



Maldivian  
**Manta Ray Project**

LAAMU ATOLL | SEASON REPORT 2017

Conservation through  
research, education and collaboration.

- *The Manta Trust*



# 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 several 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 4,650 different individual manta rays, from more than 50,000 photo-ID sightings. This makes the Maldivian manta population the largest, and one of the most intensively studied populations in the world.

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 on-going management and protection both in the Maldives, and around the world.

# OUR PARTNERSHIP WITH SIX SENSES LAAMU



For years, Six Senses Laamu has contributed to the research efforts of the Manta Trust and the MMRP, through external submissions of manta ray ID photos. In 2014 a closer partnership began to blossom, with the Manta Trust launching an exciting five-month pilot project in Laamu Atoll. The project focused on investigating the nearby manta aggregation site at Hithadhoo Corner. The pilot phase was so successful that the Manta Trust team were invited back in 2015, this time for an extended period of nine months.

In 2016, a full 12-month partnership between both parties was born, and since then the project has gone from strength to strength. The Manta Trust's MMRP now has a permanent presence on the island, working closely with the resorts' resident marine biologists and Sustainability Manager, to raise awareness surrounding the unique, yet fragile marine environment of Laamu Atoll.

## EXECUTIVE SUMMARY

This report is the fourth of its kind in a series that presents data collected by the Maldivian Manta Ray Project (MMRP) on Laamu Atoll's manta ray (*Mobula alfredi* and *Mobula birostris*) populations from January through to December 2017. We are extremely proud to continue to have Six Senses Laamu as one of the MMRP's Key Regional Partners.

Laamu Atoll continues to be one of the only places in the Maldives in which you can see reef manta rays (*M. alfredi*) at the same site consistently throughout the year. Manta rays frequent the waters of Laamu Atoll to be cleaned, however they are also witnessed courting biannually and on rare occasions, feeding. These animals have been continuously studied in Laamu Atoll since 2014 by the MMRP, the founding project of the UK charity, the Manta Trust.

Key findings of the Manta Trust at Laamu in 2017 include a total of 739 sightings of 85 individual reef manta rays; 71% of the total Laamu reef manta ray population recorded to date. This equates to a 7% increase in reef manta ray sightings compared to 2016. However, when standardised for effort and compared to previous years, 2017 sightings were consistent with those recorded between 2014 and 2017. Out of the total Laamu reef manta population of 119 individuals, 73 (61%) are female and 46 (39%) are male. Throughout the year of surveying, each of the 85 different individuals sighted were observed on average 3.07 times, a slight increase from that recorded in 2016 (average 2.79 sightings per manta) but lower than that noted for 2015 (3.59) and 2014 (3.51). The proportion of Laamu Atoll's reef manta ray population which has been seen on more than one occasion increased to 94% by the end of 2017, suggesting almost all individuals which are resident in the atoll at the current survey sites have been recorded. In 2017, October produced the highest peak in manta ray sightings, both before and after accounting for survey effort. During May the second highest number of reef manta ray sightings were recorded, comprised of the highest number of individuals seen in any month. Nine new reef manta rays were documented in 2017 (there were four new individuals recorded in 2016); this a big decrease from 2015 (n=18) and 2014 (n=28). Out of the nine new sightings only two were sighted at Hithadhoo Corner.

The remaining seven new individuals were sighted at Fushi Kanduu. Only one individual oceanic manta ray (*M. birostris*) was identified in 2017 (MV-MB-0240).

Over the past four years, reproductive activity (identified by the presence of fresh mating wounds or pregnancy bulges on females, and observable courtship behaviour) in Laamu Atoll has been at its greatest in May-June and October-November. This trend continued into 2017. Ten pregnant females were recorded during the 2017 season compared to only four in 2016, and seven in 2015. The number of recorded pregnant females in the past three years is considerably lower than the 21 pregnant individuals recorded in 2014. Studies in Baa Atoll have suggested that this decrease could be a result in a lack of food brought about by the weakened monsoons in the Maldives. Such uncertainty surrounding reproductive periodicity subsequently became the foundation of a new research project for the Laamu Manta Trust team in 2016 that continued to develop through the 2017 season. This project is the development of a contactless and dive proof ultrasound unit, with which Manta Trust hopes to accurately monitor traits, such as size and age at maturity, fecundity, and eventually the mechanisms driving reproductive periodicity in the wild. All these life history traits remain poorly defined – yet all are crucial to understanding how resilient a species is to anthropogenic pressures.

During 2016 the team in Laamu successfully measured one third of the population of manta rays in Laamu using paired-laser photogrammetry and proved that age-class segregation and sexual dimorphism exists at Hithadhoo Corner within the reef manta ray population. Following the success of this project, in 2017 the team started using a stereo video system to collect further data on growth and body size of manta rays, with the aim of presenting the findings at the 2018 Maldives Marine Science Symposium.

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 Maldivian manta ray population is crucial for the ongoing management and protection of these animals.

## STUDY AREA

Laamu Atoll has only seven channels that break the outer reef, making the current flow dynamics through this atoll different to those more open atolls further north in the archipelago. Laamu is one of the few places in the Maldives that provides year-round reliable reef manta ray sightings. Hithadhoo Corner is a cleaning station located on the western side of the two largest channels in the atoll, and like in previous years, this site has provided consistent reef manta ray sightings (Fig. 1). Located just ten minutes away by dhoni from Six Senses Laamu, the proximity of this aggregation site to the resort has enabled the MMRP team to study the local population of reef manta rays extensively since 2014. The depth of this study area varies from 16–23m so it is surveyed using SCUBA.

The large numbers of cleaner wrasse (*Labroides dimidiatus*, *Labroides bicolor* and *Thalassoma amblycephalum*) that live within the extensive coral bommies (mainly comprised of *Porites* sp.) at Hithadhoo

Corner are what bring the reef manta rays and many other species to this specific location. The combination of the large coral blocks and the many cleaner wrasse is what provides locations such as Hithadhoo Corner with the name 'cleaning station'.

Manta ray sightings have been recorded at Hithadhoo Corner by the MMRP from 2012 onward. Since the Manta Trust partnered with Six Senses Laamu in 2014, manta ray sightings have been recorded at other locations in the atoll such as Fushi Kanduu, Bodu Huraa Beyru, and Gaadhoo Beyru (Fig. 1). Although uncommon, observations of behavioural activities other than cleaning (such as feeding and courtship) have become more frequent since surveying began at these other sites. In 2018 the manta team hopes to visit these sites more often to get a better idea of the consistency of sightings, population size, structure and drivers of habitat use.

## STUDY PERIOD & SAMPLING

In 2017, the Manta Trust team conducted surveys (n=535) on as many days that conditions and logistics allowed (n=283). Surveys were either conducted on guest dives with the resorts dive centre, or as research dives. A full briefing was given before every guest dive, including details of the Manta Trust's Code of Conduct and the ten steps on 'how to swim with manta rays' (swimwithmantas.org). Data for this report was compiled using the data collected by the Manta Trust team in addition to photographs and videos submitted by external contributors. Such contributors, known as 'citizen scientists', can provide important insights into the seasonal movements of many of Laamu Atoll's reef manta rays. To account for changes in sampling efforts at key sites, data from all years was standardised where possible to give comparable results.

On each research trip, location, wind speed, wind direction, and other environmental variables were noted alongside manta ray numbers and prevalent behaviours. In-water, individual manta rays were documented by photographing the unique spot patterns on their undersides (ventral surface). The manta team are experienced professional SCUBA divers and so always ensured minimum disturbance to the animals when taking photo-ID shots. For the purposes of this report a sighting is defined as a confirmed photo identification of an individual manta ray on a given day at a single location.



**Figure 1:** Survey locations in Laamu Atoll where reef manta rays (*Mobula alfredi*) are most frequently sighted.

## NATIONAL PROTECTION & ECOTOURISM

Manta rays are of huge value for the Maldivian economy, bringing in over \$15 million USD annually. Documenting and understanding the reasons for any observed trends in, or threats to, the Maldivian manta ray population is crucial for the ongoing management and protection of these animals. All ray species were added to the National List of Protected Species by the Maldivian Government in 2014, however anthropogenic impacts (both direct and indirect) are still negatively impacting manta rays throughout the country, especially in the face of increasing tourism activities.

Six Senses Laamu is currently the only resort in Laamu Atoll, however a new resort is set to open mid-2018. The number of guest houses in Laamu is slowly increasing, with 16 already in operation. Only a small number of liveaboard vessels pass through Laamu during the dive season (northeast monsoon) when travelling to and from the south of the Maldives. Although tourism in

the atoll is increasing, the tourist related pressures at Hithadhoo Corner are still much less than those at other manta aggregation sites throughout the Maldives. At Six Senses Laamu, any divers visiting Hithadhoo Corner, or other aggregation sites in the atoll, are fully briefed on how to sustainably interact with manta rays and other marine life. The manta briefing is based on the Manta Trust's Code of Conduct which contains ten steps on 'how to swim with manta rays'. These resources are also made available to all liveaboards and guest houses that visit manta sites in Laamu.

Working together with members of the Blue Marine Foundation, we hope to provide enough evidence to the Maldivian Government to support the future designation of Hithadhoo Corner as a marine protected area. This site is important not only to the manta ray population of Laamu, but also to other marine life such as groupers that use it as a spawning aggregation site.

# MANTA RAY SIGHTINGS

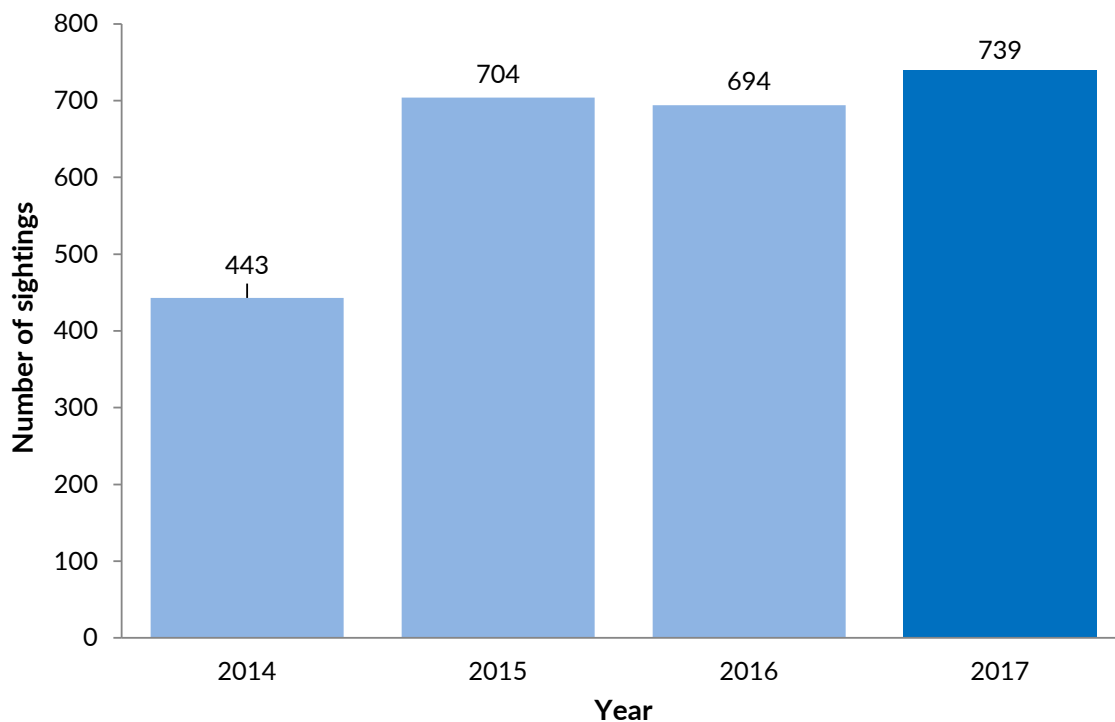
## LAAMU ATOLL

There was only one oceanic manta ray identified in 2017, and only 11 individuals have been identified in Laamu (eight females and three males) to date; each individual has only been sighted on one occasion. These low resighting rates fit with the theory that oceanic manta rays are much more migratory and offshore in their habitat use than reef manta rays, so they would be expected to have a lower residency to specific areas. Due to the small number of oceanic manta ray sightings in Laamu, no in-depth analysis can be made. The following analysis therefore only pertains to reef manta ray sightings.

