Temporal Variations in Tourism Activities at a Key Marine Protected Area in the Maldives (2010-2019)

By

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Manta
T R U S T

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Impact Statement

1.   Why was this project undertaken?

This project was undertaken to understand how tourism activity has changed in the Hanifaru Bay Marine Protected Area (MPA) and Baa Atoll UNESCO Biosphere Reserve between 2010-2019. The effectiveness of the Hanifaru Bay Management Plan will be assessed after being implemented between 2011-2012. This information will be used to administer advice to the Manta Trust and the Maldivian Government to help establish updated guidelines that are in line with new developments in the area, to reduce any adverse effects on the MPA and megafauna that use the site.

2.   How did you write up the report, to which format?

This dissertation was formatted and written in the style of an internal report for the Maldivian Manta Ray Project (MMRP) and the Manta Trust.

3.   What will the partner do with the results, conclusions and recommendations?

The findings within this report will be used to administer advice to the Manta Trust and the Maldivian Government to help establish new guidelines in the Hanifaru Bay MPA and Baa Atoll UNESCO Biosphere Reserve that are in line with new developments in the area and to reduce any adverse effects on the megafauna that use the site.

Acknowledgments

Executive Summary

Tourism activities within Hanifaru Bay Marine Protected Area (MPA) and Baa Atoll UNESCO Biosphere Reserve have increased between 2010-2019 due to increased public awareness of manta ray tourism present in the region. The Hanifaru Bay Management Plan was introduced by the Maldivian Ministry for the Environment and UNESCO between 2011-2012 and was shown to be effective in managing tourism activity between 2011-2017 with a clear reduction in both boat and snorkeller numbers present when compared to pre Management Plan levels (2010) (Environment, 2011). However, advancements in technology use within the bay and changes in accommodation capacity within Baa Atoll has seen a dramatic increase in tourism activity inside Hanifaru Bay. The 2019 season had tourist numbers return to pre-Management Plan levels as seen in 2010. These recent changes in tourist activity in Hanifaru Bay suggests the Hanifaru Bay Management Plan requires updating to cope with this increased tourist pressure.

Peak tourist activity within Hanifaru Bay was shown to occur between July to September, on flood and high tides as well as full and new moons and all correlated closely with peak manta ray activity in the bay (MMRP, 2014). To protect megafauna utilising Hanifaru Bay MPA it is recommended that ranger presence is increased during these peak times of tourist activity. Increased on site monitoring of visitor permits and snorkeller numbers by rangers should take place alongside on the spot fines to any operators breaking site rules, allowing increased enforcement and adherence to current site rules. During peak times, permit fees should be increased to discourage large numbers visiting the site and increase funding for rangers to implement more stringent on site regulations and it is recommended that tour operators voluntarily reduce guest numbers from 10 to 5 per guide to increase in water codes of conduct compliance of guests.

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1. Introduction

1.1 Biology of Manta Rays

Manta rays belong to the elasmobranch subclass in the mobulidae family and have a circumglobal distribution in both tropical and sub-tropical waters (Marshall and Bennett, 2009). There are two known species of manta rays, the reef manta (*Mobula alfredi)* which is the smaller of the two with a disc width of 4.5m and the oceanic manta ray (*Mobula birostris)* with a disc width of 7m and a slightly larger geographical range reaching into temperate waters (Marshall and Bennett, 2009). Currently manta ray life history, behaviour and populations are poorly understood globally and it is suggested that in the wild individuals can be expected to survive for an average of 29 years (Marshall and Barreto, 2018).

Manta rays have the highest brain encephalisation of any elasmobranch and as a result from this they show complex social behaviour between individuals (Ari, 2011; Perryman *et al.*, 2019). Complex social behaviour has been observed in a reef manta population in Raja Ampat, Indonesia where strong social links were observed between individuals whilst using specific cleaning stations (Perryman *et al.*, 2019). They are slow to mature taking an average of 6-8 years with the lowest fecundity of any elasmobranch (Marshall and Bennett, 2009; Ari, 2011; Dulvy *et al.*, 2014). Manta rays are ovoviviparous, gestating for a period of 12 months with single pups being born at a size of 1.5m (Marshall and Bennett, 2010). After giving birth females have a lag period of 1-2 years before mating reoccurs (Marshall and Bennett, 2010). This low fecundity and late maturity is believed to be due to the low rate of natural mortality within adults, which places the group at particular risk of overexploitation (Marshall *et al.,* 2018).

1.2 Fisheries Risks to Manta Rays

Mantas rays are often targeted by fisheries for their gill plates to be used in Asian medicine (Heinrichs *et al.*, 2011). Fishing pressure on mobulids has increased by an order of magnitude from 1998-2008 and there is clear evidence of population decline in areas around the world with a recorded decrease of manta ray landings in Indonesia, Sri Lanka and Mozambique (Heinrichs *et al.*, 2011; Lawson *et al.*, 2017). Due to their low fecundity and slow rate in reaching maturity even a small number of landings in subsistence fisheries can cause dramatic population decline. For example, in Mozambique 20-50 *M. alfredi* were being caught annually and a population decline of 80% across 9 years was recorded (Heinrichs, *et al.,* 2011).

This suggests that no level of manta ray fishery could be considered sustainable and has led to both species being added onto the International Union for Conservation of Nature's (IUCN's) Red List as 'Vulnerable to extinction' as well as being placed under Appendix I and II of CITES in 2013 (Kashiwagi *et al.*, 2011; Marshall *el al.,* 2018, Ward-Paige, Davis and Worm, 2013; Dulvy *et al.*, 2014).

The gill plate trade has an estimated worth of $11 million US dollars annually with each manta ray valued between $40-500 US dollars (Heinrichs, *et al.*, 2011). When compared to the estimated tourist value of a single manta ray over its lifetime of $1 million US dollars, it's clear that tourism is more beneficial, both for manta rays and local communities (Heinrichs *et al.,* 2011). Fortunately, the Maldives realises this and there has never been a commercial manta or mobula fishery in the Maldives and in 2014 the Maldives declared all sharks and rays as protected species in their waters (MMRP, 2014). The closest manta ray and mobulid fisheries to the Maldives are present in Sri Lanka and India (Lawson *et al.*, 2017).

Bycatch also puts global manta ray and mobulid populations at risk, particularly from bycatch in tuna purse seine nets (Dewar *et al.*, 2008; Heinrichs, *et al.,* 2011). Fortunately, all tuna fishing that occurs in the Maldives Exclusive Economic Zone (EEZ) is line caught and net methods are not used, increasing protection for the species in the region. It is worth noting that line fishing can still have negative impacts on the Maldivian manta population. For example, it has been shown that 36% of sub-lethal injuries recorded amongst manta rays visiting Baa Atoll are anthropogenic in origin with fishing line injuries making up 88% of these injuries (MMRP, 2018). Maldivian manta populations could also still be at risk from foreign tuna purse seine vessels fishing illegally in Maldivian waters (Miller *et al.*, 2017).

1.3. Manta Ray Based Tourism in the Maldives

The Maldives is a remote archipelago in the Indian Ocean comprised of atolls that stretch for 800km North to South. The region supports 1,100 species of fish and has the largest known population of reef mantas in the world, currently recorded at 4,941 individuals from the use of photographic identification (photo-ID) with an estimated total population of around 6,000 (Kitchen-Wheeler, 2010; MMRP, 2018). Tourism is the biggest business sector in the Maldives with nature-based income making up roughly 70% of the country's revenue (World Bank, 2010). Manta rays specifically are a big draw for tourists to the region with manta ray tourism contributing approximately $8.1 million US dollars in direct revenue to the Maldives each year (Anderson, *et al.,* 2011; Murray *et al.,* 2019). In 2010 alone, Hanifaru Bay, a famous destination to encounter manta rays in large numbers, had a total revenue intake of $603,284 US dollars (Brooks, 2010).

1.4. Introduction to Manta Rays in the Maldives

The Maldives is home to both species of manta rays with the reef manta ray (*Mobula alfredi*) being the most common (Anderson, *et al.,* 2011). There are distinct differences between the two species in both appearance and behaviour (Marshall and Bennett, 2009). These differences can be observed within the Maldives as reef manta populations are present in the archipelago year-round. They are often resident to one particular atoll with migration in the archipelago being heavily dependent on monsoonal conditions that drive changes in zooplankton abundance (Kitchen-Wheeler, 2010; Anderson, *et al.*, 2011; Harris *et al.*, 2020). Oceanic mantas, however, have only been recorded in substantial numbers between March-April every year at the remote southern Fuvahmulah Atoll (fig 1.6) in which there are few re-sightings of individuals (MMRP, 2019a). These lack of re-sightings suggest they are only passing through and not utilising the site for cleaning or feeding (MMRP, 2019a). Due to the lack of oceanic manta ray sightings, most of the research both globally and in the Maldives, is focused on reef manta rays so a lot less is known about the life-history of oceanic manta rays (MMRP, 2019a).

Figure 1.4. Shows tourists enjoying interacting with manta rays within Hanifaru Bay (The Manta Trust, 2018)**.**

1.5. Hanifaru Bay MPA and Baa Atoll UNESCO Biosphere Reserve
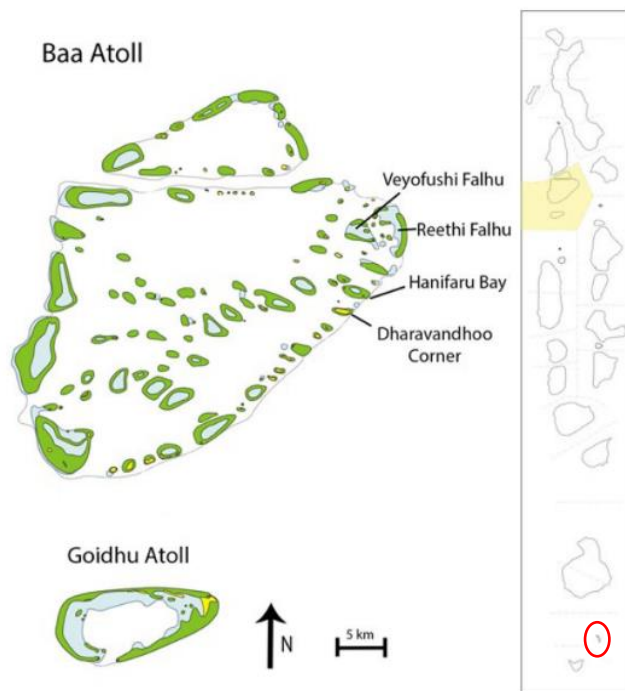
Figure 1.5. Map showing the location of Hanifaru Bay MPA and other important manta ray aggregation sites within Baa Atoll and its relation to the rest of the Maldives (MMRP, 2018). Red ring on the map of the Maldivian archipelago used to locate Fuvahmulah Atoll.

Hanifaru Bay, situated in Baa Atoll, is the most famous site to encounter manta rays in the region and is known for having the world's largest feeding aggregation of reef mantas in the world and occasional whale shark (*Rhincodon typus)* sightings (MMRP, 2014). Baa Atoll itself is of particular importance to manta rays with almost half (42%) of the Maldives reef manta ray population (*n*=4,941) being recorded in this region over the past decade (MMRP, 2019b). After increased media attention from National Geographic and BBC's 'Natural World' series in 2009-2010, the region saw an increase of 158% in tourist numbers between 2009-2010 alone (Barcott B, 2010; Brooks, 2010).

Reef manta rays visit Baa Atoll and Hanifaru Bay during the southwest monsoon (locally known as Hulhangu) between May-October each year (Anderson, *et al.,* 2011). The southwest monsoon creates strong winds causing oceanic currents to flow from the southwest to the northeast (Brooks, 2010; Anderson, *et al.*, 2011; Harris *et al.*, 2020). When this current reaches the Maldivian archipelago that rises 2,000m from the seafloor, it creates nutrient upwellings that support a sudden growth of both phytoplankton and zooplankton attracting the manta rays and whale sharks that feed upon them (Anderson, *et al.,* 2011; MMRP, 2014; Harris *et al.*, 2020). When this concentration of highly plankton rich water becomes trapped in the bay it can support up to 240 feeding mantas in one day (MMRP, 2016). Research conducted by the Maldivian Manta Ray Project highlights a strong correlation in the monsoonal wind strength and numbers of mantas present in the bay with higher winds causing an increase in mantas at the site (MMRP, 2018).

Hanifaru Bay was designated as a Marine Protected Area (MPA) by the Maldivian Government in June 2009 and local resorts implemented a memorandum of understanding on how to use the site. This involved putting voluntary codes of conduct in place that included a minimum 20m distance between mantas and boats as well as mandatory briefings for tourists (Brooks, 2010; MMRP, 2014). Despite this legal status there was no Governmental presence to monitor site use or enforce regulations up until 2010 (MMRP, 2010). This meant that in 2010 adherence to regulations was still low with site usage exceeding the recommended capacity on 29% of the days surveyed (MMRP, 2010).

The Hanifaru Bay Management Plan was set up in 2011 to combat this with a goal "To ensure the long-term sustainable management and protection of Hanifaru reef, its resources and biodiversity." This occurred alongside a suite of other MPAs in Baa Atoll as part of the UNESCO Baa Atoll Biosphere Reserve (Environment, 2011). It was slowly introduced during a transition phase between July-December 2011 before full MPA status was implemented in January 2012 (Environment, 2011).

1.5.1. Hanifaru Bay Management Plan: Phase 1

Phase 1 involved introducing alternate day permits for resorts, safari boats and guesthouses. Maximum vessel capacity at the site was capped at five at one time with specific entry and exit routes placed at the northern entrance to Hanifaru Bay (Environment, 2011). A dedicated zone for guest drop-off and collection was marked along the northeast corner of Hanifaru Bay (Environment, 2011). During this period SCUBA was actively discouraged but not banned (Environment, 2011). Visitors to the site were also limited to a maximum of 80 at one time and a time limit of 45 minutes was introduced alongside an entrance fee of 25 MVR to fund the Management Plan (Environment, 2011).
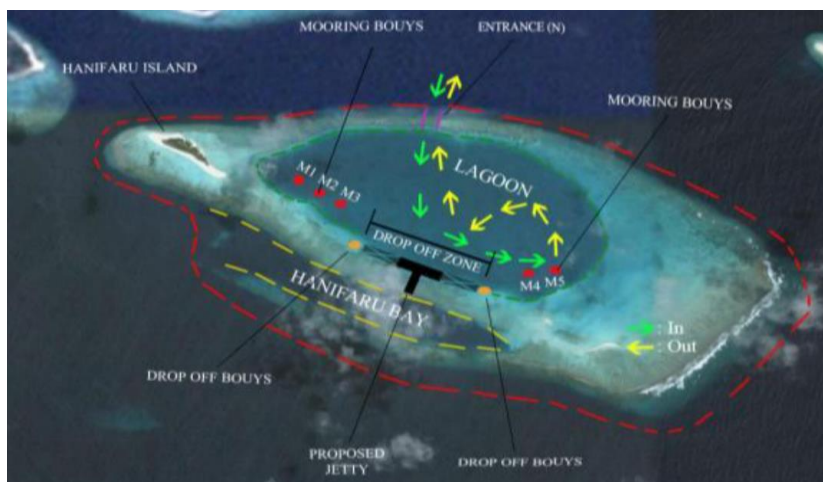
Figure 1.5.1. Shows the layout of Hanifaru Bay MPA and how vessels should utilise the site (Environment, 2011).

1.5.2. Hanifaru Bay Management Plan: Phase 2

Phase 2 introduced laws that any company and guide operating within the MPA must be certified with a Hanifaru Bay Guide License from the Biosphere Reserve. A maximum of 10 snorkellers per guide was introduced

and SCUBA was also banned within the bay from January 2012 alongside any flash photography and videography (Environment, 2011). Speed limits were put in place, 200m from the MPA to 5 knots and down to 2 knots whilst transitioning in and out of the bay (Environment, 2011). When moving through the lagoon a minimum distance of 50m between megafauna and vessels had to be maintained (Environment, 2011). Snorkellers in the water were mandated to be at least 3m away from megafauna at one time with no touching or chasing permitted (Environment, 2011).

1.5.3. Adherence to the Hanifaru Bay Management Plan

During July 2012, Biosphere Reserve Rangers from the Environmental Protection Agency (EPA) patrolled Hanifaru Bay and collected visitor permits. This meant that during the 2012 period, adherence to the site use was strictly enforced. In 2013, there was a lack of EPA rangers present which ultimately resulted in increased regulatory infractions including; SCUBA divers in the bay, poor compliance of the alternate day rule and fishing within the bay (MMRP, 2013). Fortunately, from 2014 onwards, the Biosphere Reserve Rangers resumed consistent presence within Hanifaru Bay and management regulations were reinforced (MMRP, 2014).

1.6. Tourism Risks to Manta Rays in the Maldives

As these manta ray aggregations are influenced by the tide, they are very predictable for tourist operators, so when the feeding opportunities are at their peak, often both manta and tourist numbers are at their highest (MMRP, 2014). Safari boats visiting the region increased dramatically by 308% between 2009-2010 (Brooks, 2010). In 2011 a reduction in manta sightings was recorded in Hanifaru Bay, it is not known, however, if this was related to increased tourism pressure as a lower zooplankton count was also recorded during the same year (Atkins, 2011; MMRP, 2018). Climatic observation in recent years, suggests environmental conditions had a significant role to play (Atkins, 2011; MMRP, 2018).

Anecdotal evidence suggests mantas often move to other feeding areas that are potentially less favourable when disturbed by large amounts of tourists at highly productive sites (Anderson *et al.,* 2010). This could be of detriment to manta rays in Baa Atoll, as reduced utilisation of Hanifaru Bay, as a feeding site, could have a negative impact on the fitness of the local manta population. Similar studies investigating tourism impacts on marine mammals suggests that whale watching can potentially have negative impacts on the whales being observed with individuals performing avoidance behaviours (Fiori *et al.*, 2019). It can be seen that manta rays perform avoidance behaviour in the presence of tourists which can lead to cleaning and feeding cessation when snorkellers do not adhere to codes of conducts. This is concerning as in the Maldives only 44% of manta ray-tourist interactions kept to code of conduct regulations (Murray *et al.*, 2019). These short-

term behavioural changes, like avoidance, could potentially lead to long term consequences, including reduction in feeding time (Lusseau and Bejder, 2007; Schuler *et al.*, 2019). This reduction in feeding time could reduce energy budget affecting reproduction rates resulting in population decline (Lusseau and Bejder, 2007). If manta rays exhibited avoidance behaviour of tourists at Hanifaru Bay, reducing their feeding time, it could result in reduced energy reserves and the same result may be observed.

Increased tourism will increase boat traffic in Baa Atoll and around the Hanifaru Bay MPA potentially putting the mantas and whale sharks at a higher risk to boat strikes and other disturbances (O'Malley, Lee-Brooks and Medd, 2013). A good example of the repercussions can be taken from the situation in South Ari Atoll, Maldives which is a hotspot for whale shark tourism where 40% of whale sharks in the area are seen to have boat strike injuries (Cagua *et al.*, 2014). Currently, speed limits have been put in place within the Hanifaru Bay MPA but none are present in the water surrounding it which will also be utilised by manta rays and whale sharks (MMRP, 2014). This is concerning as it could put mantas travelling to the bay at higher risk of boat strike and is an area that should be investigated in higher detail. Unfortunately, impacts of boat strike have been recorded in the Baa Atoll population with 24 individuals showing boat strike injuries (MMRP, 2018). Most famously was a well-known individual named Babaganoush (MV-MA-0033) who endured propeller injuries that were deep enough to expose internal organs of the individual. Fortunately, the individual has survived but the long-term impact of this injury is unknown (MMRP, 2018). Due to the rapid wound healing ability present in elasmobranchs the true number of boat strikes is likely to be underestimated (McGregor *et al.*, 2019). The placement of speed limits within the MPA is a great step to reduce the risk of boat strike injuries but more steps could be taken within the UNESCO Biosphere Reserve. Future investigations could examine; the location of other important manta ray feeding areas where mantas spend extended times at the surface, identify travel corridors between Hanifaru Bay and other sites within the atoll, as well as assess the spatial and temporal overlaps of manta rays and vessels in the area (Schofield *et al.*, 2013).

1.7. Evidence of Tourism Impacts within the Hanifaru Bay MPA

Currently, the Maldivian Manta Ray Project (MMRP) has carried out four MSc theses to assess and reduce the impacts of tourism behaviour in Hanifaru Bay (Brooks, 2010; Atkins, 2011; Lynam, 2012; Garrud, 2016). It was shown that the majority of manta-tourist interactions within the Maldives only complied to recommended guidelines 44 % of the time (Brooks, 2010; Atkins, 2011; Lynam, 2012; Murray *et al.*, 2019).

Major disturbance was generally observed to occur from deliberate touching of mantas and swimming too close. It was seen that manta rays are more sensitive to human presence when cleaning compared to feeding (Atkins, 2011). This also correlated with another study on grey nurse sharks in Australia that showed increased agnostic behaviour by sharks when more than 6 divers were present and when divers approached closer than 2m (Smith, *et al.,* 2010). This was applied to Hanifaru Bay's code of conduct with minimum distances set at 3m for feeding and 5m for cleaning (Murray *et al.,* 2019).

1.8. Aims and Objectives of this Report

The MMRP have observed significant changes in tourism activity within the Hanifaru Bay MPA and Baa Atoll Biosphere Reserve between 2010-2019 but currently no formal analysis has been carried out on this data to quantify the scale of this change. The aim of this study is to assess the development of tourism activities and its associated impacts within the Hanifaru Bay MPA and the Baa Atoll UNESCO Biosphere Reserve in the last decade. This study will also aim to assess the effectiveness of the Hanifaru Bay Management Plan that was implemented in 2012 and administer advice to the Manta Trust and Maldivian Government to help establish updated guidelines that are in line with new developments in the area to reduce any adverse effects on the MPA and the megafauna that use the site.

1. Collect and compile multiple data sets from the MMRP, Maldivian Ministry of Tourism, Environmental Protection Agency and UNESCO Biosphere Team on tourism within the MPA and UNESCO Biosphere Reserve.
2. Carry out a thorough analysis of the compiled data to assess changes in tourism activities in the Hanifaru Bay MPA and Baa Atoll UNESCO Biosphere Reserve between 2010-2019.
3. Summarise the study's findings into the form of an internal report that can provide advice to the Manta Trust and Maldivian Government on suitable changes to the Management Plan.

2. Methods

2.1. Study Sites

2.1.1. Baa Atoll UNESCO Biosphere Reserve

Baa Atoll (Fig 1.3.) is placed in the north west of the Maldivian archipelago and a short flight away from Malé international airport making it an easy destination for international tourists. In 2011 Baa Atoll was designated a UNESCO Biosphere Reserve. Due to this designation, it has become a popular tourism destination, particularly for tourists wanting to visit the regions famous manta ray aggregation site Hanifaru Bay (Environment, 2011). Accommodation within the atoll has adapted to support this increased tourism demand with multiple options available for tourists. Land based options include resorts and hotels, which cater for a higher end tourism market and guesthouses which focus on a budget market. During certain times of the year, water based alternatives are present in the form of safari boats that visit the area specifically to encounter the manta ray aggregations the region is famous for. Due to this, the capacity for tourists in the region can fluctuate depending on the season. Understanding how the accommodation sector has changed within Baa Atoll between 2010-2019 will give key insights into understanding tourism pressures on the Hanifaru Bay MPA.

2.1.2. Hanifaru Bay Marine Protected Area

Hanifaru Bay (latitude $5^0 10'$ N, longitude $78^0 08'$ E) (fig 1.6 and fig 1.6.1.) is situated within the north east of the Baa Atoll UNESCO Biosphere Reserve. The unique positioning of Hanifaru Bay (only 200m by 150m in size) at the end of a 1600m long channel means, when the incoming lunar tide and prevailing southwest monsoonal current are running opposite to one another, a back-eddie at the channel mouth is created (Brooks, 2010). The back-eddie causes plankton rich water to be forced into the bay. Water flowing out of the bay is then picked up again by the incoming lunar tide further concentrating the plankton inside (Brooks, 2010). These unique conditions create highly predictable aggregations of manta rays and has meant manta ray tourism within the bay has become popular within the last decade.

In recent years its profile has continued to rise with increased awareness and advertising of the site through social media from resorts and dive operators *(Sawers, pers comms.*, 2020). Gaining better insight in how this increased tourist interest is having on tourist numbers visiting Baa Atoll is key to finding ways of protecting Hanifaru Bay MPA for the future.

2.2. Data Collection

2.2.1. Tourism and Manta Ray Activity within Hanifaru Bay by Year, Month, Tide Type and Tide Cycle between 2010-2019

Tourism and manta ray data was collected within Hanifaru Bay MPA by MMRP staff with a total of 1,038 surveys conducted over ten years (2010-2019) during the southwest monsoon season (June-November). Surveys within the bay were carried out on as many days as possible, where the weather conditions allowed. Total manta ray sightings within the bay were confirmed through photo ID methods and total snorkeller and boat numbers were recorded through visual identification. Survey start and end times were recorded and tidal data for Hanifaru Bay was sourced from the Naval Oceanography Portal for the Maldives (Portal, 2020). Luna data for tide cycle analysis was sourced from timeanddates.com for Malé, Maldives (timeanddate.com, 2020).

