ATTITUDE AND LOCAL ECOLOGICAL KNOWLEDGE OF FISHERMEN WITH REFERENCE TO MOBULID CONSERVATION, ADDU ATOLL, MALDIVES

ESZTER TRIPA

A dissertation submitted in the partial fulfilment of the requirements for the degree of

Master of Science
IN INTERNATIONAL MARINE SCIENCE

School of Energy, Geoscience, Infrastructure and Society

December, 2023

Manta TRUST

HERIOT WATT UNIVERSITY

Abstract

Unregulated fishing efforts over the past few decades have been the main factor contributing to the mobulid population's rapid decline. The oceanic manta ray *Manta birostris* received endangered conservation status in recent years whereas the reef manta ray *Manta alfredi* is vulnerable. To establish conservation efforts considering the species more data is necessary. The Maldives banned the commercial harvest of manta rays and now supports the largest known population of mobulids. Addu Atoll in the southernmost Maldives is one of the few places in the world where manta and devil rays have an annual occurrence. Addu's infrastructure is subject to large-scale development in the form of a land reclamation project which may impact the otherwise healthy population of mobulids in the area.

Our primary research objectives are to assess the local ecological knowledge of fishermen, evaluate their attitude towards mobulid conservation efforts and environmental research, identify anthropogenic stressors in important manta ray habitats and explore manta and devil ray distributions across the atoll.

To achieve the above, 24 in-person interviews were conducted in Addu Atoll between May and July 2023 using semi-structured questionnaire forms. The primary topics covered included fishers' demographic profile, fishing habits and gear, fisher's attitudes and local ecological knowledge (LEK) towards mobulids. The answers were subjected to qualitative and quantitative analysis using a three-point Likert scale. Attitude and LEK indices were created and compared to the variables of participants' profiles and fishing habits. The fishermen indicated sightings of manta and devil rays were presented in a map alongside previously conducted in-field survey results.

The overwhelming majority of questioned fishermen (79%; n=19) were awarded an excellent knowledge indicator and most fishers demonstrated a positive attitude towards manta and devil ray conservation and scientific research. The distribution hot spots reported by participants were overlapping with survey results. There was a weak negative correlation between age and attitude variables.

In conclusion, our study suggests that the local ecological knowledge of users of the marine environment should be included in science and policy. The findings of this investigation will serve as baseline for future studies comparing LEK between other Maldivian atolls, as well as distribution and abundance data of mobulids.

Table of contents

1. Introduction

The Mobulidae is a family of zooplanktivorous batoid pelagic elasmobranchs that includes two species of manta rays in the genus Manta and nine species of devil rays in the genus Mobula (Couturier et al., 2012). The classification of Manta rays was re-evaluated in 2009 when the previously monotypic genus Manta was split into two species: the reef manta ray *(Mobula alfredi*) and the giant or oceanic manta ray (*Mobula birostris*) (*Marshall, 2022*). Increasing genetic evidence suggests the separation of a third possible species, the Caribbean Manta Ray (*Mobula cf. birostris)*(Marshall, a.et al., 2022).

Mobulids are charismatic animals with unique physical features that allow them to be easily distinguished from other ray species (G. Stevens, 2016). Their large horn-shaped cephalic fins located on both side of their mouth aids the mobulid's highly specialised filter-feeding behaviour directing zooplankton to the mouth cavity. *Manta birostris* is known as the world's largest ray with a wingspan of up to 7 meters, whilst the smaller *Manta alfredi* could reach a disc width of 4.5 meters.

Amongst all known cold-blooded fish, manta rays have the largest brain-to-body size ratio which makes them one of the most intelligent fish species. The study of Ari & D'Agostino, 2016 revealed that oceanic manta rays are capable of the display of particular behaviours that humans assign to self-awareness.
Mantas are circumglobally distributed species with reef manta rays inhabiting tropical or subtropical waters(Couturier et al., 2012; Garzon et al., 2023; G. Stevens, 2016) and oceanic manta rays residing in tropical and temperate waters (Marshall, a. et al., 2022). Due to their nature of high mobility, the investigation of both species as well as the assessment of their global population size is extremely difficult in the vast marine environment (Couturier et al.,

2012; Marshall, et al., 2022; Marshall, a. et al., 2022) Hence the oceanic manta ray's conservation status was classified as 'data deficient' between 2003 and 2011 (Marshall, et al., 2022).

According to the International Union for the Conservation of Nature (IUCN)'s Red List of Threatened Species, the status of reef manta rays is currently vulnerable whilst the giant manta rays were recently given endangered status (Marshall, 2022; Marshall, et al., 2022). The leading cause of the rapid population decline of mobulids is the unregulated increase of fishing efforts in the past decades which resulted in the disappearance of numerous subpopulations around the globe (Marshall, et al., 2022).

Cartilaginous fishes such as sharks and rays are frequently unable to recover fast enough once they are depleted from prolonged fishing pressure (Dulvy et al., 2014; G. Stevens, 2016). Manta rays give birth to a single pup typically every two to three years and due to their slow reproductive rate, long gestation period, low fecundity and slow growth, mobulids are particularly vulnerable/susceptible to unregulated harvesting/overfishing. Mobulids are targeted and landed in large numbers to meet the increasing demand for dried gill plates that in recent years become a valued commodity in traditional Chinese medicine markets (M. p. O'Malley et al., 2017; G. Stevens, 2016). Manta rays are frequently caught unintentionally as bycatch in commercial fisheries and significant post-release mortality is observed during accidental capture by the report of Carlson et al., 2019.

Although India and Sri Lanka are amongst the main exporters of manta ray gills supporting one of the largest manta ray fisheries (Fernando & Stewart, 2021; M. p. O'Malley et al., 2017), in the neighbouring Republic of Maldives all mobulids were granted protected status in 2014 from commercial fisheries following the export ban of ray products in 1995. Currently the Maldivian archipelago supports the largest documented manta ray populations around the globe (Harris et al., 2020; G. Stevens, 2016). Although the Maldives offers a safe haven for manta rays, unregulated tourism, boat strike injuries resulting from rapidly expanding marine traffic, coupled with habitat degradation involving the ongoing reclamation projects is ultimately having a detrimental effect on the species causing disturbance and the alteration of natural behaviour (Strike, 2020; G. Stevens, 2016).

The impacts of climate change threaten not only the survival and adaptation of mobulids by altering essential zooplankton availability but also the existence of small island nations such as the Maldives. Sea level rise observations from the Maldives are consistent with global trends as demonstrated by the studies of (Church & White, 2006) and (Woodworth, 2005). Flooding is a serious issue resulting from the growing sea levels (Speelman et al., 2021).

Land reclamation offers a solution for the country's growing population, housing crisis and limited land availability for development (MNPHI, 2023). Published studies on the effect of land reclamation projects on marine fauna are not consistent but the increased turbidity caused by dredging have the potential to significantly lower primary production levels, ultimately reducing the area's zooplankton abundance which directly affects the foraging activity of reef manta rays (G. M. W. Stevens & Froman, 2018). Coastal fishing communities are also likely to be affected but more data is needed to evaluate the consequences.

As conducting surveys to remote offshore locations can be very expensive, time and resource-consuming, alternative survey methods should be explored (van der Hoeven et al., 2004). As previously mentioned, due to the challenging accessibility of their habitat, and their unpredictable and not fully understood migratory patterns manta rays are extremely challenging to study (Andrzejaczek et al., 2020). However, relevant information about species of interest is also available through the local ecological knowledge (LEK) of people who are using the same environment (Berkes et al., 2000; AnadÓn et al., 2009). Following the definition of Rehage et al., 2019 the term local ecological knowledge refers to the cumulative knowledge through experience of long-term residents about their environment and the ecological complexities they observe.
The usage of LEK surveys is increasingly seen as an alternative source to comprehend conventional scientific data and can be specifically applied to large vertebrates (van der Hoeven et al., 2004; Jones et al., 2005). Information collected from untrained observers can be extremely useful in data-poor areas or in particular cases where biological data is not available (Bessesen & González-Suárez, 2021).

Furthermore, applying local ecological knowledge could lead to the discovery of new species that are already known to local inhabitants such as the case of the highland mangabey *(Lophocebus kipunji*) from Tanzania (Jones et al., 2005)**.**

Studies based on the LEK of fishermen are especially becoming more common. Marine ecosystems are jeopardized and the constant degradation of the marine environment can lead to an incorrect interpretation of the changes over time (Atmore et al., 2021; Rodrigues et al., 2019), see the so-called Shifting Baseline Syndrome (SBS) first described by Pauly, 1995. The phenomenon of the shifting baseline syndrome explains how human perceptions change of biological systems as the result of the lack of experience of historical environmental conditions. For example in the study of (Veneroni & Fernandes, 2021)older fishermen reported catching larger fish in the past compared to the catch of present days. However, younger fishermen who have never experienced the past of the elderly have no recollection of such events, therefore the baseline of a new standard was established which frequently results in an underestimation of species population sizes or environmental carrying capacities.

Specifically, LEK obtained from fishermen surveys can be employed to reconstruct past marine population abundance as well as species composition when insufficient data makes stock assessment challenging (Beaudreau & Levin, 2014). The accumulated knowledge of experienced fishers can be even more valuable as part of an investigation that aims to understand the population abundance change over time when a commercially targeted species is not fished anymore due to its declining numbers. As Colloca et al., (-2020) points out, although the collected information is quantitative or semi-quantitative, it has the potential to fill up knowledge gaps and be implemented into future management procedures.

Despite the wide application of fishermen's local ecological knowledge and its usage as established data source in conservation practices and decision-making, (H. de O. Braga & Schiavetti, 2013; H. O. Braga et al., 2017) the reliability of LEK surveys has been questioned and challenged by many researchers in the past decades. LEK is fundamentally limited, as revealed by the case studies of Ruddle & Davis et al.,- (2011) examining connections between scientific research and local ecological knowledge of fishers in Canada as well as

locals' fishing practices applied to seasonal monsoon variations and fish availability in Vietnam. The Nova Scotia case failed to demonstrate fishers' perception on the predation of juvenile lobsters by white hake whereas the study conducted in Vietnam showed that harvester's observations could fail to identify crucial characteristics of ecosystem processes. Additionally, a recently published article by Madsen et al., 2020 casts doubt on Colloca's (2020) assumption that LEK studies can be the key source of data in the estimation of population quantity. (Madsen et al., 2020) is critical of the possibility that the researched species are misidentified, and their presence is possibly over or underestimated by the interviewees producing misleading results.

Alternatively, the investigation of van der Hoeven et al., -(2004) makes no attempt to address this concern, as the entire study was based on the evaluation of Pooled Local Expert Opinion on the estimation of wildlife density in rainforests as a substitute of conventional scientific data collection methods. However Bessesen & González-Suárez et al.,- (2021) argues, that questionnaires should not replace but complement biomonitoring. Furthermore, it is becoming more widely acknowledged that stakeholder participation and the incorporation of traditional or local ecological knowledge to policy making/creation of legislations are essential and can help communities become more actively involved in the management of resources that they depend on (Colloca et al., 2020).

The collection of LEK data and community engagement also provide an opportunity to obtain information about local's opinions on species conservation measures (Bessesen & González-Suárez, 2021) that comprehends the understanding of environment management and aids the collaboration between the community and officials.
Unlike most locations in the Maldives mantas are present in the southernmost atoll called Addu regardless to the changing monsoon seasons. The atoll is also subject to a large-scale reclamation project taking place from the beginning of 2023.
Although Mantas are found in Addu Atoll all year round, their population is relatively unknown compare to mantas residing in other Maldivian atolls that are exposed to more research such as the famous Hanifaru Bay at Baa Atoll where one of the largest aggregations of mobulids is observed every year due to the seasonal changes and zooplankton availability (LOCKHART, 2022).

Due to the limited information available, any sightings of manta rays and other marine megafauna in the area are important for building on the baseline data to understand and better the conservation efforts of the species.

The primary aim of the present study is to assess the local ecological knowledge of the fishermen of Addu atoll and their attitude towards scientific work and manta ray conservation. More specifically the research objectives are:

1. To use LEK as an identification tool of manta ray distribution hot spots around Addu atoll and compare those to existing survey data
2. To gain new insights into the resident fishers and local community's opinions regarding conservation measures and scientific research
3. To assess the local ecological knowledge of fishermen and explore its potential and accuracy
4. To identify anthropogenic threats forward Mobulids in Addu atoll

2. Methods

2.1 Study site

The Republic of Maldives is found in the central Indian Ocean, about 645 km away from the southwest of Sri Lanka. Other neighbouring countries surrounding the archipelago are India and the Laccadives Islands. The Maldives extends from North to South over 870 km and its widest area from East to West measured at 128 km long. Its Exclusive Economic Zone stretches over 916, 000 km^2 from which only about 300 km^2 are made up of dry land (Mrc, 2003; G. Stevens, 2016).

The Maldives is composed of 26 geographical atolls or distinct reef systems and its 1192 islands are spread over 20 officially recognised administrative atolls (G. M. W. Stevens & Froman, 2018) that are controlled and directed by the capital island of Male. In 2023, a study done by the Maldives Bureau of Statistics revealed that a total of 515,122 people live in the country which includes 382,751 Maldivians and 132,371 foreigners.