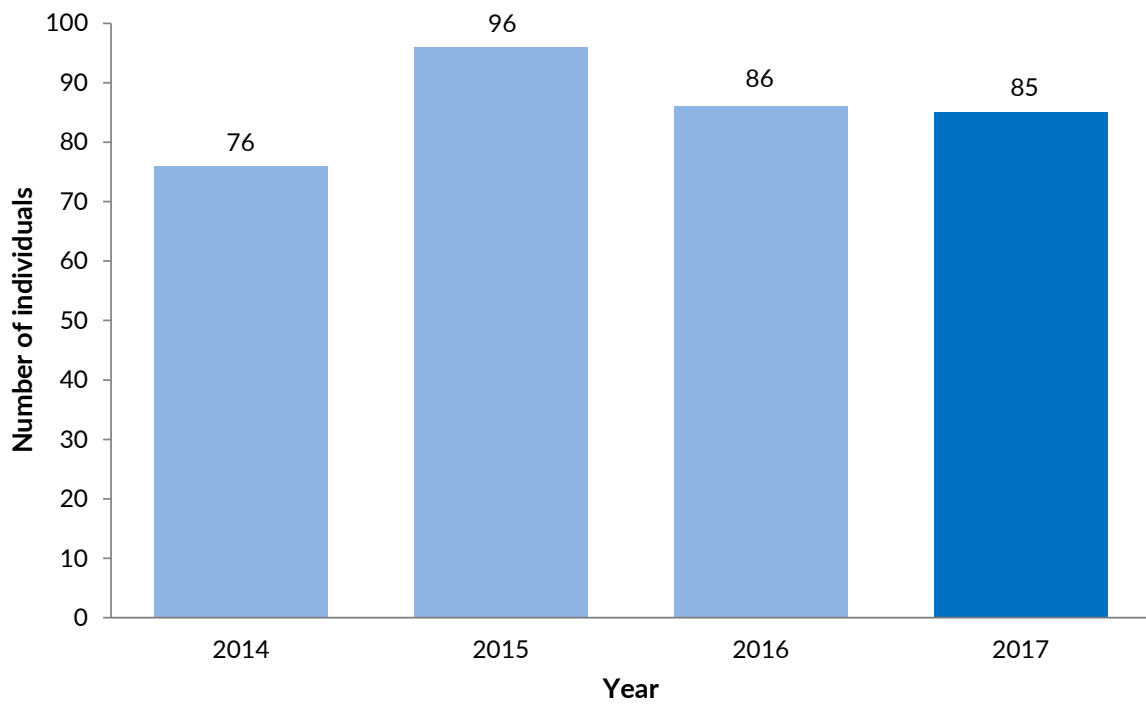
At the end of 2017 the recorded reef manta ray population for Laamu Atoll was 119 individuals (3% of the total recorded Maldivian population). In 2017, sightings throughout Laamu Atoll increased slightly, with 739 sightings (Fig. 2) of 85 individual (Fig. 3) reef

manta rays recorded. Monthly breakdowns of these sightings, standardised for survey effort, show two clear peaks in sightings; May/June and October/November (Fig. 4). In 2017, the months of May, Sept and Oct saw the highest number of individuals and sightings records (Fig. 5). These biannual sightings peaks coincide with (and are likely correlated with) increased courtship behaviour in Laamu Atoll, which is discussed later in this report.

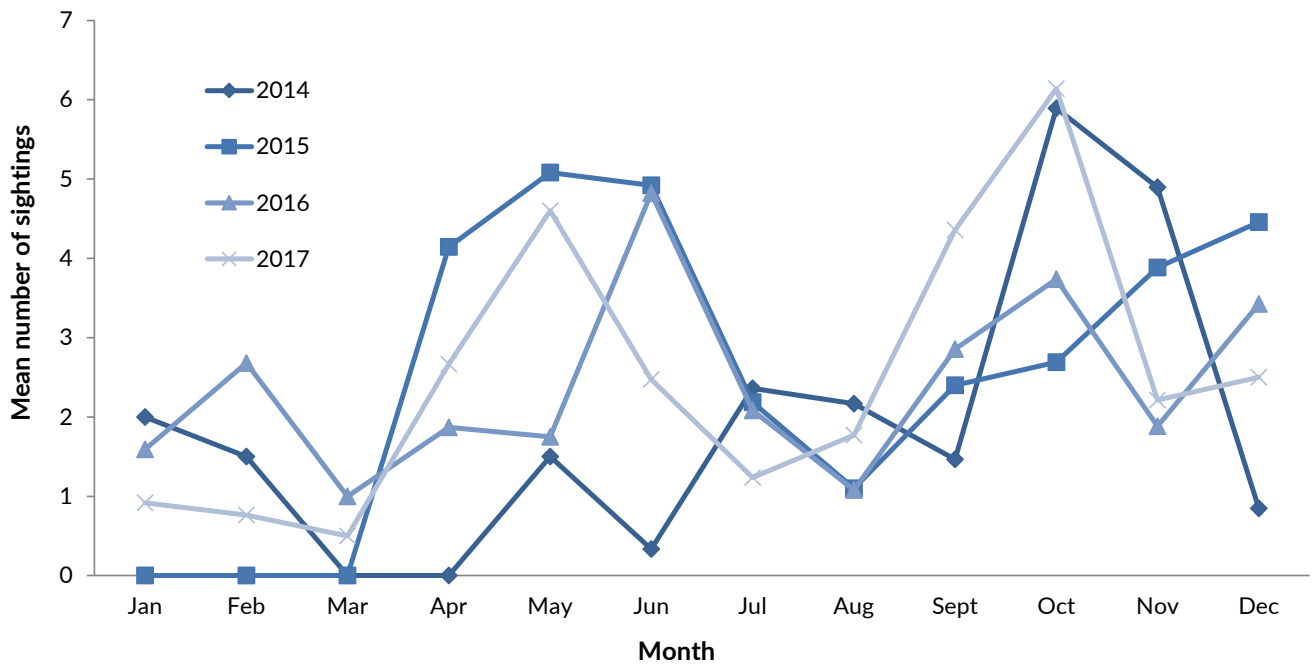
Throughout 2017 each manta was observed on average 8.69 times (Fig. 6), a slight increase from 2016 (average 8.07 sightings per individual), and a further increase from pre-2016 records. The proportion of manta rays seen on more than one occasion in 2017 was 89% (Fig. 7). This figure is slightly greater than the previous survey years.



**Figure 2:** Total annual sightings of reef manta rays (*Mobula alfredi*) in Laamu Atoll (2014-2017).



**Figure 3:** Total annual number of individual reef manta rays (*Mobula alfredi*) sighted in Laamu Atoll (2014-2017).



**Figure 4:** Mean number of reef manta ray (*Mobula alfredi*) sightings per survey day each month in Laamu Atoll (2014-2017).

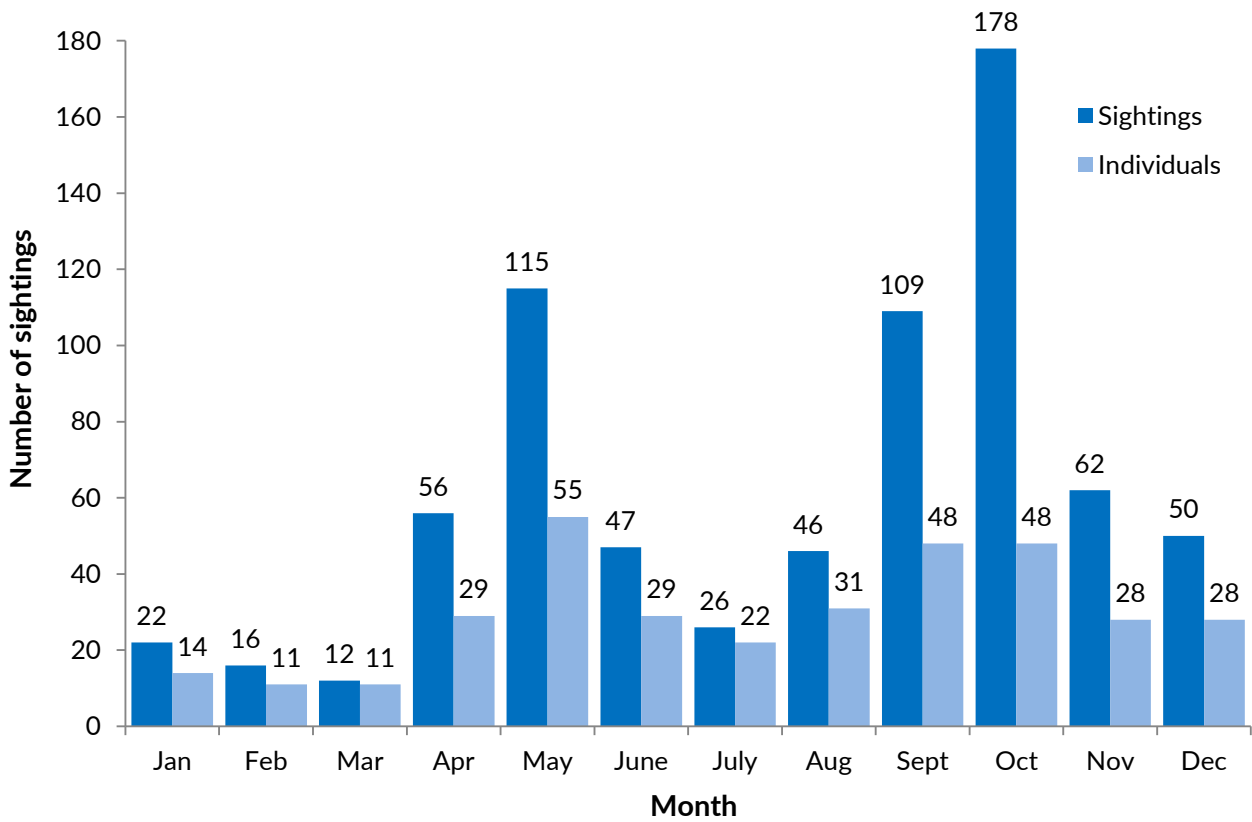


Figure 5: Total monthly sightings and individual reef manta rays (*Mobula alfredi*) in Laamu Atoll (2017).

