Manta TRUST

Maldivian Manta Ray Project

Lhaviyani Atoll | Annual Report 2018

Conservation through research, education, and colloboration

- The Manta Trust

MALDIVIAN MANTA RAY PROJECT

WHO ARE THE MANTA TRUST?

The Manta Trust is a UK and US-registered charity, formed in 2011 to co-ordinate global research and conservation efforts around manta rays. Our vision is a world where manta rays and their relatives thrive within globally healthy marine ecosystems.

The Manta Trust takes a multidisciplinary approach to conservation. We focus on conducting robust research to inform important marine management decisions. With a network of over 20 projects worldwide, we specialise in collaborating with multiple parties to drive conservation as a collective; from NGOs and governments, to businesses and local communities. Finally, we place considerable effort into raising awareness of the threats facing mantas, and educating people about the solutions needed to conserve these animals and the wider underwater world.

Conservation through research, education and collaboration; an approach that will allow the Manta Trust to deliver a globally sustainable future for manta rays, their relatives, and the wider marine environment.

MALDIVIAN MANTA RAY PROJECT

Formed in 2005, the Maldivian Manta Ray Project (MMRP) is the founding project of the Manta Trust. It consists of a country-wide network of dive instructors, biologists, communities and tourism operators, with roughly a dozen MMRP staff based across a handful of atolls.

The MMRP collects data around the country's manta population, its movements, and how the environment and tourism / human interactions affect them. Since its inception, the MMRP has identified over 4,600 different individual reef manta rays, from more than 60,000 photo-ID sightings. This makes the Maldives manta population the largest, and one of the most intensively studied populations in the world. The MMRP has also identified over 380 different individual oceanic manta rays.

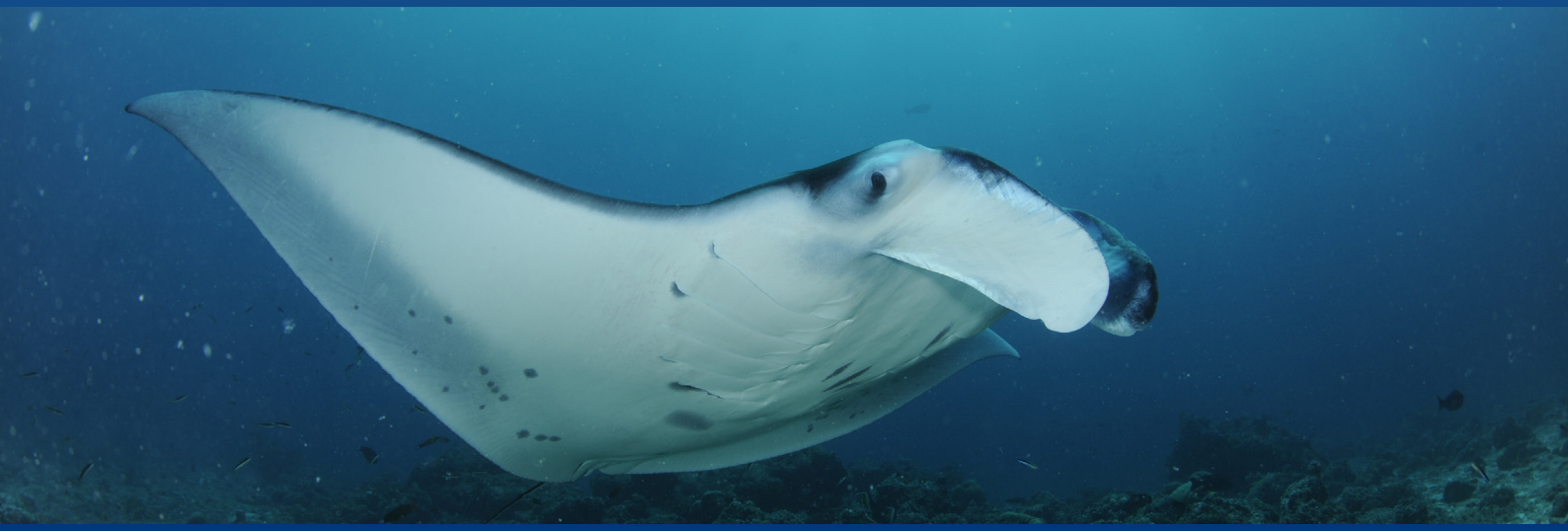
The long-term and nationwide data collected by the MMRP has allowed researchers to record and identify key patterns within this population over time. Not only does this invaluable information improve our understanding of these animals, but it informs their ongoing management and protection both in the Maldives, and around the world.

THE CONSERVATION CHALLENGE

In the last two decades, manta and mobula rays have faced increasing threats from both targeted and bycatch fisheries, due in part to a growing trade in Asia for their gill plates. The gill plates are what these rays use to filter zooplankton from the water. In Traditional Asian Medicine, it is believed these gill plates will filter the human body of a variety of ailments when consumed in tonic. There is no scientific evidence to support this claim.

Unregulated and badly managed tourism is also negatively affecting manta rays, while climate breakdown, reef degradation and pollution is reducing the manta's food supply and suitable habitat.

Manta and mobula rays are particularly vulnerable because of their aggregating behaviour and conservative life-history; they grow slowly, mature late in life, and give birth to few offspring. These traits make it very easy to wipe out entire populations in a relatively short period of time. With protection in place, populations are still slow to recover.



EXECUTIVE SUMMARY

This report is the second of its kind in a series that presents data collected by the Manta Trust's Maldivian Manta Ray Project (MMRP) on Lhaviyani Atoll's reef manta ray (*Mobula alfredi*) population from January through to December 2018.

Reef manta rays are sighted in Lhaviyani Atoll year-round but are recorded more frequently toward the end of the Southwest Monsoon (Oct-Nov) and during the Northeast Monsoon (Jan-April). During these months, favourable environmental conditions created by the monsoon winds generate an abundance of phytoplankton and zooplankton, which in turn influences manta ray abundance locally.

The MMRP conducted reef manta ray surveys (*n*=216) on 156 days throughout 2018. Key findings of the MMRP in Lhaviyani Atoll during 2018 include a total of 296 sightings of 124 different manta rays; the second highest number of sightings recorded in any survey year. Of these individuals, each manta ray was observed on average 2.4 times. The mean daily number of reef manta ray sightings for 2018 was 1.9, with a peak in daily manta ray sightings seen during the month of October. A Residency Index (RI) was calculated to gauge the extent of movement amongst those frequenting the region. The RI for 2018 (1.11) was lower than 2017 (1.48).

As of 2018, the population demographics of Lhaviyani Atoll constitutes 51% females (*n*=191), 48% males (*n*=182), and 1% (*n*=5) of individuals for which the sex could not be determined. Overall, 52% (*n*=196) comprise adult individuals, 48% (*n*=181) juveniles, and the maturation stage for the remaining 0.3% (*n*=1) of the population could not be determined.

Of these Lhaviyani Atoll manta rays (*n*=378), 83% (*n*=314) have been re-sighted and 39% (*n*=149) have been seen in at least one other geographical atoll in the Maldives.

Of the 226 new reef manta rays added to the MMRP database from across the Maldives in 2018, 22% (*n*=50) were documented in Lhaviyani Atoll. This is a large increase from the previous year (*n*=23, in 2017). Furthermore, the number of pregnancies recorded in Lhaviyani Atoll during 2018 was the highest number ever recorded during a study year, with a total of five pregnancies. Of the five pregnant females observed, 80% (*n*=4) were recorded in the later stages of gestation (3rd- 4th trimester).

In 2017 (and continuing throughout 2018), a collaboration with the local non-governmental organisation (NGO) - Naifaru Juvenile, a ten-week Marine Education Programme (Nature Club) was launched, and the resulting curriculum shared with the principle of the Lhaviyani Atoll Education Centre. The Nature Club, which aims to deepen the knowledge and awareness of young Maldivian students.

Efforts to conserve the natural heritage of Lhaviyani Atoll and manage the increasing human impacts upon the environment are encouraging, providing much to look forward to in 2019 and beyond. However, it is crucial that active research into manta rays and other marine life continues in order to monitor the effects of both tourism and environmental change. Manta rays are an incredibly important economic resource for the Maldives, bringing tens of thousands of people to the country each year to dive and snorkel with them, generating millions of USD for the economy annually. Being able to pinpoint the reasons for any observed trends in, or threats to, the Maldives manta ray population is crucial for the ongoing management and protection of these animals.

UNDERSTANDING THE MONSOONS

The fluctuating monsoons (seasons) within the Maldives play an important role in determining manta ray distribution. Therefore, understanding the South Asian Monsoon is critical to interpreting the sightings of manta rays in Lhaviyani Atoll. The monsoons, which dictate the weather in the Maldives, are characterised by their winds, which blow consistently and reverse direction seasonally. The Maldives Northeast Monsoon, or Iruvai, runs from December-March, while the Southwest Monsoon, or Hulhangu, runs from May-October each year, with the months of April and November acting as transitional periods of change between the two seasons. The Southwest Monsoon is typically characterised by more rain and cloud cover, along with reduced underwater visibility and rougher seas.

The strong monsoonal winds create oceanic currents which flow either from the northeast towards the southwest (Northeast Monsoon), or from the southwest towards the northeast (Southwest Monsoon). The Maldives' islands and atolls, rising 2,000 metres from the sea floor, act as a barrier to these currents, displacing the water as it flows through and around the atolls, creating deep-water upwelling. These upwellings bring nutrient rich water to the surface, enabling photosynthetic phytoplankton to flourish, and generating a bloom of predatory zooplankton that feed on the phytoplankton. Zooplankton is the prey of manta rays and, as strong lunar currents flow through the channels, the concentrated zooplankton is so abundant that the Maldives' waters support the world's largest known population of reef manta rays. It is at these sites where we are likely to observe feeding planktivorous megafauna. Manta rays tend to frequent cleaning stations that are in close proximity to their plankton-rich feeding sites, and thus, will migrate seasonally to utilise feeding sites and cleaning stations on the monsoonal down-current edge of the atolls. Due to the seasonal migration patterns of the manta rays, research efforts are focused on the west side of the atolls during the Northeast Monsoon, and on the east during the Southwest Monsoon. Both monsoons attract reef manta rays to the surface waters of Lhaviyani Atoll. However, sightings tend to peak towards the end of the Southwest Monsoon and during the Northeast Monsoon.

STUDY PERIOD & SAMPLING METHODOLOGY

Manta ray sightings data in the Lhaviyani Atoll was collected by both regional MMRP researchers and citizen scientists (tourists, local dive guides, snorkel leaders, and marine biologists). Individual manta rays that were sighted in the water were documented by photographing the unique spot patterns on their ventral surface, allowing for identification of individuals. In the context of this report, a sighting is defined as a confirmed photo identification (photo-ID) of an individual manta ray on a given day in at a specific location (survey site). Surveys were conducted in-water, both on SCUBA and via snorkelling, with sightings recorded at 26 different sites across all years.

During each survey performed by MMRP researchers, individual manta ray sightings were documented via photo-ID, and data on the location, manta ray numbers, and predominant behaviours were recorded. Details on environmental variables (including wind speed, current direction, and plankton density), and tourism data (including number of divers/snorkellers, number of boats, and number of paying guests) were also noted during each survey. Surveys were collected on all trips, regardless of whether manta rays were sighted or not.