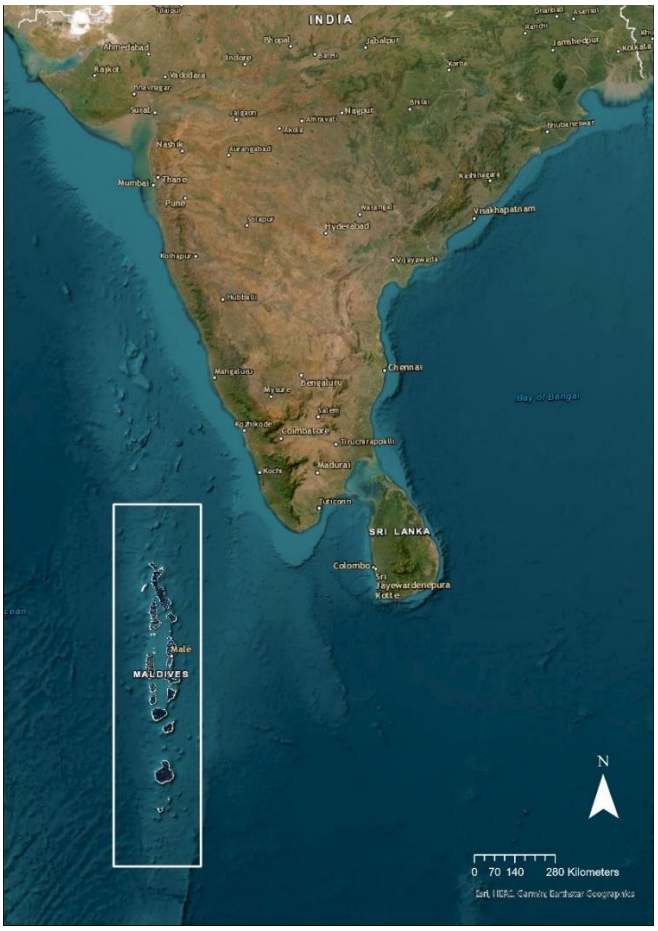


Figure 1 Study area of the fishermen in the southernmost atoll of the Maldivian archipelago, Addu Atoll

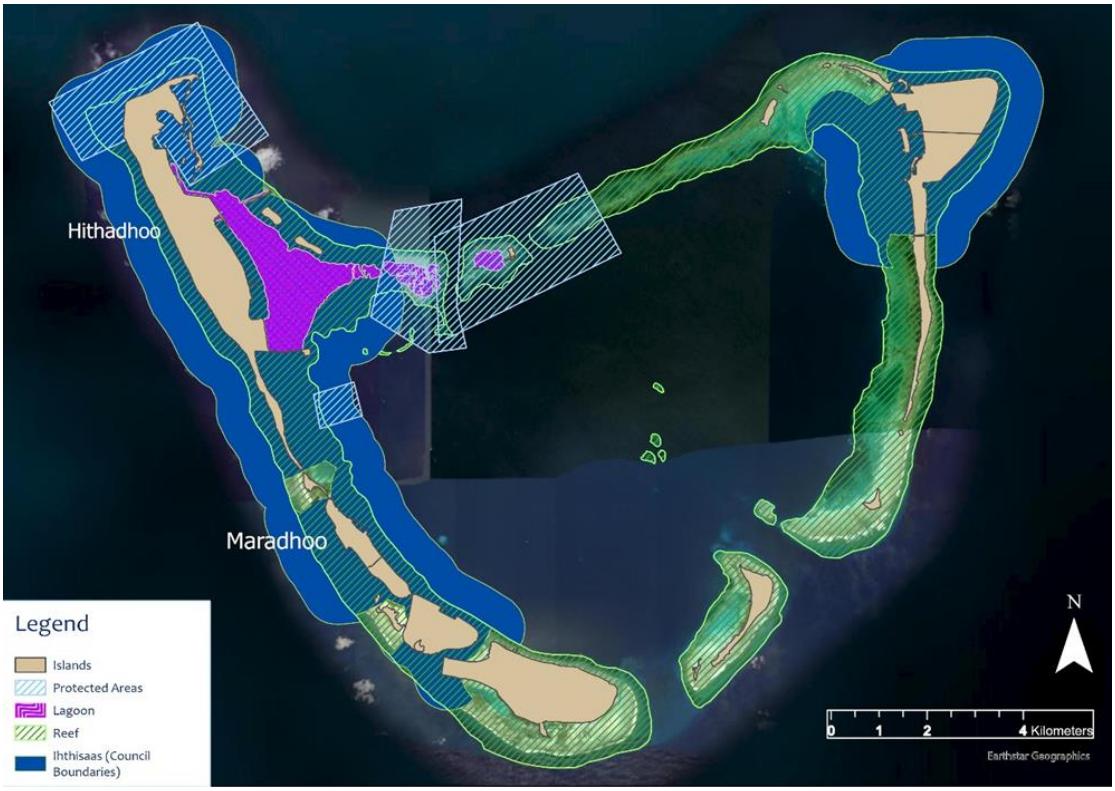


Figure 2 Addu Atoll's two islands: Hithadhoo and Maradhoo where the data collection was conducted. Addu Atoll was given Biosphere Reserve status by UNESCO due to its unique coral reef structures and rich biodiversity. This map demonstrates the seven islands of the atoll, the marine protected areas and the complex reef system.

The nation's economic development and well-being are strongly interconnected with, and reliant on, marine and coastal resources. Currently, the Maldives' primary economic engine is tourism generates the main source of income as well as employment. Due to the negative effects of the COVID-19 pandemic, the tourism sector's share of the GDP decreased from 21.5% in 2019 to just 12.1% in 2020. Despite this significant drop, the industry continues to lead the economy (Islamic Development Bank, 2022). In particular, wildlife tourism, diving and snorkelling with marine megafauna such as manta rays and sharks are one of the main drivers of the Maldivian tourism industry (Zimmerhackel et al., 2019). The economic value of manta rays in the Maldivian archipelago was estimated to generate USD 8.1 million annually (R. C. Anderson, Adam, Kitchen-Wheeler, et al., 2011) which on a global scale exceeds an estimated US$73 million per year (M. P. O'Malley et al., 2013).

Despite declining since the 1970s due to the growing impact of tourism, the fisheries sector is still considered to be the backbone of the country's economy (Sinan & Whitmarsh, 2010). Although the fishing industry's contribution to the GDB in 2020 was merely 6.4%, it remains the second biggest economic pillar of the Maldives, providing employment whilst satisfying the domestic and

international demand for protein supply as nearly 98% of the nation's export is composed of fish and fish products (Islamic Development Bank, 2022).
This study was conducted in Addu Atoll (Fig.3). Formerly referred to as Seenu Atoll, Addu is the southernmost atoll of the Maldives, located 540 km south of Male. Along with Fuvahmulah which is situated approximately 40 km away from Addu, the atoll extends the Maldivian archipelago to the Southern Hemisphere (Fig. 2). Addu Atoll consists of 7 main islands (Hithadoo, Maradhoo, Feydhoo, Meedhoo, Maradhoofeydhoo, Hulhudhoo, and Gan) (Fig. 3) and their perimeter coral reefs that act as buffer shorelines that shield the islands from storms and high waves providing protection against floods and erosion.

The deep lagoon at the Heart-shaped Addu Atoll (Fig.3) acts as a natural anchorage and it is reachable through four natural channels, two from the north named Kuda and Maa channel, one from the south: Gan channel whilst the Villingili channel provides access from the southeast. The semi-enclosed lagoon is unaffected by seasonal variations ensuring calm and safe waters all year around for sea- going vessels. In contrast to other Maldivian atolls, there are no small islands inside of the lagoon (Mrc, 2003). Although Addu is considered to be geographically small when compared to other atolls (its total length from south to north is 13 km, from East to west is 17 km), Addu city is known as the second largest city of the Maldives with the second highest population density exceeding 25 000 people currently living in the atoll (Maldives bureau of statistics, 2023).
The six main districts found in Addu are Maradhoo, Feydhoo, Meedhoo, Maradhoofeydhoo, Hulhudhoo and Hithadhoo. Hithadhoo is the largest island that also serves as the administrative capital of Addu.

All districts are connected via ferries and land links, and further connections will be established through the current land reclamation project (Fig. 4) that aims to facilitate the development of Addu city, providing solutions for housing challenges, whilst creating a more resilient land against the climate change-driven erosion and rising sea levels (MNPHI, 2023). By reclaiming a land area of 228 hectares alongside the coast of Hithadoo and Maradhoo/Maradhoo-Feydhoo as well as creating three new islands in the city's lagoon (Fig. 5), the Ministry of National Planning Housing and Infrastructure (MNPHI) intends to boost tourism by generating additional economic prospect in the area in the form of luxury resort development. Although the reclamation project is expected to elevate the tourism industry, whilst tackling the impacts of the climate crisis it will certainly affect the atoll's fishing communities. The sedimentation disturbed by dredging will inevitably affect the

atoll's fish populations, altering not only the fishery industry but the marine flora and fauna including manta and devil rays.

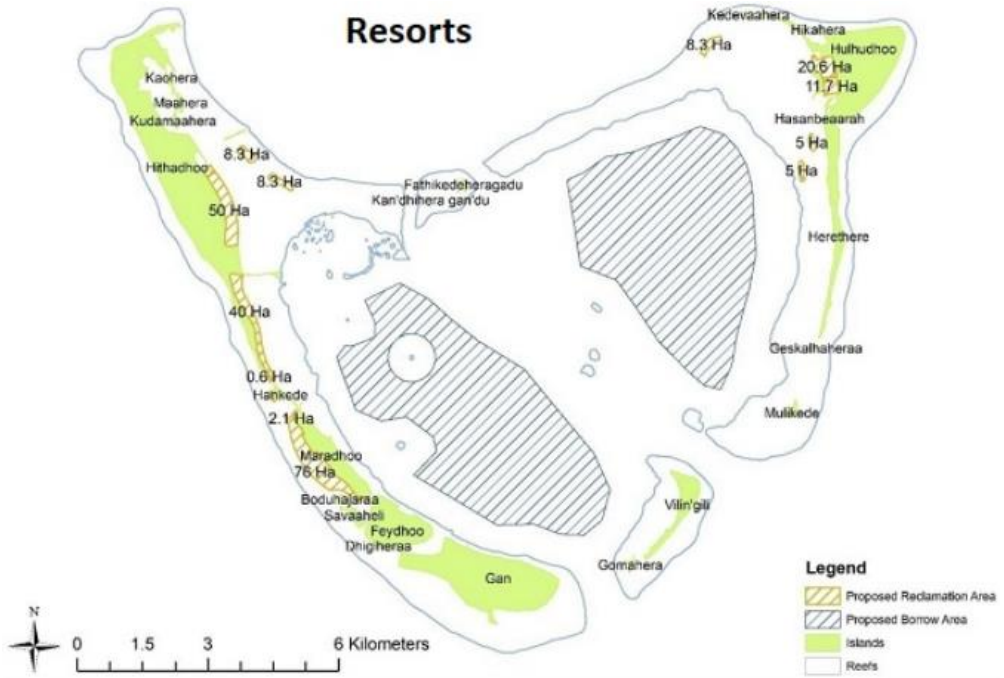


Figure 3 Map of the proposed land reclamation areas and sand borrowing areas in Addu Atoll Source: (Environmental Impact Assessment, 2022)

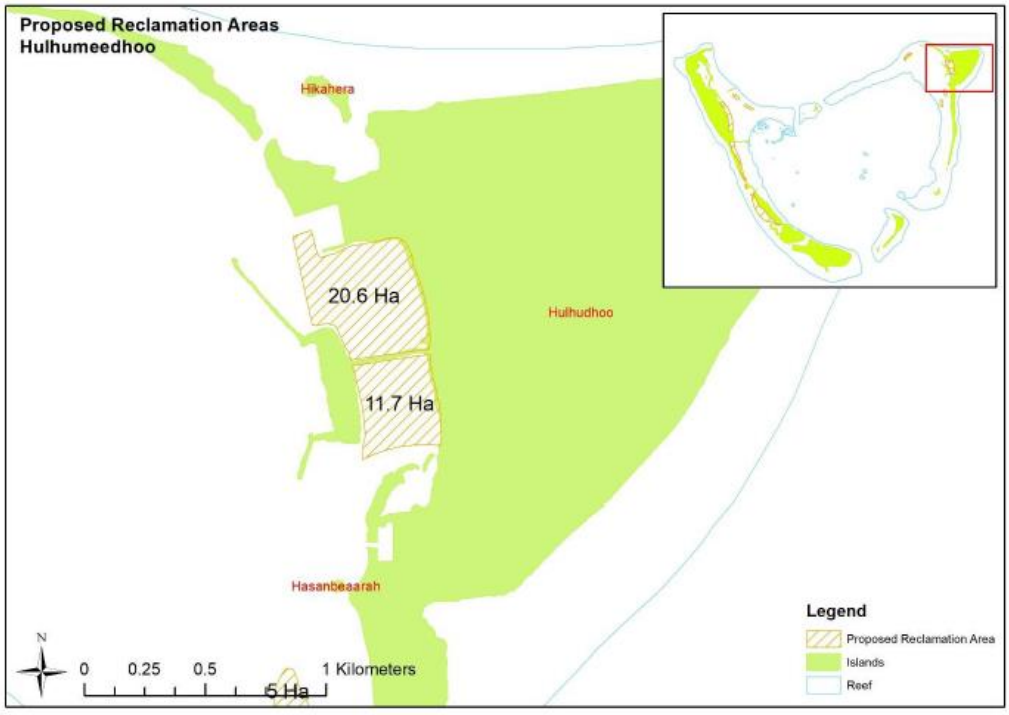


Figure 4 Proposed reclamation areas of Hulhumeedo (Source: (Environmental Impact Assessment, 2022)

According to the EIA report (Magu, 2022), over 21 hectares of coral and 120 hectares of seaweed will be covered by mud and the occurrence of sharks and rays is expected to decrease amongst some of the most important dive sites for tourism within the Atoll – for example the British Loyalty Shipwreck. The EIA also warned that damages caused to sensitive marine life in the atoll will cost the tourism industry between USD 17.4 million and USD 27.4 million.

In 2020, UNESCO's Man and the Biosphere program declared the entire Addu Atoll as Biosphere Reserve due to its rich biodiversity and coral reef structures. There are three designated marine protected areas in the atoll namely the Maa Kandu Manta Point, Kuda Kandu and British Loyalty Wreck. The MPAs are ecologically important, sensitive areas (Magu, 2022) home to numerous wildlife including various shark species as well as manta and devil rays.

The Maldivian archipelago has the largest documented manta ray populations around the globe (Harris et al., 2020; G. Stevens, 2016). The Maldives Manta Conservation Programme (MMCP) has identified and recorded more than 5500 individual reef manta rays (*Mobula alfredi)* as well as 850 oceanic manta rays (*Mobula birostris)* from over 80 000 photo ID sightings across 23 different geographical atolls (*MALDIVES MANTA CONSERVATION PROGRAMME*, 2023). Contrary to other Maldivian atolls where manta occurrences are strongly correlated with seasonal changes and monsoon variations, manta rays can be observed in Addu atoll year-round.

The rich historical background of Addu, the well-established fishing community, and the continuous presence of manta rays make this southernmost atoll an excellent location for conducting this study conduction. Data collection prior to a large-scale project such as the ongoing land reclamation could help establish an avenue for future investigations in relation to biodiversity monitoring and population estimates.

2.2 Ethical consideration and survey structure

Prior to the interviews, each participant received a brief introduction to the Manta Trust and was informed about the project's goals. Respondents were also ensured that their data and all provided information, including their answers, would be anonymised and handled with confidentiality. Before each discussion, permission was asked to conduct the interview as well and fishermen were required to confirm their consent to participate in the survey.

