Manta TRUST

Maldivian Manta Ray Project

LHAVIYANI ATOLL | ANNUAL REPORT 2020

Conservation through research, education, and collaboration

- 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 a globally healthy marine ecosystem.

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 4,942 different individual reef manta rays, from more than 70,000 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 nearly 710 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 fourth 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 2020. However, due to the Covid-19 Pandemic and subsequent temporary closure of the resort and research base in Lhaviyani Atoll, the MMRP team was only present and able to carry out routine monitoring between 1st January - 18th March, and between 18th November - 31st December 2020.

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 collected reef manta ray surveys on 73 days throughout 2020. Key findings of the MMRP in Lhaviyani Atoll during 2020 include a total of 122 sightings of 81 different manta rays. Of these individuals, each manta ray was observed on average 1.5 times. The mean daily number of reef manta ray sightings for 2020 was 1.3, with peaks in daily manta ray sightings seen during the months of February and November. A Residency Index (RI) was calculated to gauge the extent of movement amongst those frequenting the region. The RI for 2020 (2.1) was higher than 2019 (1.19).

As of 2020, the population demographics of Lhaviyani Atoll constitutes 51% females (*n*=215), 48% males (*n*=204), and 1% (*n*=5) of individuals for which the sex could not be determined. Overall, 50% (*n*=212) comprise adult individuals, 43% (*n*=184) juveniles, 6% (*n*=26) subadults, and the maturation stage for the remaining 1% (*n*=2) of the population could not be determined. Of these Lhaviyani Atoll manta rays (*n*=424), 81% (*n*=345) have been re-sighted in Lhaviyani Atoll or elsewhere in the Maldives.

Of the 90 new reef manta rays added to the MMRP database from across the Maldives in 2020, 11% (*n*=10) were documented in Lhaviyani Atoll. This is a slight decrease from the previous year (*n*=19, in 2019). Furthermore, the number of pregnancies recorded in Lhaviyani Atoll during 2020 was fewer than in 2019 (*n*=3), with a total of just one pregnancy.

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 2021 and beyond. However, it is crucial that active research into manta rays and other marine life continues 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 to March, while the Southwest Monsoon, or Hulhangu, runs from May to 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 near their plankton-rich feeding areas, and thus, will migrate seasonally to utilise feeding areas 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 Lhaviyani Atoll was collected by both regional MMRP researchers and citizen scientists (tourists, local dive guides, snorkel leaders, and marine biologists). All surveys were collected via guest excursions only. 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 at a specific location (survey site). Surveys were conducted in-water, both on SCUBA and via snorkelling, with sightings recorded at 31 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.

2020 Study Period

Due to the Covid-19 Pandemic and subsequent temporary closure of the resort and research base in Lhaviyani Atoll, the MMRP team was only present and able to carry out routine monitoring between 1st January - 18th March 2020. Research activities resumed on the 18th of November once the resort had reopened. As a result, data was only collected over four months throughout the year, except for one positively identified citizen science sighting in September 2020. During this time, when research was active, the MMRP team conducted a total of 60 surveys on days that weather conditions and logistical operations allowed (n=59), at 17 different sites. Four of these sites were classified as key aggregation sites due to the higher number of individual manta rays sighted in these locations across all study years (Fig. 1).

Data was primarily collected by MMRP researchers who were based at Hurawalhi Island Resort. In addition to the MMRP survey data, this report utilises data from a further 13 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. With a total of 73 surveys conducted by MMRP and outside submitters combined, 2020 represented a relatively low annual survey count compared to previous years (Fig. 2). This reduction in survey effort was a result of the impacts of the global pandemic, which ceased all research activities for much of the year. Despite this limitation, manta rays were still observed on 67% (n=49) of all survey trips (n=73), with ID photographs collected on 56% (n=41) of surveys in 2020. This is slightly higher than that recorded for 2019, with manta rays sighted on 60% of survey trips and ID photographs collected on 50% of the surveys.

Between January and March, survey effort focused on the western Lhaviyani Atoll manta aggregation sites: Dhanifaru (n=28) and Kanifushi Falhu (n=31), which are well-known as manta ray feeding sites. In addition, Dhidhdhoo Falhu, which is located two kilometres east of Kanifushi Falhu, and where manta rays were occasionally observed feeding in the past, demonstrated high presence of manta rays in 2020. This site was surveyed a total of 21 times in 2020. Veligadu Falhu and Felivaru (Thila and Kandu), which are historically recognised as important feeding areas for manta rays, were also surveyed in 2020 (n=8 and n=5, respectively). However, no manta rays were encountered at these sites in 2020.

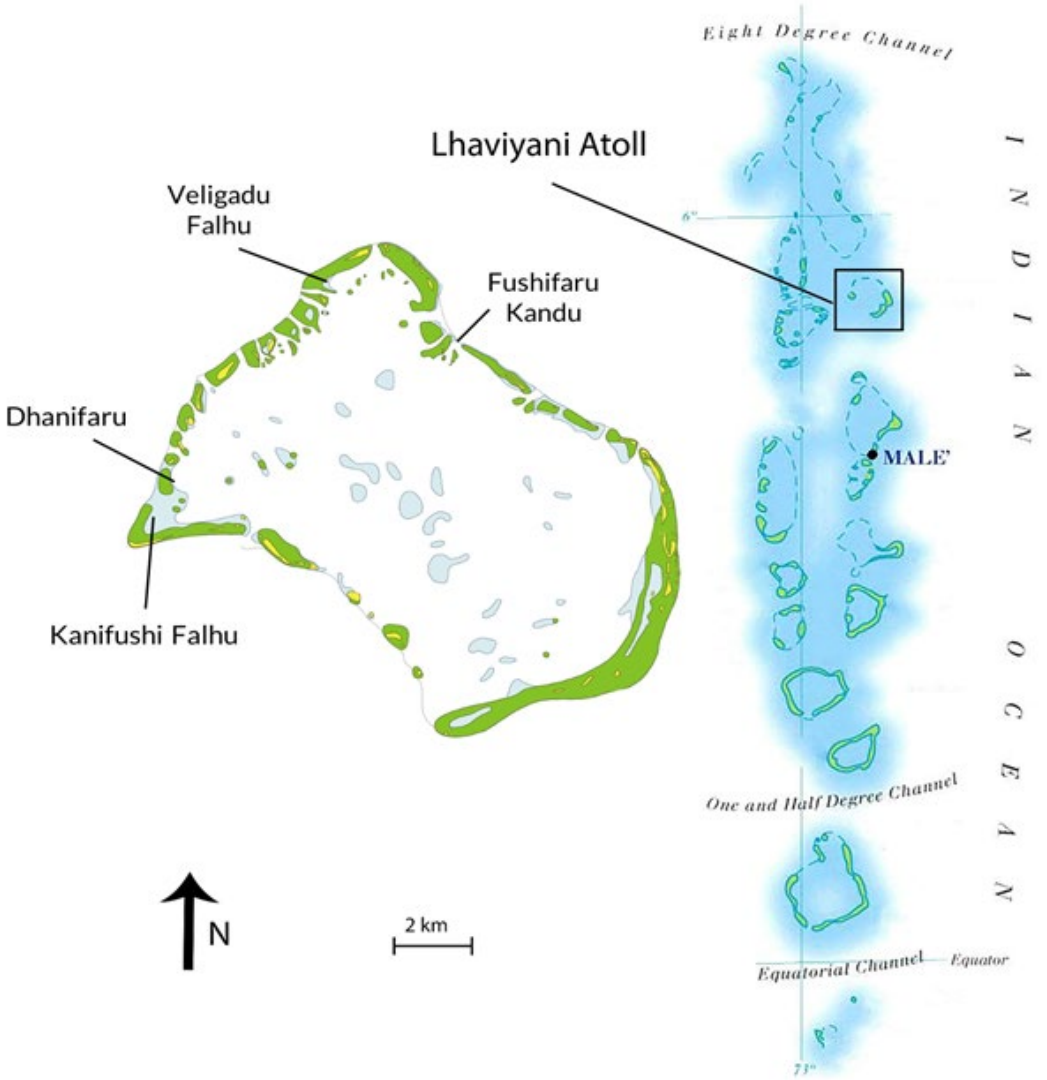

Figure 1: Map of Lhaviyani Atoll and the main reef manta ray (*Mobula alfredi*) aggregation sites. Also shown is Lhaviyani Atoll (black box) in relation to the rest of the Maldives Archipelago.

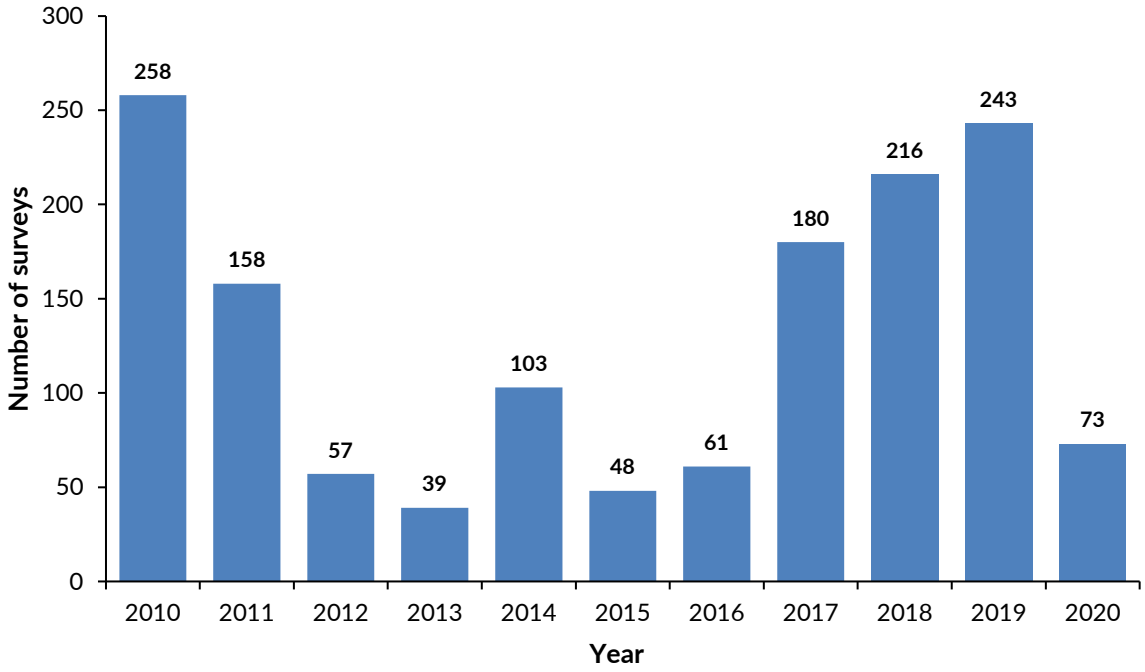

Figure 2: Number of surveys conducted annually in Lhaviyani Atoll (2010 – 2020).

