

The Value of
Diver Knowledge
for Manta Ray Conservation in the Maldives

Environment Department
MSc Marine Environmental Management
Summer Placement Project



UNIVERSITY *of* York

Table of Contents

Abstract	3
Introduction	3
Methods	5
Results	7
Manta ray sightings and seasonal patterns	7
Manta ray hotspots	7
Changes in manta ray abundance	8
Abundance of other marine species	9
Perception and knowledge of marine conservation in the Maldives	9
Hanifaru Bay	9
Manta ray conservation	10
Discussion	11
Changes in abundance of other marine animals	12
Perception and knowledge of marine conservation	13
Conclusion	13
Acknowledgements	14
References	14
Appendix 1	16
Appendix 2	20

Abstract

Manta rays (*Manta* spp.) are a major attraction for divers and snorkelers worldwide, generating US\$140 million to local economies through tourism annually. However, increasing demand for manta gill plates in Asian markets has led to unsustainable fishing pressure and reports of population declines. The Republic of Maldives, unlike many other Asian countries, does not have a manta ray fishery, instead the rays are protected, generating over US\$8 million for the local economy each year. For the last decade in the Maldives, the economically valuable reef manta ray (*M. alfredi*) has been studied by the Maldivian Manta Ray Project (MMRP). Data collected by the MMRP between 2005 and 2014 indicated considerable fluctuations in regional manta ray abundance, raising concern over the long-term health of this population. However, longer-term data series are required to more accurately assess the drivers of temporal variations in manta ray abundance. With limited quantitative data of manta populations in the Maldives available prior to 2005, this study utilised diver knowledge to gather historical observations, conducting interviews with experienced divers to assess how manta ray distribution and abundance may have changed over time. 61 interviews with working divers in the Maldives were conducted during July and August 2015, with each interviewee having on average 18 years' experience working in the country. The results found that divers were useful indicators of manta ray distribution, and their responses suggested that 'hotspots' of manta activity had not changed radically over recent years. However, many 'new' manta aggregation sites have emerged, most likely because of an expanding tourism industry and exploration for novel areas. At regularly visited sites the majority of divers (58%) perceived a decrease in manta rays since the start of their careers, and particularly since 2010. Divers also highlighted specific sites where declines may be more acute, where it was suggested anthropogenic factors could be responsible. Diver perception of marine conservation in the Maldives exposed considerable dissatisfaction with current management of Marine Protected Areas (MPAs) and criticism of the lack of communication



and collaboration between the diving industry, marine biologists, and conservationists. Nevertheless, there was general support for more conservation management initiatives, highlighting the importance of improved stakeholder engagement if successful conservation outcomes are to be achieved.

Introduction

Manta rays are large planktivorous elasmobranchs in the family Mobulidae, comprised of 11 species: two within the genus *Manta*, and nine within the genus *Mobula* (Couturier *et al.* 2011). Until recently, the former had been considered a monospecific genus, with manta rays having a circumtropical distribution. However, since 2009, taxonomic revisions have differentiated the oceanic manta (*M. birostris*) from the reef manta (*M. alfredi*) (Marshall *et al.* 2009). Both species have a wide range and are found in tropical and subtropical waters globally (Marshall *et al.* 2009). While both species venture into the mesopelagic zone, reef manta rays frequently occur inshore around coral reefs and coastlines, whereas the oceanic manta spends more time offshore (Couturier *et al.* 2011). A third species, the Caribbean manta (*M. cf. birostris*), is believed to occur in the Caribbean Sea and Atlantic Ocean, although confirmation of this is pending further taxonomic evidence (Marshall *et al.* 2009).

Due to their zooplanktivorous diet, manta rays form predictable aggregations at feeding sites and have distribution patterns associated with seasonal availability of their prey (Anderson *et al.* 2011a; Couturier *et al.* 2012). Manta rays also aggregate at cleaning stations, often in

close proximity to feeding sites, which combined, has enabled tourism to develop around these species in many countries throughout their range. The Republic of Maldives has the world's largest population of reef manta rays, enabling reliable encounters with this species within the country throughout the year. Located in the northern Indian Ocean the Maldives comprises 26 geographically distinct atolls with approximately 1,190 coral reef islands (McClanahan and Muthiga 2014). The country rarely experiences extreme weather conditions, although the biannual monsoons strongly influence the region's climate and surrounding waters (Anderson *et al.* 2011a). The northeast monsoon (December to April) winds drive oceanic currents predominantly westward, whereas during the southwest monsoon (May to November) the winds reverse, driving the currents eastward (Anderson *et al.* 2011a). As these seasonal currents pass over the Maldives ridge, which acts as a barrier to oceanic currents, upwelling causes nutrient-rich waters to become mixed in the upper euphotic zone (Anderson *et al.* 2011a). This promotes productivity blooms of phytoplankton on the leeward side of atolls, supporting a high zooplankton biomass (Anderson *et al.* 2011a), which in turn sustains the manta ray population, which migrates across the archipelago, moving with the shifting monsoons in search of prey.

Manta ray life-history characteristics, such as late maturity, low fecundity and slow growth, make them highly vulnerable to fishing-pressure (Couturier *et al.* 2012). Fished for their gill plates, which in the last two decades have become a highly sort-after ingredient in the Asian market (O'Malley *et al.* 2013), manta populations as a result have declined in several locations (Couturier *et al.* 2012). The Maldives, unlike some other countries in Asia, do not have a targeted fishery for these animals. In 2014, the Maldivian Government demonstrated foresight in recognising that a manta ray fishery could develop and so made it illegal to harm, capture, or export any ray species (Murray 2014; BABR 2014). In making this decision, the Government acknowledged the economic importance of live manta rays to the country's tourism industry, for which



the genus is estimated to generate over US\$8.1 million annually (Anderson *et al.* 2011b). The tourism industry in the Maldives has grown dramatically since 1972, with over 1.1 million tourist arrivals in 2013 to the 109 resorts and local guesthouses throughout the country (NBS 2014). Coral reefs and charismatic megafauna make the Maldives an attractive place for diving and snorkelling, with these activities being the primary purpose of visits for 17% of international tourists in 2014 (Ministry of Tourism 2015). Manta rays are now a major tourist attraction and the experience of diving and snorkelling with them has become a highly sought-after activity in many countries (Anderson *et al.* 2011b; O'Malley *et al.* 2013). In particular, tourists in the Maldives are willing to pay more for manta excursions than those offering sharks or turtles (O'Malley *et al.* 2013), and many people visit the country with an expectation of seeing these animals (Anderson *et al.* 2011b). Manta rays often feature in the marketing strategies and advertisements of tour operators, many of which have recognised the importance of offering well-informed manta

excursions, enlisting the help of marine biologists, facilitating research into manta ray biology and ecology (Anderson *et al.* 2011b).

The Maldivian Manta Ray Project (MMRP) is a research and conservation programme which has been conducting research on the resident population of reef manta rays in the Maldives since 2005 (Manta Trust 2015a). Using photographic and video monitoring techniques, the project has recorded over 35,000 individual photo-ID sightings of more than 3,700 individually identified reef manta rays (MMRP 2015). These data have improved the knowledge of manta ray abundance and behaviour and provided further insight into regional population dynamics and the location of aggregation sites (Manta Trust 2015a). As part of its programme, the MMRP works closely with tourists, local communities and surrounding resorts to educate and engage them in manta ray research and conservation (Manta Trust 2015a). The organization has been instrumental in decisions to designate Marine Protected Area (MPA) status to a unique manta aggregation site at Hanifaru Bay, and its research continues to support management plans for the surrounding area (MMRP 2015).

