

Maldivian Manta Ray Project

2013 Season Summary

Executive Summary

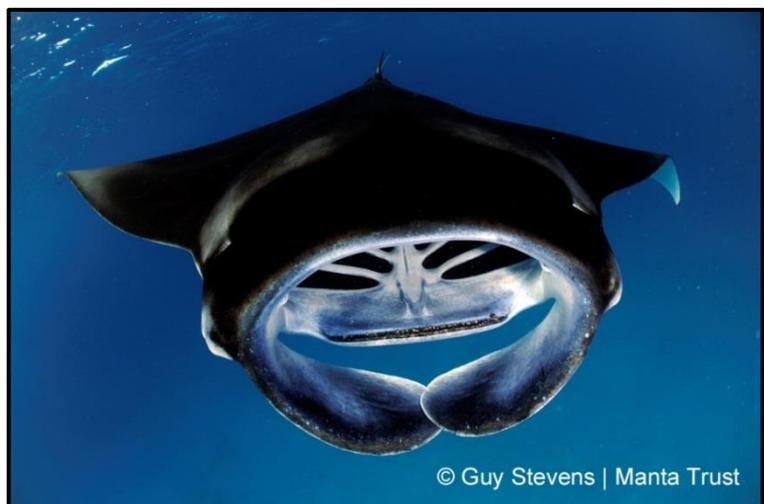
This report presents data collected by the Maldivian Manta Ray Project (MMRP) on Baa Atoll's reef manta ray (*Manta alfredi*) population between June and December 2013.

Baa Atoll has an international reputation as one of the most reliable places in the world to see manta rays and whale sharks (*Rhincodon typus*). These animals frequent the waters of Baa Atoll due to the conditions created by the South Asian Monsoon, which provides an abundant source of food for these planktivore creatures in this region. In Baa Atoll these animals have been continuously studied since 2007 by the Maldivian Manta Ray Project (MMRP), a non-profit, independent conservation and research focused organisation; and the founding project of the UK charity, The Manta Trust.

Key findings of the MMRP in 2013 include a total of 3,051 sightings of 708 individual manta rays, recorded during 150 days of survey. This equates to a slight increase in sightings compared to the previous year and a decrease of 17% in the number of individual mantas seen. Overall these numbers reflect closely the results of the 2012 season where an increase in manta sightings from 2011 suggested a direct correlation between manta sightings and environmental factors such as monsoonal strength and wind speed.

It is also worth noting however that, as for the 2012 season, the increased number of sightings has also been influenced by a greater level of effort in research in recent years and therefore when standardised and compared to previous years, 2013 sightings were in fact less on average than in 2008-2010.

Throughout the 6 months of survey 710 different individuals have been observed. When considered alongside the full sightings data set, on average each manta was observed 4.31 times during this season, a slight but further increase from 2012 (average 3.94 sightings per day). The proportion of rays seen on



more than one occasion slightly decreased from 69% in 2012, to 67%, a figure which is still in line with pre 2011 data. These facts together suggest longer residency periods for mantas in Baa Atoll again this year, strengthening the hypothesis that environmental factors and the strength of the monsoon are keys to this population of animals being present in Baa Atoll.

It is interesting to note that, unlike historical observations in previous years, during this season the total number of manta rays observed peaked in October and November with respectively 1006 and 668 encounters. The trend this year certainly reflects a shift in primary productivity as the highest level of zooplankton concentrations were recorded during those two months (October – November); there are reasons to believe that such a shift in productivity (and consequently manta sightings) might be related to changes in monsoonal activities (wind speed and direction which directly affect oceanic currents).

The lack of pregnancies observed for the past four years was one of the major concerns at the start of the 2013 season. However, courtship behaviours and mating trains, as well as fresh mating scars (indicating recent mating activity), were recorded on multiple occasions throughout the first two months of surveys. Furthermore, in October the first pregnancies were observed. By the end of the season a total of 8 females were recorded pregnant, 3 of which have never been observed pregnant before. The recommencement of reproductive activity is a reassuring event suggesting an increase in food availability and a gradual return to the pre 2010 conditions. The reasons behind the lack of reproduction observed between 2010 and 2012 are still under investigation, but appear to be linked to a reduction in productivity which can be linked to weakened monsoon conditions.

Due to the strong correlations observed in the past years between environmental variables and manta ray abundance, the MMRP continued to collect data such as wind speed, wind direction and



other weather variables. All of these environmental factors appear to have a strong influence on the numbers of manta rays seen in the atoll during the Southwest Monsoon, although wind speed especially appears to have a direct impact on manta ray numbers. This trend was again apparent in the 2013 data set. We can only speculate about the reasons for the decreased wind speeds

recorded in recent years, but it seems likely that they are linked to broader scale climatic events such

as the Indian Ocean Dipole (IOD) and El Niño-Southern Oscillation (ENSO). These large scale fluctuations in the regional climate and weather patterns in the Maldives need to be studied in more detail, as the negative implications for the fecundity of the manta population, and the overall health of the reef ecosystem as a whole, are very concerning if recent trends reappear in the coming years.

Direct human influence is also a factor considered by the MMRP in their research. Tourism in Baa Atoll has seen a significant increase over the last few years particularly due to the presence of the high numbers of manta rays and whale sharks in these waters. Recognising this, the Maldivian government has taken numerous steps to protect key areas for these species and in 2011 Baa Atoll was designated as a UNESCO World Biosphere Reserve, recognised upon its designation as having *“great potential for demonstrating sustainable development throughout the Maldives and the region,*



while relying on a green economy” and Hanifaru Bay was designated as a core protected area within the Biosphere Reserve. In 2012 the Hanifaru Bay Management plan came into full effect with a daily team of rangers whose presence helped monitoring tourism activities and implemented the stricter regulations for site uses. The success of such Management plan was not

replicated in 2013 where the lack of rangers at the site coincided with an intensification of infractions to the site use regulations. The rangers’ presence was recorded at Hanifaru Bay only twice out of the 64 days of surveys at the site. The lack of supervision resulted in frequent regulations’ infractions such as diving and fishing inside the MPA.

