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The impacts of tourism on a population of manta rays, Baa Atoll, Republic of Maldives

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Contents

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Abstract

The popularity of marine tourism has increased steadily over recent decades and is considered more sustainable than consumptive use of marine megafauna. The seasonal migration of manta rays to Republic of Maldives has resulted in a significant increase in the number of tourists participating in manta-related activities. Heavy site use has led to observations of disturbance that has the potential to cause detrimental impacts to manta rays health and behaviour. This increase in tourism pressure and possible detrimental impacts indicates investigation into human interactions with manta rays should be conducted.

Video footage of interactions between humans and manta rays were filmed at cleaning and feeding stations within Baa Atoll, Maldives. A total of 263 unique interactions of both divers and snorkelers were filmed and analysed for a number of variable including interaction type and the response elicited from manta rays. Humans exhibited behaviours such as following, intentional touching, diving under and passive observations. Manta rays reacted to interactions with response behaviours such as avoidance, flight, course re-direction and no response.

The findings suggest that human behaviours are largely passive and cause relatively little disturbance to manta rays natural behaviour. A number of minor and major disturbance behaviours can be addressed by initiating the use of a code of conduct by tourism operators. A precautionary approach to managing manta ray tourism must be taken in order to prevent tourism on larger scales causing disturbance and potentially affecting the long term health of the manta ray population. At current levels of tourism, in-water encounters appear to be sustainable and provide a significant source of revenue without long term detrimental impacts to manta rays.

Introduction

For centuries, humans have eagerly exploited the sea's resources, including the capture and killing of marine megafauna such as whales, sharks and dolphins for multiple uses. However in the last 50 years, there has been a shift in attitudes away from consumptive use and towards the protection and conservation of species (Samuels & Bejder, 2004, Hoyt, 2001). The long term economic, social and ecological value of sustainably managing such natural resources have been recognised as far greater than the short term benefits of consumptive use (Birtles et al, 2001, Brauer, 2003, Hoyt, 2001). This change in attitude has brought about a surge in demand for marine tourism activities, such as provisioning and in-water encounters with particularly charismatic species like whales and dolphins (Gallagher & Hammerschlag, 2011). In 2008, the global expenditure of whale watching tours was thought to be US$2.1 billion, up from US$1 billion in 1998 (O'Conner et al, 2009). Similar interest in elasmobranch species such as sharks has been documented with 376 shark ecotourism operations in 29 countries across the globe (Gallagher & Hammerschlag, 2011). Whale shark ecotourism generates approximately US$4.99 million annually in the Seychelles (Rowat & Engelhardt, 2007) and AUS$6 million in Ningaloo Marine Park, Australia (Caitlin et al, 2009).

The predictable aggregations of manta rays found across the world have attracted equally significant attention from tourism operators (Courturier et al, 2012). In Yap, Micronesia, manta ray dives are estimated to generate US$4 million annually, with similar revenue estimates being made for the manta 'hotspots' of Kona, Hawaii and the Socorro Islands in Mexico (Heinrichs et al, 2011). Global manta ray related activities are reported to directly generate as much as US$50 million per year (Heinrichs et al, 2011), with opportunities to interact with these placid, social animals increasing as their behaviour and migration patterns are better understood (Courturier et al, 2012).

The Republic of Maldives enjoys one of the largest known populations of manta rays in the world. The population of *Manta alfredi*, the most commonly observed species of the two in the Maldives

(Marshall et al, 2009), is estimated at around 5,000-7,000 (Manta Trust, 2012). In the last decade, the potential value of manta rays to the Maldivian economy has been recognised. As such, a number of measures have led to their protection through legislation such as a ban on the trade and export of manta ray products (Anderson & Ahmed, 1993) and creation of a Marine Protected Area in an important feeding area (Hanifaru Bay, see figure 1.2) in 2009 (Anderson et al, 2011). This legislation coupled with significant publicity has instigated a highly lucrative manta ray tourism industry in the Maldives, generating direct revenue of US$8.1 million per year between 2006 and 2008 (Anderson et al, 2010).

Manta rays are filter-feeding, oceanodromous, Mobulidae distributed around the world in tropical and sub-tropical locations between approximately 36ºS to 40ºN (Marshall et al, 2009). They live predominantly in shallow waters along the reefs of islands and mainland coastlines (Marshall et al, 2009) and are known to concentrate in areas supporting high levels of their primary food source, zooplankton (Marshall et al, 2009). The population of reef mantas (*Manta alfredi*) visiting Maldives Baa Atoll, a recently designated UNESCO Biosphere Reserve (UNESCO, 2011), is strongly influenced by the south-west monsoon. The currents deliver nutrient rich waters to the atoll driving an explosion in phytoplankton (Anderson et al, 2011) which then promotes high zooplankton productivity. This accumulation of zooplankton supports a large regional population of manta rays. The Maldivian Manta Ray Project has catalogued approximately 2,400 individuals, with around 1300 of these from Baa Atoll (Stevens, pers. comm.).

Internationally, manta rays are under increasing threat from anthropogenic activities, primarily overexploitation through fishing, both as a target species and as bycatch (Dewar et al, 2008, Heinrichs et al, 2011). Recently developing markets across the world for manta ray gill rakers (the thin cartilage filaments inside the mouth used for filtering zooplankton) as an ingredient used in Chinese traditional medicine have rapidly produced lucrative fisheries for a species that is extremely vulnerable to anthropogenic pressure (Heinrichs et al, 2011, Fowler 2002). Manta rays are slow growing, late to mature and have low fecundity, all biological constraints which severely limit their ability to sustain healthy populations when exploited (Frisk et al. 2001, Courturier et al, 2012).

Both international and national laws and regulations are vital to manta ray protection. Both *Manta birostris* and *Manta alfredi* are listed on the International Union for Conservation of Nature (IUCN) Red List as 'vulnerable' to extinction (IUCN, 2012). Furthermore, as of 2011, they feature in Appendix I and II of the Convention on Migratory Species of Wild Animals (Manta Trust, 2012) and efforts are currently underway to have both species listed on the Convention of International Trade in Endangered Species (CITES) to quash the legal trade of manta ray products internationally (Stevens, pers. comm.).

The Maldives is heavily dependent on its natural resource base as a primary source of income, with employment in tourism accounting for 58% of the workforce (Emerton et al, 2009). The regional laws imposed to protect its rich biodiversity have prevented an export –oriented fishery (Fowler, 2002) and allowed for the development of a thriving manta ray tourism industry (Brooks & Stevens, 2010). An estimated 143,000 dives and 14,000 snorkels occurred each year between 2006 and 2008 on 91 recognised manta dive sites (Anderson et al, 2010). However, while ecotourism is considered more sustainable and economically viable than consumptive use (Topelko & Dearden 2005, International Fund for Animal Welfare, 1995), there is growing concern that the rapid increase in generally unregulated tourism in manta hotspots in the Maldives may be causing undue disturbance to manta rays (Graham et al, 2012, Environmental Protection Agency (EPA), 2011, Anderson et al, 2011).

In Hanifaru Bay, Baa Atoll, famed for its mass feeding events of manta rays, site use has increased significantly in recent years (Brooks & Stevens, 2010). Manta rays frequent a number of feeding sites and cleaning stations within the atoll with a predictability that makes these sites ideal for manta watching by tourists. In August 2010, 328 boats were recorded using the bay, placing nearly 3,000 tourists in the water (Brooks & Stevens, 2010). This represents an average of 12.1 boats and 109.7

tourists using the site each day during the south-west monsoon season (Brooks & Stevens, 2010). The number of tourists visiting the bay increased by 158% between 2009 and 2010 (Brooks & Stevens, 2010). A core objective of Hanifaru Bay Management Plan is "to provide a sustainable, high quality experience for visitors that does not threaten the biodiversity" (EPA, 2011). Therefore, monitoring and regulating levels of disturbance is essential to ensure the sustainability of tourism in the bay.

Previous research into the effects of in-water tourism with marine megafauna has underlined the necessity for tourism operators to behave responsibly, limiting disturbance to marine life (Brooks, 2010, Orams, 2004). In Bora Bora, French Polynesia, it is reported that a local population of manta rays abandoned their aggregation site due to sustained pressure from anthropogenic in- water activities such as snorkelling and diving (de Rosemont 2008). Deakos et al (2011) quote 'swim-with-manta-ray' programs as one of the biggest anticipated threats in the near future to the population of manta rays in Maui, Hawaii. An investigation into a resident population of manatees in Florida found that during peak tourism season the ratio of swimmers to manatees may reach 30:1. Of more concern is the finding that human interactions were influencing manatees to a degree that negatively affected their fitness for overwintering. Furthermore, their time spent resting, nursing and feeding was reduced (King & Heinen, 2004). Diverting energy resources away from such vital activities has implications for the long term health of the animal (Quiros, 2007, Lusseau & Bejder, 2007). Management of marine resources must encompass measures, such as a code of conduct, to reduce disturbance of marine species to ensure that tourism does not negatively affect a populations' health and behaviour. Without careful management, 'ecotourism' could easily become another form of exploitation (Orams, 2004).

The deficit in research investigating the impact of human interaction with manta rays forms the basis of this research.