The base of the survey was developed by Tam Sawers at the Manta Trust and previously used to assess the local ecological knowledge (LEK) and attitude of fishermen in Baa Atoll (Sawers & Stevens, 2014) Laamu Atoll (Cox, 2022) and Fuvahmulah (Irthisham Hassan Zareer, 2022). Although some alterations were made to tailor the questionnaire to Addu Atoll, most questions were kept identical to the previous study ensuring the consistency of data and the opportunity to make comparisons between the findings.

The semi-structured questionnaire consists of 70 open and closed questions, with quantitative and qualitative answers and is designed to explore 5 main topics, including the interviewee profile (Age, home island, experience working on sea, fishing practices, fishing effort); the knowledge of native marine fauna (identification of marine species); the knowledge of mobulid occurrences; the knowledge of threats faced by manta and devil rays; and lastly the attitude towards their conservation and scientific research.

As part of the LEK questions, a species identification exercise was carried out with each participant using a sheet with randomly located photographs of various species (Newing et al., 2010). To compare reef and oceanic manta rays, photographic material was used demonstrating visual differences. To evaluate the geographical locations of mobulids, a map of Addu with fishnet was provided to the selected fishermen.

The questions followed the same order each time, encouraging the participants' answers' reliability whilst creating a dynamic flow. The structure allowed respondents to warm up with simple introductionairy questions which were followed by more sensitive topics. To conclude the interview, participants were allowed to make a comment or add any further information to the recording as well as to ask questions.

2.3 Data Collection

To evaluate the resident fishermen's local ecological knowledge and perceptions towards manta ray conservation, 24 individual face-to-face interviews were conducted between May and August 2023 in the islands of Hithadoo and Maradhoo. As Hithadoo accounts for the majority of fishing vessels and landings (about 47% of the atoll's documented catch) (Mrc, 2003) supporting more fishermen than any other islands in Addu, most of the interviews were taking place there.

Participants were randomly approached in Addu harbour sites and in social cafés where fishermen were known as regular visitors. Respondents were also asked to name and give contact details of one or more potential interviewees following the snowball or chain sampling method described by Kelly, 2011 (Patton 1990) Kirchherr & Charles, 2018.
The interviews were conducted in Dhivehivi via an interpreter. The conservations were recorded using a mobile device and the answers were then translated to English by the same interpreter. Preferably interviews were conducted individually and the answers of one participant were recorded (Bender et al., 2014). When it was not possible, interference was minimised by recording one respondent's answer at the time.

2.4 Data analysis

Data was extracted through coding the interview script and subjected to both qualitative and quantitative analysis regarding fishermen's LEK and their attitudes towards mobulid conservation. Attitude and Knowledge answers were converted into three-point Likert scale values. In terms of "Knowledge", answers were given scores between 0 and 1 with 1 being given for an absolute correct answer, 0.5 being partially correct and 0 given for wrong answer or no response.
"Attitude" answers were likewise transcribed into values using a three-point Likert scale. Score 1 was given for positive answers whilst 0 score was given for either no response or negative answers. Moderate/ impartial answers were assigned a score of 0.5. Additionally, the answers to yes/no questions were transcribed into values using yes=1, and no=0.

To construct an index for LEK and attitude, the scores of all respondents were individually summed together, then divided by the total score available. The obtained value was then multiplied by 100 resulting in a representative percentage of score for each respondent. Next, the proportional scores were grouped into classes to represent the level of knowledge and attitude indicators (See Table 1). Spearman correlation analysis (r) and Kruskal-Wallice (H) non-parametric test were performed using R Project for Statistical Computing version 4.3.2. To measure the reliability of the set of survey items, Cronbach's alpha coefficient was calculated.

For the spatial analysis, data points were determined using the grid system given to fishermen. Using Microsoft Excel, a table was created with columns and rows representing the fishnet in the picture of Addu. Each grid that was mentioned by the interviewees was allocated spatial coordinates according to the number of fishermen pointing out it as a potential occurrence hot spot. Multipoint

features were then created in Arc GIS Pro 3.2.0, 2023 and a comparison was made between the location data resulting from two surveys (one from G. Stevens, 2016 and one recently conducted in 2023) and the anecdotal identification of mobulid occurrence. To identify patterns of mobulid occurrence and represent the density of the large number of point features that, overlap Kernel Density Estimation was applied to the dataset.

3. Results

3.1 Profile of interviewed fishermen

Over the three months between May and July 2023, a total of 24 individual in-person interviews were conducted on two inhabited islands of Addu Atoll, Hithadoo and Maradhoo. Most of the participants (98%) are residents of the island where the interview was conducted whilst 2% are based in different atolls.

All study participants were male, aged between 26 and 64 (Fig. 9). The mean age of the interviewed fishermen was 40 with a median age of 37 and the mode age of 29. The respondents had an average of 17.5 years of experience working at sea from a range of 7 - 45 years with a decade of experience being the most stated.

21% of the fishermen are working as captains whilst 79% of them are crew members on various fishing vessels. Additionally, 8,3% of the participants are professional divers. When asked, the majority of them (71%) stated to spent 'most days' at sea and only 8.3% 'few times per month'. The fundamental fishing methods mentioned by 91.6% of the respondents were pole and line and hand line fishing. Other methods declared were jigging, popping and trolling (Fig 6.).

Several target species were identified from which the primary catches were Yellowfin tuna, Skipjack tuna and Reef fish (Fig 7.). Less frequently, lobster, octopus and sailfish were also mentioned.

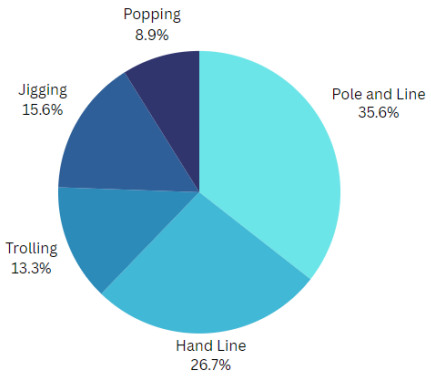


Figure 6 Fishing gear preference of participants showed in %

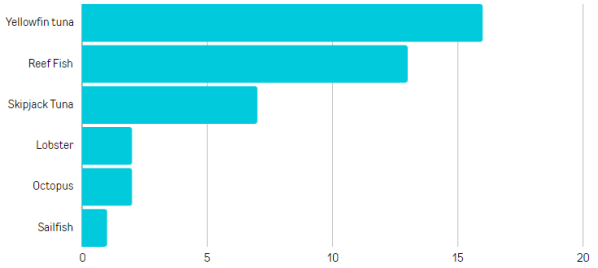


Figure 5 Target species reported by interviewees. Yellowfin tuna (Thunnus albacares) is the most important commercial fish of the Maldives.

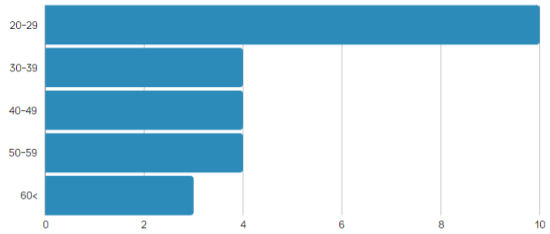


Figure 6 Age groups representatives of interviewed fishermen.

3.2. Indices of Local Ecological Knowledge

Most respondents 83% (n=20) correctly identified the native marine species of the Maldives whilst only 17% (n=4) answered partially correctly. Manta ray was encountered by all participants whereas only 63% (n=15) have seen devil rays in the past.

In response to the question regarding the identification and description of other ray species (Eagle rays, stingrays, devil rays) most of those surveyed 62% (n=15) gave correct answers naming the shown species, their habitat and diet. Partially correct answers were given by 38% (n=9) of the respondents.

When asked to describe manta rays the most frequently mentioned morphological traits were size compared to other fauna 92% (n=22), the presence of cephalic fins 50% (n=12), the absence of barbs on the whip-like tail 17% (n=4) dorsal and ventral colouration and patterns 37% (n=9). Other features stated breaching behaviour 8% (n=2), and planktivore diet 4% (n=1).

When asked to compare *M birostris* and *M alfredi*, 29% (n=7) of respondents were able to differentiate, 17% (n=4) could partially differentiate whilst the majority 54.16% (n=13) did not know the difference. Distinct traits mentioned by respondents were size 17% (n=4), markings and colouration 29% (n=7), habitat 8% (N=2), frequentness 17% (n=4).

Amongst the interviewees describing manta rays, 71% (n=17) specified the species correctly by identifying the following distinctive features: smaller size compared to manta rays mentioned by 66% (n=16), the batoid body shape of devil rays by 4% (n=1), colouration and pattern by 21% (n=5) respondents. Fishermen also noted the shy, elusive behaviour of devil rays and their significantly larger aggregations. Less frequent encounters compared to manta rays were reported by 8% (n=2) participants.

In summary, the overwhelming majority of questioned fishermen (79%; n=19) were awarded an "Excellent" knowledge indicator. Based on the collected answers, 13%; n=3) scored "Good" and 8%; n=2) as "Average". The minimum indicator recorded was 0.4 whilst the highest score achieved was maximum high. The median and the mode knowledge index was 0.8, whilst the average was 0.75.

3.3. Indices of Attitude towards manta ray conservation and scientific research

The minority of the respondents 12.5% (n=3) were neutral when asked how they feel about the work of scientists and conservationists of the Maldives whilst 83% (n=20) found it important. One interviewee argued that although "the work that scientists do is important conservation work has often been fraud and for a financial benefit"(Fig.11).

When fishermen were asked about the view of the community on the work of scientists/ conservationists, 46% (n=11) said it is positive, 37.5% (n=9) said it is neutral, and 4% (n=1) felt that it is negative. Other responses to this question included "Other" by 12.5% (n=3), emphasizing on the diversity of people's opinions (Fig.11).

Out of the 24 participants who completed the questionnaire, only 25% (n=6) indicated that they do not wish to learn more about what scientists/conservationists do and further 8% (n=2) refused to take their family/ children to swim with manta rays if the opportunity was offered.

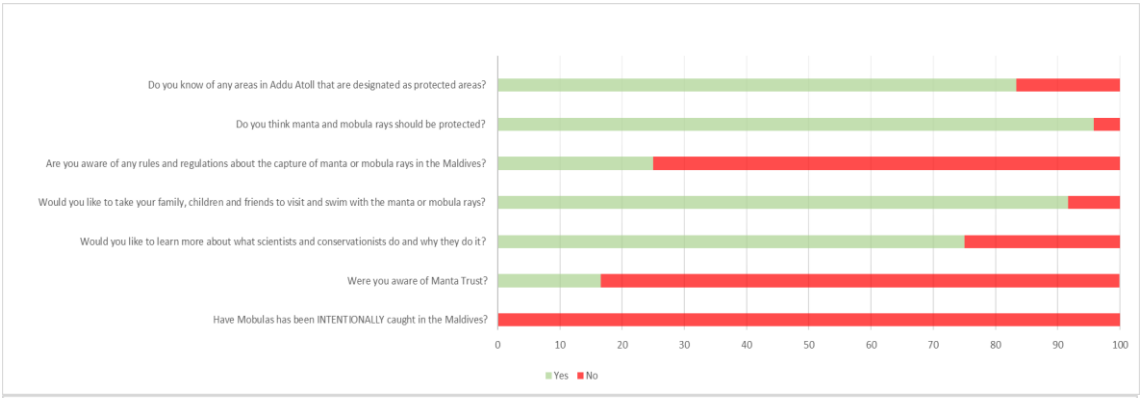
The majority of those who responded to the question about how manta rays are viewed by fishermen in general, felt that they “Don’t bother” 58% (n=14), whereas 42% (n=10) fishermen said mantas are “Respected” (Fig11).

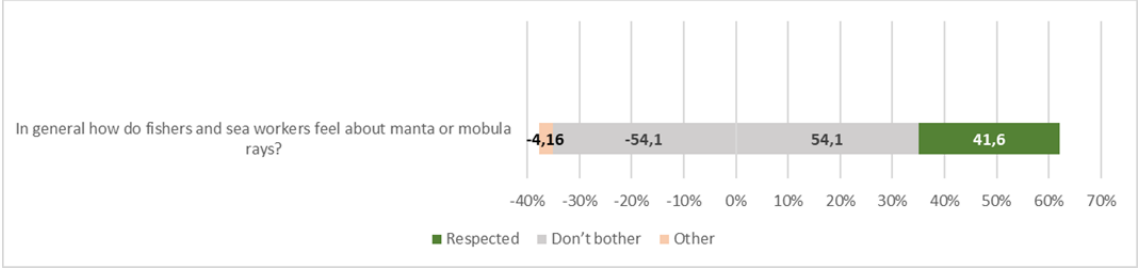
A total of 96% (n=23) participants think that mantas should be protected, and only one participant thinks protection is unnecessary. The most commonly stated reasons were: “Mantas are national heritage”, “where mantas are, fishing is better”, “tourism” and “mantas are important for the ecosystem”. These answers indicate that there is no real threat to manta rays with regards to fishing activity in Addu.

The most controversial topic was the question of protected areas with 46% (n=11) fishermen supporting the idea of the initiative whilst 25% (n=6) of them were partially supportive having doubts about management and fund allocations. Further 29% (n=7) fishers either did not wish to comment on it or were negative.

Overall, the lowest attitude indicator obtained was 0.42 by two participants, whilst the highest score achieved was the maximum 1 by a single fisherman.

To conclude, the overwhelming majority of questioned fishermen (79%; n=19) were ranked within the “positive“ class, and only 21% (n=5) scored “Moderate”. The mode of the attitude indicators was 0.92, the median value was 0.83. The average attitude index score achieved was 0.83.