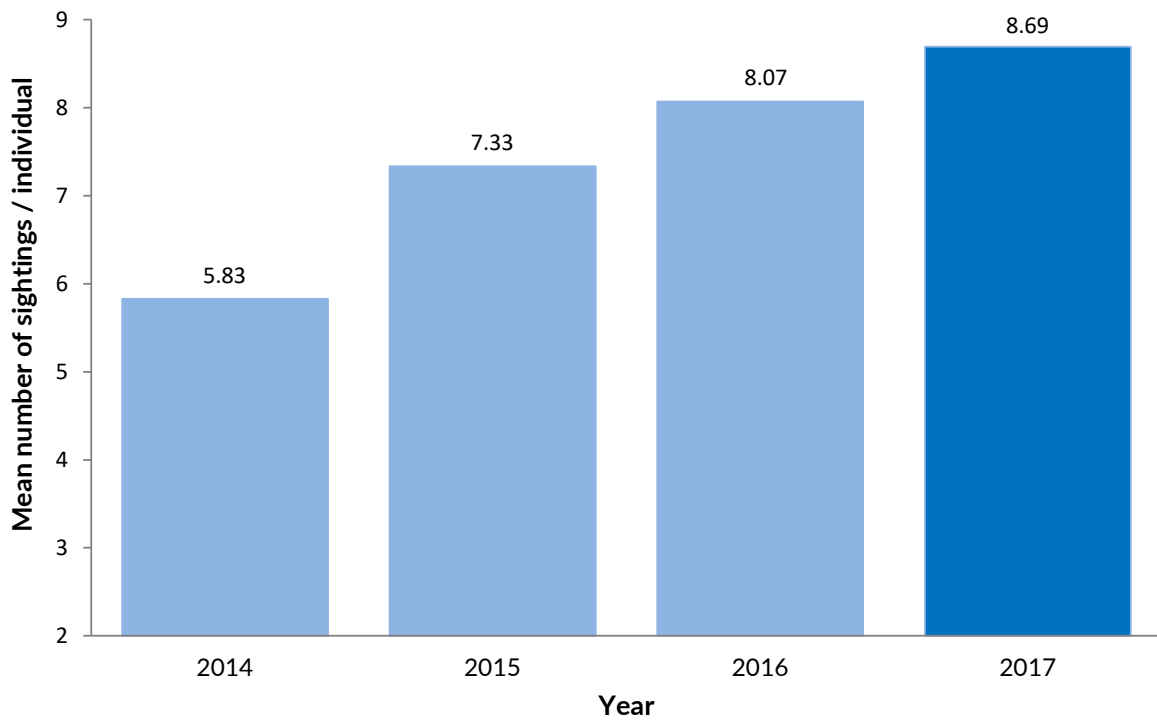
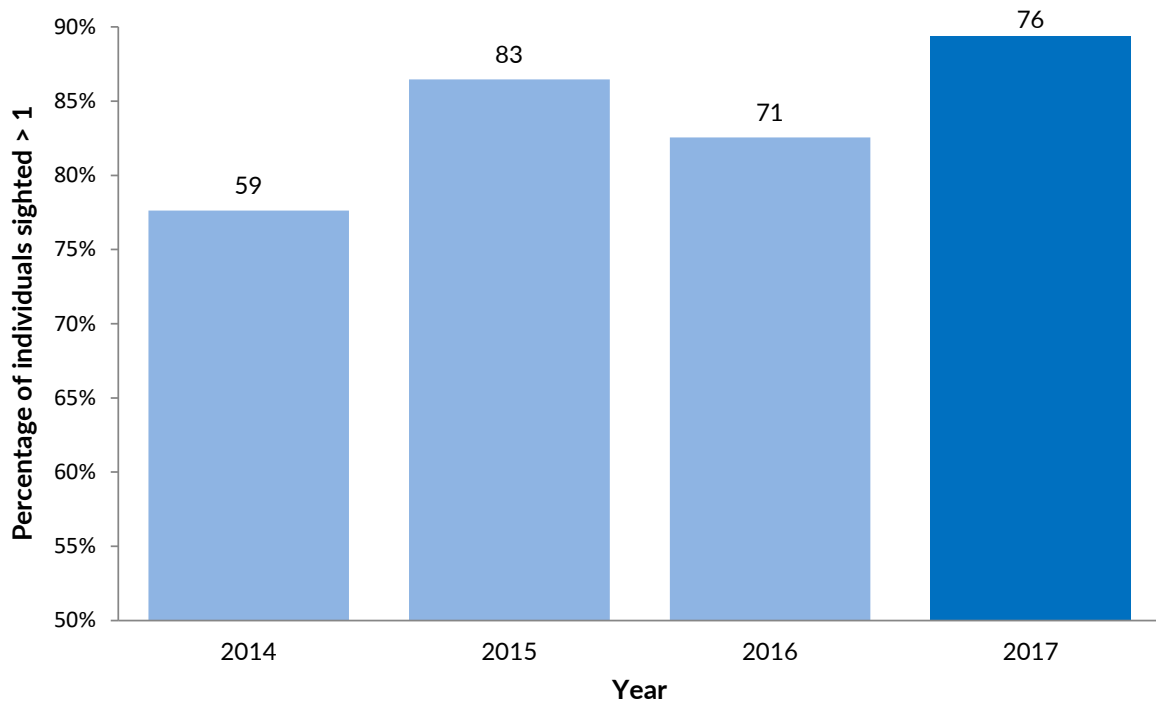
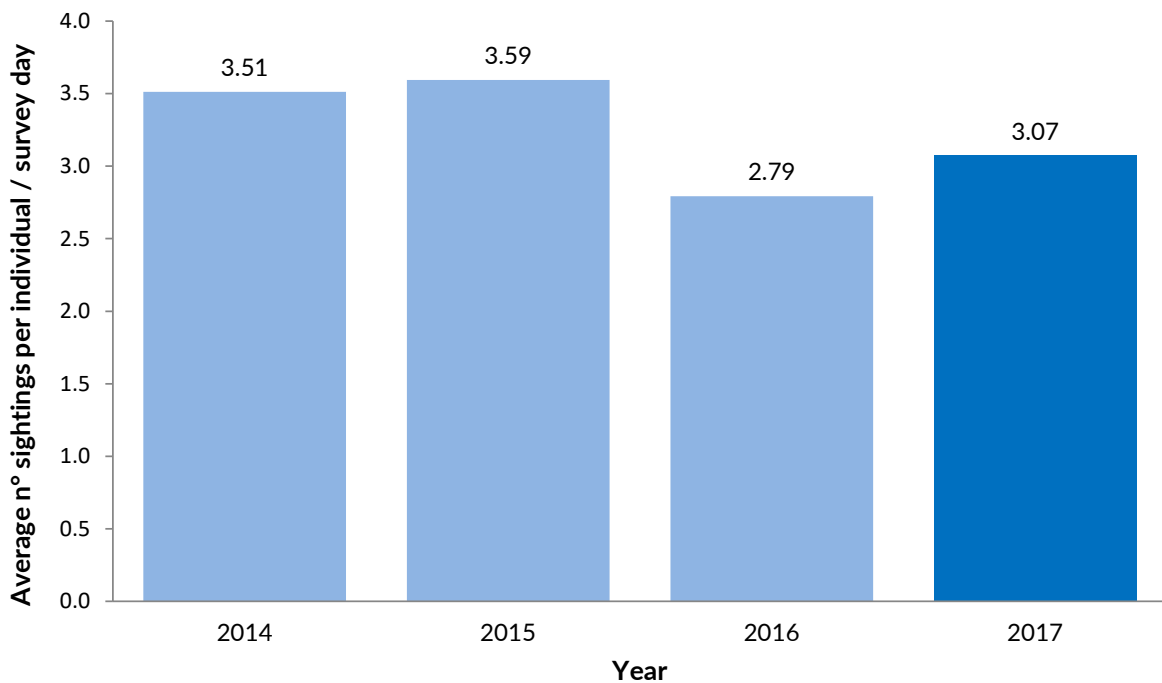


Figure 6: Mean number of sightings per individual reef manta ray (*Mobula alfredi*) in Laamu Atoll (2014-2017).





**Figure 7:** Percentage of individual reef manta rays (*Mobula alfredi*) sighted on multiple occasions per season in Laamu Atoll (2014-2017). Actual numbers presented above bars.



**Figure 8:** Average Residency Index (RI) of reef manta rays (*Mobula alfredi*) in Laamu Atoll (2014-2017). RI is calculated as the average of each individuals' residency score (number of days sighted over the total number of surveyed days).

To account for survey effort, an average Residency Index (RI) was calculated for each year based on the ratio between the number of days each individual was sighted and the total number of surveyed days (e.g. an RI of 3% means that, on average, each individual was sighted on 3% of the total surveyed days). The RI in 2017 (3.07) was slightly higher than that noted in 2016 (2.79), but lower than the RI of 2015 (3.59) and 2014 (3.51) (Fig. 8). This suggests a slightly higher residency at the survey sites in Laamu Atoll during 2017 when

compared to 2016, possibly linked to more favourable conditions (e.g. increased localised food).

Records of Laamu Atoll's reef manta rays in other atolls are low, supporting the theory that this atoll's population is more isolated than those further to the north. Indeed, only seven of Laamu Atoll's reef manta rays (n=119) were recorded in atolls outside of Laamu in 2017 (Table 1), and only 15 in total.

