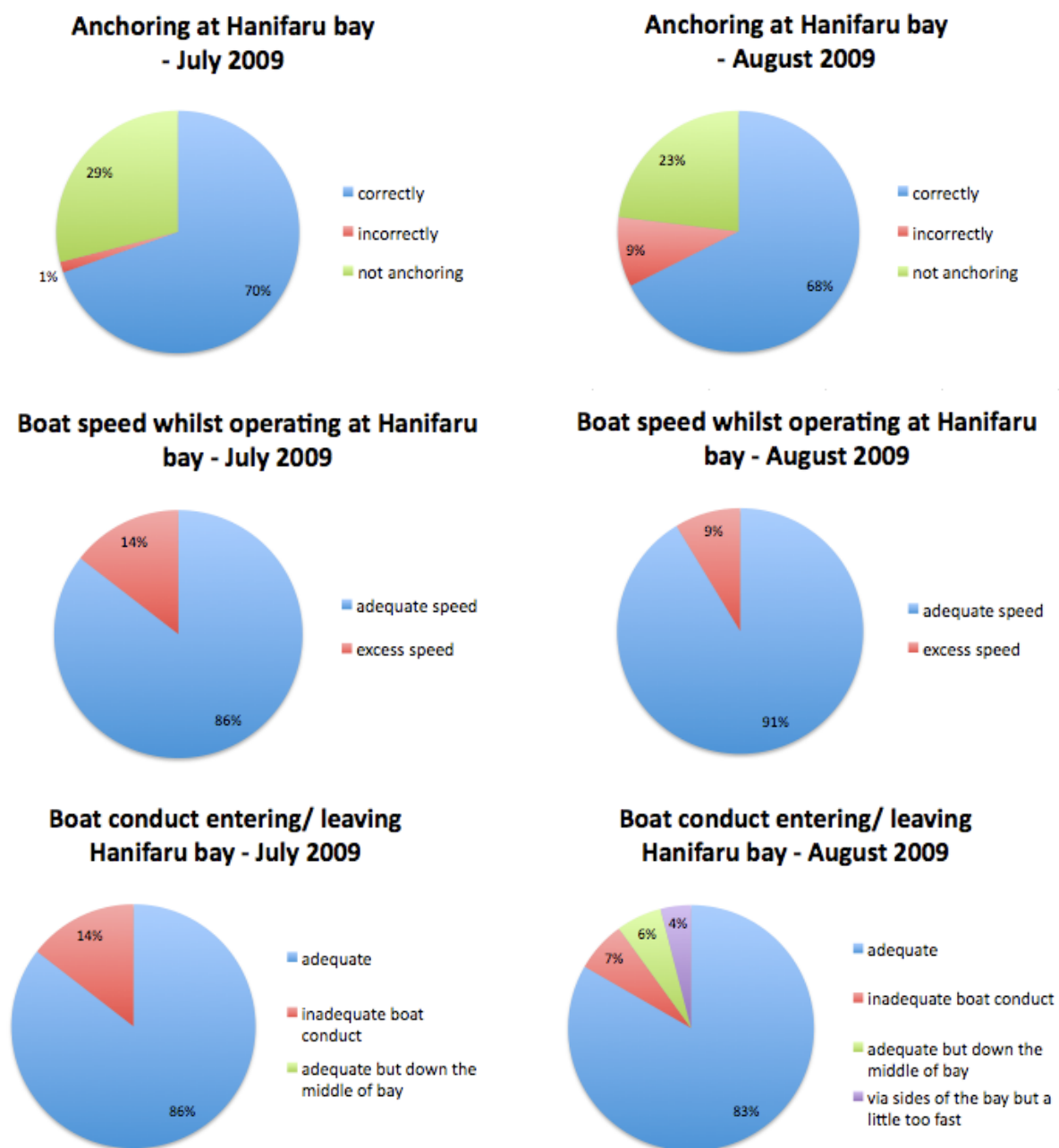


Figure 10 - Boat conduct: anchoring, speed and way of entering and/or leaving Hanifaru bay. Comparing data for July and August 2009. Definitions for the meanings of 'adequate' or 'inadequate' in each case are presented in table 3 below.

Anchors must be thrown onto the sandy bottom or sandy slope, but some boats – mainly safari dhonis – throw their anchors too close to cleaning stations or, as seen in one occasion, too close to a cruising manta. Their increase during August led to an increase

in the proportion of incorrect anchoring (figure 10). A few times during the two months, boats (safari and resort boats alike) drifted into the middle of the bay where the mantas feed, due to incorrect anchoring (refer to table 3 for definitions).

Most boats operated at a good speed whilst inside Hanifaru bay, however, the worse incidence involving speed was a safari dhoni coming into the bay to check for mantas and despite their being a whale shark present, the dhoni drove around the animal (and the people that were swimming alongside it) in a loop and left the bay at full speed. Generally, however, figures 9 and 10 show a predominance of boats following correct conduct whilst entering, leaving and operating inside Hanifaru bay.

Table 3 - Defining 'adequate' and 'inadequate' behaviour for each of the 3 components of boat conduct, based on the MoU guidelines (2009) for Hanifaru

	<b>Anchoring</b>	<b>Speed</b>	<b>Entering/ leaving the bay</b>
<i>Adequate/ correct</i>	Inside the sandy lagoon as shown in figure 5.	Slow (no wake).	Slow speed & via sides of the bay as indicated by red line in figure 5.
<i>Inadequate/ incorrect</i>	On or very near cleaning stations; near mantas or whale sharks; middle of the bay in deep water; over live coral.	Excess (wake created, engine very loud).	Excess speed & through the middle of the bay.

### 3.3.1. The problem with safari boats

The safari boat operators know little about Hanifaru and far less than the resort operators on how to behave in the bay. Whereas most resort boats operate correctly and are good at self-policing the bay, the same cannot be said for safari boats. Resorts brief their staff and guests on how to behave, but seldom is this done for the larger safari (live-aboard) boats and this is evidenced by their poorer conduct. During busy times for mantas, whale sharks and people it can be dangerous for all if these boats do not follow the appropriate codes of conduct. Observations made during this study will hopefully

help make rules for these safari boats more stringent, perhaps with penalties and fines for infringements.