2.2.2. Accommodation within the Baa Atoll UNESCO Biosphere Reserve

Land based accommodation data was collected by the Maldivian Ministry of Tourism Office and data was sourced from their Annual Tourism Yearbook Reports from 2010-2019 (Ministry of Tourism, 2019). Number of resorts and hotel data was collected from 2007-2019 alongside bed capacity. Due to limited data availability, number and bed capacity for guesthouses was only available between 2014-2019. Hotel and resort data were combined, this was decided as "Amillia Fushi" was classified as a hotel in the Annual Yearbook Reports but caters to the same upmarket clientele as resorts. Guesthouse numbers were analysed separately as they targeted a more budget tourist market.

Safari boats visiting Baa Atoll and Hanifaru Bay were recorded by MMRP staff through visual identification and this was completed during daily MMRP manta ray surveys (n=1658) over ten years (2010-2019) during the southwest monsoon season (June-November).

2.2.3. Baa Atoll Dive Operator Recommendations Questionnaire

Using the findings from the data analysis within this report, preliminary recommendations were created on how to update the Hanifaru Bay Management Plan for the future. To ensure these recommendations could be effectively implemented they needed to be practical for tourist operators to adhere to. To achieve this, a questionnaire was created and sent to local stakeholders for their opinion on the suggested recommendations and to gauge how these changes would impact their operations.

Table 2.2.1. shows the basic layout of the questionnaire. Firstly, participants were asked for their dive operation type followed by a set of questions on each potential recommendation. All potential recommendations were incorporated. These ranged from keeping the management plan as it is, to complex ticketing systems within the bay. Participants were asked which recommendation they preferred and finally asked if they felt anything was not being addressed under the proposed recommendations.

Table 2.2.1. Shows the questionnaire layout that was sent to Baa Atoll Dive Centre Operators. For full questionnaire see Appendix 7.0.

Q1. What type of operation do you run?
a) Locally based
b) resort based
c) Safari boat
Q. 2-9 Reccomendation Ideas (8 included in Survey)
a) From the perspective as a business/company operating within the Hanifaru Bay MPA what positives or negatives can you see this recommendation having on your business?
b) Do you feel this recommendation would be economically viable for your business?
c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?
Q 10. After reading these recommendations presented which do you feel is your favourite?
Q11. Are there any other recommendations that have not been mentioned you feel the Hanifaru Bay Management Plan would benefit from?

2.3. Data Analysis

2.3.1. Tourism and Manta Ray Activity within Hanifaru Bay by Year, Month, Tide Type and Tide Cycle between 2010-2019

Snorkeller, boat and confirmed manta ray sightings were analysed individually and arranged by month (June-November) and year (2010-2019). Separating the data by year and month allowed for a better understanding on how tourism changed during the season and between seasons gaining an insight into how best to provide management recommendations for the Hanifaru Bay Management Plan. Survey start and end times were recorded when MMRP staff entered and left the water.

Snorkeller, boat and confirmed manta ray sightings per survey were also assessed against tidal changes. Tidal data was transformed using the Oregon State University Tidal Model Driver (TMD) converting hourly tidal height in metres above mean sea level into four tidal categories (high tide, low tide, ebb and flood) (Egbert and Erofeeva, 2002; Peel et al., 2019; Harris et al., 2020). Using survey start times, the database was separated out into these four tide types; high tide was categorised as being an hour either side of the recorded high tide time, low tide was classed as 5 hours before or after high tide.

This was done due to the tendency for Baa Atoll tides to switch between mixed and diurnal tides. Ebb tides were classed between low and high tide on a falling tide with flood classed as a falling tide between high and low tide (Peel *et al.*, 2019).

To carry out the tide cycle analysis spring tides were calculated using predicted full and new moon dates throughout the study period. To allow for variation in tourist and manta ray activity, dates either side of the spring tide were included, this was then repeated for neap tides using first and third quarter moon phase dates. All other dates during the season were classified as mid tide.

When analysing changes in tourism and manta ray activity per 45 minute session, the same data for the survey analysis was used. Snorkeller, boat and estimated manta ray sightings were then divided by the survey length in minutes before being multiplied by 45 to get an estimated average number present per 45 minute session. It is worth noting, the 45 minute session time limit was only implemented from 2011 onwards, so the results in 2010 give a rough estimate on numbers using the site during one time as boats and snorkellers may have been present for longer than the 45 minute session length.

R studio was used to carry out all analysis on survey, tidal and per 45 minutes session data. A Shapiro-Wilk test for normality was used before running a Kruskal-Wallis Rank Sum test and a Pairwise Wilcox test was used to locate significant difference within the data.

2.3.2. Accommodation within Baa Atoll by Year between 2007-2019

The number of resorts and bed capacity for 'resorts and hotels' and guesthouses was investigated with exploratory plots using excel. The percentage share of bed capacity per year was calculated and compared to better understand the share of the tourism market within Baa Atoll. The average bed capacity per 'resort and hotel' and guesthouse was calculated and allowed insight into how accommodation capacity use has changed within the atoll. Total number of safari boats per survey in Baa Atoll was organised by year and month and a separate analysis was carried out on each category.

R studio was used to carry out safari boat data analysis, a Shapiro-Wilk test for normality was used before running a Kruskal-Wallis Rank Sum test and a Pairwise Wilcox test was used to locate significant difference within the data.

2.3.3. Baa Atoll Dive Operator Recommendations Questionnaire

Due to delays in receiving ethics approval for the questionnaire, no responses could be collected before the report deadline, so no analysis was carried out.

3. Results and Discussion

3.1. Accommodation Changes within Baa Atoll between 2007-2019

When investigating the changes in accommodation within Baa Atoll there was a clear increase in bed capacity with a 175% increase from 2007-2019 (fig 3.1.1. and fig 3.1.2.). Growth of bed capacity within resorts and hotels was steady between 2009-2015 and from 2015–2019 the rate increased dramatically (fig 3.1.1.). This same pattern was seen in the number of resort developments in Baa Atoll with an increase of 155% in the number of resorts established between 2008-2019 (Appendix 1.1.). Growth in accommodation capacity from 2010 correlated strongly with the increased profile of Hanifaru Bay influenced by articles released in National Geographic and BBC's Natural World television series during 2009 and 2010 when allowing for a delay for construction and development (Barcott B, 2010; Brooks, 2010).
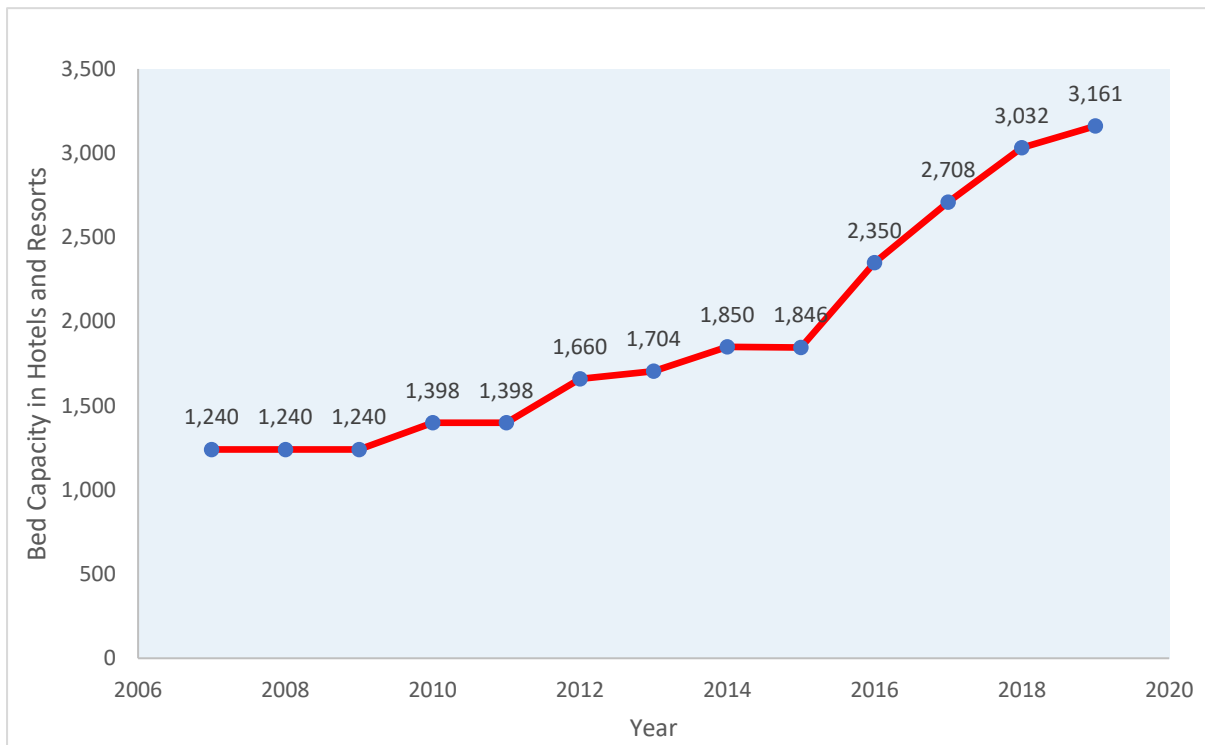
Figure 3.1.1. Shows the change in bed capacity in hotels and resorts within Baa Atoll between 2007-2019 using data sourced from the Maldivian Ministry of Tourism Office.

Unfortunately, only limited and patchy data was available on guesthouse numbers and capacity within Baa Atoll. No data was available for 2009 when guesthouse use was legalised for foreign tourists until 2014. Guesthouses were shown to have substantially increased within the Maldives making up 19% of all guesthouse capacity within the country and now provide 14% of all available beds in Baa Atoll (excluding visiting safari boats) (fig 3.1.3.) (Ministry of Tourism, 2019).

When guesthouse capacity numbers were made available in 2014, a 418% increase in bed capacity and a 192% increase in the number of registered guesthouses in Baa Atoll was seen between 2014-2019 (fig 3.1.2., Appendix 1.2.). When compared to resorts and hotels over the same time frame, a 71% increase in bed capacity and 89% increase in registered resorts was seen, suggesting guesthouses were a fast growing sector in Baa Atoll when compared to resorts (fig 3.1.1., Appendix 1.1.).

Guesthouses showed a trend in increasing their bed capacity per guesthouse with a 76% increase between 2014-2019 (Appendix 1.4.). However, a trend of decreasing bed capacity on average per resort in Baa Atoll was seen (Appendix 1.3.). The reduction in bed capacity in resorts was likely due to newer resorts having smaller capacity that cater towards a more personal service. It should be noted that some resorts increased their bed capacity from 2010-2018 with an average increase of 33 beds per resort (Ministry of Tourism, 2019).
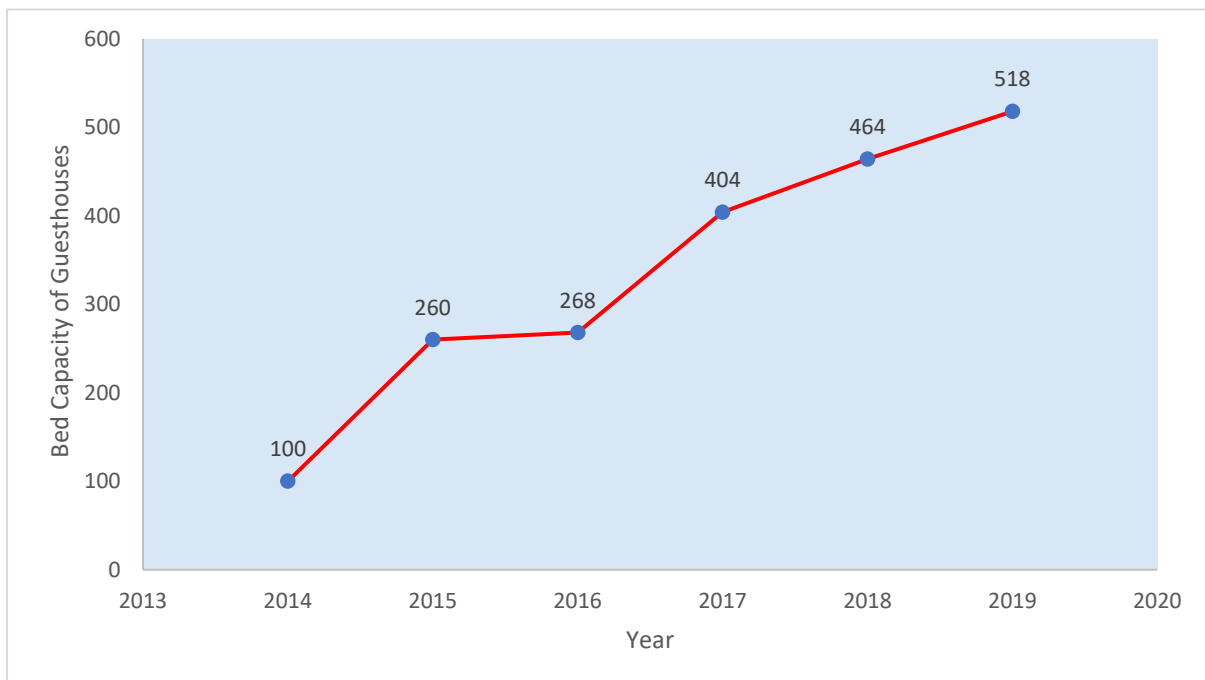
Figure 3.1.2. Shows the change in bed capacity in guesthouses within Baa Atoll between 2009-2019 using data sourced from the Maldivian Ministry of Tourism Office.

Although resorts and hotels have held the dominant share of bed capacity within Baa Atoll at 85.9% compared to guesthouses at 14.1%, the growth of the guesthouse industry has occurred faster than the resort market having gained 9% of the bed capacity share in the region from 2014-2019 (fig 3.1.3.).

A potential reason for the increased demand in more budget options for tourists, may have been due to less numbers of available safari boats visiting the region from 2012 onwards. As guesthouses (local dive centre market) share similar price brackets with safari boats when compared to resorts and hotels, who cater to a more upmarket honeymoon market (MMRP, 2016). The two to three year delay could be explained by the time delays in development permissions and construction of guesthouses and resorts.
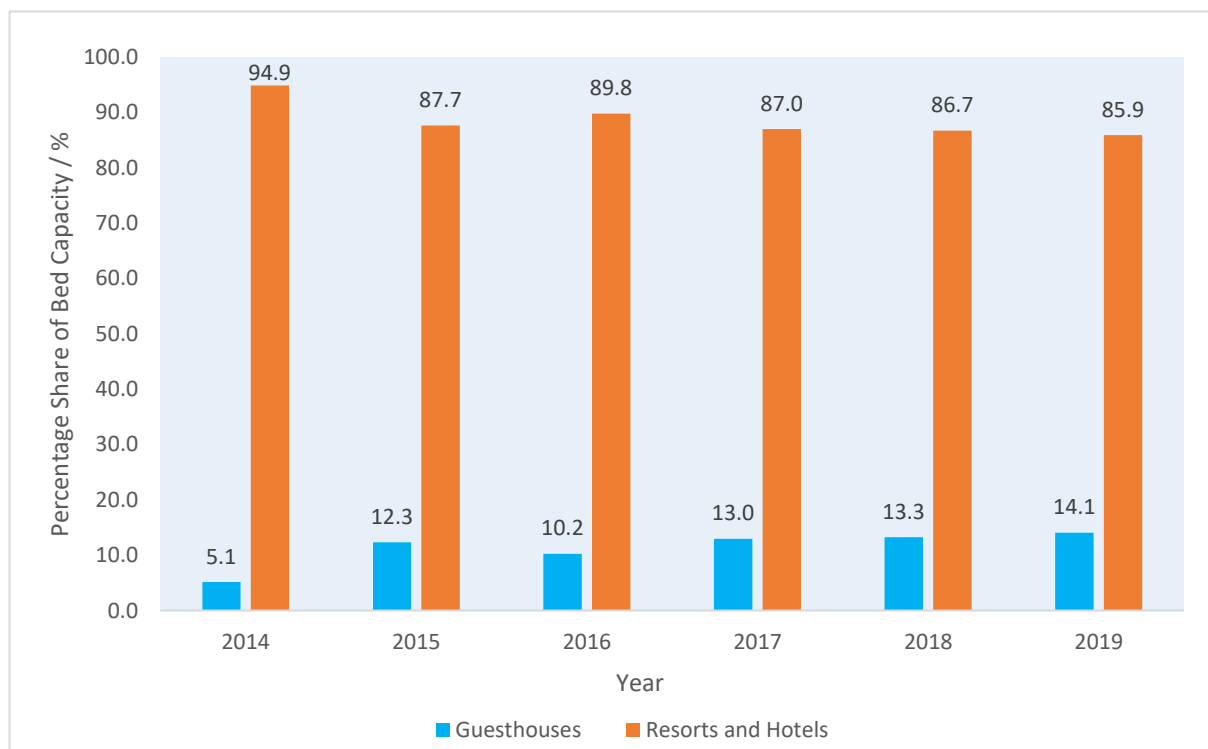
Figure 3.1.3. Shows the change in the share of bed capacity in Baa Atoll between guesthouses and resorts between 2014-2019.

3.2. Safari Boats Utilising Baa Atoll

3.2.1. Changes in Safari Boats Visiting Baa Atoll per Survey between 2010-2019

When comparing the mean number of safari boats present in Baa Atoll from 2010 to 2019,, there was a significant reduction between 2011-2012 ($n=173, n=173, p=<0.001$) (average of 3.35 and 0.6 per day) before maintaining a stable number up until 2019 (fig 3.2.1.). This pattern has already been theorised by the MMRP to be due to the introduction of alternate day permits and SCUBA ban put in place as part of the Hanifaru Bay Management Plan in 2012 (MMRP, 2016). The reduction in safari boats was due to multiple factors, as safari boats focus their services around scuba diving rather than snorkelling, coupled with the difficulty of planning trips around alternate day permits and the extra costs to factor Hanifaru Bay into their itineraries, resulting in a reduced incentive to visit Baa Atoll (MMRP, 2016). Despite these disincentives to visit Baa Atoll by safari boats, companies that promoted snorkelling in the bay were still successful (MMRP, 2016).
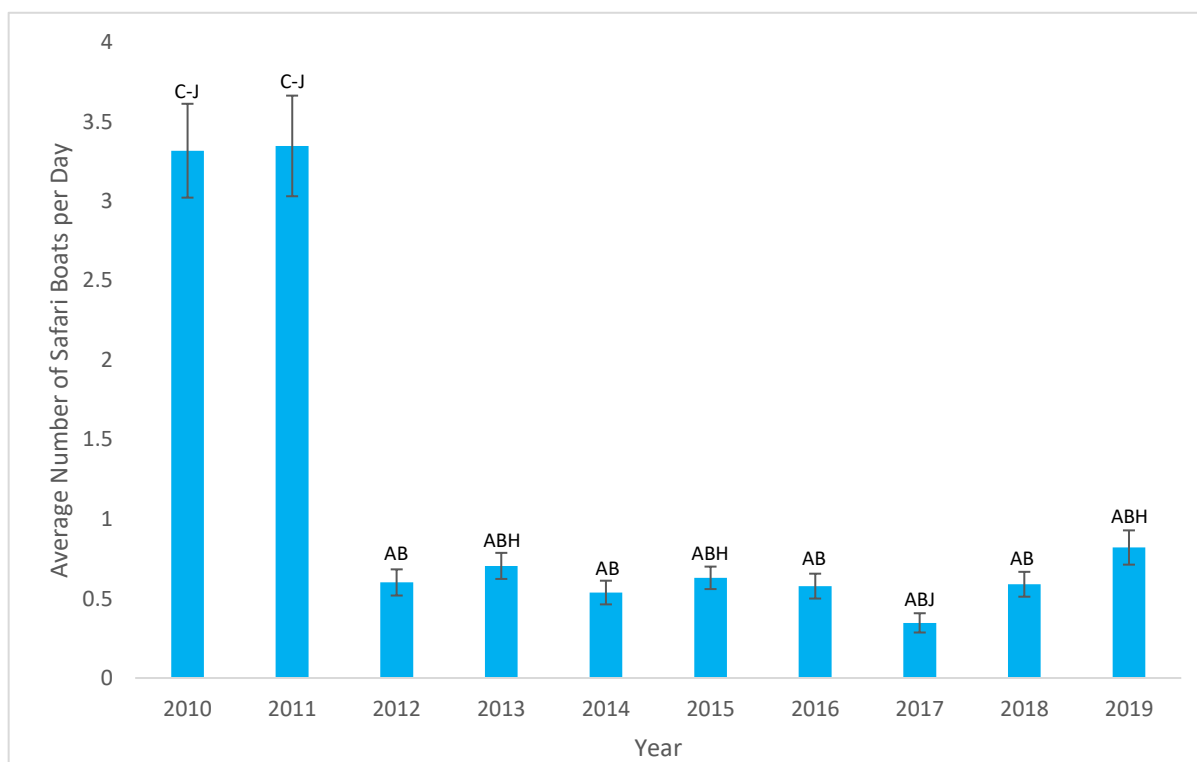
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.2.1. Shows the average number of safari boats visiting Baa Atoll per day between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.56534, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 2571.2, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

3.2.2. Changes in Safari Boats Visiting Baa Atoll per Day during the Southwest Monsoon between 2010-2019

Safari boats visiting Baa Atoll also had a much more pronounced season showing very limited numbers visiting between June, July and November with an average of 0.47 boats present per day during these months. A peak occurred over August ($n=279$,$n=260$ (June), $p=<0.001$) (average of 1.57 per day) and September ($n=271$,$n=260$ (June), $p=<0.001$) (average of 1.49 per day) with a slight reduction in October ($n=279$,$n=260$ (June),$p=<0.001$) (average of 1.05 per day) (fig 3.2.2.). Safari boats were likely to visit in a smaller window to guarantee best chances of manta ray sightings at the peak time of year as their clientele have a higher focus on manta ray encounters. This also helped to save on fuel costs that are involved when travelling from Malé to Hanifaru Bay (MMRP, 2016). The increased numbers of safari boats visiting Baa Atoll during August-October is likely an important factor causing the increased boat and snorkeller numbers in Hanifaru Bay during August and September (Section 3.5.).
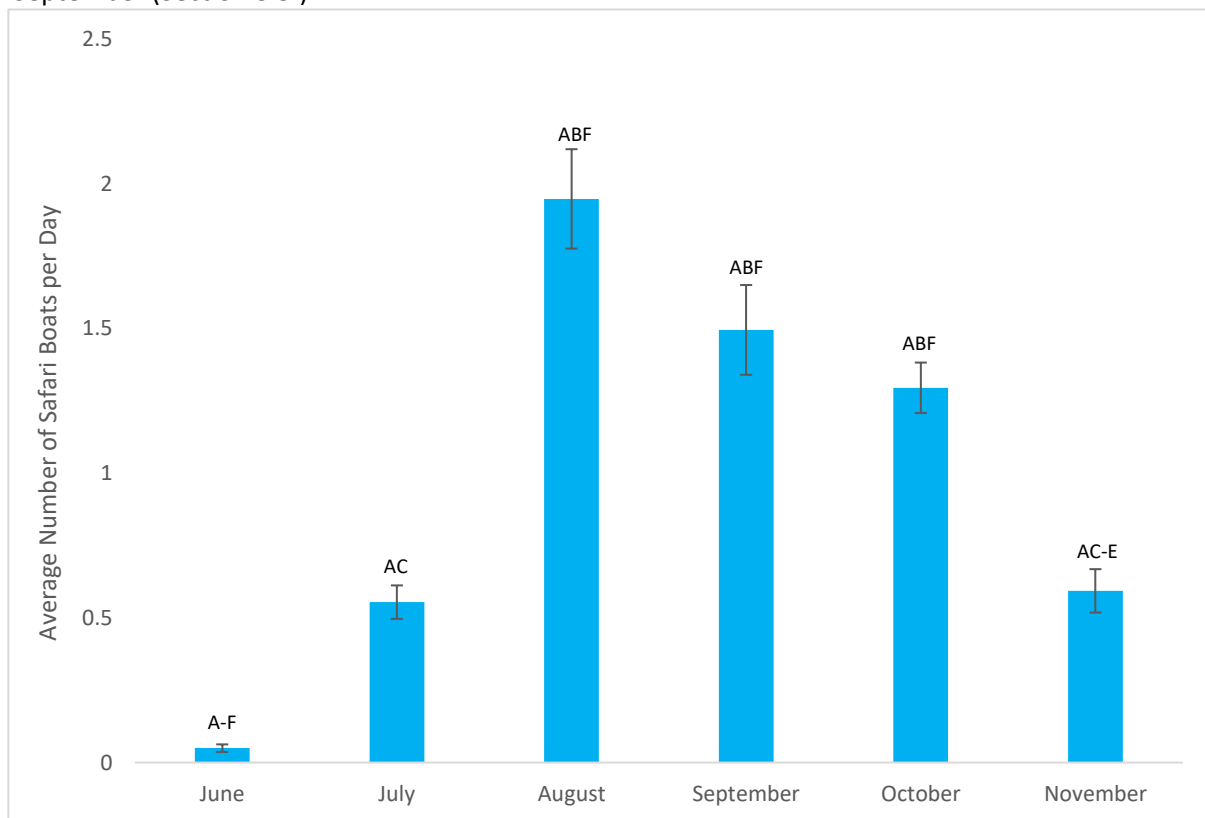
Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.2.2. Shows the average number of safari boats visiting Baa Atoll per day between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.55241, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 2707.9, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05) Error bars in standard error.