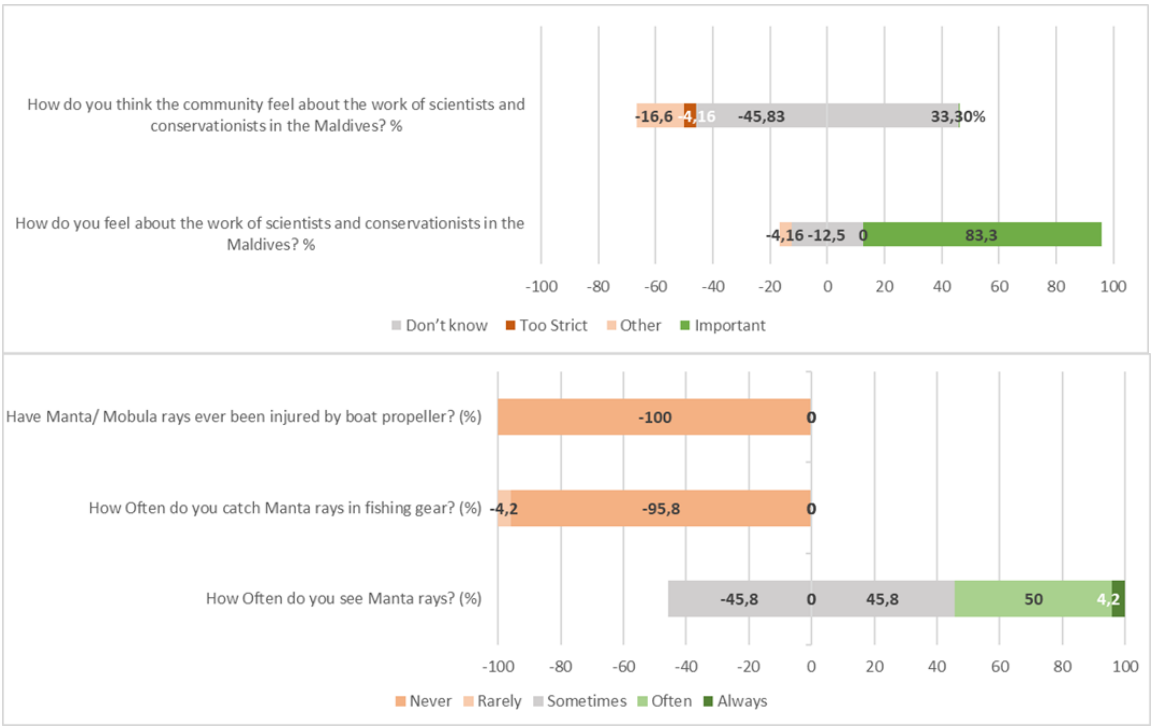


Figure 7 Likert scale demonstrating fishermen responses to various interview questions assessing the frequency of mobulids, the attitudes of fishers and any anthropologic threat.

3.4 LEK and Attitude correlation and comparison analysis

To assess the relationship between the sociodemographic variables of interviewed fishermen (including age, experience, time spent on sea and occupation) and the calculated LEK and Attitude indices, Spearman's correlation was computed.

There was no evidence that Knowledge has an influence on Attitude. No significant differences were found between the variables of Attitude and Experience, and Knowledge and Experience. Furthermore, Knowledge appeared to be unaffected by Age. While the correlation between Age and Attitude was not significant relative to the standard alpha level of 0.05, the p-value was less than 0.10. Spearman correlation between these variables revealed a negative trend, (r(df) = -0.35, p = 0.098) (Fig.12).

In line with the analysis, it can be concluded that older fishermen had a more negative attitude towards manta ray conservation than younger fishermen.

Additionally, the performed Kruskal-Wallis sum rank test did not show any significant differences between the participant's local ecological knowledge and their sea-going frequency or occupation.

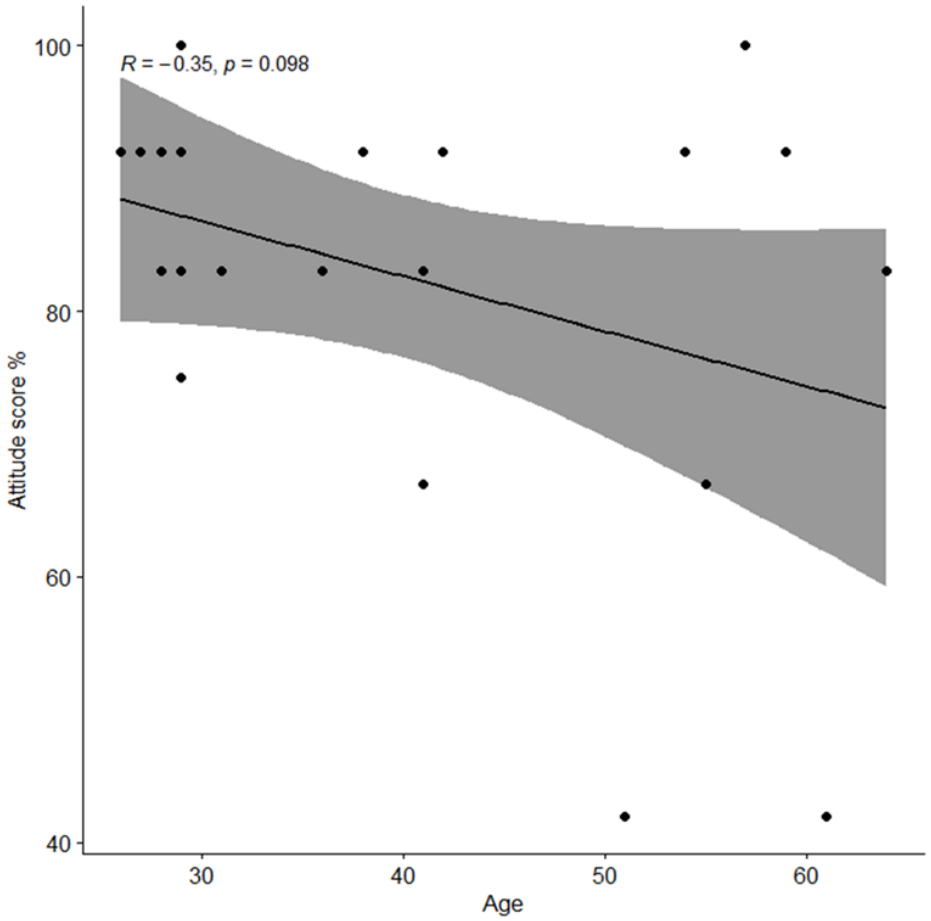


Figure 8 While the correlation between Age and Attitude was not significant relative to the standard alpha level of 0.05, the p-value was less than 0.10. Spearman correlation between these variables revealed a negative trend, (r(df) = -0.35, p = 0.098).

3.5 Manta ray sightings and abundance

The next section of the survey was concerned with the geographical distribution and abundance of manta rays around Addu Atoll.

Half of those surveyed reported that mantas were seen “often” (n=12), 46% (n=11) indicated that mantas were seen “sometimes” whilst one fisherman stated that mantas were “always” seen.

When asked what months are manta rays most commonly observed, 54% (n=13) of the respondents reported that manta rays are commonly seen in Addu Atoll throughout the year. Just over 29% (n=7) of those who answered this question indicated that manta occurrences are more frequent during the monsoon transition months (Fig.11) between November – December and April-May. Over 12.5% (n= 3)

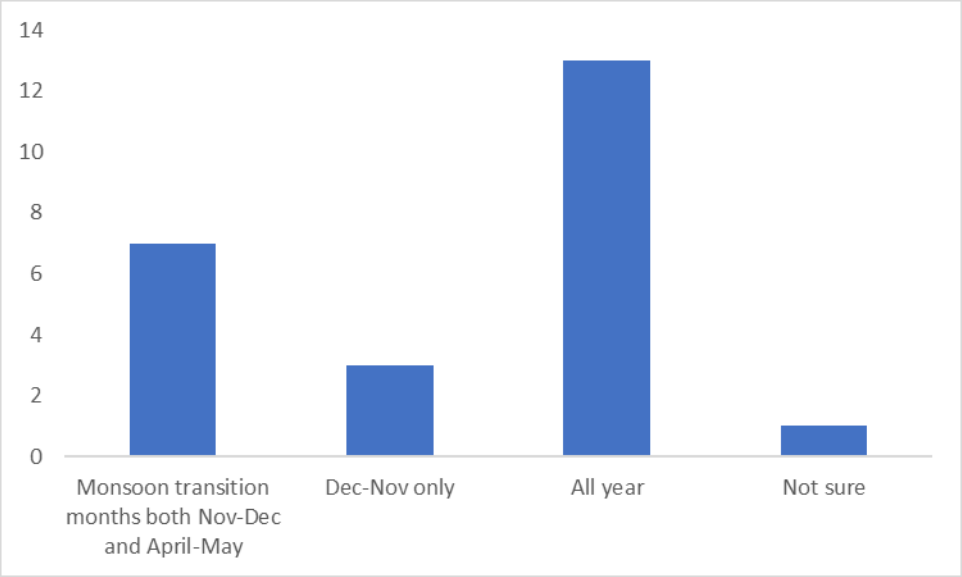


Figure 9 Fishers perception on Manta ray occurrence regarding to seasonal variability in Addu Atoll

found that manta rays are most frequently observed in the southwest monsoon period that occurs between November and December and only one participant stated “Not sure”.
When participants were asked if the period of occurrence changed since they have been working on the sea, they unanimously replied with a definite “No”.

The most commonly observed species was *M. Alfredi* 100% (n=24) but 10 participants admittedly saw manta rays offshore (5 to 15 miles offshore) mostly one specimen per occasion which could indicate the presence of oceanic manta rays.
The nightly sightings of manta and devil rays whilst bait fishing was poor, only 3 fishermen remembered encountering mantas at night but none of the encounters took place in Addu.
In terms of abundance, 21% (n=5) said that the largest number of manta rays seen together was in 2023, 8.3% (n=2) found that it was in 2021 and in 2018, one each voted for 2019 and 2016 and 3 for 2020.
Interestingly, one fisherman observed a decrease in the number of manta ray sightings whereas one fisherman described an increasing trend. The rest of the participants observed no change throughout the years.

Amongst other species observed with manta rays mentioned were cobia fish 12.5% (n=3), whale sharks 8.3% (n=2) and pilot whales 4% (n=1).
In regard to the geographical distribution in Addu, numerous manta and devil ray hot spots were located by fishermen (Fig. 12 and 13). Showing the map, a total of 38 squares were identified by 24

fishermen as the most common sighting spots/areas of manta and devil rays. The most frequently reported areas (Fig.12) were E2 (n=19); K4 (n=17); K5 (n=17); C2 (n=16) and C3 (n=15) . Further 18 squares were identified by fishers where the largest number of mobulids were observed (Fig.13) with square K4 reported most frequently by 7 participants. Additional locations stated are K5 (n=5); C2 (n=5) and C3 (n=5).

Locations are overlapping with those found during field surveys of the Manta Trust (Fig.15-16)

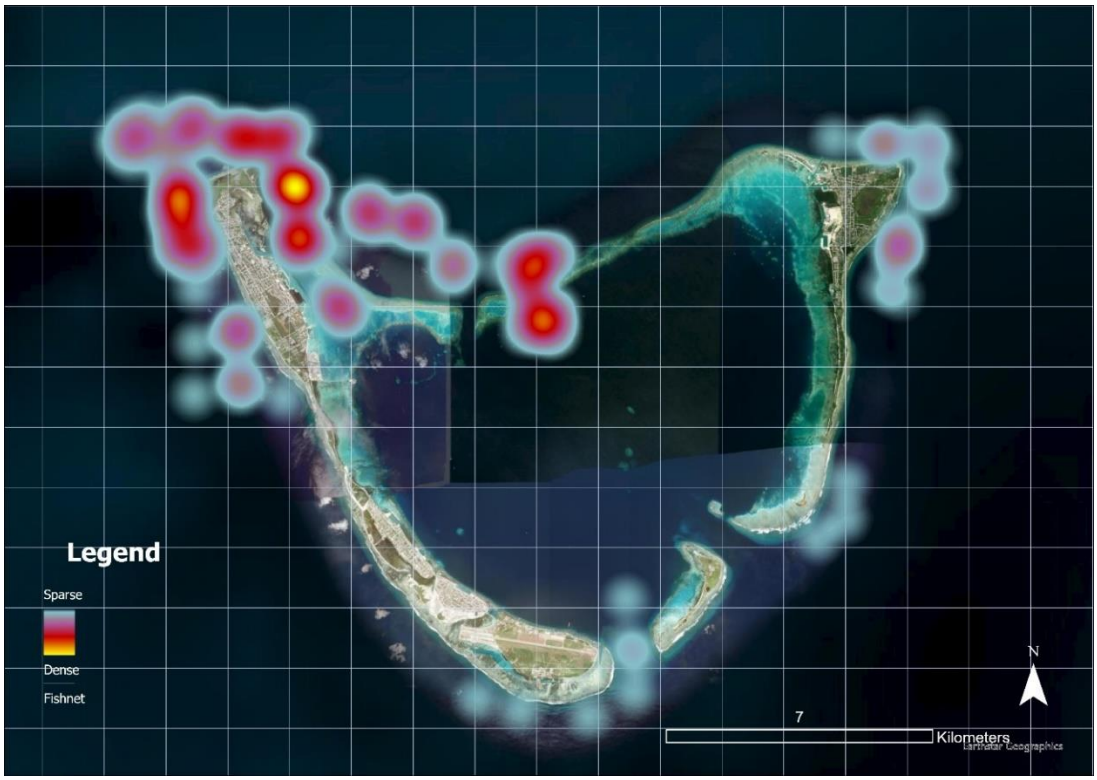


Figure 10 Location hot spots identified by fishermen where manta and devil rays are most commonly observed

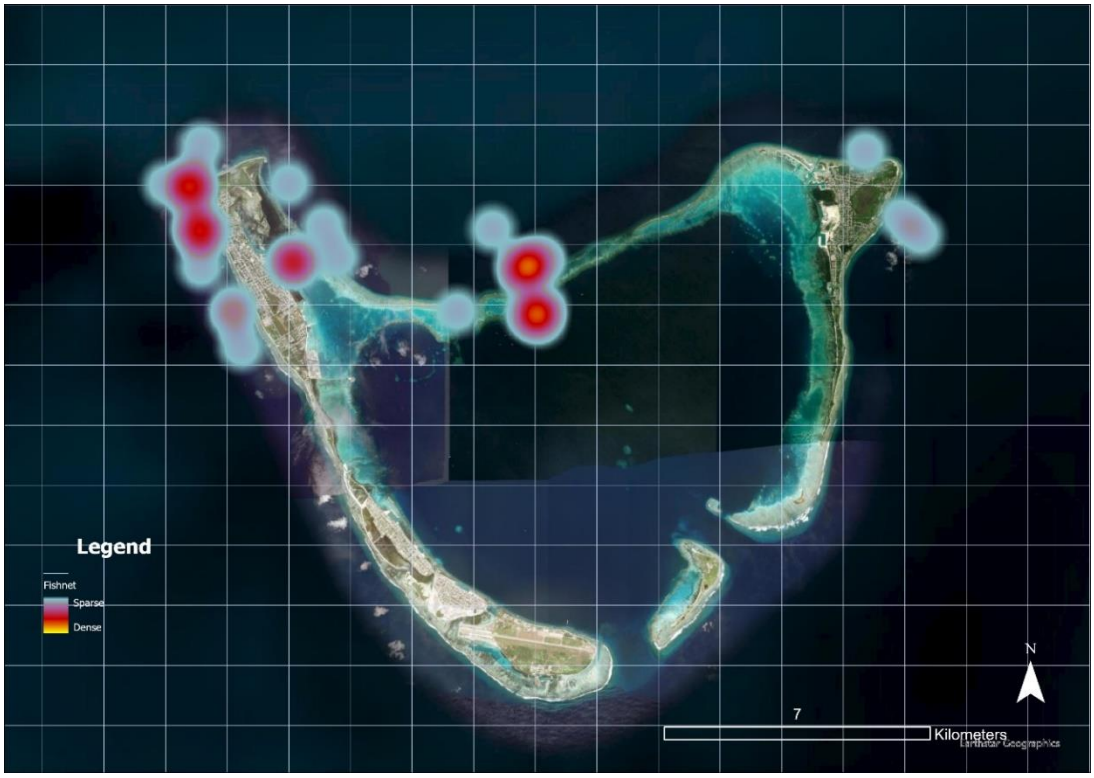


Figure 11 Location hot spots identified by fishermen where the largest aggregations of devil rays were observed.