Recent reports from the MMRP have indicated regional fluctuations in manta ray populations (Stevens and Brooks 2011; Stevens *et al.* 2012). The lowest numbers of sightings were recorded in 2011 and 2012 throughout the Maldives, with significantly fewer sightings at the key monitoring site at Hanifaru Bay in particular (Froman and Stevens 2013). This was attributed to the unseasonable weather patterns observed throughout that year. Wind strength in 2011 and 2012 was significantly lower than in previous years (Froman and Stevens 2013). Without the strong winds, it was suggested that the monsoonal currents were unable to initiate the productivity bloom upon which the zooplankton, and ultimately the manta rays, rely (Stevens and Brooks 2011). To understand local fluctuations in manta ray populations, such as the above, and to establish whether they are a recent phenomenon or part of a naturally occurring cycle, long-term observations of manta ray abundance and distribution are needed. Prior



to a study conducted by Sawers (2014), there were few data on manta ray abundance and distribution pre-2005. Sawers (2014) captured the traditional knowledge of local fishers on regional changes in the abundance of charismatic species such as manta rays and whale sharks. The results highlighted the potential of traditional knowledge in identifying 'hotspots' and regional changes to local marine life, and supported a growing acceptance that traditional knowledge is an important factor when implementing conservation and management strategies (Drew 2005; Rosa *et al.* 2005; Gandiwa 2012).

The current study extends use of historical observations through interviews with divers who have been diving in the Maldives for at least ten years to assess how manta ray distribution and abundance may have changed over time. In addition, it seeks to examine the extent of the dive community's perceptions and knowledge of marine conservation in the Maldives. The study also aims to compare the dive community's perception of changes in the abundance of other charismatic marine species with that of local fishers described by Sawers (2014).

Methods

Between July and August 2015, semi-structured interviews were conducted with divers working as guides in the Maldives. Selection of interview candidates was deliberately non-random and only those with at least ten years of diving or working experience in the Maldives were approached. Colleagues at the Manta Trust generated a

Questions from Sawers (2014)	Questions in the current study
<i>"What time of the year are manta rays most commonly observed?"</i>	<i>"Which months of the year are manta rays most commonly seen in the Maldives in general?"</i>
<i>"What time of the year are manta rays most commonly observed?"</i>	<i>"Please specify whether or not you have seen a change (increase, decrease, no change) in the numbers of: Whale sharks, Reef sharks, Sea turtles, Groupers, Baitfish, Tuna, Dolphins, Other</i>
[Referring to Hanifaru Bay MPA] <i>"Do you know why the MPA was established?" (Yes/No)</i> - <i>"If yes, what was the reasoning behind designating the Hanifaru Bay MPA?"</i> <i>"How did the establishment of the MPA affect you?"</i> <i>"Do you think the establishment of the Biosphere Reserve has been beneficial?" (Yes/No)</i> <i>"Is the Biosphere Reserve well-managed?"</i>	<i>"Do you know why the MPA was established in Hanifaru Bay?" (Y/N)</i> - <i>"If yes, what was the reasoning behind the designation?"</i> <i>"Did the establishment of the Hanifaru Bay MPA affect you?" (Y/N)</i> - <i>How?</i> <i>"Do you think the establishment of the Hanifaru Bay MPA has been beneficial?" (Y/N)</i> - <i>Why?</i> <i>"In your opinion, is the Hanifaru MPA well managed?" (Y/N)</i> - <i>Why?</i>
<i>"How do you feel about the work of scientists and conservationists in the Maldives?"</i> <i>"In general, how do fishermen feel about manta rays?"</i> i.e. are they seen as: a menace/feared/respected?	<i>"How do you feel about the work of scientists and conservationists in the Maldives?"</i> <i>"In general, how do you think the diving industry in the Maldives perceives manta rays?"</i>

Table 1. Questions posed by Sawers (2014) and their counterparts in the current study.

database of suitable candidates, all of whom were emailed to inform them about the project and to ask for their assistance. Additional contacts were acquired by asking interviewees to recommend further divers who fitted the criteria to participate. Where possible, interviews were conducted face-to-face but, due to the distance and inaccessibility of some of the islands, interviews were mainly conducted by telephone or through the Internet voice-call platform Skype. On five occasions where interviews could not be arranged, the interview questionnaire was emailed for respondents to answer and returned at their convenience.

Interview design

The interviews were designed to last between 30-45 minutes and were a mixture of 'open' and 'closed' questions, whereby the former allowed interviewees to give reasons for their answers (Appendix 1). Eight questions, highlighted in Table 1, were similar to those posed by Sawers (2014), so comparisons could be made between

her target audience of fishers and the dive community in the current study.

Interviews with 61 divers were conducted during July and August 2015. Those interviewed had an average of 18 years' experience working in the Maldives, with a maximum of 36 years and a minimum of 7 years. The interview comprised four sections: a) interviewee experience and background information, b) historical and current manta ray sightings, c) change in abundance of other marine animals, and d) perception and knowledge of marine conservation efforts in the Maldives. A map with highlighted sites (Appendix 2) was emailed to the interviewees prior to the interview, and was used to avoid misunderstandings over the location of sites. To eliminate bias, it was stressed that the respondents' answers need not be limited to those sites highlighted.

Data analysis

Microsoft Excel was used for data recording and for descriptive statistics.

Results

The majority of respondents (79%) dived everyday although 15% claimed their diving time had reduced over recent years. Almost half the respondents (n=28) had worked on both liveaboards and at resorts; 18 had worked solely at resorts or local islands, and the remaining 15 solely on liveaboards.

Manta rays

Manta ray sightings and seasonal patterns

Respondents' views on the principal months for viewing manta rays differed from those reported by Sawers (2014), where the majority of local fishers highlighted June and July when mantas were most likely to be seen. Within the dive community 46% of respondents (n=26) quoted specific months when they saw manta rays more often (Fig. 1). Of those, 72% (n=44) reported that the season when they see manta rays had not changed during their career, some stating that, 'mantas follow the monsoon which influences the currents and plankton densities at certain sites'.

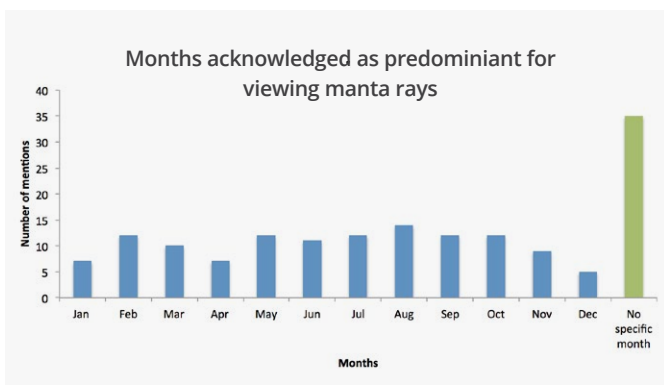


Figure 1: The principle months cited for viewing manta rays

Manta ray hotspots

Respondents were asked to specify the three manta sites they visited most often, a) prior to 2005, and b) over the last five years. From a total of 55 sites mentioned prior to 2005, five emerged as the most popular (Table 2; Fig. 2). 31 sites were mentioned only once, however nearly half of respondents referred to Lankan Beyru in North Malé Atoll (n=26). When asked about the manta sites they visit most often now (i.e. during the last five years) similar sites emerged as the most popular (Table 3; Fig. 3), however the