Between 2004 and 2016, prior to the establishment of a full-time MMRP researcher in Lhaviyani Atoll, data on manta ray sightings were collected mostly through citizen science. Tour guide operators, dive instructors and tourists would look for manta rays on both full and half day surveys. These surveys were also conducted in-water on SCUBA, or while snorkelling. Prior to 2010, only surveys resulting in a confirmed manta ray photo-ID sighting were recorded. It is unknown how many surveys were conducted annually prior to 2010. However, thereafter all data has been standardised for survey effort where possible to produce comparable results between, and within, years.

2018 Study Period

During 2018, MMRP researchers conducted a total of 111 surveys on as many days that conditions and logistical operations allowed (*n*=84), at 15 different sites. Four of these sites were classified as key aggregation sites due to higher numbers of individual manta rays sighted in these locations across the study year (Fig. 1).

Data was primarily collected by a Manta Trust researcher who was based at Hurawalhi Resort for most of the year (although no staff member was present from August to November). In addition to MMRP survey data (*n*=111), this report utilises data from a further 105 surveys which were undertaken and submitted by external contributors, which include local non-governmental organisations (NGOs), resort dive and water sports staff, as well as citizen scientists. Second only to 2010, with a total of 216 surveys from Manta Trust and outside submitters combined, 2018 resulted in the second highest survey count in the atoll since records began (Fig. 2). Overall, manta rays were sighted on 87% (*n*=187) of all survey trips (*n*=216), with ID photographs collected on 46% (*n*=100) of surveys.

From January until July, survey effort focused on the western Lhaviyani Atoll manta aggregation sites: Dhanifaru (*n*=42) – a site known for manta feeding and a close-by cleaning station (Three Rocks), Felivaru (Thila and Kandu) (*n*=7), and Veligadu Falhu (*n*=19), both manta ray feeding sites. During August, survey effort moved to focus on the manta aggregation site in the northeast of Lhaviyani Atoll (Fushifaru Kandu), which is a manta cleaning station and feeding area. From July until November, a total of 32 surveys were conducted at this site. With the beginning of the Northeast Monsoon in December, surveys were again performed in the northern and western manta aggregation sites of Lhaviyani Atoll; Veligadu Falhu (*n*=5), Felivaru (*n*=3), and Dhanifaru (*n*=3).

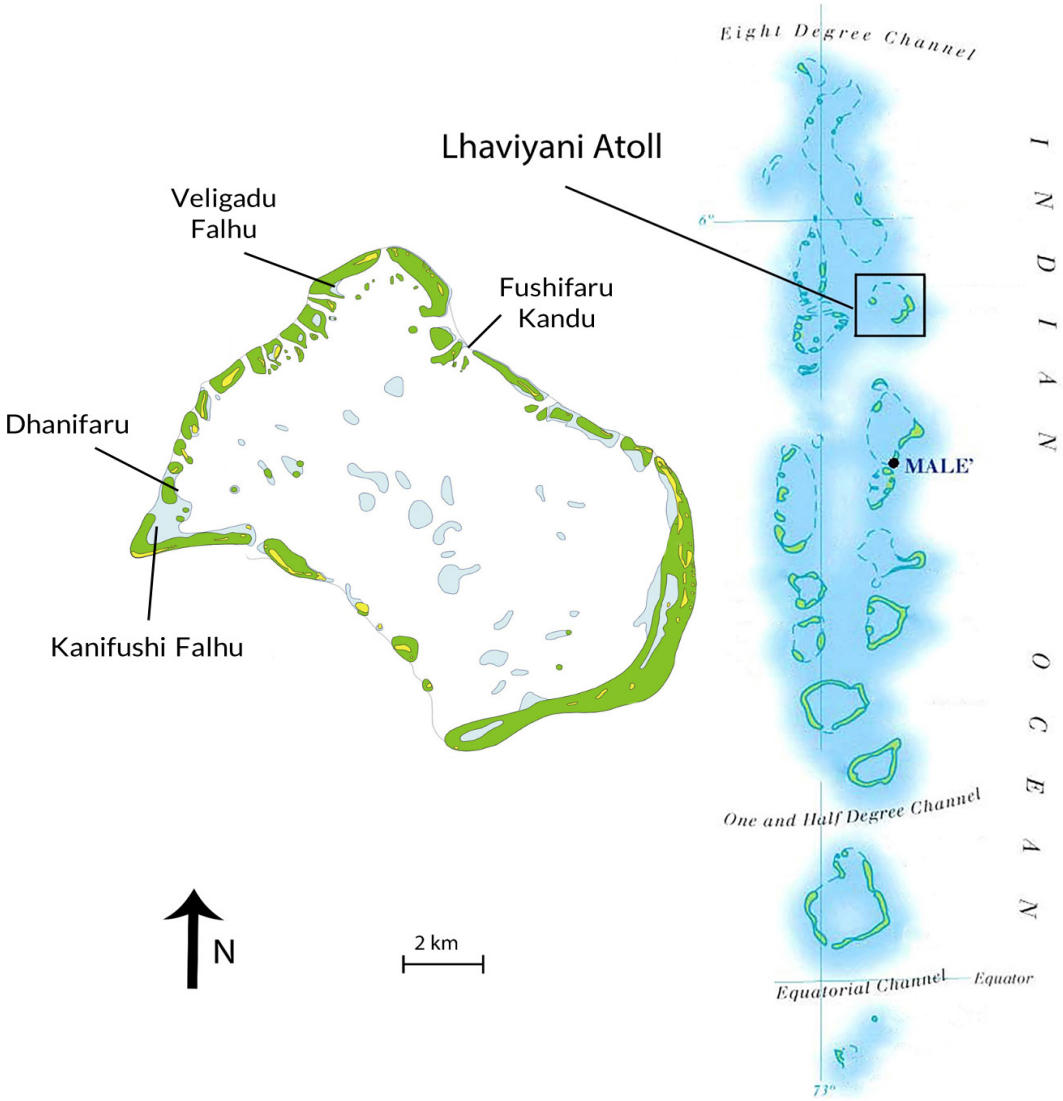


Figure 1: Map of Lhaviyani Atoll showing four sites which accounted for the highest number of reef manta ray (*Mobula alfredi*) sightings in 2018, three of which have been identified previously as the key aggregation sites (Dhanifaru, Fushifaru Kandu, and Veligadu Falhu) within the atoll across study years (2004-2018). Also shown is Lhaviyani Atoll (black box) in relation to the rest of the Maldives Archipelago.

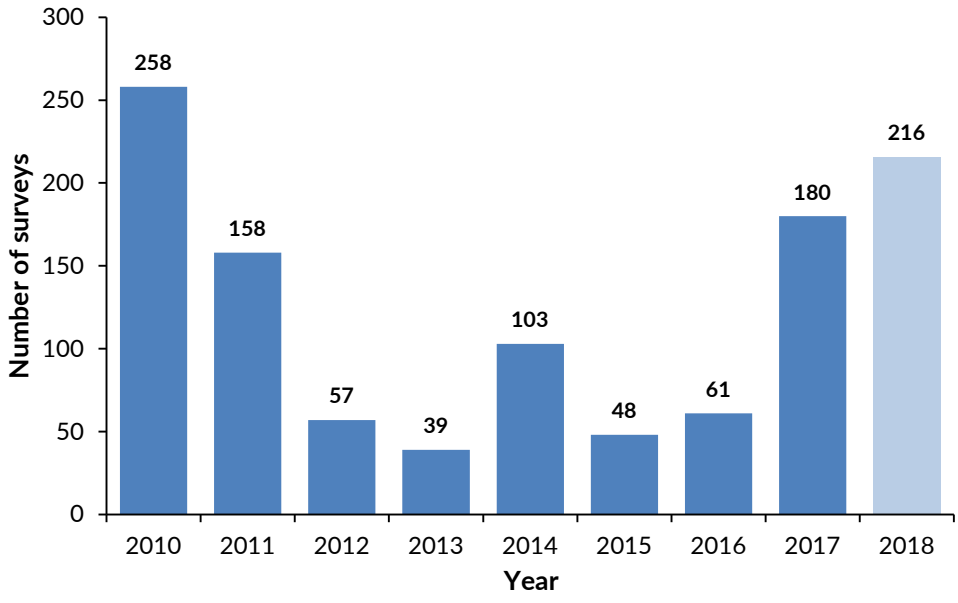


Figure 2: Number of surveys conducted annually in Lhaviyani Atoll.

Sighting Trends

A total of 1,682 reef manta ray sightings have been recorded in Lhaviyani Atoll between 2004 through 2018, with 1.4 mantas sighted per survey on average between 2010 and 2018 (when survey data was recorded) (Fig. 3). During 2018, there were 296 sightings of 124 different reef manta ray individuals in Lhaviyani Atoll, which made 2018 the year with the second highest number of manta ray sightings since data collection started in 2004 – the highest being in 2010 when 333 sightings were recorded (Fig. 3). The large number of sightings in 2018 was likely related to the high level of survey effort by the permanent Manta Trust researcher based at Hurawalhi Resort, as well as numerous manta photo-ID reports received from outside submitters, which accounted for 58% (*n*=171) of the sightings recorded in 2018.

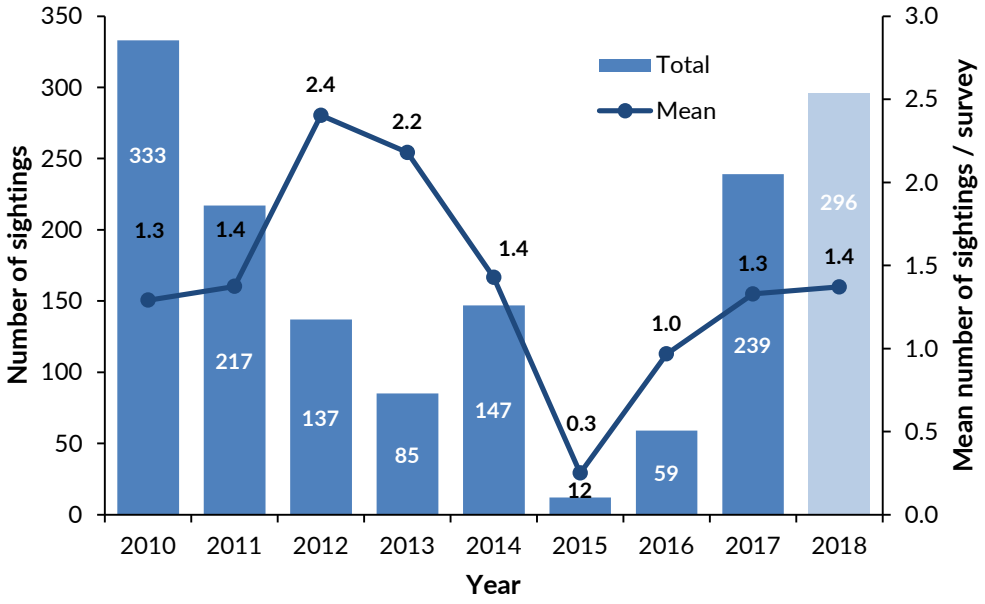


Figure 3: Total annual sightings of reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll, and the mean number of sightings per survey.