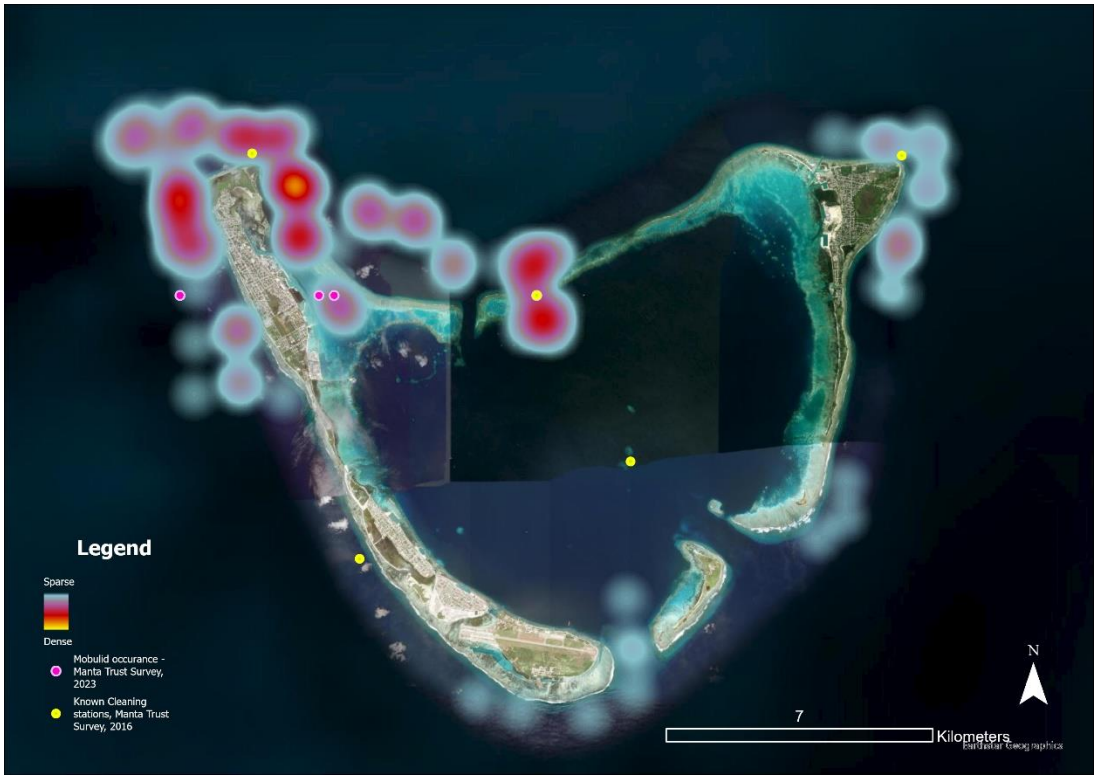


Figure 12 Location hot spots of mobulids most commonly observed by fishers and survey data conducted in 2023 and 2016

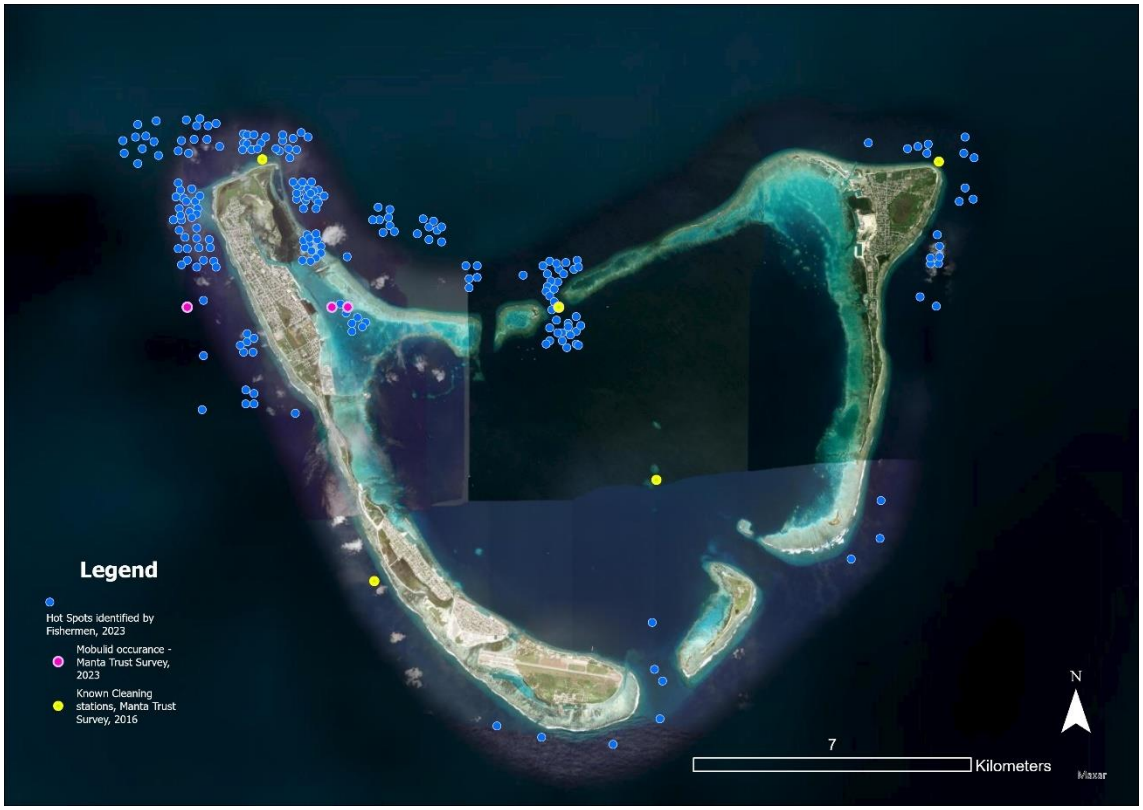


Figure 13 Locations where manta and devil rays most commonly encountered by fishermen. Survey data of the Manta trust from 2016 and 2023

3.6 Threats and Bycatch

100% of the participants answered 'never' for the question of whether mobulids were intentionally caught in the Maldives whilst 4.2 % (n=1) admitted that manta rays have been 'Rarely' caught unintentionally in gear whilst using hand line and on which occasion the line was cut to free the animal. All participants stated that manta ray has never been injured by boat propeller. The general attitudes towards the species does not indicate intentional harm.

4. Discussion

4.1 Local Ecological Knowledge of Addu Fishermen

Overall, most interviewed fishermen achieved predominantly average to excellent knowledge indicator scores regarding the identification and description of Maldivian fauna.
High knowledge scores were expected considering the high number of years in terms of sea-going experience and the high frequency of conducted fishing trips per individual which ultimately increases the probability of manta/devil ray encounters. No fisherman scored zero knowledge about the Maldivian fauna. Fishermen interviewed in Brazil (H. de O. Braga & Schiavetti, 2013) achieved similar scores, but those fishermen counted as experts in their field.

Although over half of the respondents have never encountered devil rays, the other half highlighted some important characteristics of these animals without knowing the name or genus of the species. Vast aggregations of devil rays, their elusive, timid nature and their breaching behaviour were all mentioned during the interviews. Devil rays are relatively unknown compared to the manta rays and LEK studies could provide some answers about habitats, behaviour, aggregation times and locations.

Despite, all fishermen admittingly having seen manta rays in the past, one of the most challenging questions for the interviewees appeared to be distinguishing between the two manta ray species. Sari Hani, 2021 describes the upper shoulder markings of manta ray species as a defined pattern which resembles the letter T in case of *M. birostris* and the letter Y in case of *M. alfredi*.
Numerous fishers, although did not know the exact difference between the two, stated that they saw the manta with the prominent “T” marking on its ventral side offshore whilst the manta with a white “Y” marking has been spotted close to the reefs. Some also mentioned that manta ray encountered in the open water was usually alone and significantly larger compared to those found inshore and more frequently, usually in bigger numbers.

Separating *M alfredi* and *M birostris* appeared to be a difficult task to fishermen in Laamu Atoll (Cox, 2022) as well as in the neighbouring Fuvahmulah (Irthisham Hassan Zareer, 2022). The low reliability in the accurate identification of the species verifies the study of (Marshall, Barreto, Carlson, Fernando, Fordham, Francis, Derrick, et al., 2022) who stated that one of the major issues during the population abundance assessment was the division of historical as well as present information regarding to the two species.

Another interesting point discovered through the discussions is that orcas are spotted more frequently around Addu. Initially, the photographs of orcas were included in the photo catalogue to test the reliability of fishermen's answers, as they are not recognised native to Addu's waters. Surprisingly their occurrence was later verified by footage released from local dive centres, therefore the answers of fishers were accepted.
When asked what other species of animals mantas are commonly seen with, cobia fish was reported to be one of them. The opportunistic cobia fish *Rachycentron canadum* is known to follow manta rays taking advantage of the disturbed prey along the journey (Nicholson-Jack et al., 2021).

4.2 Attitude of Addu Fishermen

In general, Addu fishermen showed a positive attitude towards scientific work and manta ray conservation. The majority was intrigued by the opportunity to learn more about future conservation projects and research whilst a quarter of the respondents did not wish to engage further they did not consider conservation and science relevant to their field of interest.
Only one fisherman advocated against the manta rays' protective status saying no need for the protection of mobulids as "nobody harms or cares about these animals". The rest of the participants were in agreement of the protective status.

Fishers were well aware of the tourism benefits of manta ray encounters in other atolls such as Baa Atoll's Hanifaru Bay and are hoping to see something similar developing in Addu Atoll in the future. The survey conducted in Laamu Atoll (Cox, 2022) showed similar results as the majority of questioned fishermen demonstrated a positive attitude due to the economic benefits associated with manta rays.
Manta rays are ecologically and economically important species of the Maldives. They are essential to the ecosystem due to their nutrient-cycling activity regulating plankton diversity and abundance. Their feeding and diving habits establish a crucial ecological link between the deep sea and the pelagic zone (Farmer et al., 2022). Due to their foraging behaviour, manta rays are commonly encountered in areas that are rich in plankton availability which also attracts other organisms, such as baitfish, which are widely used by local fishermen. Manta rays in the Maldives are locally known in Dhivehi as En-Madi which directly translates to "baitfish ray" (*en= baitfish; madi= ray)*. The term refers to the associated presence of baitfish where manta rays occur (R. C. Anderson, Adam, & Goes, 2011).

Critics of LEK often mention how participants' answers can be altered by the interviewer. It is possible that fishers shared more positive views about conservation due to the fact that the interviewer was representing a conservation organization (Cox, 2022). The interviewer's gender, nationality and religion could also potentially influence the answers widely known as the interviewer effect, which our study aimed to avoid with the help of a local interpreter conducting the meetings.

4.3 Knowledge, attitude and socio-economic variables

Fishermen who obtained higher knowledge scores did not necessarily have more positive attitude ratings towards conservation. These results reflect those of H. de O. Braga & Schiavetti,- (2013). The age range of participants was quiet representative stretching from early twenties to mid-sixties. Our analysis did not find evidence of shifting baseline syndrome (SBS) in Addu Atoll as no fisher reported change in manta and devil ray abundance/occurrence which indicates the presence of a stable, healthy population.

There was a weak correlation between Age and Attitude ($r(df) = -0.35$, $p = 0.098$).
, as younger fishermen tended to be more optimistic about scientific work and conservation practices in contrast to older fishermen who showed more septicity.
This finding broadly supports the work of other studies in this area linking age with attitude. (Alba et al., 2023) described a correlation between the individual's age and attitude towards wildlife whilst analysing perceptions of a zoo setting. A link was also found in the investigation of (Ochieng et al., 2021) where the conservation attitudes of local communities were evaluated towards the African elephant. The variables of age and gender were used to assess the attitude indices of locals. In this case study, gender was a major factor in the negative attitudes people had toward conservation, especially among women which possibly rooted in the cultural heritage of the community. Maasai women stayed at home to take care of the family and children, while the men supported the community through hunting. As a consequence, males were typically more understanding and informed about various wildlife species and conservation.

Interestingly, in terms of age younger members of Maasai communities showed a more hostile attitude towards wildlife conservation and conflict species than older participants of the study. Ochieng et al., 2021 explain this phenomenon to the lack of indigenous knowledge of younger participants. The Maasai have created strategies for coexisting with dangerous wildlife, which they

then pass on to the next generation, but contemporary social and cultural shifts have resulted in a breakdown in the transmission of traditional knowledge to the youth (Ochieng et al., 2021).
These findings could emphasize the importance of the implementation of environmental education and the involvement of stakeholders particularly the youth in conservation-focused projects and activities. Ultimately, community participation in conservation efforts and monitoring programs may lead to increased ecological knowledge and more positive attitudes of individuals.
The inclusion of other variables such as primary income could also enhance our understanding of demographic factors and favourable attitudes. For example (Ochieng et al., 2021) reported that people who have a variety of income sources typically show more positive attitudes toward conservation than people who have fewer sources of income.
Given that high-scoring participants are more likely to engage in conservation activities, attitude indices can help decision-makers and conservation practitioners prioritize resources.