### 3.4. In-water behaviour of snorkelers & divers

The MoU (2009) states that people should keep 3 to 4 meters from the manta rays and whale sharks, and there is no need to swim after the animals since they are always coming back toward the end of the bay where majority of people are swimming. However, mantas and people are often found within closer proximity to each other than 3 or 4m. This occurs partly because some mantas are so curious that they come very close to humans and sometimes because people still swim after them. Whale sharks also seem to be completely unaffected by human presence, and also come very close to people. Figure 11 shows that 22% of the total number of snorkelers and 5% of divers observed in Hanifaru, in July 2009, still chase the manta rays and/or whale sharks, worried that the animals will leave the bay before they have their chance to see them from up close. It was also observed that chasing is much a consequence of what other people in the water are doing. If one person starts chasing the animals, others also will. This is something that was seen much less often in August (figure 11), despite it having been a much busier month for tourists.

Accidental collisions with the mantas occur for various reasons, but mainly because either people come too close to the manta rays/ whale sharks or vice-versa. Snorkelers accounted for 4% and 2% of accidental collisions with mantas and whale sharks for July and August, respectively; and divers, 1% and 0.3%. The behaviour category 'near miss' means that manta rays have come too close to a person in the water and dodged suddenly at the very last minute, without actually colliding; ie. it was not a direct result of the person's behaviour, but may have been related to how close they were to the manta aggregations.

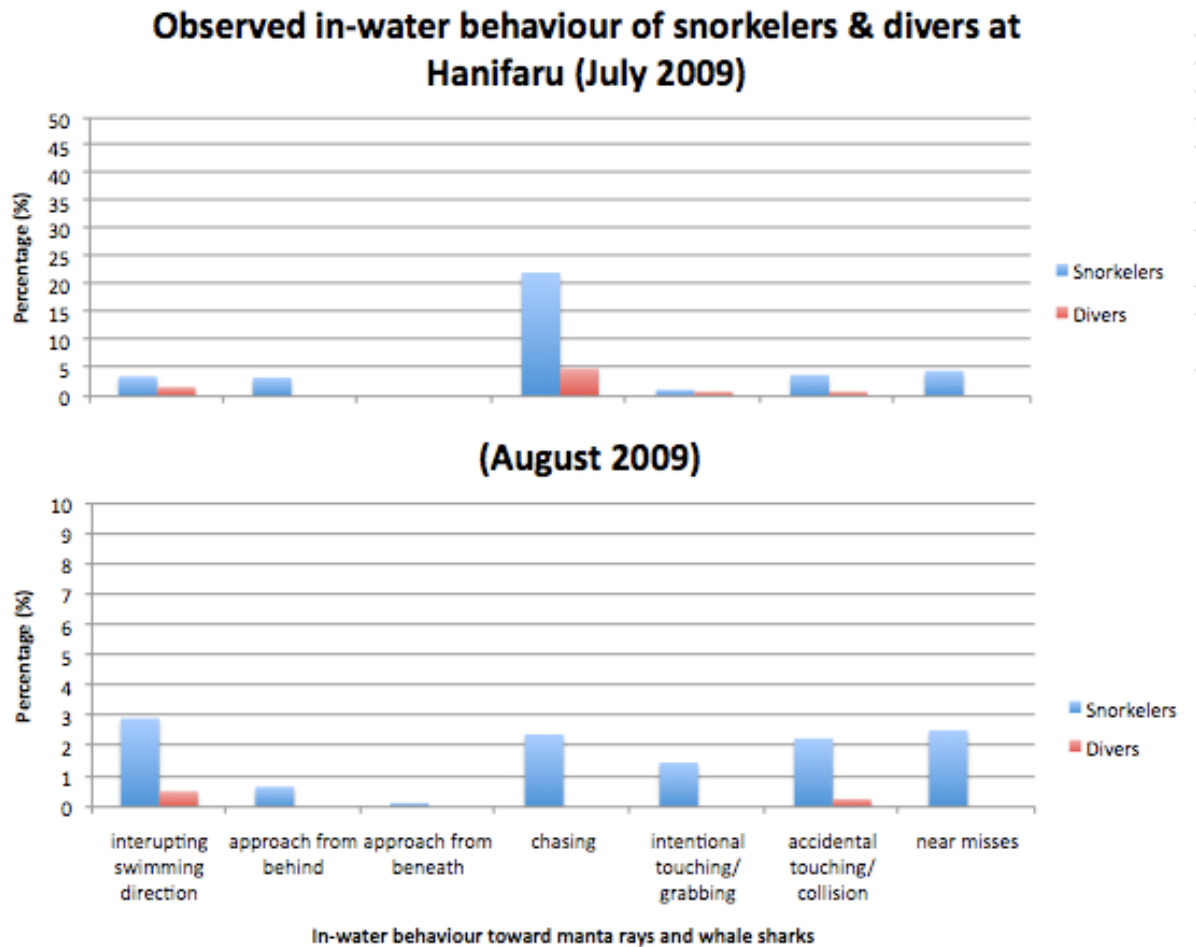


Figure 11 - People's behaviour toward manta rays and whale sharks at Hanifaru. Snorkelers and divers observed for approximately 10min each. Data for July and August 2009. NB: the % scales have been magnified so that the smaller values can be seen.

Generally, the in-water behaviour of people in Hanifaru seemed to improve from July to August, even though there were more crowded days observed in the latter. Worryingly however, there still are people grabbing and touching manta rays intentionally (figure 11), on one occasion having left scratch marks in a manta ray's pectoral fin, a level of harassment that is unnecessary.








### 3.5. Manta ray & whale shark reactions

Not all types of in-water behaviour provoke negative reactions in the manta rays and whale sharks, and different manta rays sometimes react very differently. This is illustrated in table 4 below.