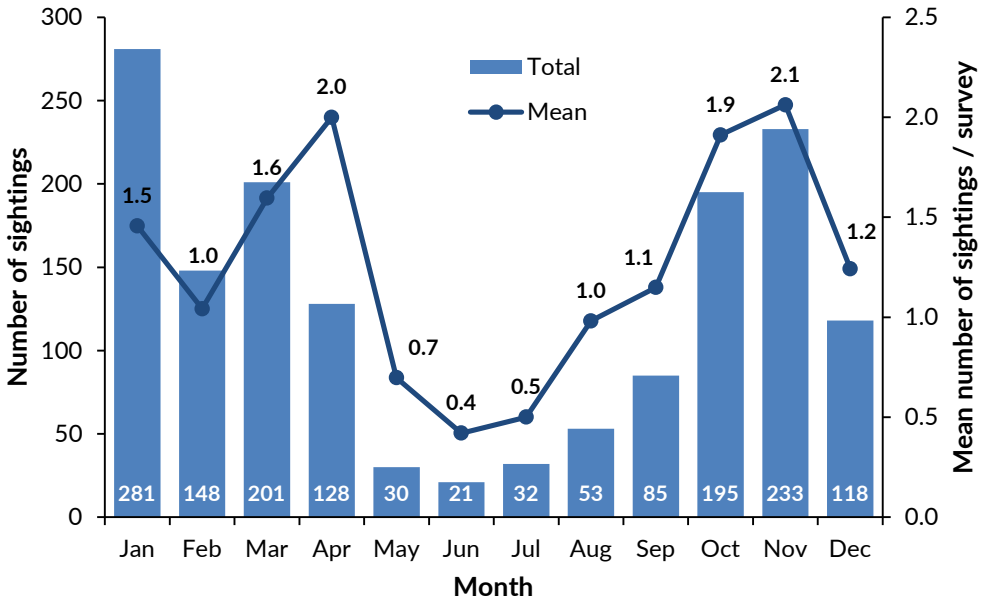


Figure 4: Total monthly sightings and mean number of sightings per survey of individual reef manta rays (*Mobula alfredi*) recorded in Lhaviyani Atoll (2010-2018).

While there is a certain degree of inter-annual variation across all study years, a general trend in sightings throughout the year can be observed. Sightings in Lhaviyani Atoll tend to peak annually during the months of January to March, then decrease between April and September, followed by a second peak during the months of October to December (Fig. 4). Reef manta ray sightings in 2018 followed a similar trend, with two main peaks in January and October (Fig. 5). Sightings recorded in November and December of 2018 were low compared to previous years; most likely due to the absence of a permanent MMRP researcher on site to carry-out regular surveys, and to encourage outsider submissions during the second half of the season.

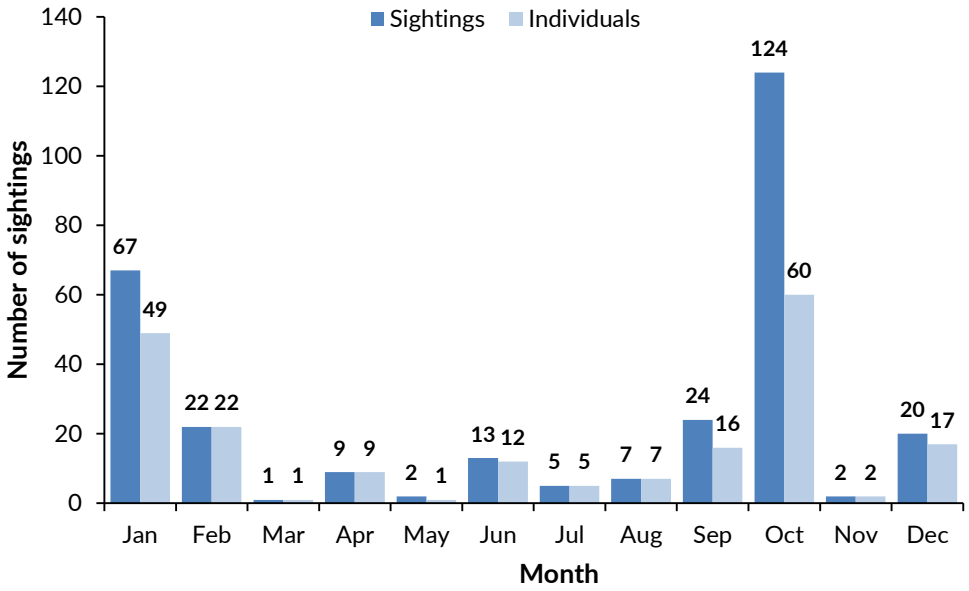


Figure 5: Total monthly sightings and the number of individual reef manta rays (*Mobula alfredi*) recorded in Lhaviyani Atoll (2018).

The seasonally observed sighting peaks reflect intra-annual variation in site use by reef manta rays around Lhaviyani Atoll. Movements of manta rays around Lhaviyani Atoll are largely influenced by the monsoons of the Maldives (seasons), which drive productivity and, ultimately, variation of manta rays' zooplankton food source in different locations throughout the year. Three key aggregation sites have previously been identified as having the highest number of sightings across study years (2004-2018); Veligadu Falhu, Dhanifaru, and Fushifaru Kandu (Fig. 1). In 2018, sightings peaked at Veligadu Falhu in January, and at Dhanifaru in January/February (Fig. 6). It seems that manta rays sighted at these two locations took advantage of localised abundances in zooplankton, as the majority of individuals were recorded while feeding. Indeed, visitations to these two sites coincided with the Northeast Monsoon, which drives productivity and food availability in the western areas of atolls within the Maldives between December and March each year.

Later in 2018, sightings peaked at Fushifaru Kandu in September/October (Fig. 6), where manta rays predominantly exhibited cleaning behaviour. This coincided with the transitional period between the Southwest and Northeast Monsoons (October to December), during which time it is typical for manta rays throughout the Maldives to engage in increased cleaning, courtship, and mating activity, with cleaning stations acting as a focal point for these behaviours.

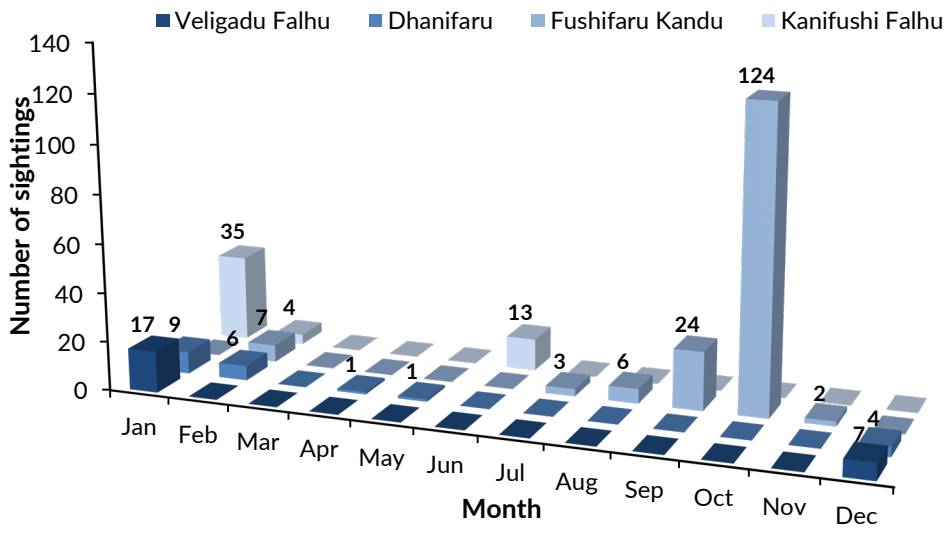


Figure 6: Monthly sightings of reef manta rays (*Mobula alfredi*) at four key aggregation sites in Lhaviyani Atoll (2018).

Interestingly, while these three key aggregation sites account for the largest proportions of reef manta ray sightings across previous study years, Kanifushi Falhu (a site immediately south of Dhanifaru) accounted for the second highest number of manta ray sightings in 2018 (18%) (Fig. 7), while sightings in Dhanifaru were uncharacteristically low that same year. This sighting variation largely occurred in January and was likely driven by a change in localised abundance of the manta ray's planktonic prey. Age demographics of manta rays sighted at Kanifushi Falhu were also very similar to those found at Dhanifaru (Fig. 8), with a relatively large proportion of juveniles sighted at each location (51% at Dhanifaru and 52% at Kanifushi Falhu) compared to other survey sites (Fig. 8). Both sites are relatively sheltered lagoons located on the inside of the atoll, which may act as nursery grounds and explain the preference of younger manta rays to these areas.

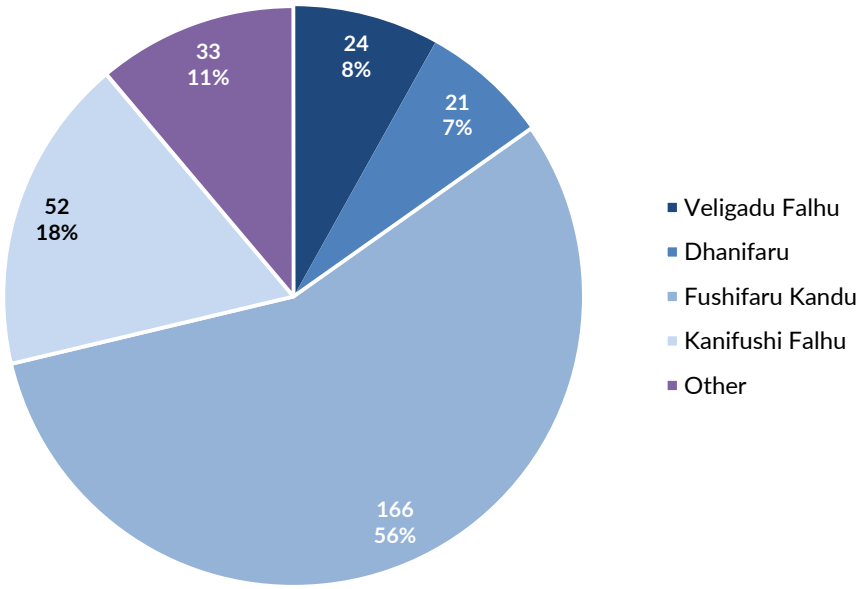


Figure 7: Proportion of total reef manta ray (*Mobula alfredi*) sightings (*n*=296) at different sites in Lhaviyani Atoll (2018).