3.3. Tourism Site Use in Hanifaru Bay Pre-Management Plan (2010) to Post Management Plan 2011-2019

3.3.1. Changes in Daily Tourism and Manta Ray Site Use between 2010-2019

Before any official Management Plans were in place, during 2010, the highest number of boats using the site was recorded at an average of 7.84 per survey (fig 3.3.1.). When the Hanifaru Bay Management Plan was introduced in 2011, visitors were limited to 80 snorkellers and 5 boats being able to visit the site at one time (Environment, 2011). SCUBA in the bay was also banned during this time (Environment, 2011). These restrictions were shown to have had a significant effect on site use at Hanifaru Bay with a clear decrease in boats (63% mean reduction) and snorkellers (49% mean reduction) using the site between 2010 to 2011 ((boats)n=140, n=84, p=<0.001) (figure 3.3.1.).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J
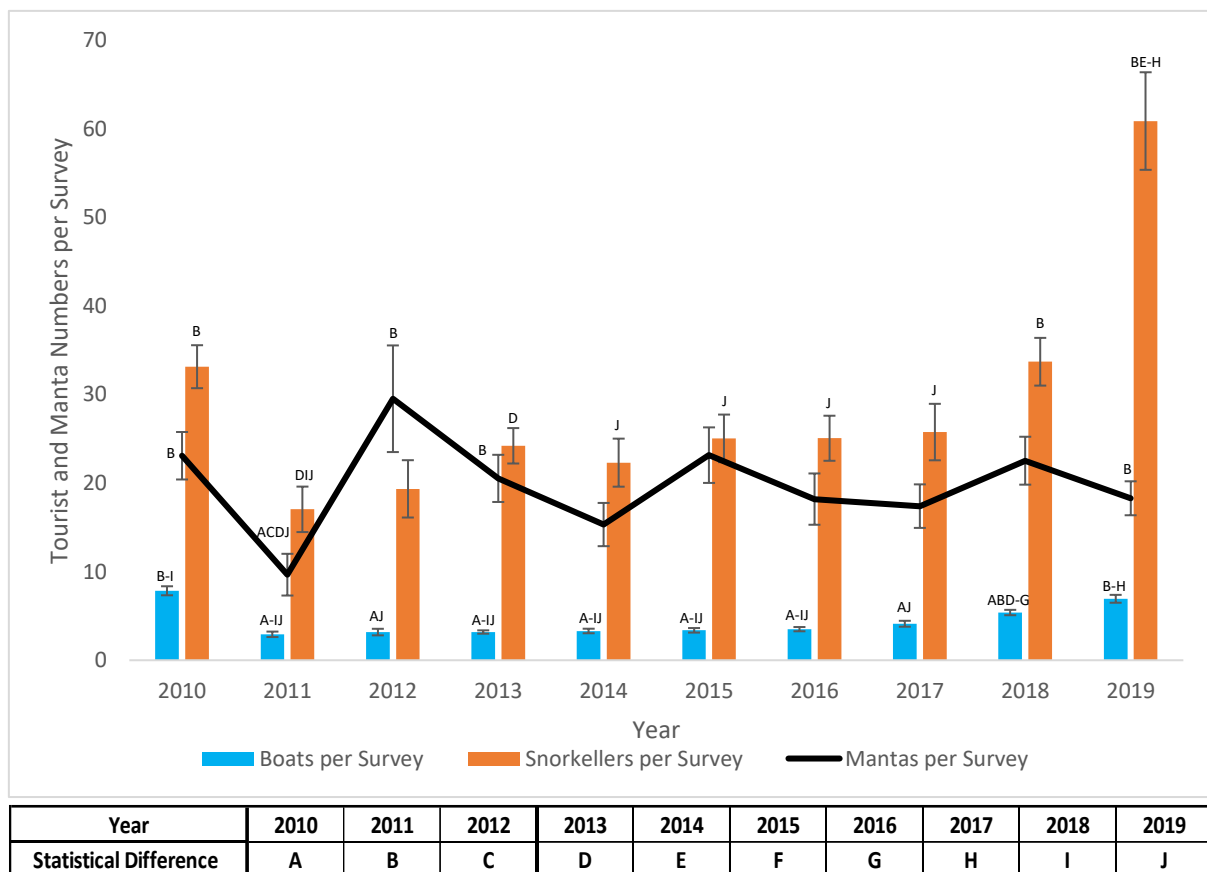
(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.3.1. Shows the average number of boats, snorkellers and manta ray (*m. alfredi*) sightings in Hanifaru Bay per survey between 2010-2019 using a Shapiro-Wilk test for normality, a Kruskal-Wallis Rank Sum test and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error. Graph is a combination of Appendices 2.1.-2.3. and full statistical results can be seen in appendix.

During the transitional year of 2011, SCUBA divers were still utilising the MPA but in very reduced numbers compared to 2010 and were not included in the snorkeller analysis (environment, 2011). The reduction in tourist numbers seen in 2011 stayed relatively constant with no significant change between 2011–2017 ($n=84$, $n=99$, $p = 1$). In recent years tourist numbers started to change, 2018 ($n=155$ $n=90$ (2013), $p=<0.001$) and 2019 ($n=145$, $n=99$ (2017), $p=<0.001$) saw a statistically significant increase compared to 2013-2017 in the numbers of boats present on site to the degree that there was no statistical difference between 2019 compared to 2010 ($n=145$, $n=140$, $p=<0.001$), when no restrictions were in place. A similar pattern was seen in snorkeller numbers with a significant reduction recorded between 2010 and 2011 ($n=142$, $n=82$, $p=<0.001$). Between 2011-2017 the number of snorkellers visiting Hanifaru Bay remained relatively stable but by 2018 visitations to the bay increased to numbers similar to those recorded prior to the introduction of the Management Plan ($n=82$ (2010), $n=155$ (2018), $p=<0.001$) ($n=142$ (2010), $n=145$ (2019), $p=0.77$) (fig 3.3.1.).

These findings suggest that introducing the Hanifaru Bay Management Plan over 2011-2012 was effective in reducing boats and snorkellers that visited the site and remained effective from 2011-2017. Due to the sudden increase in tourist pressure over 2018 and 2019 there was an increased possibility of boat and snorkeller numbers exceeding the maximum limit set by the Management Plan, however, to get a better picture of this, understanding tourist numbers per 45 minute session was required and is investigated in section 3.3.2.

The sudden increase in Hanifaru Bay site use seemed to correlate with increased bed capacity which was noted in Baa Atoll between 2015-2016 (fig 3.1.1. and fig 3.1.2.). The increased availability of land based accommodation may have been a factor for the rise being observed in tourist activity in Hanifaru Bay as safari boats visiting Baa Atoll have remained constant from 2012 as seen in section 3.2. Advancement in technology use e.g. drones within Hanifaru Bay by rangers, may have also contributed to this observed increase in tourist numbers over 2018 and 2019 as they were able to alert tour operators immediately when manta rays were present in the bay, encouraging large amounts of tour operators visiting the bay at once.

When comparing the number of mantas per year compared to boat and snorkeller numbers present at Hanifaru Bay, there did not seem to be a clear pattern. The only potential influence on manta sighting from tourist activity was seen in 2011 when there was a significantly reduced number of manta ray sightings compared to 2010 ($n=124$ (2010), $n=85$ (2011), $p=0.01$). This could have been due to the large numbers of boats and snorkellers that used the site per session and day in 2010. If this was the case, it would be expected that when snorkeller and boat numbers increased to similar

levels to 2010 from 2014-2019, there would have been a decrease in manta ray numbers present but this did not occur, suggesting another factor was influencing the pattern observed. This might have been due to natural variation in environmental conditions e.g. strength of monsoon and productivity of different feeding areas within Baa Atoll or potentially could be linked to the SCUBA ban in the bay over 2011- 2012 that reduced stressors on feeding mantas (MMRP, 2014).

3.3.2. Changes in Tourism Site Use by 45 Minute Session Length by Year

When the Hanifaru Bay Management Plan was introduced, visitors to the bay were limited to a maximum of 45 minutes within the bay. Unfortunately, no data was available on exact numbers present at a single time, so an approximation was required. Snorkeller and boat numbers per 45 minute session declined between 2010 -2011 (n=141, n=84, p=<0.001) after the Management Plan was introduced (figure 3.3.2.).
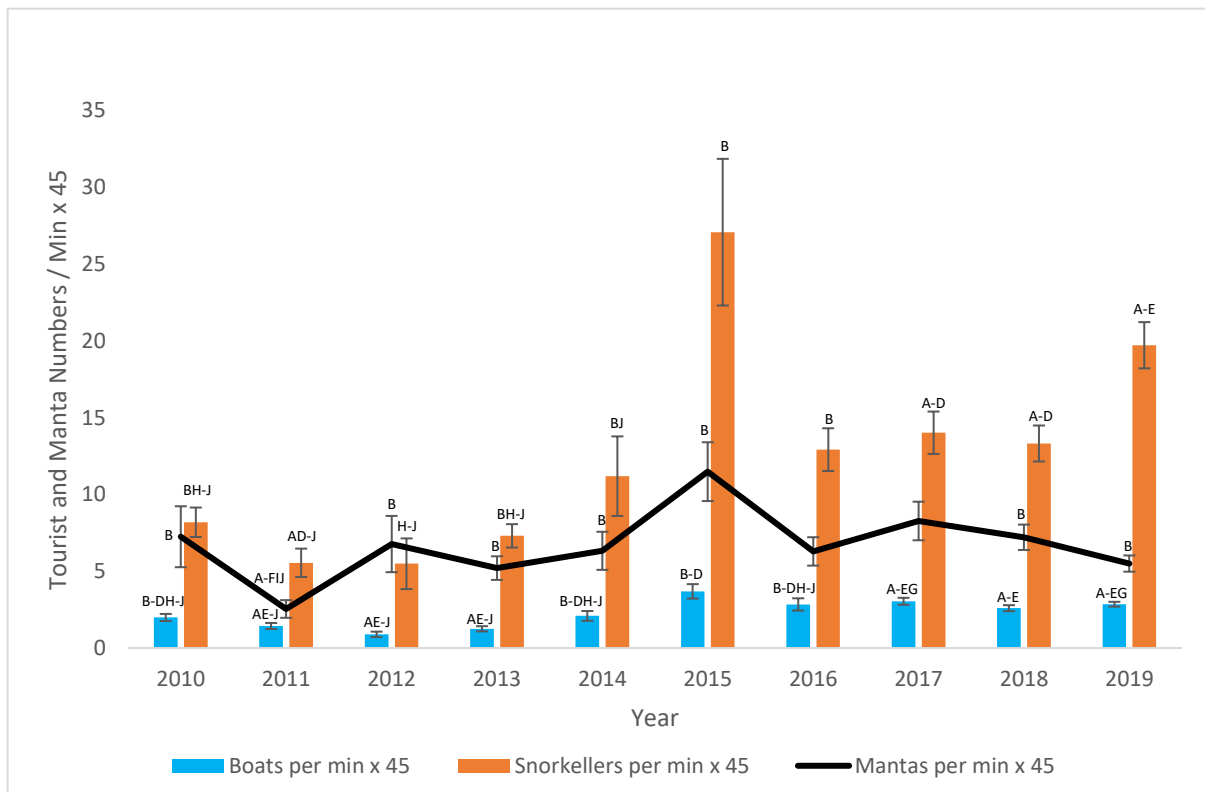
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.3.2. Shows the average number of boats, snorkellers and manta rays (*m. alfredi*) in Hanifaru Bay per 45 minute session between 2010-2019 using a Shapiro-Wilk test for normality, a Kruskal-Wallis Rank Sum test and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error. Graph is a combination of Appendices 3.1-3.3 and full statistical results can be seen in appendix.

The reduction in boat numbers was sustained between 2011 -2013 ($n=84$, $n=90$, $p=1$) and from 2014 - 2019 ($n=92$, $n=145$, $p=<0.001$) boat numbers showed an increasing trend each year (fig 3.3.2.). The same pattern could be seen in snorkeller numbers, however, it was less pronounced than boat numbers (fig 3.3.2.).

It was noted that in all years, the average number of boats and snorkellers did not exceed the maximum capacity of Hanifaru Bay at one time. Although, it could not be confirmed whether these limits were being adhered to from this data, as an average numbers per min x 45 was used rather than direct session data. During MMRP survey periods in Hanifaru Bay, bottlenecking could have occurred e.g. operators visiting in large numbers just after high tide when manta ray activity was predicted to be at its highest with lower numbers during the rest of the survey periods (MMRP, 2014). It does suggest from 2014-2019 there was an increased possibility that exceeding boat and snorkeller limits could have occurred with an increased average number of boats and snorkellers in place at the site. Understanding when during the day these bottlenecking events might have occurred was key and is discussed in more detail when assessing tidal influences on tourist site use and was investigated in section 3.4.

These increased numbers in both boat and snorkellers visiting Hanifaru Bay per session could have been due to an improved understanding of feeding patterns within the bay, meaning operators increasingly only utilise the site during predicted peak feeding periods from 2014-2019. Whereas during 2010-2013, operators visited the bay more sporadically in the hope they encountered feeding aggregations. Increase use of technology e.g. drones by rangers also allowed tour operators to be alerted immediately when large aggregations of manta rays were present in the bay encouraging a racing effect to the bay.

There was a slight trend in decreased manta ray sightings within Hanifaru bay per 45 minute session over three consecutive years between 2017-2019 that coincided with increased tourist activity within the bay. A previous study at a manta ray cleaning station in Raja Ampat, Indonesia showed a decrease in manta ray numbers visiting each year with an increased tourism presence (Papilaya, *et al.,* 2019). The decreased number of manta ray sightings seen in Hanifaru Bay was not statistically significant ($n=100$, $n=145$, p=1) but the precautionary principle should be applied and should be considered as an early warning sign of negative impacts on manta rays present at the site. Equally, this decrease could have been due to natural variations in manta numbers caused by yearly changes in environmental conditions, so determining exactly why this observed decrease occurred is difficult (MMRP, 2014).

3.3.3. MMRP Survey Lengths in Hanifaru Bay

When MMRP survey length was analysed, a general trend in a reduction of survey lengths within the bay was seen between 2010-2019 (n=146, n=145, p=<0.001) (fig 3.3.4.). Reduced survey length could have explained why the recorded number of boats and snorkellers increased per session length (fig 3.3.4.). A reduction in survey lengths noted in more recent years, could also have been explained by the fact that MMRP and tourism operators are better able to predict when manta ray aggregations occur within the bay. MMRP have also increased the number of survey sites they visited within Baa Atoll between 2010-2019 meaning time provisioning at Hanifaru Bay has decreased. Visiting other manta sites coupled with increased monitoring of Hanifaru Bay by rangers using drones and mobile phones to contact MMRP when manta rays were present in the bay is likely to have been why survey times at Hanifaru Bay have been reduced between 2010-2019.
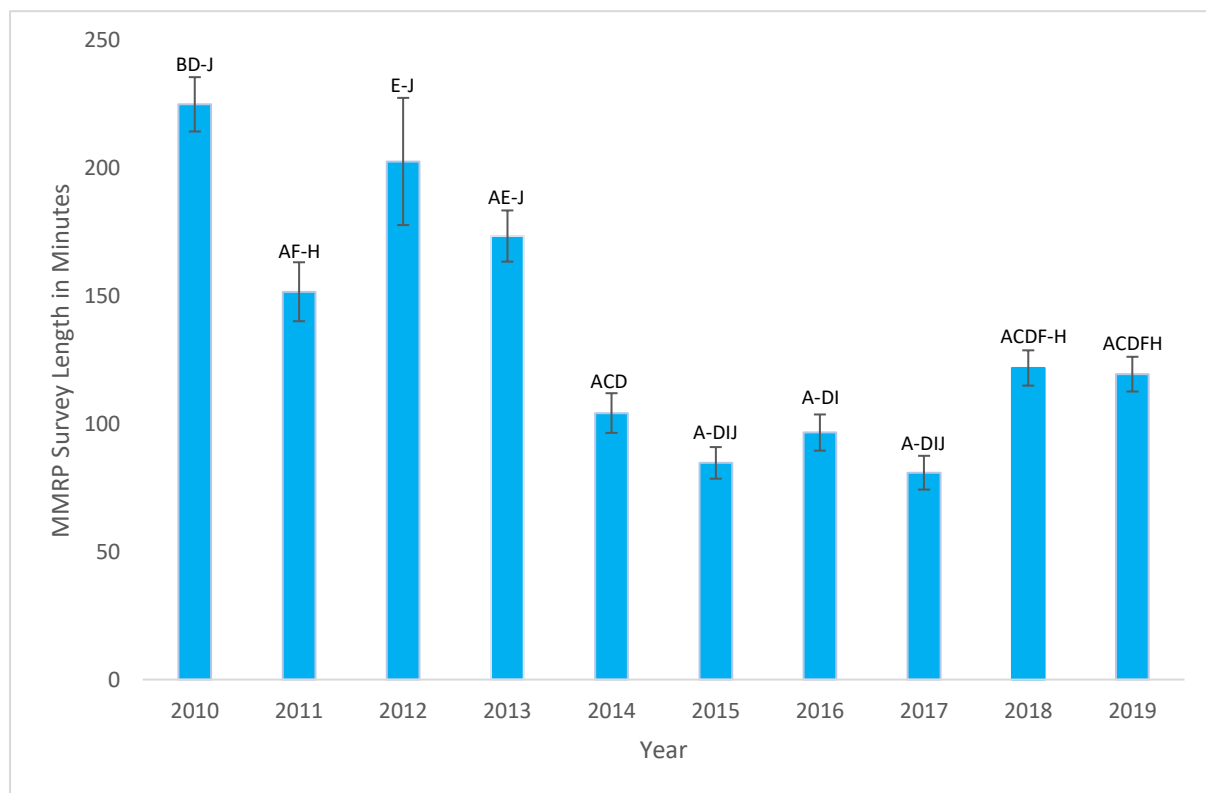
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.3.3. Shows the average MMRP survey length in Hanifaru Bay per survey between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.91761, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1644.5, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

As the number of manta rays showed no increasing trend (n=124 (2010), n=145 (2019), p=1) with a reduction in survey length at both daily and session lengths, this suggests that trends shown in boat and snorkeller numbers by year was due to changes in site use rather than sampling bias (fig 3.3.4.).

3.4. Tourist Activity within Hanifaru Bay by Tide

3.4.1. Tourist Activity within Hanifaru Bay by Daily Tide Type between 2010-2019

Snorkeller and boat activity peaked within the bay around flood and high tide when compared to ebb and low tide (Appendix 4.1 (n=383,n=133, p=0.015)) (Appendix 4.1 (n=521,n=53, p=<0.001)) (fig 3.4.1.). Manta ray activity correlated closely with tourist activity and was shown to peak around flood and high tide, although this was not statistically significant (MMRP, 2014). MMRP also focused their surveys around flood and high tide due to increased manta ray activities over that time and may have influenced the results seen (fig 3.4.2.).

Tide Type	Flood	High Tide	Ebb	Low Tide
Statistical Difference	A	B	C	D

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.4.1. Shows the average number of boats, snorkellers and manta rays (*m. alfredi*) in Hanifaru Bay by tide type between 2010-2019 using a Shapiro-Wilk test for normality, a Kruskal - Wallis Rank Sum test and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error. Graph is a combination of Appendices 4.1.-4.3. and full statistical results can be seen in appendix.

As rangers and dive operators monitored the bay regularly outside peak times, they would have alerted MMRP when manta rays were present in the bay. Due to this ranger presence, the trend seen was likely due to changes in manta ray activity rather than bias to visit during specific periods of the day.

These findings were key in understanding how to adapt management of the site and identified a clear bottleneck in site activity over flood and high tide where peak manta ray activity and tourist activity occurred.
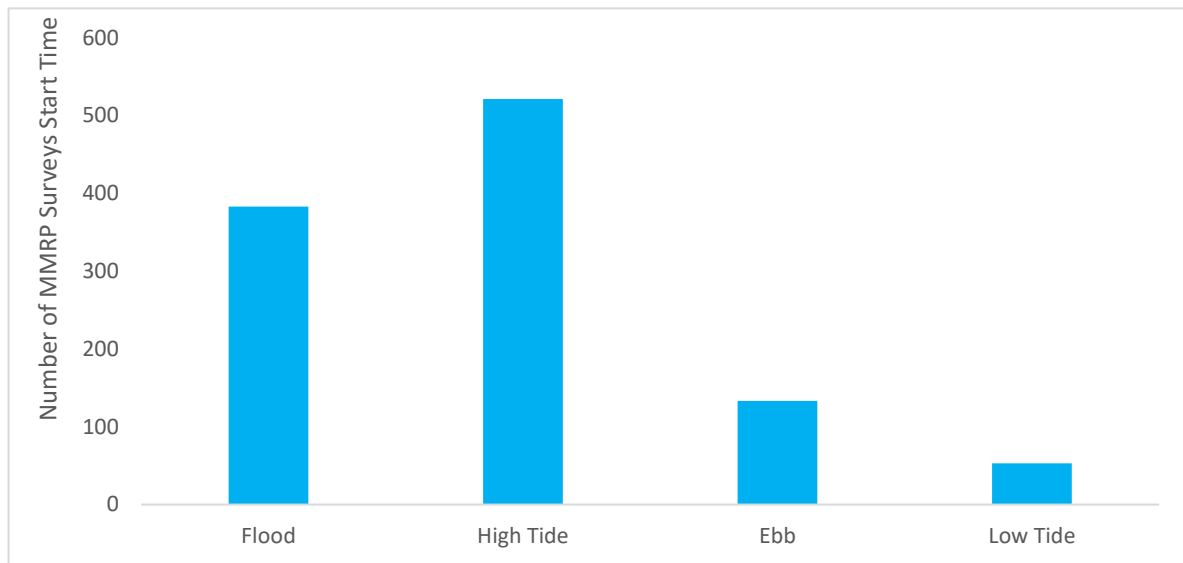
Figure 3.4.2. Graph showing the MMRP survey start time within Hanifaru Bay by tide type.

3.4.2. Tourist Activity by Monthly Tidal Cycles within Hanifaru Bay between 2010-2019

Snorkeller (n=233, n=186, p=<0.001) and boat (n=239, n=195, p=<0.001) numbers were shown to peak over spring tides (full and new moon) with the least amount of snorkeller and boat activity occurring over neap tides (fig 3.4.3.). Manta ray activity correlated very closely to tourist activity (n=236, n=193, p=<0.001) which also peaked on spring tides and was the lowest over neap tides (fig 3.4.3.).

These findings provide further support for studies carried out both globally and in Hanifaru Bay (Jaine *et al.*, 2012; MMRP, 2014). Manta ray feeding activity often peaks over new and full moon as the larger tidal movements associated with these times, cause larger planktonic upwellings to become concentrated in Hanifaru Bay, suppling more feeding opportunities for manta rays (Jaine *et al.*, 2012; MMRP, 2014).

As this feeding behaviour is well known by researchers and tour operators, tourists are often advised to visit Baa Atoll to coincide with full and new moons, to increase their chances to encounter larger aggregations of manta rays. This in turn leads to a peak in tourism activity during these times.
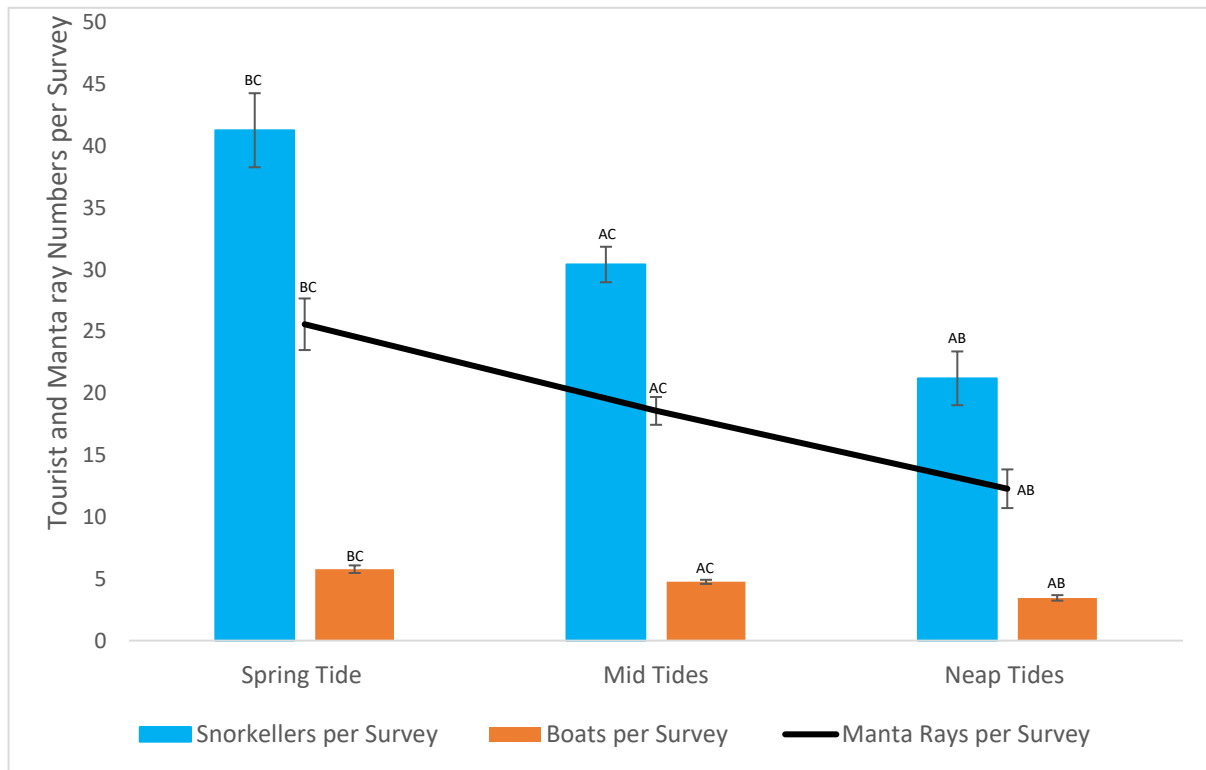
Tide Cycle	Spring Tides	Mid Tides	Neap Tides
Statistical Difference	A	B	C

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.4.3. Shows the average number of boats, snorkellers and manta rays (*m. alfredi*) in Hanifaru Bay by tide cycle between 2010-2019 using a Shapiro-Wilk test for normality, a Kruskal-Wallis Rank Sum test and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error. Graph is a combination of Appendices 4.1.-4.3. and full statistical results can be seen in appendix.