**Table 1:** Laamu Atoll's reef manta rays (*Mobula alfredi*) which were recorded in other atolls during 2017.

Manta ID	Other atoll sightings
MV-MA-0801	Lhaviyani
MV-MA-1090	Baa
MV-MA-2908	Meemu
MV-MA-2578	Thaa
MV-MA-3002	Rasdhu
MV-MA-3220	Rasdhu
MV-MA-3636	Lhaviyani

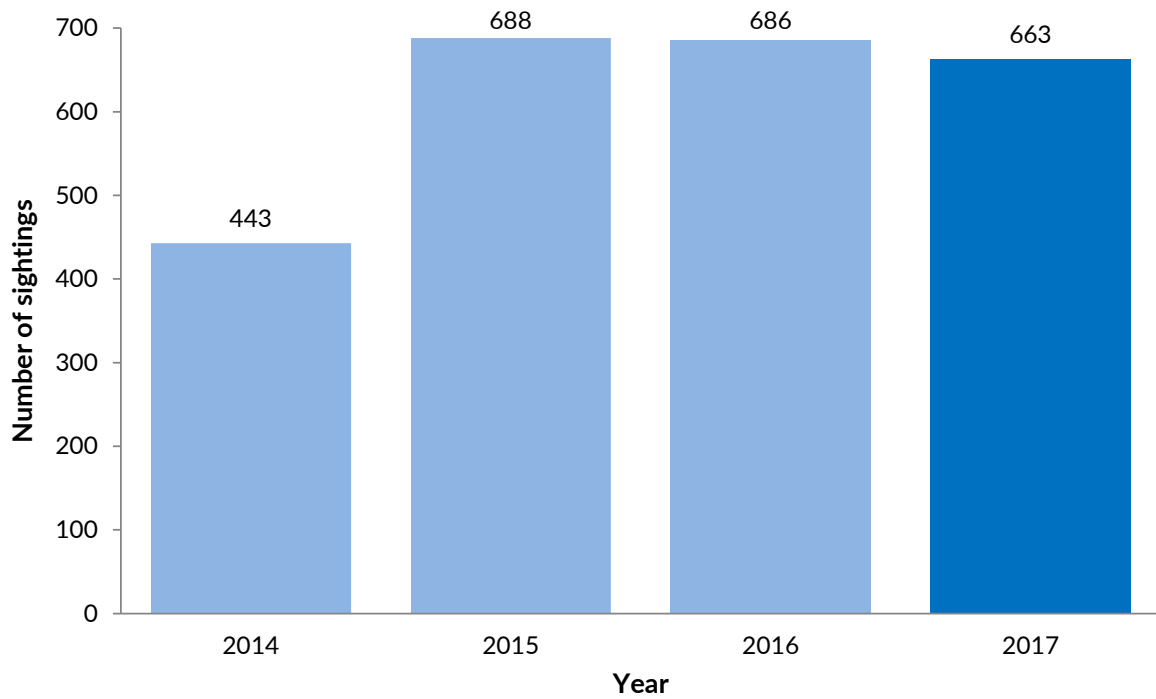
## HITHADHOO CORNER

Sightings of reef manta rays at Hithadhoo Corner in 2017 remained consistent with those recorded at this site since 2015 (Fig. 9). The standardised graph for survey effort reveals that the number of manta rays sighted per day also remained consistent with previous years, peaking at an average of 6.5 individuals per survey day during October, the highest since 2014 (Fig. 10).

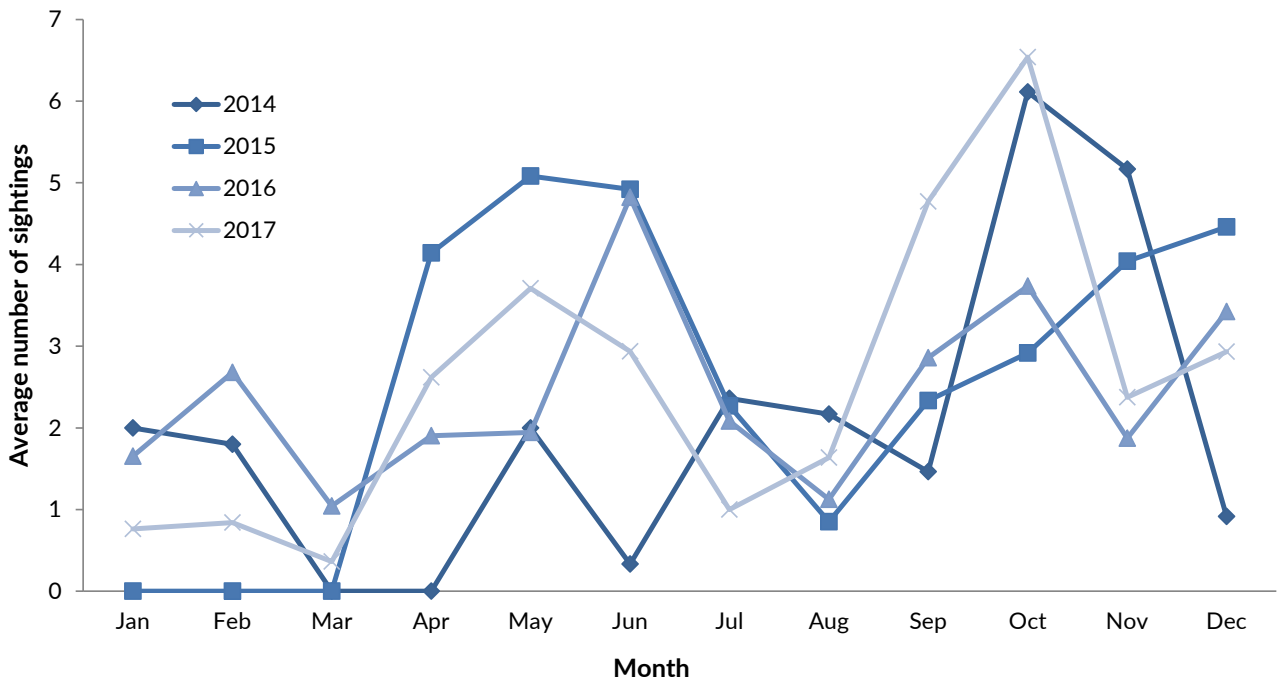
Out of 119 reef manta rays recorded in Laamu Atoll, 73 (61%) are females and 46 (39%) are males. The overall demographic trend displays a bias towards females at Hithadhoo Corner. This female bias is echoed in other reef manta ray populations focused at cleaning stations throughout the Maldives, and indeed globally. However, when sightings data from other aggregation sites (e.g. feeding sites like Hanifaru Bay in Baa Atoll)

are included, the overall sex ratio of the Maldives reef manta ray population is 50:50 males to females.

A total of 72 (60%) of Laamu Atoll's 119 individually identified reef manta rays were documented at Hithadhoo Corner in 2017 (summarised in Table 2). Of these 72 individuals, seven were seen on only one occasion. As in 2016, only one individual was seen >40 times for the entire year (n=44); MV-MA-2551 (Fig. 11). Given that on average female reef manta rays exhibit much greater fidelity to cleaning stations than males, the high visitation rates displayed by this mature male year after year are unusual.



**Figure 9:** Total annual sightings of reef manta rays (*Mobula alfredi*) at Hithadhoo Corner Cleaning Station, Laamu Atoll (2014-2017).



**Figure 10:** Mean number of reef manta ray (*Mobula alfredi*) sightings per survey day each month at Hithadhoo Corner Cleaning Station, Laamu Atoll (2014-2017).

**Table 2:** Variation in sighting frequency of the individual reef manta rays (*Mobula alfredi*) sighted at Hithadhoo Corner, Laamu Atoll (2017).

Sighting Frequency	Number of Individuals	Proportion of Population
1	7	9.7%
2	10	13.9%
3 to 5	14	19.4%
6 to 10	21	29.1%
11 to 15	8	11.1%
16 to 20	4	5.6%
21 to 25	1	1.3%
26 to 30	4	5.6%
31 to 35	2	2.8%
36 to 40	0	0.0%
41 to 45	1	1.3%
>46	0	0.0%
<b>TOTAL</b>	<b>72</b>	<b>100%</b>

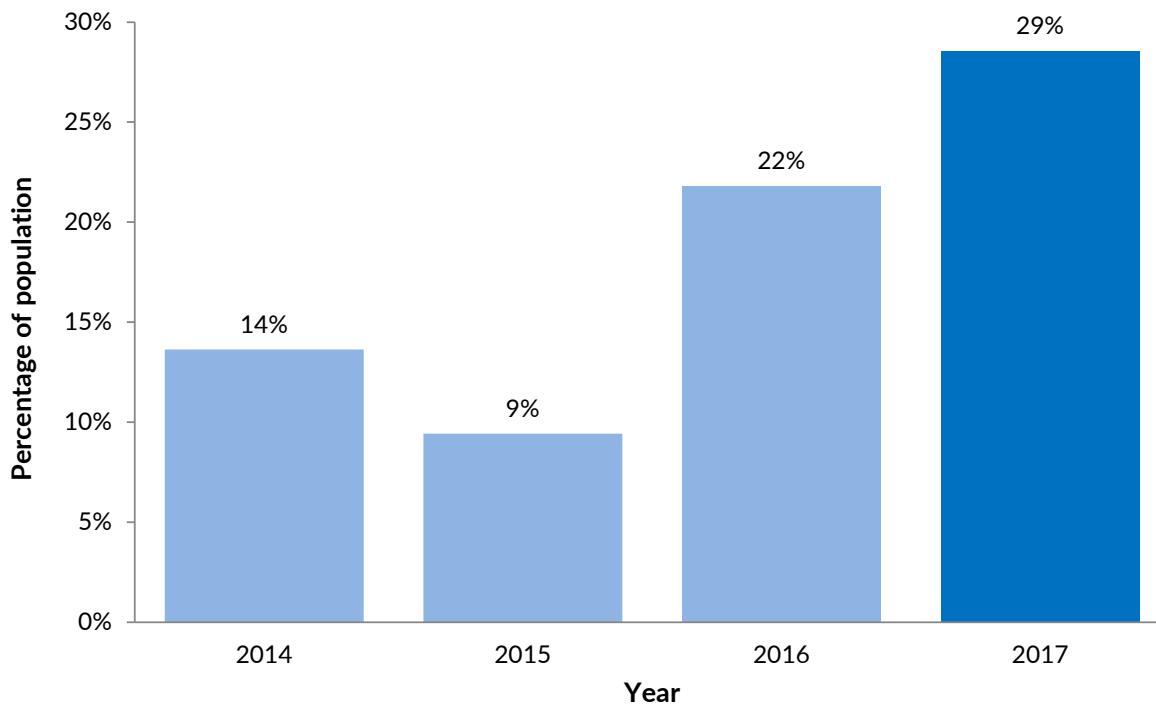
Recording the absence of certain individuals is just as important as recording their presence. Such data can help better understand the overall site fidelity of Laamu Atoll's reef manta rays and enable the examination of potential factors (e.g. temperature variability) which may be driving sporadic, seasonal, or indeed long-term absences of manta rays from Hithadhoo Corner. Throughout 2017, 29% of the Laamu Atoll reef manta

ray population were not recorded, this is the largest proportion to be absent in one year since surveying began in 2014 (Fig. 12). Throughout the entirety of the 2014-2017 survey period, only 4% of the total population (two males and three females) originally documented prior to 2014, have not been re-sighted again since their first sighting (Table 3). Out of these five manta rays, only one (MV-MA-2908) has been sighted



**Figure 11:** MV-MA-2551 (Michele); the most sighted reef manta (*Mobula alfredi*) in Laamu Atoll across all survey years.