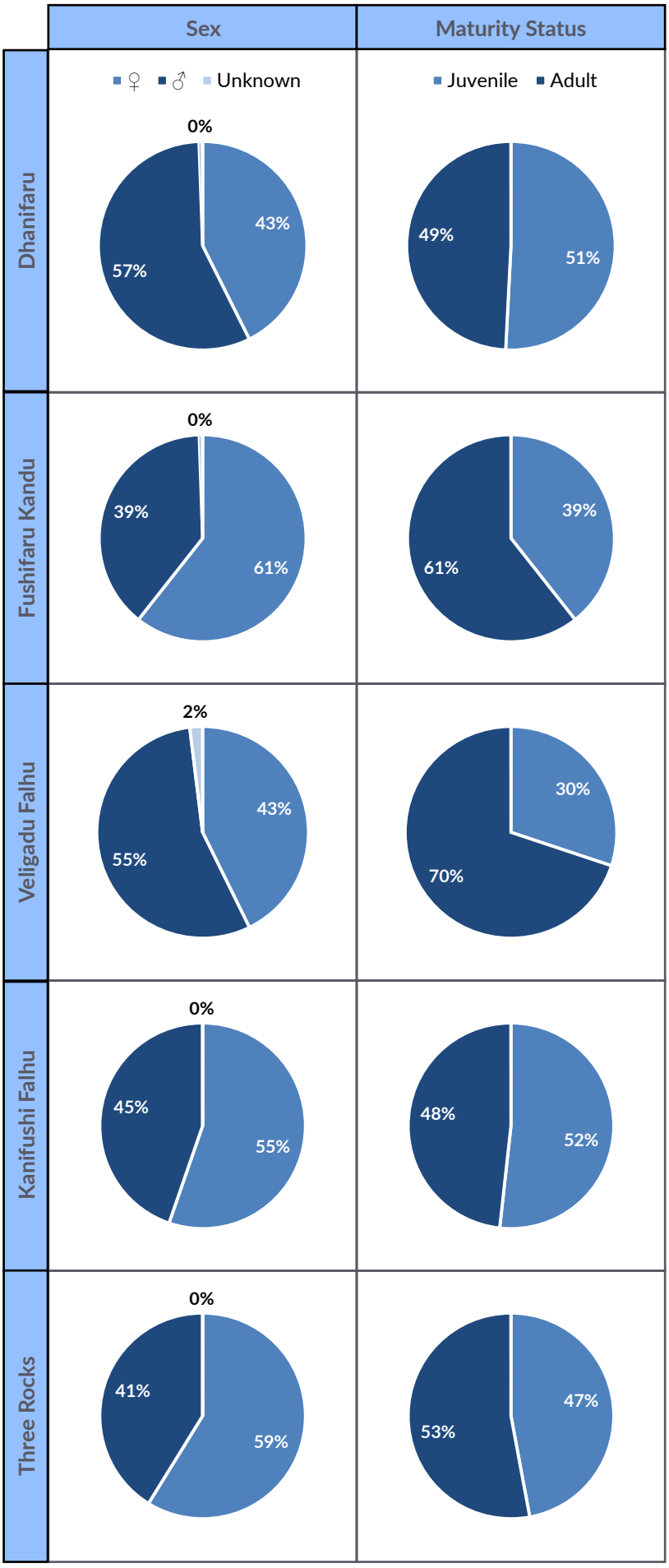


Figure 8: Demographics of the reef manta rays (*Mobula alfredi*) recorded at the four key aggregation sites in Lhaviyani Atoll (2004-2018).

Population Demographics

During 2018, fifty new reef manta rays were identified in Lhaviyani Atoll, bringing the total recorded population since 2004 to 378 individuals. The sex ratio of this population is almost even; with 51% females (*n*=191) and 48% males (*n*=182), while sex could not be determined for the remaining 1% of individuals (*n*=5). Age demographics are similarly even; juveniles account for 48% of the population (*n*=181), and adults 52% (*n*=196), while maturity could not be determined for the remaining 0.3% of individuals (*n*=1) (Fig. 9). Maturity was defined by the presence of mating scars and visible pregnancies in females, and by the enlargement and calcification of claspers in males. Furthermore, if an individual was estimated to be at, or larger than, the known size at maturation for this species in the Maldives (320-330 cm disc width for females, 270-280 cm disc width for males), adult status was also assigned. All other individuals were classified as juveniles.

Overall, 68% (*n*=256) of the atoll's population have been sighted more than once in Lhaviyani, and 83% (*n*=314) have been re-sighted either in Lhaviyani or elsewhere in the Maldives. This suggests that the vast majority of reef manta rays, that frequent this region, have now been discovered.

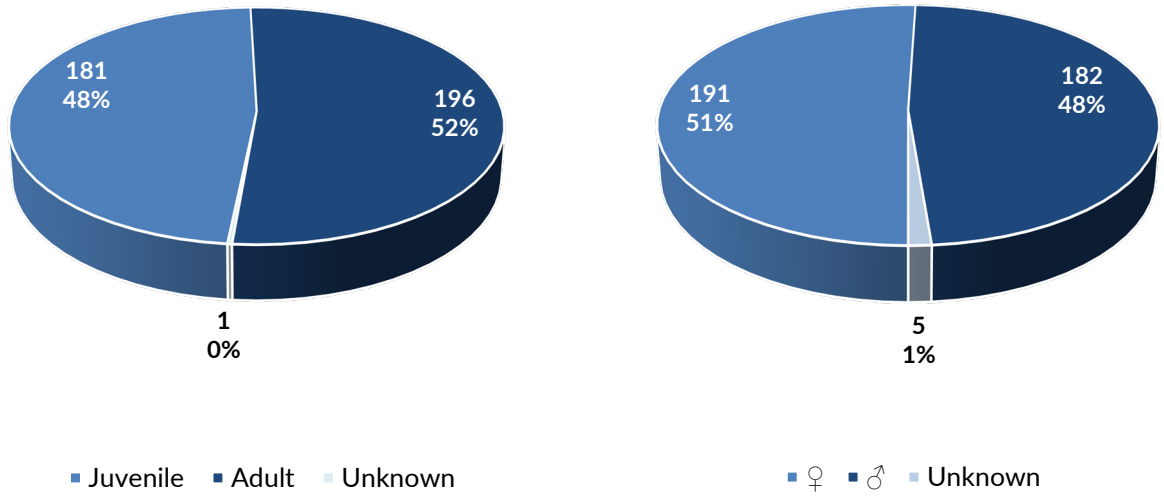


Figure 9: Demographics of the total Lhaviyani Atoll reef manta ray (*Mobula alfredi*) population (*n*=378).

The proportion of newly sighted individuals has followed a slight upward trend in recent years (c.a. 2015) (Fig. 10), which can largely be attributed to the increased survey effort (Fig. 2), due to the presence of a resident Manta Trust researcher in the atoll since November of 2016, and increased reproductive activity. Indeed, 2018 saw one of the highest numbers of new individuals added to the population since records began in 2004, second only to 2010, and accounted for 40% of individuals sighted in Lhaviyani Atoll that year. Fushifaru Kandu and Kanifushi Falhu were the locations where the largest proportions of 2018's new reef manta rays were first sighted, accounting for 56% (*n*=28) and 24% (*n*=12), respectively; this was consistent with locations of overall manta sightings in 2018 (Fig. 7). The majority (74%) of new manta rays were juveniles (*n*=37).

Of the 50 new manta rays, 29 individuals had never before been recorded by the Manta Trust, while the remaining 21 had been sighted elsewhere in the Maldives previously. Of the manta rays that were previously unrecorded, five were estimated to be pups born that year. This was consistent with relatively high numbers of pups sighted across the Maldives in 2018.

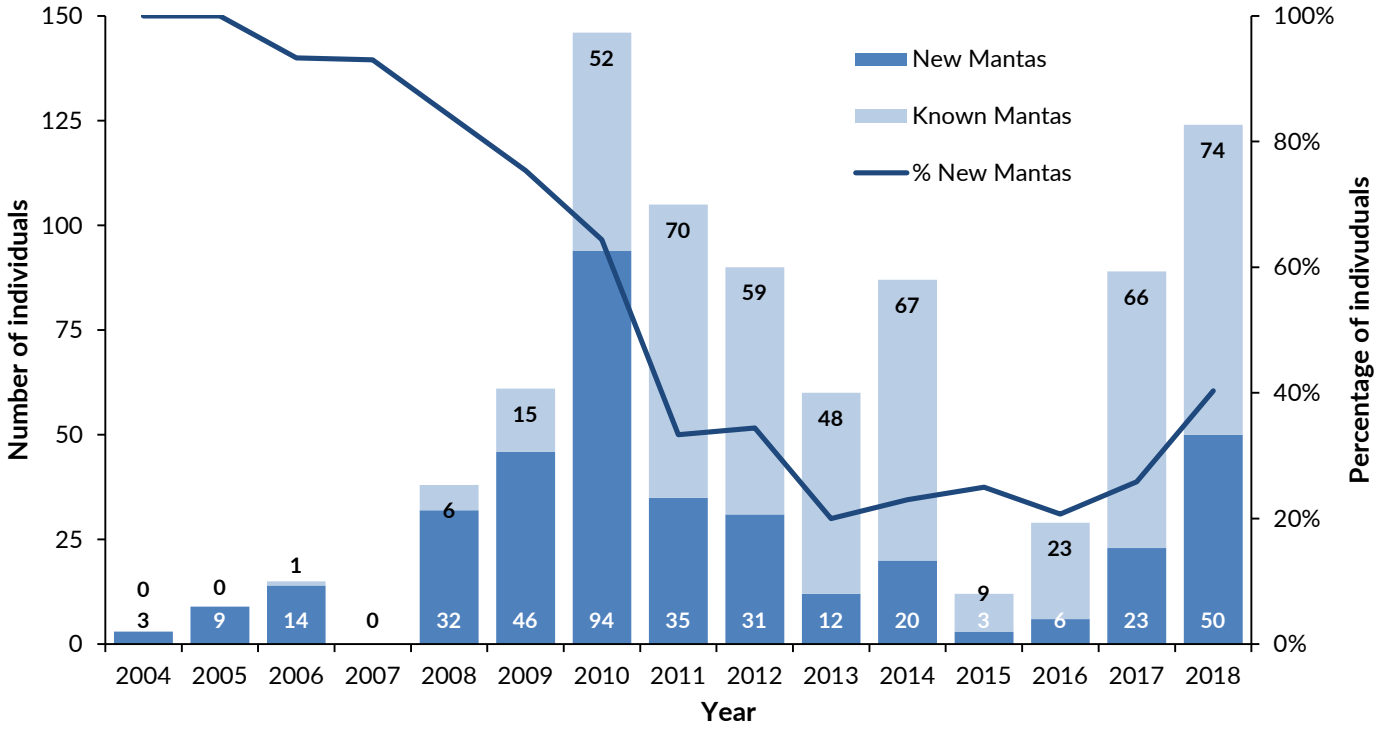


Figure 10: Total number of reef manta rays (*Mobula alfredi*) sighted annually in Lhaviyani Atoll, and the number and percentage of individuals which were newly recorded.

Migrations & Residency

Of the 378 reef manta rays that have been sighted in Lhaviyani Atoll across all study years, 39% (*n*=149) have been recorded by the MMRP in other atolls across the Maldives. Naturally, inter-atoll migrations are most common between atolls which are geographically closest to Lhaviyani Atoll. As of 2018, 92 individuals in the Lhaviyani population have been recorded in Baa Atoll, 30 in Raa, and 23 each in Ari and Thiladhunmathi Atolls (Fig. 11). Each manta ray sighted within Lhaviyani Atoll population tends to exhibit strong site fidelity, with 87% of individuals only recorded in one (*n*=229) or two (*n*=101) atolls (Fig. 12).