3.5. Tourism Activity within Hanifaru Bay across the Southwest Monsoon

3.5.1. Tourism and Manta Ray Activity in Hanifaru Bay per Survey by Month between 2010-2019

There was a peak in the average numbers of snorkellers within Hanifaru Bay during August (n=196, n=139 (November), p=0.0015) (average of 42.57 per survey) with June and November (n=141 (November), n=196 (August), p=<0.001) (average of 26.15 and 25.8 per survey) having the least amount of tourist activity (fig 3.5.1.).

Tourist activity correlated well with peak manta ray activity in Hanifaru Bay that occurred between July-August (n=201 (July), n=188 (September), p=0.028). Boats showed a similar trend with a peak in August (n=128, n=139 (November), p=<0.001) (average of 6.1 per survey) with boat numbers being at their lowest over June and November (average of 3.75 and 3.77 per survey) (fig 3.5.1.).

These findings suggest that August was likely to have the biggest possibility of having harmful impacts on manta rays as this was when both tourist and manta ray activity were at their highest. The increased tourist numbers recorded in the month of August was likely due to the fact that this month had the best likelihood of encountering large aggregations of manta rays within the bay and was also when safari boat numbers were highest within the Atoll (fig 3.5.1. and fig 3.2.2.) (MMRP, 2014).
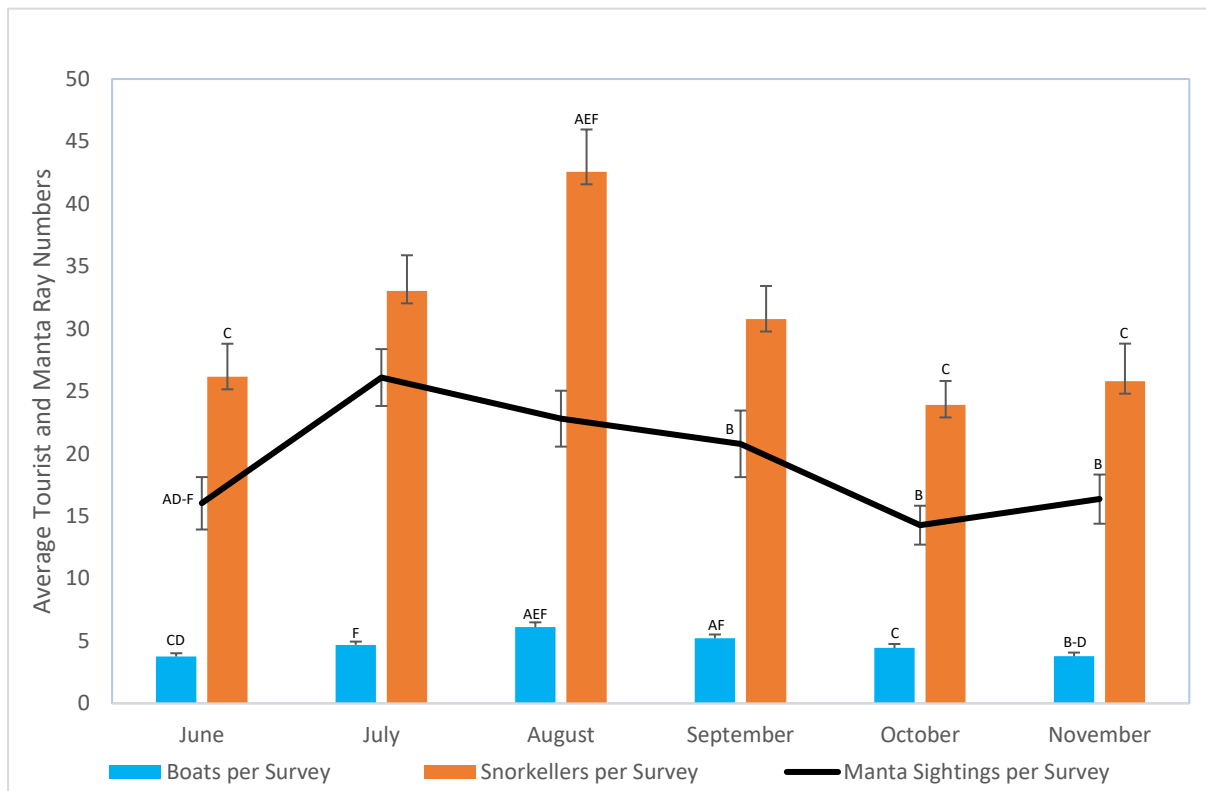
Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

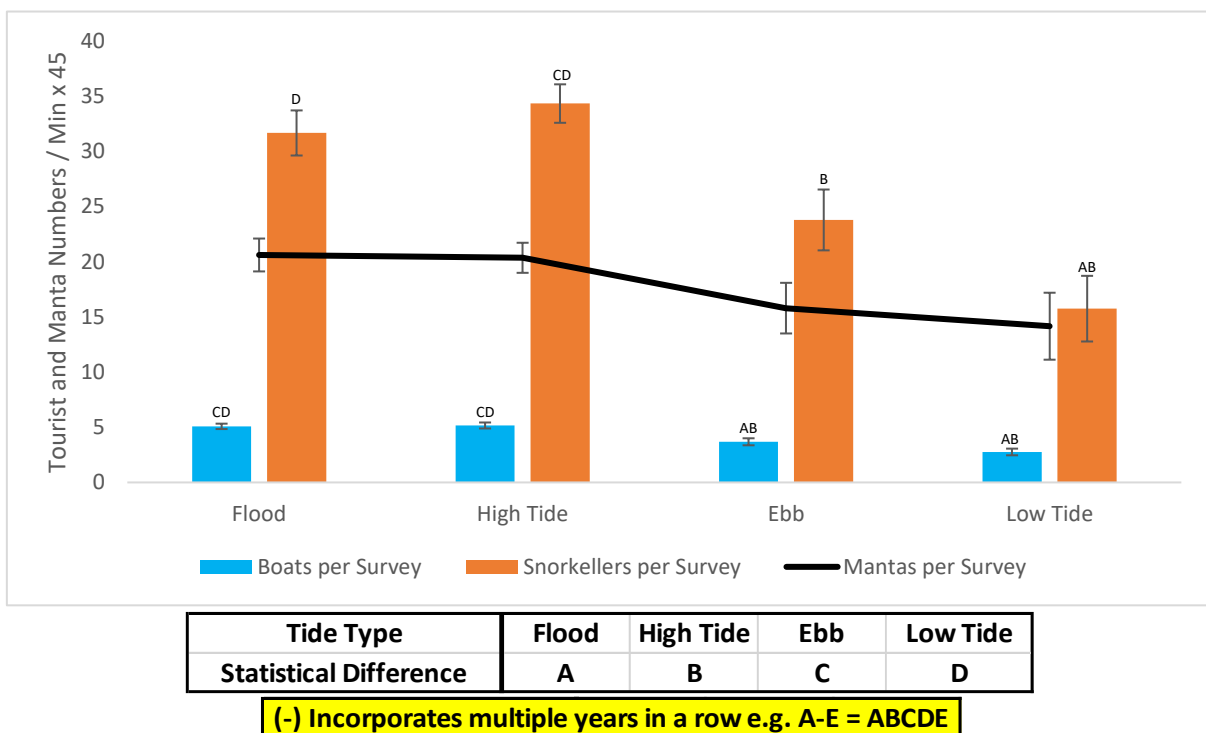**(-) Incorporates multiple years in a row e.g. A-E = ABCDE**

Figure 3.5.1. Shows the average number of boats, snorkellers and manta ray sightings (*m. alfredi*) in Hanifaru Bay per survey between 2010-2019 by month using a Shapiro-Wilk test for normality, a Kruskal-Wallis Rank Sum test and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error. Graph is a combination of Appendices 5.1.-5.3. and full statistical results can be seen in appendix.

3.5.2. Changes in Tourism Site Use by 45 Minute Session Length by Month

When the change in the average numbers of boats and snorkellers present per 45 minute session in Hanifaru Bay was investigated, there was no clear or statistically significant pattern with the exception of boats in July, which was significantly less than September (*n*=151, *n*=189, *p*=0.028) so it was difficult to draw robust conclusions from this data (fig 3.5.2.). However, snorkeller and boat numbers did follow the same pattern with the lowest number of boats present in July and peak numbers per session occurred over August and September (fig 3.5.2.).

The observed reduction of tourists present within Hanifaru Bay in July may be related to the fact that it was still early in the manta ray season, meaning manta ray activity in July between years is less predictable leading to less tourists present on site at one time, although this is not clear.
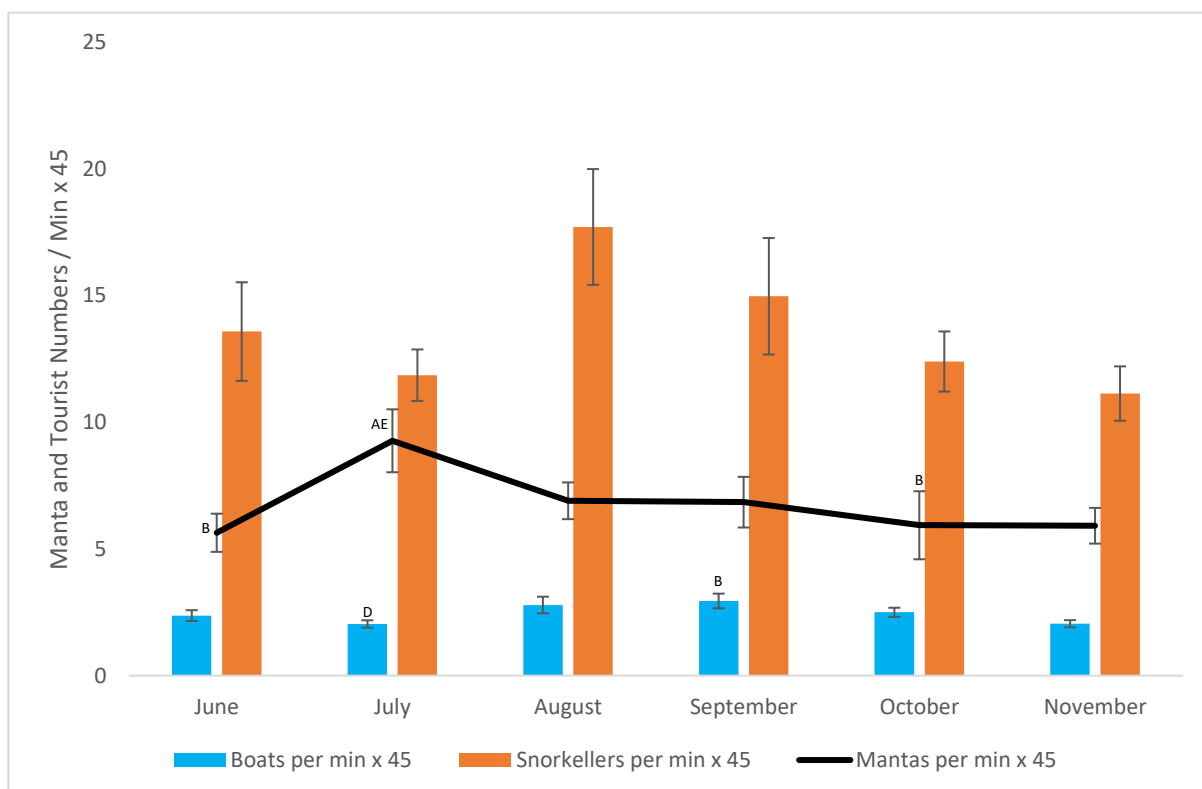
Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F
(-) Incorporates multiple years in a row e.g. A-E = ABCDE						

Figure 3.5.2. Shows the average number of boats, snorkellers and manta rays (*m. alfredi*) Hanifaru Bay per 45 minute session between 2010-2019 by month using a Shapiro-Wilk test for normality, a Kruskal-Wallis Rank Sum test and Pairwise Wilcox test showing significance (*p* = <0.05). Error Bars in standard error. Graph is a combination of Appendices 6.1.-6.3. and full statistical results can be seen in appendix.

3.5.3. MMRP Survey Length by Month

Survey lengths were statistically longer during July (n=209, n=151 (June), p=<0.001) and August (n=195, n=145 (November), p=0.002) compared to the rest of the months (fig 3.5.3.). It was seen that increased survey lengths overlapped with the peak in both manta ray and tourist activity within the bay (fig 3.5.3.). The increase in survey length was likely due to increased use of the bay by manta rays encouraging MMRP staff to survey more regularly during these times, increasing the survey length rather than any sampling bias from MMRP staff.
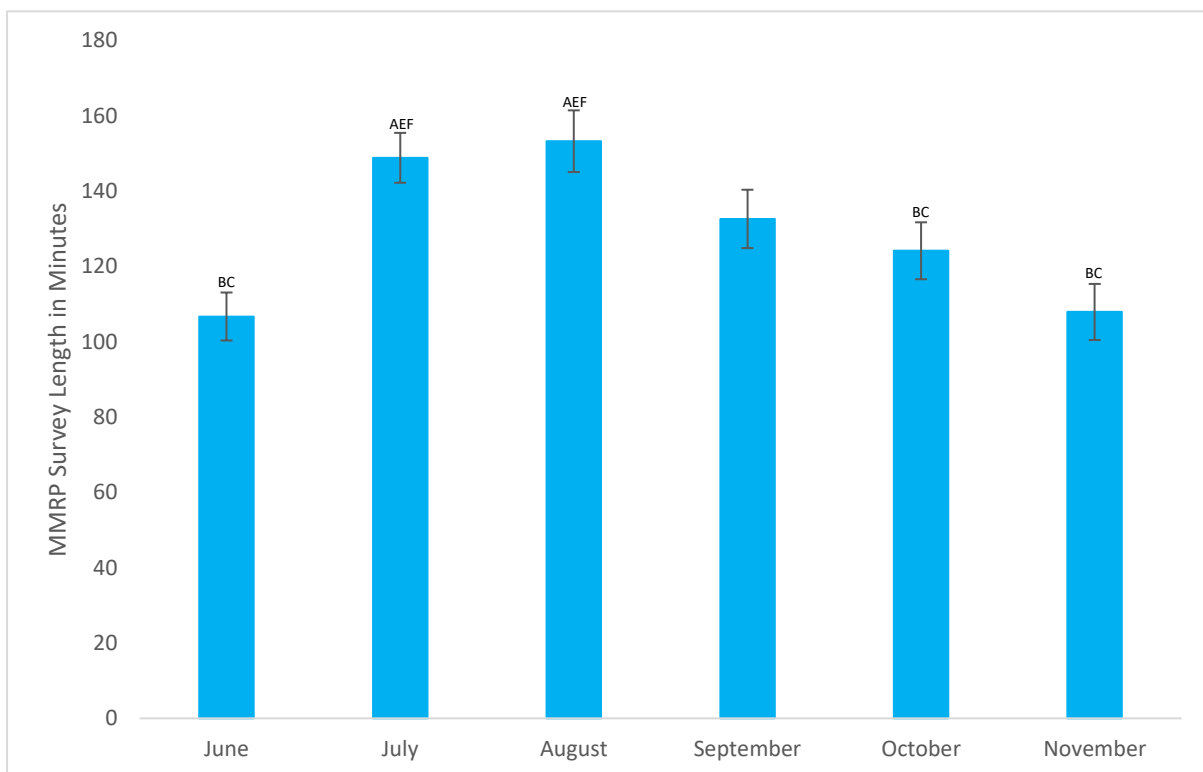
Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Figure 3.5.3. Shows the average MMRP survey length in Hanifaru Bay per 45 minute session between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.91711, p = <0.001), a Kruskal-Wallis Rank Sum test (p = < 0.001) and Pairwise Wilcox test showing significance (chi-squared = 1644.8, df = 1, p = <0.05). Error bars in standard error.

3.6. Dive Operator Recommendations Questionnaire

Unfortunately, due to time restrictions, data was not able to be collected so no analysis could be carried out for this report. If any late responses are received from dive operators over the coming months, once the deadline has passed, these will be analysed and any amended recommendations will be formulated and forwarded to MMRP and other relevant bodies.

4. Conclusions

Introducing the Hanifaru Bay Management Plan in 2011 worked effectively in managing tourist numbers within the bay and remained effective until 2017. Within recent years, after the designation of the Baa Atoll UNESCO Biosphere Reserve and social media advertising of the region, public awareness has continued to increase. The increased publicity has contributed to the growth of accommodation available within Baa Atoll with a 43% increase in bed capacity between 2015-2019 allowing more tourists to visit the region. Hanifaru Bay has seen a significant increase in snorkellers and boats using the site in recent years causing tourist numbers to return to pre-Management Plan levels during the 2019 season. This pattern suggests there may have been a relaxation of rules and regulations within the bay and when correcting for 45 minute session lengths, tourist numbers were seen to be increasing each year between 2014-2019 supporting this statement. As MMRP do not record the maximum number of boats and snorkellers at one time this is difficult to assess directly. Due to this, it is recommended that MMRP record maximum snorkeller and boat numbers present within the bay alongside their current recording of snorkeller and boat numbers per survey. This would allow for MMRP to place more accountability on rangers managing the MPA if enforcement within the bay becomes more relaxed in the future.

Advancement in technology through the use of drones by rangers within the MPA and the development of communication networks has meant, when manta rays are sighted within the bay dive operators and MMRP are notified immediately, resulting in large numbers of tour operators visiting the bay at once. These new developments, alongside increased tourist numbers visiting Baa Atoll are likely to be the primary reasons why tourist activity has been shown to be increasing between 2018 and 2019. These recent tourist changes in the bay suggest current Hanifaru Bay Management Plan rules and regulations need to be reassessed and updated for the current pressures being placed on the MPA.

Highest tourist activity (both boat and snorkeller numbers) occurred over flood and high tides which also heavily overlaps with manta ray sightings in the bay. This tourist activity was amplified even more around full and new moons with both tourist and manta ray activity peaking at this time. July to September was shown to be peak season for both tourist and manta ray numbers within Hanifaru Bay and safari boats have shown to visit Baa Atoll in large numbers in August-October, when the chances to reliably encounter the largest aggregations of manta rays are at their highest. This means tourist pressure is at its highest within Hanifaru Bay when site use is at its peak importance for manta rays and should be monitored closely during these times (MMRP, 2014).

If increased tourism pressure continues it is likely to have a significant impact on the manta rays utilising Hanifaru Bay (Murray et al., 2019). Previous studies within the bay have observed that over half of manta-tourist interactions were in breach of codes of conduct, 20.7% of these were accidental interactions that included touching and blocking the manta ray's feeding path (Murray et al., 2019). More worryingly, 34.9% deliberately approached manta rays for photographs and selfies (Murray et al., 2019). These recorded tourist behaviours could lead to significant impacts on manta rays utilising the site, causing avoidance behaviour resulting in early feeding cessation, reducing population fitness (Lusseau and Bejder, 2007; Murray *et al.*, 2019).

In 2011, there was a distinct decrease in the number of manta rays within the bay, which may have been a result of increased tourist pressure present in the previous years before the Management Plan was put in place. Manta ray numbers increased again in 2012 after SCUBA was banned within the bay potentially reducing stressors on feeding mantas within the bay (MMRP, 2014). A similar observation can be seen alongside increased tourism numbers in 2017-2019 with a decreasing trend of manta ray numbers within the bay, but this was not statistically significant. These reductions in manta rays observed could potentially be an early warning sign of negative impacts from increasing tourism within the region. However, as this and previous studies show, manta ray activity in Hanifaru Bay can be very variable between years and has been linked to climatic variations in the monsoonal wind strength (MMRP, 2014). So making any concrete conclusions on why these changes in manta ray activity in Hanifaru Bay occurred during 2011 and 2017-2019 is difficult (MMRP, 2014).

4.1. Developing Updated Management Plan Recommendations

During peak tourism periods, rangers need to have a stronger presence within the bay and become more active in enforcing the rules that are already in place. This can go alongside introducing on site permit checks to ensure snorkeller numbers and alternate site use days are being adhered to. Entrance fees should also be raised during peak times, discouraging larger numbers of tourists visiting the site and would allow tourists who visit the region specifically for manta rays to benefit from better encounters. Ensuring full funding is key in protecting the Hanifaru Bay MPA as a lack of resources is the most common factor in MPAs failing to meet conservation targets. Previous studies show tourists are willing to pay extra to observe healthy marine habitats and manta ray encounters if clear conservation value is demonstrated (Thur, 2010; Gelcich *et al.*, 2013; Murphy, Campbell and Drew, 2018). It is important to ensure pricing is not increased to a level that makes visiting too expensive for the budget market as this would have a larger economic impact on local guesthouses and dive operators rather than resorts.

In water infractions could be reduced through multiple methods. Firstly, enforcing strict fines on tourists who intentionally breach codes of conduct rules, this has shown to be effective in reducing negative behaviour in the water in whale shark interactions in Oslob, Phillipines and can be directly applied to Hanifaru Bay (Ponzo *et al.*, 2013). Secondly, increased intervention by guides would also dramatically help increase compliance and can be achieved by voluntarily reducing snorkellers to 5 from the current 10 snorkellers per guide (Environment, 2011; Murray et al., 2019).

Applying new measures for the Hanifaru Bay Management Plan could include introducing a Sipadan style permit system (Sipadan, 2020). The Sipadan permit system has shown to be effective in its application in Sipadan, Malaysia and is reported to have a high satisfaction rate from tourists visiting the area (Emang, *et al.,* 2016). Adapting this style of management would involve supplying a set number of permits equally distributed between tourist operators. Permits for a one hour time slot could be sold over peak times on flood and high tides inside the bay. These permits could be bought months in advance by tourists via their tour operator guaranteeing visits to Hanifaru Bay at peak manta times without encouraging overcrowding. If operators have spare slots available, they can sell them to local dive centres to ensure spots are not wasted. This can be implemented in addition to alternate day site restrictions and should discourage operators racing to the site when large numbers of manta rays are sighted and may mean that outside these peak times current practices could still occur. A management measure like this would require large amounts of funding and close organisation between dive operators and rangers to work effectively so will necessitate extensive discussions with stakeholders before being implemented.

The increased bed capacity of 43% between 2015-2019 within Baa Atoll has likely contributed to the increased number of tourists utilising the bay. Putting more restrictions in place that reduce the growth in resorts and guesthouses, is likely to have the biggest benefit on the protection of Hanifaru Bay and Baa Atoll UNESCO Biosphere Reserve. However, getting the balance between maintaining a healthy tourist industry and protecting sites like Hanifaru Bay is difficult. A similar outcome could be achieved through diversifying tourism activities advertised in the region allowing the same number of tourists visiting the atoll, but a decrease in demand to visit Hanifaru Bay specifically, whilst promoting other manta sites within Baa Atoll e.g. Angafaru. If this does occur, similar codes of conduct as applied to Hanifaru Bay should be introduced on these new manta ray sites.

4.2. Considering the "New Normal" Hanifaru Bay MPA during Covid – 19

During the ongoing global Covid-19 pandemic in 2020, tourism within Baa Atoll and Hanifaru Bay has been severely affected, meaning tourism activity within the bay is currently very limited. Unfortunately, due to national restrictions in the Maldives, the MMRP team were only able to return to carry out daily surveys in August and are planning on continuing to collect data until the end of the season. This gives MMRP a unique opportunity to understand how manta rays utilise the bay during periods of tourist absence and as tourist numbers start to return to normal over the coming years. During September 2020, the MMRP team have recorded mass feeding events within Hanifaru Bay that have lasted far longer than usual when compared to previously recorded daily site use of manta rays within the region (Sawers, *pers comms,* 2020). These mass feeding events could just be an anomaly and only through continued data collection for the rest of this season and next season, will we be able to confirm whether these observed changes are linked with reduced tourism pressure within the bay.