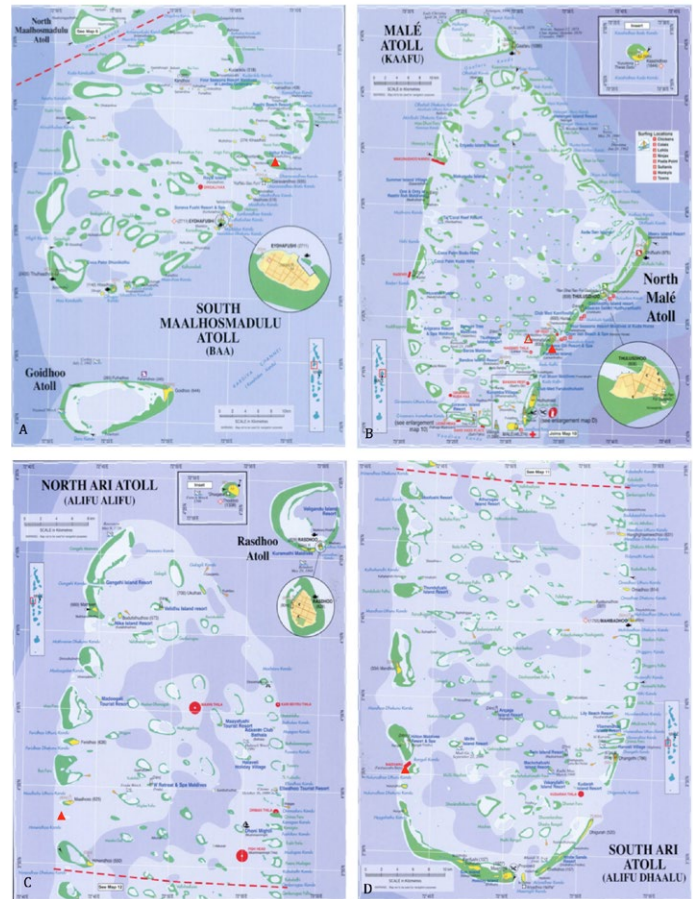


Figure 2: Location of the five most popular manta sites visited by respondents prior to 2005. Each site is highlighted by a triangle: Hanifaru Bay (Baa Atoll, Map A), Lankan Beyru (North Malé Atoll, Map B, filled triangle), Sunlight Faru (North Malé Atoll, Map B, unfilled triangle), Dhonkalo Thila (North Ari Atoll, Map C), Rangali Madivaru (South Ari Atoll, Map D).

Site	No. of respondents who mentioned visiting each site
Lankan Beyru	26
Dhonkalo Thila	17
Rangali Madivaru	17
Sunlight Faru	11
Hanifaru Bay	10

Table 2: The five most commonly visited sites prior to 2005

total number of sites mentioned by all respondents (n=70) was greater than those prior to 2015; 36 sites were 'new', i.e. not mentioned in the earlier timeframe. Lankan Beyru was again the most popular site visited over the last five years, listed by 18 respondents; a slight decrease from 26 prior to 2005. The area of Moofushi emerged as a popular site in the last five years, replacing Dhonkalo Thila whose popularity decreased five-fold.

The largest aggregations of manta rays were witnessed by respondents at cleaning stations in Lankan Beyru and

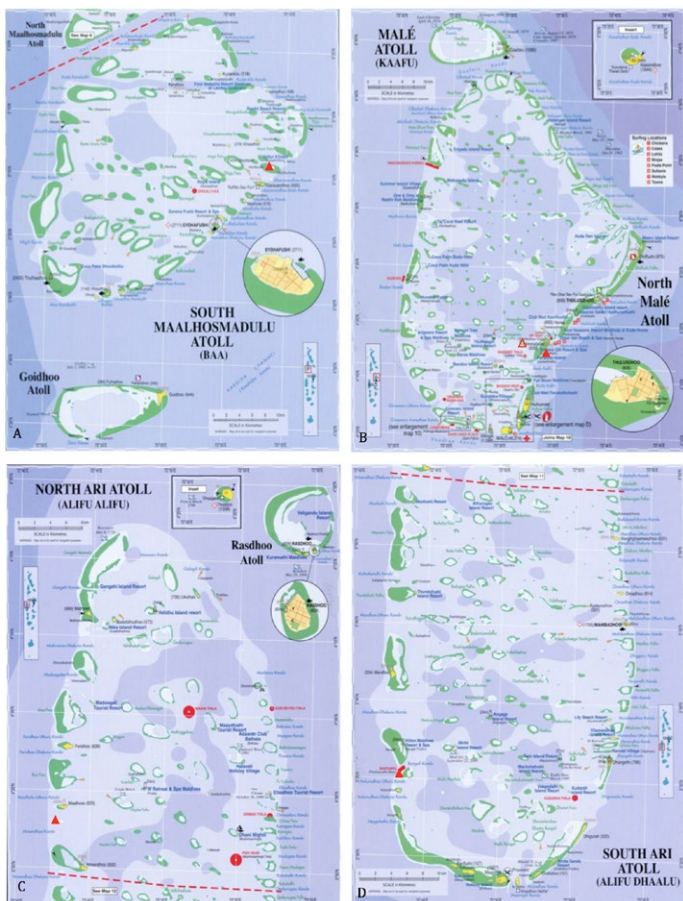


Figure 3: Location of the five most popular manta sites visited by respondents during the last five years. Each site is highlighted by a triangle: Hanifaru Bay (Baa Atoll, Map A), Lankan Beyru (North Malé Atoll, Map B, filled triangle), Sunlight Faru (North Malé Atoll, Map B, unfilled triangle), Moofushi (South Ari Atoll, Map C, filled triangle), Rangali Madivaru (South Ari Atoll, Map C, unfilled triangle).

Site	No. of respondents who mentioned visiting each site
Lankan Beyru	18
Dhonkalo Thila	17
Rangali Madivaru	14
Moofushi	12
Hanifaru Bay	10

Table 3: The five most commonly visited sites during the last five years

Dhonkalo Thila and at the feeding station Hanifaru Bay (33%, 26% and 53% respectively), particularly during 2007 (Figs. 4 and 5).

Changes in manta ray abundance

57% of respondents suggested that manta rays had become less common at one or more of the three sites they visited most often during the last five years (Fig. 6). More specifically, at Lankan Beyru, Rangali Madivaru, Sunlight Faru and Hanifaru Bay, respondents perceived manta rays to be less common than at earlier visits (Fig. 7). However,

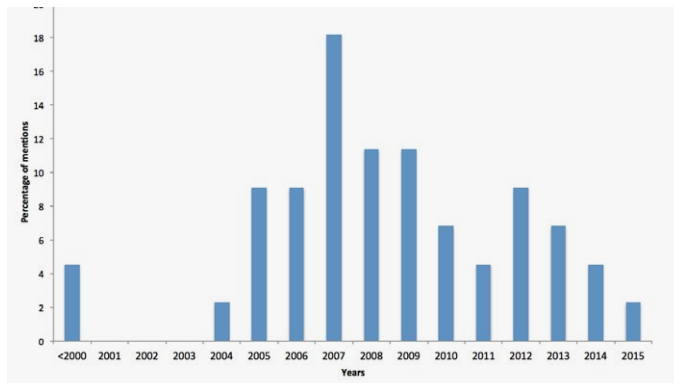


Figure 4: Years when the largest aggregations of manta rays were seen at feeding stations (n=44).