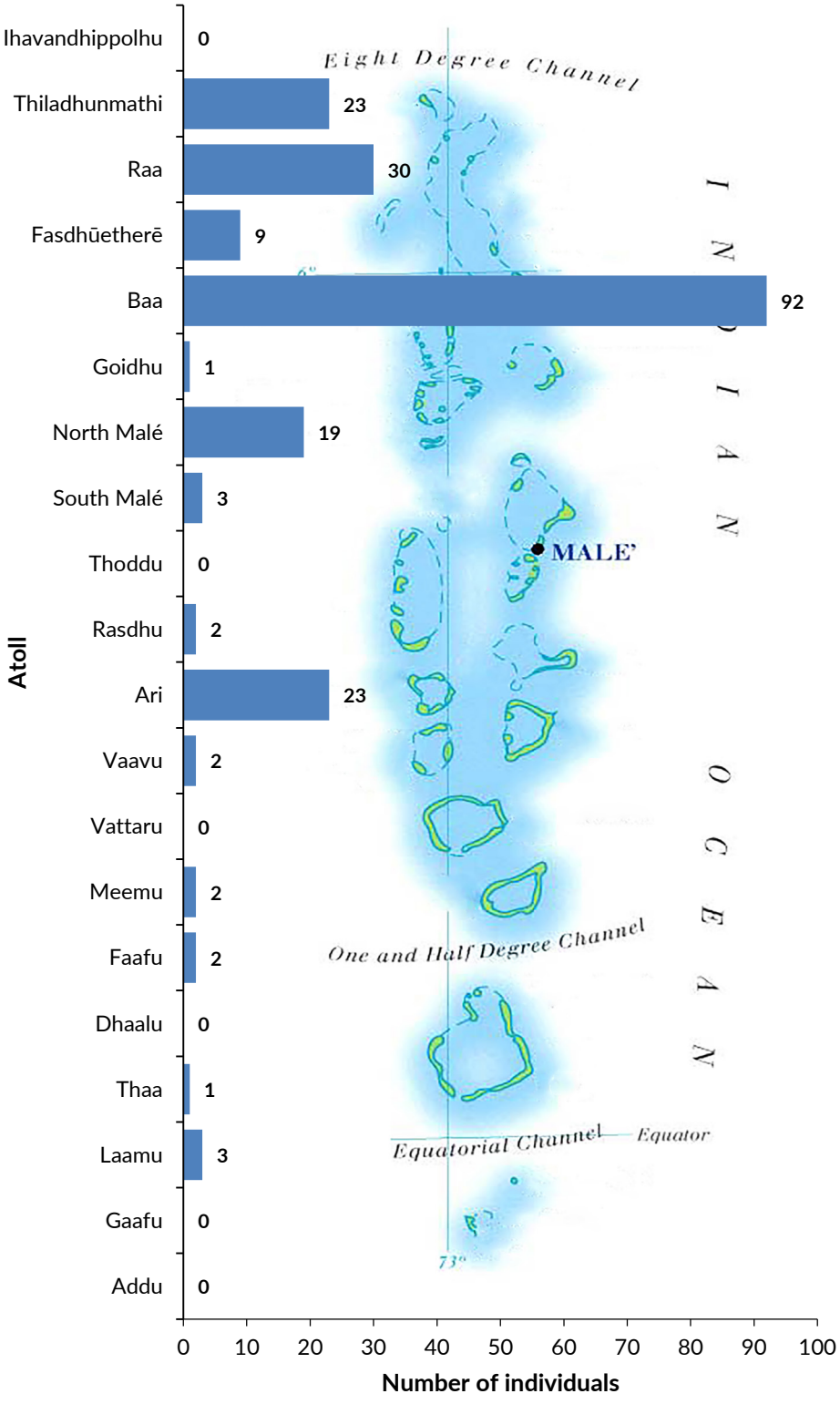


Figure 11: Number of reef manta rays (*Mobula alfredi*) (*n*=212) from within the Lhaviyani Atoll population (*n*=378) which have been recorded in other atolls throughout the Maldives Archipelago. Note – some individuals have been sighted in more than one atoll outside Lhaviyani Atoll.

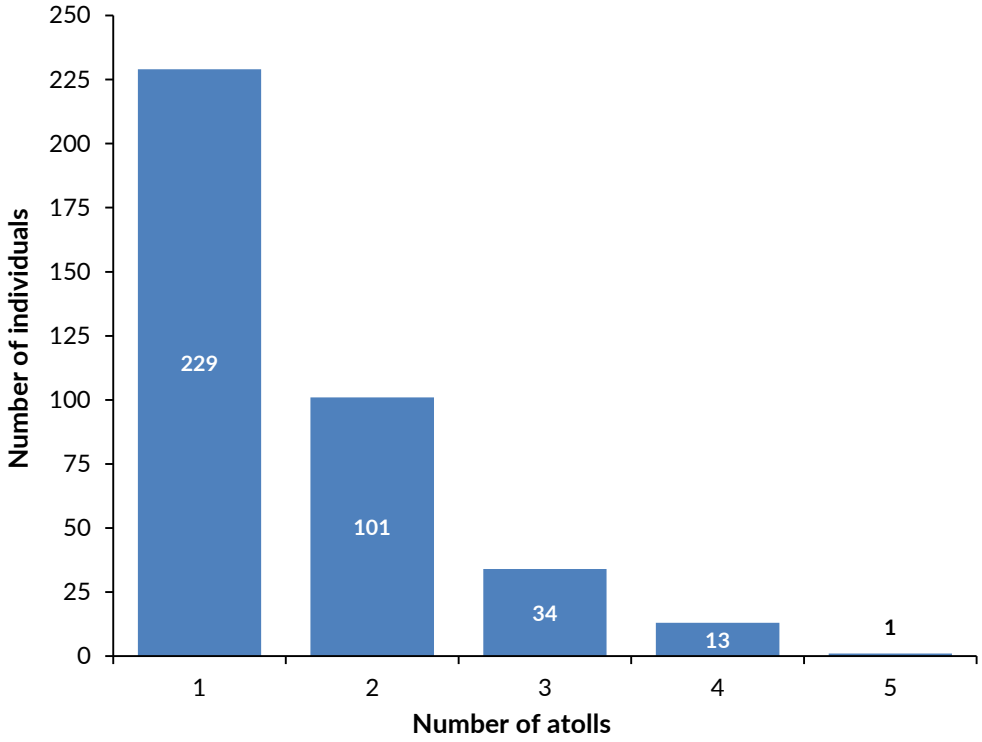


Figure 12: Number of geographical atolls that each reef manta rays (*Mobula alfredi*) within the Lhaviyani Atoll population (*n*=378) has been recorded in.

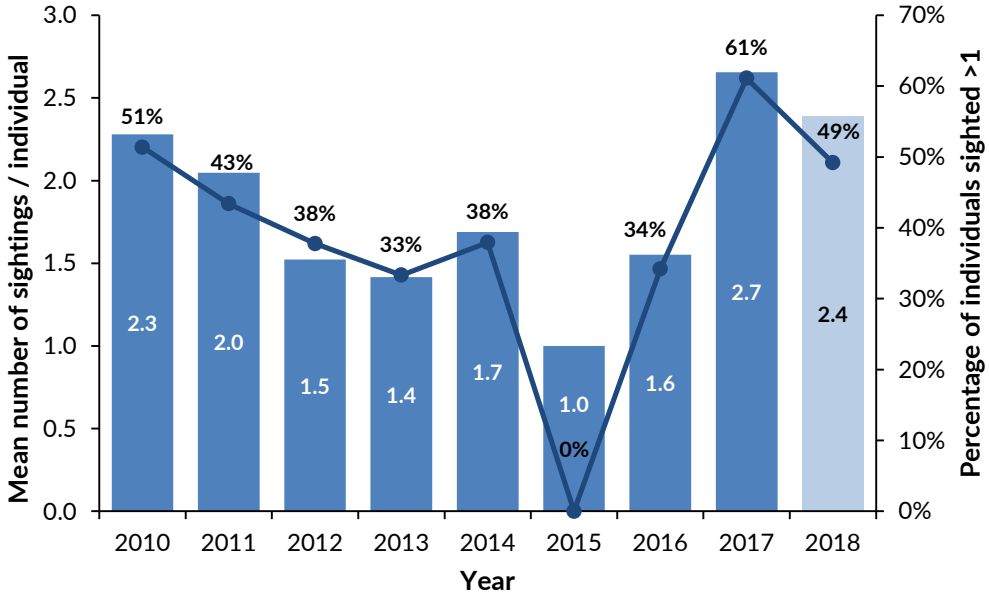


Figure 13: Mean number of sightings per individual reef manta ray (*Mobula alfredi*) in Lhaviyani Atoll, and the percentage of individuals sighted on multiple occasions during the same year.

In 2018, individual reef manta rays were sighted 2.4 times each on average (Fig. 13). When survey effort is accounted for, residency index (RI) indicates that each manta ray was recorded on 1.1% of total surveys that year. This is one of the lowest indices recorded in recent years, and second lowest within the survey period, after 2010 (Fig. 14). It is important to note however, that 2018 and 2010 were two years with the highest number of surveys (Fig. 2). It seems that RI is inversely correlated with survey effort, as sightings of individual manta rays within a year does not increase linearly with number of surveys conducted (Fig. 15), owing to the fact that some mantas are highly resident, and others less so. It is likely that the residency of reef manta rays in Lhaviyani Atoll during 2018 reflects more transient behaviour, with manta ray movements likely dictated by more favourable conditions elsewhere.

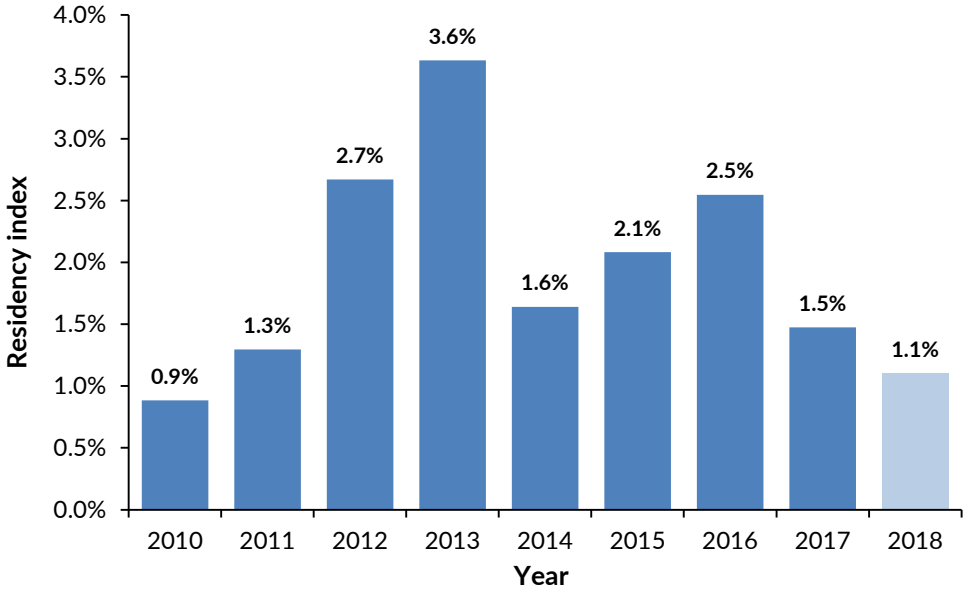


Figure 14: Annual Residency Index (RI) of reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll. RI is calculated as the average of each individuals' residency (number of times sighted annually divided by the total number of surveys).