5. Recommendations

- Maximum daily tourist numbers present at one time within the bay should be recorded by rangers and MMRP staff to allow for greater accountability to enforce the current Management Plans rules and regulations.
- Increased ranger presence over peak tourist periods between July-September, over flood and high tide and on full and new moons.
- Increased entrance fees during times of predicted peak manta ray activities to fund increased ranger patrols.
- Increased monitoring of visitor permits by boarding a select number of boats during visitation hours to check permits and snorkeller numbers, ensuring operator compliance.
- Apply on the spot fines for any operators breaking on site rules or visiting the bay outside their designated day.
- Ensure alternate day site use is fully enforced within the bay alongside maximum boat and snorkeller numbers.
- Recommend voluntary reduction of 5 snorkellers to one guide within the bay to increase tourist compliance.
- Develop a ticketing system as seen in Sipadan, Malaysia where tourists can book time slots months in advance allowing tourists to guarantee visiting the site without too many tourists.

6. References

Anderson, R. C., Adam, M. S. and Goes, J. I. (2011a) 'From monsoons to mantas: Seasonal distribution of Manta alfredi in the Maldives', *Fisheries Oceanography*, 20(2), pp. 104–113. doi: 10.1111/j.1365-2419.2011.00571.x.

Anderson, R. C., Adam, M. S. and Goes, J. I. (2011b) 'From monsoons to mantas: Seasonal distribution of Manta alfredi in the Maldives', *Fisheries Oceanography*, 20(2), pp. 104–113. doi: 10.1111/j.1365-2419.2011.00571.x.

Ari, C. (2011) 'Encephalization and Brain Organization of Mobulid Rays (Myliobatiformes, Elasmobranchii) with Ecological Perspectives', *The Open Anatomy Journal*, 3(1), pp. 1–13. doi: 10.2174/1877609401103010001.

Atkins, R. (2011) *Manta ray (Manta alfredi) tourism in Baa Atoll, Republic of Maldives: human interactions, behavioural impacts and management implications.*, *MSc Thesis*. York.

Barcott, B. (2010) *Feeding Frenzy*, *National Geographic*. Available at: https://www.nationalgeographic.com/magazine/2009/07/manta-rays/ (Accessed: 3 June 2020).

Brooks, K. (2010) *Investigating tourism at Hanifaru Bay marine protected area, Maldives*, *MSc Thesis*. York.

Cagua, E. F. *et al.* (2014) 'Whale shark economics: A valuation of wildlife tourism in South Ari Atoll, Maldives', *PeerJ*, (1), pp. 1–17. doi: 10.7717/peerj.515.

Dewar, H. *et al.* (2008) 'Movements and site fidelity of the giant manta ray, Manta birostris, in the Komodo Marine Park, Indonesia', *Marine Biology*, 155(2), pp. 121–133. doi: 10.1007/s00227-008-0988-x.

Dulvy, N. K. *et al.* (2014) 'Diagnosing the dangerous demography of manta rays using life history theory', *PeerJ*, 2014(1), pp. 1–19. doi: 10.7717/peerj.400.

Egbert, G. D. and Erofeeva, S. Y. (2002) *Efficient Inverse Modeling of Barotropic Ocean Tides*, *Journal of Atmospheric and Oceanic Technology*. American Meteorological Society. doi: 10.1175/1520-0426(2002)019<0183:EIMOBO>2.0.CO;2.

Emang, D., Lundhede, T. H. and Thorsen, B. J. (2016) 'Funding conservation through use and potentials for price discrimination among scuba divers at Sipadan, Malaysia', *Journal of Environmental Management*. Academic Press, 182, pp. 436–445. doi: 10.1016/j.jenvman.2016.07.033.

Environment, M. M. of (2011) *Management Plan For Hanifaru Marine Protected Area Baa Atoll , Maldives*. Malé.

Fiori, L. *et al.* (2019) 'Effects of whale-based tourism in Vava'u, Kingdom of Tonga: Behavioural responses of humpback whales to vessel and swimming tourism activities', *PLoS ONE*, 14(7), pp. 1–21. doi: 10.1371/journal.pone.0219364.

Garrud, E. (2016) *Does tourist behaviour affect reef manta ray feeding behaviour? An analysis of human and Manta alfredi interactions in Baa Atoll, the Maldives*, *MSc Thesis*. York.

Gelcich, S. *et al.* (2013) 'Financing marine protected areas through visitor fees: Insights from tourists willingness to pay in Chile', *Ambio*, 42(8), pp. 975–984. doi: 10.1007/s13280-013-0453-z.

Harris, J. L. *et al.* (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*. John Wiley and Sons Ltd, 30(8), pp. 1649–1664. doi: 10.1002/aqc.3350.

Heinrichs, S., O'Malley, M. and Hilton, P. (2011) *The Global Threat To Manta and Mobula Rays*, *Shark savers*.

Jaine, F. R. A. *et al.* (2012) 'When Giants Turn Up: Sighting Trends, Environmental Influences and Habitat Use of the Manta Ray Manta alfredi at a Coral Reef', *PLoS ONE*. Public Library of Science, 7(10). doi: 10.1371/journal.pone.0046170.

Kashiwagi, T. *et al.* (2011) 'Habitat segregation and mosaic sympatry of the two species of manta ray in the Indian and Pacific Oceans: Manta alfredi and M. birostris', *Marine Biodiversity Records*, 4(53), pp. 1–9. doi: 10.1017/S1755267211000479.

Kitchen-Wheeler, A. M. (2010) 'Visual identification of individual manta ray (Manta alfredi) in the Maldives Islands, Western Indian Ocean', *Marine Biology Research*, 6(4), pp. 351–363. doi: 10.1080/17451000903233763.

Lawson, J. M. *et al.* (2017) 'Sympathy for the devil: A conservation strategy for devil and manta rays', *PeerJ*, 2017(3). doi: 10.7717/peerj.3027.

Lusseau, D. and Bejder, L. (2007) 'The long-term consequences of short-term responses to disturbance experiences from whalewatching impact assessment', *International Journal of Comparative Psychology*, 20(May 2014), pp. 228–236.

Lynam, R. (2012) *The impacts of tourism on a population of manta rays, Baa Atoll, Republic of*

Maldives., *MSc Thesis*. York.

Marshall, A. and 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. (2018) 'Mobula alfredi: 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.', *IUCN Red List of Threatened Species*. doi: 10.2305/iucn.uk.2019-3.rlts.t195459a68632178.en.

Marshall, A. D. and Bennett, M. B. (2009) 'Redescription Of The Genus Manta With Resurrection Of Manta Alfredi (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae) Parasites of commercial fishes of Moreton Bay: a multi-disciplinary analysis of diversity View project Global Manta Ray Project V', *Zootaxa*, 2301, pp. 1–28. doi: 10.5281/zenodo.191734.

Marshall, A. D. and Bennett, M. B. (2010) 'Reproductive ecology of the reef manta ray Manta alfredi in southern Mozambique', *Journal of Fish Biology*. John Wiley & Sons, Ltd, 77(1), pp. 169–190. doi: 10.1111/j.1095-8649.2010.02669.x.

McGregor, F. *et al.* (2019) 'Rapid wound healing in a reef manta ray masks the extent of vessel strike', *PLoS ONE*, 14(12), pp. 1–11. doi: 10.1371/journal.pone.0225681.

Miller, K. I. *et al.* (2017) 'Bycatch in the Maldivian pole-and-line tuna fishery', *PLoS ONE*, 12(5), pp. 1–21. doi: 10.1371/journal.pone.0177391.

Ministry of Tourism, R. of M. (2019) *Tourism Yearbook 2019*. Malé. Available at: https://www.tourism.gov.mv/en/downloads/publications.

MMRP (2010) *Developing Tourism at Hanifaru Bay Marine Protected Area (MPA)*, *Maldivian Manta Ray Project*. Available at: https://static1.squarespace.com/static/5a196500914e6b09132e911f/t/5ce40b88950a3000014b7e44/1558449038441/MT_MMRP_Hanifaru+Bay+MPA_Report+for+Maldivian+Government_2010.pdf.

MMRP (2013) 'Maldivian Manta Ray Project 2013 Season Summary', 2012, pp. 1–12.

MMRP (2014) *Manta Ray Project - Baa Atoll Annual Report 2014*. Available at: https://static1.squarespace.com/static/5a196500914e6b09132e911f/t/5ce40b9985cf6c0001e1eff6/1558449060279/MT_MMRP_Report_Baa+Atoll_2014.pdf.

MMRP (2016) *Manta Ray Project - Baa Atoll Annual Report 2016*. Available at: https://danny-copeland-mxe4.squarespace.com/s/MT_MMRP_Report_Baa-Atoll_2016.pdf.

MMRP (2018) *Manta Ray Project - Baa Atoll Annual Report 2018*. Available at: https://static1.squarespace.com/static/5a196500914e6b09132e911f/t/5f0c4e40fe97c9602d27834e/1594641997302/MT_MMRP_Annual+Report_Baa+Atoll_2018_FINAL.pdf.

MMRP (2019a) *Oceanic Manta Ray Summary report 2019*. Available at: https://www.mantatrust.org/chagos.

MMRP (2019b) *Manta Ray Project Baa Atoll Annual Report - 2019*. Available at: https://www.mantatrust.org/chagos.

Murphy, S. E., Campbell, I. and Drew, J. A. (2018) 'Examination of tourists' willingness to pay under different conservation scenarios; Evidence from reef manta ray snorkeling in Fiji', *PLoS ONE*, 13(8), pp. 1–15. doi: 10.1371/journal.pone.0198279.

Murray, A. *et al.* (2019) 'Protecting the million-dollar mantas; creating an evidence-based code of conduct for manta ray tourism interactions', *Journal of Ecotourism*, 19(2), pp. 132–147. doi: 10.1080/14724049.2019.1659802.

O'Malley, M. P., Lee-Brooks, K. and Medd, H. B. (2013) 'The Global Economic Impact of Manta Ray Watching Tourism', *PLoS ONE*, 8(5), pp. 1–11. doi: 10.1371/journal.pone.0065051.

Papilaya, R. L., Boli, P. and Nikijuluw, V. P. H. (2019) 'Carrying Capacity of Diving Tourism in Dampier Strait Marine Conservation Area-District of Raja Ampat Recent citations Carrying Capacity of Diving Tourism in Dampier Strait Marine Conservation Area-District of Raja Ampat', *Earth and Environmental Science*, (246). doi: 10.1088/1755-1315/246/1/012060.

Peel, L. R. *et al.* (2019) 'Movement and residency patterns of reef manta rays Mobula alfredi in the Amirante Islands, Seychelles', *Marine Ecology Progress Series*, 621, pp. 169–184. doi: 10.3354/meps12995.

Perryman, R. J. Y. *et al.* (2019) 'Social preferences and network structure in a population of reef manta rays', *Behavioral Ecology and Sociobiology*. Springer Verlag, 73(8), pp. 1–18. doi: 10.1007/s00265-019-2720-x.

Ponzo, A. *et al.* (2013) *Whale Shark Provisioning: What do we know and where do we stand; The case study of Oslob, Philippines*. PeerJ Inc. doi: 10.7287/peerj.preprints.69v1.

Portal, N. O. (2020) *Data Services — Naval Oceanography Portal, Naval Oceanography Portal*. Available at: https://www.usno.navy.mil/USNO/astronomical-applications/data-services (Accessed: 25 July 2020).

Sawers, T. (2020) 'Personal Communication'. MMRP.

Schofield, G. *et al.* (2013) 'Evidence-based marine protected area planning for a highly mobile endangered marine vertebrate', *Biological Conservation*. Elsevier Ltd, 161, pp. 101–109. doi: 10.1016/j.biocon.2013.03.004.

Schuler, A. R. *et al.* (2019) 'Humpback Whale Movements and Behavior in Response to Whale-Watching Vessels in Juneau, AK', *Frontiers in Marine Science*, 6(November), pp. 1–13. doi: 10.3389/fmars.2019.00710.

Sipadan (2020) *Sipadan Permits*. Available at: https://www.sipadan.com/Sipadan-Permits.php (Accessed: 9 August 2020).

Smith, K., Scarr, M. and Scarpaci, C. (2010) 'Grey nurse shark (Carcharias taurus) diving tourism: Tourist compliance and shark behaviour at fish rock, Australia', *Environmental Management*, 46(5), pp. 699–710. doi: 10.1007/s00267-010-9561-8.

The Manta Trust (2018) *How to Swim with Manta Rays*. Available at: https://swimwithmantas.org/ (Accessed: 20 August 2020).

Thur, S. M. (2010) 'User fees as sustainable financing mechanisms for marine protected areas: An application to the Bonaire National Marine Park', *Marine Policy*, 34(1), pp. 63–69. doi: 10.1016/j.marpol.2009.04.008.

timeanddate.com (2020) *www.timeanddate.com*. Available at: https://www.timeanddate.com/moon/phases/maldives/male (Accessed: 15 September 2020).

Ward-Paige, C. A., Davis, B. and Worm, B. (2013) 'Global population trends and human use patterns of Manta and Mobula rays', *PLoS ONE*, 8(9), pp. 1–9. doi: 10.1371/journal.pone.0074835.

World Bank (2010) *Climate Change in the Maldives*, *World Bank*. Available at: https://www.worldbank.org/en/news/feature/2010/04/06/climate-change-in-the-maldives (Accessed: 3 June 2020).

7.0. Appendix Section

Appendix 1.0. - Accommodation in Baa Atoll

Appendix 1.1. - Graph showing Numbers of Resorts and Hotels in Baa Atoll between 2007-2019
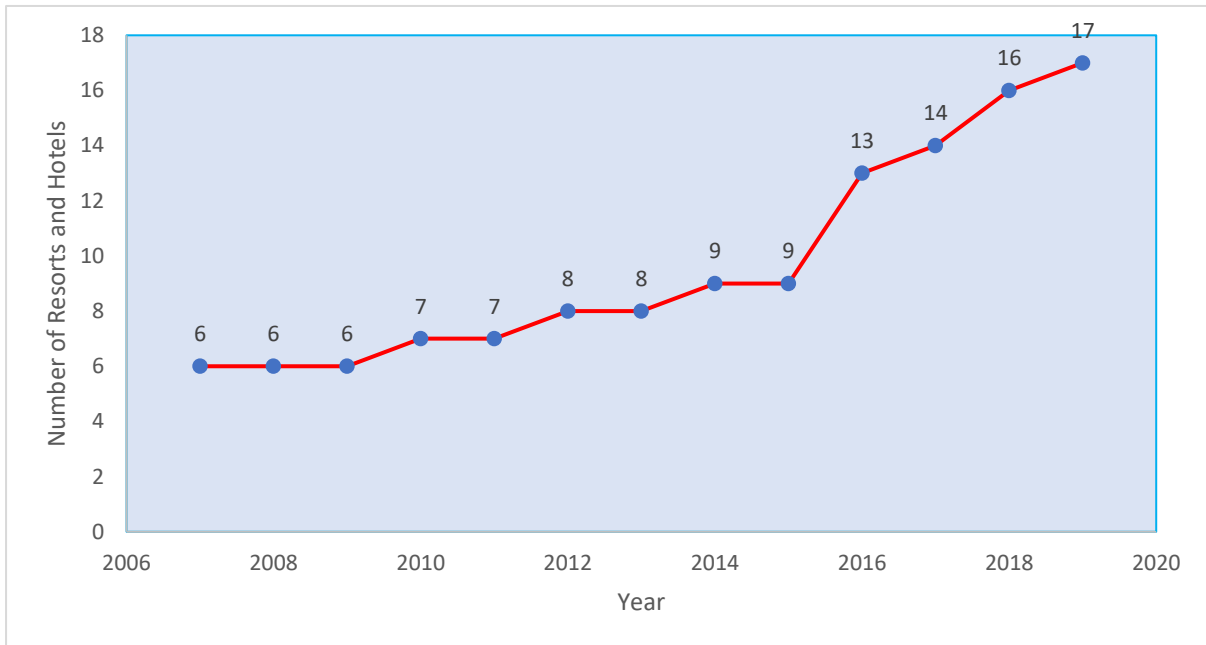
Appendix 1.1. Shows the change in bed capacity in resorts and hotels within Baa Atoll between 2007-2019 using data sourced from the Maldivian Ministry of Tourism Office.

Appendix 1.2. – Graph showing Numbers of Guesthouses in Baa Atoll between 2014-2019
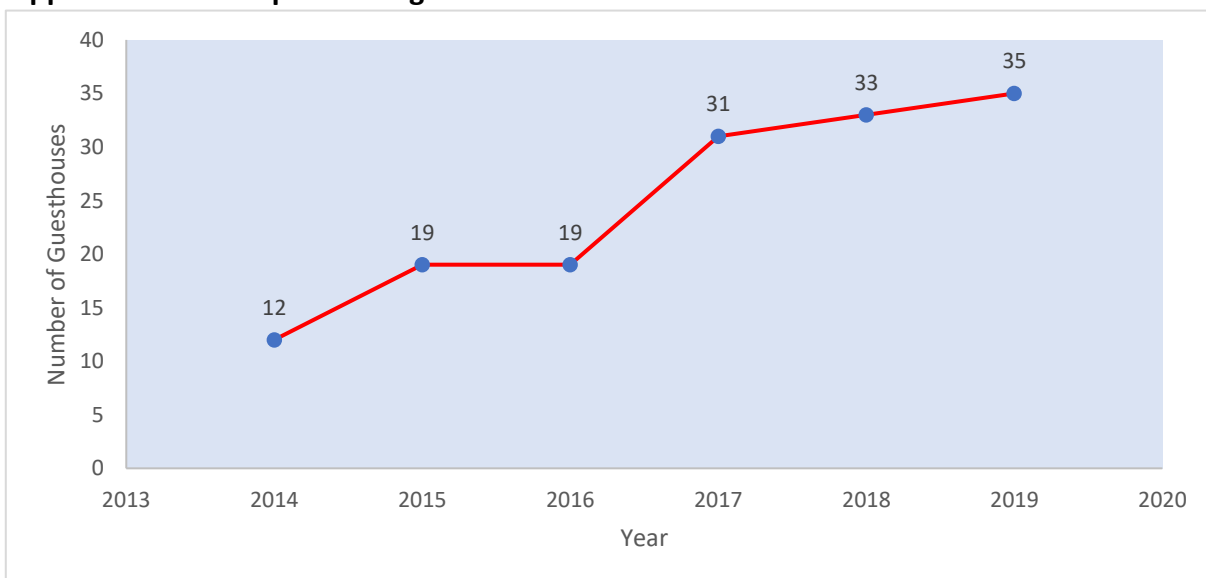
Appendix 1.2. Shows the change in the number of guesthouses within Baa Atoll between 2014 and 2019 using data sourced from the Maldivian Ministry of Tourism Office.

Appendix 1.3. – Graph showing Average Number of Beds per Resort and Hotel between 2007-2019
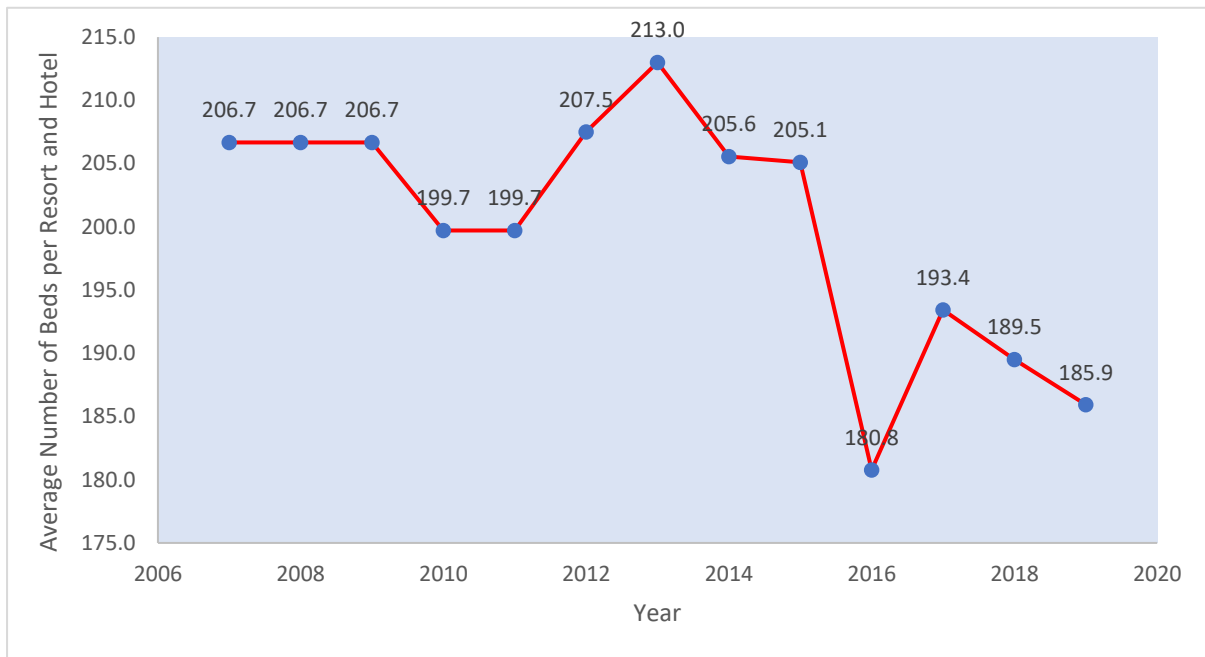
Appendix 1.3. Shows the change in average bed capacity per resort and hotel within Baa Atoll between 2007 and 2019 using data sourced from the Maldivian Ministry of Tourism Office.

Appendix 1.4. – Graph showing Average Number of Beds per Guesthouse in Baa Atoll between 2014-2019
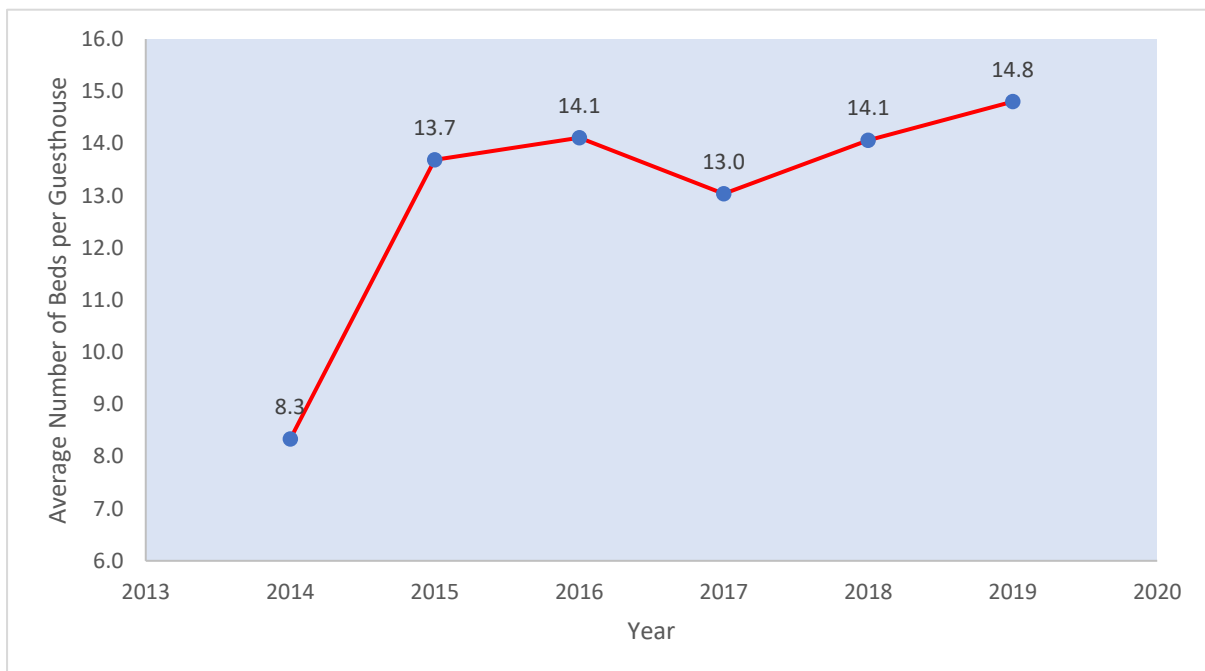
Appendix 1.4. Shows the change in average bed capacity per guesthouse within Baa Atoll between 2014 and 2019 using data sourced from the Maldivian Ministry of Tourism Office.