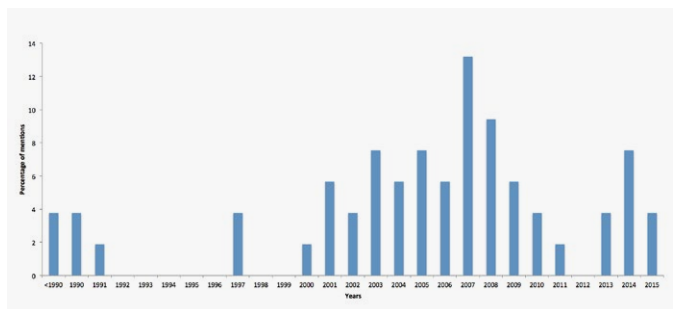


Figure 5: Years when the largest aggregations of manta rays were seen at cleaning stations (n=53).

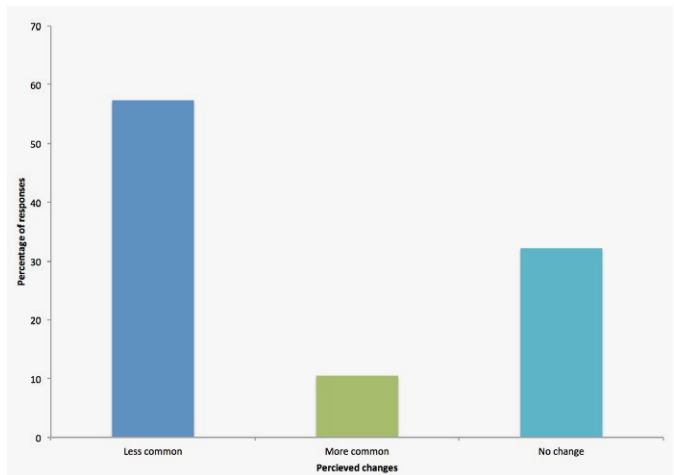


Figure 6: Perceived changes in the abundance of manta rays at sites most commonly visited during the last five years (n=171).

the dive community had very different views on the abundance of manta rays at Moofushi and responses were evenly split between less common, more common and no change (Fig. 7). 66% of respondents reported such a decrease in manta rays that they very rarely, or no longer, see them at some sites, most notably Dhonkalo Thila and Lankan Beyru (25% and 15% of respondents respectively). The majority of respondents (19%) identified 2010 as the year when they first noticed an apparent decrease in manta rays; half of those who specified Dhonkalo Thila also cited 2010. In contrast, 16 respondents (the majority

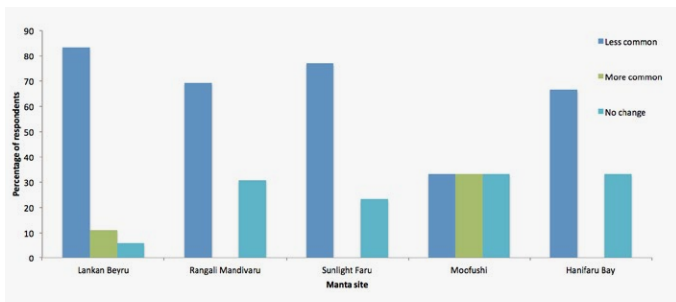


Figure 7: Perceived changes in the abundance of manta rays at the five most commonly mentioned sites respondents visited over the last five years.

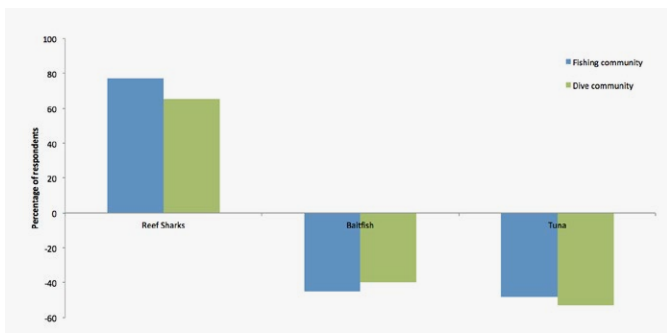


Figure 8: A comparison of perceptions in fishing and dive communities regarding changes in abundance of marine species. The data points below zero indicate the percentage of respondents who perceived a decrease in abundance of marine species. Fishers n=62; dive community n=61.

with current or past experience of liveaboard work) noted manta rays visiting 15 new sites, notably Moofushi.

Abundance of other marine species

60% (n=36) of respondents in the current study reported a change in whale shark abundance; similar to the 58% described by the local fishing community in Sawers (2014) study. However all of the fishers who reported a change in the numbers of whale sharks referred to population decline, whereas only 33% of respondents from the diving community agreed; the remaining 27% of divers reporting a change, perceived an increase in abundance. The majority of divers attributed this increase to running tourist or scientifically-based excursions focused on whale sharks, or to a transfer of workplace to South Ari Atoll where the majority of whale sharks can be found. The remaining respondents in the current study (37%) thought the numbers of whale sharks had not changed.

Perceived changes in abundance of reef shark, baitfish and tuna were broadly similar between the two communities (Fig. 8). The majority of fishers and divers (77% and 65% respectively) considered reef sharks to have increased and attributed this to the recent ban on shark

fishing and exportation of shark products in 2010; for example one person commented, “there had been a notable increase [in the numbers of sharks] especially over the last two years”. Decreases in the abundance of tuna and baitfish were also recognised by both communities (Fig. 8) although 47% of divers saw no change in the numbers of baitfish and a number of respondents commented they are, “extremely seasonal” and “their numbers have been fluctuating for years”. Nearly half of respondents from the dive community noticed a decrease in the number of groupers reporting that they, “do not see any large ones anymore” and “the sizes are definitely getting smaller”.

Perception and knowledge of marine conservation in the Maldives

Most respondents (89%) thought scientists and marine conservationists in the Maldives, “do a good job” and their work is important, although several thought scientists “can cause problems and can be unnecessary”. Despite this, the majority of respondents (70%) were currently involved, and 10% said they had been involved with at least one conservation programme in the past. These ranged from PADI’s Project Aware programme, to assisting coral restoration projects and taking identification photos for the Manta Trust or the Maldives Whale Shark Research Programme.

Respondents were also asked, “Are you satisfied with the level of communication and collaboration between the scientists/conservationists and the tourism industry?” Over half replied they were not (56%); some stressed that, “scientists don’t share any information”, “there is no coordination of efforts” highlighting, “there is definitely a wall between stakeholders and the scientists”. When asked how this could be improved, social media was emphasised as a platform. The need for “more collaboration between scientists and dive guides” was also highlighted, as was the desire for scientists and conservationists to give more presentations to guests, both on resorts and liveaboards.

Hanifaru Bay

All respondents had heard of the Hanifaru Bay Marine Protected Area (MPA), while 95% had heard of the

UNESCO World Biosphere Reserve covering the entirety of Baa Atoll. Regarding Hanifaru Bay, almost all respondents (97%) knew why the area was established as a MPA, the majority citing, “protection of mantas and whale sharks that aggregate there” as the reason for designation. Thirteen respondents recognised the human impact on the area, commenting that protection was put in place, “to decrease the human pressure on the area” and, “for the safety of people in the water”.

Over half of respondents (59%) stated the establishment of the MPA had not affected them; mainly citing we are “too far away for it to affect us”. Those respondents who had been affected (38%) gave varied reasons stating, “there are now more fees for guests and [tour] operators” and, “you now have to buy permits and pay to enter even if you don’t see mantas”. Two respondents also highlighted that, “liveaboards can only [visit] on certain days” ultimately, “restricting the routes [we can take]”. The majority of respondents who had been affected either currently worked on a liveaboard or had some liveaboard experience (n=18). However, the majority of respondents (85%) believed the establishment of the MPA had been beneficial stating, “it regulates the numbers of people swimming with the mantas, allowing the mantas more space and less abuse” and had also, “increased the education and awareness of mantas”, although comments were made suggesting, “the [management] regulations need to be tightened”. Nearly a quarter of respondents (23%) thought the MPA was well managed and acknowledged the presence of the Rangers who, “are there to collect the money and enforce the rules”, and the management of liveaboards and resorts that, “have their specific days on which they can enter the Bay”. 46% (n=28) declared they did not know if the MPA was well managed, 17 of which specified they were too far away from Hanifaru Bay or had never visited so did not know. 8% of respondents responded negatively, while 23% gave variable answers, reasoning, “the management level was ok” or, “[Hanifaru Bay] is well managed now, but not when it was first established” and also that Hanifaru Bay is “well managed in concept but not in practice”.