Upon resuming research activities in November, survey effort moved to focus on the manta ray aggregation site in the northeast of Lhaviyani Atoll at Fushifaru Kandu; a manta cleaning station and feeding area. From November until December, a total of 16 surveys were conducted at this site. With the onset of the Northeast Monsoon in December, surveys were again performed at the northern and western manta ray aggregation sites of Lhaviyani Atoll, including Dhanifaru (*n*=9) and Kanifushi Falhu (*n*=3).

REEF MANTA RAY POPULATION & SIGHTING TRENDS

Sightings

A total of 2,159 reef manta ray sightings have been recorded in Lhaviyani Atoll between 2004 through 2020, with 1.4 manta rays sighted per survey on average between 2010 and 2020 (when survey data was recorded) (Fig. 3). During 2020, there were 122 sightings of 81 different reef manta ray individuals in Lhaviyani Atoll. This is the lowest number of sightings recorded since the establishment of a full-time MMRP researcher in Lhaviyani Atoll and can be explained by the lack of research monitoring for eight months in 2020.

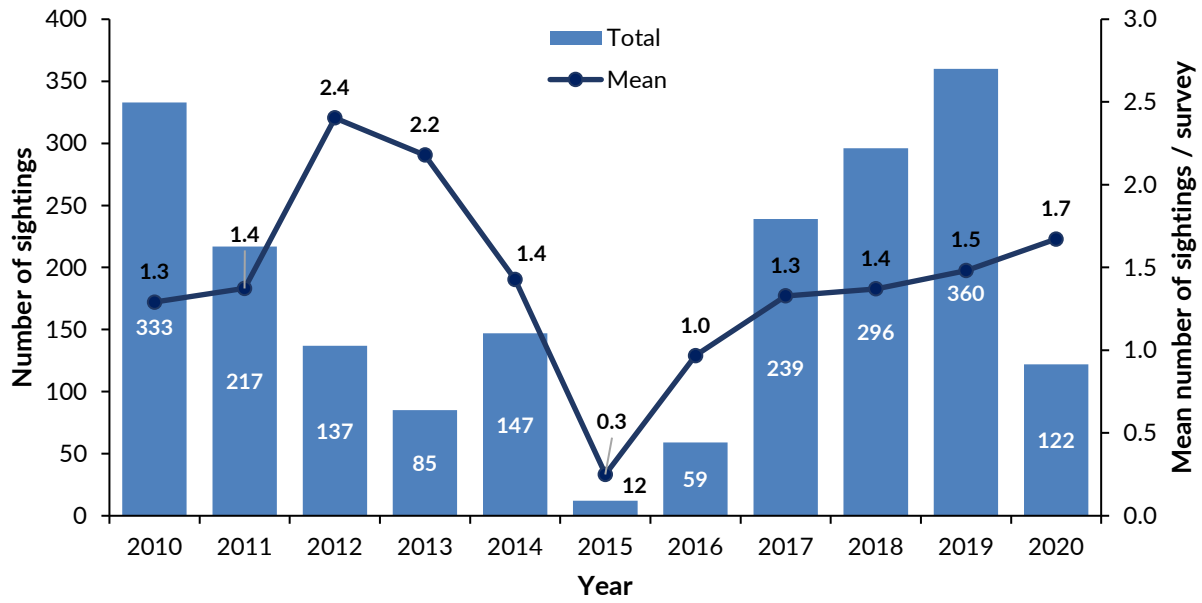

Figure 3: Annual sightings of reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll, and the mean number of sightings per survey.

While there is a certain degree of inter-annual variation across all study years, a general trend in sightings in any given 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). Due to the lack of data collected between mid-March to mid-November, it is not possible to confirm that manta ray sightings during 2020 followed a similar pattern. However, sightings did appear to spike early in the year (February), before all research activities were halted (Fig. 5). Moreover, despite limited survey effort in November (*n*=7), the number of sightings recorded per survey (*n*=4.1) far exceeded the average number of sightings per survey for all research years recorded during this month (*n*=1.9); suggesting that sightings in 2020 might have exhibited a similar peak towards the end of the year, conforming to the overall observed trends (Figs. 4 & 5).

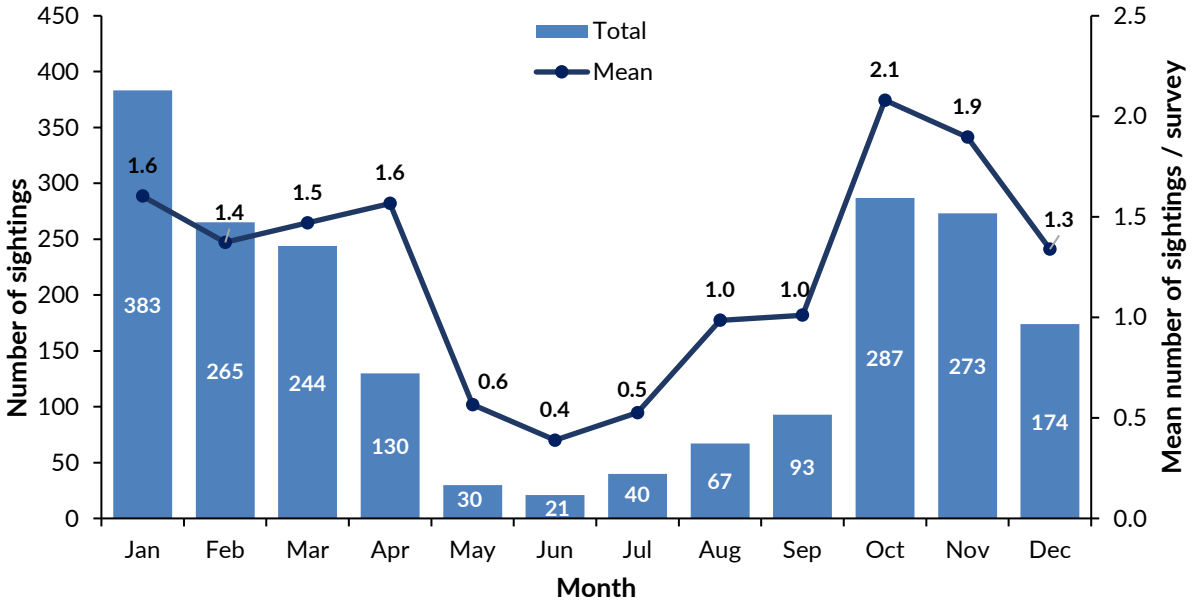

Figure 4: Monthly sightings and mean number of sightings per survey of individual reef manta rays (*Mobula alfredi*) recorded in Lhaviyani Atoll (2010 – 2020).

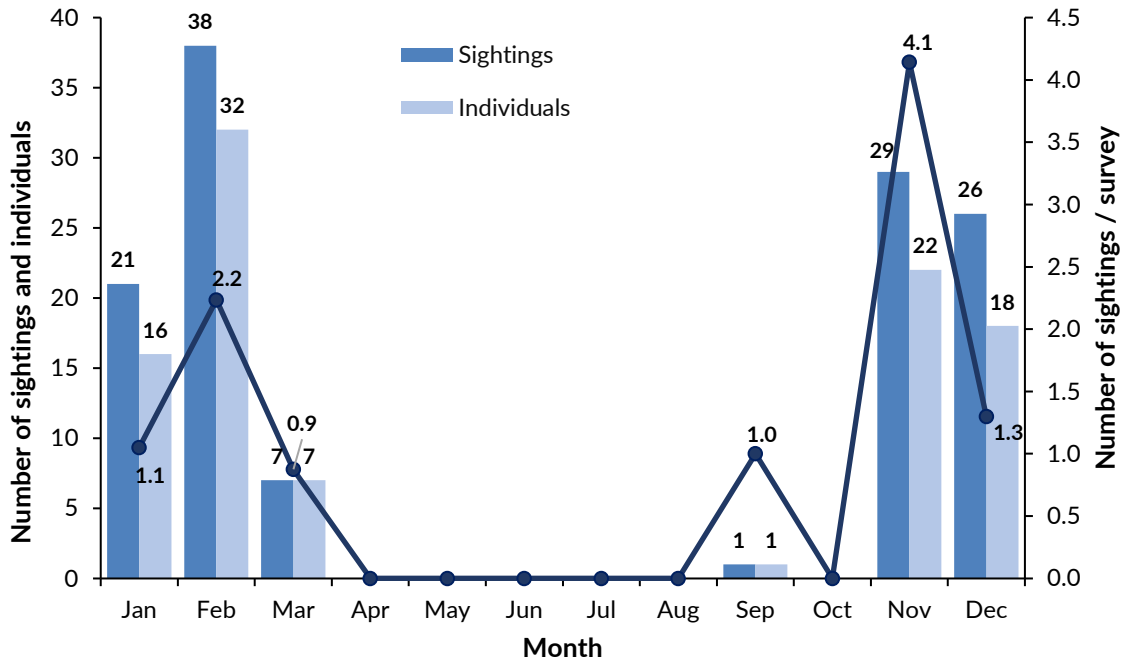

Figure 5: Monthly sightings and the number of individual reef manta rays (*Mobula alfredi*) recorded in Lhaviyani Atoll (2020).