Appendix 2.0. – Statistical Analysis of Tourist and Manta Ray Activity in Hanifaru Bay between 2010-2019

Appendix 2.1. - Boats Utilising Hanifaru Bay per Survey by Year between 2010-2019
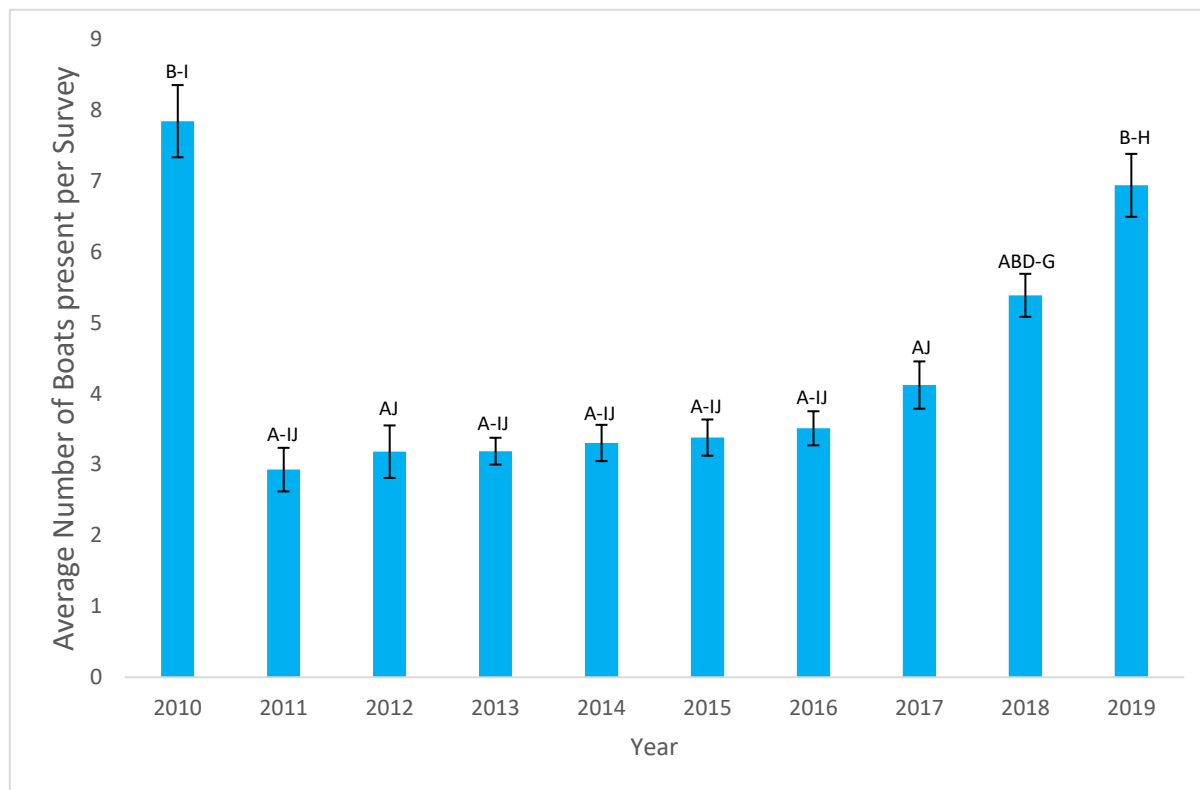
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 2.1. Shows the average number of boats in Hanifaru Bay per survey between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.82594, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1562.9, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 2.1. Shows the p value results from a Pairwise Wilcox test of the average number of boats in Hanifaru Bay per survey between 2010-2019. Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	<0.001	-	-	-	-	-	-	-	-
2012	0.00328	1	1	-	-	-	-	-	-
2013	<0.001	0.33	1	1	-	-	-	-	-
2014	<0.001	1	1	1	1	-	-	-	-
2015	<0.001	1	1	1	1	1	-	-	-
2016	<0.001	0.98	1	1	1	1	-	-	-
2017	<0.001	0.089	1	1	1	1	1	-	-
2018	0.02734	<0.001	0.33	<0.001	<0.001	<0.001	<0.001	0.11	-
2019	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.97

Appendix 2.2. - Snorkellers Utilising Hanifaru Bay per Survey by Year between 2010-2019

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J
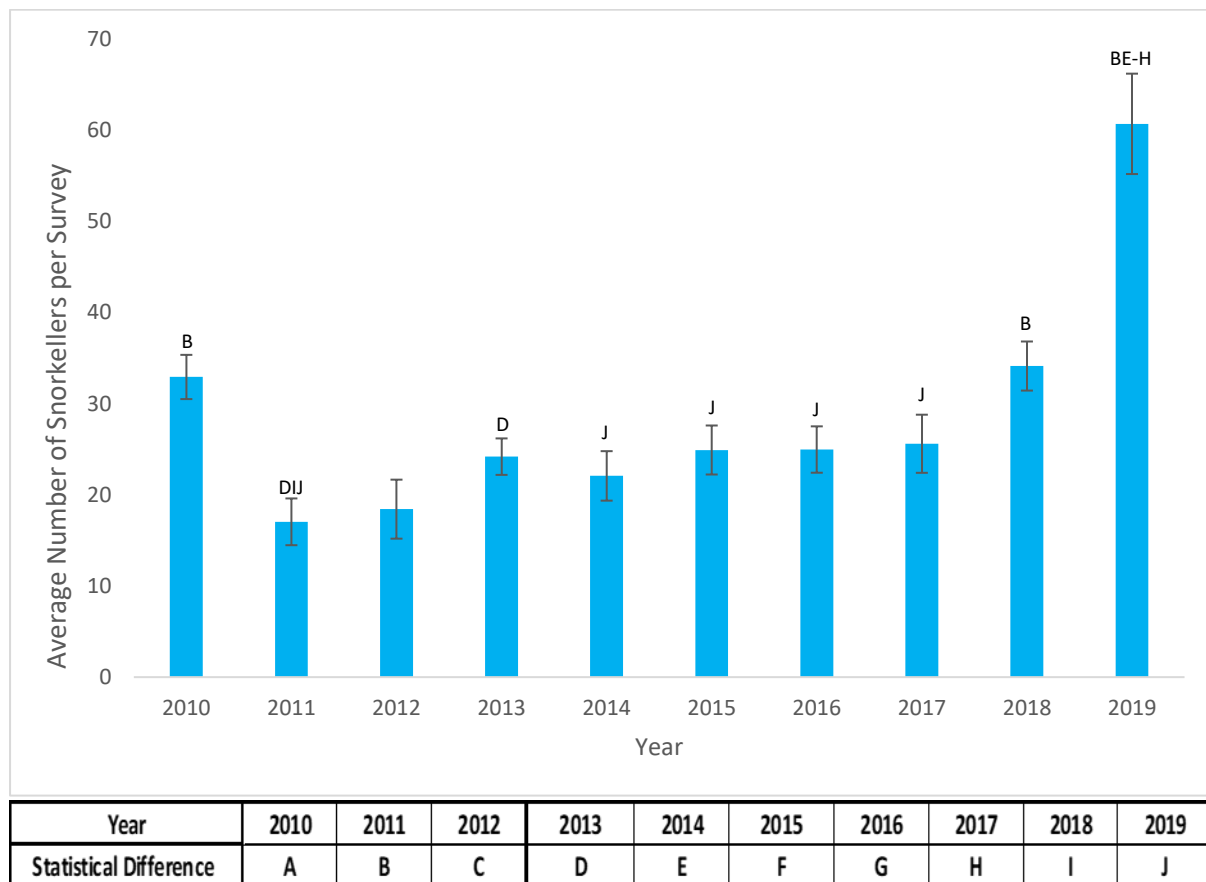
(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 2.2. Shows the average number of snorkellers in Hanifaru Bay per survey between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.75598, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1550.2, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 2.2. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers in Hanifaru Bay per survey between 2010-2019 Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	<0.001	-	-	-	-	-	-	-	-
2012	1	1	-	-	-	-	-	-	-
2013	1	0.003	1	-	-	-	-	-	-
2014	0.13	0.96	1	1	-	-	-	-	-
2015	0.3	0.32	1	1	1	-	-	-	-
2016	0.4	0.35	1	1	1	1	-	-	-
2017	0.77	0.3	1	1	1	1	1	-	-
2018	1	<0.001	1	1	0.16	0.35	0.29	0.49	-
2019	0.77	<0.001	1	0.37	0.0068	0.0085	0.0033	0.021	0.85

Appendix 2.3. - Confirmed Manta Ray Sightings per Survey by Year between 2010-2019
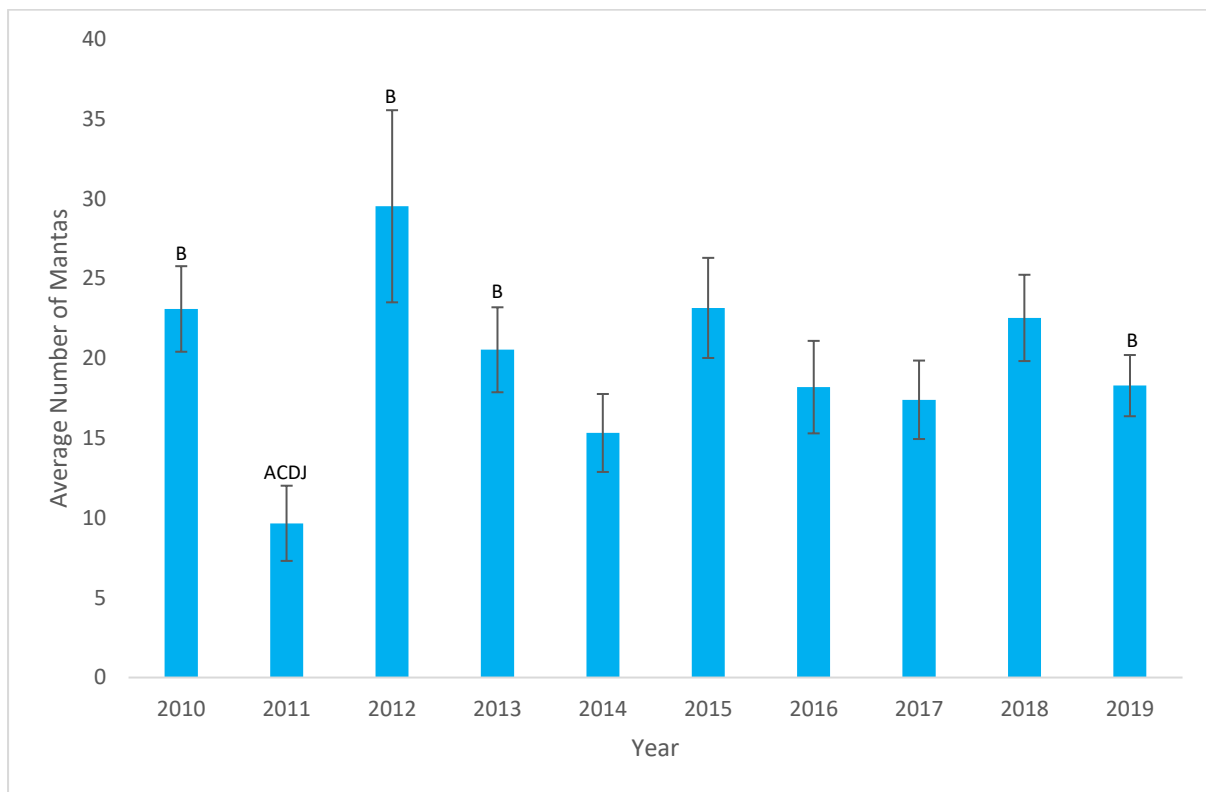
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 2.3. Shows the average number of manta ray sightings (*m. alfredi*) in Hanifaru Bay per survey between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.70184, *p* = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1638.3, df = 1, *p*-value = < 0.001) and Pairwise Wilcox test showing significance (*p* = <0.05). Error bars in standard error.

Table 2.3. Shows the *p* value results from a Pairwise Wilcox test of the average number of manta ray sightings in Hanifaru Bay per survey between 2010-2019 Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	0.01	-	-	-	-	-	-	-	-
2012	1	0.0019	-	-	-	-	-	-	-
2013	1	0.0022	1	-	-	-	-	-	-
2014	1	0.38	0.27	1	-	-	-	-	-
2015	1	0.076	1	1	1	-	-	-	-
2016	0.96	1	0.11	0.57	1	1	-	-	-
2017	1	1	0.21	1	1	1	1	-	-
2018	1	0.22	0.82	1	1	1	1	1	-
2019	1	0.029	0.7	1	1	1	1	1	1

Appendix 3.0. – Statistical Analysis of Tourist and Manta Ray Activity Corrected for 45 Minute Sessions in Hanifaru Bay between 2010-2019

Appendix 3.1. - Boats Utilising Hanifaru Bay Accounting for 45 Minute Session Lengths by Year between 2010-2019
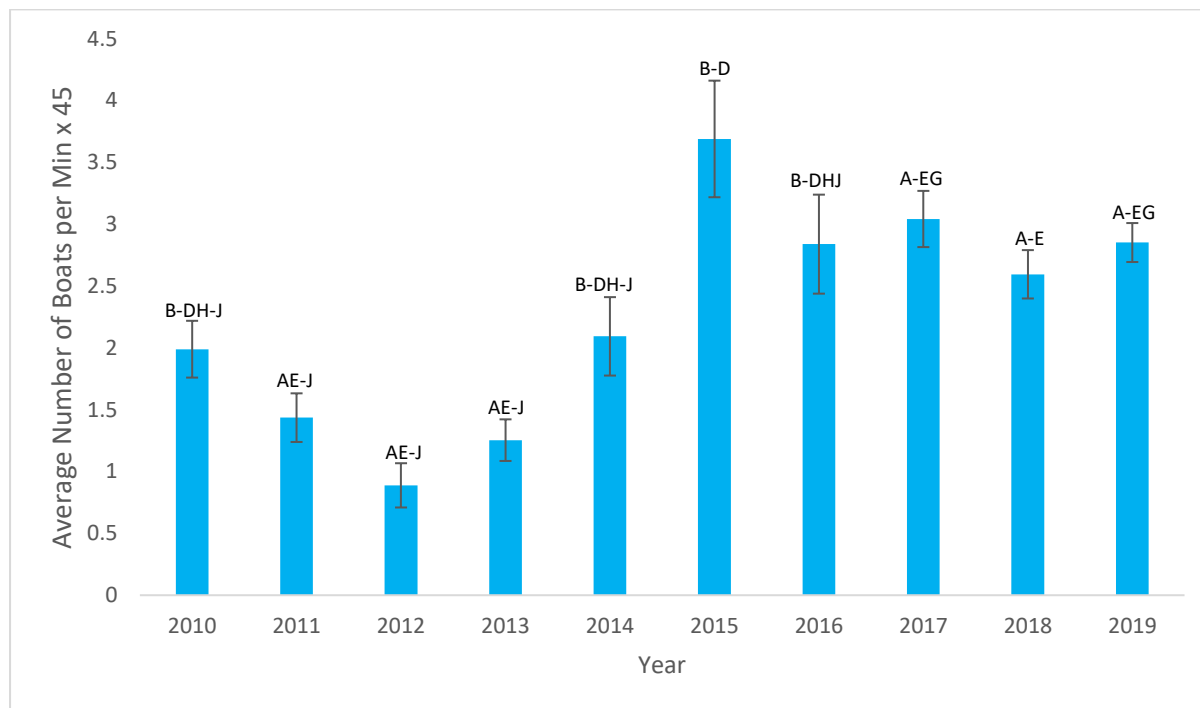
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 3.1. Shows the average number of boats in Hanifaru Bay per 45 minute session between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.54992, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1633.2, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 3.1. Shows the p value results from a Pairwise Wilcox test of the average number of boats per 45 minute session in Hanifaru Bay per survey between 2010-2019. Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	<0.001	-	-	-	-	-	-	-	-
2012	<0.001	1	-	-	-	-	-	-	-
2013	<0.001	1	1	-	-	-	-	-	-
2014	1	0.003	0.001	<0.001	-	-	-	-	-
2015	0.5	<0.001	<0.001	<0.001	1	-	-	-	-
2016	0.5	<0.001	<0.001	<0.001	1	1	-	-	-
2017	<0.001	<0.001	<0.001	<0.001	0.001	1	0.048	-	-
2018	<0.001	<0.001	<0.001	<0.001	0.009	1	1	0.4	-
2019	<0.001	<0.001	<0.001	<0.001	<0.001	1	0.028	1	0.25

Appendix 3.2. - Snorkellers Utilising Hanifaru Bay Accounting for 45 Minute Session Lengths by Year between 2010-2019

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

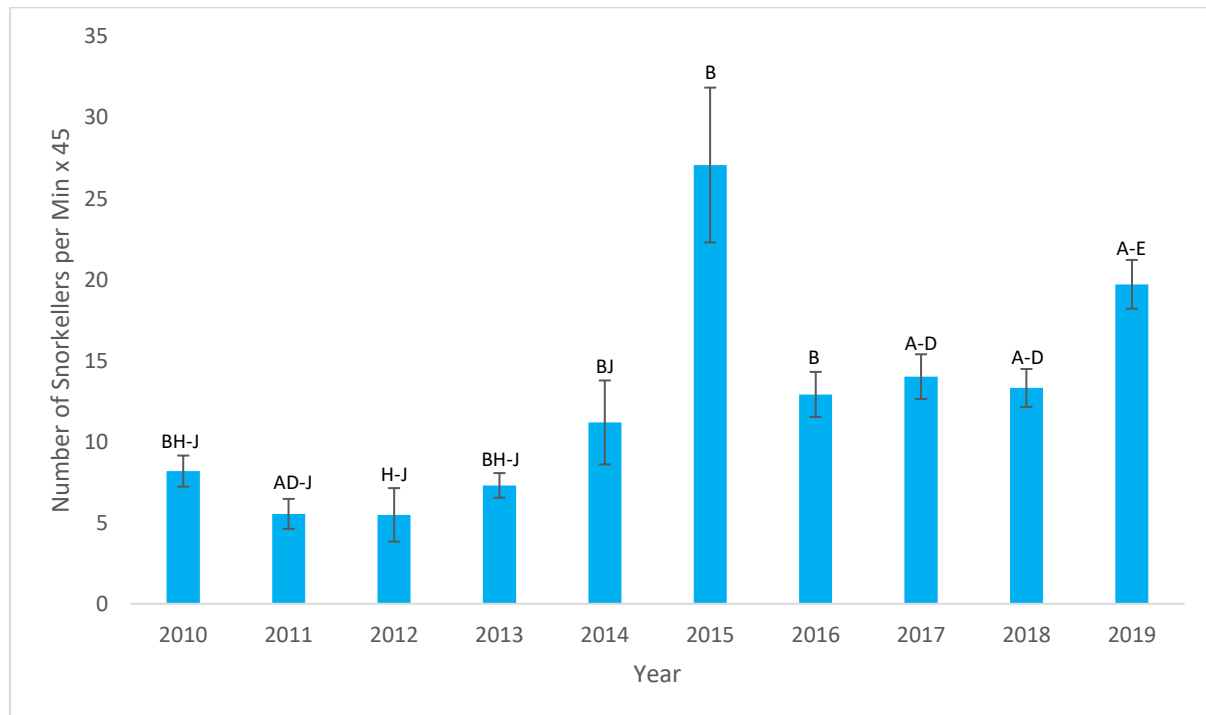(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 3.2. Shows the average number of snorkellers in Hanifaru Bay per 45 minute session between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.50643, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1617.9, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 3.2. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per 45 minute session in Hanifaru Bay per survey between 2010-2019. Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	0.0042	-	-	-	-	-	-	-	-
2012	0.7	1	-	-	-	-	-	-	-
2013	1	0.015	0.84	-	-	-	-	-	-
2014	1	0.036	0.85	1	-	-	-	-	-
2015	0.28	<0.001	0.32	0.28	0.45	-	-	-	-
2016	0.69	<0.001	0.28	0.71	1	1	-	-	-
2017	0.011	<0.001	0.023	0.018	0.082	1	1	-	-
2018	0.007	<0.001	0.029	0.025	0.14	1	1	1	-
2019	<0.001	<0.001	0.015	<0.001	0.0012	1	0.09	0.95	0.28

Appendix 3.3. - Confirmed Manta Sightings per Min x 45 by Year between 2010-2019
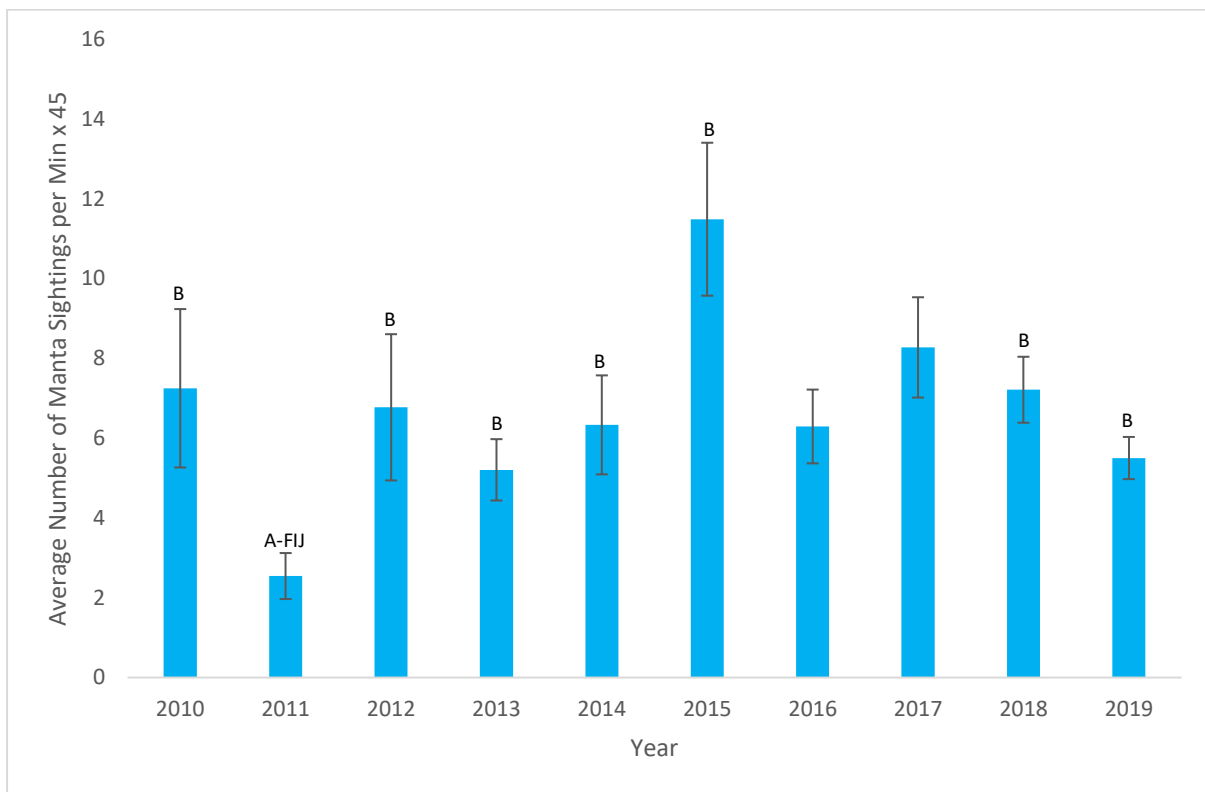
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Statistical Difference	A	B	C	D	E	F	G	H	I	J

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 3.3. Shows the average number of manta ray sightings (*m. alfredi*) in Hanifaru Bay per 45 minute session between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.44959, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1636.5, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 3.3. Shows the p value results from a Pairwise Wilcox test of the average number of manta rays per 45 minute session in Hanifaru Bay per survey between 2010-2019. Any highlighted values indicate significance between years.

