Manta TRUST

Maldives Manta Conservation Programme

Oceanic Manta Ray Project | Summary Report 2023

Conservation through research, education, and collaboration

- The Manta Trust

MALDIVES MANTA CONSERVATION PROGRAMME

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 29 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 manta rays, 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.

MALDIVES MANTA CONSERVATION PROGRAMME

Formed in 2005, the Maldives Manta Conservation Programme (MMCP), formerly the Maldivian Manta Ray Project (MMRP), is the founding project of the Manta Trust, and has been a Maldives registered charity since 2022. It consists of a country-wide network of dive instructors, biologists, communities and tourism operators, with more than a dozen MMCP staff based across a handful of atolls, on both resort islands and local islands.

The MMCP collects data around the country's manta population, its movements, and how the environment and tourism / human interactions affect them. Since its inception, the MMCP has identified over 5,500 different individual reef manta rays, from more than 80,000 photo-ID sightings. This makes the Maldives manta population the largest, and one of the most intensively studied populations in the world. The MMCP has also identified more than 900 different individual oceanic manta rays.

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, and in turn the tourism industry, 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 presents data collected by the Maldives Manta Conservation Programme (MMCP) on the oceanic manta ray (*Mobula birostris*) population sighted throughout the Maldives Archipelago in 2023, with a focus on the oceanic manta ray peak sightings period (April). The Maldives is widely regarded as one of the best places in the world to see reef manta rays (*Mobula alfredi*). However, the Maldives is also frequented by their larger oceanic relative. Both manta species have been continuously studied since 2007 by the MMCP, the founding project of the UK-registered charity, the Manta Trust; a non-profit, independent conservation, research, and education focused organisation.

Throughout 2023, there were 116 sightings of 106 individual oceanic manta rays in the Maldives. The 2023 peak sighting period around Fuvahmulah Atoll ran from April 12th to April 25th, during which a total of 61 sightings of 55 individuals were recorded directly by MMCP researchers or submitted to the Manta Trust by citizen scientists. Eight of the individuals documented around Fuvahmulah in 2023 were already known from previous years. The re-sighting rate of individuals within the season continued to be low this year, suggesting a transient population with minimal residency around Fuvahmulah Atoll. As with other years, the primary behaviour recorded was 'cruising'.

Sri Lanka, which is situated 300 kilometres to the north of the Maldives, is home to one of the largest manta and devil ray fisheries in the world. Fisheries research studies conducted by a Manta Trust affiliate in Sri Lanka have estimated that thousands of these threatened rays are landed every year across the country. The relatively close distance (1,000 km) between the aggregation sites in the south of the Maldives and the extensive fishery in Sri Lanka is a cause for concern, especially as the Sri Lankan fleet fishes intensively throughout this region of the Indian Ocean. However, at present we have no knowledge of the extent, if any, of the connectivity between these populations.

In 2023, the Manta Trust's MMCP team continued their increased research efforts at Fuvahmulah Atoll. It is now clear that the reefs around this island are a world class location for both recreational diving and marine research because of the abundance and diversity of marine megafauna. A dedicated environmental research and education centre has been agreed for Fuvahmulah, which would benefit visiting researchers, and involve local scientists from Fuvahmulah and the Maldives. We will be working with Fuvahmulah City Council over the coming years to implement these plans. Our hope it that such a centre will inspire and educate the next generation of Maldivians about the incredibly unique biodiversity surrounding Fuvahmulah Island.

STUDY PERIOD & SAMPLING METHODOLOGY

This report builds on the findings summarised in the Manta Trust's Oceanic Manta Ray Summary Reports between 2018 and 2022. This report covers all data collected on oceanic manta rays up until the end of 2023. However, the report focuses primarily on the oceanic manta season from the 12th of April to 25th of April 2023 in the sub equatorial atoll of Fuvahmulah in the Maldives.

The two most frequently sighted locations of oceanic manta rays in Fuvahmulah are the southernmost tip of the reef spur and the northeast corner of the Island referred to hereafter as Farikede Faru and Thundi Faru, respectively (Fig. 1). On Farikede Faru there is a shelf plateau at approximately forty-five metres depth which extends out from the reef.

In 2023, the MMCP conducted an extensive research season in Fuvahmulah Atoll to study the oceanic manta population. From the 1st – 30th of April, the MMCP had researchers based on Fuvahmulah Island conducting four-hour snorkel and boat surveys to collect photo-ID data on the oceanic manta rays. Additional drone surveys were used to survey larger areas in a shorter period. This period coincides with the period in which the highest numbers of sightings have been recorded in previous years. In addition, through collaborations with local dive schools and liveaboard operators, the MMCP has grown an extensive network of citizen scientists who submitted sightings during the season. These sightings are included in this report's findings.

In-water, individual manta rays were documented by photographing the unique spot patterns on their underside (ventral surface). The whole team were experienced scuba divers and free divers, allowing them to obtain photo-ID shots whilst ensuring minimum disturbance to the animals. For the purposes of this report, a sighting is defined as a confirmed photo-ID of an individual manta ray on a given day, multiple sightings, or submissions of the same individual from the same location on the same day are counted only once.

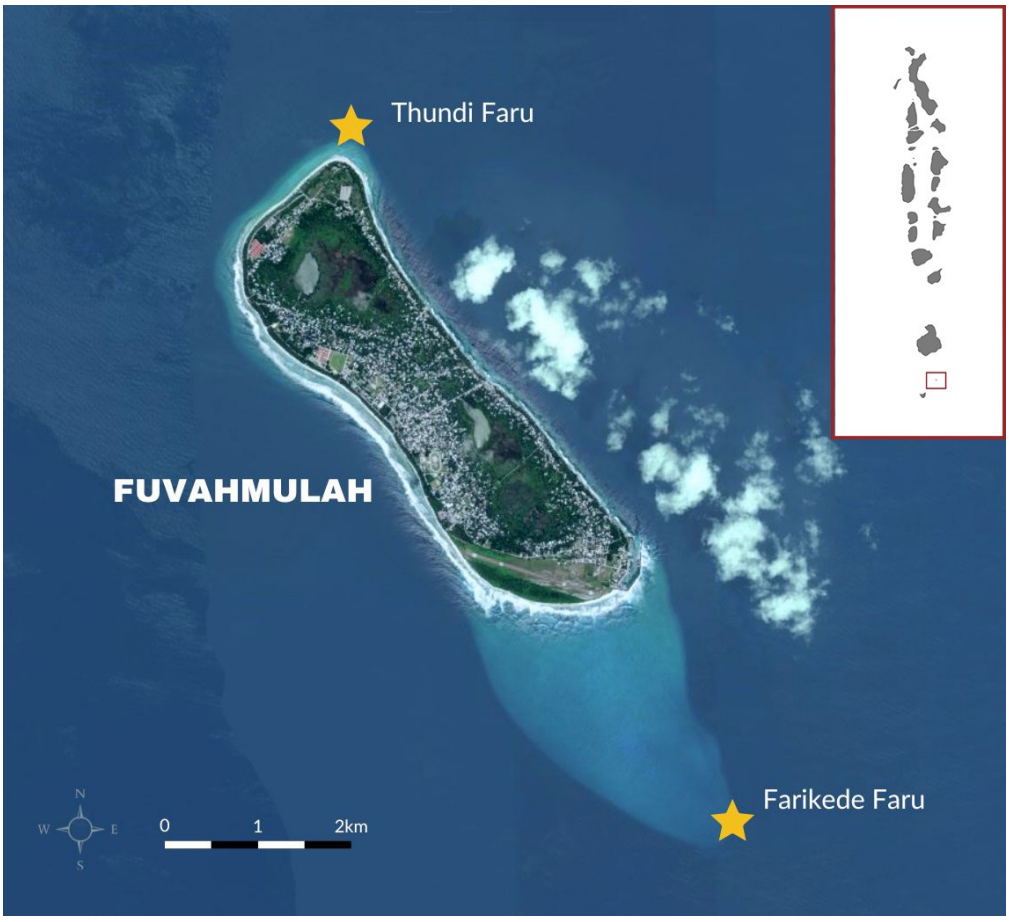

Figure 1: Map of Fuvahmulah Atoll in the Maldives archipelago (inset) with the two primary study sites where oceanic manta rays (*Mobula birostris*) have been sighted most often (2018 – 2023).