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. Four key aggregation sites have been previously identified as having the highest number of sightings across all study years (2004 - 2019); Veligadu Falhu, Fushifaru Kandu, Dhanifaru, and Kanifushi Falhu (Refer to: 2019 Lhaviyani Annual Report).

While no sightings were recorded at Veligadu Falhu in 2020, manta ray activity followed a similar trend to that noted in previous years, with sightings predominantly reported from locations along the western border of the atoll (namely key aggregation sites: Dhanifaru and Kanifushi Falhu) during the Northeast Monsoon (January-March; December) with relatively little activity reported from Fushifaru Kandu along the east of the atoll at this time. Instead, sightings at this location peaked during the Southwest Monsoon (November), followed by a rapid drop in December with the expected seasonal migration of manta rays (Fig 6).

Based on preliminary surveys conducted in 2019, Dhidhdhoo Falhu was identified as potential manta ray aggregation site which required further monitoring. In 2020, survey effort increased here, resulting in 34 sightings of 29 different individuals being recorded at this site. Located along the western border of Lhaviyani Atoll, Dhidhdhoo Falhu was most active with manta ray sightings during the Northeast Monsoon (January – February). It seems that manta rays sighted here, and at other sites along the west of the atoll, took advantage of localised abundance in zooplankton, as all individuals were recorded while feeding.

On the eastern side of Lhaviyani Atoll, sightings were highest at Fushifaru Kandu in November (Fig. 6). On most surveys, manta rays predominantly exhibited feeding (*n*=7) and cleaning (*n*=3) behaviour. This coincided with the end of the Southwest Monsoon, which drives increased food availability in the eastern areas of atolls within the Maldives. Further, November is also typically recognised as the transitional period between the Southwest and Northeast Monsoons; it is characteristic for manta rays throughout the Maldives to engage in increased cleaning, courtship, and mating activity, with cleaning stations (in this case Fushifaru Kandu) acting as a focal point for these behaviours.

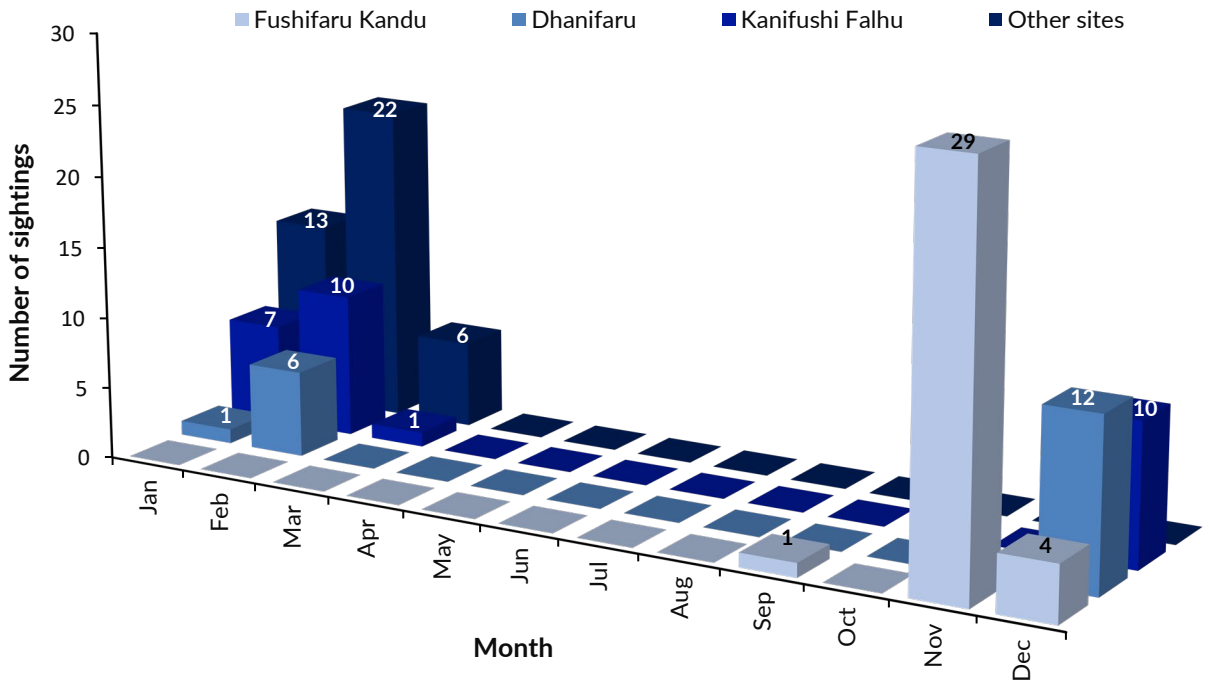

Figure 6: Monthly sightings of reef manta rays (*Mobula alfredi*) at key aggregation sites in Lhaviyani Atoll (2020). Note: 83% of sightings recorded at "Other sites" occurred at Dhidhdhoo Falhu – a potential new aggregation site on the west of Lhaviyani Atoll.

Population Demographics

During 2020, 13 new reef manta rays were identified in Lhaviyani Atoll, bringing the total recorded population to 424 individuals. The population demographics of Lhaviyani Atoll constitute 48% male (*n*=204), 51% female (*n*=215), and 1% (*n*=5) for which sex cannot be determined. Overall, 50% (*n*=212) comprise adult individuals, 43% (*n*=184) juveniles, 6% (*n*=26) are considered subadult, and for 0.5% (*n*=2) the maturity could not be determined (Fig 7). Maturity was defined by the presence of mating scars and visible pregnancies in females, and by the enlargement and calcification of claspers in males. 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 subadults or juveniles.

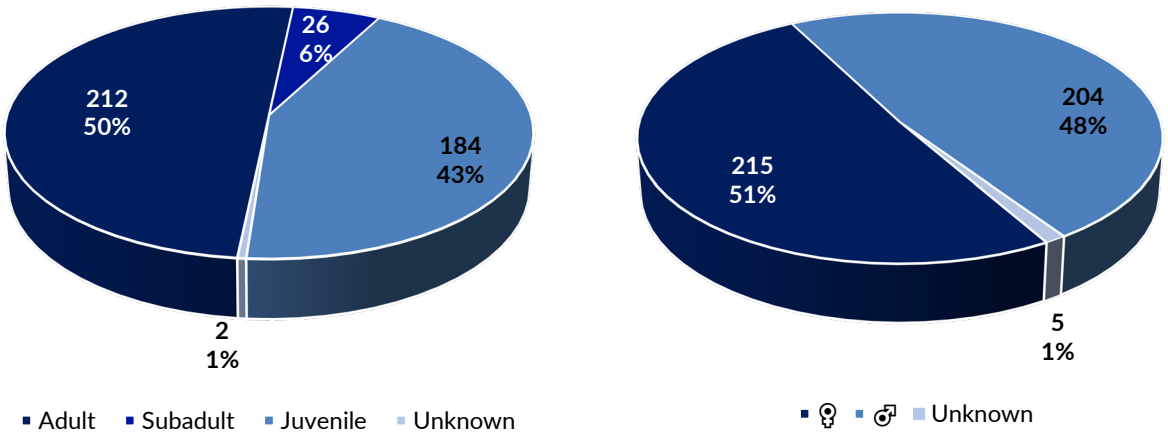

Figure 7: Demographics of the recorded Lhaviyani Atoll reef manta ray (*Mobula alfredi*) population (*n*=424).

Overall, 81% (*n*=345) of the Atoll's population has been re-sighted either in Lhaviyani Atoll or elsewhere in the Maldives. This suggests most of the reef manta rays that frequent this region have now been discovered.

The proportion of newly sighted individuals decreased from 2019 to 2020 (Fig. 8), accounting for 16% (*n*=13) of individuals sighted, compared to 27% (*n*=33) the previous year. Although research effort was affected by Covid-19 restrictions, a downward trend in newly sighted individuals has become evident in recent years despite year-round monitoring. This downward trend is expected as years pass and more data has been collected, and sightings of new manta rays become less frequent.

Of the 13 new manta rays, 10 individuals had never been recorded by the MMRP, while three individuals had been sighted elsewhere in the Maldives previously (in Baa Atoll). Ninety-two percent of these sightings of new individuals occurred along the west side of the Atoll in Dhidhdhoo Falhu (*n*=6), Dhanifaru (*n*=2), Kanifushi Falhu (*n*=2) and Veyvah Faru (*n*=2), and 8% (*n*=1) occurred on the east at Fushifaru Kandu, which is consistent with locations of overall manta ray sightings in 2020 (Fig. 9). Of the 10 new individuals recorded in 2020, 60% (*n*=6) were estimated to be young of the year, based on their small disc widths, measuring approximately 150 centimetres. Overall, 80% (*n*=8) of the newly identified manta rays are juveniles (including those categorised as young of the year), while adults and subadults represent only 10% each (*n*=2). Seventy percent (*n*=7) were females, and the remaining 30 percent were males (*n*=3).