Aims of the study

- To investigate different types of interactions between humans and manta rays.
- To investigate responses to different interaction types given by manta rays
- To compare data collected between 2011 and 2012
- To develop a Code of Conduct, based on the findings, for interacting with manta rays which can be used internationally at other manta aggregation sites.

Methods

Study site

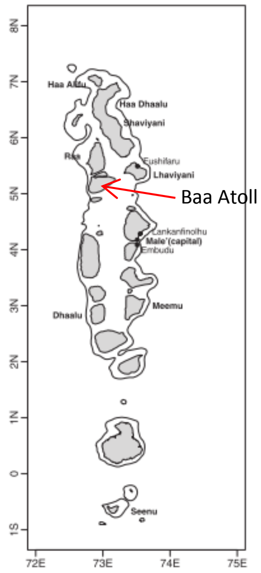

Figure 1.1. Map of Maldives showing location of Baa Atoll

The study was conducted at a number of manta aggregation sites throughout Baa Atoll. Baa Atoll (see fig.1.1 & 1.2), comprised primarily of ocean, is one of twenty-six coral atolls, approximately 63km long and encompassing 1,200km^2, in the Republic of Maldives. Data collection was conducted during the south-west monsoon season (June to November) due to the high number of manta rays resident in the atoll at this time. The manta rays are attracted by high quantities of zooplankton generated by prevailing winds and subsequent upwelling of nutrients (Anderson et al, 2011).

Data collection

Data was collected between June 29th and August 26th, 2012, between the hours of 09:00 and 18:00. Time spent at each site was determined by weather conditions, tidal patterns and the number of mantas present.

Figure 1.2. Satellite view of Baa atoll showing locations of research base at Four Seasons Resort and a primary data collection site, Hanifaru Bay

Data was collected at feeding sites when both the research vessel and a resort vessel with snorkellers were present on as many days as weather conditions allowed. Data from cleaning stations was collected on SCUBA when accompanying The Four Seasons Dive Centre staff on dives to local dive sites. In order to prevent influencing natural behaviours, snorkellers and divers were not aware of the purpose of the research.

Data collection was conducted using a Sea&Sea DX-2G digital camera with wide angle wet lens in an underwater housing. Video footage of snorkellers and divers interacting with manta rays was filmed and later analysed for interaction/response type. The researcher positioned herself at a distance from and behind both the snorkellers and manta rays wherever possible to prevent interference with the unique interaction. Feeding data was taken from five feeding aggregation sites (table 2.4) and cleaning data from five cleaning stations (table 2.1) within the atoll.

Data Analysis

All footage containing manta rays and people qualified for analysis, which was conducted within 48 hours of being taken. Each video was assessed several times and data verified by Guy Stevens (Manta Trust Director and project co-ordinator) when necessary. Video clips may contain multiple interactions but each was documented separately and a number of variables recorded (table 1.1). As some interactions involved a number of manta rays the 'response' variable was classified according to the dominant response exhibited by all the mantas. Response variables were further classified into different levels of disturbance (table 1.2). Major disturbance is categorised as behaviour which resulted in greater energy expenditure or loss of feeding time for the manta ray.

Subject	Variables collected
General	• Date • Video clip number • Video clip duration • Location of site • Water temperature • Specific details regarding the interaction
At feeding sites	• Number of vessels entering Hanifaru Bay (while research vessel present) • Number of snorkellers aboard each resort vessel entering the water • Wind direction • Water visibility • Duration of time each snorkelling group spent in water • Occurrence of vessel/ people violations (e.g. speeding)
At cleaning stations	• Number and length of dives • Water temperature • Number of divers entering the water
Manta rays	• Number of manta rays in the interaction • Total estimate of manta rays seen at the site • Individual manta ID number and sex (where possible) • Position of manta at start of the interaction (surface, midwater, bottom) • Response to human interaction • Did the manta stop behaviour in response to interaction? • Did the manta resume behaviour again?
Humans	• Estimated closest distance observed between manta and human during interaction • Natural behaviour type (e.g. feeding, etc.) • Type of interaction (e.g. chasing, etc.) • Primary direction human came from (e.g. usually underneath if diving, surface if snorkelling) • Secondary direction human came from (e.g. side, front, behind)

Table 1.1. Data variable collected throughout research period at both cleaning and feeding sites.

Level of Disturbance		
No disturbance	**Minor disturbance**	**Major disturbance**
Approaches snorkeller/diver	Avoidance	Flight
No response	Dive avoidance	Stops feeding
	Course re-direction	
	Stops cleaning	

Table 1.2. Classification of disturbance level to manta rays according to response type

In order to maintain consistency in data collection and analysis between years, the table of behaviours and responses of manta rays and people defined by a previous researcher were used (Atkins, 2011, see tables 1.3, 1.4 and 1.5) to analyse data. The same methods of data collection were used to facilitate comparison. The data set was compared to data taken in 2011 over the same period (Atkins, 2011). Several days were taken before data analysis began to facilitate correct identification of natural manta ray behaviours (e.g. cleaning, feeding) and responses. An additional behavioural response (course re-direction) was included this year to separate more subtle behaviours exhibited by manta rays.

Natural undisturbed behaviour	Characterisation
Individual Feeding	Surface, bottom and barrel rolling feeding behaviours - travelling in a given direction/orientation with mouth wide open and cephalic fins unfurled.
Co-operative Feeding	Chain, cyclone and stacked feeding behaviours - two or more mantas travelling together in a given direction/orientation with mouth wide open and cephalic fins unfurled.
Travelling	Swimming through an area with mouth closed and usually accompanied by cephalic fins rolled up.
Cleaning	Present at a cleaning station, cleaner fish actively cleaning manta, cephalic fins usually unrolled, but may be rolled up.

Table 1.3. Characterisation of natural undisturbed behaviours observed by humans.

Following	**Swimming after manta whilst maintaining appropriate distance (>5m) and/or pace.**
Chasing	Swimming after manta without consideration of distance to be maintained, and may include swimming after manta at a quickened pace (distance <5m).
Accidental contact	Unintentional contact - may include touching or kicking whilst swimming out of path of manta or contact whilst manta swam around snorkeler or diver.
Intentional touching	Intentionally approaching and touching manta with hand.
Intentional attempt to touch / make contact	Intentionally trying to make contact with manta with hands or feet, without success.
Diving under or near manta	Snorkelers duck-diving down or divers diving deeper to position themselves nearer to or underneath manta.
Accidental obstruction	Unintentionally in the path of approaching manta i.e. manta swimming towards human and human remaining in or maintaining position.
Intentional obstruction	Intentionally swimming into path of approaching manta.
Diver bubbles	Bubbles exhaled from regulator of diver in path of manta / make contact with manta.
Over-crowding at feeding aggregation	20 or more snorkelers per feeding manta, within 15m of manta.
Over-crowding at cleaning station	10 or more divers per manta present at cleaning station, within 15m of manta.
Riding manta	Diver or snorkeler grabbing onto manta with one or both hands and towed along.
Flash photography	Snorkelers or divers using flash photography within range of manta.
Passive observation	Snorkeler or diver remaining in one position to passively observe mantas either at depth or at the surface.
Splashing / fin kicking	Splashing with hands or fins at surface

Table 1.4. Classification of different human interactions with manta rays.

Flight	**Manta swims away from diver or snorkeler with a quick burst of speed, may include a sudden change in direction.**
Course re-direction	Manta makes slight adjustment in intended path to avoid collision with human. No signs of concern for presence of diver/snorkeller, continues with previous path and activity
Avoidance	Manta makes a change in direction due to presence of diver/snorkeller and swims away from the diver or snorkeler without gaining speed. May include shallow dive.
Dive Avoidance	Manta dives steeply to greater depth to avoid snorkelers or divers.
Approach diver / snorkeler	Manta makes no attempt to maintain distance between itself and divers or snorkelers, may come within 1m of diver or snorkeler, and may repeatedly return to diver or snorkelers' location. May also include manta displaying ventral surface towards diver or snorkeler, and swimming underneath or around diver or snorkeler for a closer look.
Stops feeding	Manta closes mouth, may be accompanied by cephalic fins being rolled up.
Stops cleaning	Manta moves away from cleaning station directly following interaction with human(s).
No response	No alteration in behaviour observed.

Table 1.5. Characterisation of commonly observed responses to human interaction types.

Results

Human and manta ray interactions at cleaning stations

Throughout the study period, thirteen dive sites were utilised for data collection in addition to the cleaning station present in Hanifaru Bay (where no diving is permitted). Over 39 hours on SCUBA over 23 days yielded video of manta rays and people on cleaning stations from five of these sites (table 2.1) totalling 26 minutes of footage. Eight-six percent of clips were filmed on two cleaning stations, which lie in close proximity to Hanifaru Bay. Thirty separate interactions were filmed with the number of divers/snorkelers in each clip ranging between 1 and 6 (average 2.6). The number of manta rays in each individual interaction ranged between 1 and 9 (average 1.6) with the majority of manta rays being in midwater at the beginning of each interaction (25/30) and the remaining proportion being close to the bottom of the surrounding substrate.

Site Name	Number of clips recorded here
Dharavandhoo Thila	14
Dhigu Thila	1
Dhonfan Pinnacle	1
Dhonfan Reef	12
Hanifaru	2
Grand Total	**30**

Table 2.1. Cleaning stations where footage was collected and number of clips each site produced.