MANTA RAY SIGHTINGS

Nationwide

Throughout the Maldives Archipelago, a total of 1,018 sightings of 946 oceanic manta ray individuals have been recorded between 1996 and the end of 2023. These sightings were obtained from 16 of the 26 geographical atolls of the Maldives; from Thiladhunmathi Atoll in the north through to Addu Atoll in the south (Fig. 2).

Throughout the country, there were 118 sightings of oceanic manta rays in 2023 (Fig. 3). A significant difference has been identified over the years between sightings of oceanic manta rays in the deep south of the Maldives (Fuvahmulah and Addu Atolls) and the rest of the country. For this reason, sightings from these regions will be analysed separately.

The recorded photo-IDs showed no significantly biased gender split (sex ratio 1F:1.13M, $\chi 2 = 3.291$, df = 1, $p < 0.05$), across the total recorded population with 470 males (50%) and 416 females (44%). However, there are 60 individuals (6%) with unknown gender.

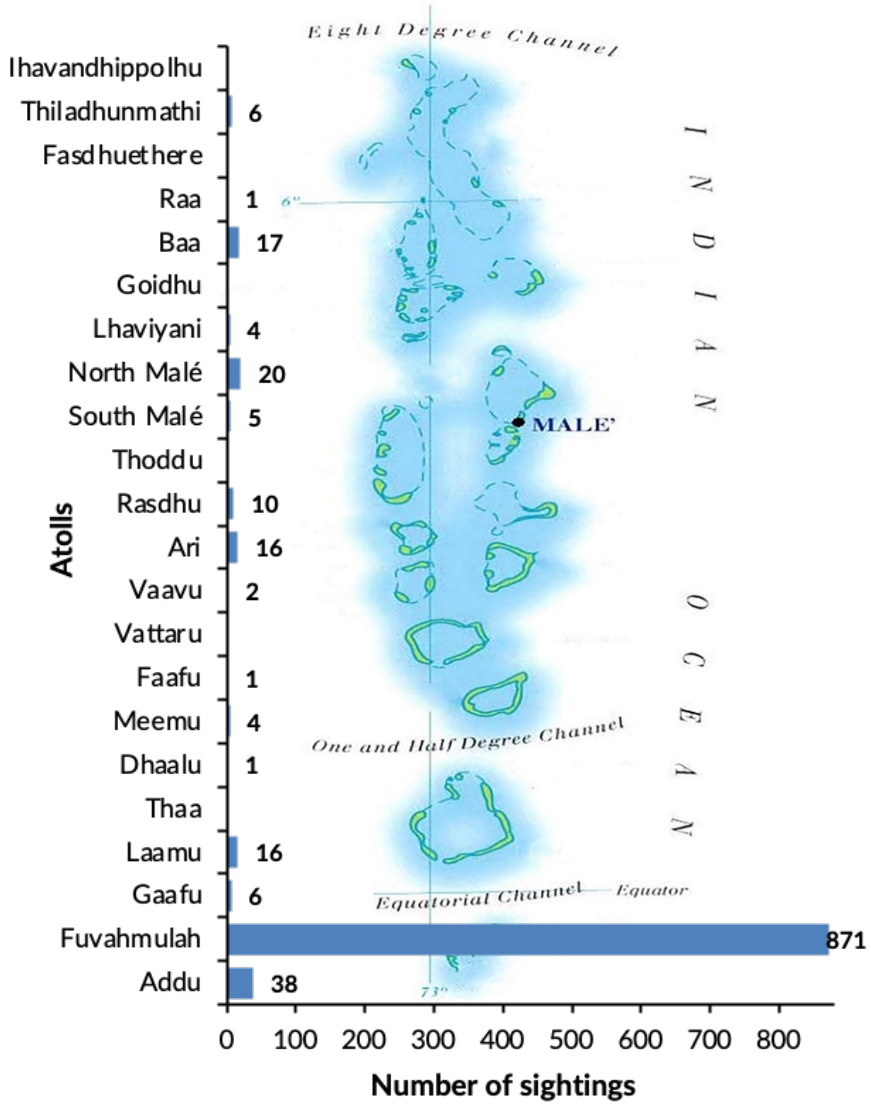

Figure 2: Number of sightings (*n*=1,018) of oceanic manta rays (*Mobula birostris*) across atolls throughout the Maldives (1996 – 2023). Note – some individuals have been sighted in more than one atoll throughout the Maldives Archipelago.

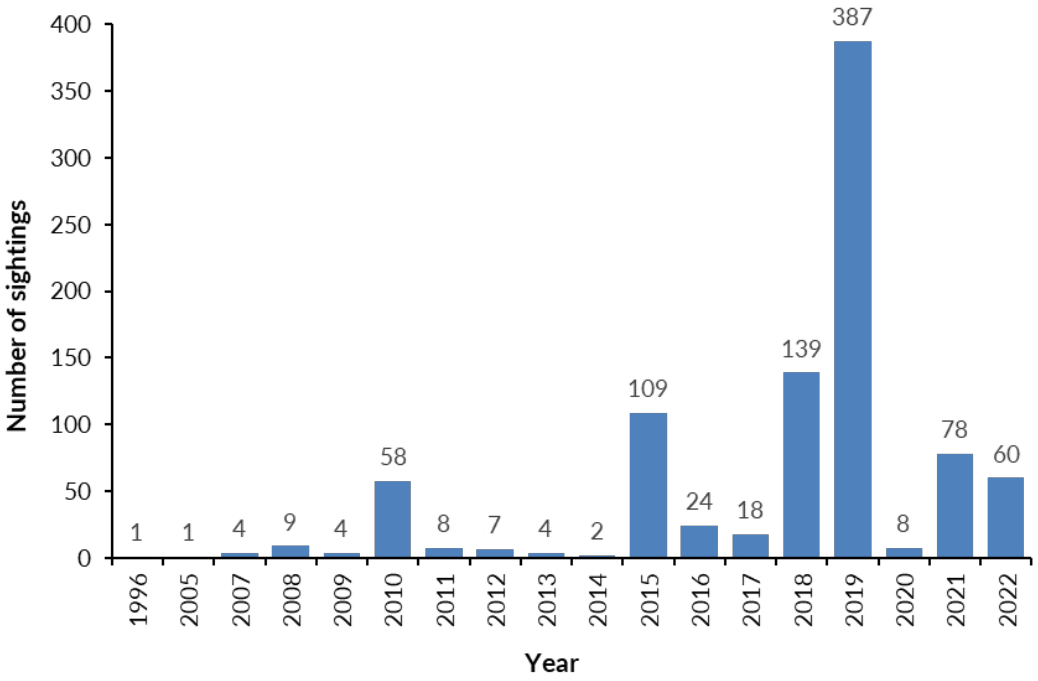

Figure 3: Number of oceanic manta ray (*Mobula birostris*) sightings throughout the Maldives (1996 – 2023).

NATIONWIDE (EXCLUDING FUVAHMULAH AND ADDU ATOLLS)

Manta Ray Sightings

Between January and December 2023, 17 sightings of 16 individuals were recorded nationwide (Table 1).

Table 1: Number of sightings of oceanic manta rays (*Mobula birostris*) in 2023 from all atolls (excluding Fuvahmulah and Addu Atoll).

Atoll	2023
Ari Atoll	1
Baa Atoll	1
Gaafu Atoll	1
Laamu Atoll	3
North Malé Atoll	5
Rasdhu Atoll	4
South Malé Atoll	2
Total	17

Re-sightings

Three of the 17 sightings were re-sightings of already documented oceanic manta rays. One individual, MV-MB-0884, an adult male, was seen three times over the course of eight days.

Of interest, is the re-sighting of MV-MB-0028, an adult female manta first seen in 2010 in South Ari Atoll. This individual was re-sighted again in April 2023 in North Male Atoll, 4,831 days (over 13 years) later. This constitutes the longest re-sighting period of an oceanic manta ray in the Maldives.