#### Key for reactions & corresponding severity of intrusion to the animals

##### Key for manta reactions:

	Manta flinches & swims away frightened (temporary)	3	Intrusive
	Manta dodges last minute / sometimes frightened away	2	Sometimes
	Manta swims faster to avoid encounter (temporary)	1	No evidence
	No change in the manta's behaviour	0	Non-intrusive
	Manta sometimes seeks interaction	-1	Non-intrusive

##### Key for whale shark reactions:





	Whale shark flinches & swims away frightened (temporary)	3	Intrusive
	Eyes roll backwards but whale shark doesn't change its course	2	Partly
	Whale shark nudges people away and continues swimming/ dives deeper	1	No evidence
	No change in whale shark's behaviour	0	Non-intrusive

Table 4 - Matrix showing the reactions of manta rays and whale sharks to different types of in-water behaviour by snorkelers and divers (2 months observations).






















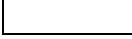












Manta (M) or whale shark (WS) data	Interrupting swimming direction	Approach from behind	Approach from beneath	Chasing	Intentional touching/ grabbing	Accidental touching/ collision	Flash	Close proximity to manta/ whale shark	Diver bubbles
M									
									
									
									
Overall level of intrusion	2	1	2	2	2	2	2	1	1
WS									
									
Overall level of intrusion	0	0	0	1	2	1	2	0	0

Table 4 shows just how differently individual manta rays react to a particular human behaviour. The best example is when snorkelers and divers swim directly in front of the manta, or directly toward it (see 'interrupt swimming direction' column). Some mantas react very suddenly as soon as they can sense people and swim away frightened, other mantas will slowly manoeuvre away, and in some cases the manta will not react, coming closer and closer to people to a point that they may risk collisions. Generally some manta rays seem a lot more sensitive to human approach than others, whether it is from the front, from behind or from beneath. Whale sharks do not seem to react in any way to these types of behaviour.

Some mantas react abruptly to being chased whilst others just speed up or dive down (or both) to get away from snorkelers or divers. Once again, whale sharks do not seem to be affected by chasing, seen as most of the time no behaviour changes are seen. Sometimes it just slowly dives deeper and continues on its heading, but does not seem to be intrusive. Strangely, some manta rays collide with people whilst surface feeding, or even whilst barrel rolling, and just keep swimming without having reacted at all. Even touching, depending on how it happens eg. a mild accidental brush, may not create any change to the animals' natural behaviour.

Flash is used mostly by professional photographers that visit Hanifaru and whilst some mantas react negatively others do not show evidence of intrusion – they continue cleaning, feeding or cruising just as before. Whale sharks roll their eyes backwards but they do not alter their swimming direction.

Some manta rays are very curious and will often swim in circles around snorkelers or backwards and forwards through groups of people. Whether or not they seek human interaction is unknown, but it shows how at least some individuals are not negatively affected by close proximity to people. Other mantas are frightened easily, or simply (perhaps) avoid interaction with humans.

Diver bubbles sometimes scares off manta rays, which quickly swim away, but some individuals seem to enjoy being 'tickled' by the bubbles and will hover directly over them. Even if a diver tries to purge their regulators toward a manta's ventral side, it will

not leave. This may also be a form for the manta to try to clean itself, letting the bubbles through its gills (Stevens, pers.comm.). Once again, whale sharks seemed unresponsive to the same situation.

In general, whale sharks just cruise around Hanifaru bay feeding and hardly ever respond to the behaviours of humans swimming around it (table 4). The few exceptions are the use of flash, as mentioned, and intentional touching, which sometimes scares them. Even upon colliding with a person – mostly snorkelers distracted at the surface as the whale sharks sneak up closely behind them – the whale shark does not react and when it does, it nudges them away or gradually dives deeper but with no apparent evidence of disturbance. Unlike manta rays that sometimes react at the very last moment before collision occurs, whale sharks will not and will more frequently collide with swimmers.

Also importantly however, is that none of the observations on human behaviour or animal reaction seem to suggest permanent avoidance by the manta or whale shark toward snorkelers or divers. The question therefore arises on whether or not an increase in tourism levels in Hanifaru bay may permanently drive manta rays and/or whale sharks away.

If all the behavioural data from the categories in table 4 are combined, the actual proportion of snorkelers and divers causing clear negative disturbance to the mantas or whale sharks is quite low (table 5).

Table 5 - Summarising in-water behaviour of snorkelers and divers at Hanifaru during July and August 2009, according to level of intrusion.

	July			August			Total
	Intrusive	Sometimes intrusive	Non-intrusive/ no evidence of intrusion	Intrusive	Sometimes intrusive	Non-intrusive/ no evidence of intrusion	
Snorkelers	8%	16%	19%	1%	3%	8%	55%
Divers	1%	0%	8%	0%	0%	1%	10%

NB: The remaining 35% of all the people observed did not behave according to any of the categories analysed in this section; they just swam at the surface whilst snorkelling, or hovered near the bottom, whilst diving.

## 4. Discussion

### 4.1. Sightings & implications for management

The manta rays (*Manta birostris*) sighted during the course of this study followed lunar cycles, with greater number of individuals seen on days of full or new moons, or a couple days before and after. This sort of rhythmicity has also been reported in other regions of the world. For example, in Komodo Marine Park, Indonesia, manta ray abundance was higher when tidal intensity was greatest during full and new moons (Dewar *et al*, 2008). Annual seasonality has also been reported from a few other locations including southeastern Brazil (Luiz Jr. *et al*, 2009). However, the images analysed in this nine-year study were not of *M. birostris*, but of the now recognized second manta ray specie. This still makes the results of the study very interesting: even this larger and more migratory specie seems to regularly occur in certain areas. Sightings were greatest during the austral winter (June–September), which coincides with the seasonality seen in the Maldives (Barcott, 2009). Its re-appearance in Brazil is due to the presence of a coastal front at the study site in winter (Luiz Jr *et al*, 2009). Several other reports of *M. birostris* sightings around the world are thus now in need of revision. It is important to realise

this difference since the two species have different movement habits and degree of site fidelity, which affects their conservation and management.