Travelling behaviour accounted for half of natural behaviours observed at cleaning stations closely followed by cleaning behaviour in 44% of clips analysed (fig. 2.1).

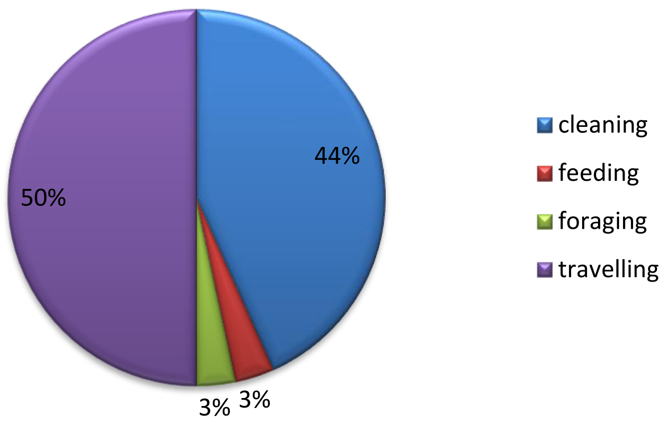

Figure 2.1. Percentage of natural behaviours observed at cleaning stations

The predominant type of interaction between humans and manta rays was a passive observation representing over 83% of all interactions captured. There was just one instance each of five other interaction types observed throughout the study on cleaning stations (fig. 2.2).

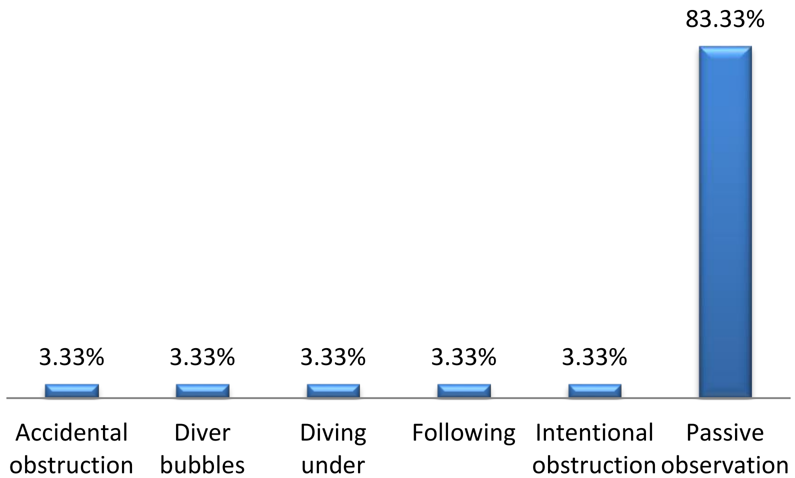

Figure 2.2. The percentage of each interaction type observed on cleaning stations

In 70% of interactions the response exhibited by manta rays was one of no response. The response to human interaction was either avoidance or to stop cleaning in just one interaction. The remaining proportion of responses shown by manta rays was course re-direction (fig. 2.3).

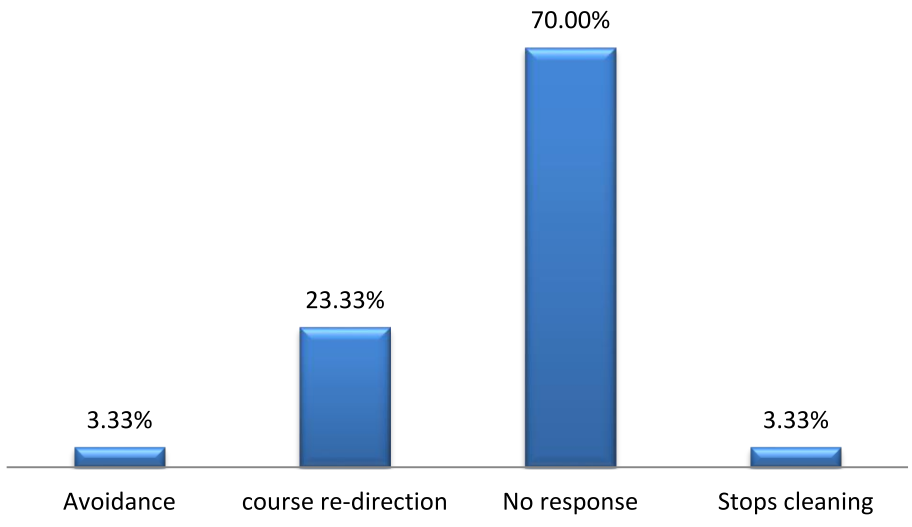

Figure 2.3. The response by manta rays to human interactions on cleaning stations (%).

Looking at the relationship between interaction type and response given (table 2.2), the majority of passive observation interactions yielded no response from manta rays. Diver bubbles were responded to with avoidance in one interaction. Course re-direction was initiated when the interaction type with humans was a minor disturbance including accidental obstruction, diving under and following. No major disturbance behaviours were elicited by any of the interactions.

Response Type					
Interaction Type	**Avoidance**	**Course re-direction**	**No response**	**Stops cleaning**	**Grand Total**
Accidental obstruction		1			1
Diver bubbles	1				1
Diving under		1			1
Following		1			1
Intentional obstruction		1			1
Passive observation		3	21	1	25
Grand Total	**1**	**7**	**21**	**1**	**30**

Table 2.2. Type of interaction between human and manta ray and the response shown by manta ray at cleaning stations.

No response was demonstrated when passive interactions took place at distances between 1 and 9 metres. Minor disturbance responses were all elicited from manta rays when the closest distance between human and manta during interaction was 3 metres or less (table 2.3).

Distance Estimation (m)	Response Type				
Interaction Type	**Avoidance**	**Course re-direction**	**No response**	**Stops cleaning**	**Grand Total**
0.50			**1**		**1**
Passive observation			1		1
1.00		**2**			**2**
Diving under		1			1
Intentional obstruction		1			1
2.00	**1**	**3**	**2**		**6**
Accidental obstruction		1			1
Diver bubbles	1				1
Following		1			1
Passive observation		1	2		3
3.00		**2**	**4**		**6**
Passive observation		2	4		6
4.00			**3**	**1**	**4**
Passive observation			3	1	4
5.00			**7**		**7**
Passive observation			7		7
6.00			**1**		**1**
Passive observation			1		1
7.00			**1**		**1**
Passive observation			1		1
8.00			**1**		**1**
Passive observation			1		1
9.00			**1**		**1**
Passive observation			1		1

Table 2.3. Relationship between estimated closest distance (between human and manta ray) and response observed during various interaction types at cleaning stations.

Human and manta ray interactions at feeding sites

A total of 30 days were spent snorkelling at a number of manta ray feeding sites, with 233 separate interactions being filmed, totalling 109 minutes of footage. Over 88% of clips were taken at Hanifaru Bay (table 2.4) with between 1 and 20 (average of 3.4) snorkellers in each interaction. The average number of manta rays in an interaction was 2.5 but as many as 25 mantas were recorded in several interactions. When an interaction began, 61.37% (143/233) of manta rays were on the surface of the water, 38.2% were in midwater.

Site name	No. of clips filmed at location
Hanifaru Bay	206
Hurai faru	2
Veyofushi Reef	3
Veyofushi Thila	22
Grand Total	**233**

Table 2.4. Location of feeding sites where footage was captured.

Feeding behaviour was observed in 96% of interactions. This is separated into co-operative and individual feeding of which the latter constituted 60% of natural behaviour types filmed (fig. 2.4).

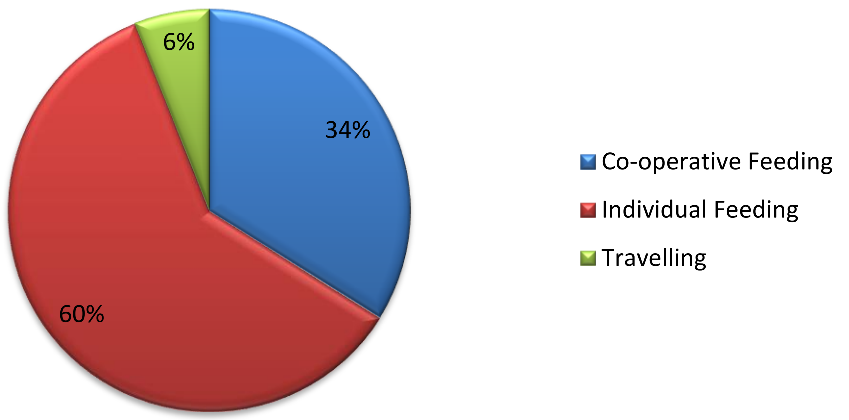

Figure 2.4. Percentage of natural behaviours observed at feeding sites.

Passive observations accounted for nearly 60% of all interaction types (fig. 2.5). Diving under (free diving) was the second most common type of interaction. The more intrusive behaviours of intentional touching/obstructing and chasing manta rays were observed in 6% of interactions.