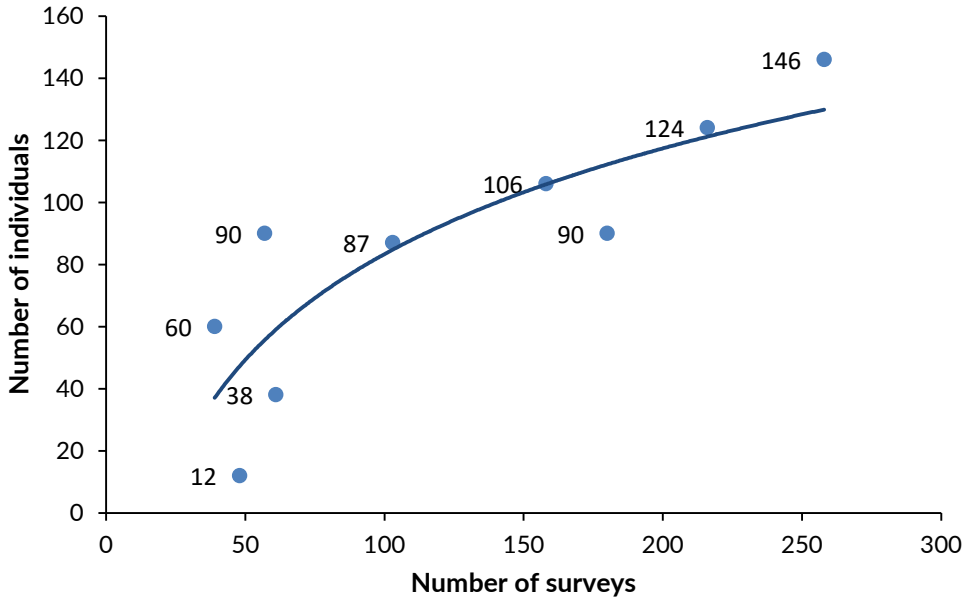


Figure 15: Non-linear relationship between the number of surveys conducted and the number of individual reef manta rays (*Mobula alfredi*) recorded within a study year in Lhaviyani Atoll (2010-2018)

Within Lhaviyani Atoll, fidelity of reef manta rays to different aggregation sites varies between individuals. Three key hotspots have been identified (as described previously); Dhanifaru (a sheltered lagoon to the west of the atoll), Fushifaru Kandu (a key cleaning station to the northeast), and Veligadu Falhu (an elongated sandbank to the northwest). Of those manta rays that frequent these three key sites, a large proportion have been recorded only at Dhanifaru (*n*=88), or only at Fushifaru Kandu (*n*=98) (Fig. 16). There is also a large degree of overlap between these two sites (*n*=67). Meanwhile, the majority of individuals sighted at Veligadu Falhu have also been recorded at either one or both of the other key sites (*n*=74), compared to only 29 individuals which have been sighted there only (Fig. 16). Further study is required to investigate the degree to which these may represent sub-populations within the atoll, and what factors might determine site preference. Indeed, these sites appear to be utilised by different age and sex demographics within the population (Fig. 8). Across study years, Dhanifaru was visited by a relatively large proportion of juvenile manta rays, which may be due to the fact that young individuals tend to prefer more sheltered

lagoon areas. Meanwhile, the majority of those individuals recorded at Fushifaru Kandu and Veligadu Falhu were adults. Furthermore, while Dhanifaru and Veligadu Falhu were favoured slightly by males, 61% of individuals sighted at Fushifaru Kandu were female. The preference of mature manta rays, particularly females, to Fushifaru Kandu is unsurprising, given that adults commonly visit cleaning stations which act as focal points for courtship activity, and are typically dominated by females which invest more time in cleaning than males.

Overall, these findings highlight the importance of surveying across different sites and support the protection of multiple areas around the atoll in order to protect different demographics of reef manta rays and their habitats. Of the three key sites described, only Fushifaru Kandu is currently designated as a marine protected area (MPA), with protective legislation banning fishing within 1,400 ha of the surrounding area. However, there is no enforcement or monitoring of regulations in this area, and it is not made clear what the guidelines are for this specific area. In December of 2017, a proposal for the creation of two new MPAs at Veligadu Falhu and Dhanifaru was presented to the Lhaviyani Atoll Council by a MMRP researcher in collaboration with Naifaru Juvenile, another local NGO. The proposal was unsuccessful, however; before moving to create new MPAs within Lhaviyani Atoll, it is necessary that regulations are being enforced and monitored in existing protected areas.

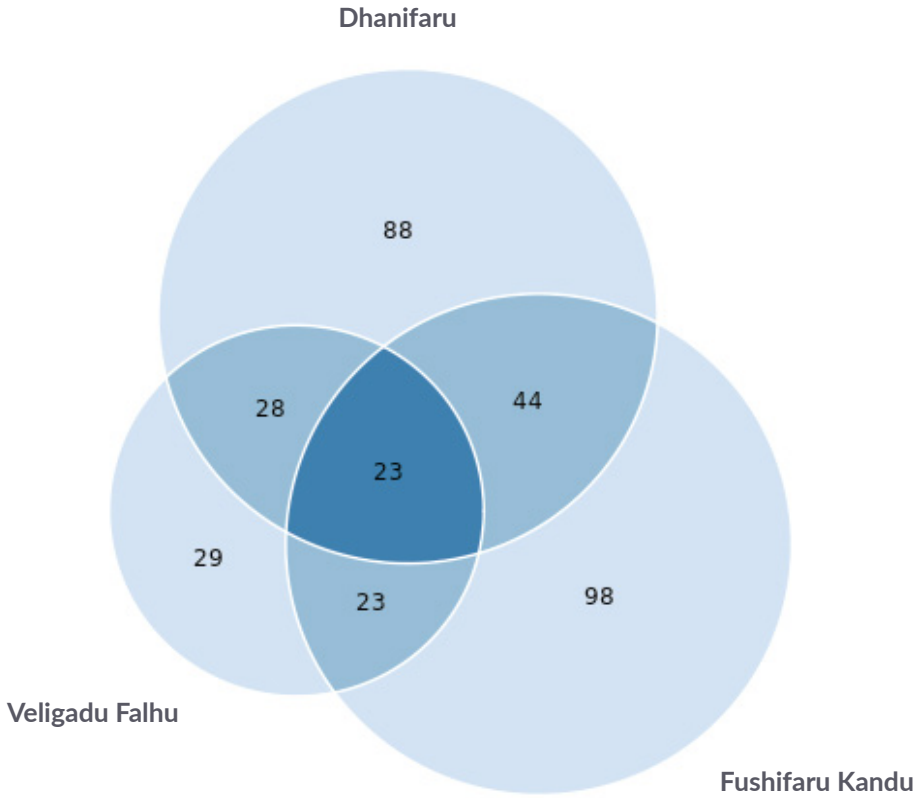


Figure 16: Number of individual reef manta rays (*Mobula alfredi*) (*n*=333) recorded at, and between, three key aggregation sites in Lhaviyani Atoll (2004-2018).

Pregnancies & Courtship

The Lhaviyani Atoll reef manta ray population comprises a total of 69 mature females, 18 of which were sighted during 2018. Of these, five were observed pregnant, making 2018 the year with the highest number of recorded pregnancies since this study began in this atoll (Fig. 17). On average, only 13% of mature females sighted annually between 2004 and 2018 have been observed pregnant, indicating very low fecundity within the population, which is consistent with reproductive rates of manta rays elsewhere in the Maldives. Indeed, of the 17 females that have been observed pregnant in Lhaviyani Atoll across the study period, only three individuals have been recorded pregnant more than once (Table 1). Furthermore, there are very few records of courtship behaviour in Lhaviyani Atoll. In 2018, there were just two events; one at Kanifushi Falhu in January, and one at Fushifaru Kandu in September.

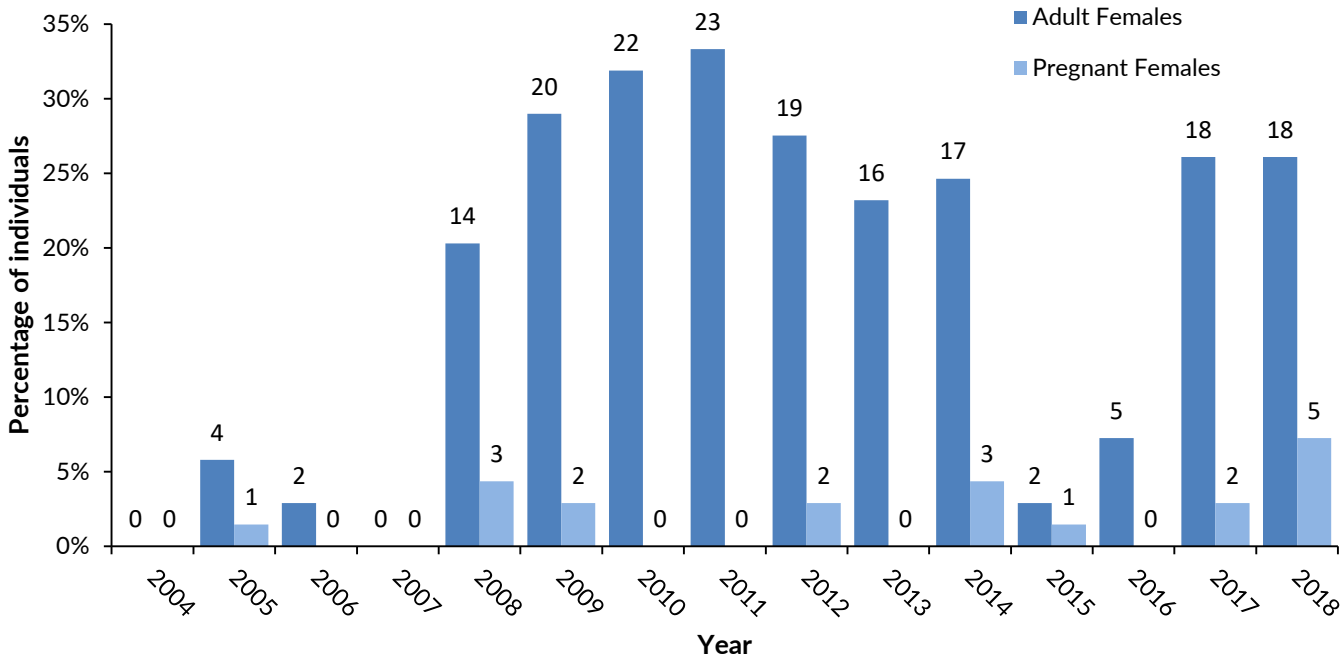


Figure 17: Percentage of Lhaviyani Atoll's adult female reef manta ray (*Mobula alfredi*) population (*n*=69) sighted annually, and the percentage of those females which were recorded pregnant in the same year. Actual numbers above bars.

A female manta ray leading a male in a courtship train in Fushifaru Kandu, Lhaviyani

Table 1: Annual sightings of 17 commonly sighted female reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll which have been recorded pregnant. Years where the individual was observed pregnant are highlighted in dark blue.

ID	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
MV-MA-0040		1													
MV-MA-0041		1			4	2	8	4	6		2		1	6	15
MV-MA-0042		1			1				2	1	4			7	6
MV-MA-0043		1			1	1	1								
MV-MA-0939					1		2	2	1		3	1		6	
MV-MA-1090							1								1
MV-MA-1184					1		1	2						2	1
MV-MA-1185					1										
MV-MA-1186					2										
MV-MA-1412						1			1		1				
MV-MA-1419						2	2								
MV-MA-1421						1		3			4			6	3
MV-MA-1424						1	1	4	1						
MV-MA-1975								1		2				2	3
MV-MA-2798									2						
MV-MA-3161										1	1				4
MV-MA-3233											1				
Total Pregnant	0	1	0	0	3	2	0	0	2	0	3	1	0	2	5

Sub-lethal Injuries

During each photo-ID sighting, data on any injuries of the reef manta rays was also recorded. Within the Lhaviyani Atoll reef manta ray population, 66% (*n*=250) have no significant injuries, while the remaining 34% (*n*=128) have been recorded with sub-lethal injuries. Of those, 11 individuals had not one, but two injuries, and one individual had a superficial injury which healed and left no scarring.