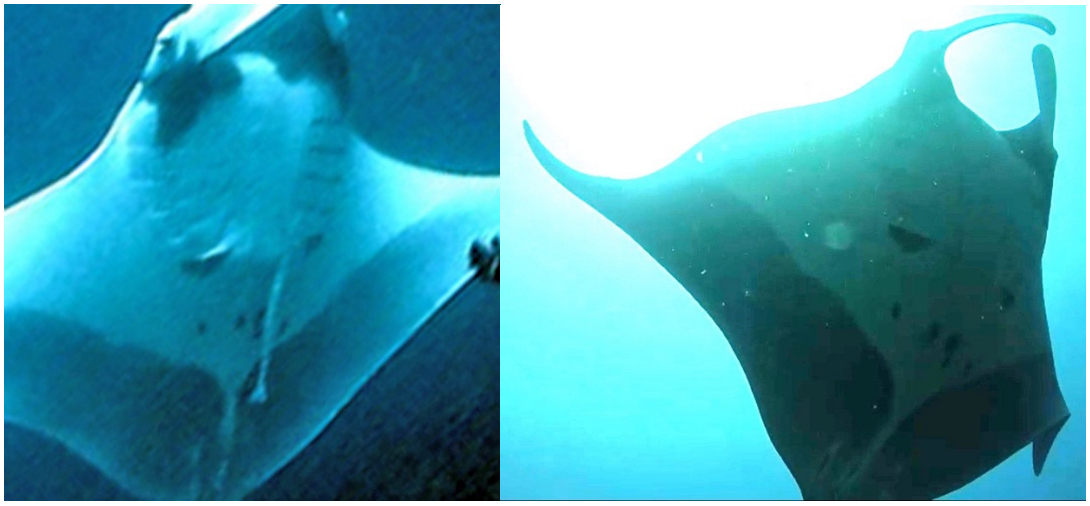

Figure 4: a) initial (Jan 2010) and b) re-sighting (Apr 2023) image of MV-MB-0028. Photo credit: Loic Deny and One & Only Reethi Rah.

Population Demographics

In 2023, there were more females recorded than males (sex ratio 1.33F:1M) with nine females and six males. However, due to small sample sizes, statistical analysis on significant differences was not worthwhile. All individuals were adults, and of the nine females, four had ventral mating scars and one individual was recorded as being visibly pregnant.

When not considering Fuvahmulah and Addu Atolls, none of the oceanic manta rays sighted in 2023 throughout the rest of the Maldives were melanistic, all were chevron colour morphs.

Behavioural Observations

The primary behaviour that the manta rays were exhibiting was recorded during each encounter. Most sightings throughout 2023 were of cruising or just swimming individuals (Table 2). Two oceanic manta sightings were at cleaning stations in North Malé Atoll and one individual was recorded feeding in Hanifaru Bay in Baa Atoll alongside approximately 50 reef manta rays (*Mobula alfredi*).

Table 2: Primary behaviour recorded during oceanic manta ray (*Mobula birostris*) encounters in the Maldives (excluding Fuvahmulah and Addu Atoll) in 2023.

Behaviour	Number of sightings
Cleaning	2
Courtship	0
Cruising / Just Swimming	14
Feeding	1

FUVAHMULAH & ADDU ATOLLS

Manta Ray Sightings

Fuvahmulah and Addu Atolls, the two southern most atolls of the Maldives, have historically been the area with the most oceanic manta ray sightings. In 2023, there were 101 confirmed sightings of 93 oceanic manta ray individuals from Fuvahmulah Atoll, and zero from Addu Atoll (Fig. 5). Of the 101 sightings, 61 sightings of 55 individuals were recorded during a 14-day period between April 12th and April 25th (Fig. 6), referred to hereafter as 'the peak season'. Seasonality of sightings around Fuvahmulah in 2022 align with those in previous years, with a peak sighting period around March to April time (Fig. 7).

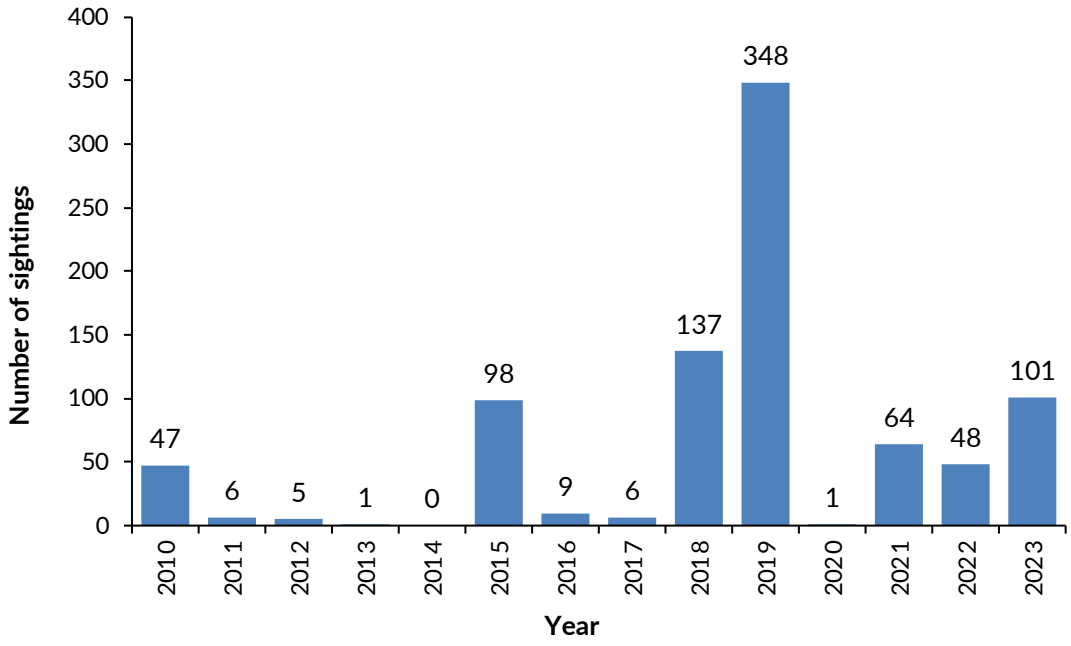

Figure 5: Annual total number of sightings of oceanic manta rays (*Mobula birostris*) from Fuvahmulah Atoll (2005 – 2023).

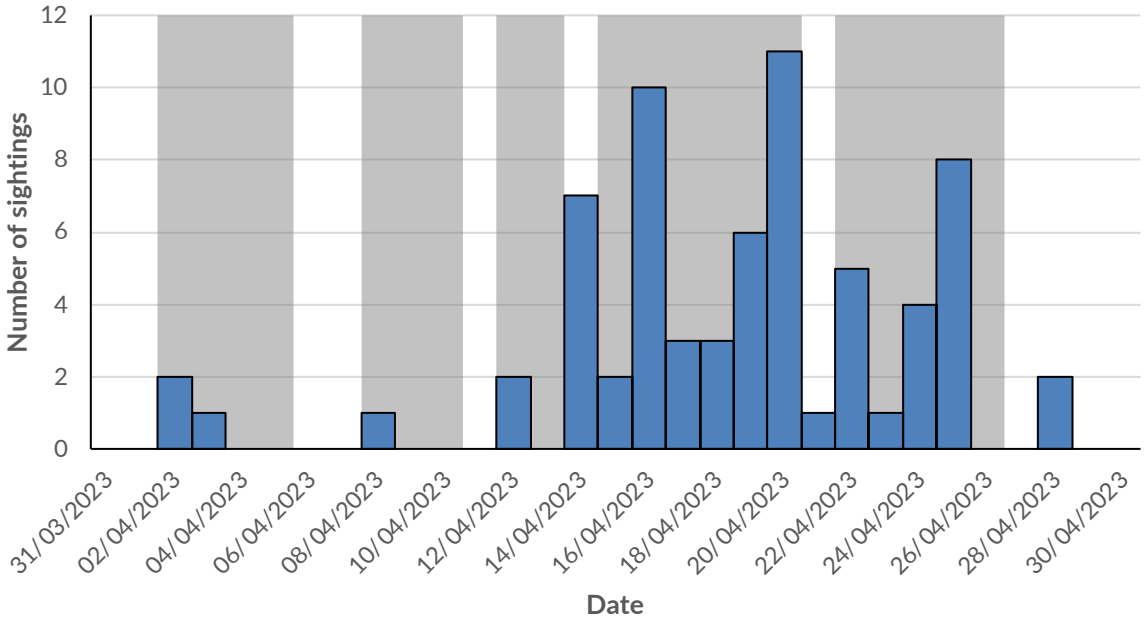

Figure 6: Number of oceanic manta ray (*Mobula birostris*) sightings per day (blue bars) between March 31st and April 30th in 2023. Manta Trust research team survey days (*n*=20) during this period are greyed out.