Whale sharks have also been found to aggregate seasonally in areas such as Ningaloo Park, Australia (Taylor, 1996, Norman, 1999, Wilson *et al*, 2006); Thailand (Theberge and Dearden, 2006); Mexico (Clark and Nelson, 1997); Belize (Heyman *et al*, 2001); Djibouti (Peschak, pers.comm.); South Africa (Beckley, 1997); Seychelles (Rowat and Gore, 2007) the Maldives (Stevens, pers.comm.) and several others. These sightings are extremely important in defining conservation strategies for the species, especially since not much is known about their movements when they are not aggregating to feed or breed (Stevens, 2007). The whale shark sightings recorded during this 2-month study seemed to follow lunar cycles, which increases their predictability at Hanifaru. This predictability can help increase the success of whale shark-human interactions, something which visitors have demonstrated they would be willing to pay for (Davis *et al*, 1997, Cohun, 2005). Funds generated through visitor fees would greatly help future conservation management of both whale sharks and manta rays at Hanifaru.

#### 4.2. Site use: impacts from boats, snorkelers & divers

A total of 231 boats, 1,257 snorkelers and 509 divers were recorded in Hanifaru bay during July and August 2009. Vast majority of these were observed (85-95%) for their conduct and behaviour. The results show that the proportion of people that behaved in a way that was clearly intrusive to manta rays and whale sharks was quite low (<10%), and another 17% were sometimes intrusive. The kinds of differences seen in the animals' behaviour makes it difficult to judge how intrusive certain human behaviours may be (table 4). Levels of intrusion may also vary with different people's perceptions. Rules and regulations on people's interaction with manta rays and whale sharks should therefore be created conservatively. However, a problem may occur in the future if rules become too strict: researchers and other professionals who have been working to help achieve better protection of Hanifaru and its inhabitants, become reprimanded for doing what they always have done. For example, if strict rules are created on free diving with the manta rays and whale sharks, researchers may be hindered in collecting

identification photos<sup>1</sup> and information that allow them to continuously study manta ray and whale shark populations. On the other hand, it is very difficult to allow double standards and create 'special' circumstances for certain groups of people. This is something that must be discussed during the creation of Hanifaru MPA's rules and regulations. Nonetheless, there are some types of behaviour that should not be encouraged such as touching, riding or swimming after the animals. Studies on marine mammals show that chasing or grabbing will frighten the animal, lowering opportunities and enjoyment for all other visitors, and touching may result in scratching, which could potentially cause skin infections or diseases (Hoyt, 1999). It is possible that these effects would also be seen for manta rays and whale sharks.

Anchoring, speed and manner of entering/ leaving Hanifaru bay are good representations of how well or how badly the boats operate. It was observed that boat skippers that operate at slower speeds, navigate carefully in the bay and anchor correctly are strongly associated to those who are more cautious of the mantas or whale sharks that may be present in the bay and take care to ensure the boat is kept within safe distance from the animals. These 3 behaviours are also easily observed from the distance, and can therefore, be used as a proxy for judging how adequately the boats (or skippers) behave, even if information cannot be collected for every aspect as shown in figure 9. This will be useful when patrolling the site if indeed, a patrolling force is assigned to this area.

Overall, both people and boats visiting Hanifaru behaved according to the MoU (2009) guidelines (figures 9, 10, 11). Some resort boats still make mistakes whilst anchoring and/or position themselves over deep water for too long, unnecessarily (figure 9); but most inadequate behaviour originates from safari dhonis, who are less well informed about Hanifaru and its inhabitants. Although no collisions were observed between any boats and the animals, this remains a problem in other areas of the Baa Atoll, evidenced by the propeller scars in most whale sharks seen inside Hanifaru bay (figure 12). Most manta rays also have some form of scarring, although mostly from fishing lines and

---

<sup>1</sup> Identification photos of manta rays must be taken from their ventral side, which often means researchers must free dive down and between manta aggregations to obtain them.

hooks. All these issues need to be managed on a wider scale in order to ensure manta rays and whale sharks keep returning to Hanifaru to feed.



Figure 12 - Manta ray scarred and without a cephalic fin due to fishing line and a whale shark with a fresh boat propeller scar seen inside Hanifaru bay. Neither were apparently caused in Hanifaru but possibly in surrounding areas of the Baa Atoll. Photos by Luiza Neves.

Some concerns exist about the growing popularity of Hanifaru and services such as ‘manta on call’ attracting more and more people to the site. However, this is not necessarily all bad news. Documentaries filmed at Hanifaru or articles created such as the recent ‘Feeding Frenzy’ in National Geographic’s July 2009 issue, have contributed to raising public awareness and support on an international level, which has made it possible to increase the levels of protection at Hanifaru. These should therefore not be viewed negatively. Growth in the site’s popularity is inevitable and highly probable, yet this is not something to be feared, just actively managed. Additionally, ‘manta on call’ and other types of trips made to Hanifaru also help raise the public’s awareness on manta rays and whale sharks. Briefings and sometimes entire educational sessions are given to visitors prior to taking them to the site, something which has had tremendous positive impact on people behaving appropriately when in the water with the animals. On the other hand, some guests still behave inappropriately regardless of being briefed beforehand. This emphasises the need to keep giving briefings and perhaps more than once, for example, during educational sessions in the resorts and a few minutes before arriving to the site. Fines can also be created for individuals who are seen to disturb or

harass the animals, but this would need to be done by some authoritative body, which presently does not exist. In Australia, fines up to AUS\$10,000 are charged to people purposely touching or otherwise interfering with whale sharks (Davis *et al*, 1997).