As the measures to conserve and manage the environment and human impacts in Baa Atoll become constant and more rigorous, there is much to look forward to in 2014 and beyond. It is, however, crucial that active research into manta rays and other marine life continues in order to monitor the effects of both tourism and environmental change. Manta rays are an incredibly important economic resource for the Maldives bringing tens of thousands of people to the country each year to dive and snorkel with them, generating millions of USD for the economy annually. Being able to pinpoint the reasons for any observed trends in, or threats too, the Maldivian manta ray population is crucial for the ongoing management and protection of these animals.



Understanding the Southwest Monsoon

As outlined in previous MMRP reports, understanding the effects of the Maldives Southwest Monsoon is critical to understanding the reasons for the abundance of manta rays and whale sharks that are seen in Baa Atoll during this season.

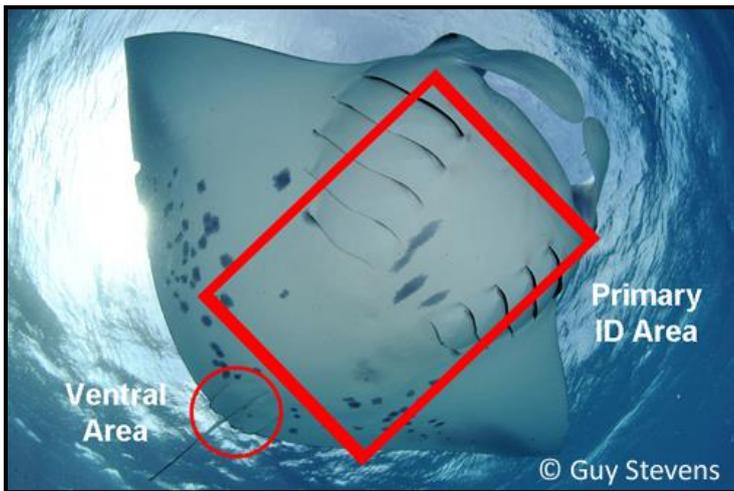
The monsoons, which dictate the weather in the Maldives, are characterised by their winds, which blow consistently and reverse their direction seasonally. The Maldives Southwest Monsoon, or Hulhangu, runs from May-October, while the Northeast Monsoon, or Iruvai, runs from December-March each year, with the months of November and April acting as transitional periods of change in between. The Southwest Monsoon typically brings with it much more rain and cloud cover, with reduced visibility and rougher seas.

During the Southwest Monsoon the strong winds in turn create oceanic currents which flow from the southwest towards the northeast. The Maldivian islands and atolls, rising some 2,000 meters from the sea floor, act like a barrier to these currents, displacing the water as it flows through and around the atolls creating deep-water upwelling. These upwellings bring nutrient rich water within reach of the sun's life giving energy and through photosynthesis kick start the food chain, first with phytoplankton, then with zooplankton which predate upon the phytoplankton. Zooplankton is the prey of manta rays (and whale sharks) and as strong lunar currents flow into the shallows of the atolls through the channels, the concentrated zooplankton is so abundant that the Maldivian waters support the world's largest known population of reef manta rays.

During a typical Southwest Monsoon the wind blows consistently and steadily from the southwest, causing the greatest concentrations of the manta planktonic food on the monsoonal down-current edges of the atolls. Stronger monsoonal winds generate stronger currents, more upwelling and more primary productivity, which in turn generate more of the zooplankton food, therefore attracting higher numbers of these animals into the shallow waters. When tidal exchanges bring water from the outside of the atoll in through the channels along the atoll's eastern edges they become, temporarily, dense plankton funnels and these are the sites at which we are more likely to observe planktivorous megafauna in the greatest concentrations.

Study Period and Sampling

Surveys to look for manta rays were carried out in Baa Atoll between the 4th June and the 29th November 2013 on as many days as possible where conditions allowed. Survey trips were made on 150 days within this 179 day survey period.



As per the 2012 season, management measures (see section below) meant that access to the main study site Hanifaru Bay MPA was more restricted than in the years prior to 2011. Therefore both Hanifaru and other sites around the eastern border of Baa Atoll were surveyed, as per the protocol implemented during 2011. To account for changes in sampling efforts at key sites data from all years, data was standardised where possible to give comparable results.

On each research trip location, wind speed, wind direction and other environmental weather variables were noted alongside manta ray numbers and prevalent behaviours. In-water, individual mantas were documented by photographing the unique spot patterns on their undersides (ventral surface). The whole team were experienced free divers, using this advanced snorkelling technique to allow them to take photo-ID shots with the minimum of disturbance to the animals. For the purposes of this report a *sighting* is defined as a confirmed photo identification of an individual manta ray on a given day.

Management Changes and Initiatives

Management initiatives at Hanifaru Bay MPA are continuing to be implemented as per 2012. The main regulations include a ban on SCUBA diving inside Hanifaru Bay MPA, a fishing ban inside the bay and within a buffer zone surrounding it, a schedule for the alternation of entrance days between liveboard and resort boats and boats' entrance speed limit and the use of a specific entrance path.

Snorkel guides using Hanifaru Bay were also required to sit an exam qualifying them to guide tourists inside the bay. Minimum levels of in-water/dive qualifications and first aid certifications were also required for these guides.