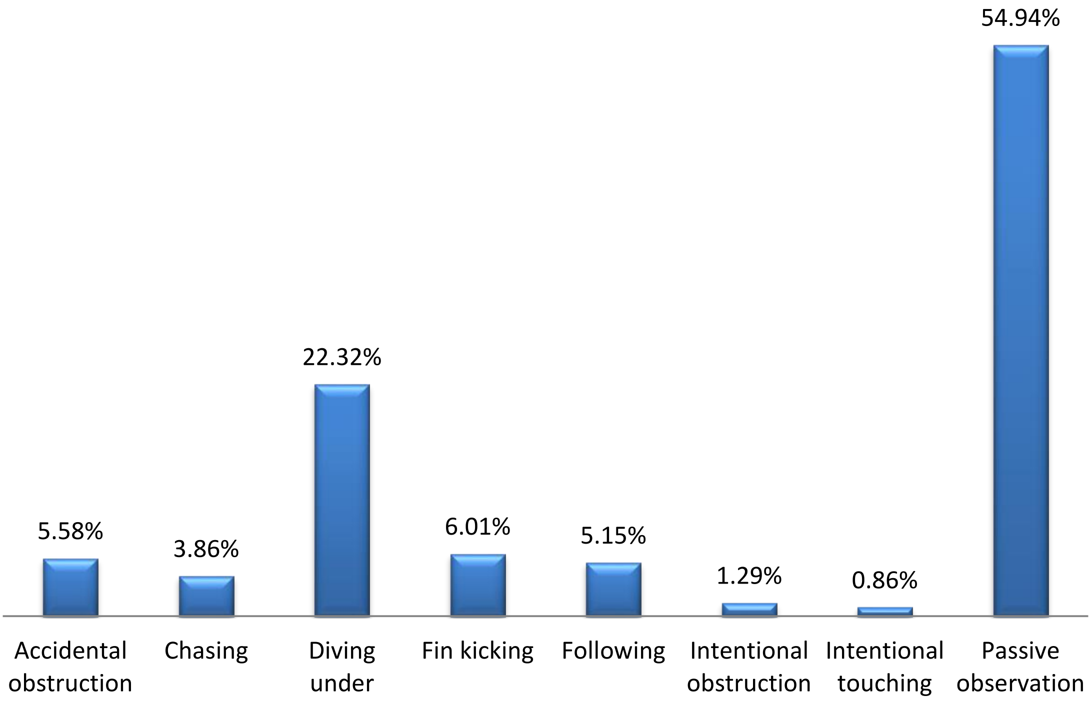

Figure 2.5. The percentage of each interaction type observed on feeding sites.

No response was the most commonly observed response to human interactions (58.37%). In 19.31% of interactions, manta rays exhibited course re-direction. The major disturbance response of flight occurred in just 3 interactions (1.29%) (fig. 2.6). Manta rays were observed to approach snorkelers in nearly 5% of interactions.

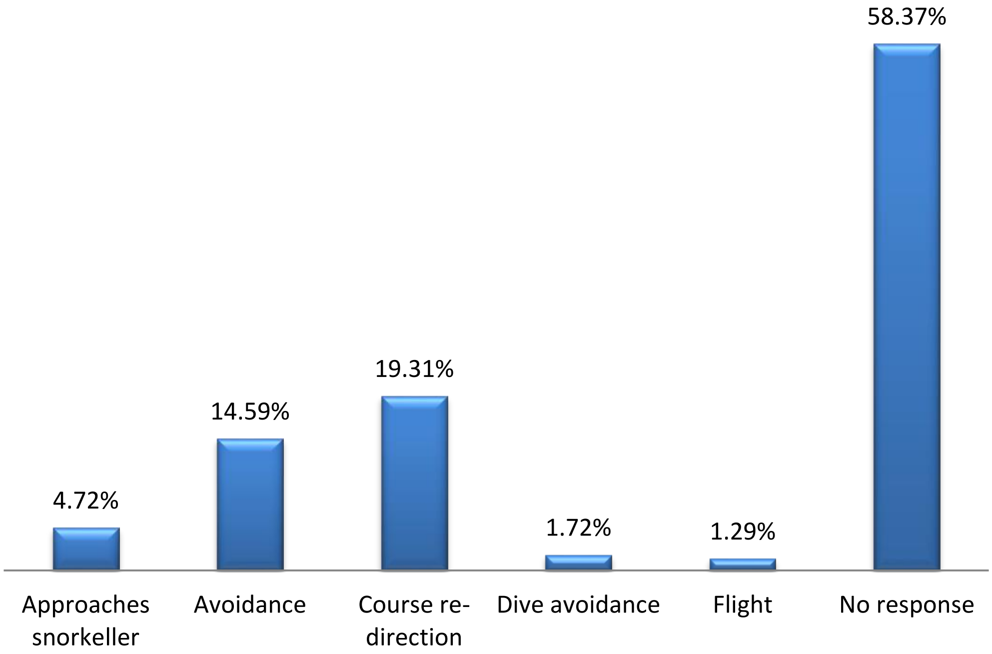

Figure 2.6. The response by manta ray/s to human interactions on feeding sites (%).

Of 128 passive interactions observed, the response behaviour was no response on 96 occasions (table 2.5). The major disturbance response of flight occurred through intentional touching, diving under and accidental obstruction. Intentional obstruction of manta rays was also met with avoidance or course re-direction. The second most commonly observed interaction type (diving under) was met primarily with no response but also avoidance or course re-direction in 26 occurrences (11.16%) of total response types. Only during passive interactions did instances of manta rays approaching snorkellers occur.

Response Type							
Interaction Type	**Approaches snorkeller**	**Avoidance**	**Course re-direction**	**Dive avoidance**	**Flight**	**No response**	**Grand Total**
Accidental obstruction		4	8		1		13
Chasing		4	1			4	9
Diving under		11	15	1	1	24	52
Fin kicking		3	6	1		4	14
Following		3	1	1		7	12
Intentional obstruction		2	1				3
Intentional touching					1	1	2
Passive observation	11	7	13	1		96	128
Grand Total	**11**	**34**	**45**	**4**	**3**	**136**	**233**

Table 2.5. Type of interaction between human and manta ray and response shown by manta ray at feeding sites.

No response by manta rays occurred during interactions between 1 and 6 metres distance. All other response types were elicited when the closest distance during interaction was less than 5 metres (table 2.6). All flight responses occurred during interactions at 2 metres or less from the manta ray. Additionally, 73.5% (25/34) of avoidance responses resulted from interactions at 2 metres or less. All manta rays approaching humans came within 1.5 metres of a person. Two hundred and eleven (90.5%) of the recorded interactions at feeding stations occurred within 3 metres of a manta ray.

Distance Estimation (m)	Interaction Type						
Response Type	**Approaches snorkeller**	**Avoidance**	**Course re-direction**	**Dive avoidance**	**Flight**	**No response**	**Grand Total**
0.00						**1**	**1**
Intentional touching						1	1
0.50	**3**		**4**		**1**	**11**	**19**
Accidental obstruction			1				1
Diving under			2			1	3
Intentional touching					1		1
Passive observation	3		1			10	14
1.00	**7**	**8**	**13**	**1**	**1**	**39**	**69**
Accidental obstruction			5		1		6
Chasing		1				2	3
Diving under		3	3	1		7	14
Fin kicking		2	3			1	6
Following		1					1
Passive observation	7	1	2			29	39
1.50	**1**	**5**	**13**			**27**	**46**
Chasing		1				2	3
Diving under		2	4			4	10
Fin kicking			2				2
Following						1	1
Intentional obstruction		1	1				2
Passive observation	1	1	6			20	28
2.00		**12**	**6**	**2**	**1**	**23**	**44**
Accidental obstruction		4	1				5
Chasing		1					1
Diving under		3	4		1	5	13
Fin kicking				1		1	2

Following		1		1			2
Passive observation		3	1			17	21
2.50		**1**	**4**			**4**	**9**
Accidental obstruction			1				1
Chasing			1				1
Diving under			2			1	3
Fin kicking		1					1
Passive observation						3	3
3.00		**5**	**3**			**15**	**23**
Chasing		1					1
Diving under		2				5	7
Fin kicking			1			2	3
Following						2	2
Intentional obstruction		1					1
Passive observation		1	2			6	9
3.50		**1**				**1**	**2**
Diving under						1	1
Passive observation		1					1
4.00		**1**	**2**			**6**	**9**
Diving under		1					1
Following			1			2	3
Passive observation			1			4	5
5.00		**1**		**1**		**7**	**9**
Following		1				2	3
Passive observation				1		5	6
6.00						**2**	**2**
Passive observation						2	2
Grand Total	**11**	**34**	**45**	**4**	**3**	**136**	**233**

Table 2.6. Relationship between estimated closest distance (between human and manta ray) and response observed during various interaction types at feeding sites.

The majority of interactions did not cause manta rays to cease their natural behaviour. Only seven out of 263 total interactions filmed caused a manta to stop their behaviour (table 2.7). Only one instance of cleaning behaviour being stopped was recorded. Six instances of feeding behaviour being interrupted were filmed, all resulting from minor disturbance human interactions. No instances of co-operative feeding or travelling being ceased were recorded.

Interaction Type	**Behaviour stopped**		
Response Type	**Cleaning**	**Feeding**	**Grand Total**
Accidental obstruction		**2**	**2**
Course re-direction		2	2
Diving under		**2**	**2**
Avoidance		2	2
Fin kicking		**1**	**1**
Dive avoidance		1	1
Following		**1**	**1**
Dive avoidance		1	1
Passive observation	**1**		**1**
Stops cleaning	1		1
Grand Total	**1**	**6**	**7**

Table 2.7. Interactions (and responses given) which caused manta rays to cease natural behaviour.