This study showed that busy (popular) months were not directly correlated with a higher proportion of 'bad' behaviour by its visitor. August 2009 was a busier month than July: totals of 74 and 157 boats, 504 and 753 snorkelers and 120 and 389 divers were recorded for July and August, respectively. Yet, table 5 shows an overall lower level of intrusive behaviour by guests during August (although generally worse behaviour was recorded for boats this month, primarily due to the increase in safari dhonis). Similarly, busy years (more popular years) do not *necessarily* mean an increase in 'bad' behaviour will be seen. Furthermore, observations on the animals' reactions throughout this study did not show evidence of permanent avoidance. It was possible to watch an individual manta ray by recognizing its unique spot pattern, and whale sharks were mostly seen singly, and both species kept coming back and/or circling inside Hanifaru bay. Additionally, manta rays seen at Hanifaru these 2 months are recognized regulars and have come back since last year which was a far busier year (figure 8). Thus, based on this study's results, it does not seem likely that people could cause permanent avoidance of manta rays or whale sharks from Hanifaru, if they continue to behave as they do. More time would be needed to investigate this issue further.

Popularity may, however, bring some negative impacts such as overcrowding. Hanifaru bay is relatively small, and snorkelers and divers aggregate at the end of the bay nearest to the shallow areas and cleaning stations, which is also the main feeding site for the manta rays and whale sharks (figure 5). Searching through primary literature there have been no studies to demonstrate the effects of overcrowding on manta rays or whale sharks, particularly over the longer term (Davis *et al*, 1997). However, a study has shown that high concentrations of people over a relatively small area can affect the plankton in which the animals are feeding on (Wilson *et al*, 2001). However, this may be different for Hanifaru since the plankton becomes trapped in the bay for a relatively long time rather than rapidly dispersing in areas of open sea, as in the location of the study by Wilson *et al*, (2001). Once again, more time and more observations are needed to make clear conclusions on the effects that overcrowding may be having on the manta



rays and whale sharks of Hanifaru. Nonetheless, overcrowding was seen to increase chances of collisions with the animals, particularly if they crowded amidst the plankton in which the animals were feeding on.

Another problem observed related to overcrowding is that people tend to imitate one another: if one person starts touching manta rays, soon there will be a second and a third. Small groups chasing a whale shark soon turn into a large one. On a couple occasions during the 2 months of this study, one person touching a manta ray was encouraging another to do the same. Admittedly, some people simply do not see what is wrong with touching manta rays or whale sharks, but as previously described, it can be disturbing to them. Both guests and guides alike should therefore be briefed on the *reasons* why manta rays and whale sharks should not be touched, rather than simply telling them it should not be done. Interventions should be made every time an inadequate conduct is seen. Overcrowding can also decrease the satisfaction of the experience of other visitors (Davis *et al*, 1997, Cohen, 2005).

One way to help prevent overcrowding is by imposing a limit on boat access and visitor use. The MoU (2009) suggests a maximum of 5 boats present at Hanifaru at any one time. Once during this study, there were 6 resort dhonis anchored on the sandy lagoon at the end of the bay and 2 small speedboats tied up to 2 of the dhonis, all at once. They were all anchoring correctly, however, the only reason none of them drifted onto the reef or into deeper water was that it was a calm day. When conditions are not as prime, boats easily drift with the current and can make it very difficult for more than 5 boats to be anchored safely at once. For these reasons, the 5 boat limit is seen as appropriate, but should extend to a maximum number for snorkelers and divers as well. In total during the 2 months, 5 days had 100+ visitors (figure 7). These were seen throughout the day however, and not all at once, with the exception of one day, which seemed particularly overcrowded. As mentioned, overcrowded days are not necessarily correlated with a greater proportion of 'bad' behaviour, but may increase the probability of accidental collisions with the animals if too many people aggregate over a small area at once. Based on the MoU guideline and personal observations, the suggested maximum number of visitors (snorkelers and divers) for Hanifaru bay at any particular time is 100. This figure is also based on the average number of visitors taken to Hanifaru by a single

dhoni during a busy season (=20). By comparison to other geographic areas this may be regarded a high number: in Australia, the number of swimmers in the water with a whale shark is limited to a maximum of 10 at any one time (Davis *et al*, 2001); there is a lack of information on carrying capacity related to a site with frequently sighted manta rays. Nonetheless, based on all the behavioural data collected in this study (for boats, people and the animals' reactions) the limits proposed here are thought to be appropriate for Hanifaru. The author encourages any opinions on such a recommendation by other stakeholders involved in the protection and management of Hanifaru.

#### 4.3. Recommendations & future work

- Guides should continue to brief their guests to remain 3 to 4m away from mantas or whale sharks to prevent collisions or harassment. Often, the manta rays and whale sharks themselves come within closer distance than this; visitors should use their good judgment to prevent collisions or scaring the animals.
- Boats need to be monitored not just inside Hanifaru bay, but also on a larger scale throughout the Baa Atoll, since many whale sharks (and sometimes manta rays) are seen with propeller scarring.
- Safari boats and safari dhonis should be monitored closely. A suggestion is to have a marine biologist go aboard these boats and formally brief both guests and staff on Hanifaru and its inhabitants, as well as the codes of conduct to follow.
- A limit on visitor use should be set at 5 boats and 100 people max. (snorkelers and divers).
- If the willingness to pay (WTP) exists amongst visitors, fees collected could help fund management and protection of Hanifaru. The WTP study initiated should therefore be promoted and encourage maximum participation possible.
- Rules and regulations should be passed into law and an authoritative body should be created to impose these rules and penalties for infringements. Patrolling of Hanifaru and surrounding areas should be a high priority.

- Continue recording site use and monitoring people's behaviour to be used with the baseline data from this study, to help assess whether or not an increase in the popularity of the site (as predicted) or possible overcrowding will have any detrimental impact on the manta rays or whale sharks of Hanifaru.