Photo © Marteyne van Well



**Figure 12:** Percentage of the total Laamu Atoll reef manta ray (*Mobula alfredi*) population not resighted annually (2014-2017).

again at other sites outside Laamu; once in 2015, once in 2016, and three times in 2017, all at Kurali Kandu in Meemu Atoll. One manta ray (MV-MA-2811) was sighted again in 2017 after not being encountered since surveying began in 2014 (Fig. 13).

High inter and intra annual re-sighting rates (78-89%) imply long-term site fidelity to the main study site; Hithadhoo Corner. The few sighting records of Laamu Atoll's reef manta rays in other atolls suggest a high

degree of fidelity to Laamu Atoll. This localised home range, if representative of this population's behaviour, would therefore benefit from localised, targeted protective management. Whilst deaths and migrations away from the survey region are likely to explain many of these 'missing' manta rays, it is also possible that some of these individuals still frequent our study sites, but that we simply have not encountered them on our surveys.

**Figure 13:** MV-MA-2811 (Musthagbal); sighted in 2017 at Hithadhoo Corner in Laamu Atoll for the first time since surveying began in 2014. This male reef manta ray (*Mobula alfredi*) was not sighted anywhere else in the Maldives during this period of absence.

Photo © Marteyne van Well



**Table 3:** Individual reef manta rays (*Mobula alfredi*) not resighted in Laamu Atoll during the survey period (2014 – 2017). Data highlighted in red denotes that the individual was not recorded in any MMRP survey year (i.e. only sighted prior to 2014) and cells filled with N/A indicate that the manta ray had not yet been identified in Laamu.

Manta ID	Sex (M/F)	Absent 2014	Absent 2015	Absent 2016	Absent 2017
MV-MA-0035	F			X	
MV-MA-1791	M			X	X
MV-MA-2106	M				X
MV-MA-2409	M			X	X
MV-MA-2411	F				X
MV-MA-2413	F				X
MV-MA-2550	F				X
MV-MA-2552	F		X		
MV-MA-2808	F	X			
MV-MA-2811	M		X	X	
MV-MA-2816	F	X			
MV-MA-2862	M	X			
<b>MV-MA-2908</b>	<b>M</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
MV-MA-2909	M				X
MV-MA-2915	M	X		X	X
<b>MV-MA-2916</b>	<b>F</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
MV-MA-2917	F			X	X
MV-MA-2920	F			X	X
<b>MV-MA-2921</b>	<b>F</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
MV-MA-2924	F				X
MV-MA-2925	F		X		
<b>MV-MA-2926</b>	<b>M</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
MV-MA-2928	F				X
MV-MA-2929	F	X		X	X
<b>MV-MA-2932</b>	<b>F</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
MV-MA-2971	F				X
MV-MA-3328	F			X	X
MV-MA-3330	F			X	X

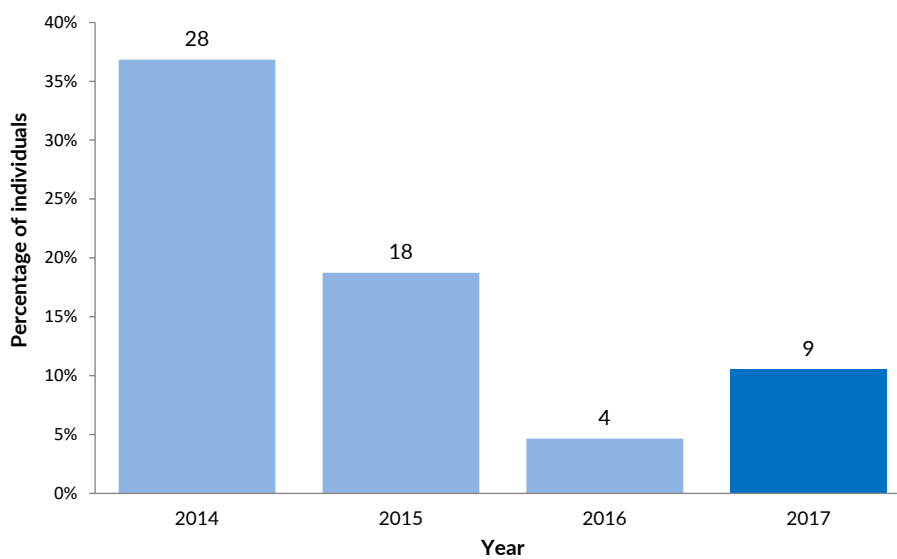
**Table 3 (cont.):** Individual reef manta rays (*Mobula alfredi*) not resighted in Laamu Atoll during the survey period (2014 – 2017). Data highlighted in red denotes that the individual was not recorded in any MMRP survey year (i.e. only sighted prior to 2014) and cells filled with N/A indicate that the manta ray had not yet been identified in Laamu.

Manta ID	Sex (M/F)	Absent 2014	Absent 2015	Absent 2016	Absent 2017
MV-MA-3376	M			X	X
MV-MA-3427	F				X
MV-MA-3429	M				X
MV-MA-3432	M			X	X
MV-MA-3602	F				X
MV-MA-3603	F				X
MV-MA-3604	F			X	X
MV-MA-3636	F			X	X
MV-MA-3640	M	N/A			
MV-MA-3641	F	N/A		X	
MV-MA-3713	F	N/A	N/A		X
MV-MA-3729	F	N/A			X
MV-MA-3730	M	N/A		X	X
MV-MA-3756	F	N/A		X	X
MV-MA-3811	M	N/A			X
MV-MA-3879	F	N/A		X	

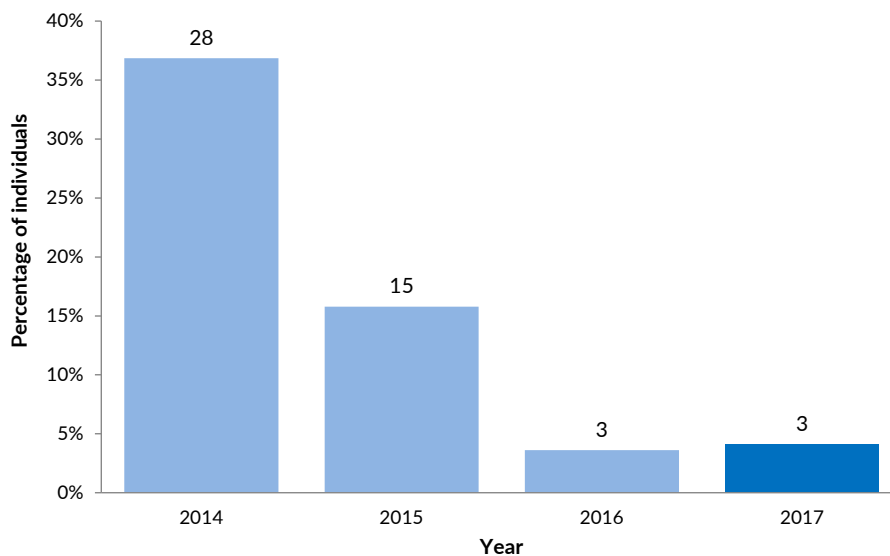
## NEW MANTA RAYS

Nine new individual manta rays were identified during the survey period in Laamu Atoll in 2017 (Fig. 14). The proportion of the total individuals sighted annually which were new to the database followed a downward trend from 2014-2016. However, 2017 saw a slight increase in this percentage at the atoll level. It should however be highlighted that out of the nine new individuals recorded across the atoll, only two were sighted at Hithadhoo Corner; the remainder were sighted at Fushi Kanduu. Hithadhoo Corner has been intensively surveyed for the last four years, therefore the vast majority of individuals which frequent this site

have now been recorded (Fig. 15), while survey effort at Fushi Kanduu during the southwest monsoon (when the mantas are present at this site) had, until 2017, been low (Fig. 16). We expect to record more new individuals at Fushi Kanduu in 2018 with increased survey effort to this site. Anecdotal reports suggest Munnafushee Kanduu in the north of Laamu Atoll is also frequented by a small population of reef manta rays during the northeast monsoon, although further investigation is required to ascertain if these individuals are the same as the ones which frequent Hithadhoo Corner and Fushi Kanduu.

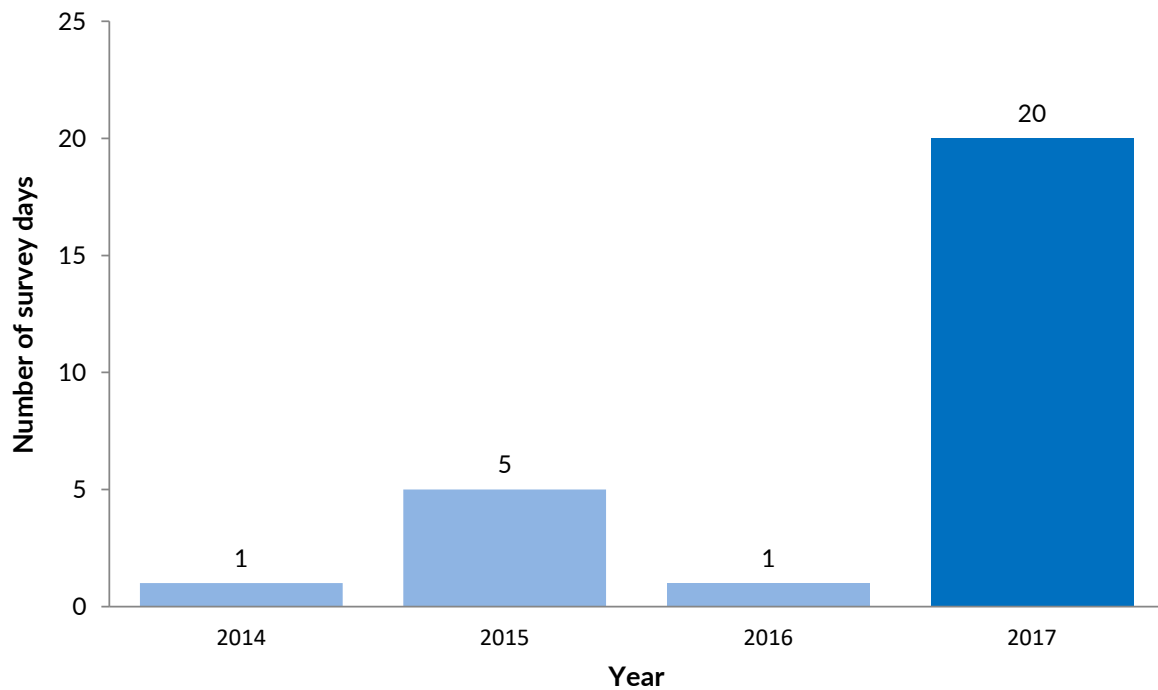


**Figure 14:** Proportion of total individual reef manta rays (*Mobula alfredi*) recorded annually in Laamu Atoll which were sighted for the first time that year (2014-2017). Actual numbers presented above bars.