Manta ray conservation

Respondents were asked, “How do you think the diving industry in the Maldives perceives manta rays?”, and almost all of the responses (n=59) regarded manta rays as, “useful for tourism purposes”; one respondent going so far as to say, “[the diving industry] overlay the manta with the dollar sign”. There were however, references to the intrinsic value of manta rays, with responses such as, “manta rays are adored, people love seeing them” and, “manta rays are respected”. It was therefore unsurprising that 82% of respondents knew that manta rays were a legally-protected species in the Maldives and 93% thought they should be legally protected. However, there were references (n=4) to the fact that there isn’t an established manta fishery in the Maldives, “so why are they protected”, although nine respondents praised the Government’s foresight commenting that, “the protection is good in case a dedicated manta fishery does open up here in the Maldives”.

Only two respondents were unaware of rules or regulations regarding diving or snorkelling with manta rays. The remaining 59 did know of such rules or regulations with eight in particular being highlighted, the most common (n=35) being, “don’t touch the manta rays”. Eight respondents recognised one “shouldn’t get too close to the manta rays”, whereas another 19 specifically mentioned proximity to cleaning stations, stating one “shouldn’t go on top of, or too close to a manta cleaning station”. 22 respondents commented that the rules or guidelines they were aware of were “the guidelines issued by the Manta



providing broad scale, long-term information on elasmobranch populations (Ward-Paige and Lotze 2011; Ward-Paige *et al.* 2013). Due to the regularity with which divers visit certain sites, they can become very familiar with the features of local flora and fauna (Ward-Paige and Lotze 2011) and it is therefore suggested they could become sensitive to changes in the location or abundance of particular species. Divers often take well-documented logs of their dives, including date, location and commentary on notable observations (pers. obs.). These logged accounts could therefore provide a valuable reference for temporal population fluctuations. There is a working assumption in the current study that, due to the popularity of manta rays, dive guides, masters and instructors will have a tendency to visit the sites most frequented by manta rays (hotspots) in order to satisfy guests, and to abandon those sites where manta rays are no longer encountered. However, it became apparent during the course of interviews that some information was withheld, because divers were reluctant to divulge knowledge of key sites to preserve their commercial advantage.

Trust" or, "the rules my resort issues". Respondents were therefore asked, "Do you think there should be Government regulations in place, such as a code of conduct to control interactions with manta rays", to which the majority (n=50) were in favour. The remaining 11 had reservations stating "no one will follow the rules, even if they were in place" or commenting that the drive for controlling interactions with manta rays "really needs to come from within the diving industry itself", with "community-made rules, sanctions and more self-discipline".

Discussion

Results from the current study contribute to continuing research into the Maldivian population of reef manta rays; in particular, how distribution and abundance may have changed over time. The results also give further insight into societal awareness and attitudes towards marine conservation in the Maldives, which may have implications for future marine management programmes.

The use of traditional knowledge has become increasingly recognised as a source of valuable information (Davis and Wagner 2003) and scientists have traditionally enlisted the help of extractive resource users, such as fishers, to gather ecological information about species encountered by traditional peoples (Drew 2005). This has led to a greater understanding of animal abundance and population trends and has also assisted in the implementation of suitable management programmes for key conservation areas (Drew 2005; Rosa *et al.* 2005; Gandiwa 2012). The current study enlisted the help of experienced divers, which have been recognised in previous studies for

The results highlighted a number of manta sites that were regularly frequented by divers, (Tables 2 and 3; Figs 2 and 3.). There was little difference between the most popular sites during the two time periods (pre-2005 and during the last five years); Lankan Beyru, Rangali Madivaru, Sunlight Faru and Hanifaru Bay were mentioned most often. This suggests these sites are still manta ray 'hotspots' since divers would not continue to visit if manta rays were absent. Furthermore, three of the most popular dive sites (Lankan Beyru, Dhonkalo Thila and Hanifaru Bay) were also those where respondents had witnessed the largest aggregations of manta rays. It is reasonable to conclude that the popularity of these sites is due to a high likelihood of seeing large numbers of manta rays. The decreased popularity of one site (Dhonkalo Thila) further supports this assumption; the number of respondents quoting it as a popular site decreased five-fold since 2005. Moreover, nearly a quarter of respondents commented that manta rays have decreased to a point where they no longer, or very rarely, see them anymore. There was however, an

increase in the overall number of manta sites (55 to 70) mentioned by respondents over the two time-periods. This may reflect the increased diversity of sites being discovered and frequented by an expanding tourism industry. For example, one site (Moofushi) emerged as a relatively 'new' site for encountering manta rays (Table 3; Fig. 3).

There was a consensus that manta rays are less common now, particularly at Lankan Beyru, Rangali Madivaru, Sunlight Faru and Hanifaru Bay, than during earlier visits; the majority of respondents first noted a decline, especially at Dhonkalo Thila, from 2010. Hanifaru Bay, as a designated MPA, has been particularly well studied since 2008 and MMRP reports show that annual sightings have been significantly lower over the last two years (Stevens and Froman 2014). The MMRP also recorded the lowest number of sightings (n=2085) across the whole of Baa Atoll in 2011 (Stevens and Froman 2014). This was attributed to unseasonable conditions recorded during the southwest monsoon affecting the concentration of zooplankton and therefore manta ray activity (Stevens and Brooks 2011). However, anecdotal evidence from the current study implied that human activity may have caused the manta rays to desert key sites. Respondents suggested that fewer manta rays were seen, "because the cleaning stations are occupied by divers instead", and there are "too many people crowding [the cleaning station]". The incessant pressure on popular manta sites, as described by one respondent, can be seen, "from 08.00 in the morning to 17.00 in the afternoon" where "sometimes you can see four mantas with about 50 or 60 divers".

Several studies have reported direct and indirect negative impacts from diving and snorkelling activities on coral reef ecosystems, for example unintentional contact from fins or equipment (Tratalos and Austin 2001; Barker and Roberts 2004). Despite MMRP data on boat and tourist pressure (Stevens and Froman 2014), little is known about the impacts of disturbance on the behaviour of manta rays at cleaning and feeding stations. Some studies have



suggested that improperly managed marine megafauna tourism may have a negative affect (Graham 2007; Quiros 2007). The current study reinforces the need for more research, and a project is currently underway to gain a better understanding of human-manta interactions (Annie Murray pers. comm.).

Changes in abundance of other marine animals

Sawers (2014) speculated that a perceived increase in the numbers of reef sharks by local fishers may be associated with their wish to reinstate limited shark fishing. Although not directly comparable due to spatial differences, the fishers' observations were corroborated by results in the current study, where over half (65%) of divers also perceived an increase. This perception was attributed to the shark fishing and export ban (implemented in 2010) and suggested that conservation efforts to recover dwindling populations were having a positive effect. In contrast, whale sharks have been declining throughout Baa Atoll over the last seven years (Stevens and Froman 2014); a trend also noted by local fishers (Sawers 2014). A third of respondents (33%) in the current study reported a decrease in whale shark numbers since the start of their career whilst a further 27% perceived an increase; this was attributed to either a change of workplace or to increased excursions focused on whale sharks specifically. It has been suggested that whale shark sightings could be linked to environmental changes (Sequeira *et al.* 2014) or to migration and subsequent exploitation elsewhere (Bradshaw *et al.* 2008; Sawers 2014).