## 5. Conclusions

Interactions between humans and wildlife have become increasingly popular throughout the world. In Hanifaru, staff from the local resorts have been contributing to the protection of manta rays and whale sharks by self-policing the site and ensuring their guests follow adequate behaviour. If people continue to behave as they do it does not seem likely that they could cause permanent avoidance of manta rays or whale sharks from Hanifaru. Still, to prevent possible effects of overcrowding, visitor numbers should be adequately managed. The carrying capacity for Hanifaru bay, based on observations during this study and the MoU (2009) guidelines is suggested at 5 boats no bigger than a 'dhoni' and a maximum of 100 visitors (snorkelers and divers). Creating law-bound rules and regulations for Hanifaru MPA, along with an authoritative body to impose them, will greatly help management of the site and the protection of its regularly occurring manta rays and whale sharks.

## References:

- AEC (2009a) Our vision & implementation strategy. Information booklet. Baa Atoll, Republic of the Maldives. 6pp.
- AEC (2009b) Baa Atoll: a UNESCO World Biosphere Reserve? Consultation document for high level stakeholders. Working report. 28pp.
- Alava M.N.R., Dolumbaló E.R.Z., Yaptinchay A.A. and Trono R.B. (2002) Fishery and Trade of Whale Sharks and Manta Rays in the Bohol Sea, Philippines. In: The IUCN Species Survival Commission, *Elasmobranch Biodiversity, Conservation and Management*. Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997 (eds) Fowler S.L., Reed T.M. and Dipper F.A. 132-148pp.
- Anderson RC and Ahmed H (1993) The Shark Fisheries of the Maldives. A report for the Ministry of Fisheries and Agriculture, Republic of the Maldives and Food and Agriculture Organization of the United Nations. 84 pp.
- Barcott, B. (2009) Feeding Frenzy. National Geographic Magazine. July issue. 5pp.
- Baughman J.L. (1955) The Oviparity of the Whale Shark, *Rhincodon typus*, with Records of This and Other Fishes in Texas Waters *Copeia*, 1955(1): 54-55.
- Beckley L.E., Cliff G., Smale M.J. and Compagno L.J.V. (1997) Recent strandings and sightings of whale sharks in South Africa. *Environmental Biology of Fishes*, 50(3): 343-348.
- Clark E. and Nelson D.R. (1997) Young whale sharks, *Rhincodon typus*, feeding on a copepod bloom near La Paz, Mexico. *Environ. Biol. Fish.*, 50: 63-73.
- Clark T. (2005) Remote tracking of the manta ray (*Manta birostris*) in Hawai'i. *Pac. Sci.*, 59: 111.
- Cohun K. (2005) Managing the Gladden Spit Marine Reserve: An Analysis of the Whale Sharks Dive Tourism Industry in Placencia, Belize. MSc project for Duke University, USA. Available at <http://dukespace.lib.duke.edu/dspace/bitstream/10161/224/1/Cohun%20MP%202005.pdf>.
- Davis D., Banks S., Birtles A., Valentine P. and Cuthill M. (1997) Whale sharks in Ningaloo Marine Park: managing tourism in an Australian marine protected area. *Tourism Management*, 18(5): 259-271.

- Dearden P., Topelko K.N. and Ziegler J. (2008) Tourist Interactions with Sharks.  
In: Higham J.E.S. and Lück M., *Marine wildlife and tourism management: insights from the natural and social*. Google books. Available at  
[http://books.google.co.uk/books?hl=en&lr=&id=TsRZW0dU-6MC&oi=fnd&pg=PA66&ots=01FGktXOgl&sig=ewp0c-w3UihNR6cJPIK6mR\\_sg#v=onepage&q=whale%20shark&f=false](http://books.google.co.uk/books?hl=en&lr=&id=TsRZW0dU-6MC&oi=fnd&pg=PA66&ots=01FGktXOgl&sig=ewp0c-w3UihNR6cJPIK6mR_sg#v=onepage&q=whale%20shark&f=false).
- Dewar H., Mous P., Domeier M., Muljadi A., Pet J. and Whitty J. (2008) Movements and site fidelity of the giant manta ray, *Manta birostris*, in the Komodo Marine Park, Indonesia. *Marine Biology*, 155(2): 121-133.
- Duffy C.A.J. and Abbott D. (2003) Sightings of mobulid rays from northern New Zealand, with confirmation of the occurrence of *Manta birostris* in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research*, 37: 715-721.
- Dulvy N.K., Baum J.K., Clarke S., Comapagno L.J.V., Cortes E., Domingo A., Fordham S., Fowler S., Francis M.P., Gibson C., Martinez J., Musik J.A., Soldo A., Stevens J.D. and Valenti S. (2008) You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conserv: Mar. Freshw. Ecosyst*. Published online in Wiley InterScience. 24pp.
- Eckert S.A., Dolar L.L., Kooyman G.L., Perrin W. and Rahman R.A. (2002) Movements of whale sharks (*Rhincodon typus*) in South-east Asian waters as determined by satellite telemetry. *Journal of Zoology*, 257(1): 111-115.
- Emerton (2009) The Economic Value of Marine and Coastal Biodiversity to the Maldives economy. Produced for the Atoll Ecosystem Conservation (AEC) Project by IUCN. 66 pp.
- Graham R.T., Roberts C.M. and Smart J.C.R. (2006) Diving behaviour of whale sharks in relation to a predictable food pulse *J. R. Soc. Interface*, 3: 109-116.
- Gudger E.W. (1940) Whale sharks rammed by ocean vessels. How these sluggish leviathans aid in their own destruction. *N. Engl. Nat.*, 7: 1-10.
- Gunn J.S., Stevens J.D., Davis T.L.O. and Norman B.M. (1999) Observations on the short-term movements and behaviour of whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia *Marine Biology*, 135(3): 553-559.
- Heyman WD, Graham, RT, Kjerfve B. and Johannes RE (2001) Whale Shark *Rhincodon typus* aggregate to feed on fish spwan in Belize. *Marine Ecology Progress Series*, 215: 275-282.