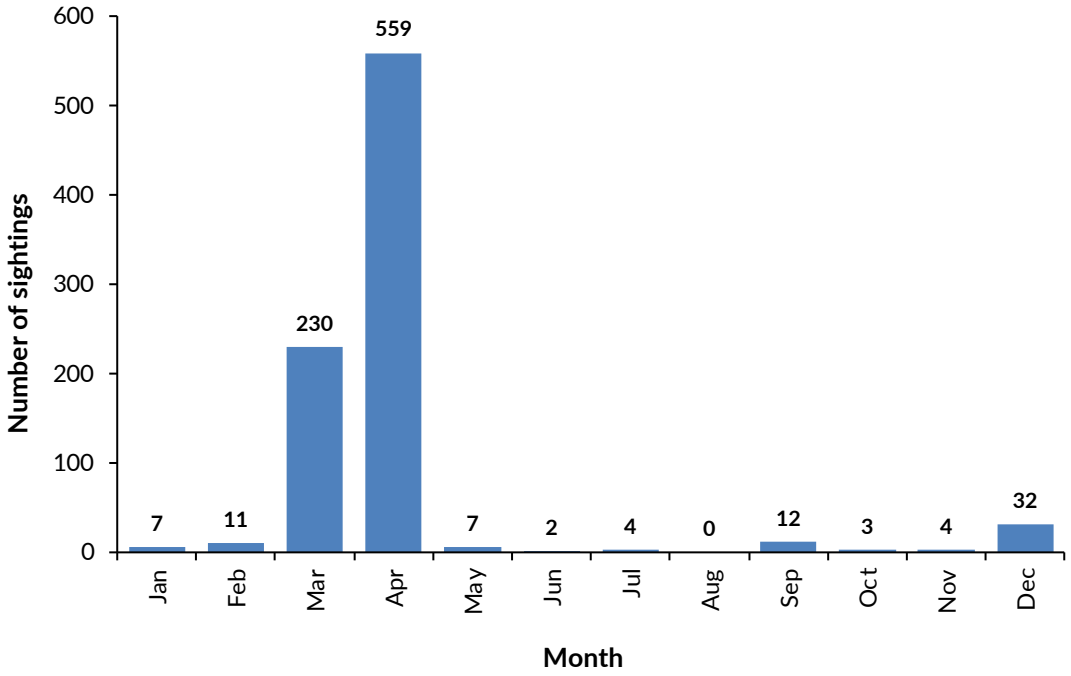

Figure 7: The total number of oceanic manta ray (*Mobula birostris*) sightings (*n*=851) each month from Fuvahmulah Atoll (2008 – 2023).

Although the Manta Trust do not have standardised survey effort throughout the year, the dive logs from a local dive operator show that there are dives at Farikede Faru year-round. Despite this year-round diving effort from local dive operators, reports of manta ray sightings and citizen science submissions outside of March and April are rarely received. In 2023, however, there was an uncharacteristic spike in sightings in September with seven confirmed IDs and more sightings reported, and a spike in December with 19 IDs submitted. Fuvahmulah Dive School reported that this coincided with a change in ocean currents around the island.

The Manta Trust MMCP team conducted surveys around the whole island, although we focused on the two primary sighting locations of Farikede Faru and Thundi Faru, where 84% (*n*=85) of the sightings originated from during the peak season.

Re-sightings

Of the 93 individuals recorded around Fuvahmulah in 2023, 15% (*n*=14) had been recorded in the database prior to 2023. Eight (9%) of these had been documented prior to 2023 and constitute inter-annual re-sightings. In previous years the number of inter-annual sightings has also been low (2% in 2021, and 1% in 2019). Such a low incidence of resighted individuals suggests that a very large population of this species is likely to exist in the region, numbering from thousands to possibly tens of thousands.

During the peak season in 2023, seven of the 53 individuals were re-sighted within the season. This equates to just 13% of the individuals being re-sighted within season despite near daily surveys. The periods between re-sightings ranged from zero (a re-sighting on the same day between two sites) to 10 days.

Table 3: Demographics and details of the re-sighted oceanic manta rays (*Mobula birostris*) (*n*=14) around Fuvahmulah Atoll in 2023.

Mobulid Ray ID Number	Demographic	Initial Sighting Date	Initial Sighting Location	Re-Sighting Date	Re-Sighting Location	Days Between Sightings
MV-MB-0079	Adult female	01/04/2015	Fuvahmulah Atoll	16/04/2023	Fuvahmulah Atoll	2937
MV-MB-0175	Adult Male	19/03/2016	Fuvahmulah Atoll	22/04/2023	Fuvahmulah Atoll	2590
MV-MB-0239	Adult Male	16/04/2017	Addu Atoll	20/04/2023 & 22/04/2023	Fuvahmulah Atoll	2195 & 2
MV-MB-0365	Unknown Male	28/04/2018	Fuvahmulah Atoll	08/02/2023	Fuvahmulah Atoll	1747
MV-MB-0407	Adult Male	11/03/2019	Fuvahmulah Atoll	14/04/2023	Fuvahmulah Atoll	1495
MV-MB-0581	Adult Unknown	03/04/2019	Fuvahmulah Atoll	19/04/2023	Fuvahmulah Atoll	1477
MV-MB-0709	Adult Male	06/12/2019	Fuvahmulah Atoll	24/04/2023	Fuvahmulah Atoll	1235
MV-MB-0762	Adult Male	27/04/2021	Fuvahmulah Atoll	22/04/2023	Fuvahmulah Atoll	725
MV-MB-0855	Adult Male	02/04/2023	Fuvahmulah Atoll	03/04/2023	Fuvahmulah Atoll	1
MV-MB-0856	Adult Male	02/04/2023	Fuvahmulah Atoll	12/04/2023	Fuvahmulah Atoll	10
MV-MB-0862	Adult Male	16/04/2023	Fuvahmulah Atoll	17/04/2023 & 20/04/2023	Fuvahmulah Atoll	1 & 3
MV-MB-0870	Adult Female	19/04/2023	Fuvahmulah Atoll	19/04/2023	Fuvahmulah Atoll	0
MV-MB-0882	Adult Female	20/04/2023	Fuvahmulah Atoll	25/04/2023	Fuvahmulah Atoll	5
MV-MB-0894	Adult Male	19/04/2023	Fuvahmulah Atoll	22/04/2023	Fuvahmulah Atoll	3

Population Demographics

There was a significant difference ($\chi 2 = 6.96$, df = 1, $p < 0.05$) between the number of male (*n*=35) and female (*n*=16) manta rays observed in the 2023 peak season around Fuvahmulah (for four individuals the sex was undetermined).

Of the 16 females observed, 19% (*n*=3) had visible mating scars or mating wounds. No pregnant females were recorded in 2023 and all but one individual (both males and females) were assessed to be adults based on their size, and in the case of males, on the size and calcification of their claspers. This is in accordance with previous years' observations, which have been represented predominately by an adult population with low incidences of pregnancies. Of the 55 identified oceanic manta rays in 2023 around Fuvahmulah, just 2% (*n*=1) were melanistic. This is in line with the nation-wide trend, with melanistic oceanic manta rays making up just 1.9% (*n*=18) of the known population (*n*=924). Interestingly, there has never been a sighting of a black morph reef manta ray recorded in the Maldives despite it hosting the largest known population of this species in the world.

Behavioural Observations

The primary behaviour observed during each manta encountered was noted. There were no confirmed sightings of courtship, feeding, or cleaning individuals during the peak sighting period in 2023. Sightings were from throughout the water column, from the surface waters down to below the limits of recreational diving at 30 metres.