Perception and knowledge of marine conservation

Respondents seemed very knowledgeable about appropriate behaviour when diving or snorkelling with manta rays. There was also a high level of awareness of the establishment of the Hanifaru Bay MPA and the Baa Atoll UNESCO World Biosphere Reserve. Many referred to compliance, either with guidelines issued by their operator, or with the Best Practice Code of Conduct issued by the Manta Trust. This scientific, evidence-based approach provides tourists and operators with advice for interacting with manta rays both at cleaning stations and during feeding events whilst snorkelling or diving (Manta Trust 2015b). These include recommendations on vessel activity and personal behaviour in the water; refraining from chasing or touching the manta rays was a practice most frequently recognised by respondents. The Manta Trust also recommends a 3m diver or snorkeler approach limit; most respondents were aware of this but referred to a range of 2m to 5m. Whilst the use of best practice guidelines has been effective elsewhere, for example minimising the negative effect of humans on whale sharks (Mau 2008; Pierce *et al.* 2010), those issued by the Manta Trust are local recommendations for tourism operators and there are no regulations covering the region as a whole. There was wide support amongst respondents for enforcement of a legal code of conduct to facilitate more effective control of interactions with manta rays.

In contrast to local fishers (Sawers 2014), the majority of respondents in the current study regarded the establishment of the Hanifaru Bay MPA as beneficial. They highlighted benefits from reducing the numbers of tourists in the Bay at any one time, and increased awareness of manta rays. However, strong opinions were expressed regarding management practices. Whilst there was general recognition of improvements, including reduced over-crowding from well-defined 'user days' alternating between resorts and liveaboards, these restrictions presented difficulties for liveaboards in scheduling itineraries and route planning. Liveaboards cater primarily for divers, and many of the respondents were unhappy about the prohi-

bition introduced in 2012. 38% of respondents stated the designation of Hanifaru Bay MPA had adversely affected them, the majority of whom had some kind of liveaboard experience.

The interviewees also expressed the need for more interaction between scientists and the diving industry. There was considerable dissatisfaction with the current level of communication and collaboration between these two sectors; respondents stressed the importance of working together to increase awareness of the marine environment. Enhanced awareness of scientific research, and the outcome of projects, would limit misunderstanding and strengthen the relationship between the two groups. Greater use of social media was frequently mentioned as an outlet through which information could be shared and viewed easily. Recent studies have emphasised the value of social media, such as Facebook, in encouraging development of wider ocean literacy (Fauville *et al.* 2015). If posts, particularly videos or pictures, trigger an interest by being shared and discussed, it can encourage individuals to explore the ideas further, by reading more about the subject (Fauville *et al.* 2015).

Conclusions

Use of historical knowledge has provided further insight into the distribution and changing abundance of the Maldivian population of manta rays. Accounts from divers across the region have indicated a general decrease in manta ray abundance and specified certain sites where declines may be more acute. Concerns were expressed regarding the impact of increasing numbers of divers or snorkelers at cleaning and feeding stations on manta ray behaviour, including contributing to population decline at sites such as Dhonkalo Thila. Opinions varied on management practices at key sites, however, it was generally recognised that greater cohesion and improved communication is needed between the diving industry and marine biologists for successful implementation of future conservation management strategies in the Maldives.

Acknowledgments

I am extremely grateful to have been afforded the opportunity to conduct this research project in the Maldives. I wish to thank Guy Stevens, Niv Froman, Annie Murray and Tam Sawers for this incredible opportunity, and for their continued support and guidance during the research process. To the Four Seasons at Landaa Giraavaru for hosting me during my time in the Maldives and to the respondents who completed the interviews, enabling this research to take place.

References

- Anderson R. C., Adam M. S., Goes J. I. (2011a) From monsoons to mantas: Seasonal distribution of *Manta alfredi* in the Maldives. *Fisheries Oceanography*. 20(2), 104–113
- Anderson R. C., Adam M. S., Kitchen-Wheeler A-M., Stevens G. (2011b) Extent and economic value of manta ray watching in Maldives. *Tourism in Marine Environments*. 7(1), 15–27
- BABR (2014) *Rays included in the protected species list*. Baa Atoll Biosphere Reserve. URL: <http://www.broffice.gov.mv/en/index.php/news-events/166-rays-included-in-the-protected-species-list> [Accessed: 12th September 2015]
- Barker N. H. L., Roberts C. M. (2004) Scuba diver behaviour and the management of diving impacts on coral reefs. *Biological Conservation*. 120:481–489
- Bradshaw C. J. A., Fitzpatrick B. M., Steinberg C. C., Brook B. W., Meekan M. G. (2008) Decline in whale shark size and abundance at Ningaloo Reef over the past decade: The world's largest fish is getting smaller. *Biological Conservation*. 141:1894–1905
- Couturier L. I. E., Jaine F. R. A., Townsend K. A., Weeks S. J., Richardson A. J., Bennett M. B. (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*. 62:628–637
- 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*. 80:1075–1119
- Davis A, Wagner J. R. (2003) Who Knows? On the importance of identifying 'expert' when researching local ecological knowledge. *Human Ecology*. 31(3)463–489
- Drew J. A. (2005) Use of traditional ecological knowledge in marine conservation. *Conservation Biology*. 19:1286–1293
- Fauville G., Dupont S., von Thun S., Lundin J. (2015) Can Facebook be used to increase scientific literacy? A case study of the Monterey Bay Aquarium Research Institute Facebook page and ocean literacy. *Computers and Education*. 82:60–73
- Gandiwa E. (2012) Local knowledge and perceptions of animal population abundances by communities adjacent to the northern Gonarezhou National Park, Zimbabwe. *Tropical Conservation Science*. 5(3)255–269
- Graham R. T. (2007) Whale sharks of the Western Caribbean: an overview of current research and conservation efforts and future needs for effective management of the species. *Gulf and Caribbean Research*. 19(2)149–159
- Lack M., Sant G. (2009) *Trends in Global Shark Catch and Recent Developments in Management*. TRAFFIC international
- Manta Trust (2015a) The Maldivian manta ray project. URL: <http://www.mantatrust.org/in-the-field/maldives/> [Accessed: 12th September 2015]
- Manta Trust (2015b) Swimming with mantas. URL: <http://www.mantatrust.org/conservation/swimming-with-mantas/> [Accessed: 17th September 2015]
- Marshall A. D., Compagno L. J. V., Bennett M. B. (2009) Redescription of the genus *Manta* with resurrection of *M. alfredi* (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). *Zootaxa*. 28(2301)1–28
- Mau R. (2008) Managing for Conservation and Recreation: The Ningaloo Whale Shark Experience. *Journal of Ecotourism*. 7:213–225
- McClanahan T. R., Muthiga N. A. (2014) Community change and evidence for variable warm-water temperature adaptation of corals in Northern Malé Atoll, Maldives. *Marine Pollution Bulletin*. 80:107–113