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2011	0.037	-	-	-	-	-	-	-	-
2012	1	0.008	-	-	-	-	-	-	-
2013	1	0.0011	1	-	-	-	-	-	-
2014	1	<0.001	1	1	-	-	-	-	-
2015	0.52	<0.001	1	1	1	-	-	-	-
2016	1	0.16	1	1	1	1	-	-	-
2017	1	0.317	1	1	1	1	1	-	-
2018	1	0.0071	1	1	1	1	1	1	-
2019	1	<0.001	1	1	1	1	1	1	1

Appendix 4.0. - Manta Ray and Tourist Activity by Tide

Appendix 4.1. - Average Number of Boats Present per Survey by Tide Type

Tide Type	Flood	High Tide	Ebb	Low Tide
Statistical Difference	A	B	C	D

(-) Incorporates multiple years in a row e.g. A-E = ABCDE
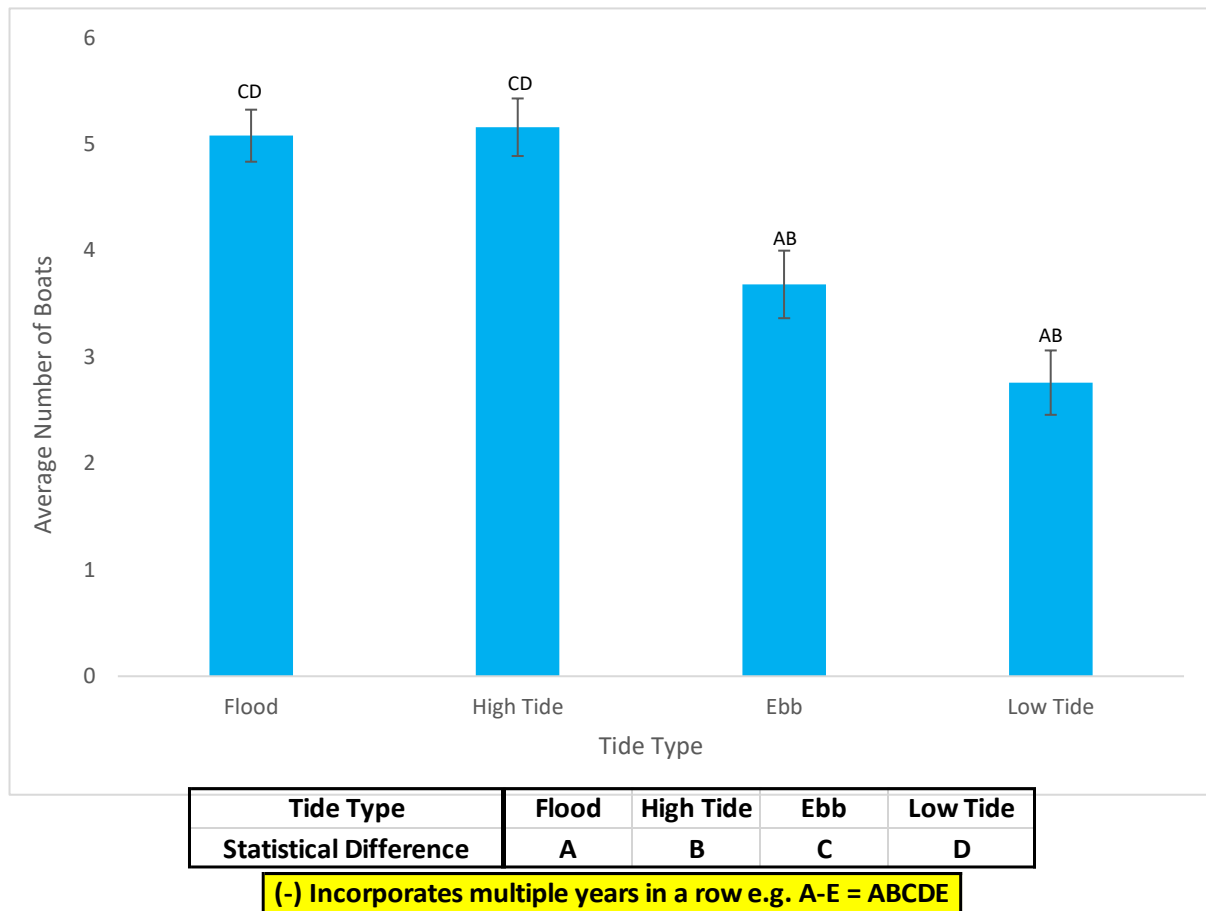
Appendix 4.1. Shows the average number of boats in Hanifaru Bay by tide type between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.60803, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1660.7, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 4.1. Shows the p value results from a Pairwise Wilcox test of the average number of boats per survey in Hanifaru Bay by tide type between 2010-2019 Any highlighted values indicate significance between years.

	Ebb	Flood	High Tide
Flood	0.015	-	-
High Tide	<0.001	0.36	-
Low Tide	0.18	0.001	<0.001

Appendix 4.2. - Average Number of Snorkellers Present per Survey by Tide Type

Tide Type	Flood	High Tide	Ebb	Low Tide
Statistical Difference	A	B	C	D

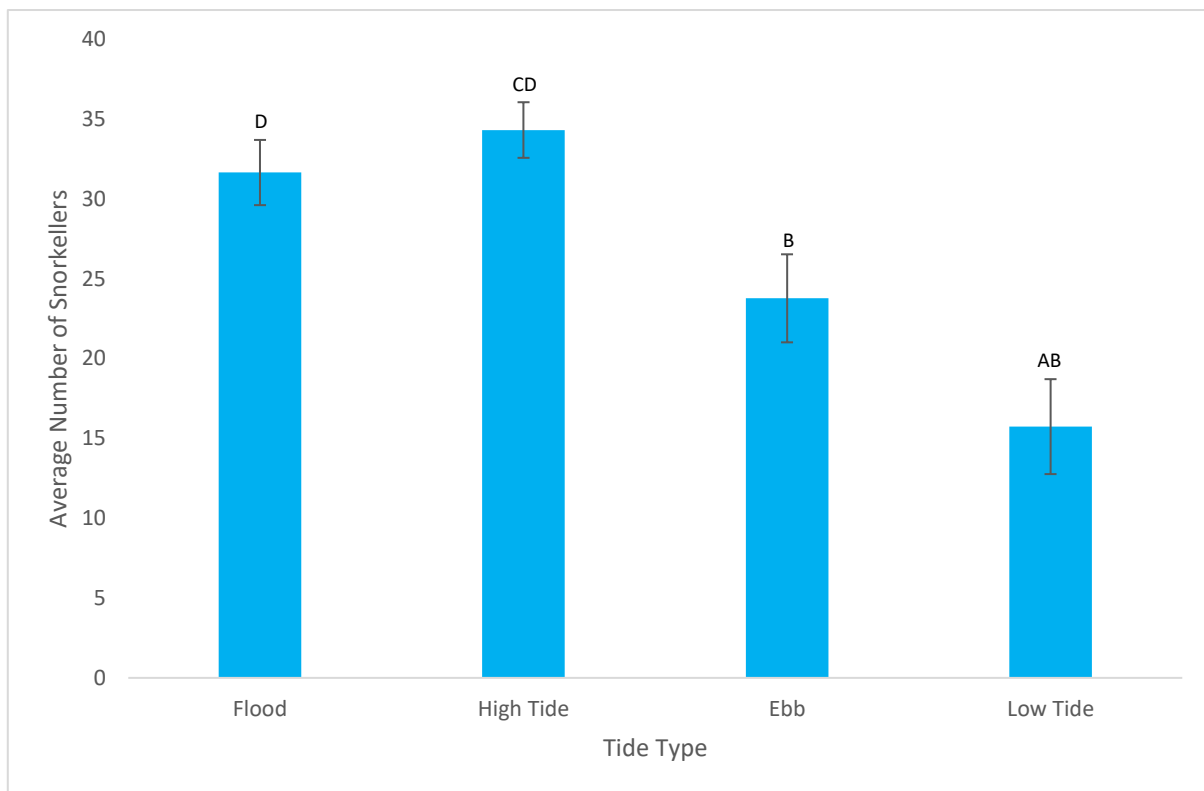**(-) Incorporates multiple years in a row e.g. A-E = ABCDE**

Appendix 4.2. Shows the average number of snorkellers in Hanifaru Bay by tide type between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.76809, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1644.9, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 4.2. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per survey in Hanifaru Bay by tide type between 2010-2019. Any highlighted values indicate significance between years.

	Ebb	Flood	High Tide
Flood	0.21	-	-
High Tide	0.0092	0.21	-
Low Tide	0.21	0.0094	<0.001

Appendix 4.3. - Confirmed Manta Sightings per Survey by Tide

Tide Type	Flood	High Tide	Ebb	Low Tide
Statistical Difference	A	B	C	D

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 4.3. Shows the average number of manta ray sightings (*m. alfredi*) in Hanifaru Bay by tide type between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.70184, *p* = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1665.5, df = 1, *p* = < 0.001) and Pairwise Wilcox test showing significance (*p* = <0.05). Error bars in standard error.

Table 4.3. Shows the *p* value results from a Pairwise Wilcox test of the average number of manta rays per survey in Hanifaru Bay by tide type between 2010-2019. Any highlighted values indicate significance between years.

	Ebb	Flood	High Tide
Flood	0.21	-	-
High Tide	0.21	1	-
Low Tide	1	0.25	0.25

Appendix 4.4. – Average Number of Snorkellers Present by Tide Cycle

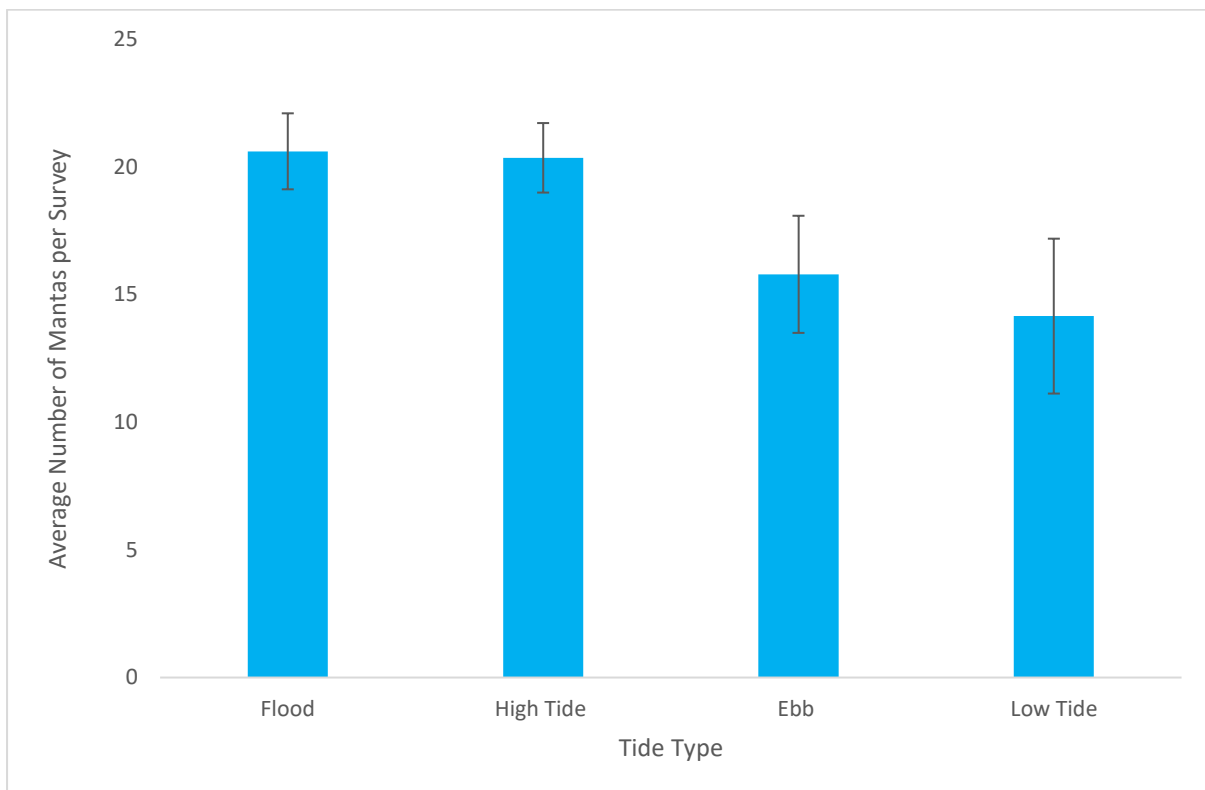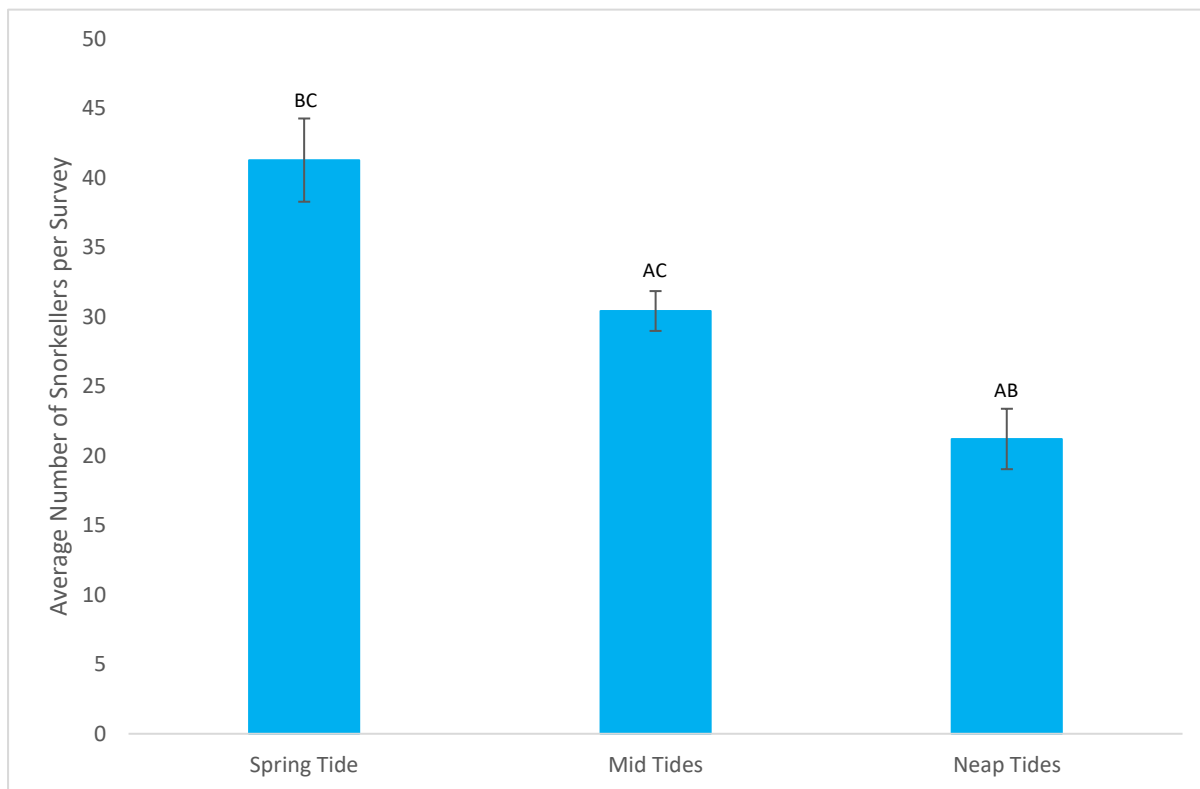| Tide Cycle	Spring Tides	Mid Tides	Neap Tides
Statistical Difference	A	B	C
(-) Incorporates multiple years in a row e.g. A-E = ABCDE			

Appendix 4.4. Shows the average number of snorkellers in Hanifaru Bay by tide cycle between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.76787, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1665.2, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 4.4. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per survey in Hanifaru Bay by tide cycle between 2010-2019. Any highlighted values indicate significance between years.

	Mid Tides	Neap Tides
Neap Tides	<0.001	-
Spring Tides	<0.001	<0.001

Appendix 4.5. – Average Number of Boats Present by Tide Cycle

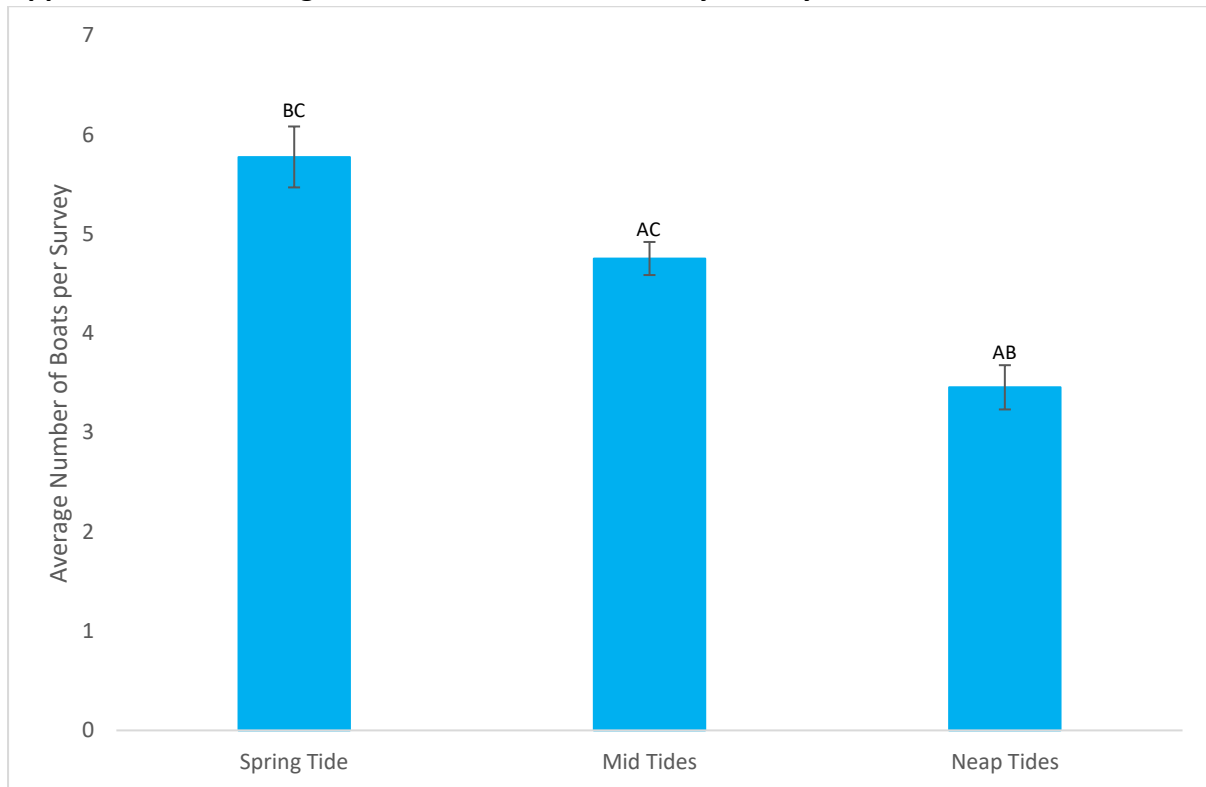| Tide Cycle	Spring Tides	Mid Tides	Neap Tides
Statistical Difference	A	B	C
(-) Incorporates multiple years in a row e.g. A-E = ABCDE			

Appendix 4.5. Shows the average number of boats in Hanifaru Bay by tide cycle between 2010-2019 using a Shapiro-Wilk test for normality ($W = 0.82449$, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1680.8, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 4.5. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per survey in Hanifaru Bay by tide cycle between 2010-2019. Any highlighted values indicate significance between years.

	Mid Tides	Neap Tides
Neap Tides	<0.001	-
Spring Tides	0.0033	<0.001

Appendix 4.6. – Average Number of Manta Ray Sightings Present by Tide Cycle
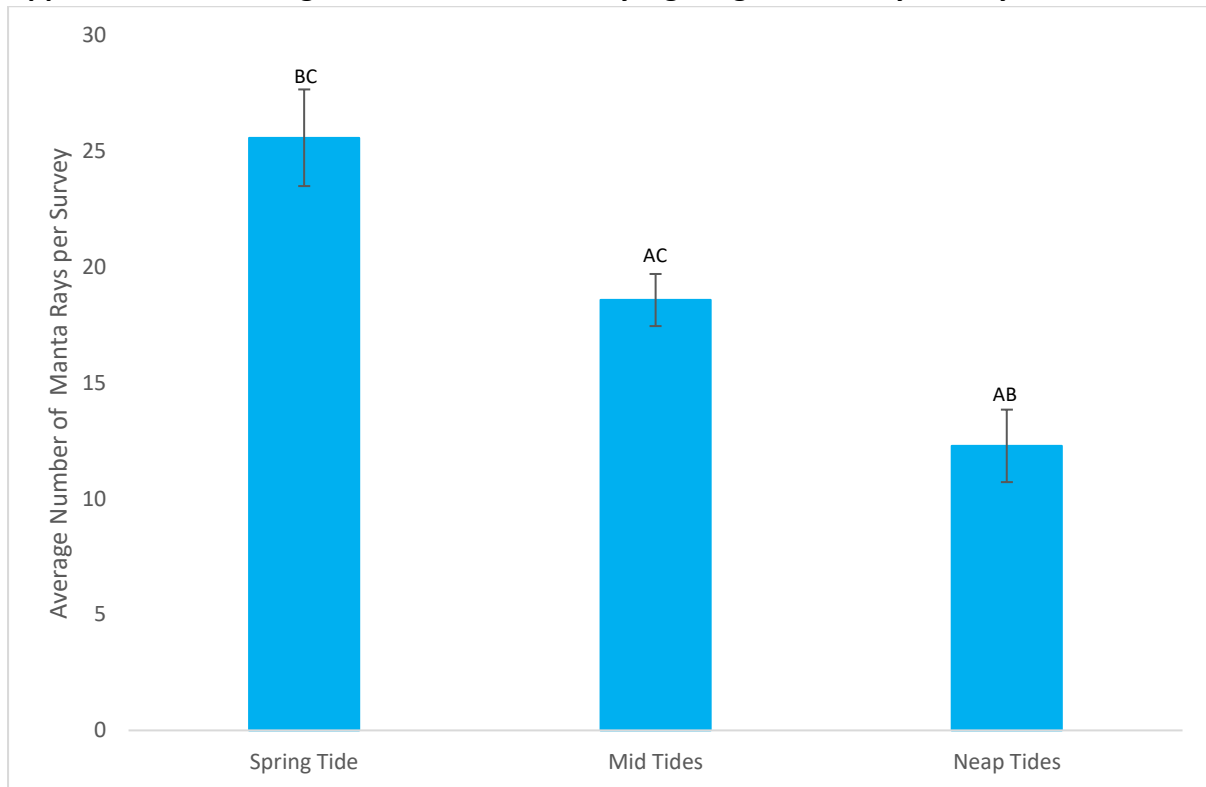
Tide Cycle	Spring Tides	Mid Tides	Neap Tides
Statistical Difference	A	B	C
(-) Incorporates multiple years in a row e.g. A-E = ABCDE			

Appendix 4.6. Shows the average number of manta ray (*m.alfredi*) sightings in Hanifaru Bay by tide cycle between 2010-2019 using a Shapiro-Wilk test for normality (W = 0.69332, *p* = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1677.3, df = 1, *p* = < 0.001) and Pairwise Wilcox test showing significance (*p* = <0.05). Error bars in standard error.

Table 4.6. Shows the *p* value results from a Pairwise Wilcox test of the average number of manta rays (*m.alfredi*) per survey in Hanifaru Bay by tide cycle between 2010-2019. Any highlighted values indicate significance between years.

	Mid Tides	Neap Tides
Neap Tides	<0.001	-
Spring Tides	<0.001	<0.001

Appendix 4.7 – Number of MMRP Surveys by Monthly Tide Type

Appendix 4.7. – Number of MMRP Surveys by monthly tide type between 2010-2019.

Appendix 5.0. - Tourist and Manta Ray Activity in Hanifaru Bay by Month

Appendix 5.1. - Number of Boats Utilising Hanifaru Bay per Survey by Month between 2010-2019

Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

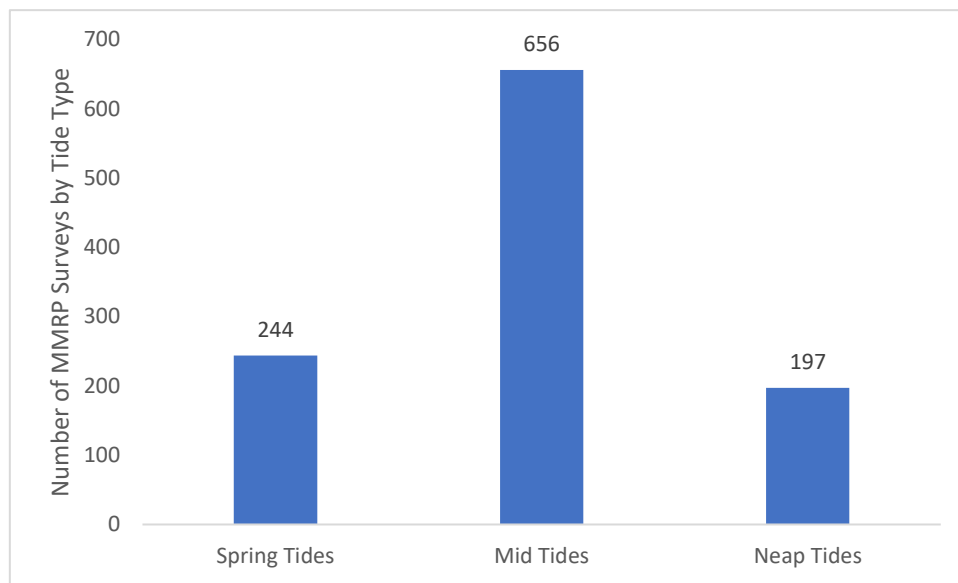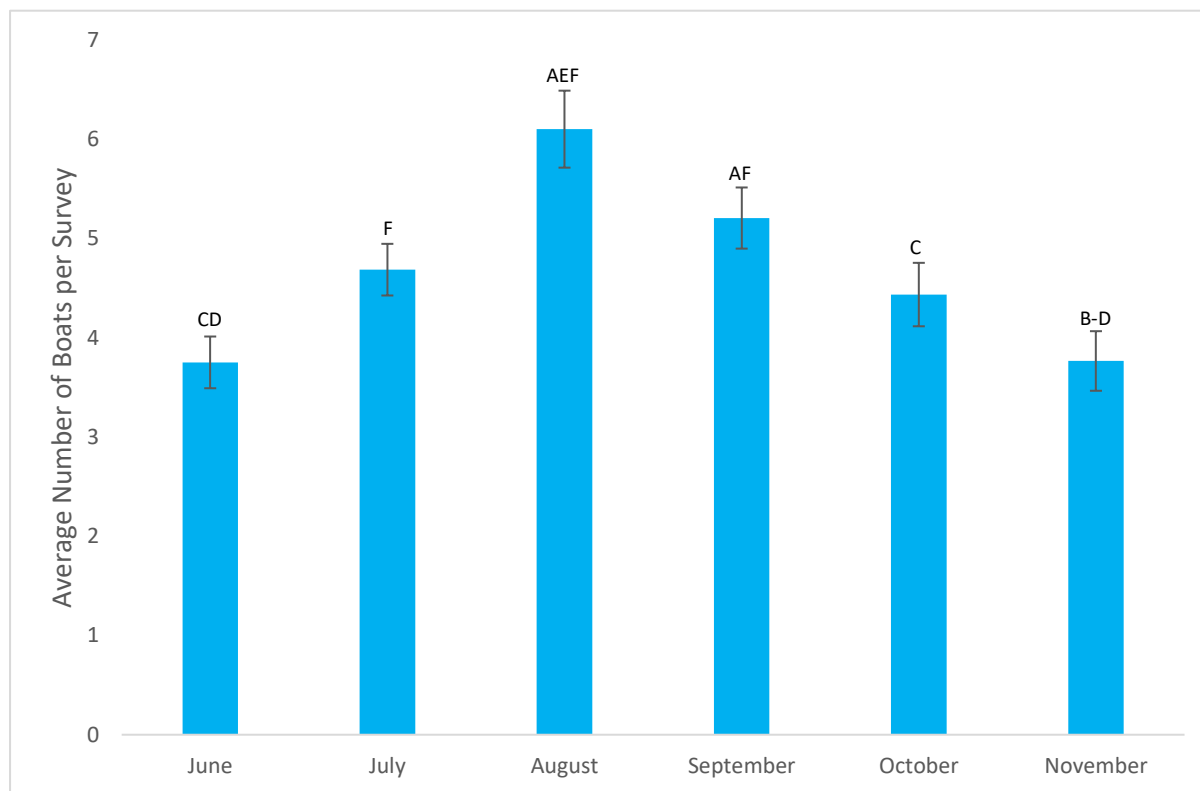**(-) Incorporates multiple years in a row e.g. A-E = ABCDE**

Appendix 5.1. Shows the average number of boats in Hanifaru Bay per survey between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.82729, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1567.7, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 5.1. Shows the p value results from a Pairwise Wilcox test of the average number of boats per survey in Hanifaru Bay by month between 2010-2019. Any highlighted values indicate significance between years.