RESEARCH ACTIVITIES

Crittercam Deployments

In 2023, permits to deploy National Geographic Society (NGS) Crittercam units on oceanic manta rays were obtained. Kyler Abernathy from the NGS joined the research team in the Maldives to train them on the set up, deployment, and retrieval of the units.

In collaboration with the Manta Trust, the NGS developed a new iteration of their animal-borne ocean observing devices (Crittercam) for manta rays in 2015. This version of Crittercam was relatively simplistic in that Crittercams were equipped with a single camera and VHF beacon on a buoyant suction cup attachment. One major limitation of these systems was the inability to film at night or at depth due to a lack of light. The aim of this project was to advance the Crittercam systems to incorporate a light unit to document manta ray behaviour under poor light conditions (at night and below 100m depth), and to increase tag deployment time to get a preliminary insight into short range movements.

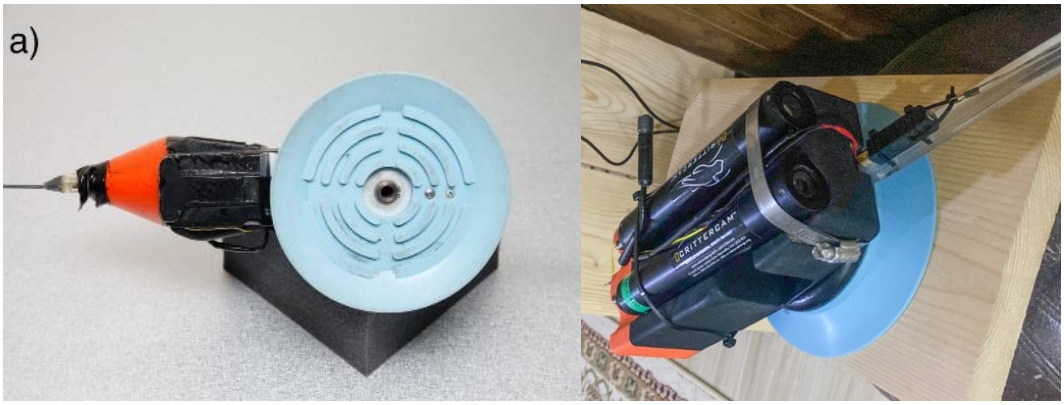

Figure 8: The old (a) and new (b) designs of the National Geographic Society Crittercam systems.

A new version of the Crittercam was developed by the NGS in 2023 (Fig. 8b). The buoyant foam block was enlarged to encompass two 1" tubes side by side: one would house the camera and the other an LED light with a magnetic switch. This configuration could also theoretically allow for two cameras, one forward facing and one rear facing, to be attached, However, this was not tested.

A satellite tag was also attached to the units so that if we achieved longer deployments of a few hours or more, and the animals had moved out of range of the VHF radio and goniometer, we would have some initial GPS pings of the location and an indication of where to start the search. The suction cup attachment, and the programmed timed release safety clasp were the same as previous models of the Crittercam unit.

Finally, we also incorporated a Star-Oddi 3-axis accelerometer data pill. This small 12-gram instrument collects fine scale data on the pitch, roll and yaw of the manta during deployments.

During the boat surveys, the team deployed both Crittercam units during encounters with oceanic manta rays. A total of five successful attachments were made (Table 4), with deployments ranging from one minute to 21 minutes. During these dives, manta rays were recorded diving to a depth of 60m with a minimum water temperature of 27.8°C.

Table 4: Summary data of Crittercam deployments on oceanic manta rays (*Mobula birostris*) around Fuvahmulah Atoll, Maldives.

Deployment No	Date	Deployment Length	Max Depth (m)	Min Temp (°C)
1	16/04/2023	4min 54sec	46.79	27.76
2	17/04/2023	21min 9sec	60.02	25.9
3	20/04/2023	1min 0sec	14.15	30.57
4	20/04/2023	4min 12sec	24.5	30.16
5	20/04/2023	5min 48sec	36.06	29.51

The camera footage collected from these deployments shows great potential for these systems: we can see different habitat use by the oceanic manta rays (manta swimming in open blue water to over the reef), we have captured behavioural indicators (unfurling of cephalic fin as would happen during feeding), as well as recording the presence of other marine species (Fig. 9). However, the Crittercams had very short retention times and detached within 100m from deployment location, preventing an in-depth analysis of the behaviour and tracking of short-range movements.

Previous studies by the Manta Trust and the National Geographic Society using older versions of Crittercams have been published in peer-reviewed studies, including a recent publication on deployments on reef manta rays (*Mobula alfredi*) in the Maldives (Pelletier et al., 2023; Stewart et al., 2019). However, both publications highlighted the limitations of the system's ability to document behaviours at night. Overall, the modified Crittercam systems with onboard lighting showed real promise to improve the quality and quantity of data collection over the older version. We are using the test results from the 2023 season to improve the attachment system and ensure longer deployments in 2024.

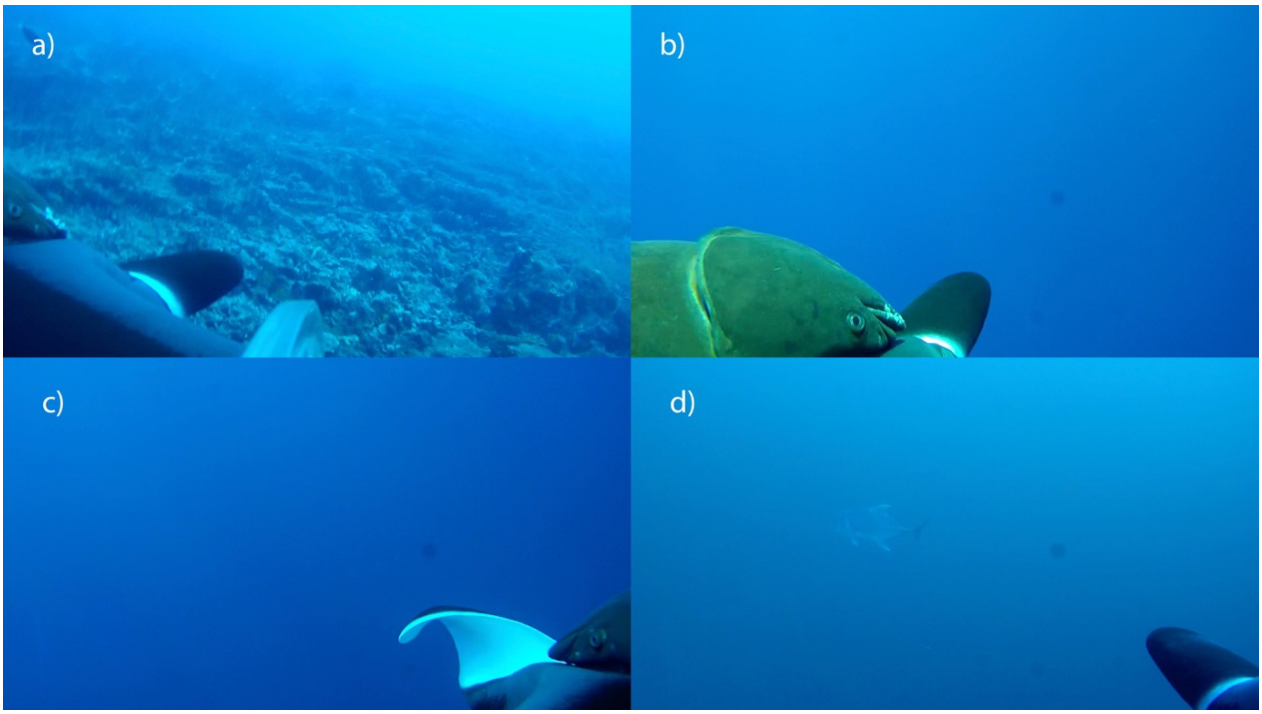

Figure 9: National Geographic Society Crittercam system deployed on an oceanic manta ray (*Mobula birostris*) in Fuvahmulah Atoll in 2023 showing, a) an individual swimming over the reef at 32m, b) an individual in open water, c) the unfurling of the cephalic fins, and d) other species documented by the camera (in this case a giant trevally, Caranx ignobilis).