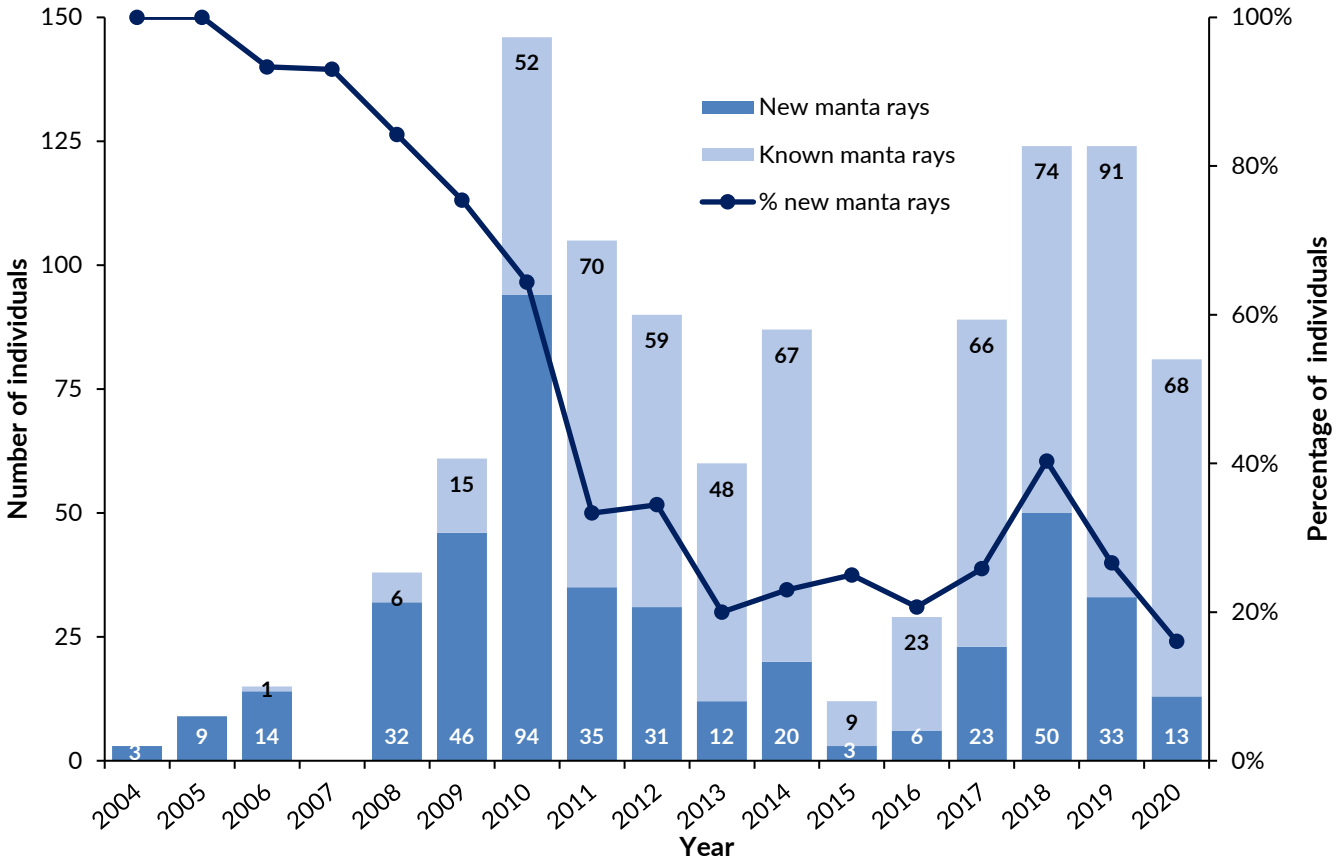

Figure 8: Number of reef manta rays (*Mobula alfredi*) sighted annually in Lhaviyani Atoll, and the proportion of those individuals which were newly recorded.

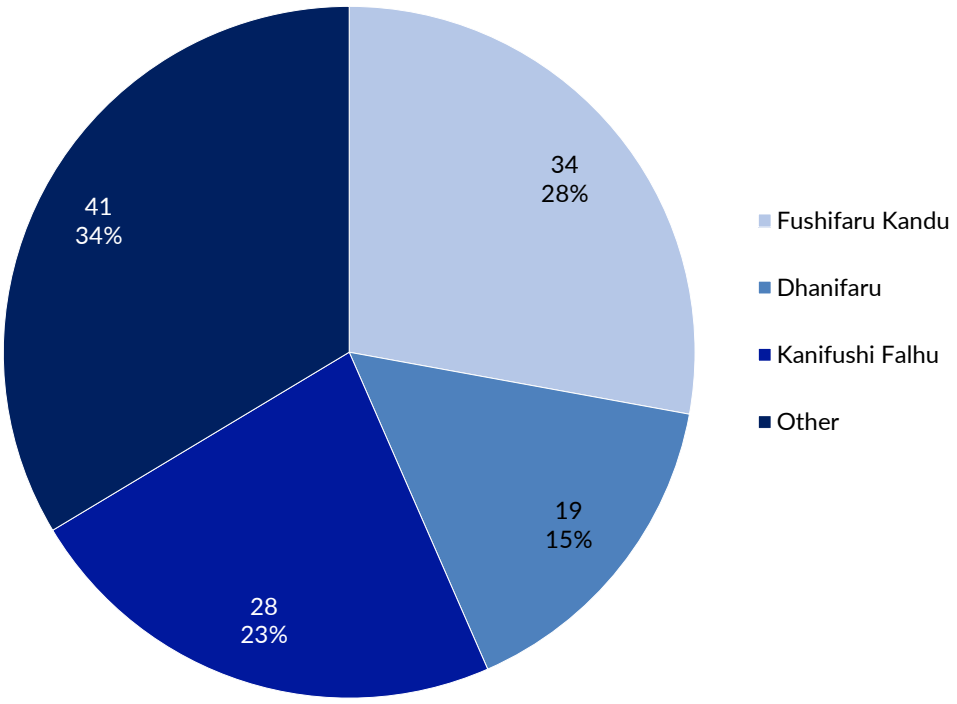

Figure 9: Proportion of total reef manta ray (*Mobula alfredi*) sightings (*n*=122) recorded at the study sites in Lhaviyani Atoll (2020).
Note: Dhidhdhoo Falhu sightings account for 83% of the "other" category

Migrations & Residency

Of the 424 reef manta rays that have been sighted in Lhaviyani Atoll across all study years, 41% (*n*=173) 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 2020, 110 individuals in the Lhaviyani population have been recorded in Baa Atoll, 33 in Raa Atoll, 29 in Thiladhunmathi Atoll, and 23 in Ari Atoll (Fig. 10). Each manta ray sighted within Lhaviyani Atoll population tends to exhibit strong site fidelity, with 88% of individuals only recorded in one (*n*=251) or two (*n*=121) atolls (Fig. 11).

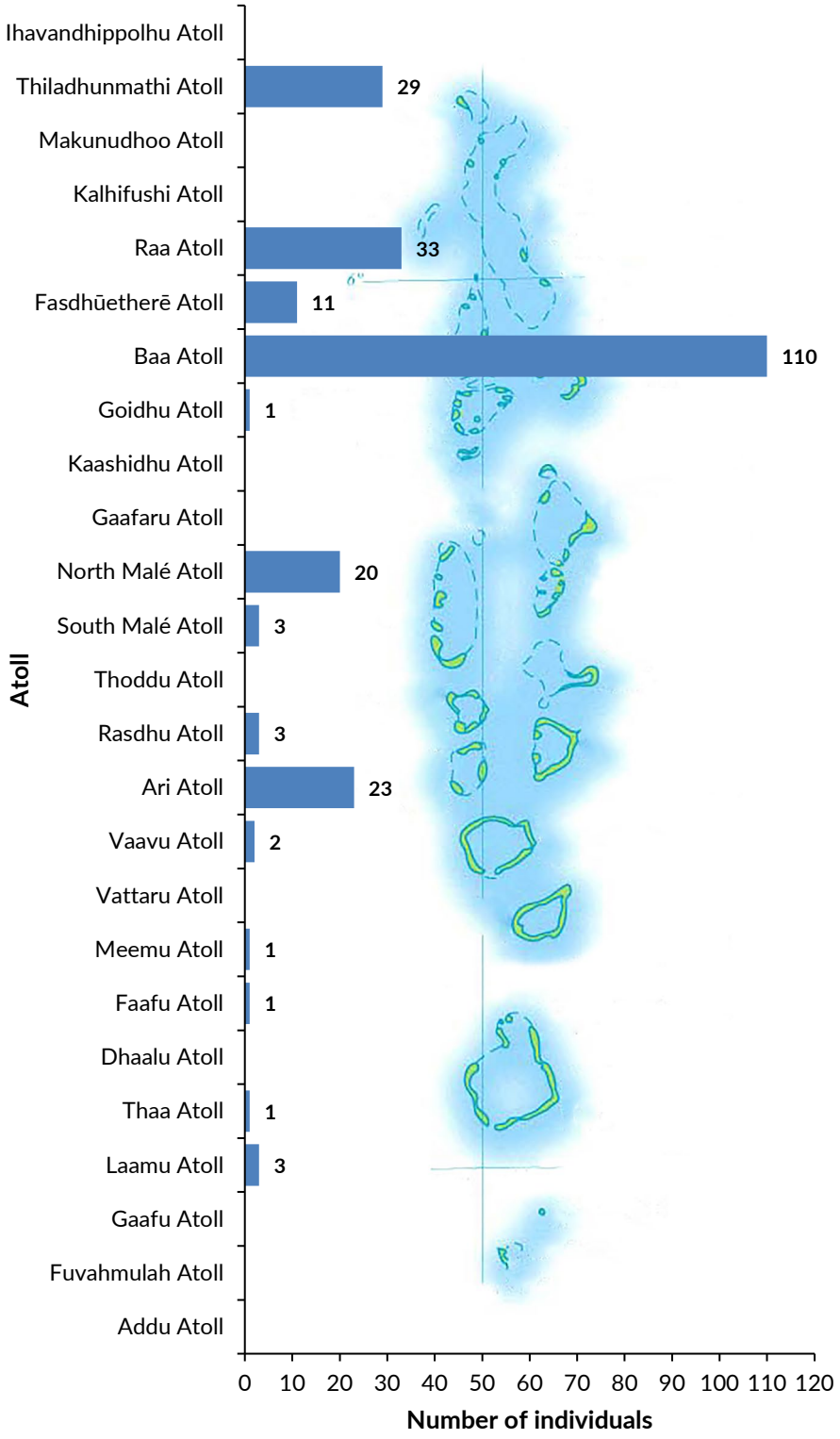

Figure 10: Number of reef manta rays (*Mobula alfredi*) (*n*=173) from within the Lhaviyani Atoll population (*n*=424) which have been recorded in other atolls throughout the Maldives Archipelago. *Note - some individuals have been sighted in more than one atoll outside Lhaviyani Atoll.*