**Figure 15:** Proportion of total individual reef manta rays (*Mobula alfredi*) recorded annually at Hithadhoo Corner in Laamu Atoll which were sighted for the first time that year (2014-2017). Actual numbers presented above bars.





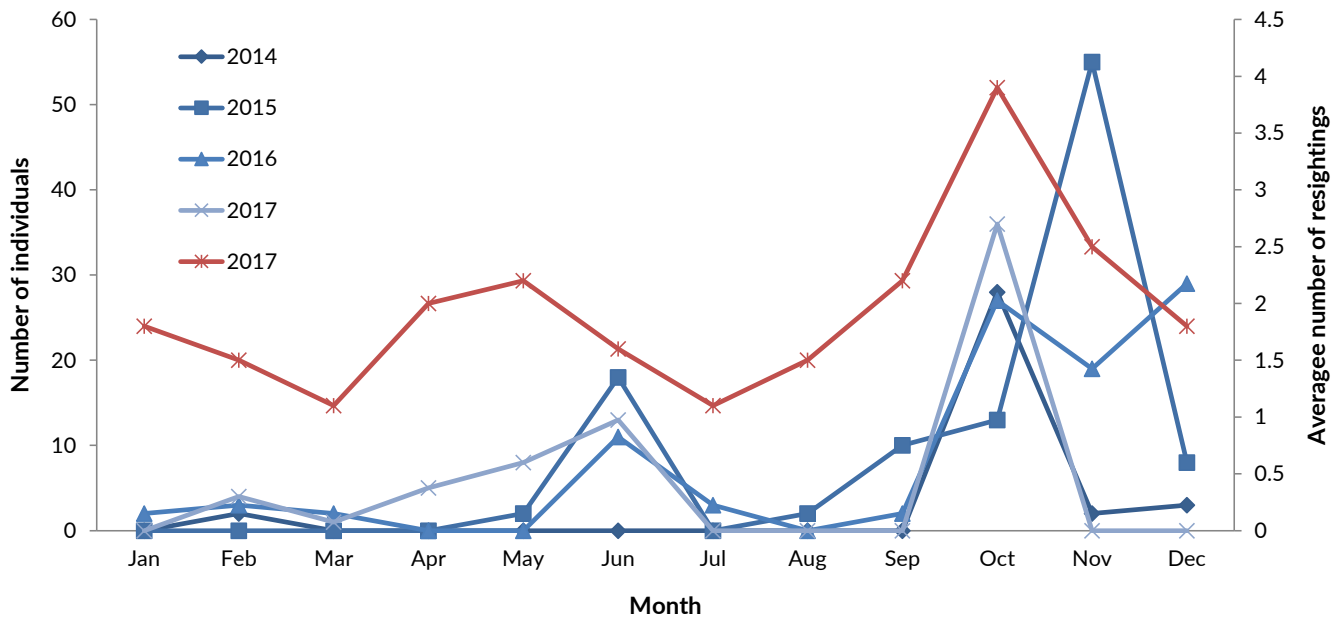
**Figure 16:** Total number of survey days at Fushi Kandu, Laamu Atoll (2014-2017).

## REPRODUCTION, COURTSHIP & MATING BEHAVIOUR

Individual reef manta ray resighting rates were highest during the months when courtship activity was most often observed (May and October), suggesting a higher residency period at the main study site of Hithadhoo Corner during these periods (Fig. 17). Throughout their range globally, manta ray reproductive activity is often seasonally variable. In the Maldives, courtship and mating behaviour is much more frequently observed during the months of May-June, and again in October-November. It is around these peak courtship periods that increased numbers of pregnant females are also recorded. The recorded instances of courtship behaviour and the number of pregnant females in Laamu Atoll both peak in October (Fig. 18). Female manta rays, like some other elasmobranchs, are most likely able to store sperm to enable inter-birth recovery intervals. It is likely that these strategies have also been developed in order to provide offspring with the best chances of survival by ensuring that they are born during years which have favourable conditions.

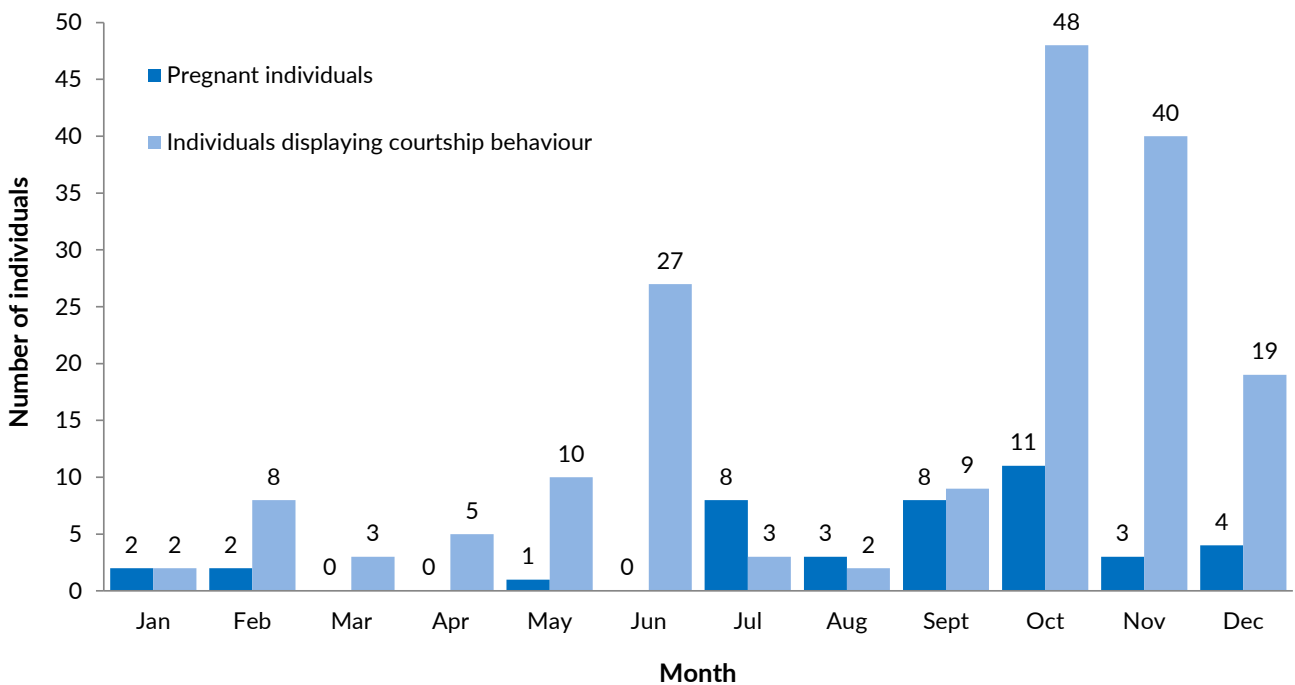
2017 was the fourth consecutive year the MMRP recorded pregnancies among the Laamu manta ray

population. A total of ten different females were observed to be pregnant throughout 2017 in Laamu Atoll (Fig. 19); 10% of the pregnancies recorded for the entire Maldivian manta ray population. The number of pregnancies recorded among Laamu Atoll's population of mature female reef manta rays in 2017 was higher than that recorded in 2015 and 2016, but nearly half of the number recorded in 2014. This indicates a highly variable reproductive fecundity interannually, and an overall very slow reproductive rate; with on average only 14% of the adult females observed annually in Laamu Atoll reproducing each year (Fig. 20). With such low fecundity, this population is extremely vulnerable to anthropogenic impacts. This loss of just a handful of the breeding adult females could lead to population declines and possible local extinction. Effective measures therefore should include the establishment of functional MPAs and the adherence to sustainable tourism activities at key manta ray mating, cleaning and feeding sites.

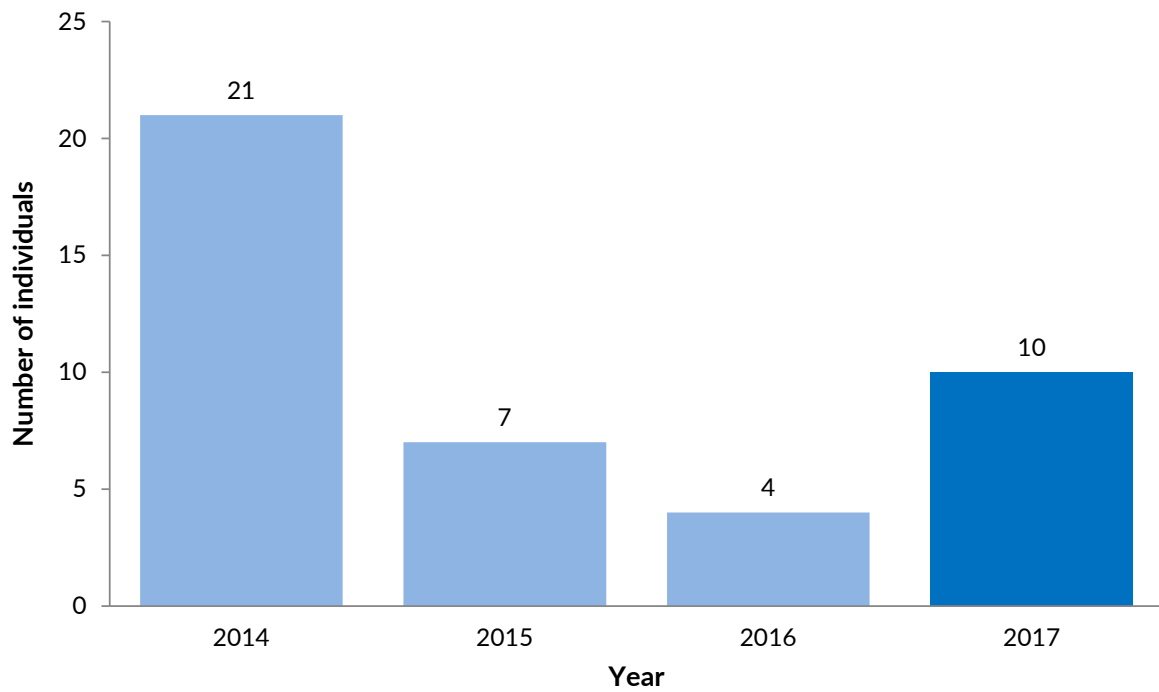


**Figure 17:** Average monthly re-sighting rates of individual reef manta rays (*Mobula alfredi*) at Hithadhoo Corner (2017) in red and the number of individuals seen engaging in courtship behaviour in Laamu Atoll (2014-2017) in blue.