Tissue Biopsy

Tissue samples of oceanic manta rays were collected by using a pole spear and pneu-dart tips under EPA and MoFA permits. A single sample was collected from 14 different individuals with no individual biopsied twice. Where the sample size allowed, they were sub-sampled into tissue type to conduct different analyses. Sample preservation also varied as required for comparison to different previous studies. Blue Resources Trust in Sri Lanka have collected a further six tissue samples in 2023 which will be included in this data set for genetic and stable isotope comparison. We will be applying for CITES export permits to send the samples to the UK and Australia for stable isotope and genetic analysis respectively.

Local Maldivian researchers were trained in the collection, preservation, and processing of tissue samples for genetic and stable isotope analysis.

Table 5: Samples and subsequent sub-samples of oceanic manta ray tissue samples collected in 2023 for their respective analysis.

Manta ID	Tissue Sample	Tissue Type	Preservation Method (all frozen within a few hours, then...)	Analysis
MV-MB-ZZZA	001-1	Muscle	Ethanol	Genetics
	001-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	001-3	Muscle	Dehydrated	Stable Isotope
	001-4	Connective Tissue	Ethanol	Gen/SI
	001-5	Skin	Ethanol	Gen/SI
MV-MB-0867	002-1	Muscle	Ethanol	Genetics
	002-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	002-3	Muscle	Dehydrated	Stable Isotope
	002-4	Connective Tissue	Ethanol	Gen/SI
	002-5	Skin	Ethanol	Gen/SI
MV-MB-ZZZA	003-1	Muscle	Ethanol	Genetics
	003-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	003-3	Connective Tissue	Ethanol	Gen/SI
	003-4	Skin	Ethanol	Gen/SI
MV-MB-0875	004-1	Muscle	Ethanol	Stable Isotope
	004-2	Connective Tissue	Ethanol	Genetics
	004-3	Skin	Ethanol	Genetics
MV-MB-ZZZB	005-1	Muscle	Ethanol	Genetics
	005-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	005-3	Connective Tissue	Ethanol	Gen/SI
	005-4	Skin	Ethanol	Gen/SI
MV-MB-0893	006-1	Muscle	Ethanol	Genetics
	006-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	006-3	Muscle	Dehydrated	Stable Isotope
	006-4	Skin & Connective Tissue	Ethanol	Gen/SI
MV-MB-0896	007-1	Muscle	Ethanol	Genetics
	007-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	007-3	Skin & Connective Tissue	Ethanol	Gen/SI
MV-MB-0897	008-1	Muscle & Connective Tissue	Ethanol	Genetics
	008-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	008-3	Skin & Connective Tissue	Ethanol	Gen/SI
MV-MB-0898	009-1	Muscle	Ethanol, then dehydrated	Stable Isotope
	009-2	Skin, Connective Tissue & Muscle	Ethanol	Genetics
MV-MB-0899	010-1	Muscle	Ethanol	Genetics
	010-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	010-3	Muscle	Dehydrated	Stable Isotope
	010-4	Connective Tissue	Ethanol	Gen/SI
	010-5	Skin	Ethanol	Gen/SI
MV-MB-0902	011-1	Skin, Connective Tissue & Muscle	Ethanol	Gen/SI
MV-MB-0904	012-1	Muscle	Ethanol	Genetics
	012-2	Muscle	Ethanol, then dehydrated	Stable Isotope
	012-3	Muscle	Dehydrated	Stable Isotope
	012-4	Skin & Connective Tissue	Ethanol	Gen/SI
MV-MB-0905	013-1	Muscle	Ethanol	Stable Isotope
	013-2	Skin, Connective Tissue & Muscle	Ethanol	Genetics
MV-MB-0906	014-1	Muscle	Ethanol	Stable Isotope
	014-2	Skin, Connective Tissue & Muscle	Ethanol	Genetics

Satellite Telemetry

To better understand the movements, migration, habitat use and connectivity of populations, the Manta Trust has applied for permits to deploy satellite tags in 2021 and 2022. In both seasons permits were not granted and therefore these research activities were not undertaken. However, in line with requests from the Maldives EPA, extensive education and outreach was conducted with the local community on Fuvahmulah Island. All the dive centres, and their staff, were invited to attend presentations and hands on workshops to see the equipment mentioned in the permit application first hand and to learn about field techniques and data analysis for these research methods.

Letters of no objection for satellite tagging and tissue biopsying studies were obtained from the Fuvahmulah City Council, Maldives National University as well as local dive centres following these workshops.

It is apparent that any opposition to such research techniques is based off misinformation and a lack of understanding of how these technologies and methods work. After workshops and knowledge sharing, the perception towards these methodologies improved.

In 2023, the EPA granted a permit for the deployment of satellite tags, however the Ministry of Fisheries and Agriculture rejected the same permit application. This was the first instance in which two government ministries in the Maldives have given opposing decisions on a permit application. Without full permit approval we could not proceed with this aspect of the study in 2023.

This has sparked discussions between the ministries to streamline the process and complete the migration of all research activities on protected species to fall under the remit of the Maldives EPA. We are in continued conversations with the two institutions so that this can be approved for 2024.

Despite this set back, we ran extensive training sessions with the local Maldivian researchers on the team on satellite tagging methodologies including tag set up, deployment, and analysis.

The Manta Trust's MMCP will reapply for permits to conduct satellite tagging studies in 2024.

Entanglements

Entanglements of manta rays in fishing gear in the Maldives have been frequented document and the Manta Trust has published a paper on this already (Strike et al. 2022). In 2023, during the peak oceanic manta season in Fuvahmulah, several entangled manta rays were sighted. Local dive operators and the research team were able to remove and retain some of these fishing gears.

In 2023, five entangled oceanic manta rays were cut free from longline fishing gear (Fig. 10a). Two hooks (Fig. 10b), one squid lure (Fig. 10c), and three samples of fishing line were removed (Fig. 10d). Both hooks removed were all nearly identical. They were circle hooks with a ring eyelet. The fishing line associated with the hooks was monofilament line of 0.18 cm thickness.

Two segments of gill net were removed during two separate encounters around Fuvahmulah in April 2023 and then North Male Atoll in August 2023 (Fig. 10e-g).

Local fishermen and researchers at the Maldives Marine Research Institute as well as the Olive Ridley Project were contact to try to determine the origin of these fishing gear. There was consensus that these fishing gears are not Maldivian in origin. However, the net and hooks are common across Indian Ocean fisheries.