- Homma K., Maruyama T., Itoh T., Ishihara H., Uchida S. (1999) Biology of the manta ray, *Manta birostris* Walbaum, in the Indo-Pacific. In: Seret B. and Sire J-Y. (eds) Proceedings of the 5th Indo Pacific Fish Conference, Noumea, 1997. Societe' Francaise d'Ichthyologie. Paris. 209–216pp.
- Hoyt E. (1999) The *Potential* of Whale Watching in the Caribbean: 1999+. Whale and Dolphin Conservatin Society, Bath, UK, 1-80pp.
- IUCN Red list wesbite: [www.iucnredlist.org](http://www.iucnredlist.org). Accessed August 2009.
- Joung S-J., Chen C-T., Clark E. Uchida S., Huang W.Y.P. (1996) The whale shark, *Rhincodon typus*, is a livebearer: 300 embryos found in one 'megamamma' supreme. *Environ. Biol. Fish.*, 46: 219-223.
- Luiz Jr O.J., Balboni A.P., Kodja G., Andrade M. and Marum H. (2009) Seasonal occurrences of *Manta birostris* (Chondrichthyes: Mobulidae) in southeastern Brazil. *Ichthyological Research*, 56(1): 96-99.
- Solandt J-L. and Wood C. (2005) Observations of reef conditions on central Maldives reefs, 2005. A report by the Marine Conservation Society in collaboration with Maldives Scuba Tours. 39pp.
- Marshall A., Ishihara H., Dudley S.F.J., Clark T.B., Jorgensen S., Smith W.D. and Bizzarro J.J. (2006) *Manta birostris*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <[www.iucnredlist.org](http://www.iucnredlist.org)>.
- MWSRP (no date) Whale Shark Fact Sheet. Maldives Whale Shark Research Programme. Information leaflet. Landaa Giraavaru, Republic of the Maldives.
- National Geographic (2009) Manta Rays, Whale Sharks Receive the Protection of Maldives. In web: <http://blogs.nationalgeographic.com/blogs/news/chiefeditor/2009/06/manta-rays-whale-sharks-maldives.html>.
- Norman B.M. (1999) Aspects of the biology and ecotourism industry of the whale shark *Rhincodon typus* in north-western Australia. MSc Thesis for Murdoch University, Western Australia. Available at <https://wwwlib.murdoch.edu.au/adt/pubfiles/adt-MU20071003.121017/01Front.pdf>.
- Owen C-S. (2008) New manta ray species discovered. Telegraph News. In web: [www.telegraph.co.uk](http://www.telegraph.co.uk). Accessed July 2009.
- Owen C-S. (2009) Maldives Protects Manta Rays. In web: [www.saveourseas.com](http://www.saveourseas.com)

- Accessed June 2009.
- Personal Communication: Guy Stevens, Landaa Giraavaru, Maldives. July 2009.
- Personal Communication: Thomas Peschak, Landaa Giraavaru, Maldives. August 2009.
- Rowat D. and Gore M. (2007) Regional scale horizontal and local scale vertical movements of whale sharks in the Indian Ocean off Seychelles. *Fisheries Research*, 84(1): 32-40.
- Save Our Seas website [www.saveourseas.com](http://www.saveourseas.com). Accessed July 2009.
- SEMARNAT (2007) Plan de Manejo Tipo para realizar Aprovechamiento No Extractivo de Tiburón ballena (*Rhincodon typus*) en México. DIRECCIÓN GENERAL DE VIDA SILVESTRE / COMISIÓN NACIONAL DE ÁREAS NATURALES PROTEGIDAS. 50 pp.
- Shark Trust website: [www.sharktrust.org](http://www.sharktrust.org). Accessed August 2009.
- Stevens J.D. (2007) Whale shark (*Rhincodon typus*) biology and ecology: A review of the primary literature. *Fisheries Research*, 84(1): 4-9.
- Stevens G. (no date) Hanifaru Preservation Action Plan. White paper. Landaa Giraavaru, Republic of the Maldives. 3pp.
- Stevens G. and Stevens K. (no date) Manta Fact Sheet. Maldivian Manta Ray Project. Landaa Giraavaru, Republic of the Maldives.
- Taylor J.G. (1996) Seasonal occurrence, distribution and movements of the whale shark, *Rhincodon typus*, at Ningaloo Reef, Western Australia. *Marine and Freshwater Research*, 47(4): 637-642.
- Theberge M.M. and Dearden P. (2006) Seasonality seen in Andaman Sea, Thailand - Detecting a decline in whale shark *Rhincodon typus* sightings in the Andaman Sea, Thailand, using ecotourist operator-collected data. *Oryx*, 40(3): 337-342.
- Trent L., Parshley D.E. and Carlson J. K. (1997) Catch and Bycatch in the Shark Drift Gillnet Fishery off Georgia and East Florida. *Marine Fisheries Review*, 59(1): 19-28.
- United Nations (2007) Common Country Assessment 2007: Republic of Maldives. United Nations System in the Maldives, Male.
- Vivekanandan E. and Zala M.S. (1994) Whale shark fishery off Veraval. *Indian J. Fish.*, 41: 37-40.

- Yano K., Sato F. and Takahashi T. (2007) Observations of mating behavior of the manta ray, *manta birostris*, at the Ogasawara Islands, Japan. *Ichthyological Research*, 46(3): 289-296.
- White W.T., Gile J., Dharmadi and Potter I. (2006) Data on the bycatch fishery and reproductive biology of mobulid rays (Myliobatiformes) in Indonesia. *Fisheries Research*, 82(1-3): 65-73pp.
- Wildlife Extra News (2008) Manta Rays are two distinct species. In web: [www.wildlifeextra.com](http://www.wildlifeextra.com). Accessed July 2009.
- Wilkinson C. (2004). Status of the Coral reefs of the World, 2004. Australian Institute of Marine Science, Townsville, Australia. Vol.2: 213-234.
- Wilson S.G. (2002) A whale shark feeding in association with a school of giant herring at Ningaloo Reef, Western Australia. *Journal of the Royal Society of Western Australia*, 85: 43-44.
- Wilson S.G., Pauly T. and Meekan M.G. (2001a) Daytime surface swarming by *Pseudoeuphausia latifrons* (Crustacea, Euphausiacea) off Ningaloo Reef, Western Australia. *Bulletin of Marine Science*, 68(1): 157–162.
- Wilson S.G., Polovina J.J., Stewart B.S. and Meekan M.G. (2006) Movements of whale sharks (*Rhincodon typus*) tagged at Ningaloo Reef, Western Australia. *Marine Biology*, 148(5): 1157-1166.
- Wilson S.G., Taylor J.G. and Pearce A.F. (2001b) The Seasonal Aggregation of Whale Sharks at Ningaloo Reef, Western Australia: Currents, Migrations and the El Niño/ Southern Oscillation. *Environmental Biology of Fishes*, 61(1): 1-11.
- Zeeberg J., Corten A. and de Graaf E. (2006) Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research*, 78(2-3): 186-195.