Human interactions and manta ray responses at cleaning stations over time

Cleaning accounted for over 90% of natural behaviours observed in 2011, while cleaning accounted for 43% of behaviours observed at cleaning stations in 2012 (table 2.8).

	Year		
Behaviour Type	**2011**	**2012**	**Grand Total**
Cleaning	91.89%	43.33%	70.15%
feeding	0.00%	3.33%	1.49%
foraging	0.00%	3.33%	1.49%
Travelling	8.11%	50.00%	26.87%
Grand Total	**100.00%**	**100.00%**	**100.00%**

Table 2.8. Proportion of behaviours filmed each year at cleaning stations.

In both years, the majority of interactions filmed were of passive observation by humans (fig. 2.7). However, a larger proportion of intrusive interactions in 2011 were filmed, such as following and diver bubbles. No accounts of particularly intrusive behaviours such as chasing, riding or intentionally touching manta rays were recorded in either year.

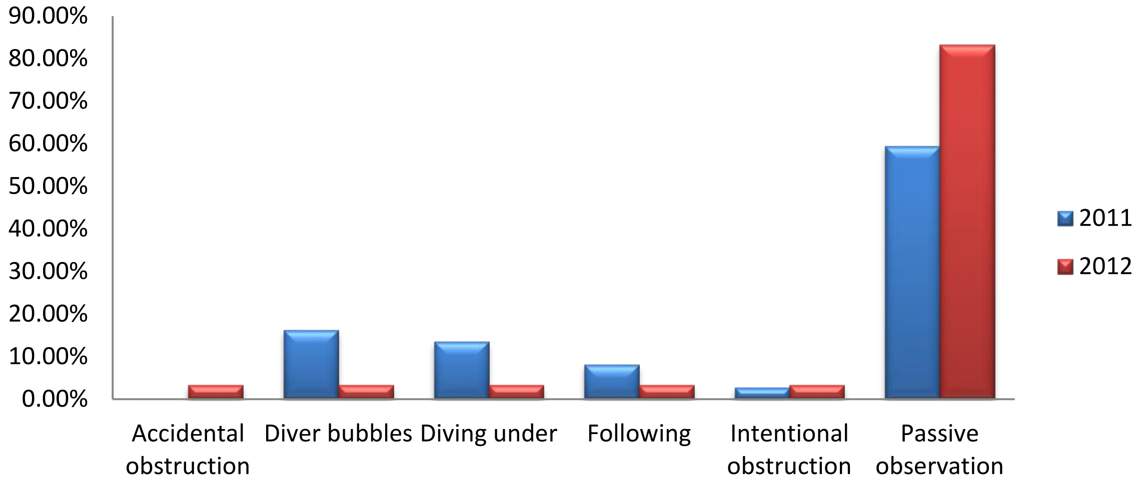

Figure 2.7. The percentage of each interaction type observed on cleaning stations for 2011 and 2012.

No response was exhibited primarily by manta rays to human interactions across years. A larger proportion of course re-direction was observed in 2012 with more flight responses being filmed in 2011 (fig. 2.8).

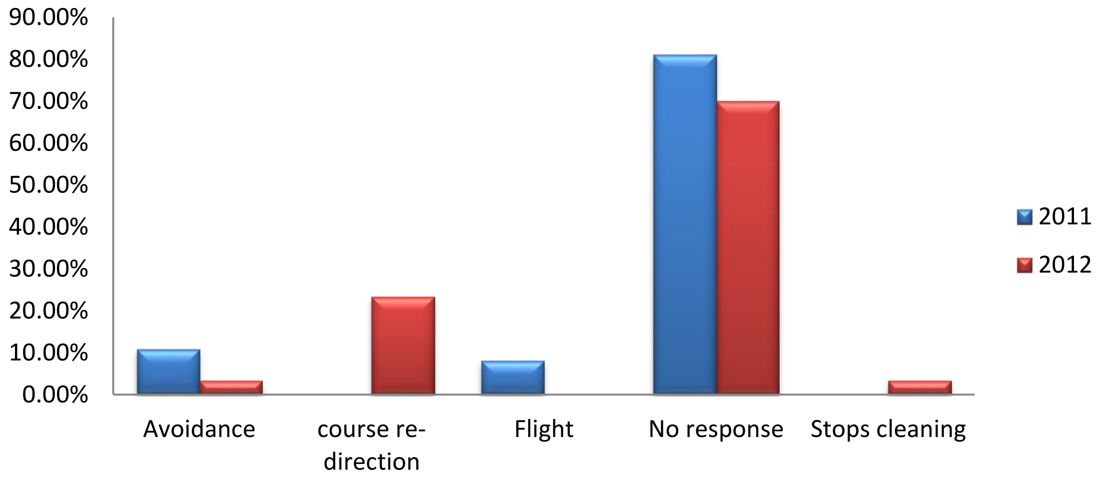

Figure 2.8. The response by manta rays to human interactions on cleaning stations for 2011 and 2012(%).

Human interactions and manta ray responses at feeding sites over time

For the months of July and August for 2011 and 2012, natural behaviours filmed by the researcher were relatively similar in occurrence. The predominant observed natural behaviour was individual feeding for both years (66.57% and 60.09%), followed by co-operative feeding (table 2.9).

	Year		
Behaviour type	**2011**	**2012**	**Grand Total**
Co-operative Feeding	22.89%	33.91%	27.43%
Individual Feeding	66.57%	60.09%	63.89%
Travelling	10.54%	6.01%	8.67%
Grand Total	**100.00%**	**100.00%**	**100.00%**

Table 2.9. Proportion of natural behaviour types filmed in 2011 and 2012.

Passive observation was the most commonly filmed type of interaction in both years. Similarly low levels of more intrusive behaviours such as chasing and intentional touching were observed between years. The major difference observed was that accidental obstruction accounted for a much larger proportion of interaction types filmed in 2011 and diving under accounted for more interaction types in 2012 (fig. 2.9).

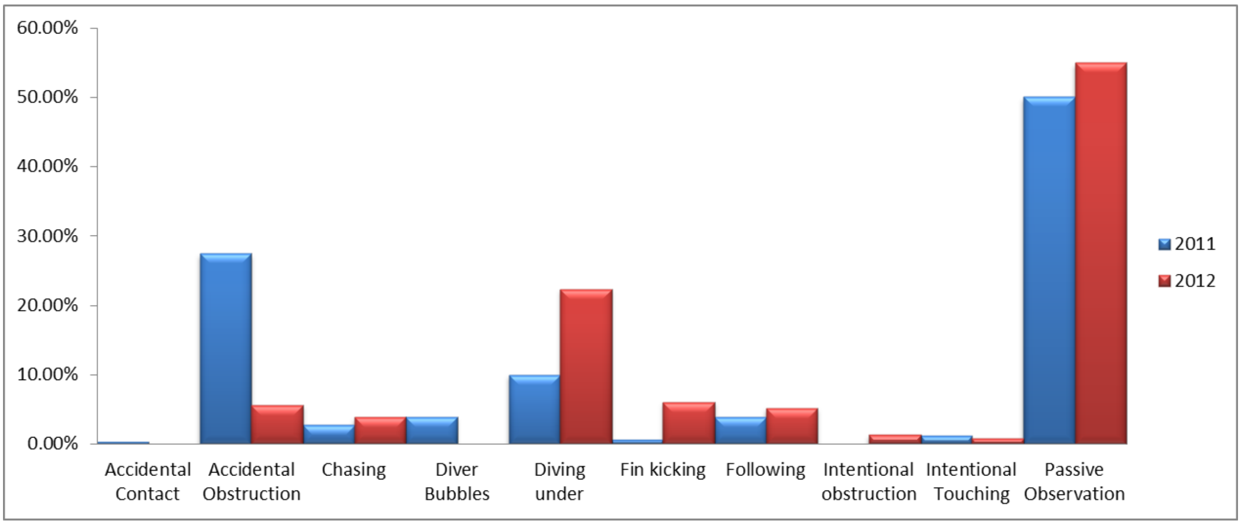

Figure 2.9. The percentage of each interaction type observed on feeding sites for 2011 and 2012.

The predominant response by manta rays to human interactions was no response in both years. The more disruptive behaviours of flight and dive avoidance were seen in equally low numbers in 2011 and 2012 (fig. 2.10). More avoidance behaviours were filmed in 2011.