4.4 Threats and bycatch

It is essential to recognize the importance of fishermen in identifying and exposing the factors contributing to the extinction of specific species as well as the shifts in human behaviour that lead to these population declines that endanger biodiversity (Bessesen & González-Suárez, 2021).
Only one fisher reported an incident during which a manta ray was unintentionally caught whilst fishing with handline gear and tuna belly used as bait. The line has been cut to free the animal.
Not reporting sensitive information that involves the potential harm to protected species could result from the lack of trust of the interviewed fishermen (Manzan & Lopes, 2015)towards the Manta Trust but it also could lead back to fisher's gear choice.

The study of (H. de O. Braga & Schiavetti, 2013) also revealed that although sea turtles are constantly caught accidentally by long lines, nets are responsible for the majority of deaths.
The study of Cox, 2022 found that in Laamu Atoll 42% of the interviewed fishermen caught manta ray accidentally and the majority of these fishers primarily used nets. This study has been unable to demonstrate that manta rays are caught accidentally in Addu Atoll.

Mobulids are frequently caught as bycatch in fisheries that use nets such as purse seines, trawls, driftnets, gillnets, traps, and longlines (Carlson et al., 2019; Fernando & Stewart, 2021). Drifting ghost nets or discarded fishing gear also poses threats to most marine megafauna (Fernando & Stewart, 2021). Consequently, commercial net fishing is prohibited in the Maldives due to the high

risk it poses to marine biodiversity (MoFMRA, 2019). Net fishing is only allowed for personal consumption and during bait fishing (MoFMRA, 2019).
Fishing for the Maldives' most important species, tuna, compromises two distinct fisheries: an offshore fishery to catch tuna and an inshore fishery to catch the necessary live bait that is used for catching tuna (Anderson, 1997). During the 1970s the fishermen of Addu Atoll began to use lights to attract the essential live bait to their nets (Anderson, 1997). The method was developed due to the lack of bait fish in the area and slowly spread across other atolls in the south of Maldives (Anderson, 1997).

Present-day live bait is still considered to be scarce in the southernmost atolls particularly in Addu (R. Anderson, 2009) and most interviewed fishermen need to travel to other atolls to catch bait or find alternatives such as tuna belly. Hence bait fish is not widely available in the Addu region local fishermen rarely use net as gear. This could explain the extremely low tendency of bycatch reports of manta and devil rays during the questionnaire.

4.5 Fishermen identified spatial Manta and Devil ray hotspots

According to Papworth et al., 2009 question design could potentially alter the answers given, for example, the recollection of memories regarding historical species abundance may indicate the over-promotion of change. According to most fishers in Addu, no change was observed between historical and present manta ray occurrence which indicates a stable, healthy population.
Conducting an in-field survey is expensive. Asking stakeholders in the form of citizen science and LEK to locate on a map where various species have been seen is a common way to find hot spots which could later serve as an area of research or further investigation (Madsen et al., 2020) (safaris, dolphin watch, bird watch).

As local ecological knowledge should be always compared to conventional scientific knowledge, I argue that primarily LEK should be used to explore data deficient, brand-new areas to find locations of interest which are then can be focused on to carry out scientific surveys. This way could provide an economic solution whereby expenses can be kept to a minimum, and time is saved.
Our study shows that there is an overlap between location hot spots identified by fishers and the conducted scientific surveys. According to the data, Addu's mobulid population is concentrated on the north-west of the atoll, it is where they are most commonly observed and where the largest aggregations occur. Some additional locations were added by fishers in the southern-most of Addu.

It was clear from the previous survey's data sets and from the description of fishermen that the largest manta and devil ray aggregations occur in the Northwest of Addu greatly overlapping with the marine protected areas. Various environmental factors trigger the grouping of mobulids as well as their social behaviour, courtship and mating, feeding, avoiding predation, and thermoregulation (Palacios et al., 2023). Where conditions are favourable, mobulids return repetitively (Palacios et al., 2023). How these sites are going to be affected upon the completion of the reclamation project is not well understood yet.

Most harvesters reported that mobulids are observed around Addu Atoll all year-round whilst others emphasized that monsoonal variations that play a key role in manta and devil ray sighting frequency and distribution. This highlights that Addu Atoll is unique compare to other atolls hosting healthy population of mobulids annually. This finding is important as the increased likelihood of manta ray encounters may as well attract more tourism to the area.

The study of (Colloca et al., 2020) indicated that abundance data of elasmobranchs gathered through fisheries monitoring programs and surveys are not always accurate in the determination of the status populations. His study urged to combine various data sources with local ecological knowledge to gain a wider perspective on how commercial fishing activity affects sharks, rays and skates.

We suggest that LEK can be and should be used as an important tool to bridge the gap in the current understanding of the occurrence and condition of mobulid populations, especially in unknown areas and particularly in the case of species that are subject to paucity of scientific data.

4.6 Limitations

There were several limitations encountered during the survey conduction. One major drawback was that in-person surveys were time-consuming to schedule and conduct and the project was given only three months from start to finish.

Fishermen approached in Addu Atoll were not as accommodating as was previously experienced during LEK surveys amongst other atolls. A possible explanation for this might be that the majority of respondents never heard about the Manta Trust and locals were somewhat sceptical about the organization's work possibly due to a lack of familiarity.

Although the primary goal was to collect 75 interviews for the duration of the project (25 each month) only 24 discussions were scheduled in the end. Because there were only a small number of

respondents with a range of experience levels and personal traits, our evaluation of LEK may not have been able to fully capture all the variables influencing respondents' opinions.
Being limited to such a small sample size, the conclusions drawn from the investigation could have been undermined. Furthermore, small sample sizes are known to compromise a study's external and internal validity (Faber & Fonseca, 2014)

Being less powerful than parametric tests, nonparametric tests require a bigger sample size in order to have the same power and accuracy as parametric tests to find correlations and differences between the studied groups when variations are applicable (Sullivan & Artino, 2013). Applying nonparametric data analysis to a small sample size will indubitably reduce the likelihood of detecting any effects.
Therefore, the study would have been more relevant if we had included a wider community of local inhabitants instead of solely focusing on the perspective of fishermen.

One of the main criticisms of LEK is based on the reliability of the respondents (Pauly, 1995). Respondents might not feel motivated to give truthful, accurate answers, or do not remember well to certain events. It is also possible that participants may not feel comfortable answering questions that cast them in a negative light which could be a possible case as to why the survey did not obtain any information about the anthropogenic threats of manta and devil rays in Addu Atoll. Numerous LEK studies suggest the use of “experts” in the survey to increase the reliability of the information shared by participants (van der Hoeven et al., 2004; Braga & Schiavetti, 2013 RUDDLE & DAVIS, 2013). It was certainly not an option available due to the short time and few volunteering participants.

The questionnaire would have been more useful if it had asked fishermen about more demographic details such as the level of education, the primary income, and the number of children if applicable, to increase the number of variables and to explore more links and causation between knowledge and attitude.
As *RUDDLE & DAVIS, 2013* described the term "local ecological knowledge" is peculiar because it never truly is "local," and the approximate boundaries of the geographic area where supposedly "local knowledge" is shared should be clearly defined by the researcher prior to investigation. Fishermen from only two islands (Hithadoo and Maradhoo) agreed to participate in our research which made our results less representative.

Finally, our conclusions might have been much more interesting if we had addressed the ongoing reclamation project in the questionnaire to record locals' perceptions of the developments.

5. Conclusion

5.2. Recommendations

To develop a full picture of Addu's manta and devil ray hot spots, additional studies will be needed to cover the implications of land reclamation projects. Locations identified by fishermen and surveys of the Manta Trust should be reassessed in the future to monitor the movement and abundance of marine megafauna following such large-scale disturbance.
Recording data now could provide an excellent base for future investigations and it might shed light on accelerated environmental or ecological changes. Re-interviewing those who agreed to be contacted for follow-up questions could also ensure traceability and the accurate assessment of change.

Further work is needed to compare and contrast the findings of all fishermen's LEK and attitude surveys conducted in the Maldives. Contrasting the investigations of different atolls could provide a better understanding of the knowledge and perspective of communities as well as the various anthropogenic stressors faced by mobulids.

5.3 Conclusion

This study was important to increase our understanding on the perspectives of Maldivian fishermen and to compare and contrast findings between the already investigated atolls.
Local Ecological Knowledge scores were amongst the highest when considering the knowledge indices of the other atolls as well as the scientific literature. Attitudes towards mobulid conservation and scientific work were predominantly positive. Age had an impact on the level of attitudes which emphasizes the implementation of early environmental education.
The conducted survey did not find information about anthropogenic threats of manta and devil rays. Mobulid location hot spots were aligned with those areas identified during scientific surveys. New areas were also suggested by fishermen which requires future investigation.
Our project demonstrated that local fishermen can frequently provide information on historical, and regional trends of abundance and marine biodiversity which can be used to complement the conventional scientific research methods providing a more economical solution for data collection (Bessesen & González-Suárez, 2021)**.** The combination of periodic biomonitoring and local ecological

knowledge surveys may provide a better picture where conservation effort and resources should be prioritised.

Similar to other studies (H. de O. Braga & Schiavetti, 2013; H. O. Braga et al., 2017; Veneroni & Fernandes, 2021), we recommend the involvement of users of marine resources in the fields of science and policy by bringing community members and various stakeholders closer to conservation efforts (Bessesen & González-Suárez, 2021).

REFERENCES

(MNPHI), M. of N. P. H. and I. (2023). *ADDU DEVELOPMENT PROJECT*. https://addudevelopment.mv/about-the-project

Alba, A. C., Ferrie, G. M., Schook, M. W., Leahy, M., & Cronin, K. A. (2023). Gender and Age, but Not Visual Context, Impact Wildlife Attitudes and Perceptions of Animals in Zoos. *Journal of Zoological and Botanical Gardens*. https://doi.org/10.3390/jzbg4010013

AnadÓn, J. D., GimÉnez, A., Ballestar, R., & PÉrez, I. (2009). Evaluation of local ecological knowledge as a method for collecting extensive data on animal abundance. *Conservation Biology*. https://doi.org/10.1111/j.1523-1739.2008.01145.x

Anderson, R. (2009). *Technical Assistance To Bait Fisheries Monitoring*. *December*, 1–32. http://www.mhe.gov.mv/memp/wp-content/uploads/downloads/2011/12/MEMP-Bait-Fisheries-Monitoring1.pdf

Anderson, R. C., Adam, M. S., & Goes, J. I. (2011). From monsoons to mantas: Seasonal distribution of Manta alfredi in the Maldives. *Fisheries Oceanography*. https://doi.org/10.1111/j.1365-2419.2011.00571.x

Anderson, R. C., Adam, M. S., Kitchen-Wheeler, A. M., & Stevens, G. (2011). Extent and economic value of manta ray watching in maldives. *Tourism in Marine Environments*. https://doi.org/10.3727/154427310X12826772784793

Andrzejaczek, S., Chapple, T. K., Curnick, D. J., Carlisle, A. B., Castleton, M., Jacoby, D. M. P., Peel, L. R., Schallert, R. J., Tickler, D. M., & Block, B. A. (2020). Individual variation in residency and regional movements of reef manta rays Mobula alfredi in a large marine protected area. *Marine Ecology Progress Series*, *639*, 137–153. https://doi.org/10.3354/meps13270

Ari, C., & D'Agostino, D. P. (2016). Contingency checking and self-directed behaviors in giant manta rays: Do elasmobranchs have self-awareness? *Journal of Ethology*. https://doi.org/10.1007/s10164-016-0462-z

Atmore, L. M., Aiken, M., & Furni, F. (2021). Shifting Baselines to Thresholds: Reframing Exploitation in the Marine Environment. *Frontiers in Marine Science*. https://doi.org/10.3389/fmars.2021.742188

Beaudreau, A. H., & Levin, P. S. (2014). Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. *Ecological Applications*. https://doi.org/10.1890/13-0817.1

Bender, M. G., Machado, G. R., De Azevedo Silva, P. J., Floeter, S. R., Monteiro-Netto, C., Luiz, O. J., & Ferreira, C. E. L. (2014). Local ecological knowledge and scientific data reveal overexploitation by multigear artisanal fisheries in the Southwestern Atlantic. *PLoS ONE*, *9*(10). https://doi.org/10.1371/journal.pone.0110332

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of Traditional Ecological Knowledge as adaptive management. In *Ecological Applications*. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Bessesen, B. L., & González-Suárez, M. (2021). The value and limitations of local ecological knowledge: Longitudinal and retrospective assessment of flagship species in Golfo Dulce, Costa

Rica. *People and Nature*, *3*(3), 627–638. https://doi.org/10.1002/pan3.10219

Braga, H. de O., & Schiavetti, A. (2013). Attitudes and local ecological knowledge of experts fishermen in relation to conservation and bycatch of sea turtles (reptilia: Testudines), Southern Bahia, Brazil. *Journal of Ethnobiology and Ethnomedicine*. https://doi.org/10.1186/1746-4269-9-15

Braga, H. O., Azeiteiro, U. M., Oliveira, H. M. F., & Pardal, M. A. (2017). Evaluating fishermen's conservation attitudes and local ecological knowledge of the European sardine (Sardina pilchardus), Peniche, Portugal. *Journal of Ethnobiology and Ethnomedicine*. https://doi.org/10.1186/s13002-017-0154-y

Carlson, J. K., Horn, C., & Creager, S. B. (2019). Safe Handling and Release Guidelines for Manta and Devil Rays(Mobulid Species). *NOAA Technical Memorandum NMFS-SEFSC-733*, *February*, 1–46. https://doi.org/10.1016/j.snb.2019.127013

Church, J. A., & White, N. J. (2006). A 20th century acceleration in global sea-level rise. *Geophysical Research Letters*. https://doi.org/10.1029/2005GL024826

Colloca, F., Carrozzi, V., Simonetti, A., & Di Lorenzo, M. (2020). Using Local Ecological Knowledge of Fishers to Reconstruct Abundance Trends of Elasmobranch Populations in the Strait of Sicily. *Frontiers in Marine Science*. https://doi.org/10.3389/fmars.2020.00508

Couturier, L. I. E., Marshall, A. D., Jaine, F. R. A., Kashiwagi, T., Pierce, S. J., Townsend, K. A., Weeks, S. J., Bennett, M. B., & Richardson, A. J. (2012). Biology, ecology and conservation of the Mobulidae. In *Journal of Fish Biology*. https://doi.org/10.1111/j.1095-8649.2012.03264.x

Cox, H. (2022). The Use of Fishers ' Local Ecological Knowledge (LEK) in mobulid conservation. In *Ecology and Society* (Issue 640036625).