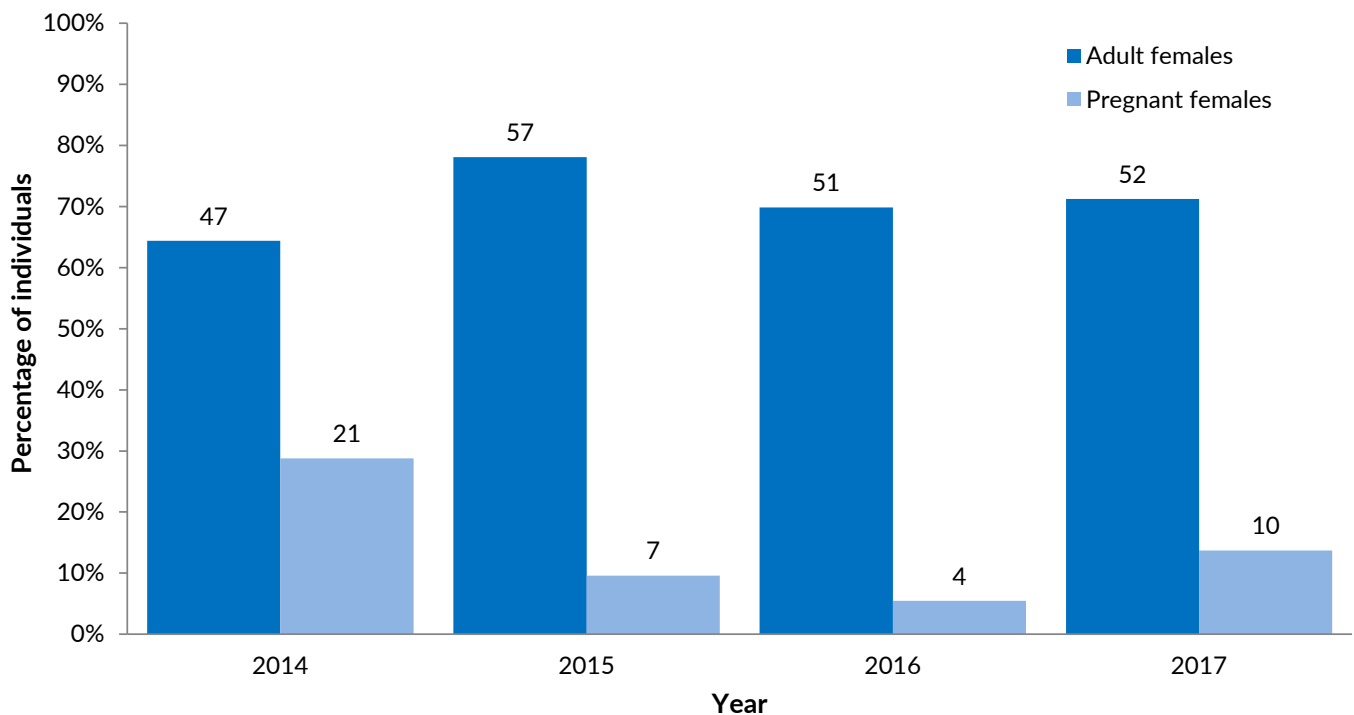
It should be noted that the absence of sightings recorded for April 2014 and March 2015 were due to the MMRP staff not being on site during these months, with data sourced solely from external submissions.



**Figure 18:** Number of pregnant reef manta rays (*Mobula alfredi*) and the number of individuals sighted engaged in courtship behaviour each month in Laamu Atoll (2014-2017).



**Figure 19:** Number of pregnant female reef mantas (*Mobula alfredi*) sighted annually in Laamu Atoll (2014-2017).



**Figure 20:** Percentage of Laamu Atolls adult female reef manta ray (*Mobula alfredi*) population (n=73) sighted annually, and the percentage of those females which were recorded pregnant in the same year (2014-2017). Actual numbers presented above bars.

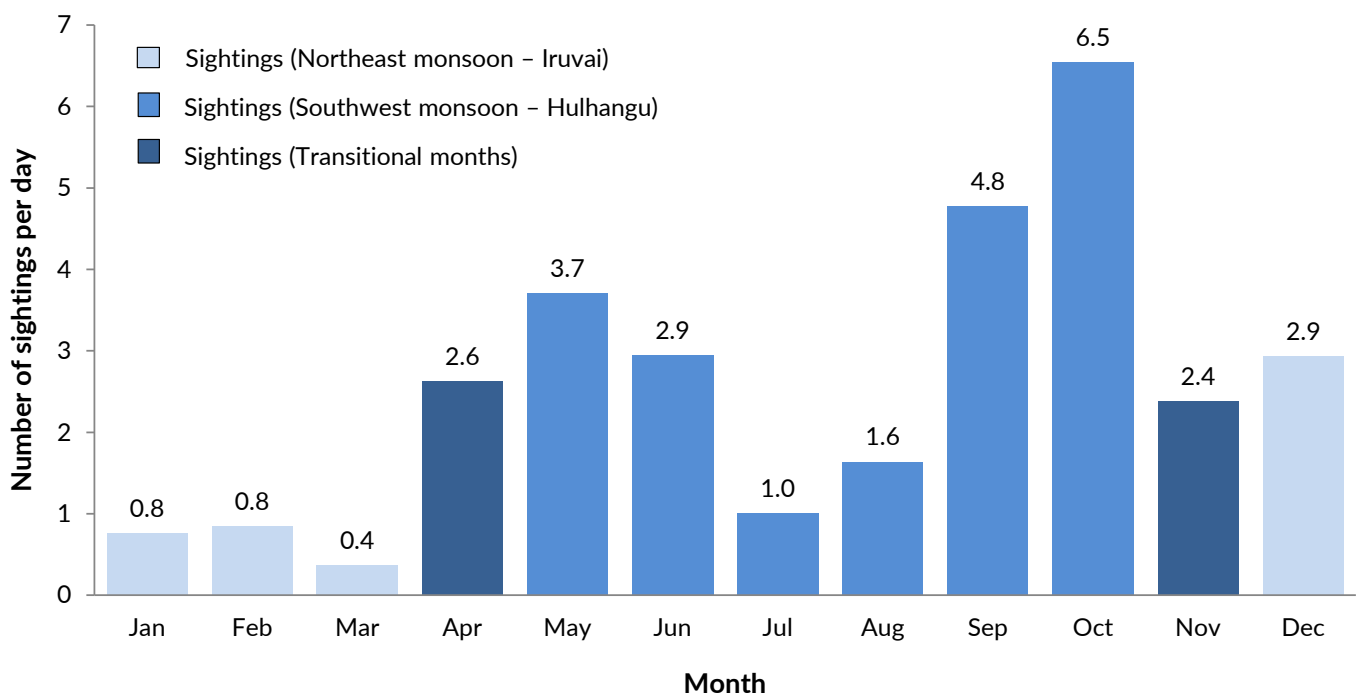
## MONSOONS & OTHER ENVIRONMENTAL VARIABLES

As detailed in previous Laamu Atoll project reports, it is important to understand the effects that environmental conditions have on manta ray behaviour and aggregations. There are two monsoons (or seasons) that the Maldives experiences each year; the southwest (Hulhangu/wet) from May to October and the northeast (Iruvai/dry) from December to March. This leaves November and April as transitional months between monsoons. The weather in the Maldives (e.g. wind direction, strength and precipitation) are heavily influenced by the different monsoons. The 'transitional months' have the most unpredictable weather.

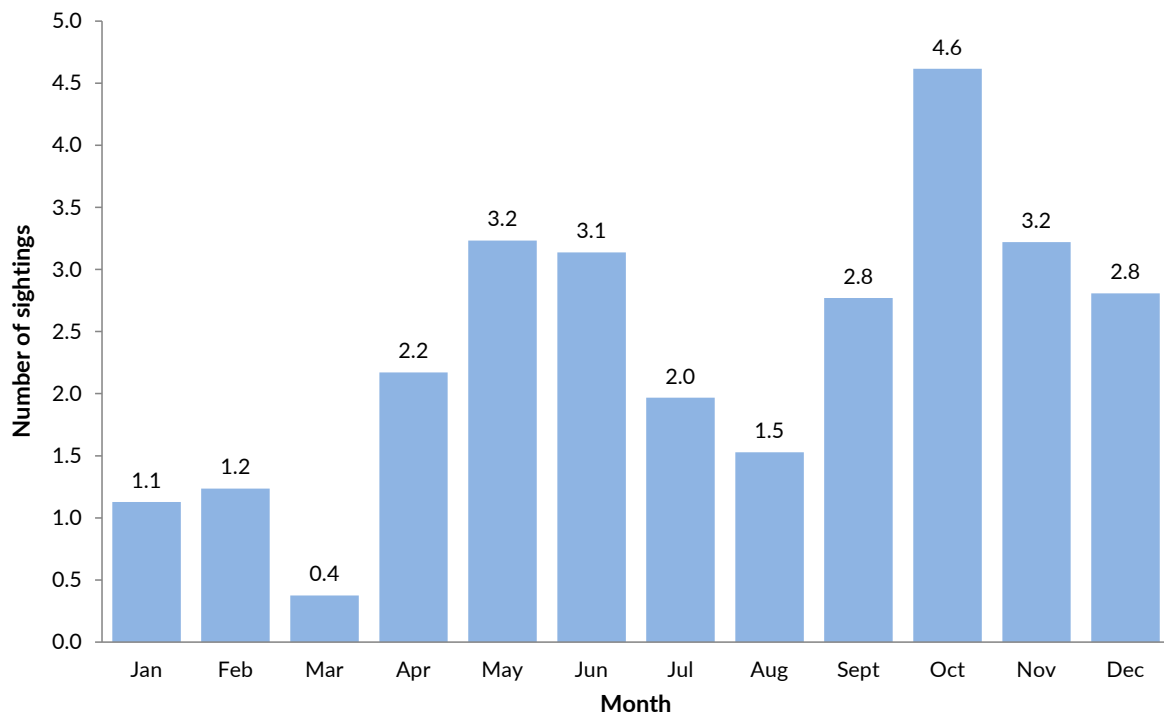
Reef manta ray sightings at Hithadhoo Corner are generally higher during the southwest monsoon (Fig.21). When comparing the average combined annual sightings per month across all survey years there is a higher presence of manta rays during the beginning and the end of the southwest monsoon (Fig. 22). During a typical southwest monsoon, the wind blows consistently and steadily from the southwest, causing the greatest

concentrations of the manta ray's zooplanktonic food on the monsoonal down-current edges of the atolls. Stronger monsoonal winds generate stronger currents, more localised upwelling and productivity, which in turn attracts more reef manta rays into the area. Hithadhoo Corner is therefore likely to have increased productivity during the southwest monsoon, leading to higher manta ray sightings. Conversely, reduced prey availability in the southern area of Laamu Atoll during the northeast monsoon is the likely reason for the decreased sighting records at Hithadhoo Corner during January-March in 2017.