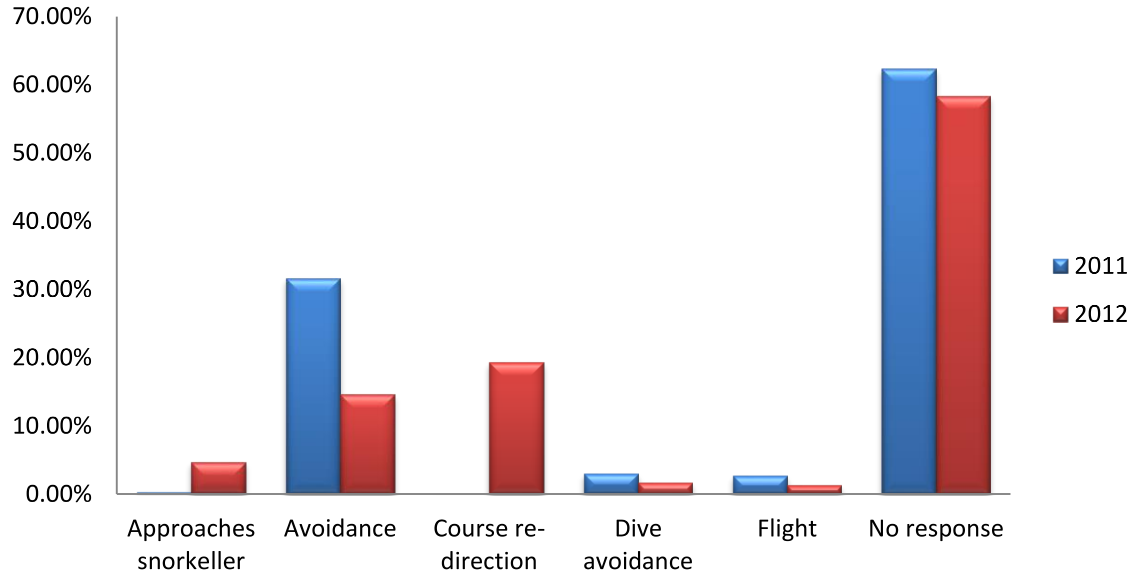

Figure 2.10. The response by manta rays to human interactions on feeding sites for 2011 and 2012 (%).

In 2011 all interactions contained three or less manta rays with 71.08% analysed containing just one manta ray. In 2012, 15.58% of clips contained four or more manta rays in each interaction, up to a maximum of 25.

Discussion

In order for marine tourism to operate sustainably while meeting the needs and expectations of tourists, managers must take steps to ensure that marine wildlife is not significantly disturbed in the process (Sorice et al, 2003). The data collected shows that human interactions with manta rays are largely passive in nature. Furthermore, the primary response of manta rays to human interaction is no response in over 58% of interactions. These results are comparative to those found by Atkins (2011) and show a relative consistency in behaviour of both humans and manta rays between years. This demonstrates that tourists largely act responsibly during in-water encounters with manta rays causing limited visible disturbance.

Human interactions at cleaning stations

The majority of interactions filmed were passive observations which were primarily responded to with no response from manta rays. The small proportion of minor disturbance responses elicited from manta rays were observed when humans were at a distance of 3 metres or less at some point during the interaction. Comparable data from Atkins in 2011 demonstrated minor disturbances were caused at distances of 5 metres or less and that passive observations also constituted the largest proportion of interaction types. Given that cleaning behaviour is primarily encountered on SCUBA dives, these types of behaviours can be reduced by giving thorough pre-dive briefings, advising tourists of behaviours to avoid when interacting with manta rays and other marine wildlife (Medio et al, 1997).

Proportionally manta rays were less disturbed on cleaning stations than during encounters at feeding aggregations. This is possibly due to the difference in activity type at each location. Dive briefings, which include behaviours to avoid, were given from the dive vessel whereas it is not known if snorkel groups were given briefings by guides before entering the water. The researcher observed during Four Seasons ‘Manta-on-Call’ snorkel excursions that briefings on in-water conduct were not always given. Moreover, the in-water proficiency of snorkelling tourists was observed to be much lower on average than the proficiency level of divers. The ‘comfort’ level of tourists in-water may negatively affect their interaction type and may account for the higher proportion of minor disturbance behaviours at feeding sites (Dearden et al, 2006).

Human interactions at feeding sites

Diving under was the second most frequently filmed interaction type and was met with avoidance and course re-direction in 50% of interactions. This behaviour type was often observed as a result of tourists attempting to take photos of manta rays at depth. All flight responses and 73% of avoidance responses resulted from interactions at less than 2 metres. Furthermore, the only instances of manta rays approaching humans were during passive observations. This evidence supports the need for implementing a code of conduct for interaction with manta rays (Quiros, 2007), including setting a minimum distance during approach (Manta Watch, 2012) and limits on the type of activities permitted.

The primary reaction to humans at feeding sites was one of no response. Given that the second most commonly filmed response was course re-direction (the mantas alters course slightly to avoid collision but displays no discomfort with human presence) this possibly indicates a level of habituation with humans (King & Heinen, 2004), whereby the species continues with normal behaviour ignoring the presence of humans. Orams (2004) makes the distinction between adaptive behaviours and detrimental ones, arguing that a change in behaviour does not necessarily indicate a negative consequence for the target species. However, because the behaviour of many large marine species is complex and dynamic, establishing the cause of observed behaviour can be problematic (Orams, 2004). Furthermore, an observed behavioural response may mask physiological responses (Lusseau & Bejder, 2007). This is compounded by our lack of understanding of the basic biological ecology of species (Orams, 2004, Courturier et al, 2011).

The higher proportion of passive observations by humans filmed at feeding stations this year may in part be linked to the ban on diving in Hanifaru Bay and a reduction in the number of vessels allowed in the bay at one time. Both factors reduce the overall number of people entering the water simultaneously and it is possible that a less crowded environment makes passive viewing of manta rays easier as tourists do not have to contend with large numbers of other snorkelers on the surface. Furthermore, the absence of divers gives manta rays greater area to avoid interaction with humans.

A possible explanation for the high number of no responses by manta rays may be linked to the intensity of feeding activity. A high abundance of zooplankton may be related to increases in co-operative feeding, which is a possible indication of an increase in feeding intensity (Manta Trust, 2012). In Hanifaru Bay, where the majority of feeding behaviours were filmed (208/233), the proportion of manta rays that showed no response to interactions with humans during co-operative feeding was 67.65%, compared to 51.20% during individual feeding (Appendix 1). Furthermore, the number of responses showing disturbance (avoidance, flight, etc.) was nearly 30% during co-op feeding but 40% during individual feeding. This provides some support for the idea that manta rays are less easily disturbed during activities that are critical for maintaining their health, a phenomenon often discussed between researchers (Stevens, pers. comm).

For the month of July, tourist numbers were relatively low compared to previous years (248 people in total from resorts), with no violations on the number of vessels or number of people allowed in the bay being witnessed (Appendix 3). The maximum number of people in-water with manta rays at any one time during July was 52. This year the number was 44. It is possible that because the bay was not overcrowded (according to legislation) this is the reason manta rays commonly exhibited no response to human interactions. However, site use will fluctuate throughout a season and across years. Therefore, while limited disturbance was observed, the research is context-specific as more people and prolonged periods of site use in the future may evoke more disturbance responses from manta rays.

Only six interactions out of 233 caused manta rays to stop feeding temporarily indicating that major disturbance responses to human interaction are low in frequency. This factor and the low level of energy expenditure associated with other response types suggest that the health of manta rays is unlikely to be severely negatively affected (Heyman et al, 2010). Efforts to increase education of tourists must be made to highlight the importance of not disrupting natural behaviours of manta rays (O'Neill et al, 2004).

The collection of a small sample size limits the use of this data. The number of video clips collected was affected by denial of a research permit allowing access to Hanifaru Bay (EPA, 2012) for all of August 2012 which hindered data collection. Furthermore, the implementation of a regulation limiting access to no more than 5 boats entering the bay at any one time further suppressed opportunities for data collection, albeit a positive step towards protection of manta rays in the bay.

The response classification of 'course re-direction' was not used last year by the researcher and represents a subtle difference between two behaviours which, without the use of a separate category, would have been analysed as avoidance behaviour. This can therefore explain in part the different levels of these two categories observed between years on both cleaning and feeding stations.

Positive steps to reduce the impacts of tourism on the population of manta rays in Baa Atoll have been taken by the Environmental Protection Agency (EPA, 2011), including the prohibition of SCUBA diving within Hanifaru Bay (Appendix 3), significantly reducing the number of vessels to the area (Brooks, 2010). However, regulations such as restrictions on vessel access could cause tourism operators to compensate for this by either increasing the number of tourists per vessel or increasing the number of vessels, both of which have the potential to cause excessive and sustained disturbance to manta rays. Therefore, continued research and monitoring of site use is important to maintaining sustainable levels of tourism activities (Hawkins et al, 2005). A key factor in reducing detrimental behaviours is to educate resource users, which could be achieved through better information dissemination prior to entering the water with marine animals (Marion & Rogers, 1994).

Conclusions

Human interactions with manta rays in Baa Atoll are generally passive in nature and cause relatively little disturbance to manta ray activities. However, as the number of tourists visiting these sites rises, the potential for detrimental impacts increases also (O'Neill et al, 2004). Furthermore, high levels of disturbance could be exacerbated by other anthropogenic pressures faced by manta rays such as entanglement in marine debris and climate change (Courturier et al, 2012), both of which have limited scope for being addressed at the regional level. Exercising a precautionary approach, whereby anticipatory measures are implemented before a detrimental impact is detected, should ensure this type of activity is sustainable (Heyman et al, 2010). This approach has been applied successfully in Australia when top-down pressure for increasing the number of whale shark licenses was rejected in favour of more stringent controls on tourism to protect the whale shark population (Mau, 2008).