- Ministry of Tourism (2015) *Maldives Visitor Survey 2014*. Available at: <http://www.tourism.gov.mv/latest-documents-en/maldives-visitor-survey-june-2014/> [Accessed: 12th September 2015]
- MMRP (2015) *Maldivian Manta Ray Project volunteer handbook*.
- Murray A. (2014) *The Maldives announces all ray species now added to the Maldives Protected Species List*. Press release: <http://www.mantatrust.org/wp-content/uploads/2012/03/Maldives-Protection-for-all-Ray-Species-Manta-Trust-Maldivian-Manta-Ray-Project-Save-Our-Seas-Foundation-5th-June-2014.pdf> [Accessed: 17th September 2015]
- NBS (2014) *Tourist arrivals and tourist bed-nights 2011-2013*. National Bureau of Statistics. Available at: <http://www.planning.gov.mv/yearbook2014/yearbook/Tourism/10.5.pdf> [Accessed: 12th September 2015]
- O'Malley M. P., Lee-Brooks K., Medd H. B. (2013) The global economic impact of manta Ray watching tourism. *PLoS One*. 8(5)1-11
- Pierce S. J., Méndez-Jiménez A., Collins K., Rosero-Caicedo M., Monadjem A. (2010) Developing a Code of Conduct for whale shark interactions in Mozambique. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 20(7)782-788
- Quiros A. L. (2007) Tourist compliance to a Code of Conduct and the resulting effects on whale shark (*Rhincodon typus*) behavior in Donsol, Philippines. *Fisheries Research* 84:102-108
- Rosa I. M., Alves R. R., Bonifácio K. M., Mourão J. S., Osório F. M., Oliveira T. P., Nottingham M. C. (2005) Fishers' knowledge and seahorse conservation in Brazil. *Journal of Ethnobiology and Ethnomedicine*. 1:1-12
- Sawers T. (2014) The value of traditional knowledge in manta ray conservation in the Maldives. Master's thesis, The University of York, England
- Sequeira A. M. M., Mellin C., Fordham D. A., Meekan M. G., Bradshaw C. J. A. (2014) Predicting current and future global distributions of whale sharks. *Global Change Biology*. 20(3)778-789
- Stevens G., Brooks K. (2011) *Maldivian Manta Ray Project 2011 Season Summary*. A short report for the Ministry of Environment, Maldives; EPA and AEC Project
- Stevens G., Froman N. (2014) *Maldivian Manta Ray Project 2014 Season Summary*. A short report for the Ministry of Environment, Maldives; EPA and AEC Project
- Stevens G., Lee-Brooks K., Sciambi D. (2012) *Maldivian Manta Ray Project 2012 Season Summary*. A short report for the Ministry of Environment and Fisheries, Maldives; EPA and MRC
- Tratalos J. A., Austin T. J. (2001) Impacts of recreational SCUBA diving on coral communities of the Caribbean island of Grand Cayman. *Biological Conservation*. 102:67-75
- Ward-Paige C. A, Davis B., Worm B. (2013) Global population trends and human use patterns of Manta and Mobula rays. *PLoS One*. 8(9)1-9
- Ward-Paige C. A., Lotze H. K. (2011) Assessing the value of recreational divers for censusing elasmobranchs. *PLoS One*. 6(10)1-11

Appendix I

Interview questions, preceded by an introduction to the project

Introduction:

My name is Nicola and I would like to thank you for agreeing to assist me with my survey. I am studying for a Masters' Degree at the University of York, in England and have chosen to focus my research on Manta Rays in the Maldives; in particular the historical status of these animals, their movements and population dynamics prior to 2005.

So, since 2005, researchers and conservationists have been gathering information on the manta rays that live here. However, in order for us to fully understand and interpret this information we need to know more about manta ray occurrences in the past (or prior to 2005), as well as other large animals such as whale sharks. Which is why we want to talk to you.

At the outset it is very important for you to understand that everything we discuss today will be completely confidential and all information will be anonymous.

I will begin by asking you about your diving experience, in particular those dive sites you visit the most and more general questions about manta ray sightings in the Maldives. I will then move onto questions regarding specific dive sites: when and where you see manta rays. If you do not understand anything or want to ask any questions during the interview, please stop me at any time.

It is crucial that you answer each question as accurately as possible. If you are not sure of the answer to a question, please state this as your answer.

Right, let us begin:

Background

1. When did you start diving in the Maldives?
2. How often do you dive/snorkel?
3. Have there been any long periods of inactivity since you started diving? (Y/N)
 - a. When?
4. Are you based on a Resort or Liveaboard? Both?
5. Have you changed working location since you started diving in the Maldives?
If yes:
 - a. When?
 - b. Where did you move from and to (Atoll)?
6. Which Atoll do you and have you dived the most?
7. Please take a look at the map of the **manta sites**, can you name the three sites you dived or snorkelled at most often between **1990 and 2005**. If a site is not included in the list I have given you, please state the name of the site and Atoll.
8. Using the same map, what are the top three sites you dive/snorkel **most often now** – after 2010? Again, please mention any that are not included in the list.

Manta ray sightings

Across the Maldives

9. Which months of the year are the manta rays most commonly seen in the Maldives in general?
10. Has this season changed since you started diving in the Maldives? (Y/N)
 - a. How?
E.g.
 1. They arrive later
 2. They arrive earlier
 3. They are here for a shorter time period
 4. They are here for a longer time period

Peak abundance – cleaning and feeding stations

11. These questions relate specifically to manta ray abundance at **cleaning stations**, which are marked on the map legend you have in front of you.
 - a. At which site have you seen the largest numbers of manta rays? The site does not have to be restricted to those listed on the map
 - b. Can you remember which **year** you saw them?
12. These questions relate to manta ray abundance at **feeding stations**, three are marked on the map legend you have in front of you.
 - a. At which site have you seen the largest numbers of manta rays? The sites does not have to be restricted to those listed on the map
 - b. Can you remember which **year** you saw them?

Sightings and fluctuations – specific dive sites

The following questions relate to manta ray populations on a more local scale. So for this, I will be using the three dive/snorkel sites you mentioned you visit most frequently, at the beginning of this interview.

13. You mentioned you dived/snorkelled at, [*the 3 sites they list*], **before 2005**, what months of the year were manta rays most commonly seen at each of them?
14. At the dive sites you mentioned **you dive at now** [*list the 3 dive sites*], what time of the year do you see manta rays most commonly seen at each of them?
15. At [*indicate their top 3 dive sites*], how often do you see manta rays on your dives during the manta season at this site?
E.g.
 - a. Every time I visit the site
 - b. Almost every time I visit the site
 - c. Occasionally
 - d. Rarely
 - e. Never

16. Do you think the numbers of manta rays has changed since you began diving at (name each of their top 3 dive sites visit now)? (Y/N)

a. Are they more or less common today than they were when you first started diving in the Maldives?

Changes in manta sightings

These questions relate to changes in manta sightings at dive sites

17. Are there any dive sites that you used to/still dive at, but no longer see manta rays at anymore? (Y/N)

If yes:

a. Which sites are they?

b. When did you first start diving there?

c. When did you first notice manta rays had stopped visiting the site(s)

18. Are there any sites where you now see manta rays, whereas before they weren't there? (Y/N)

If yes:

a. Which sites are they?

b. When did you first start diving there?

c. When did you first notice the manta rays start visiting the site(s)?

Other marine animals

I will now move onto questions regarding other marine animals in the Maldives, and whether you have seen a change in their numbers since you started diving in the Maldives.

19. Please specify whether, or not, you have seen a change (increase, decrease or no change) in the numbers of:

Marine animal	Change in numbers? <i>Increase, decrease or no change</i>
a) Whale shark	
b) Reef shark	
c) Sea turtles	
d) Groupers	
e) Baitfish	
f) Tunas	
g) Dolphins	
Other. Please specify	

Perception of conservation efforts in the Maldives

I'm now going to move onto questions regarding conservation efforts in the Maldives.