Dulvy, N. K., Fowler, S. L., Musick, J. A., Cavanagh, R. D., Kyne, P. M., Harrison, L. R., Carlson, J. K., Davidson, L. N., Fordham, S. V, Francis, M. P., Pollock, C. M., Simpfendorfer, C. A., Burgess, G. H., Carpenter, K. E., Compagno, L. J., Ebert, D. A., Gibson, C., Heupel, M. R., Livingstone, S. R., … White, W. T. (2014). Extinction risk and conservation of the world's sharks and rays. *ELife*. https://doi.org/10.7554/elife.00590

Faber, J., & Fonseca, L. M. (2014). How sample size influences research outcomes. *Dental Press Journal of Orthodontics*. https://doi.org/10.1590/2176-9451.19.4.027-029.ebo

Farmer, N. A., Garrison, L. P., Horn, C., Miller, M., Gowan, T., Kenney, R. D., Vukovich, M., Willmott, J. R., Pate, J., Harry Webb, D., Mullican, T. J., Stewart, J. D., Bassos-Hull, K., Jones, C., Adams, D., Pelletier, N. A., Waldron, J., & Kajiura, S. (2022). The distribution of manta rays in the western North Atlantic Ocean off the eastern United States. *Scientific Reports*. https://doi.org/10.1038/s41598-022-10482-8

Fernando, D., & Stewart, J. D. (2021). High bycatch rates of manta and devil rays in the "small-scale" artisanal fisheries of Sri Lanka. *PeerJ*. https://doi.org/10.7717/peerj.11994

Garzon, F., Seymour, Z. T. A., Monteiro, Z. L., & Graham, R. T. (2023). Spatial ecology of a newly described oceanic manta ray population in the Atlantic Ocean. *Marine Biology*. https://doi.org/10.1007/s00227-023-04219-y

Harris, J. L., McGregor, P. K., Oates, Y., & Stevens, G. M. W. (2020). Gone with the wind: Seasonal distribution and habitat use by the reef manta ray (Mobula alfredi) in the Maldives, implications for conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems*. https://doi.org/10.1002/aqc.3350

Irthisham Hassan Zareer. (2022). *Assessment of Oceanic Manta Ray (Mobula birostris) and Whale Shark (Rhincodon typus) sightings in Fuvahmulah using Local Ecological Knowledge (LEK)* (Issue November).

Islamic Development Bank. (2022). *Member country Partnership strategy for the Republic of Indonesia (2022-2025)*. 1–69.

Jones, T., Ehardt, C. L., Butynski, T. M., Davenport, T. R. B., Mpunga, N. E., Machaga, S. J., & De Luca, D. W. (2005). The highland mangabey Lophocebus kipunji: A new species of African monkey. *Science*. https://doi.org/10.1126/science.1109191

KATIE LOCKHART. (2022). *The gentle giants of Hanifaru Bay, Maldives*. National Geographic Travel. https://www.nationalgeographic.com/travel/article/paid-content-hanifaru-bay-maldives-manta-rays

Kelly, M. J. (2011). Qualitative Evaluation Research. *Qualitative Research Practice*, 462–477. https://doi.org/10.4135/9781848608191.d38

Kirchherr, J., & Charles, K. (2018). Enhancing the sample diversity of snowball samples: Recommendations from a research project on anti-dam movements in Southeast Asia. *PLoS ONE*, *13*(8), 1–17. https://doi.org/10.1371/journal.pone.0201710

Madsen, E. K., Elliot, N. B., Mjingo, E. E., Masenga, E. H., Jackson, C. R., May, R. F., Røskaft, E., & Broekhuis, F. (2020). Evaluating the use of local ecological knowledge (LEK) in determining habitat preference and occurrence of multiple large carnivores. *Ecological Indicators*. https://doi.org/10.1016/j.ecolind.2020.106737

Magu, A. (2022). *ENVIRONMENTAL IMPACT ASSESSMENT REPORT For the Proposed Reclamation Project at Addu City, Maldives*. *960*.

Maldives bureau of statistics, M. of national planning, housing & infrastructure. (2023). *2022 Maldives population and housing census provisional results summary*. 15. https://census.gov.mv/2022/wp-content/uploads/2023/04/Provisional-Result-Publication-amnded-2423.pdf

MALDIVES MANTA CONSERVATION PROGRAMME. (2023). https://www.mantatrust.org/maldives

Manzan, M. F., & Lopes, P. F. M. (2015). Fishers' knowledge as a source of information about the estuarine dolphin (Sotalia guianensis, van Bénéden, 1864). *Environmental Monitoring and Assessment*. https://doi.org/10.1007/s10661-014-4096-8

Marshall, A., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., Derrick, D., Herman, K., Jabado, R. W., Liu, K. M., Rigby, C. L., & Romanov, E. (2022). Mobula birostris (amended version of 2020 assessment). *The IUCN Red List of Threatened Species*, *8235*, e.T198921A214397182. https://www.iucnredlist.org/species/198921/214397182

Marshall, A., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M. P., Herman, K., Jabado, R. W., Liu, K. M., Pacoureau, N., Rigby, C. L., Romanov, E., & Sherley, R. B. (2022). Mobula alfredi (amended version of 2019 assessment). The IUCN Red List of Threatened Species 2022: e.T195459A214395983. *The IUCN Red List of Threatened Species*, *e.T195459A*, 21.

MoFMRA. (2019). *Fisheries Act of the Maldives*. *14*, 55.

Mrc. (2003). A Review of Addu Atoll's Fishery. In *Maldives Marine Research Bulletin* (Vol. 7, Issue December).

Newing, H., Eagle, C. M., Puri, R. K., & Watson, C. W. (2010). Conducting research in conservation: Social science methods and practice. *Conducting Research in Conservation: Social Science*

Methods and Practice, *May*, 1–376. https://doi.org/10.4324/9780203846452

Nicholson-Jack, A. E., Harris, J. L., Ballard, K., Turner, K. M. E., & Stevens, G. M. W. (2021). A hitchhiker guide to manta rays: Patterns of association between Mobula alfredi, M. birostris, their symbionts, and other fishes in the Maldives. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0253704

O'Malley, M. P., Lee-Brooks, K., & Medd, H. B. (2013). The Global Economic Impact of Manta Ray Watching Tourism. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0065051

O'Malley, M. p., Townsend, K. A., Hilton, P., Heinrichs, S., & Stewart, J. D. (2017). Characterization of the trade in manta and devil ray gill plates in China and South-east Asia through trader surveys. *Aquatic Conservation: Marine and Freshwater Ecosystems*. https://doi.org/10.1002/aqc.2670

Ochieng, N. T., Elizabeth, K. N., & Nigel, L. W. (2021). Measuring the conservation attitudes of local communities towards the African elephant Loxodonta africana, a flagship species in the Mara ecosystem. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0253234

Palacios, M. D., Stewart, J. D., Croll, D. A., Cronin, M. R., Trejo-Ramírez, A., Stevens, G. M. W., Lezama-Ochoa, N., Zilliacus, K. M., González−Armas, R., Notarbartolo di Sciara, G., & Galván−Magaña, F. (2023). Manta and devil ray aggregations: conservation challenges and developments in the field. In *Frontiers in Marine Science*. https://doi.org/10.3389/fmars.2023.1148234

Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. In *Trends in Ecology & Evolution*. https://doi.org/10.1016/S0169-5347(00)89171-5

Rehage, J. S., Santos, R. O., Kroloff, E. K. N., Heinen, J. T., Lai, Q., Black, B. D., Boucek, R. E., & Adams, A. J. (2019). How has the quality of bonefishing changed over the past 40 years? Using local ecological knowledge to quantitatively inform population declines in the South Florida flats fishery. *Environmental Biology of Fishes*. https://doi.org/10.1007/s10641-018-0831-2

Ruddle, K., & Davis, A. (2011). What is "ecological" in local ecological knowledge? lessons from Canada and Vietnam. *Society and Natural Resources*, *24*(9), 887–901. https://doi.org/10.1080/08941921003598796

RUDDLE, K., & DAVIS, A. (2013). Local Ecological Knowledge (LEK) in Interdisciplinary Research and Application: a Critical Review. *Asian Fisheries Science*, *26*(2). https://doi.org/10.33997/j.afs.2013.26.2.002

Sari Hani, M. (2021). Manta Ray Tourism. In *Tourism*. https://doi.org/10.5772/intechopen.93924

Sawers, T., & Stevens, G. (2014). *The Value of Traditional Knowledge in Manta Ray Conservation in the Maldives*. http://www.mantatrust.org/wp-content/uploads/2016/05/Manta-Trust_MMRP_Traditional-Knowledge_Thesis-Report_Tam-Sawers_2014.pdf

Sinan, H., & Whitmarsh, D. (2010). Wealth-based fisheries management and resource rent capture: An application to the Maldives marine fisheries. *Marine Policy*, *34*(3), 389–394. https://doi.org/10.1016/j.marpol.2009.09.001

Speelman, L. H., Nicholls, R. J., & Safra de Campos, R. (2021). The role of migration and demographic change in small island futures. *Asian and Pacific Migration Journal*. https://doi.org/10.1177/01171968211044082

Stevens, G. (2016). Conservation and Population Ecology of Manta Rays in the Maldives. *PhD Thesis, University of York*, *August*, 1–207. https://etheses.whiterose.ac.uk/16981/1/Guy Stevens_Doctoral Thesis_Conservation and Population Ecology of Manta Rays in the

Maldives_2016.pdf

Stevens, G. M. W., & Froman, N. (2018). The maldives archipelago. In *World Seas: An Environmental Evaluation Volume II: The Indian Ocean to the Pacific* (Second Edi). Elsevier Ltd. https://doi.org/10.1016/B978-0-08-100853-9.00010-5

Strike, E. (2020). *Variations in sub-lethal injuries to manta rays in the Maldives*.

Sullivan, G. M., & Artino, A. R. (2013). Analyzing and Interpreting Data From Likert-Type Scales. *Journal of Graduate Medical Education*. https://doi.org/10.4300/jgme-5-4-18

van der Hoeven, C. A., de Boer, W. F., & Prins, H. H. T. (2004). Pooling local expert opinions for estimating mammal densities in tropical rainforests. *Journal for Nature Conservation*. https://doi.org/10.1016/j.jnc.2004.06.003

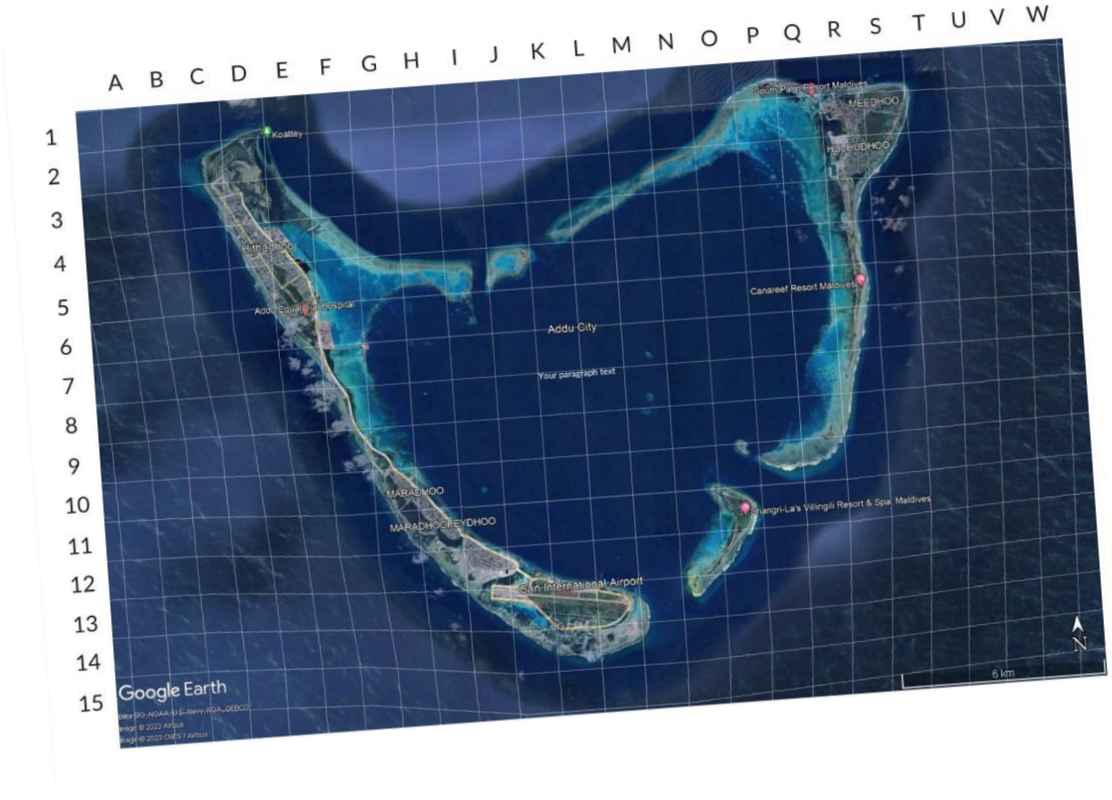
Veneroni, B., & Fernandes, P. G. (2021). Fishers' knowledge detects ecological decay in the Mediterranean Sea. *Ambio*. https://doi.org/10.1007/s13280-020-01452-3

Woodworth, P. L. (2005). Have there been large recent sea level changes in the Maldive Islands? *Global and Planetary Change*. https://doi.org/10.1016/j.gloplacha.2005.04.001

Zimmerhackel, J. S., Kragt, M. E., Rogers, A. A., Ali, K., & Meekan, M. G. (2019). Evidence of increased economic benefits from shark-diving tourism in the Maldives. *Marine Policy*, *100*(July 2018), 21–26. https://doi.org/10.1016/j.marpol.2018.11.004

Appendix

Appendix 1: Map used during the interview to record manta and devil ray hotspots identified by local fishers



Appendix 2 questionnaire used during the interviews

FISHERMEN QUESTIONNAIRE

Introduction

"Introduction My name Fauz and I would like to ask you a few questions. This interview forms part of a project being carried out by the Manta Trust and myself, to better understand the communities' understanding of manta rays, awareness of and attitude towards conservation regulations, and determine if any anthropogenic pressures are threatening such species to identify how management can aid their conservation. Everything that we discuss today will be completely confidential and all information will be anonymous.