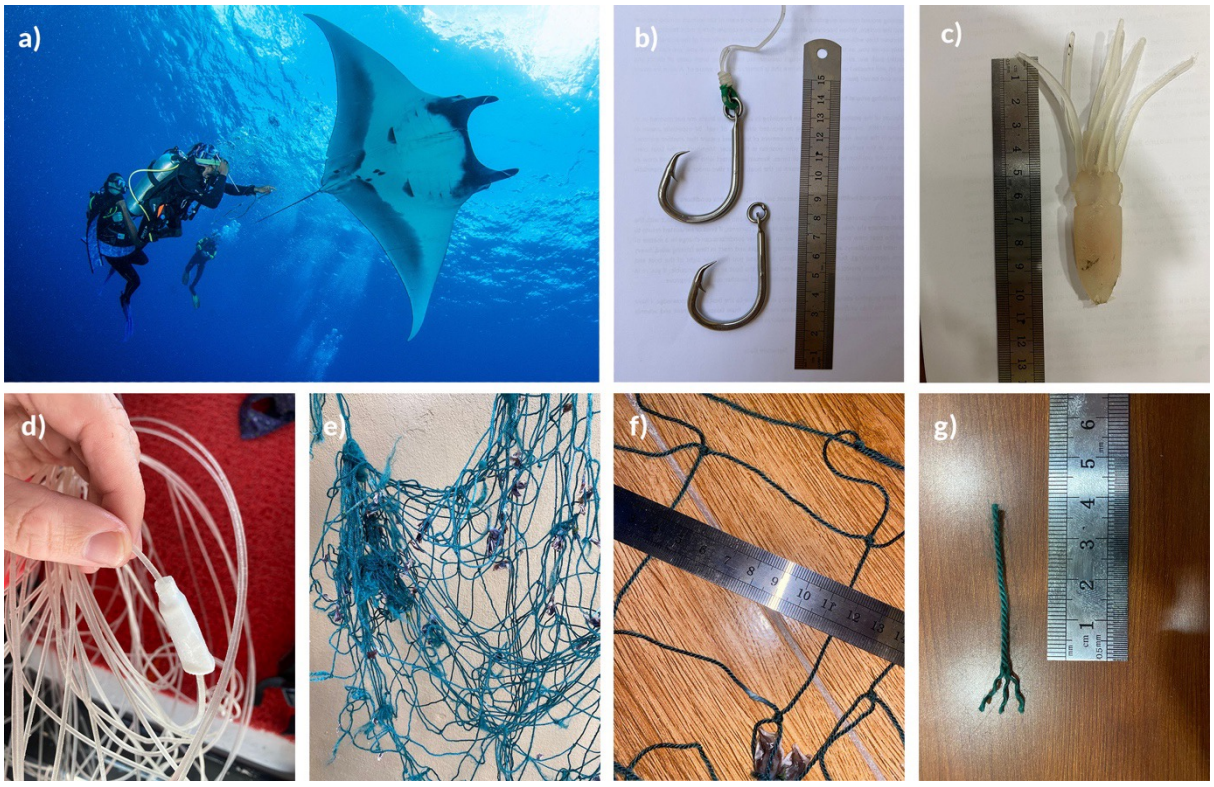

Figure 10: Fuvahmulah Dive School dive guides removing fishing line from an entangled oceanic manta ray in the Maldives (a). Two hooks (b), a squid lure (c), segments of monofilament fishing line (d), and gill net (e-g) were cut from during various encounters and preserved.

Indian Ocean Tuna Commission Working Parties on Ecosystems and Bycatch

Following collection of multiple records of oceanic manta ray entanglements in the Maldives (above section), and conclusion that these were from foreign fishing vessels, we submitted a note on the topic to the Indian Ocean Tuna Commission Working Party on Ecosystems and Bycatch 19, which took place in Réunion in September 2023.

Important Shark and Ray Areas

In 2023, the Manta Trust was requested by IUCN's Shark Specialist Group to submit proposals for sites in the Maldives to be included as Important Shark and Ray Areas (ISRAs). Fuvahmulah Atoll was submitted by the Manta Trust / MMCP as one of 34 potential sites. The Manta Trust / MMCP led this proposal with the support of MMRI, Nekton Mission, MWSRP, Fuvahmulah Dive School and Pelagic Divers Fuvahmulah. The entire atoll was accepted as an ISRA with numerous species qualifying across multiple criteria including 'undefined aggregations' of oceanic manta rays (Table 6).

Table 6: Qualifying species and the criteria met for the successful designation of Fuvahmulah Atoll as an Important Shark and Ray Area.

Scientific Name[1]	Common Name[1]	IUCN Red List	Global Depth Range (m)[1]	ISRA Criteria/Sub-criteria Met (mark with an 'X')								
				A	B	C1	C2	C3	C4	C5	D1	D2
SHARKS												
Alopias pelagicus	Pelagic Thresher	EN	0–300	X							X	
Carcharhinus albimarginatus	Silvertip Shark	VU	0–800	X						X		
Carcharhinus amblyrhynchos	Grey Reef Shark	EN	0–280	X						X		
Galeocerdo cuvier	Tiger Shark	NT	0–1,136			X						
Sphyrna lewini	Scalloped Hammerhead	CR	0–1,043	X						X		
Triaenodon obesus	Whitetip Reef Shark	VU	0–330	X		X		X		X		
RAYS												
Mobula birostris	Oceanic Manta Ray	EN	0–1,896	X						X		

Maldives Red List Species

The Manta Trust has been requested by Ministry of Environment Climate Change and Technology to conduct an IUCN Red List National Assessment of all the ray species in the Maldives. The assessment of oceanic manta rays is being conducted by the oceanic manta project research team. Although this assessment has not been completed, it has already identified knowledge gaps for this species in the Maldives.

Two Maldives Populations

Over recent years, a potential trend has emerged with oceanic manta ray sightings in the Maldives. Despite a far greater number of oceanic manta rays sighted in the sub-equatorial atolls of Addu and Fuvahmulah (*n*=847), none of these individuals have been re-sighted in atolls further north and only two (0.2%) have been seen in more than one atoll. Contrarily, above the equator, only 99 individuals have been documented, but five (5%) have been recorded in multiple atolls. It is surprising that none of the oceanic manta rays from Fuvahmulah and Addu Atolls have been sighted further north, leading to the hypothesis that oceanic manta rays sighted throughout the Maldives may originate from two distinct sub-populations separated by the equator.

Equatorial currents flow in opposite directions above and below the equator which would likely be a significant driving force for the population separation. Satellite telemetry work would be required to further investigate this hypothesis.

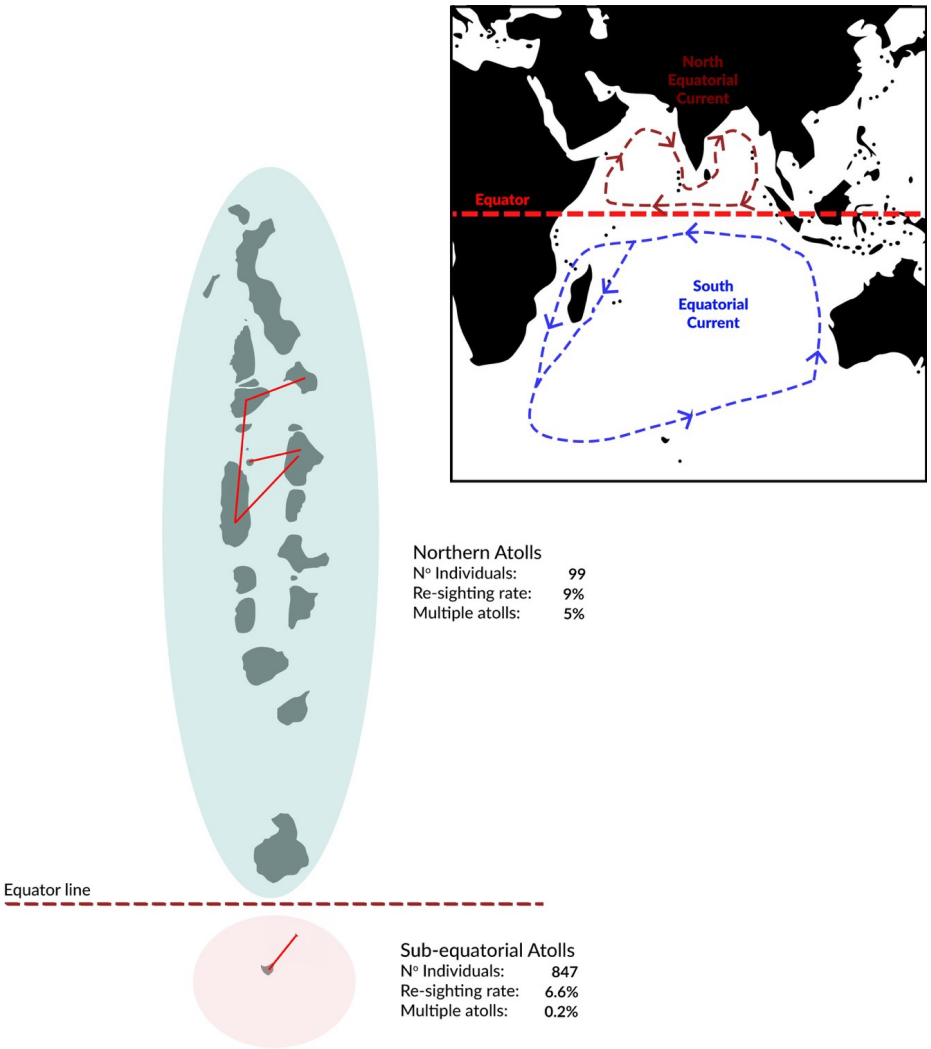

Figure 11: Map of the Maldives Archipelagos illustrating the potential two sub-populations of oceanic manta ray (*Mobula birostris*) found on either side of the equator. Red lines denote re-sighting connectivity between atolls.