In conjunction with controlling the number of vessels and tourists accessing manta ray aggregation sites to prevent overcrowding, a Code of Conduct should be used by tourism operators and encompass the behavioural instructions below (fig. 3.1). This would ensure a rewarding experience for humans can be enjoyed, minimising disturbance to manta ray populations, while promoting greater understanding of the marine environment and the implications of irresponsible behaviour to manta rays and wildlife in general (O'Neill et al, 2004).

DON'T:

- Touch, chase, ride or obstruct manta rays
- Interfere with their natural undisturbed behaviour
- Free dive close to or without consideration of the position of surrounding mantas
- Engage in sudden movements which may startle a manta ray

DO:

- Move slowly in the water, allowing mantas to approach you
- Adhere to rules and regulations outlined in dive/snorkel briefings
- Attempt to maintain a distance of at least 3 metres from a manta ray

Figure 3.1. Behavioural instructions for inclusion in a Code of Conduct for interacting with manta rays.

A number of organisations have developed their own Codes of Conduct or recommendations for interaction with a range of marine megafauna (table 3.1). The findings from this report strengthen some of the recommendations suggested by these organisations by providing quantitative research into the effects of human behaviours on manta rays. Enforcement of such a code of conduct will be vital in reducing the level of disturbance experienced by manta rays to ensure sustainability of manta tourism (Barker & Roberts, 2004). Future research investigating tourism at different scales would provide further information on the sustainability of in-water manta ray tourism.

	Organisation/Author								
Recommendations	AMAR (Divers Association of Mozambique)	Manta Watch	PADI Manta Awareness Speciality	WiseOceans	Daw & McGregor	Heidi Dewar	The Travel Foundation	Wild Scotland	National Marine Fisheries Service (NOAA)
Don’t touch/ride	✓	✓	✓	✓		✓	✓	✓	✓
Don’t enter cleaning station	✓		✓	✓					
Listen to briefings given by guides	✓	✓		✓	✓				✓
Respect space of animal (maximum distance)	✓	✓ (max. 3m)			✓ (max. 2m)	✓	✓ (max. 2m)		✓
Limit group size		✓ (8 divers)		✓				✓	✓
Divers should stay close to bottom		✓		✓		✓			
Move slowly		✓				✓		✓	✓
Avoid flash photography		✓		✓		✓	✓		✓
Do not disturb natural behaviours				✓		✓			
Limit interaction time								✓	

Table 3.1. Recommendations on interacting with marine wildlife suggested by a number of researchers and organisations.

References

- Anderson, R.C. & Ahmed, H. 1993. The Shark Fisheries in the Maldives. Rome: FAO, Ministry of Fisheries and Male Agriculture, 73 pp.
- Anderson, R.C. Anderson, R. C. Adam, M. S. Kitchen-Wheeler, A. Stevens, G., 2010. Extent and economic value of manta ray watching in Maldives. *Tourism in Marine Environments*, 7(1).
- Anderson, R.C., Shiham, M. & Goes, J.I., 2011. From monsoons to mantas : seasonal distribution of Manta alfredi in the Maldives. *Fisheries Oceanography*, 20(2), pp.104–113.
- Atkins, R., 2011. Manta ray (*Manta alfredi*) tourism in Baa Atoll, Republic of Maldives: human interactions, behavioural impacts and management implications. Thesis, University of York, UK.
- Barker, N.H.L. & Roberts, C.M., 2004. Scuba diver behaviour and the management of diving impacts on coral reefs. *Biological Conservation*, 120(4) pp. 481-489.
- Birtles, B.A., Valentine, P. & Curnock, M., 2001. Tourism based on free-ranging marine wildlife: Opportunities and responsibilities. Wildlife tourism research report series: no. 11 Status Assessment of Wildlife Tourism in Australia Series. P.65
- Bräuer, I., 2003. Money as an indicator: to make use of economic evaluation for biodiversity conservation. *Agriculture, Ecosystems & Environment*, 98(1-3), pp.483–491. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0167880903001075. [Accessed June 18, 2012].
- Brooks, K., 2010. *Investigating tourism at Hanifaru Bay marine protected area, Maldives.*Thesis, University of York, UK.
- Brooks, K.S. & Stevens, G., 2010. *Developing Tourism at Hanifaru Bay Marine Protected Area (MPA)*. A short report for the Ministry of Environment, Maldives; EPA and AEC. Maldivian Manta Ray Project.
- Caitlin, J. et al., 2009. Consolidation in a Wildlife Tourism Industry : The Changing Impact of Whale. *International Journal of Tourism Research*. 12, pp.134–148.
- Couturier, L.I.E. et al., 2011. Distribution, site affinity and regional movements of the manta ray, Manta alfredi (Krefft, 1868), along the east coast of Australia. *Marine and Freshwater Research*, 62(6), p.628. Available at: http://www.publish.csiro.au/?paper=MF10148. [Accessed August 27, 2012]
- Couturier, L.I.E. Marshall, A D. Jaine, F. R. A. Kashiwagi, T. Pierce, S. J. Townsend, K. A. Weeks, S. J. Bennett, M. B. & Richardson, A. J., 2012. Biology, ecology and conservation of the Mobulidae. *Journal of fish biology*, 80(5), pp.1075–119. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22497374 [Accessed August 2, 2012].
- de Rosemont, M., 2008. Observation and sighting description of the *Manta birostris*, in Bora Bora Island (French Polynesia, South Pacific). In: Donnelly MA (ed) 2008 Joint Meeting of Ichthyologists and Herpetologists. Montreal, Canada, p 106
- Deakos, M.H., Baker, J.D. & Bejder, L., 2011. Characteristics of a manta ray Manta alfredi - population off Maui, Hawaii, and implications for management. *Marine Ecology Progress Series*, 429, pp.245–260. Available at: http://www.int-res.com/abstracts/meps/v429/p245-260/ [Accessed March 18, 2011].
- Dearden, P., Bennett, M. & Rollins, R., 2006. Implications for coral reef conservation of diver specialization. *Coastal Management*, 35(2/3), pp.305–317.

- Dewar, H. Mous, P. Domeier, M. Muljadi, A. Pet, J. Whitty, J., 2008. Movements and site fidelity of the giant manta ray, *Manta birostris*, in the Komodo Marine Park, Indonesia. *Marine Biology*, 155(2), pp.121–133. Available at: http://www.springerlink.com/index/10.1007/s00227-008-0988-x [Accessed August 22, 2011].
- Emerton L., Baig S., and Saleem M., 2009. Valuing Biodiversity. The economic case for biodiversity conservation in the Maldives. AEC Project, Ministry of Housing, Transport and Environment, Government of Maldives and UNDP Maldives.
- Environmental Protection Agency (EPA), 2011. Management plan for Hanifaru marine protected area, Baa atoll, Maldives. Atoll Ecosystem Conservation Project. p. 0–22. Available at: http://www.epa.gov.mv/images/stories/publications/Hanifaru%20Management%20Plan%20-%20English%20%28July%2020-2011%29.pdf [Accessed June 1, 2012]
- Environmental Protection Agency, 2012. Environmental Protection Agency, Republic of Maldives. [Online] Available at: http://epa.gov.mv/index.php?option=com_content&view=article&id=816:epa-has-decided-not-to-renew-the-research-permit-of-manta-trust&catid=1:latestnews&Itemid=6 [Accessed August 20, 2012]
- Fowler, S.L., Reed, T.M. and Dipper, F.A. (eds). 2002. Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. xv + 258 pp.
- Frisk. M, Miller. T, Fogarty. M., 2001. Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. *Can J Fish Aquat Sci*. 58:969–981
- Gallagher, A.J. & Hammerschlag, N., 2011. Global shark currency: the distribution, frequency, and economic value of shark ecotourism. *Current Issues in Tourism*, 14(8), 797-812
- Graham, R.T. Witt, M. J. Castellanos, D. W. Remolina, F. Maxwell, S. Godley, B. J. & Hawkes, L. A., 2012. Satellite Tracking of Manta Rays Highlights Challenges to Their Conservation H. Browman, ed. *PLoS ONE*, 7(5), p.e36834. Available at: http://dx.plos.org/10.1371/journal.pone.0036834 [Accessed May 12, 2012].
- Hawkins, J.P. et al., 2005. Sustainability of Scuba Diving Tourism on Coral Reefs of Saba. *Coastal Management*, 33, pp.373–387.
- Heinrichs, S. O'Malley, M. Medd, H. & Hilton, P., 2011. *Manta ray of Hope: The global threat to manta and mobulid rays*, p.40.
- Heyman, W.D., Carr, L.M. & Lobel, P.S., 2010. Diver ecotourism and disturbance to reef fish spawning aggregations: It is better to be disturbed than to be dead. *Marine Ecology Progress Series*, 419, pp.201–210. Available at: http://www.int-res.com/abstracts/meps/v419/p201-210/ [Accessed August 6, 2012].
- Hoyt, E. 2001. Whale watching worldwide tourism, numbers, expenditures and expanding socioeconomic benefits. Report to IFAW, Crowborough, Sussex, UK. 157pp. [Available from IFAW].
- International Fund for Animal Welfare and Tethys European Conservation. (1995). Report of the Workshop on the Scientific Aspects of Managing Whale Watching. Montecastello di Vibio, Italy: Author.