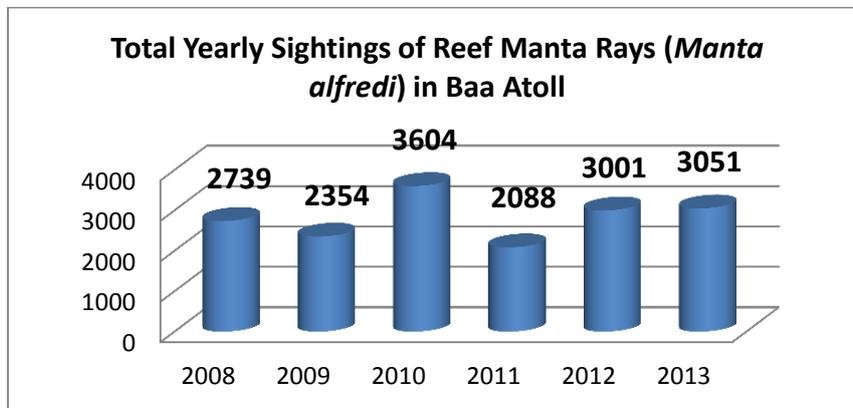
Differently from 2012, this season lacked the presence of EPA Rangers on site which resulted in an increase of infractions such as SCUBA diving inside the bay, disrespectfulness of scheduled alternation days (Liveboards/Resorts), fishing inside the bay and throughout the buffer zone and more. Fishing using long lining technique (a particularly dangerous method for marine megafauna) was also observed and documented nearby Hanifaru MPA on multiple occasions. The lack of EPA Rangers on site also implied the lack of entry tokens' collection and revenue generation to support the management of the Biosphere Reserve.

Manta Ray Sightings

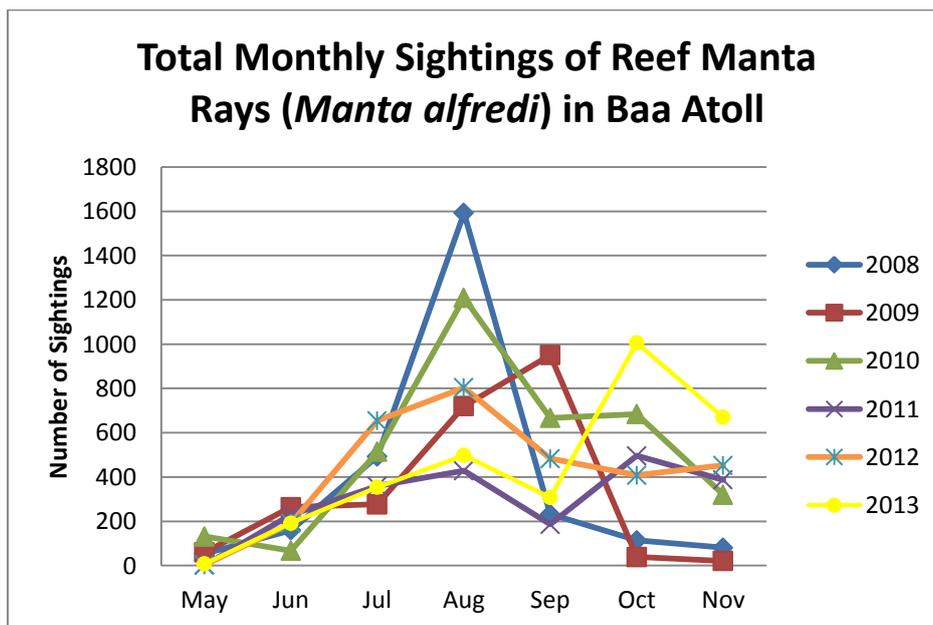
Total Baa Atoll Sightings:

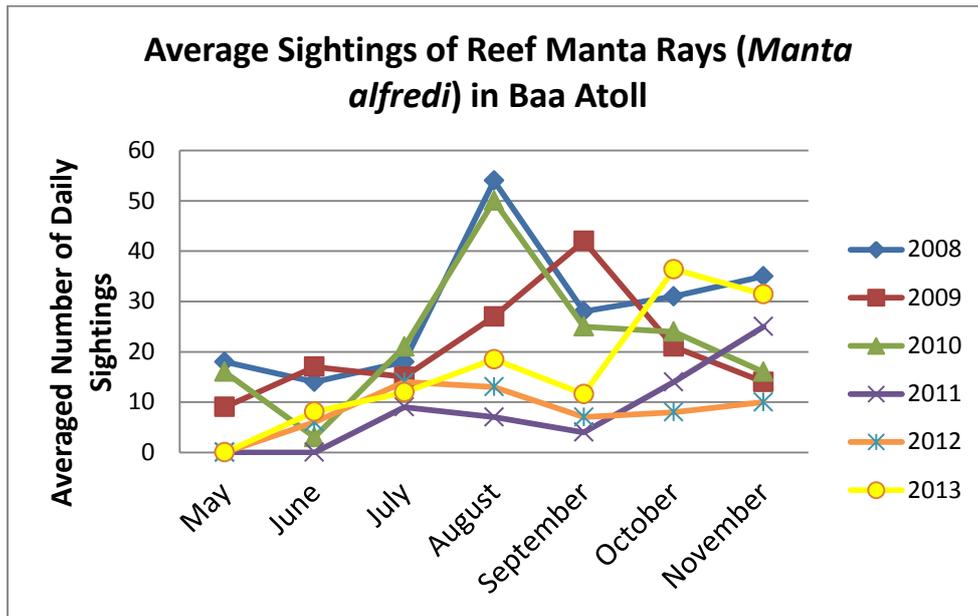
Sightings across the whole of Baa Atoll in 2013 have slightly increased from the total collected in 2012, although this is likely to be a result of the ban from Hanifaru Bay MPA imposed last year from August 2012 to the Manta Trust research vessel and the increased number of survey days in 2013. The monthly breakdown interestingly shows a peak in October and November, a shift from the historical August's peak observed since 2007.