Over half (58%) of the sub-lethal injuries recorded on the Lhaviyani reef manta ray population have natural origins (*n*=80), while 32% (*n*=45) of injuries were caused by anthropogenic impacts. The origin of the remaining 10% (*n*=14) of recorded sub-lethal injuries could not be clearly identified (Fig. 18). Naturally caused injuries included deformity (*n*=4), and predatory bites (*n*=73). Injuries caused due to anthropogenic impact included boat strikes (n=4), injuries caused by fishing line (*n*=39), and manta rays being entangled in fishing nets (*n*=1) (Fig. 19). Ghost nets and discarded fishing gear are regularly encountered in Lhaviyani Atoll, which may explain the large number of injuries caused by fishing lines in the region. Of the 128 manta rays recorded with injuries, 86% (*n*=110) had injuries inflicted upon their pectoral fins, 13% (*n*=17) on the tail and dorsal areas, 10% (*n*=13) on the cephalic fins, and 2% on the gill slits (*n*=3) (Fig. 20).

In 2018, four manta rays were recorded with new injuries in Lhaviyani Atoll. Of these, three had injuries caused by anthropogenic impacts; two mantas showed scarring from fishing lines, and one manta had a cut on its pectoral fin from a boat propeller strike. The remaining manta had a new shark bite injury.

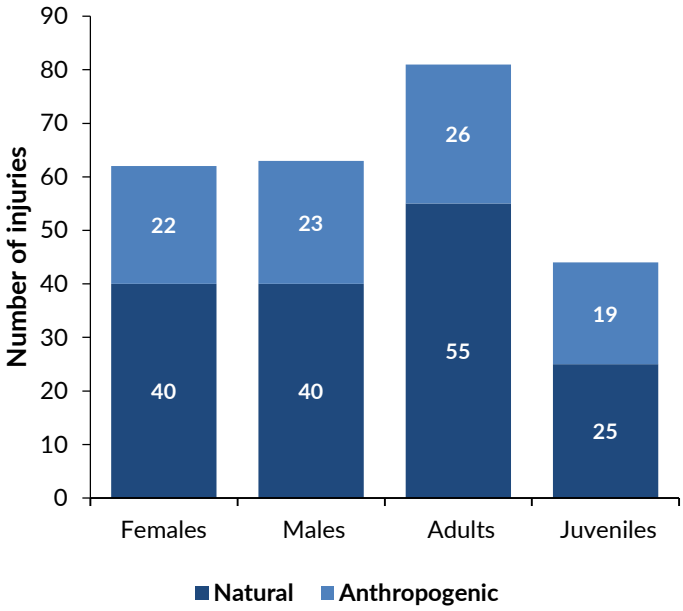


Figure 18: Demographic variations in the likely origin (natural or anthropogenic) of sub-lethal injuries (*n*=139) within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=128).

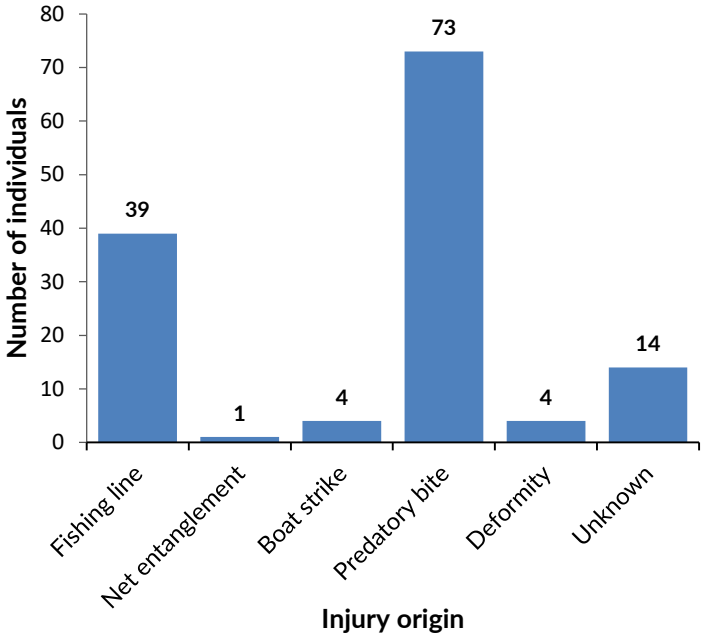


Figure 19: Variations in the origin of sub-lethal injuries within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=128).

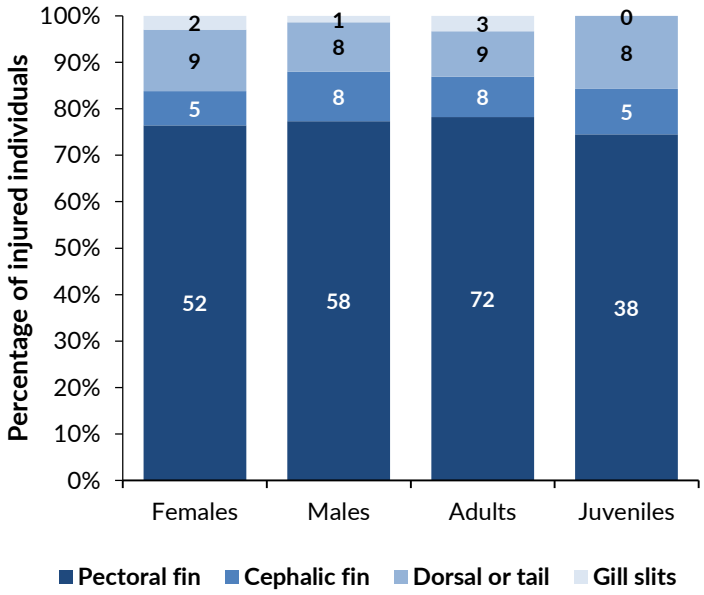


Figure 20: Variations in the location and number of sub-lethal injuries within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=128) and their demographic variation (actual number of individuals on bars).

ENVIRONMENTAL VARIABLES

Within Lhaviyani Atoll, site use by manta rays appears to be linked to wind direction, which changes with the monsoons. Wind direction was recorded on 301 of the surveys conducted by resident Manta Trust researchers (*n*=424), which have been based in the atoll since November 2016. The majority of reef manta ray sightings at Fushifaru Kandu occurred when winds were blowing from the northwest (*n*=60), west (*n*=27), or southwest (*n*=21) (Fig. 21), and mostly occurred during the transition between the Southwest and Northeast Monsoons. In contrast, north-easterly monsoon winds account for the largest proportion of sightings at Dhanifaru and Veligadu Falhu (Fig. 21), which are both sites on the western side of the atoll and are most associated with feeding behaviour. Winds of the Northeast Monsoon drive upwelling and primary productivity on the outer edge of the atoll between December and March each year. When combined with tidal currents, this results in localised abundances of zooplankton within the western side of Lhaviyani during this time. In addition to wind direction, wind speed is also an important factor in influencing manta ray sightings. In 2018, sightings appeared to correlate with wind speed during the Northeast Monsoon and transitional months (Fig. 22). Higher wind speeds are likely to be associated with an increase in upwelling and productivity in the region at these times, driving higher abundance of manta rays' zooplankton food source on the western side of the atoll. Sightings did not appear to be strongly associated with the prevailing winds during the heart of the Southwest Monsoon (June – September) in Lhaviyani Atoll (Fig. 21); it is possible that manta rays may be feeding on the eastern side of the atoll during this period, however, no feeding aggregation site has so far been identified. Exploratory trips to identify key feeding sites along the eastern borders of Lhaviyani Atoll will continue in 2019.

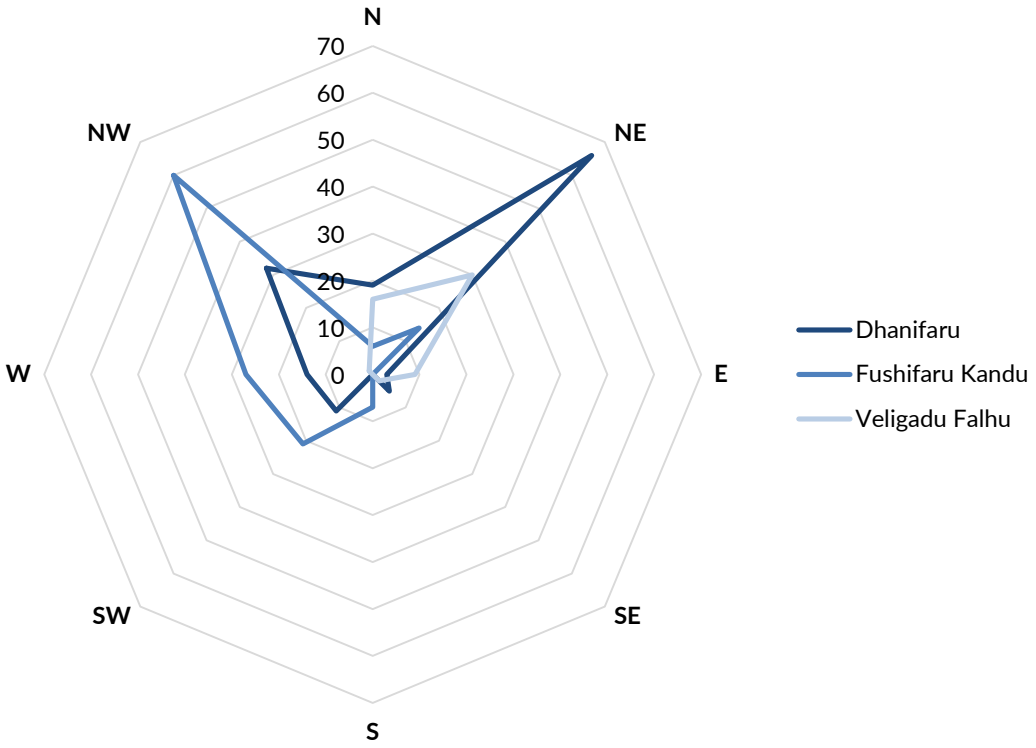


Figure 21: Total number of reef manta ray (*Mobula alfredi*) sightings in relation to prevailing wind direction at three key aggregation sites in Lhaviyani Atoll (2016-2018); obtained from surveys where wind direction was recorded (*n*=301).