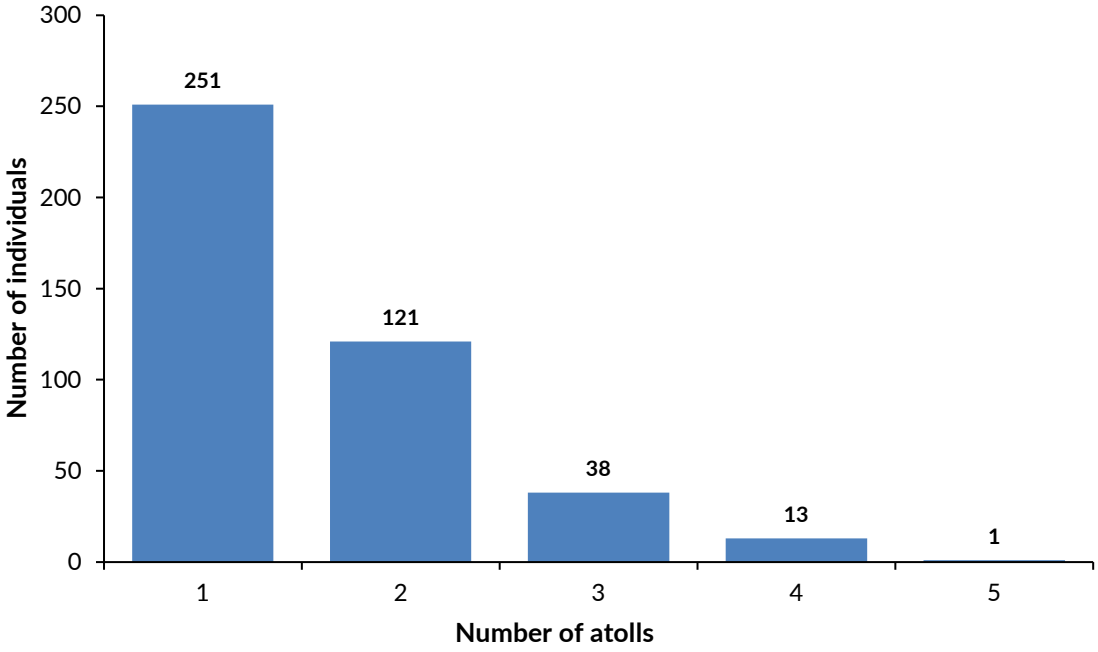

Figure 11: Number of geographical atolls each individual reef manta ray (*Mobula alfredi*) in the Lhaviyani Atoll population (*n*=424) has been recorded within.

In 2020, individual reef manta rays were sighted 1.5 times each on average (Fig. 12). When survey effort is accounted for, residency index (RI) indicates that each manta ray was recorded on 2.1% of total surveys in 2020 (Fig. 13). The higher residency of manta rays evident in Lhaviyani in 2020 is likely the result of reduced survey effort, as RI is inversely correlated with the number of surveys conducted (Fig. 14). Had 2020 represented a typical year of full-term research monitoring, this high residency could also indicate less transient behaviour, with manta ray movements dictated by favourable conditions within the atoll.

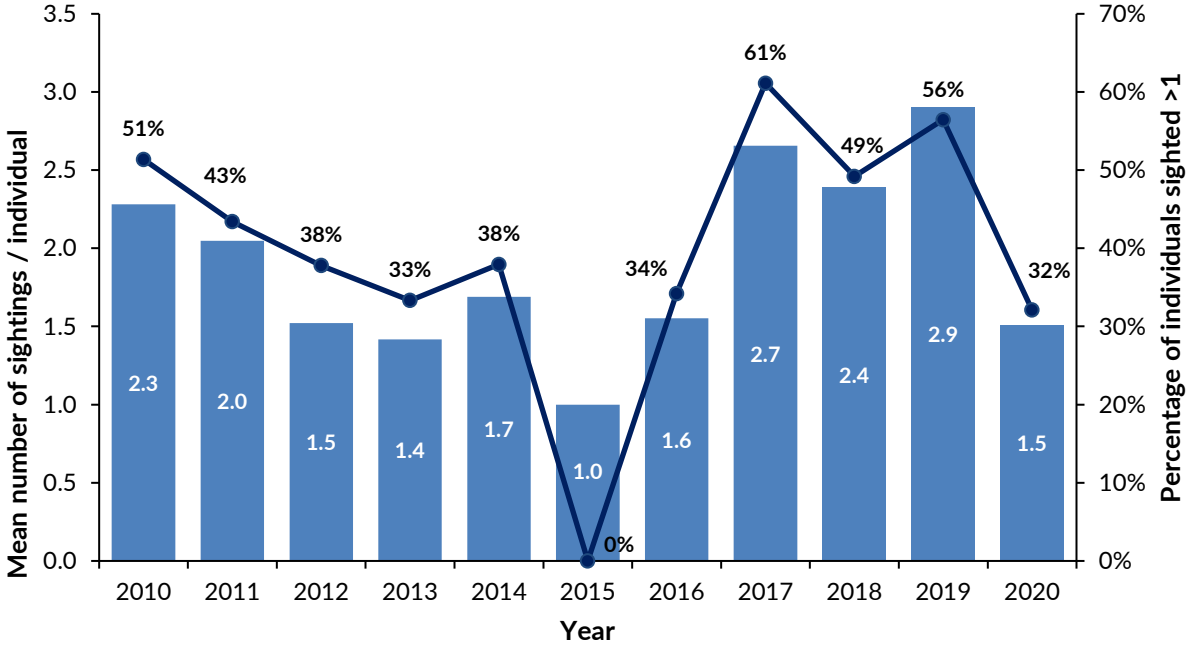

Figure 12: Mean number of sightings per individual reef manta ray (*Mobula alfredi*) in Lhaviyani Atoll, and the percentage of individuals sighted on multiple occasions during the same year.

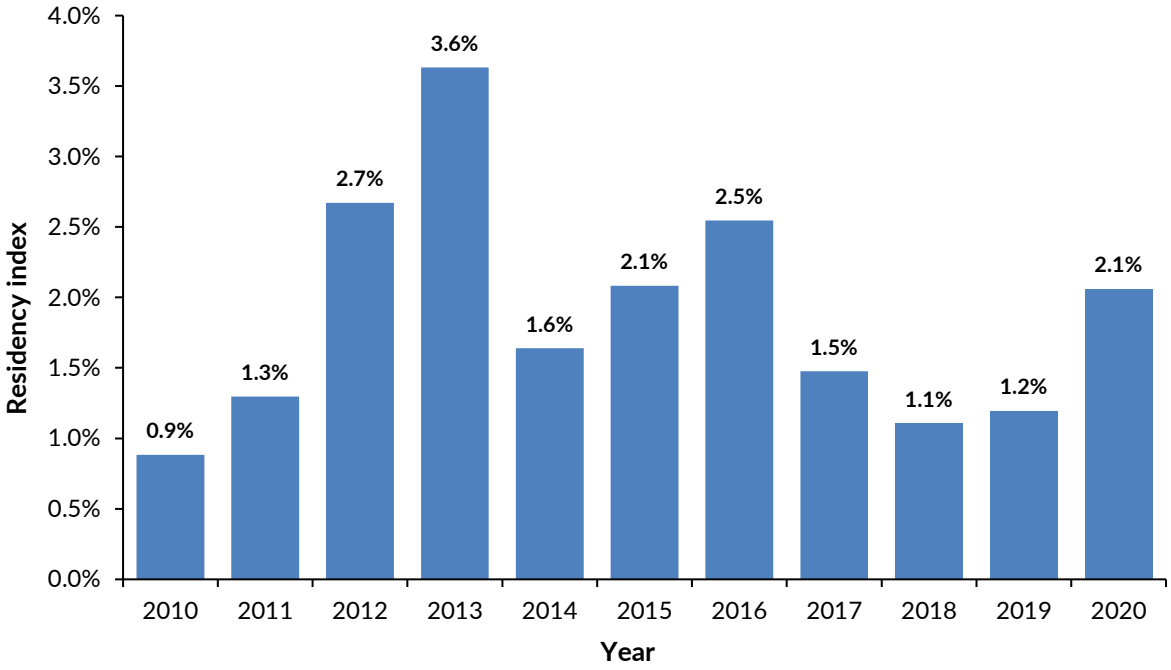

Figure 13: Annual residency index (RI) of reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll. RI is calculated as the average of each individuals' residency (number of times sighted annually) divided by the total number of surveys