The graphs below depict total number of sightings over the years:



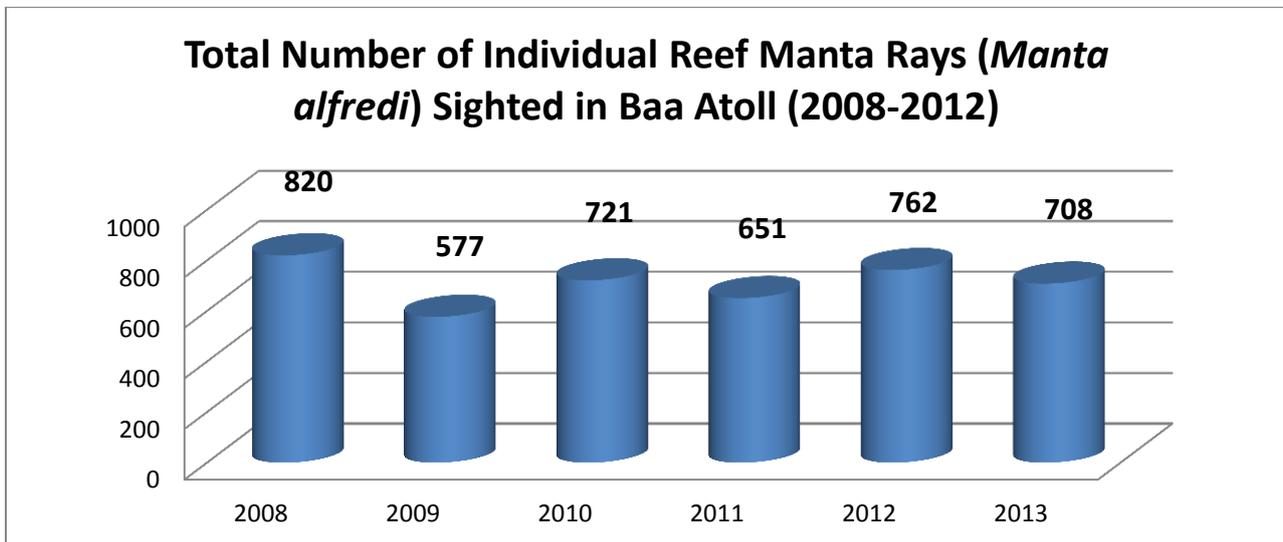
When number of sightings per month is standardised for survey effort the peak observed in October and November becomes even more pronounced (see below).



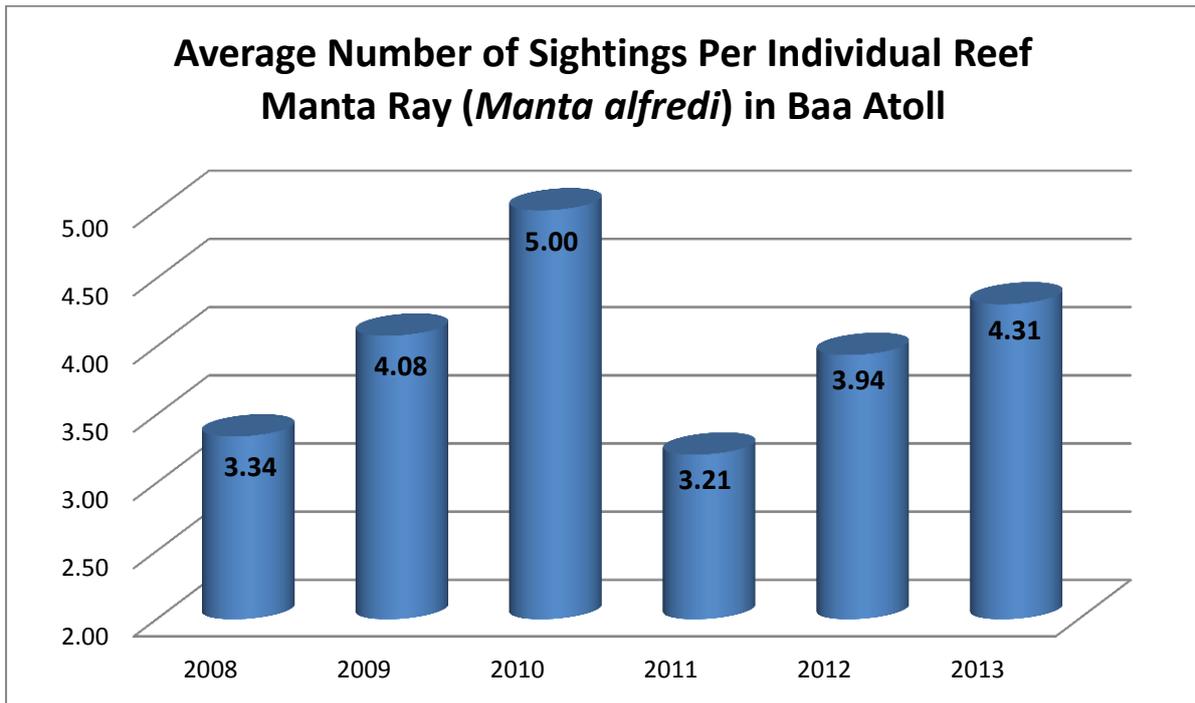


Total Number of Manta Rays:

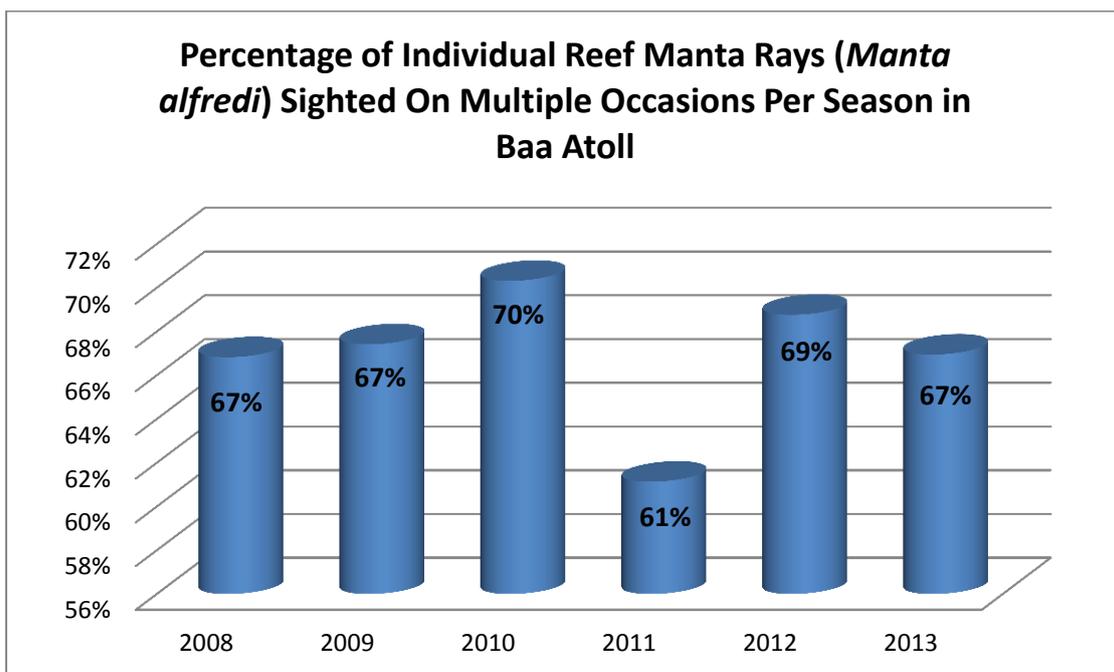
A total of 708 different individual manta rays were recorded in Baa Atoll during the 2013 southwest monsoon, which is 23% of the total recorded Maldivian population of 3,119 individuals. In the last six years the total number of different individual mantas which have been recorded in Baa Atoll is 1,563, or 50% of the total recorded population in the Maldives.



Throughout the season each manta was observed 4.31 times, a slight but further increase from 2012 (average 3.94 sightings per day). The proportion of rays seen on more than one occasion slightly decreased from 2012 to 67%, a figure still in line with pre 2011 data. These data further suggest the anomaly of 2011 were likely as a result of the weakened monsoon.



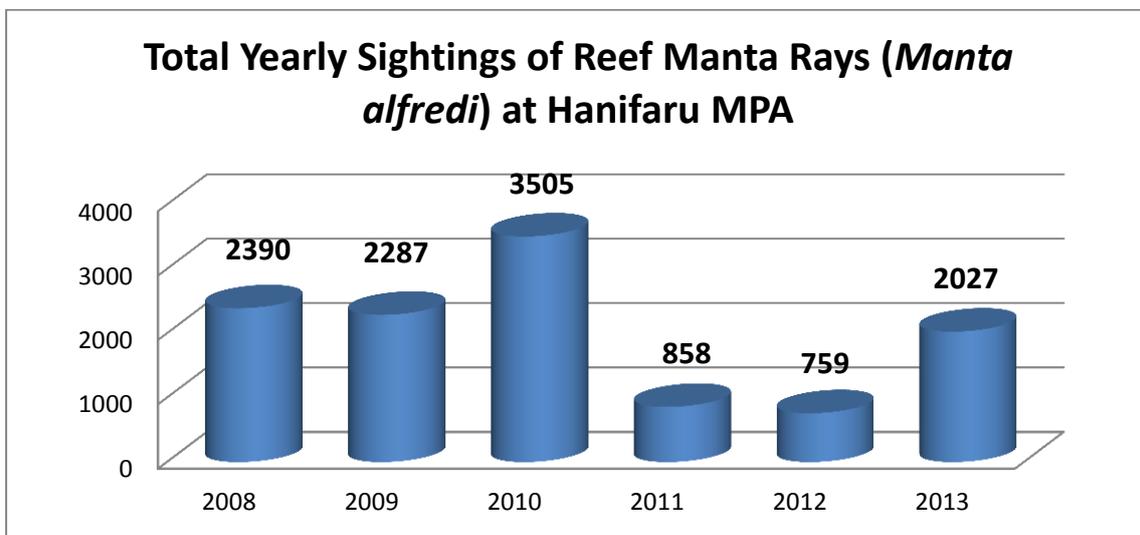
Complementing the averaged sighting data it is interesting to note the percentage of individual manta rays sighted on multiple occasions per season compared between years (see graph below). In the 2011 survey period there was a marked reduction in the number of individuals sighted on multiple occasions, again suggesting a more transient population of mantas during this time likely to be linked to a reduction in the localised abundance of the manta ray's planktonic food source. In 2012 and 2013 the sighting frequency returned to levels exhibited in the first three study years.



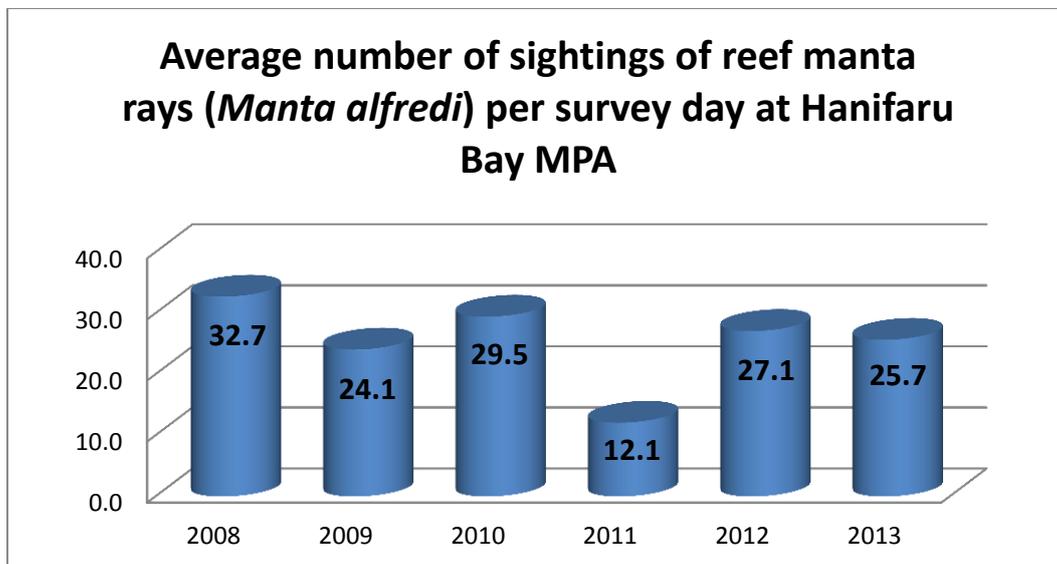
Sightings at Hanifaru Bay MPA:

Sightings of mantas rays at Hanifaru Bay (MPA) saw a dramatic increase compared to the past two years, although this is partly due to the access restrictions which led to insufficient data collection within Hanifaru Bay from August to November 2012. The standardised graph for survey effort reveals that the number of manta rays sighted per day in 2013 is slightly lower than that of previous years, excluding the anomaly of 2011 for reasons discussed above.