Education and Outreach

In 2023, Ramadan coincided with the research season and subsequent school and office closures made some of our education and outreach objectives harder to achieve.

Kyler Abernathy from the National Geographic Society hosted a presentation on Crittercam projects around the world for local dive centres and their guests. He also gave a similar presentation to the research team where he expended on the methodologies and results from Crittercam studies worldwide.

Dr. Josh Stewart, an Associate Director of the Manta Trust and researcher at Oregon State University visited the project in Fuvahmulah and gave a stimulating talk to the research team about the oceanic manta population on the west coast of Mexico.

As mentioned in the Research Activities section of this report, we also ran in-depth workshops with nine local divers on research methods. These involved hands-on practical sessions with satellite tags, biopsy tips and applicator poles. We demonstrated how the data is collected and processed using examples from other locations as well as a full demonstration of the photo identification method and sightings database inputting.

We plan to increase our education and outreach activities in 2024 by having a dedicated staff member running a condensed version of the Manta Trust's Moodhu Madharusaa Programme. This has been agreed in principle with the Atoll's Education Centre.

Tourism

Anecdotal observations of tourism numbers in Fuvahmulah suggest a sharp increase in divers in recent years. Before the COVID-19 pandemic the number of safari boats visiting Fuvahmulah between December and April (Iruvai Season), appeared to be increasing.

Although there is no data on the total number of liveaboards or divers visiting Fuvahmulah, there has been an increase in the number of dive centres operating on the island as well as the number of registered tourist accommodation and beds available (Fig. 12). It is expected that this trend will increase as awareness and promotion of Fuvahmulah as a world class dive destination continues.

There are very few locations worldwide where divers can see whale sharks, oceanic manta rays, thresher sharks, tiger sharks, silvertip sharks, and hammerhead sharks during a single trip, and as a result, the marketability of Fuvahmulah as a top dive destination is very high. However, there is growing concern among the local dive community and within marine conservation groups (including the Manta Trust) that the number of divers may soon reach unsustainable levels. Much of the diving in Fuvahmulah is centred around Farikede and Thundi Faru. As a result, all the local dive operators and the visiting liveaboards often dive these sites en masse, leading to overcrowding. The Manta Trust recommends limiting the number of divers and operators either per day, and/or per season, to prevent detrimental impacts on the reefs and megafauna from unrestricted tourism.

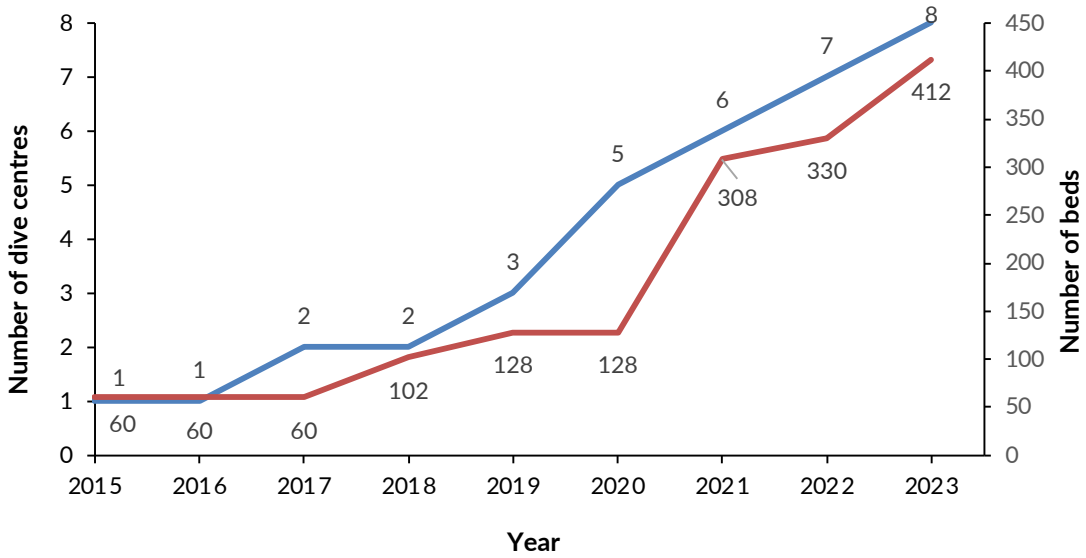

Figure 12: Number of operational dive centres and tourist beds on Fuvahmulah Island (2015-2023).

Marine Protected Areas

In 2020, Addu and Fuvahmulah Atolls were listed as UNESCO Biosphere Reserves. Data on the presence of oceanic manta rays around these islands supported the application.

The Manta Trust have been informed that we will be consulted as a stake holder in the planning stages of the UNESCO Biosphere Reserve management plan. However, to date, we have not been contacted regarding this.

Fuvahmulah Environmental Research Centre

Fuvahmulah is a unique diving destination in the Maldives, on par with some of the best diving locations in the world. Numerous pelagic species visit the single island atoll, which are rarely seen elsewhere in the Maldives, or globally. For this reason, Fuvahmulah lends itself to being a prime location for marine research and education. The Manta Trust envisages a dedicated environmental research and education centre on Fuvahmulah Island where visiting scientists and researchers can be based, using onsite facilities to further education and research. This centre would include both laboratory and computer facilities, but also a tourist and local visitor centre where people can learn about the flora and fauna unique to Fuvahmulah and its coastal waters.

It is important that the local community is involved with, and benefit from the research activities being conducted, and this will be facilitated by a marine research and education centre. The Manta Trust put forward a proposal to the Fuvahmulah City Council and obtained their support for such a project. The marine research and education centre will encompass a visitor centre full of information about the maritime history of Fuvahmulah, information about the marine biodiversity and species around the island as well as on-going research. This information will be in both English and Dhivehi. Additionally, the centre will have a multipurpose function room, classrooms, office space, marine biology lab, and accommodation for visiting researchers. The lab facilities will be available for Fuvahmulah and visiting Maldivian school groups to use.

Depending on the plans of the UNESCO Biosphere Reserve in Fuvahmulah, it would make sense to incorporate any staff, rangers, and ticketing office into this facility. Plans and developments for the centre progressed in 2022 and a more detailed account of the facilities. It is apparent that for the longevity of such a centre there would need to be a continual source of funding with the obvious solution being a portion of any biosphere visitor fees being allocated to such a centre. A masters student with the Manta Trust has been conducting interviews with tourists about their willingness to pay a marine park fee.

CONCLUSION

Little is known about the population of oceanic manta rays which frequent the Maldives. Most sightings, particularly from the aggregations in the “Deep South”, are noted to be of individuals primarily just cruising through the site. The low resighting rate during the season suggests that the population is transient, and only passing through the waters of Fuvahmulah, rather than using it as a location for foraging, cleaning, or mating.

In 2023, we recorded the highest re-sighting rate during the April season in Fuvahmulah. It is expected that with further research and increased survey effort, more returning individuals will be recorded. However, the additional sightings in September and December were all new individuals which highlights we are still a long way off knowing the full population size.

Despite the growing knowledge of this species in Maldives waters, the threat from Sri Lankan and Indian fishing fleets outside the Maldives Economic Exclusion Zone remains a major concern. Every year, our understanding of the oceanic manta ray aggregation around Fuvahmulah grows, yet nothing is known about where these animals travel, and what they are doing, when they leave the reefs of these southern atolls. With a growing tourism industry relying heavily on the oceanic manta rays as one of the main attractions, it is important to develop our understanding of their movements so they can be effectively protected. To address these protections, research efforts will rely heavily on the ability to conduct telemetry studies. It is hoped that these will be permitted research methods for marine scientists in the Maldives very soon.

This report was made possible thanks to

MALDIVES MANTA CONSERVATION PROGRAMME (MMCP)

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

Manta TRUST

MALDIVES MANTA CONSERVATION PROGRAMME

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