We know very little about the manta rays of the world, but here in the Maldives we have a great opportunity to study them. Given your experiences and knowledge of the sea/area, we'd like to

learn from you and gather info on manta rays in the Maldives. This is why we want to talk to you.

This interview will begin by asking you about your experience at sea. I then would like to ask some questions about manta rays and other big fish. If you do not understand anything or want to ask any questions during the interview, please stop me at any time.

The interview should last no longer than 45min -1hr. The interview will be recorded and notes taken, once the interview is transcribed the recording will be deleted. Only anonymised and grouped data will be used in the analysis and reporting. By taking part in this interview you are consenting to your data being used as part of this study. You have the right to withdraw from this interview or to request your data be removed from the project at any time. You do not have to answer any individual question that you do not wish to answer. It is crucial that you answer each question as accurately as possible. If you are not sure of the answer to a question, please state this as your answer.

Finally, please confirm your willingness to participate in this study and your understanding that you may withdraw consent at any time and discontinue participation.

Right, let us begin."

Questionnaire

Section	Questions
	Date_____Island_____
Background Information	**How old are you?**
	Are you based on this island? ***(If yes) How many years have you lived here?*** ***(If no) Where are you based?***
	What is the nature of your work at sea?
Background Information	**How many years have you been working at sea?**
Fishing practices employed and primary catch	**How often are you at sea in a typical month? (Never, a few times a month, a few times a week, most days, everyday)**
	How many years have you been fishing for?
	How often are you fishing at sea in a typical month? (Never, a few times a month, a few times a week, most days, everyday)
	What did/do you fish for?
	What is/was your method of fishing? (Pole and line, hand line, trolling, Other)

Fishing practices employed and primary catch	**Has your method changed since you began fishing?** ***(If yes) When did this change occur? Why did this change occur?***
Knowledge about native marine species and mobulids	**Which of these species can be observed in the Maldives? (Appendix 1)**
	Have you seen a manta ray before? ***(If yes) Could you describe it to me?***
	Can you tell the difference between these two species? (Appendix 2)
Knowledge about native marine species and mobulids	**Have you seen a mobula ray before?** ***(If yes) Could you describe it to me?***
Knowledge about mobulid occurrences and threats faced by the group	**Can you tell me anything about these species of rays? (Appendix 3)**
	What months are manta and mobula rays most commonly observed?
	Has this changed since you started working at sea? ***(If yes) How has it changed?***
	How often do you see manta or mobula rays when at sea? (Never, rarely, sometimes, often, always)
Knowledge about mobulid occurrences and threats faced by the group	**Which species do you see most regularly?**
	Where do you most often see manta or rays? (Using Appendix 4)
Attitude towards and awareness of conservation of	**Has this changed since you started working at sea?** ***(If yes) How has it changed?***

the taxonomic group	**What is the largest number of manta or mobula rays you have ever seen at once?**
	Where did you see them? (Using Appendix 4)
	Can you remember what year you saw them in?
	Do you think the numbers of manta or mobula rays have changed since you began working at sea? ***(If yes) Are they more or less common today than they were then?***
	Are manta or mobula rays ever seen together with any other fish? ***(If yes) Which species are they likely to be seen with?***
	Have you ever seen manta or mobula rays offshore? ***(If yes) How far offshore? Where did you see this? (Using Appendix 4) How many individuals did you see?***
	Have you ever seen manta or mobula rays whilst bait fishing at night? ***(If yes) Do you remember where this occurred?***
	Have manta or mobula rays ever been intentionally caught in the Maldives? ***(If yes) What were they fished for? How many would be caught? When did this happen?***
	How often do you catch a manta or mobula ray in your fishing gear (intentionally or unintentionally)? (Never, rarely, sometimes, often, always) ***(If not never) In which type of gear? Was there anything different in the technique/method used for fishing in this case? What type of lure/bait was used on this occasion?*** **(Try to obtain as much info as possible about type of gear and way in which this manta was caught)** ***Is there a month during the year when this occurs more frequently?***

	What happens to any manta or mobula rays that are caught (by you or by others)?
	Have manta or mobula rays ever been caused injury by your boat propeller? (Never, rarely, sometimes, often, always)
	Before this interview, were you aware of the organisation 'The Manta Trust'? ***(If yes) What activities do they do?***
	How do you feel about the work of scientists and conservationists in the Maldives? (Important, too strict, cause problems, unnecessary, don't know, other) ***Why?***
	How do you think the rest of your community feels about the work of scientists and conservationists? (Important, too strict, cause problems, unnecessary, don't know, other) ***Why?***
Attitude towards and awareness of conservation of the taxonomic group	**Would you like to learn more about what scientists and conservationists do and why they do it?**
	What information would like to receive from scientists?
Final reflections	**What benefits do you expect to receive from conservation programmes in the Maldives?**
	Would you like to take your family, children and friends to visit and swim with the manta or mobula rays?
	Are you aware of any rules and regulations about the capture of manta or mobula rays in the Maldives? ***(If yes) What is your understanding of the rules?***
	In general how do fishers and sea workers feel about manta or mobula rays? (Menace, feared, respected, don't bother, don't know, other)

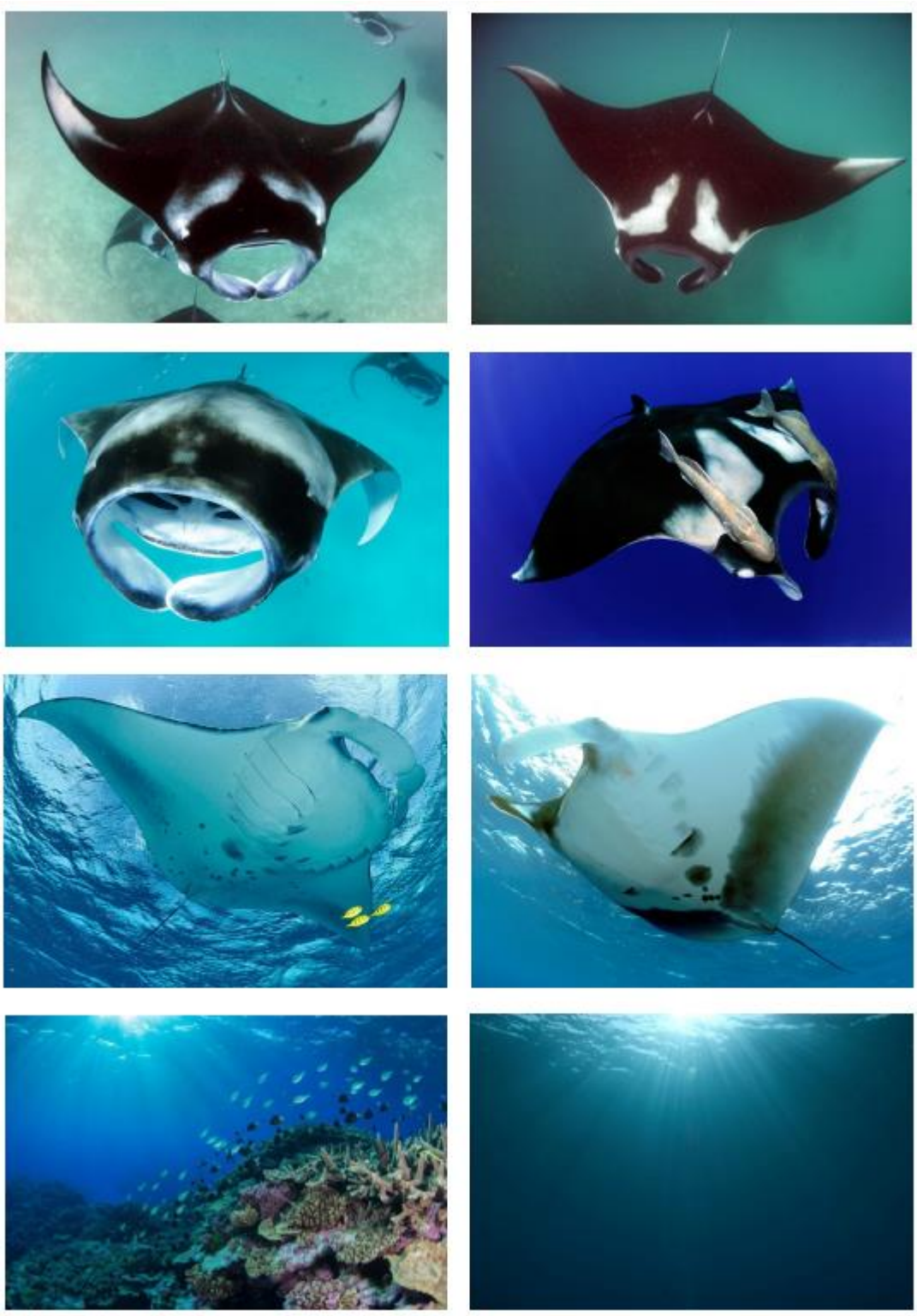
	Why?
	Do you think manta and mobula rays should be protected?
	Why?
	Do you know of any areas in Addu Atoll that are designated as protected areas? What do you think this means for you?
	Is there anything else you would like to tell me?
	Is there anything you would like to ask me?
	Having completed this survey, can you recommend anybody else we should talk to?

Section	Questions
Introduction	**Now we have finished the main interview, I would like to ask you about the possibility of contacting you in the future regarding the results of our study and any future manta ray sightings. The Manta Trust will only contact you with your express permission and you may withdraw your permission at any time and erase your contact details from our system.**
	The following questions will outline how we will contact you in the future and what we will contact you about.
	Can you confirm you are happy to proceed?
(If yes) Contact details	**Name**
	Email

	Phone
	Location (Island)
Permissions	**Do you give us permission to use this data?**
	Can we use this data to update you with the results of this survey?
	Do we have your permission to contact you regarding future manta or mobula ray sightings in your area?

Appendix 3: Eight species shown to fishers to assess their knowledge of local marine fauna.

Appendix 4: pictures shown to test if fishers can distinguish between reef (left) and oceanic (right) manta rays



Appendix 5: pictures shown to fishermen to test their knowledge on some of the native marine fauna spotted eagle ray, cowtail stingray and spinetail devil ray.

EGIS Undergraduate (UG) and Postgraduate Taught (PGT) Student Research Ethics Review Form

To be completed by <u>all</u> EGIS UG/PGT students conducting research and included in written outputs (e.g. dissertation, field project report) as an Appendix. The 'Research Ethics Guide for EGIS UG/PGT Students' should be read prior to completion.

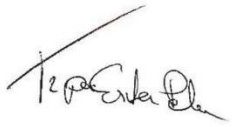
Student name:	Eszter P Tripa	
Project title:	Assessing the Local Ecological Knowledge of Fishermen at Addu Atoll, Maldives	
Application type:	☐ Undergraduate	✓ Postgraduate Taught
Course code and title:	A11RP- ILES Environment Dissertation 2023-24	
Supervisor name:	Prof. Alex Poulton	

SECTION A: BASIC CHECKLIST	**Yes**	**No**
Does your study:		
• Involve human participants?	✓	☐
• Involve animals?	☐	✓
• Use personal data from external sources (i.e. secondary data which relates to identifiable living persons)?	✓	☐
• Raise ethical issues for other reasons?	☐	✓
If you answered 'yes' to one or more of these questions proceed to Section B. Otherwise skip to Section D.		

SECTION B: ETHICAL CONSIDERATIONS	**Yes**	**No**	**N/A**
B1) Adherence to ethical principles			
1. Will all participants be recruited to the study on the understanding that their participation is voluntary?	✓	☐	☐
2. Will all participants be appropriately informed of the aim(s) of the study, their expected contribution, how their data will be used, and their right to withdraw?	✓	☐	☐
3. Will appropriate consent be obtained from all participants?	✓	☐	☐
4. Will de-identification procedures (i.e. anonymisation or pseudonymisation) be used to ensure that participants are not identifiable in your data and research outputs (e.g. dissertation)?	✓	☐	☐
5. Will all electronic data collected be stored securely on Heriot-Watt systems (e.g. university home drive or OneDrive)?	✓	☐	☐
6. Will any mobile data recording or storage devices used (e.g. voice recorder, laptop) be PIN/password protected and/or encrypted?	✓	☐	☐
7. [Research involving animals only] Will your study employ the 3R principles (i.e. replacement, reduction, refinement)?	☐	☐	✓

8. [Research involving animals that are regulated by the Animals (Scientific Procedures) Act 1986 (ASPA) (e.g. vertebrates or cephalopods) only] Do you have an ASPA licence for your research?	☐	☐	✓
If you answered 'no' to one or more of Questions 1-8 skip to Section C. Otherwise proceed to Section B2.			
B2) Risk indicators			
9. Will your study involve the participation of any of the following vulnerable groups:			
• Children?	☐	✓	☐
• Adults who lack capacity to consent (due to learning disability or other cognitive impairment, for example)?	☐	✓	☐
• People who may be vulnerable due to their past experiences or current circumstances (e.g. refugees, homeless people, people with mental health issues etc.)	☐	✓	☐
10. Will your study involve collection of sensitive ('special category') data (i.e. political opinions, religious or philosophical opinions, racial or ethnic origin, trade union membership, physical or mental health, sex life or sexual orientation, alleged or proven offences)?	☐	✓	☐
11. Is there any risk that participants may potentially experience stressful or unpleasant situations as a result of their participation?	☐	✓	☐
12. Are there potential negative outcomes from the study for participants? (e.g. compromise or damage to their physical, psychological, financial or social wellbeing)	☐	✓	☐
13. Are there any conflicts of interest relating to your study? (NB: A conflict of interest exists where a researcher(s) could profit in any way or if there is a pre-existing dependent relationship between a researcher and participant)	☐	✓	☐
If you answered 'yes' to one or more of Questions 9-13, proceed to Section C. Otherwise skip to Section D.			

SECTION C: FULL ETHICAL APPROVAL (for projects involving higher levels of risk only)	
Your responses above indicate that your study presents potential risks and requires detailed ethical appraisal by EGIS' Research Ethics Committee. You must complete an application for full ethical approval via Heriot-Watt's Ethics Management System (EMS) and provide the approval number below. Access EMS training and apply on-line at: https://ethics.hw.ac.uk.	
EMS approval number:	

SECTION D: DECLARATIONS			
I have read the *Research Ethics Guide for EGIS UG/PGT Students* and understand my responsibility as a student/supervisor in this ethics review process. The information provided in this form is accurate to the best of my knowledge.			
Student signature:		**Date:**	19/10/2023

Supervisor signature:		**Date:**	20/10/2023