The graph below shows the total numbers of sightings recorded at Hanifaru per year since 2008:



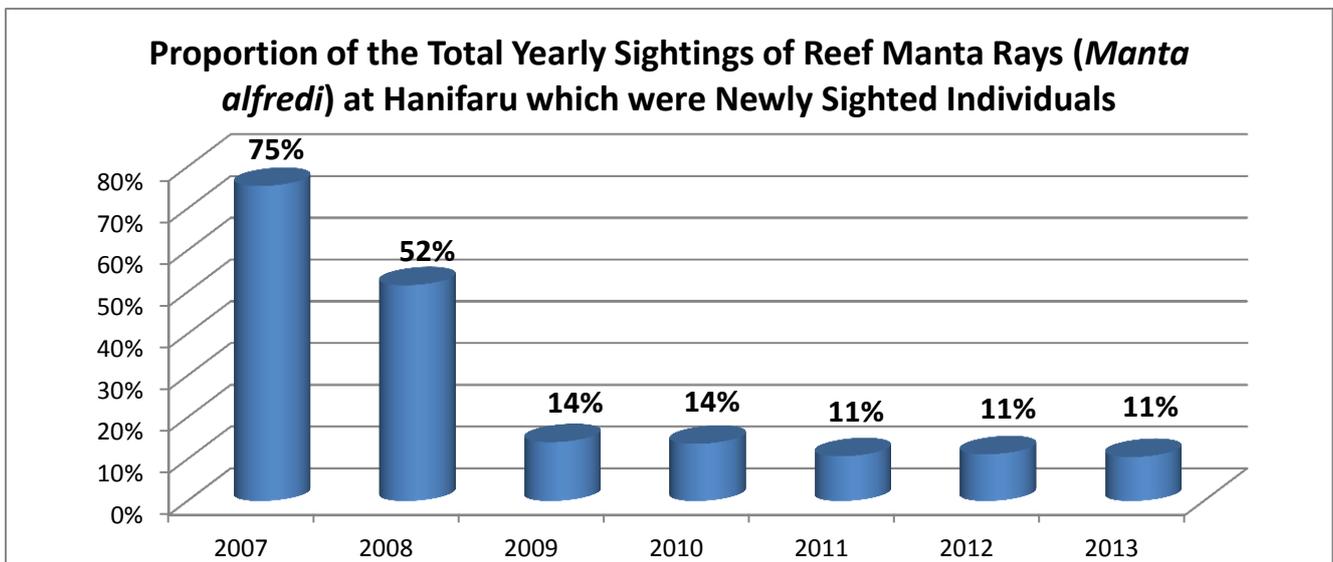
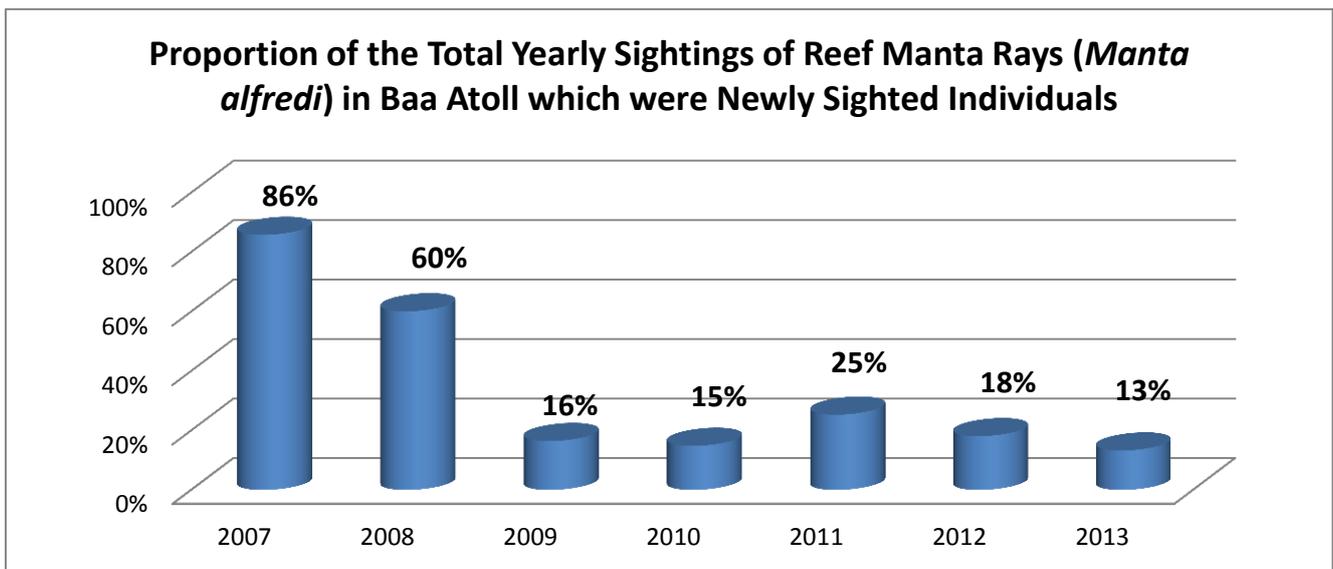
To account for the changes in sampling effort over the last 5 years the graph below shows the averaged daily numbers of mantas (standardised for effort) observed between May and December each year since 2008:



New Individual Manta Rays:

In total 94 new individual manta rays were identified during the survey period in Baa Atoll in 2012.