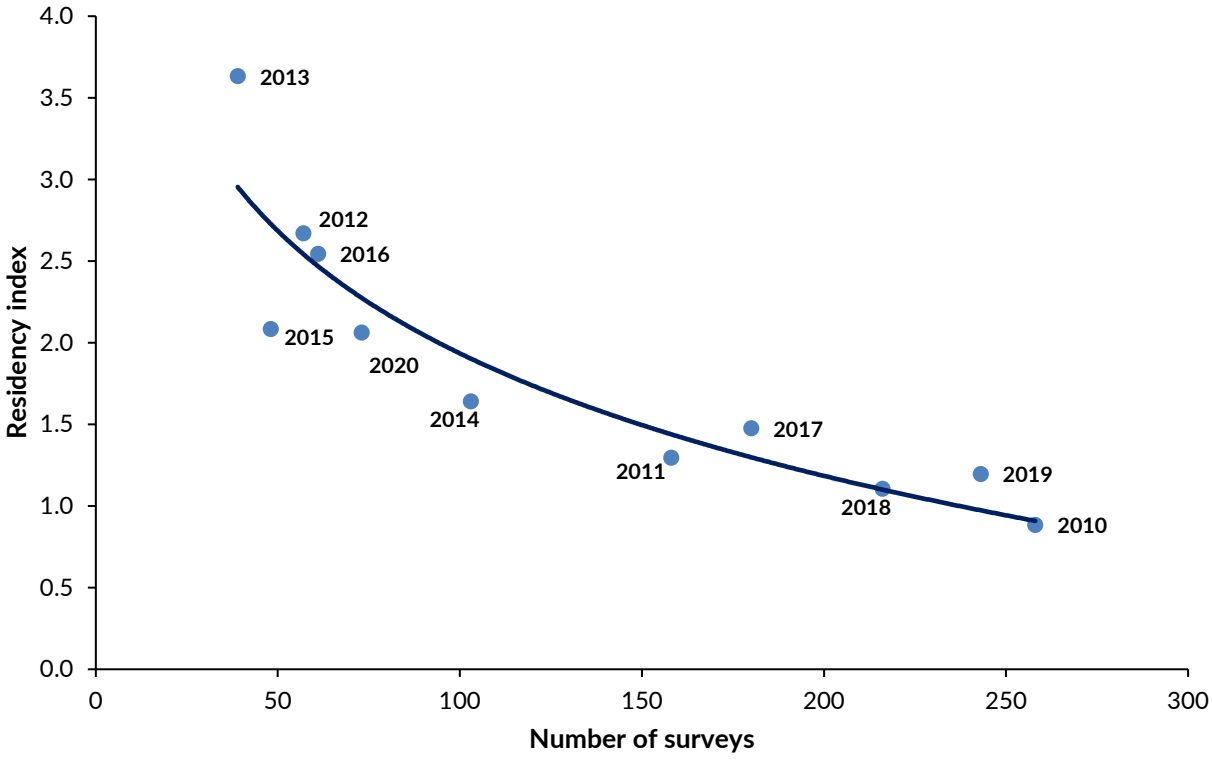

Figure 14: Relationship between the number of surveys conducted and the residency index of reef manta rays (*Mobula alfredi*) recorded within a study year in Lhaviyani Atoll (2010 – 2020).

Within Lhaviyani Atoll, fidelity of reef manta rays to different aggregation sites varies between individuals. Four key hotspots have been identified (as described previously); Dhanifaru and Kanifushi Falhu (both sheltered lagoons 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 the manta rays that frequent these four key sites (*n*=357), 36% (*n*=128) have been recorded at one of these locations only, indicating variation in site preference among individuals. Indeed, these sites appear to be utilised by different age and sex demographics within the population (Fig. 15). Across all study years, Dhanifaru and Kanifushi Falhu were visited by a relatively large proportion of juvenile and subadult manta rays, which may be because young individuals tend to prefer more sheltered lagoon areas. Meanwhile, most of those individuals recorded at Fushifaru Kandu and Veligadu Falhu were adults. Furthermore, while Dhanifaru and Veligadu Falhu were favoured slightly by males, 58% 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.

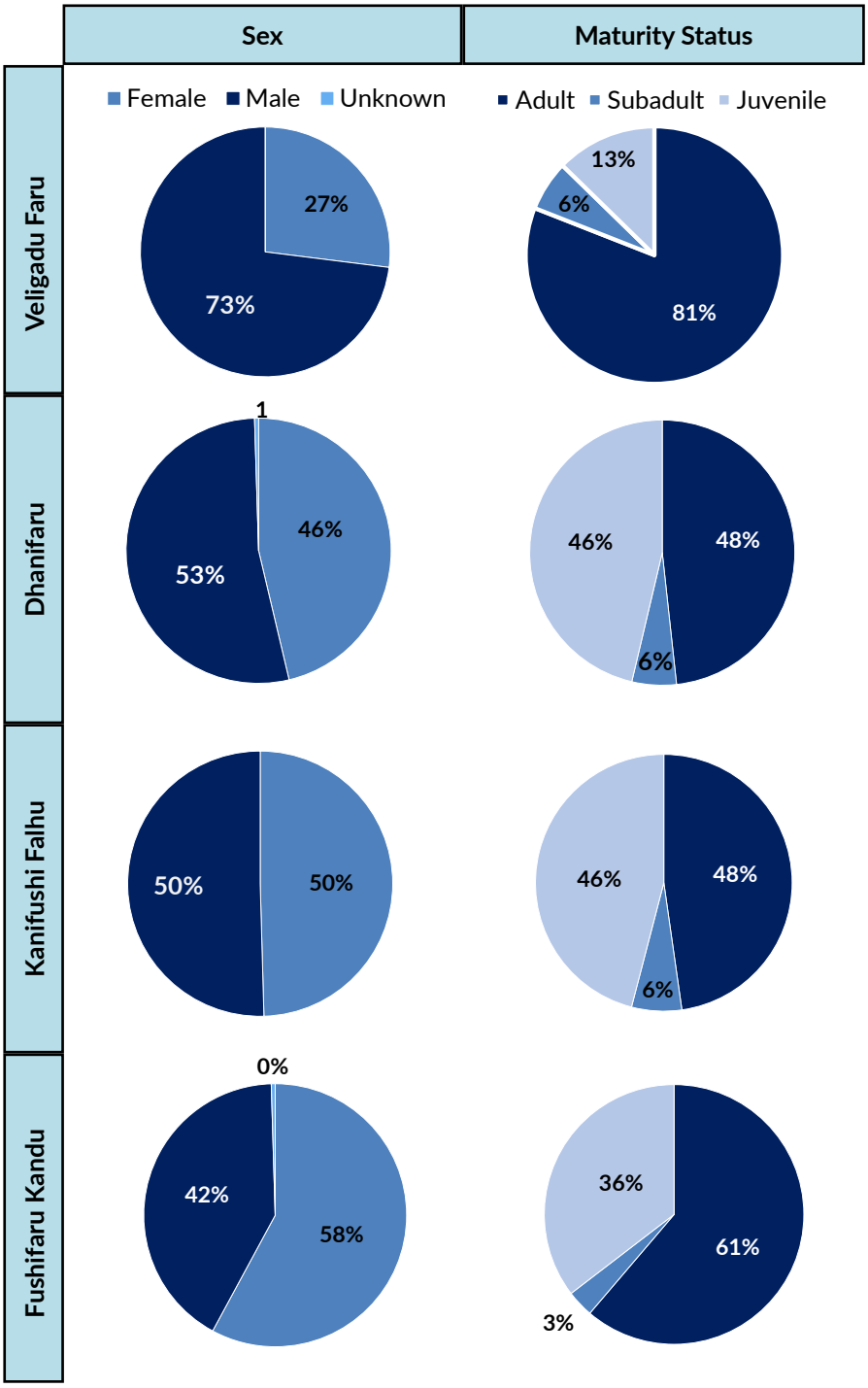

Figure 15: Demographics of the reef manta rays (*Mobula alfredi*) recorded at the four key aggregation sites in Lhaviyani Atoll (2004 – 2020).

While 66% of manta ray sightings occurred in these key aggregation sites in 2020, none were recorded in Veligadu Falhu, which is unusual for the months of January - March (Refer to: 2019 Lhaviyani Annual Report). Instead, Dhidhdhoo Falhu, a location identified in 2019 as a potential aggregation site, accounted for 28% (*n*=34) of the total sightings recorded this year. The gender distribution of the reef manta rays sighted at this location (*n*=29) is almost even, with 48% (*n*=14) females and 52% (*n*=15) males. Sixty-five percent (*n*=19) of these individuals were juveniles, 31% (*n*=9) adults, and 3% (*n*=1) subadults (Fig. 16). The relatively large proportion of juveniles reported from this site provides further support for the theory that young individuals tend to prefer more sheltered lagoon areas. Despite the high frequency of manta ray sightings in Dhidhdhoo Falhu in 2020, further monitoring is needed over the next year to define it as a new key aggregation site.

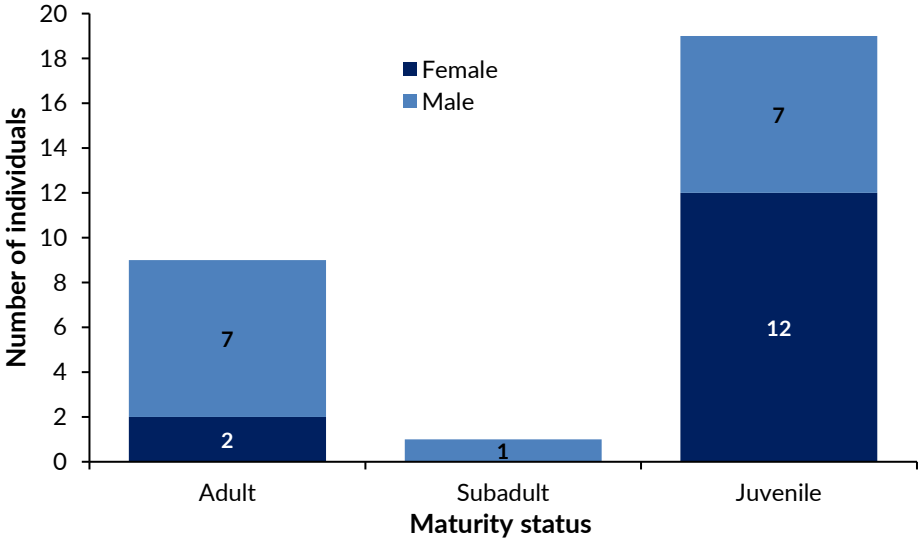

Figure 16: Demographics of the reef manta ray (*Mobula alfredi*) individuals recorded at Dhidhdhoo Falhu (*n*=29) in 2020.