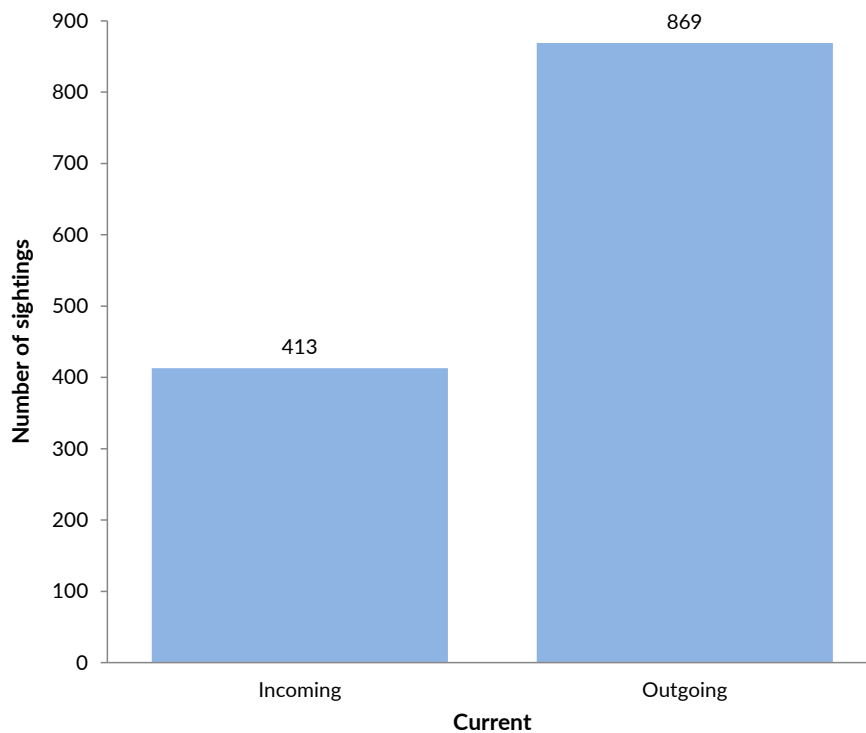
Data from 2014-2017 has also shown that manta ray encounters at Hithadhoo Corner are far less likely to occur during incoming currents (Fig. 23). This could be due to plankton rich waters from the open ocean being concentrated and driven inside the atoll, attracting reef manta rays to feed rather than clean.



**Figure 21:** Average monthly and seasonal variations in the number of reef manta ray (*Mobula alfredi*) sightings per survey day (2017).



**Figure 22:** Average number of reef manta rays (*Mobula alfredi*) sighted per survey day each month in Laamu Atoll (2014-2017).



**Figure 23:** Variations in the sighting frequency of reef manta rays (*Mobula alfredi*) at Hithadhoo Corner cleaning stations in Laamu Atoll during incoming and outgoing currents (2014-2017).

## RESEARCH PROJECTS

### STEREO VIDEO PHOTOGRAMMETRY

In 2016, we successfully measured over one third of the total manta ray population using paired-laser photogrammetry and proved that age-class segregation and sexual dimorphism exist at Hithadhoo Corner. Our findings were selected for presentation at the Maldives' first ever Marine Science Symposium in Malé. Following the success of this project, in 2017 we began using a

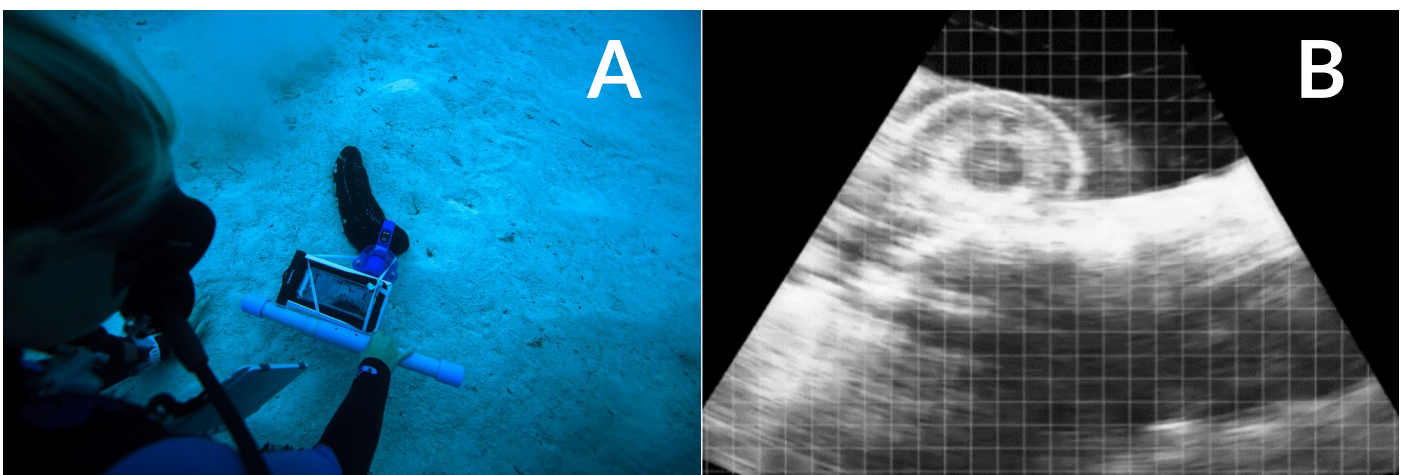
stereo video system, which allows for even greater measurement accuracy. The Laamu Manta Trust team began preliminary surveys using this new methodology in 2017, and in 2018 the aim is to collect updated measurements for those manta rays which have already been measured to determine any size increases, and to validate the research findings from 2016.

### ULTRASOUND PROJECT

The Manta Trust is very excited about the ongoing development of the cutting edge, portable and dive-proof ultrasound unit. The unit is being developed by experts at BCF Technology and uses field knowledge of researchers from the Manta Trust and the ultrasonography experience of veterinary experts, such as Ray Rochester from Vetsonic. It is hoped that this innovative ultrasound unit will allow us to document the internal maturation and gestation processes of reef manta rays. By using seawater as the transmission medium, we eradicate the need to make contact with the subject, and as such, stress and other detrimental physiological impacts are greatly reduced during the research. By better understanding the reproductive strategies and maturation process in manta rays, the Manta Trust team can combine this research with genetic, morphometric and behavioural data from

Laamu Atoll. With this combined data we can start to accurately monitor traits such as size- and age-at-maturity, fecundity and eventually the mechanisms driving reproductive periodicity in the wild, and therefore inform far more robust management decisions for this species in the Maldives and globally.

In August 2017 the second prototype version of the unit was trialled for the first time. Since then the ultrasound images that have been collected by the Manta Trust staff continue to improve. So far subjects such as turtles, sea cucumbers and fish have been scanned underwater (Fig. 24). The next step is to continue to improve scanning techniques in the lead up to scanning manta rays with the new version of the unit, which is scheduled for completion in 2018. This new version should enable the collection of clearer images from deeper within the subjects being scanned.



**Figure 24:** Laamu Project Manager, Beth Faulkner, using the ultrasound prototype to scan a sea cucumber (A) and a sea cucumber ultrasound scan picture (B).

Upon completion of the trial phase, the third version (V3.) of the unit will be used for the first time to scan manta rays at Hithadhoo Corner. After the initial scans have been made in Laamu Atoll, the Manta Trust team will subsequently progress to surveying other manta

ray aggregation sites around the Maldives as part of a larger phase of the project, in order to gain a broader understanding of manta reproductive periodicity regionally and nationally.

## GENETIC TISSUE SAMPLING

The Manta Ray Genetics Project works to better understand the genetic underpinnings of the fascinating lives of manta rays. Novel genetic methods can now enable a better understanding of speciation, evolution and adaptation - all of which have important implications for conservation. In 2016, approval for ten genetic tissue samples to be taken from the reef manta ray population in Laamu Atoll was given to the MMRP by the Maldivian government (sampled in August/September 2016 at Hithadhoo Corner). In June 2017, a revised genetics application allowing further tissue sampling of the Maldivian manta ray populations was granted; allowing the team to collect another ten samples from the region. However, no samples were taken in 2017 due to logistical constraints.

Sampling was carried out using underwater biopsy probes. For marine species that are difficult to capture, tissue collection via biopsy probe is a highly desirable and effective method of obtaining samples

and as such, is used by elasmobranch scientists worldwide. This method is considered to be advantageous as it reduces stress and injury to individuals. In-water observations showed manta rays were minimally affected by the probes, with some only slightly flinching and others making a short dart off site only to return a couple of minutes later to continue feeding or cleaning, seemingly unperturbed by the sampling initiative. In addition, it should be noted that the small puncture wounds resulting from these biopsy probes healed shortly after carrying out the sampling (within days). As in accordance with permit regulations, we do not conduct any biopsy sampling with guests present. The samples were prepared and stored on-site at Six Senses Laamu until they were collected and taken to Europe for analysis. Scientific peer reviewed publications presenting the results of this sampling effort will be published in 2018.

## FUTURE RESEARCH PROJECTS

### REMOTE UNDERWATER VIDEO (RUV)

In 2017 we began the deployment of remote underwater video systems (RUVS) to collect both photo-ID shots and behavioural data on the reef manta rays whilst there are no divers at the survey sites. Throughout 2018 we will continue to deploy RUVS at Hithadhoo Corner and other manta aggregation sites in Laamu Atoll. So far, the units can only be deployed for a couple of hours at a time due to the battery life of the cameras (GoPro's) so in future we hope to develop the activity by leaving the set up (with an additional battery pack) to continuously record until retrieval the following day. On this basis, we will aim for 2-3 deployments per week (during a 6-day working week). We will alternate which cleaning stations we leave the

cameras on to ensure a representative survey effort across the entirety of cleaning stations at Hithadhoo Corner and the other sites.

During the peak courtship months we aim to make sure we set up more than one camera at different cleaning stations to be confident we are not missing certain interactions due to the bias of camera placement. By removing human presence (remote censoring), we also hope to assess the impacts of diver pressure on the manta rays at these sites. It should be noted that adverse weather conditions, lack of boat availability and guest presence could affect the frequency of this activity.

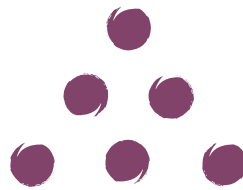
*This report was made possible thanks to:*



## **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 Maldivian government for the long-term management and conservation of these species in Maldivian waters. 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.*

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



**SIX SENSES**

LAAMU

## **SIX SENSES RESORT LAAMU**

*The Manta Trust and the MMRP would like to extend our huge and warm felt thanks to everyone at Six Senses Laamu, for their continued support of manta ray research and conservation.*





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

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