## Appendix I – Memorandum of Understanding 2009

### MEMORANDUM OF UNDERSTANDING

Because of Hani Faru's extreme importance to the manta rays and whale sharks in the Maldives as well as to the local tourism industry, [\[Resort / Dive Centre / Water Sports Centre\]](#) formally agrees to follow the below Code of Conduct when visiting the Hani Faru area in order to avoid any injuries to animal and visitors.

1. Boats ENTERING and LEAVING the Hani Faru area MUST reduce their speed and have a staff member at the front of the boat looking out for animals and swimmers on the surface. Should mantas or whale sharks be spotted, the boat must keep a safe distance of at least 20 meters away from animals and people.
2. Once in Hani Faru, boats MUST leave the bay area where the animals are feeding and anchor in the shallow sandy lagoon. If the animals are near the middle Thila\*, snorkellers can be dropped in the water at a safe distance; then the boat MUST move to the anchoring site. Snorkellers MUST swim back to the boat. If mantas are spotted at the entrance of Hani Faru, snorkellers can be dropped and picked up at a safe distance from the animals.
3. We formally agree that there should be a maximum of 5 boats anchored in the designated area. In order to avoid an excessive number of boats at Hani Faru, resorts and dive centres should communicate with each other to avoid overcrowding the area. (Snorkelling boats from:- Valtur:12:15-13:00 / Soneva Fushi:13:00-13:45 / Four Seasons:14:00-15:00 / Reethi Beach:15:00-16:00 hrs resort time) Also, the number of boats per resort and dive centre should be coordinated and restricted to as few as possible.
4. Guides, boat crews and dive instructors MUST brief the visitors about the fact that the boat will be anchored and that they have to swim back to the boat. NO pick up will be allowed inside the bay area, except if an emergency arises.
5. Guides, boat crews and instructors have to brief the visitors, "It is NOT allowed to TOUCH, RIDE or SWIM AFTER any animal". Divers and snorkellers should keep the suggested distance of 3 to 4 meters from the animals (whale sharks, manta rays or any other marine life). (This place is so unique, that the feeding animals are always coming back toward the end of the bay.)

6. Resorts sending snorkellers must ensure that there is always an in-water supervisor. The ratio SHOULD be at least 1 guide for a maximum of 8 guests. Where possible each boat should not have more than 16 guests. Snorkellers must be proficient swimmers.
7. Should a diver or snorkelling enthusiast not follow these guidelines and rules, the guide / instructor or boat crew MUST intervene to ensure the animals are not bothered.
8. Boat captains, dive masters and guides MUST have sufficient training on the boat guidelines and appropriate in-water behaviour.
9. Boat captains, dive masters and guides not following the guidelines should be reprimanded by their resort management. Adhering to the above STATED RULES is a MUST.
10. Outside boats, such as Safari boats, need to be kindly instructed about the rules and provided with information material. Every Baa Atoll resort boat visiting Hani Faru should have a spare set of information material for this purpose.
11. Jet skis, catamarans and other such small vessels should not be allowed within Hani Faru.

\* The little shallow reef inside the bay at the southern edge of the bay. To be highlighted in the Map

Date: .....

Representative (in print): .....

Signature: .....

## Appendix II - Participation in additional projects & activities

### A) Manta ray identification study

For the past 5 years, Guy Stevens has been researching the manta ray populations in the Maldives. I participated in his project by helping to take identification photos of the manta rays throughout the 2 months, and by identifying individuals by matching their pictures up against ones in the database. The spot patterns between their gills were the main identification features but also sex, tail length and the presence of scars or injuries.

Project in collaboration with Save Our Seas Foundation and Four Seasons Resort, Landaa Giraavaru, Maldives. Website: [www.maldivianmantas.com](http://www.maldivianmantas.com)

### B) Coral reef rehabilitation project

Artificial reefs using cement trays were created and placed around the resort island to help restore coral reefs that were destroyed in the 1997/98 El Nino event. Coral fragments collected from damaged areas are first tied on to the structure and then transplanted back into the sea. The coral trays have been successful in providing adequate substrate for the coral fragments to re-grow quickly, helping to restore healthy colonies around the island. They also increase opportunities for guests to encounter reef fish typically found in the healthier and larger coral reef systems. I participated in this project on a couple occasions, assisting apprentice Four Season staff and school children during activity days.

Led by Seamarc in collaboration with Four Seasons Resort, Landaa Giraavaru and Save Our Seas Foundation. E-mail: [info@seamarc.com](mailto:info@seamarc.com)

### C) Divemaster services

This involved occasionally assisting the dive centre at the Four Seasons Resort by guiding dives and helping out with their guests.

### D) Willingness-to-pay survey

I initiated a WTP questionnaire-based survey that will hopefully be carried on throughout the next few months to see whether or not visitors would be willing to pay a nominal amount that would go toward a fund to be used solely in the management of Hanifaru and its manta rays and whale sharks. It will also help give an idea of how much people would be willing to pay, but a more in-depth study would perhaps address bias that could not be covered at this stage. The questionnaires were distributed electronically to the 6 resorts that visit Hanifaru most frequently as well as hard copies whenever they were encountered on-site. The AEC project and the Ministry of Environment, Maldives support this survey.