These findings demonstrate the importance of surveying across different sites and support the protection of multiple areas around the atoll to protect different demographics of reef manta rays and their habitats. Of the four key sites described, only Fushifaru Kandu is currently designated as a marine protected area (MPA), with protective legislation banning fishing in 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 unfortunately unsuccessful. Although new and larger MPAs are urgently needed in Lhaviyani Atoll, it is also imperative that regulations are enforced and monitored in the existing protected areas.

Pregnancies & Courtship Observations

The Lhaviyani reef manta ray population comprises a total of 75 mature females, six of which were sighted during 2020. Of these, only one individual was observed pregnant (Fig. 17). On average, only 10% of mature females sighted annually between 2004 and 2020 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 four individuals have been recorded pregnant more than once, two of which has been recorded pregnant in three different years (Table 1). Furthermore, there are very few records of courtship behaviour in Lhaviyani Atoll, with no courtship events documented in 2020.

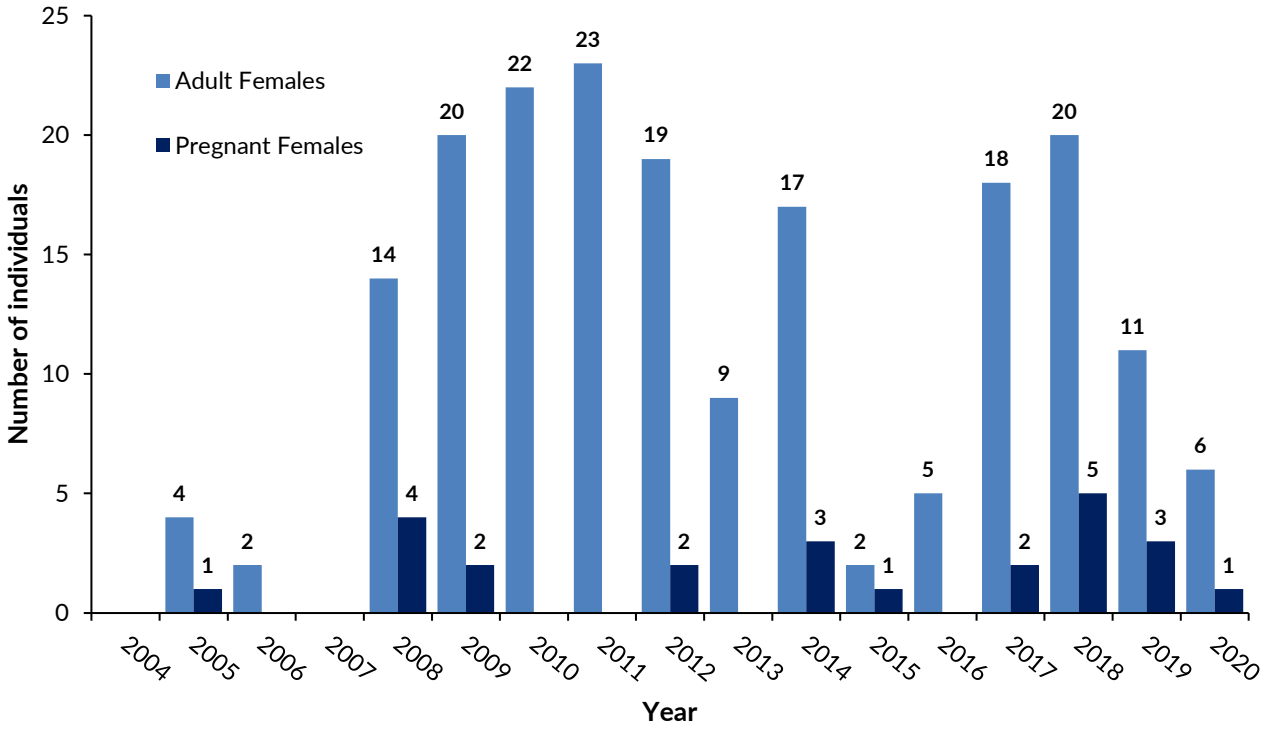

Figure 17: Number of adult and pregnant female reef manta rays (*Mobula alfredi*) sighted each year in Lhaviyani Atoll (2004 – 2020).

Table 1: Annual sightings of the 17 adult female reef manta rays (*Mobula alfredi*) in Lhaviyani Atoll which have been recorded pregnant at least once.

ID	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MV-MA-0040		1															
MV-MA-0041		1			4	2	5	4	3		1		1	5	6	12	2
MV-MA-0042		1			1				1	1	3		1	3	4		
MV-MA-0935					1												
MV-MA-0937					1	1	1	3	2		2			3	2	2	4
MV-MA-0939					1		2	2	1		2	1		2			
MV-MA-1090							1								1		
MV-MA-1184					1		1	1						2	1		
MV-MA-1185					1												
MV-MA-1186					2												
MV-MA-1412						1			1		1						
MV-MA-1419						1	1										
MV-MA-1421						1		1			3			3	2	7	
MV-MA-1424						1	1	2	1								
MV-MA-1975								1		1				2	2	3	1
MV-MA-2798									1								
MV-MA-3161										1	1				3		
MV-MA-3233											1						
Total pregnant	0	1	0	0	4	2	0	0	2	0	3	1	0	2	5	3	1

Sub-lethal Injuries

During each photo-ID sighting, data on any injuries to the reef manta rays was also recorded. Within the Lhaviyani Atoll reef manta ray population, 66% (*n*=279) have no significant injuries, while the remaining 34% (*n*=145) have been recorded with sub-lethal injuries. Of those, 21 individuals had more than one injury.

Over half (61%) of injured individuals in the Lhaviyani Atoll reef manta ray population have injuries from natural origins (*n*=89), while 29% (*n*=42) have injuries caused by anthropogenic impacts. Seventeen percent (*n*=24) of injured individuals have an injury for which the origin could not be clearly identified. The proportion of injured males is slightly higher than female (53%, *n*=77 and 47%, *n*=68) and 62% (*n*=90) were recorded in adult manta rays, while 33% (*n*=48) in juvenile and 5% (*n*=7) in subadults (Fig 18).

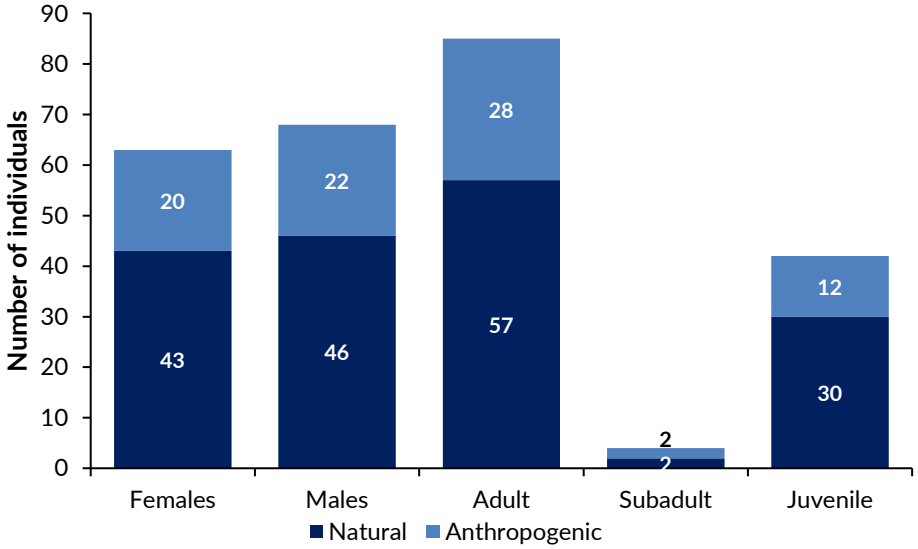

Figure 18: Demographic variations in the likely origin (natural or anthropogenic) of sub-lethal injuries within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=145).

Naturally caused injuries included infection or disease (*n*=1), deformity (*n*=5), and predatory bites (*n*=85). Injuries caused due to anthropogenic impact included boat strikes (*n*=4), injuries caused by fishing line (*n*=36), and manta rays being entangled in fishing nets (*n*=2) (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 145 manta rays recorded with injuries, 88% (*n*=127) had injuries inflicted upon their pectoral fins, 14% (*n*=20) on the tail and dorsal areas, 10% (*n*=15) on the cephalic fins, and 2% on the gill slits (*n*=3) (Fig. 20).