The graphs below shows how the proportion of newly sighted individuals recorded between 2007 and 2012 both in Baa Atoll as a whole and more specifically in Hanifaru Bay. As expected the number of new mantas seen as a proportion of the population follows a downward trend, as more years pass and more data is collected, new mantas become less frequent.

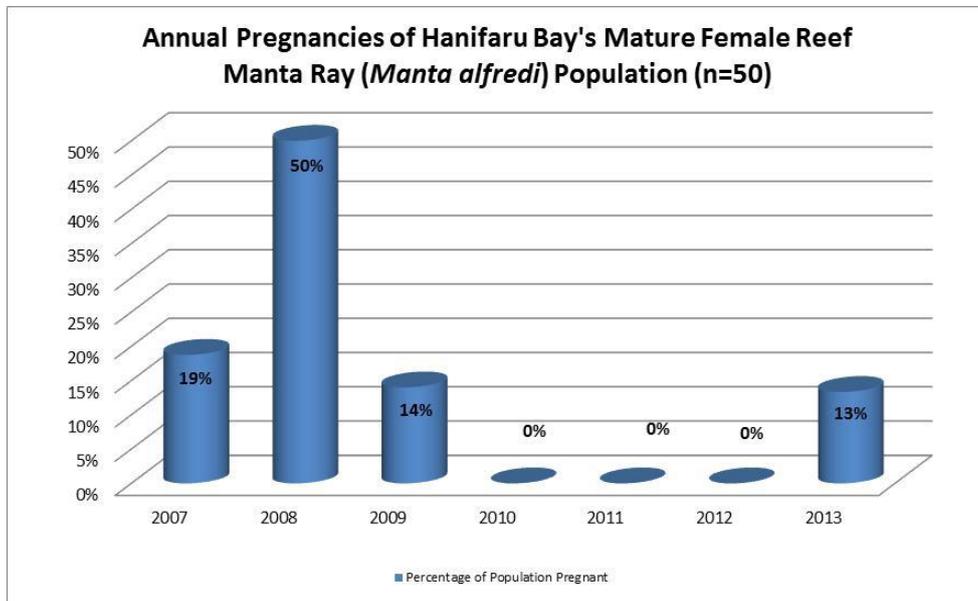


The slight increase in the proportion of newly sighted individuals in Baa Atoll observed in 2011 and 2012 was due to the addition of several new survey sites established in the region when daily access to Hanifaru became limited. After the third year of regular surveying of those new sites the

percentage of newly identified individuals is now at the lowest of the past 7 years (13% in 2013) suggesting that most of the Baa atoll mantas’ population has been recorded and identified.

Total Number of Pregnant Manta Rays:

After three consecutive years without pregnancies recorded, at the end of this season we observed signs of certain pregnancy on 8 different females, reducing our concerns for the health of the Maldivian manta rays’ population. The graph below shows the annual percentage of pregnancies recorded within a core group of Hanifaru Bay's most frequently sighted mature females:

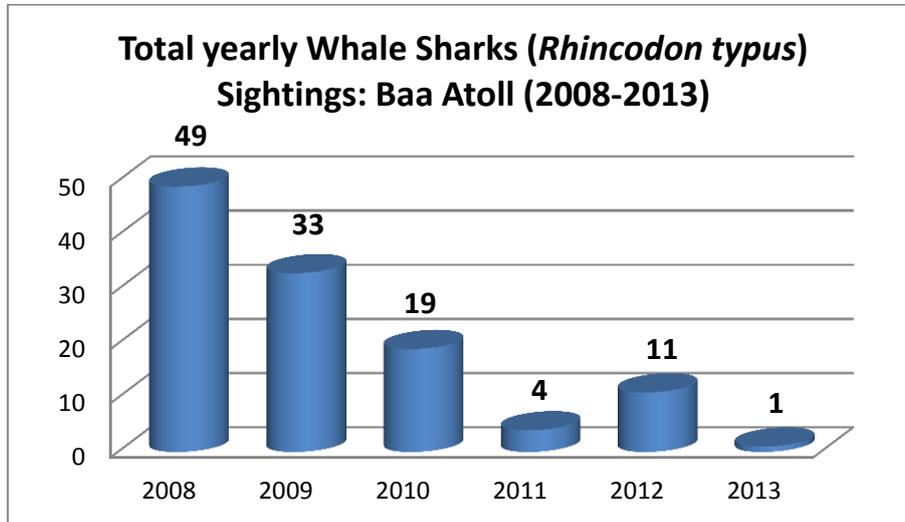


Courtship behaviours as well as signs of mating activity have been recorded throughout the season and the increase in planktonic food availability toward the last months of the South West monsoon probably gave a boost to foetal growth allowing clear signs of pregnancies to be visible. Courtship behaviour and pregnancies have also been observed in other atolls of the Maldives raising hope for a further increase in reproduction in 2014.