	August	July	June	November	October
July	0.35	-	-	-	-
June	0.0016	0.14	-	-	-
November	<0.001	0.021	0.96	-	-
October	0.03	0.73	0.96	0.38	-
September	0.96	0.96	0.034	0.007	0.35

Appendix 5.2. - Number of Snorkellers Utilising Hanifaru Bay per Survey by Month between 2010-2019

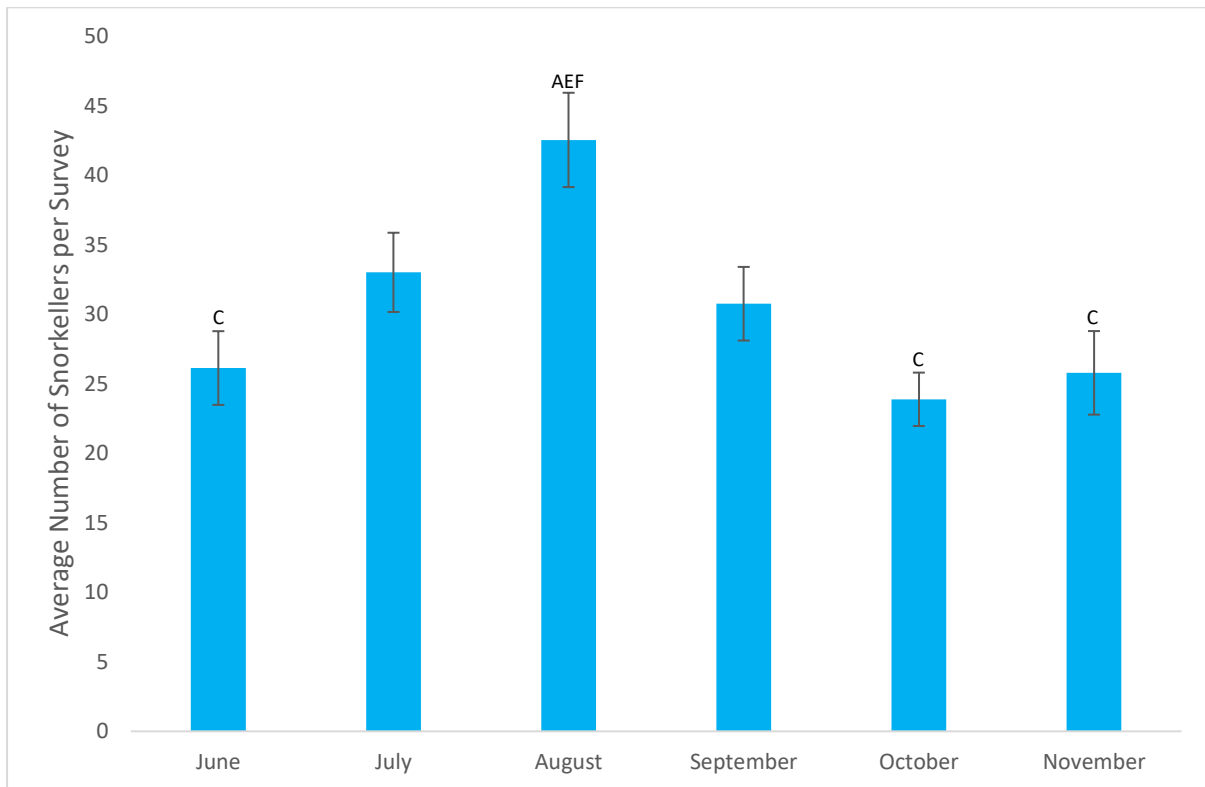| Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 5.2. Shows the average number of snorkellers in Hanifaru Bay per survey between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.75598, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1553.4, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 5.2. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per survey in Hanifaru Bay by month between 2010-2019. Any highlighted values indicate significance between years.

	August	July	June	November	October
July	0.34	-	-	-	-
June	<0.044	1	-	-	-
November	0.0015	0.25	1	-	-
October	0.0085	1	1	1	-
September	0.13	1	1	1	1

Appendix 5.3. - Confirmed Manta Ray Sightings per Survey by Month for 2010-2019
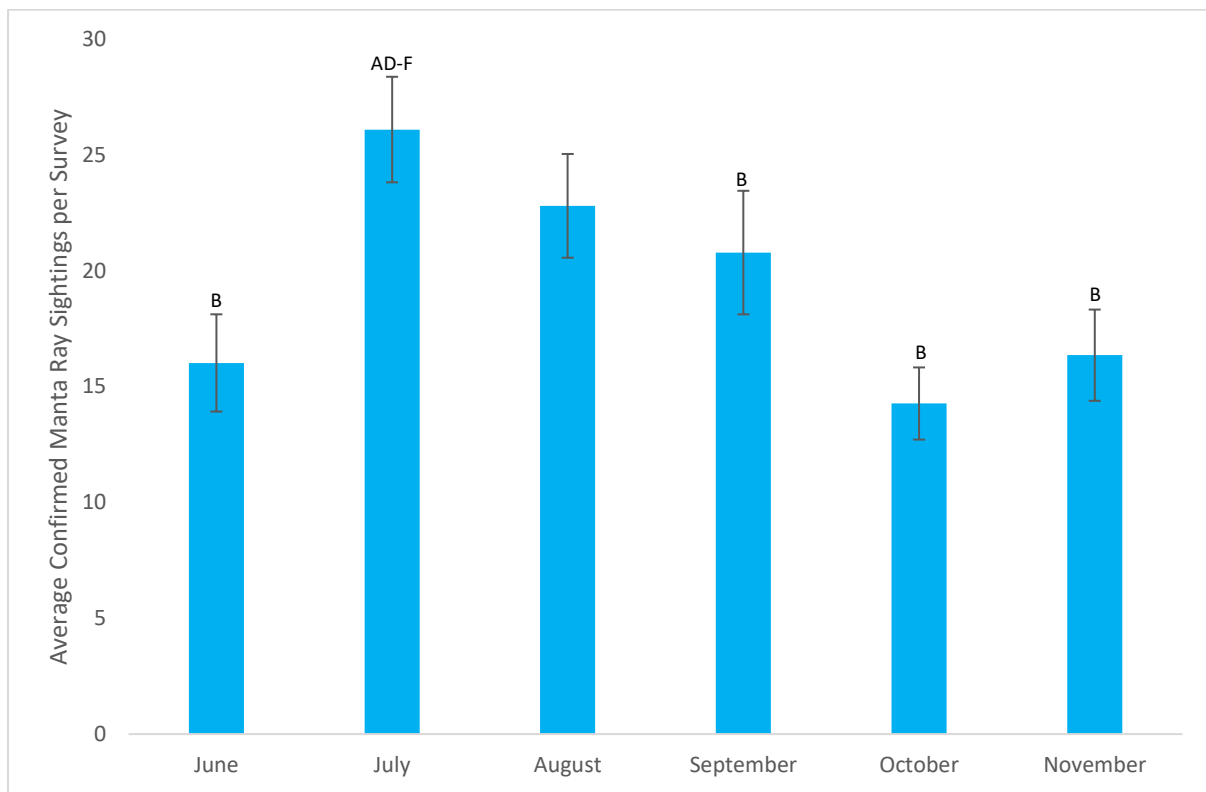
Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 5.3. Shows the average number of manta ray sightings (*m. alfredi*) in Hanifaru Bay per survey bet ween 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.70372, p = <0.001), a Kruskal-Wall is Rank Sum test (chi-squared = 1617.5, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 5.3. Shows the p value results from a Pairwise Wilcox test of the average number of manta ray sightings per survey in Hanifaru Bay by month between 2010-2019. Any highlighted values indicate significance between years.

	August	July	June	November	October
July	0.382	-	-	-	-
June	1	1	-	-	-
November	1	1	1	-	-
October	1	0.076	1	1	-
September	1	0.028	0.875	1	1

Appendix 6.0. – Statistical Analysis of Tourist and Manta Ray Activity in Hanifaru Bay Correcting for 45 Minute Sessions by Month between 2010-2019

Appendix 6.1. - Number of Boats Utilising Hanifaru Bay Accounting for 45 Minute Session by Month between 2010-2019

Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F
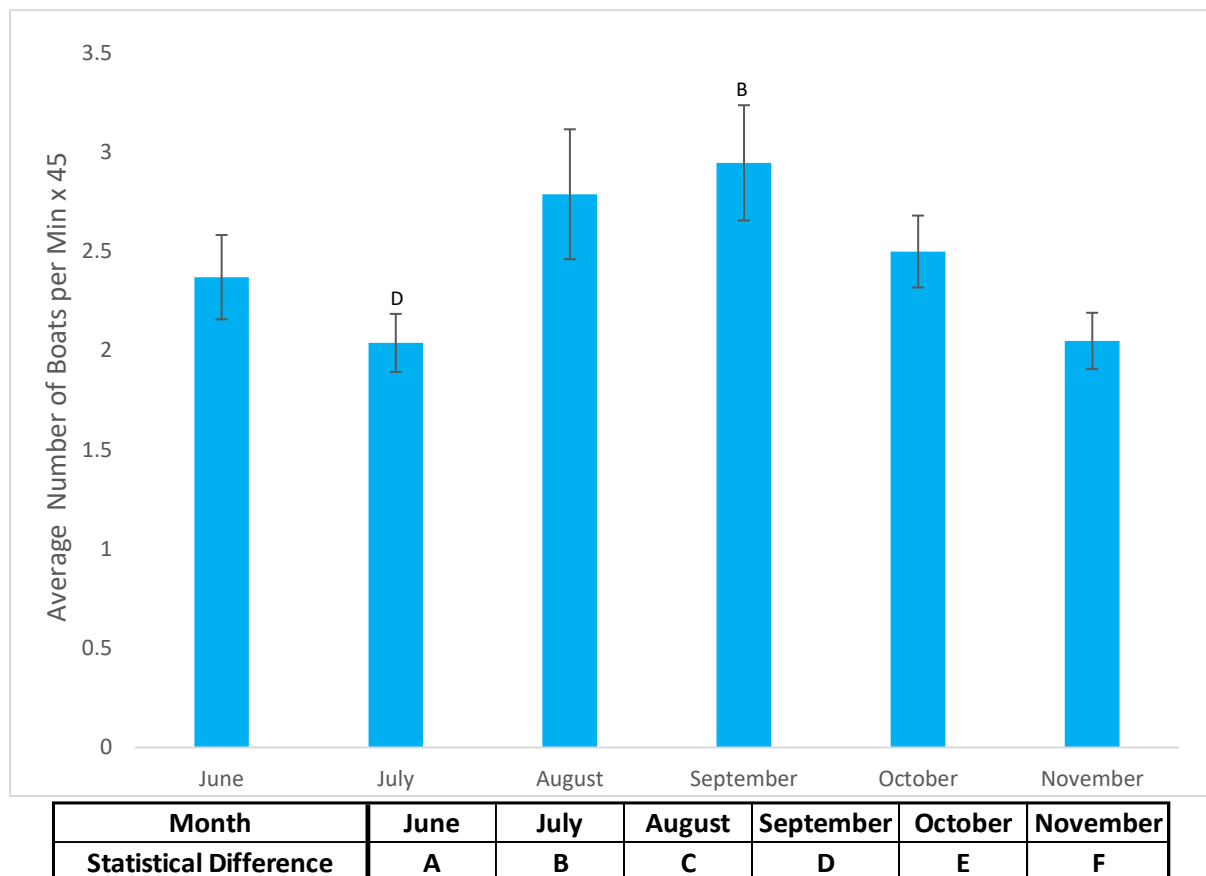
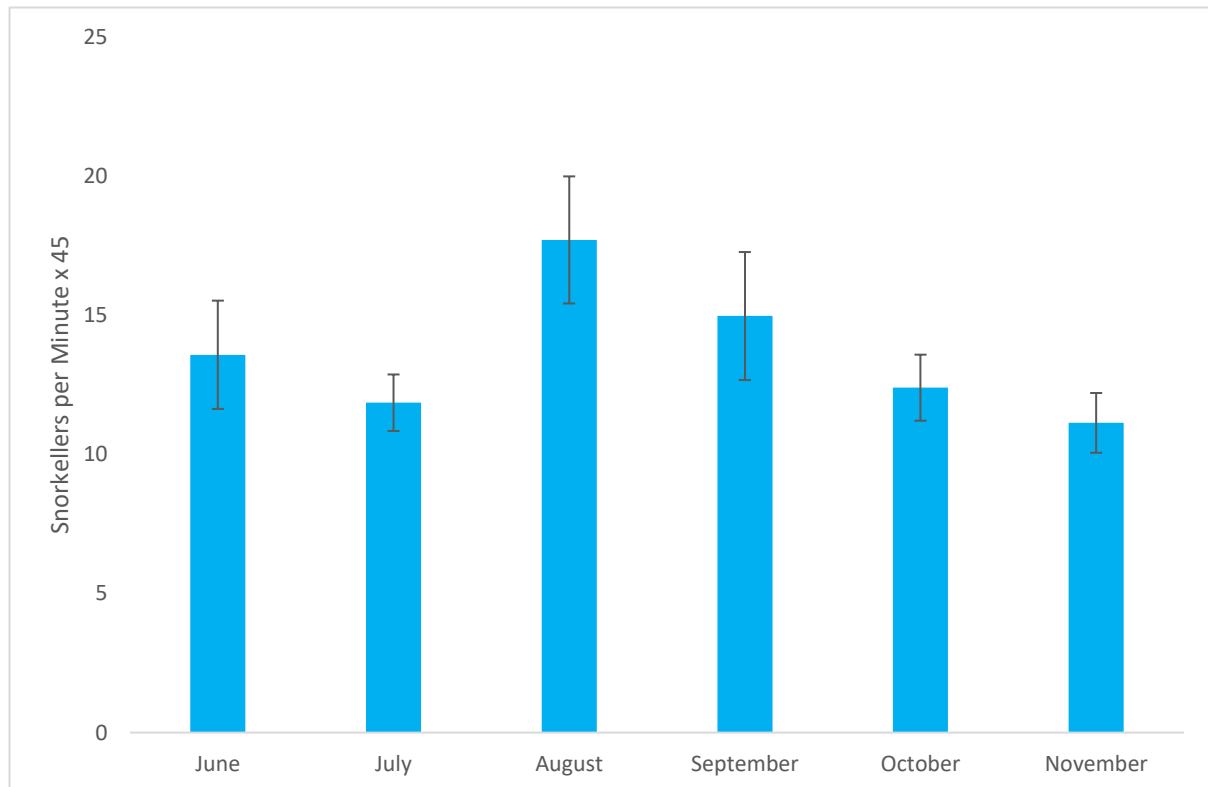**(-) Incorporates multiple years in a row e.g. A-E = ABCDE**

Appendix 6.1. Shows the average number of boats in Hanifaru Bay per 45 minute session between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.55015, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1634.3, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 6.1. Shows the p value results from a Pairwise Wilcox test of the average number of boats per 45 minute session in Hanifaru Bay by month between 2010-2019. Any highlighted values indicate significance between years.

	August	July	June	November	October
July	0.382	-	-	-	-
June	1	1	-	-	-
November	1	1	1	-	-
October	1	0.076	1	1	-
September	1	0.028	0.875	1	1

Appendix 6.2. - Snorkellers per Day in Hanifaru Bay per 45 Minute Session by Month between 2010-2019

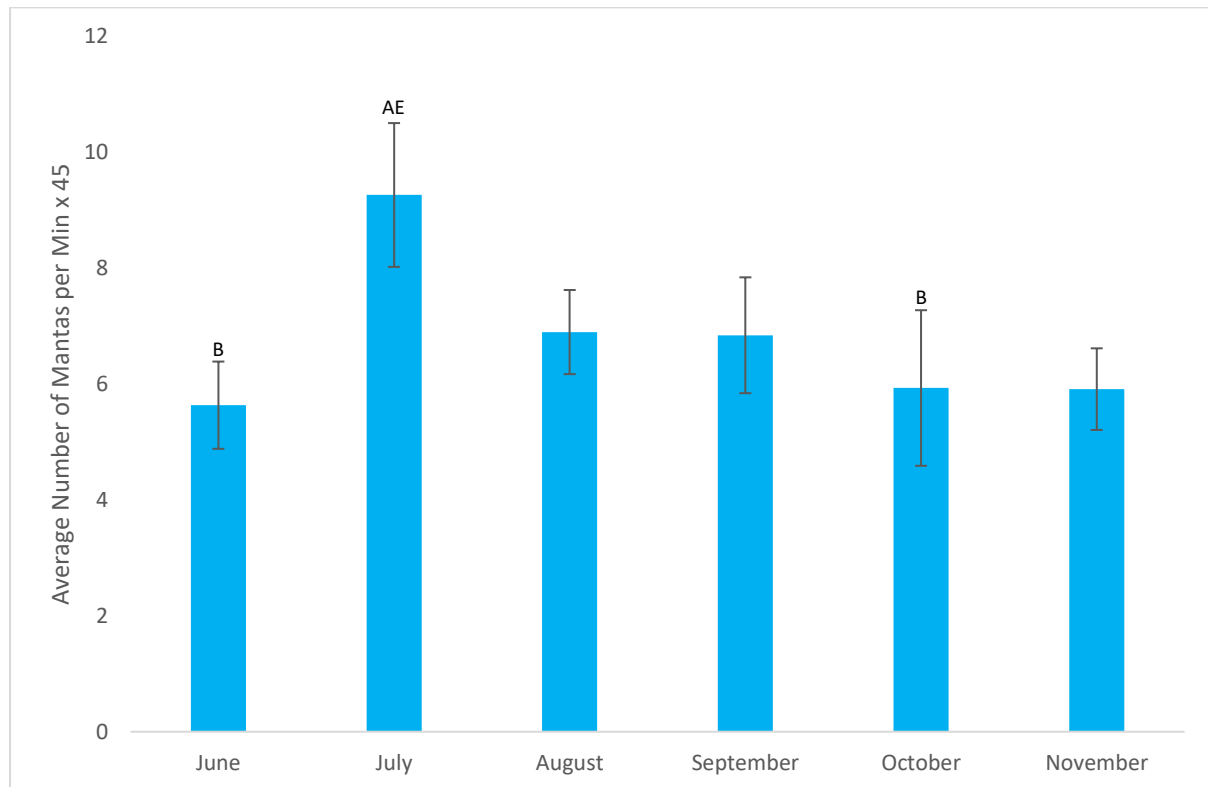| Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 6.2. Shows the average number of snorkellers in Hanifaru Bay per 45 minute session between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.47197, p = <0.001), a Kruskal-Wallis Rank Sum test (chi-squared = 1640.4, df = 1, p = < 0.001) and Pairwise Wilcox test showing significance (p = <0.05). Error bars in standard error.

Table 6.2. Shows the p value results from a Pairwise Wilcox test of the average number of snorkellers per 45 minute session in Hanifaru Bay by month between 2010-2019 Any highlighted values indicate significance between years.

	August	July	June	November	October
July	0.94	-	-	-	-
June	1	1	-	-	-
November	1	1	1	-	-
October	1	1	1	1	-
September	1	1	1	1	1

Appendix 6.3. - Confirmed Manta Ray Sightings per Min x 45 by Month between 2010-2019

Month	June	July	August	September	October	November
Statistical Difference	A	B	C	D	E	F

(-) Incorporates multiple years in a row e.g. A-E = ABCDE

Appendix 6.3. Shows the average number of manta ray sightings (*m. alfredi*) in Hanifaru Bay per 45 minute session between 2010-2019 by month using a Shapiro-Wilk test for normality (W = 0.44959, *p* = <0.001), a Kruskal- Wallis Rank Sum test (chi-squared = 1636.2, df = 1, *p* = < 0.001) and Pairwise Wilcox test showing significance (*p* = <0.05). Error bars in standard error.

Table 6.3. Shows the *p* value results from a Pairwise Wilcox test of the average number of manta rays per 45 minute session in Hanifaru Bay by month between 2010-2019. Any highlighted values indicate significance between years.

	August	July	June	November	October
July	1	-	-	-	-
June	0.56	0.026	-	-	-
November	1	0.33	1	-	-
October	0.18	0.0035	1	1	-
September	1	0.11	1	1	1

Appendix 7.0. - Baa Atoll Dive Operator Recommendations Questionnaire

CHECK spacing of line and alignment of questions

11. **Which type of operation do you run?**

 a) Resort/Hotel?

b) Guesthouse/ Local dive centre

c) Safari boat / Liveaboard

2. **Ensure alternate day site use is enforced within the bay alongside maximum boat and snorkeller numbers.**

a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation having on your business?

b) **Do you feel this recommendation would be economically viable for your business?**

c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

3. **Keeping the Hanifaru Bay Management Plan with no changes at all.**

a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation having on your business?

b) **Do you feel this recommendation would be economically viable for your business?**

c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

4. Increase ranger presence over peak tourist periods between July-September, over flood and high tide and on full and new moons.

a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation will have on your business?

b) Do you feel this recommendation would be economically viable for your business?

c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

5. **Increase entrance fee during peak times of predicted peak manta activities to fund increased ranger patrols.**

a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation will have on your business?

b) Do you feel this recommendation would be economically viable for your business?

c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

6. **Increased monitoring of visitor permits by boarding a select number of boats during the visitation hours to check permits and snorkeller numbers ensuring operator compliance.**

    a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation will have on your business?

    b) Do you feel this recommendation would be economically viable for your business?

    c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

7. **Apply on the spot fines for any operators breaking on site rules or visiting the bay outside their designated day.**

    a) From the perspective as a business/company operating within the Hanifaru Bay MPA, what positives or negatives can you see this recommendation will have on your business?

    b) Do you feel this recommendation would be economically viable for your business?

    c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

8. Recommend a reduction of 5 snorkellers to one guide within the bay to increase tourist in water compliance to current recommended codes of conduct.

a) From the perspective as a business/company operating within the Hanifaru Bay MPA,, what positives or negatives can you see this recommendation will have on your business?

b) Do you feel this recommendation would be economically viable for your business?

c) How well do you feel this recommendation could protect manta rays from tourist activity within the bay?

9. Introducing a Sipadan style permit system into the Hanifaru Bay Management Plan.

This would involve supplying a set number of permits equally distributed between tourist operators. Permits for an hour time slot (whilst keeping in water activity to 45 minutes maximum) would be sold over peak times on a flood and high tide inside the bay. These permits could be bought months in advance by tourists via their tour operator, guaranteeing visits to Hanifaru Bay at potential peak manta ray feeding times, without encouraging overcrowding. If operators have spare slots available, they can sell them to local dive centres to ensure spots are not wasted. This would be implemented alongside the current alternate day site restrictions in place and outside these peak times current practices could still occur.

a) After reading the above idea of introducing a Sipadan style permit system to the Hanifaru Bay Management Plan, do you feel this could be effectively enforced or would it be too complicated for operators and rangers to adhere to?

b) Do you feel this style of permit system would positively or negatively impact your clients experience whilst visiting Hanifaru Bay?

c) Do you feel this permit system would be economically viable for your business?

10. After reading these recommendations presented which do you feel is your favourite?

11. Are there any other recommendations that have not been mentioned you feel the Hanifaru Bay Management Plan would benefit from?