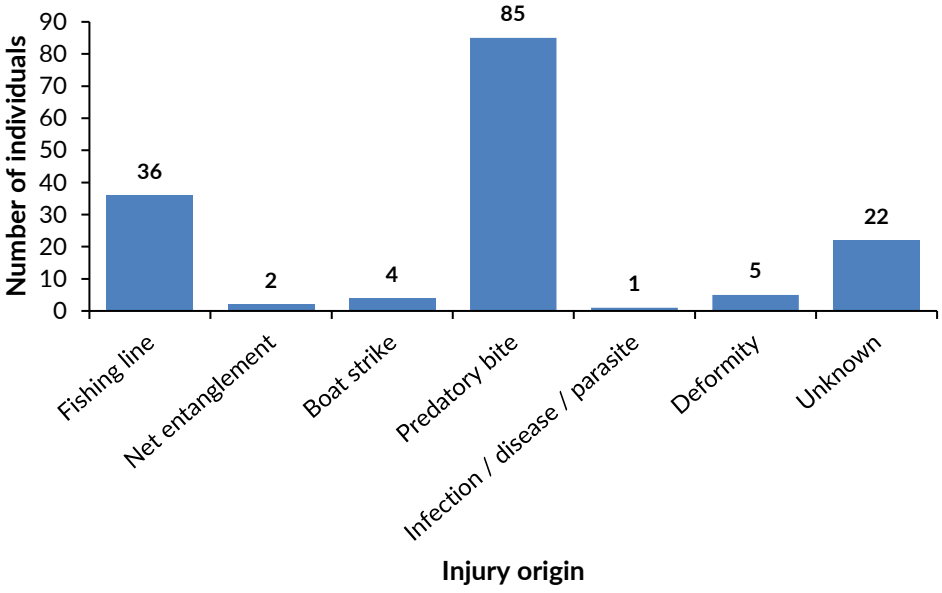

Figure 19: Variations in the origin of sub-lethal injuries within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=145).
**Note some individuals have multiple injuries originating from different causes.*

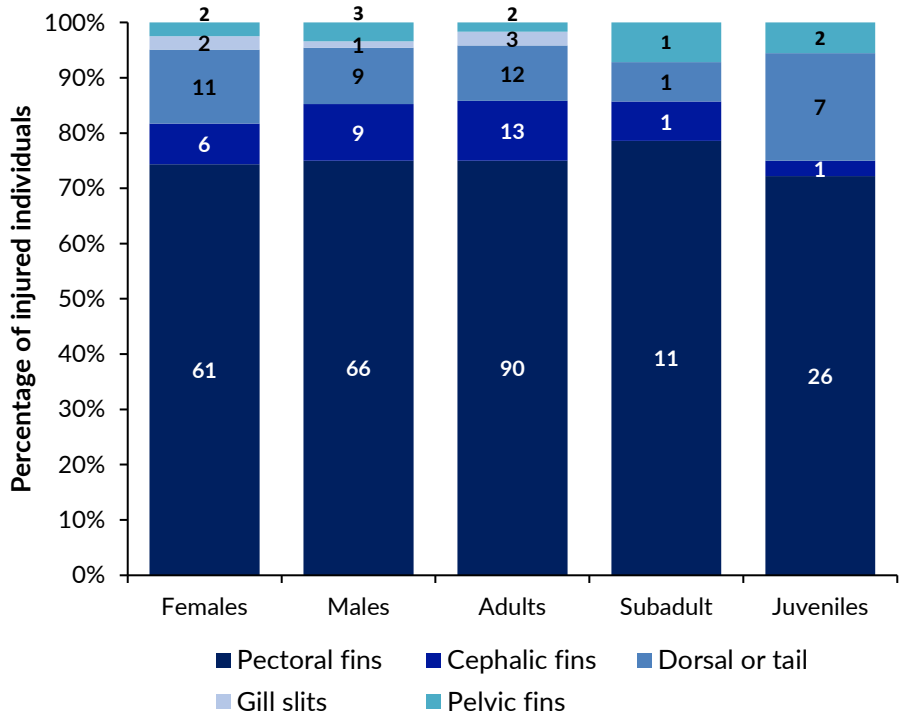

Figure 20: Variations in the location and number of sub-lethal injuries within the injured reef manta ray (*Mobula alfredi*) population of Lhaviyani Atoll (*n*=145), and their demographic variation (actual number of individuals on bars).

In 2020, eight manta rays were recorded with new injuries, including one of the newly identified individuals. Of these, two manta rays had injuries caused by anthropogenic impacts; one with fishing line damage, and one had a fishing net entangled around the left cephalic fin. A further five manta rays had injuries from natural causes: predatory bites. The cause of injuries on the five remaining injured manta rays could not be determined.

Fatalities

Boat mooring and buoy lines have been widely used in the Maldives for decades. However, as the number of these lines greatly increases throughout the country due to tourism development, they are increasingly posing a serious threat to the reef manta ray population.

The tragic incident of 2019, where one reef manta ray became entangled in a mooring line and died, has highlighted the importance of ensuring that all mooring and buoy lines in the Maldives are modified to reduce the risk of manta ray entanglements. To aid these efforts, the Manta Trust has developed a few simple actions which can be taken to help prevent future manta ray entanglements, and guidance on how to respond in the event of an entanglement. These can be found on the Manta Trust website. The MMRP team based at Hurawalhi Island Resort have secured all mooring lines around the resort and have urged all resorts within Lhaviyani Atoll to do the same.

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 during all surveys conducted by resident MMRP researchers (*n*=60) in 2020, and on six of the 13 surveys conducted by external contributors. Due to limited research activity during the pandemic, all surveys conducted in 2020 fell within the months of the Northeast Monsoon (January – March; December), or the transition between seasons (November), and as a result manta ray sightings occurred when the wind direction recorded was predominantly from an easterly/north-easterly direction. Notably, north-easterly monsoon winds accounted for the largest proportion of sightings at Kanifushi Falhu (*n*=15) (Fig. 21). 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 concentrating along the western side of Lhaviyani during this time. Correspondingly, most sightings recorded during this period in 2020 were from sites located on the west of Lhaviyani Atoll (Fig. 21).

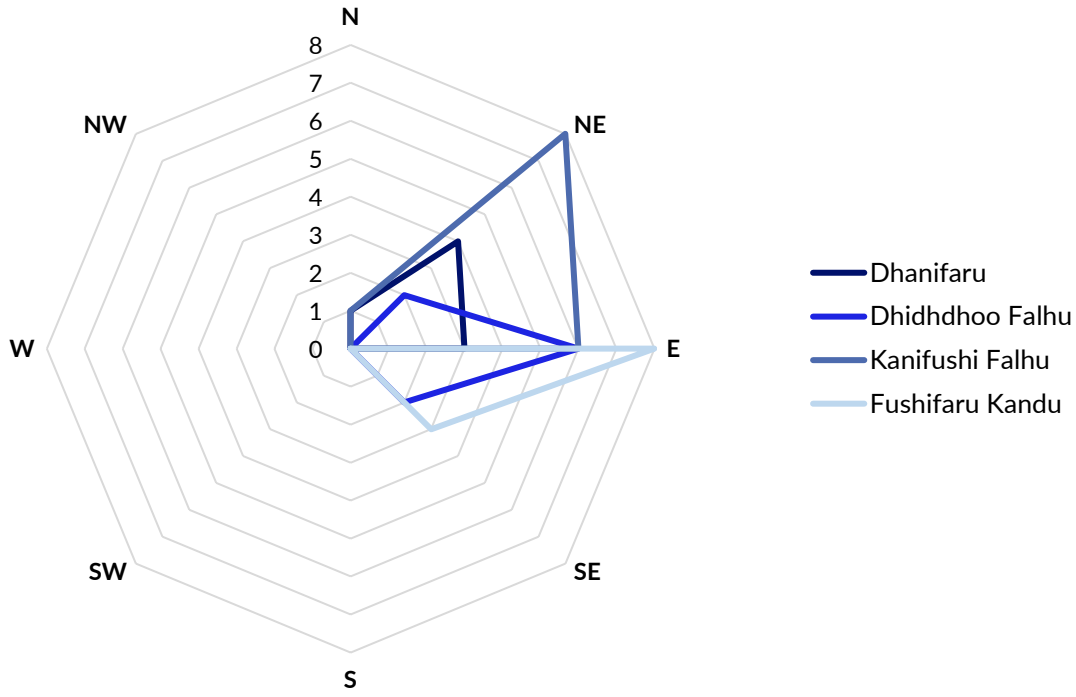

Figure 21: Number of reef manta ray (*Mobula alfredi*) sightings in relation to prevailing wind direction at three key aggregation sites and one potential new aggregation site (Dhidhdhoo Falhu) in Lhaviyani Atoll (2020); obtained from surveys where wind direction was recorded (*n*=44).

The lack of data collected during the Southwest Monsoon makes it impossible to confirm whether the pattern typically exhibited by manta rays migrating from the west to the east of the Atoll was followed in 2020. However, with research resuming during the transition between the Southwest and Northeast Monsoons (November), the data collected hereafter does hint at the likelihood that manta ray movements did indeed conform to this pattern. During the Southwest Monsoon, food availability is concentrated toward the eastern side of the atolls in the Maldives, and manta rays utilise feeding areas, as well as nearby cleaning stations as the monsoon draws to a close. All sightings recorded upon resuming research activities in November were from Fushifaru Kandu, which is located along the northeast of the Atoll. Furthermore, during this transitional period between the monsoons, 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. Consequently, as a historically recognised cleaning station, the concentration of manta sightings at Fushifaru Kandu during the month of November is what would be expected of manta ray activity during a typically research year.

TOURIST & MANTA RAY INTERACTIONS

The MMRP strive to improve the sustainability of manta ray tourism activities in Lhaviyani Atoll. In 2020, the MMRP researchers continued to collect tourism related data within the region and noticed a decrease in the average number of tourist boats and snorkellers present per survey when compared to 2019 records. On average, 1.7 boats and 5.1 snorkellers were recorded per survey trip in 2020, compared to 2.6 boats and 8.3 snorkellers recorded per survey in 2019. This drop in tourism activity is likely related to the decline in tourism following the global pandemic.

As tourism increases post-pandemic, manta ray excursions continue to become more popular with visitors to the atoll and MMRP researchers have continued to encourage sustainable tourism practices to be administered. During 2020, 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 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.

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 Manta Rays" 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 2020 were properly briefed by the MMRP researcher and/or the Prodivers staff on how to behave in water.

This report was made possible thanks to

MALDIVES GOVERNMENT 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 scientists 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:

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