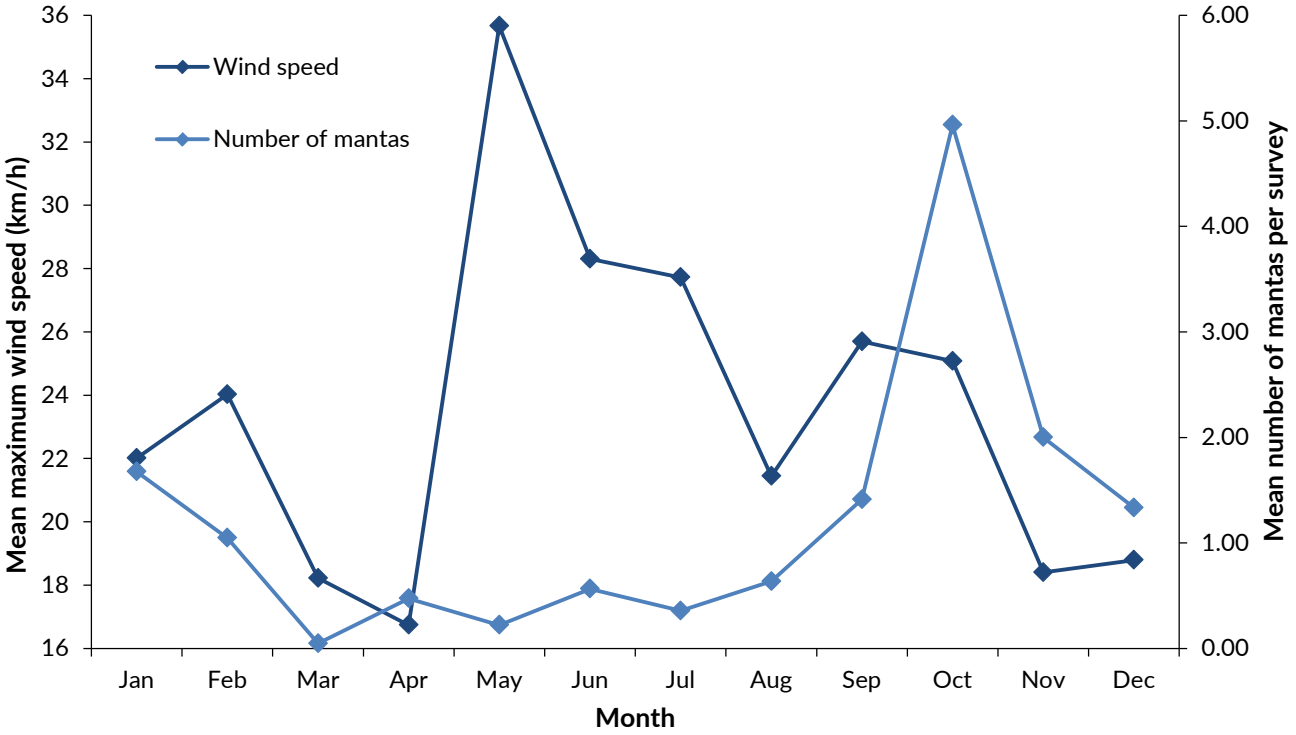


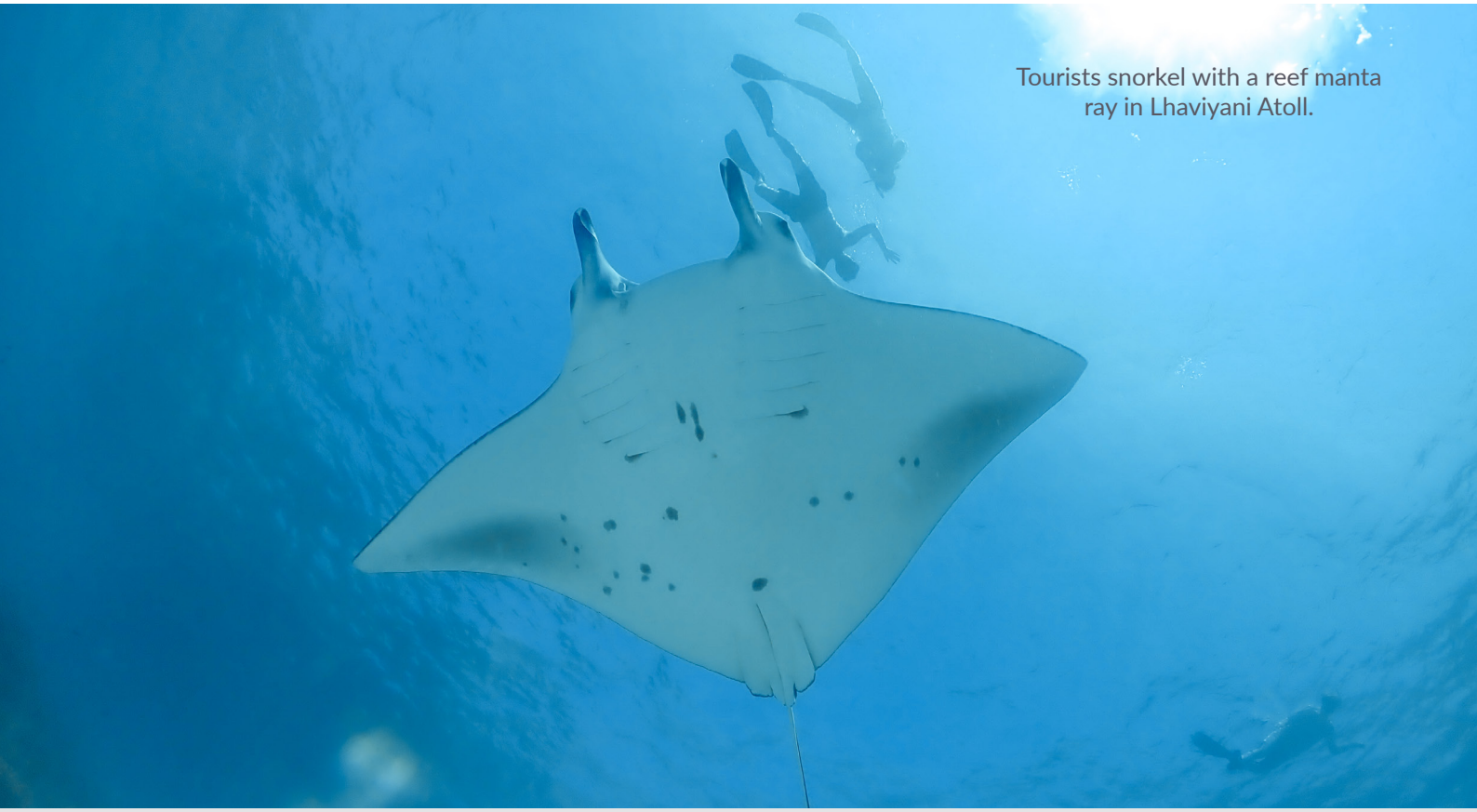
Figure 22: Monthly mean maximum wind speed (km/h) and mean number of reef manta ray (*Mobula alfredi*) sightings per survey in Lhaviyani Atoll (2018).

TOURISM ACTIVITIES

The MMRP strives to improve the sustainability of manta ray tourism activities in Lhaviyani Atoll. In 2018, the MMRP researcher continued to collect tourism related data within the region and noticed a slight decrease in the average number of tourist boats and snorkellers present per survey when compared to 2017 records. On average, 1.1 boats and 5.6 snorkellers were recorded per survey in 2018, compared to 2.0 boats and 6.9 snorkellers recorded per survey in 2017. This may be in part due to the lack of MMRP presence within the atoll between August and December, and therefore an inability to track these tourism indices over this period. Interestingly, the ratio of guests to manta rays during in-water surveys decreased slightly between 2017 and 2018, which is likely due to a larger number of manta rays seen per survey in 2018 than seen in 2017. With a year-round researcher presence in 2019, it is hoped that further insight into tourism influences will be identified and guidelines to mitigate any negative impacts and encourage sustainable tourism practices will be administered.

During 2018, the MMRP team organised a series of informative presentations and workshops aimed at those leading swim-with-manta-ray tourism initiatives. The information sharing events provided education on manta ray biology, ecology, the history of the MMRP, the research the MMRP conducts in the Maldives, and the best Codes of Conduct (CoC) for interacting with manta rays in the water. The aim was to provide marine users with the necessary tools to conduct sustainable manta ray tourism activities, in order to safeguard against negative ramifications of human-manta ray interactions and ensure the conservation of the Maldives manta ray population. The information sharing events were a success. One workshop held prior to manta season had over 25 attendees from a variety of resorts.

Beyond educating marine users, it is crucial to the conservation of the Maldives manta ray population that there is improved monitoring of diver and snorkeller manta ray tourism activities at manta sites (and other protected areas) in Lhaviyani Atoll. Wide distribution of the CoC and the "how to swim with mantas" guidelines across all dive centres and live-aboard vessels that operate in Lhaviyani Atoll is becoming increasingly important, as new resorts and guest houses are opened and more tourists join manta excursions each year. All tourists who joined manta snorkel excursions or dives from Hurawalhi Resort in 2018 were properly briefed by the MMRP's Manta Trust researcher and/or the Prodivers staff on how to behave in water.



Tourists snorkel with a reef manta ray in Lhaviyani Atoll.

MARINE EDUCATION PROGRAMME

In 2017, the Manta Trust researcher based on Hurawalhi Resort first collaborated with the local NGO Naifaru Juvenile to initiate an educational programme for young Maldivians. In 2018, this collaboration continued, and resulted in a voluntary after-school educational programme for students of Hinnavaru School, known as Nature Club. A 10-session syllabus was developed for students who have previously shown interest in biology and conservation related subjects and was designed to teach the students about the marine environment and some of the threats currently faced by it. Interactive classroom sessions were set in the context of the Maldives and their community, and encouraged students to think independently and creatively about how to protect marine habitats. High emphasis was put on the value of marine ecosystems in terms of tourism, fisheries, and research. Outdoor excursions were scheduled in addition to classroom sessions held at Hinnavaru School, including a beach clean-up and a visit to the Marine Centre. The programme proved to be a huge success amongst students, teachers and the local community. Discussions have already begun to expand and deliver a similar programme of activities in 2019.

This report was made possible thanks to

MALDIVES GOVERMENT AUTHORITIES

The Manta Trust is grateful for the opportunities provided by the Ministry of Environment and Energy, the Ministry of Fisheries, Marine Resources and Agriculture, the Environmental Protection Agency, and the Marine Research Centre. All data was collected in accordance with the relevant permit requirements of the aforementioned governing bodies.

The Manta Trust would also like to extend a warm thank you to all the other resorts, guest houses, liveaboards, dive centres and watersports teams as well as the marine biologists and citizen scienteists who have supported our research and submitted sightings.

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

MALDIVIAN MANTA RAY PROJECT (MMRP)

The MMRP is highly regarded within the scientific community. It is the largest and one of the longest running manta ray research programmes in the world. We would welcome the opportunity to continue to work with the Maldives government and our other partners for the long-term management and conservation of these species in Maldivian waters.

The opportunities that the Manta Trust's MMRP have in the Maldives are unparalleled. Working in an area that is home to the largest aggregation of reef manta rays in the world, our research continues to expand every year. We are humbled by the thought of being able to further pursue our research programmes alongside the Maldives government. The opportunity we have to learn about manta rays in the Maldives is unique and has many implications on a global scale for manta ray conservation.

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

Tiff Bond - BSc (Hons)
Project Manager - Lhaviyani Atoll

Lynn Kessler - MSc
Project Manager - Lhaviyani Atoll

Tam Sawers - MSc (Hons)
MMRP Project Leader

Dr. Guy Stevens
Chief Executive & Co-Founder

This document was created by:

Simon Hilbourne - MSc (Hons)
Digital Media & Communications Manager

For further information, please email:

lhaviyani@mantatrust.org **info@mantatrust.org**