- International Union for the Conservation of Nature (IUCN) 2012. IUCN Red List of Threatened Species. Version 2012.1. Available at: www.iucnredlist.org. [Accessed Sep 12 2012].
- King, J.M. & Heinen, J.T., 2004. An assessment of the behaviours of overwintering manatees as influenced by interactions with tourists at two sites in central Florida. *Biological Conservation*, 117(3), pp.227–234. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0006320703002957 [Accessed June 18, 2012].
- Leujak, W. & Ormond, R.F.G., 2007. Visitor Perceptions and the Shifting Social Carrying Capacity of South Sinai's Coral Reefs. *Environmental Management*, pp.472–489.
- Lusseau, D. & Bejder, L., 2007. The Long-term Consequences of Short-term Responses to Disturbance Experiences from Whale-watching Impact Assessment. *International Journal of Comparative Psychology*, 20(2), pp.228–236.
- Manta Trust, 2012. Manta Trust [Online] http://www.mantatrust.org/ [Accessed December 12, 2011].
- Manta Watch, 2012. Manta ray code of conduct [Online]. http://mantawatch.com/site/#axzz26iWn0HAB [Accessed on Sept 5, 2012]
- Marshall, A.D., Compagno, L. & Bennett, M., 2009. Zootaxa, Redescription of the genus Manta with resurrection of Manta alfredi (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). *Zootaxa*, 28, pp.1–28.
- Mau R., 2008. Managing for Conservation and Recreation : The Ningaloo Whale Shark Managing for Conservation and Recreation : The Ningaloo Whale Shark Experience. *Journal of Ecotourism*. 7(2):213–25.
- Medio, D., Ormond, R.F.G. & Pearson, M., 1997. Effect of briefings on rates of damage to corals by SCUBA divers. *Biological conservation*, 79(1), pp.91–95. Available at: http://cat.inist.fr/?aModele=afficheN&cpsidt=2548702 [Accessed September 1, 2012].
- O'Connor, S., Campbell, R., Cortez, H., & Knowles, T., 2009. Whale Watching Worldwide: tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare, Yarmouth MA, USA, prepared by Economists at Large.
- O'Neill, F., Barnard, S. & Lee, D., 2004. Best practice and interpretation in tourist/wildlife encounters : A wild dolphin swim tour example. Wildlife tourism research report series: no. 25. p.58.
- Orams, M., 2004. Why dolphins may get ulcers : considering the impacts of cetacean-based tourism in New Zealand. Tourism in Marine Environments. 1, pg. 1-12.
- Quiros, A.L., 2007. Tourist compliance to a Code of Conduct and the resulting effects on whale shark (*Rhincodon typus*) behaviour in Donsol, Philippines. *Fisheries Research*, 84(1), pp.102–108. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0165783606004061 [Accessed June 18, 2012].
- Rowat, D. & Engelhardt, U., 2007. Seychelles: A case study of community involvement in the development of whale shark ecotourism and its socio-economic impact. *Fisheries Research*, 84(1), pp.109–113. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0165783606004073 [Accessed July 8, 2012].
- Samuels, A. & Bejder, L., 2004. Chronic interaction between humans and free-ranging bottle-nose dolphins near Panama City Beach, Florida, USA. , 6(1), pp.69–77.

- Sorice, M.G., Shafer, C.S. & Scott, D., 2003. Managing Endangered Species within the Use/Preservation Paradox: Understanding and Defining Harassment of the West Indian Manatee (*Trichechus manatus*). *Coastal Management*, 31(4), pp.319–338. Available at: http://www.tandfonline.com/doi/abs/10.1080/08920750390232983 [Accessed July 18, 2012].
- Stevens, G. Personal communication (July-September 2012). Director of the Manta Trust and the Maldivian Manta Ray Project, Maldives.
- Topelko, K.N. & Dearden, P., 2005. The Shark Watching Industry and its Potential Contribution to Shark Conservation. *Journal of Ecotourism*, 4(2), pp.108–128.
- UNESCO, 2011. Global list of biosphere reserves, UNESCO. [Online] http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_mab_BR2012.pdf [Accessed Sept 2, 2012]

Appendices

Appendix 1.

The proportion of natural undisturbed manta ray behaviours at Hanifaru Bay and the number of responses elicited during each behaviour type.

Natural Behaviour Type	**Site**
Response type	**Hanifaru**
co-op feeding	**33.01%**
Approaches snorkeller	2.94%
Avoidance	8.82%
Course re-direction	17.65%
Dive avoidance	1.47%
Flight	1.47%
No response	67.65%
feeding	**60.68%**
Approaches snorkeller	7.20%
Avoidance	15.20%
Course re-direction	21.60%
Dive avoidance	2.40%
Flight	1.60%
No response	51.20%
UNK	0.80%
travelling	**6.31%**
Course re-direction	23.08%
No response	76.92%
Grand Total	**100.00%**

Appendix 2.

Additional activities

- As an extension to the current research project I am also analysing footage of humans and manta rays interacting taken from You Tube. Uploaded footage on this site is largely personal footage of diver and/or snorkeller encounters with manta rays. This will incorporate a number of other variables into the project such as different locations and inclusion of interactions with *Manta birostris.* This exploration of further video data will allow exploration of these other variables and likely support the current findings suggesting the implementation of a code of conduct is important for sustainable manta watching.
- During dives on manta cleaning stations there were not always manta rays present to film. I used the time not spent filming to create a catalogue of photographs of pink line disease on *Porites lutea* at various dive sites across the atoll. These have been sent to a researcher who is currently analysing coral disease data for IUCN.
- While conducting the research project I collected tourism data for the Manta Trust, including number of boats in the bay, number of people aboard each vessel, violations committed, and various environmental variables. This data is used to document site use both spatially and temporally and will be explored to investigate the level of tourism over time.
- One of the main aims of the Maldivian Manta Ray Project is to catalogue the sighting of individual mantas in order to explore their behaviour and migration patterns. I assisted with this by collecting manta ID photographs through free diving while out on the research vessel. The photographs were later edited and analysed and placed into the extensive manta ray database.
- In order to increase data collection I often accompanied the Four Seasons dive boat and Manta-on-call boat. During this time I acted as a source of information on manta rays to the guests and spent many hours talking to them about different aspects of our work and manta behaviour generally. At feeding sites I assisted the guides in helping direct guests to the right spot to locate mantas and get the most out of their manta ray encounter. Further time was spent talking to guests at Managers Cocktails each week, giving me the opportunity to talk about the work being carried out by the Maldivian Manta Ray Project. This encouraged greater participation in 'Manta-on-call' and attendance at the weekly Manta Ray talk at the Marine Discovery Centre.
- I led the staff charter to various sites around the atoll to find manta rays which gave land-based staff the rare opportunity to interact with mantas. In this way, they are able to talk to guests about their encounter and provide more information about opportunities to interact with mantas encouraging participation in manta activities.

Appendix 3

Regulations found in the EPA Management Plan for Hanifaru Marine Protected Area (2011)

Guild lines for Phase 1:

- The schedule for the users will accommodate safari vessels and resorts to use Hanifaru area in an orderly manner. Hence the each safari vessels as well as resort and local vessels (not carrying international tourists) will only be allowed access on every other day. EPA will issue the schedule.
- Only five vessels (excluding rangers) are allowed to enter Hanifaru at a given time.
- The resorts and the liveaboards/safari boats will themselves organize a booking system or other arrangements to determine how they will operate within the 5 slots that are available at any one time.
- All vessels should enter/exit Hanifaru from the Northern Entrance Only (which is marked).
- Proceed to the drop area on the northern side of the bay (a jetty will be available from 2012).
- Visitors should enter Hanifaru Bay by swimming. Each group of visitors are allowed to stay in water for a maximum of 45 minutes.
- After dropping visitors, vessels should proceed to the mooring buoys established in the lagoon.
- Once observation is completed, visitors must return to the drop off area.
- Vessels should move to the drop off area (or to the jetty) to pick up their visitors.
- All vessels should leave Hanifaru from the northern Entrance only.

3.2 Visitor Activities within Hanifaru Bay

- All tours operators and tour guides must have an official permit to enter Hanifaru bay.
- All tour groups (visitors) must be accompanied by an official certified tour guide with a maximum of 10 clients per guide.
- The number of persons in the water of the Bay at any one time shall not exceed 80.
- Tour operators are legally responsible for their client's behaviour and actions.
- All tour operators need to ensure all clients entering Hanifaru Bay are fully aware and abide by the specific requirements of their permit and the Hanifaru Management Plan.
- Only free diving (snorkeling) is permitted from January 2012.
- SCUBA diving is prohibited from January 2012.
- Use of any motorized diving equipment (e.g. underwater scooter) is prohibited.
- Use of flash photography/videography is prohibited without a special permit from EPA.
- All physical contact (e.g. touching, ride on) with the mega fauna is prohibited.
- All visitors and guides are to maintain a minimum distance of three (3) meters from all mega fauna and every effort must be taken not to actively swim directly in front of any animal. In the case that an animal swims directly at a tourist the individual needs to remain motionless (e.g. floating) at the surface until the animal moves away.
- All research activities require a written permit from EPA; this permit must be produced upon request.
- Commercial videography / photography require special written permission from EPA. Hanifaru Management Authority reserves the right to charge for any commercial videography / photography.