Hanifaru Bay and the Biosphere Reserve

20. Have you heard of the UNESCO World Biosphere reserve covering the entirety of Baa Atoll? (Y/N)

21. Have you heard of the Hanifaru Bay MPA (Y/N)

22. Do you know why the MPA was established in Hanifaru Bay? (Y/N)

a. If yes, what was the reasoning behind the designation?

23. Did the establishment of the Hanifaru Bay MPA effect you? (Y/N)

a. How?

24. Do you think the establishment of the Hanifaru Bay MPA has been beneficial? (Y/N)

a. Why?

25. In your opinion, is the Hanifaru MPA well managed? (Y/N)

a. Why?

All MPAs in the Maldives

26. Are you aware of any other MPAs in the Maldives? (Y/N)

a. Can you name three?

27. In your opinion, are they well managed? (Y/N)

a. Why?

28. How do you feel about the level of management of MPAs in the Maldives? (e.g. *is there too much, too little, would you like greater/less management*)

a. Why?

Work of scientists and conservationists

29. How do you feel about the work of scientists and conservationists in the Maldives? (e.g. *important/too strict/they cause problems/it's unnecessary*)

30. Are you aware of any rules and regulations about diving or snorkelling with manta rays? (Y/N)

a. What are they?

31. Do you think there should be Government regulations in place, such as a code of conduct to control interactions with manta rays (e.g. *vessel speed on approach, rules about touching mantas, max. numbers of tourists per dive-guide etc.*) (Y/N)

32. Are you actively involved/or do you participate in any conservation program? (Y/N)

a. If **yes**, which one?

b. If **no** would you be interested in becoming involved in such programs?

33. Are you satisfied with the level of communication and collaboration between conservationists/scientists and the tourism industry?

a. If not, how would you like to see it improved?

5. *Useful for tourism purposes*

6. *Other. Please specify*

35. Are manta rays a legally protected species in the Maldives? (Y/N)

36. Do you think manta rays should be protected? (Y/N)

37. Having completed this survey, can you recommend anybody else I could talk to?

38. Is there anything you would like to ask or tell me?

Final questions

34. In general, how do you think the diving industry in the Maldives perceives manta rays?

E.g. Are they...

1. *Seen as a menace*

2. *Feared*

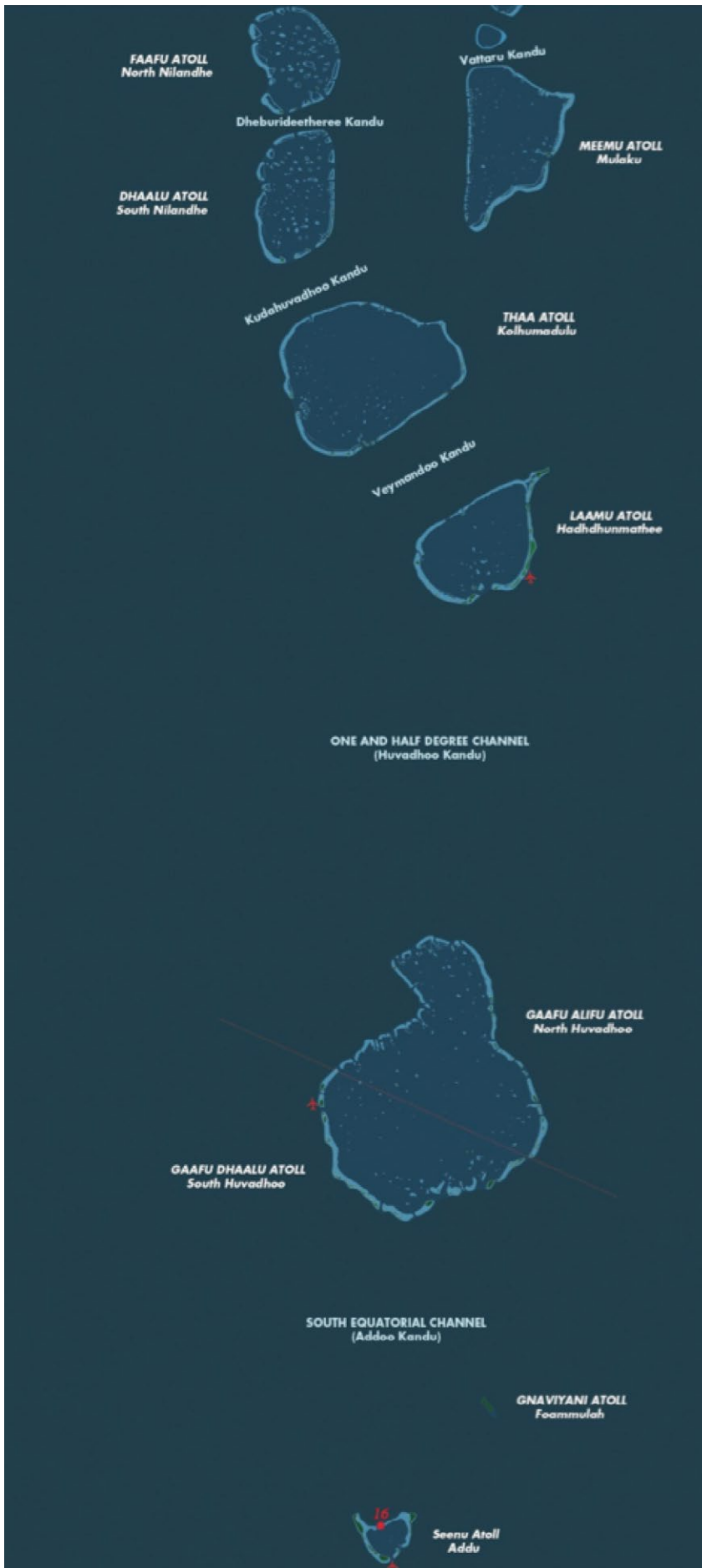
3. *Respected*

4. *Adored*

Appendix 2

Map of selected manta sites for interviewee reference (split over two pages for appendix)





Haa Alifu Atoll

1- Aquarium

Lhaviyani Atoll

2- Fushifaru Kandu (Fushifaru Thila)

3- Dhanifaru (Vaavaru)

Baa Atoll

4- Hanifaru Bay

5- Dharavandhoo Thila

6- Dhigu Thila (Anga Faru)

7- Nelivaru Thila (Nelivaru Haa)

North Malé Atoll

8- Boduhithi Thila (Rasfari North)

9- Sunlight Faru (Thulhaagiri)

10- Lankan Beyru (Manta Point) South Malé Atoll

11- Sand Dune (Banana Reef / Guraidhoo Falhu)

Ari Atoll

12- Dhonkalo Thila (Table Thila)

13- Kalhahandi Huraa (Panettone)

14- Huravalhi Fahlu (Lilly Beach)

15- Rangali Madivaru (Manta Point)

Addu Atoll

16- Mudakan (Manta Point / Maa Kandu)



This report was compiled on behalf of the MMRP and the Manta Trust by:

Nicola Bassett - BSc (Hons), MSc (Hons)
Project Manager - Maldivian Manta Ray Project

Guy Stevens - BSc (Hons), PhD Candidate
Chief Executive / Founder - The Manta Trust.

The MMRP and the Manta Trust are happy to share any data collected as a part of this study.

For further information please email:
nicola@mantatrust.org or guy@mantatrust.org

The information and ideas within this report are the intellectual property of The Manta Trust. Any scientific data distributed to our collaborators and partners belongs to The Manta Trust and are not to be shared with a third party without prior permission from The Manta Trust.