Whale Shark Sightings

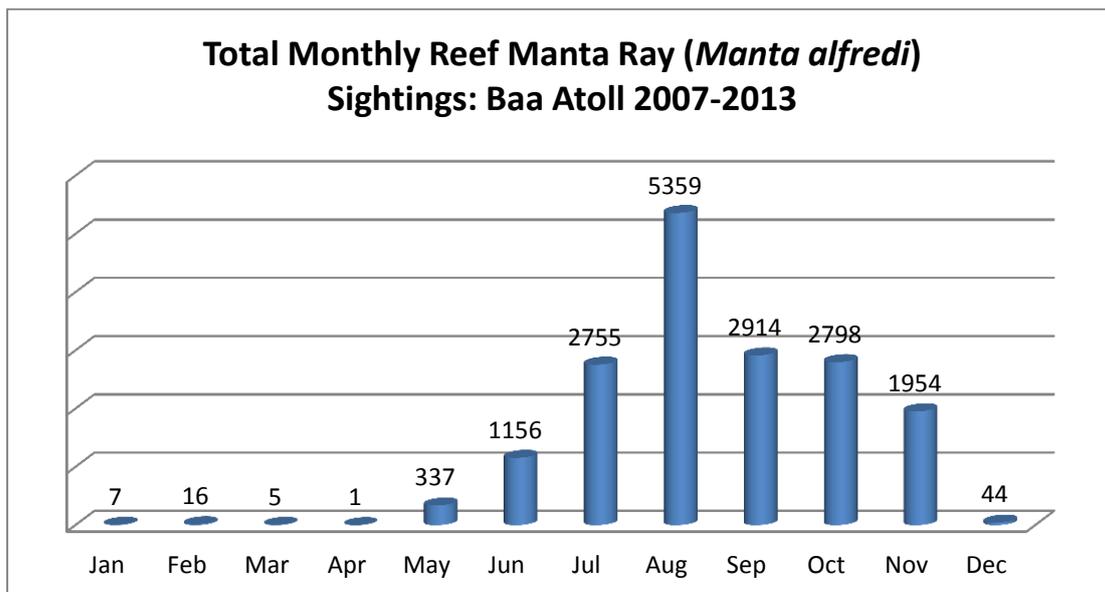
Surveys for manta rays as described above also looked for whale sharks as the two species often aggregate at the same locations to feed. During the 2013 season in Baa Atoll whale shark sightings have dramatically decreased reaching the lowest recorded in 7 years of surveys, 1 single sighting. The lack of whale sharks in the region is somewhat puzzling when compared to the relative abundance of manta rays. The lack of localised, consistent and predictable availability of planktonic food may be an explanation to such an observed drop in whale shark sightings. We further know from reliable sources that whale shark sightings have actually increased in other regions (mainly South Ari MPA).

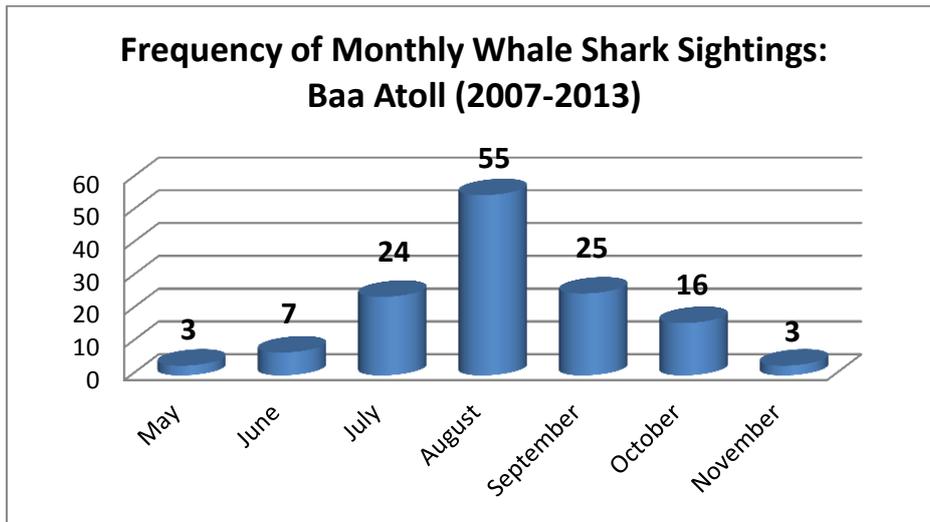
The occurrence of high zooplankton concentrations in such areas may have prevented sharks from migrating to other sites such as Baa Atoll in search of food.



In Season Sighting Variation:

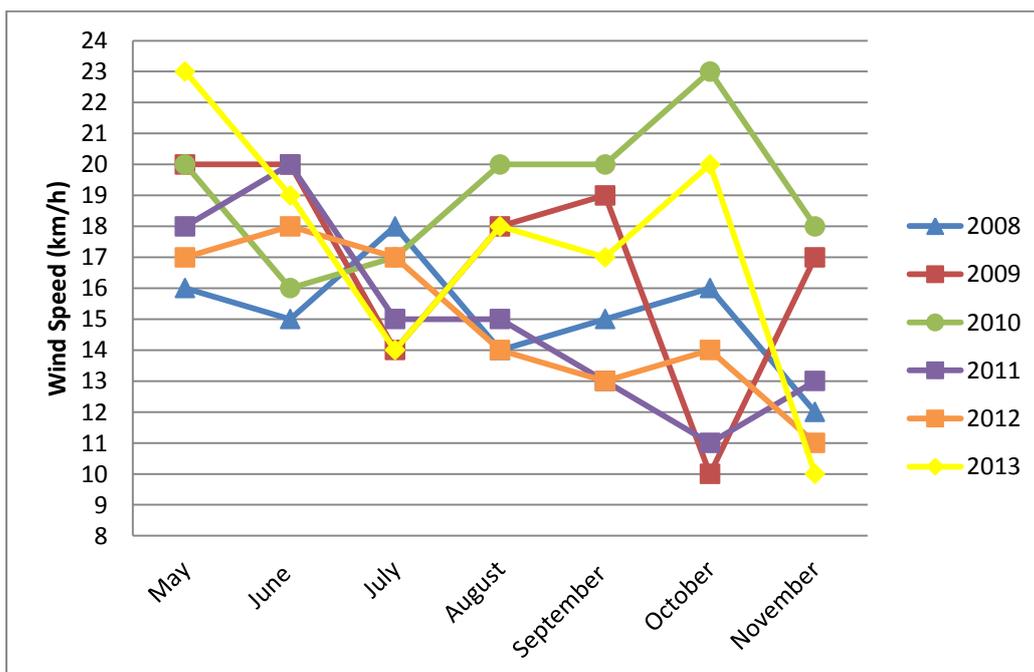
The two graphs below clearly show the concentration of sightings for both manta rays and whale sharks occur in the months of June through November, with 30% and 41% of the total yearly manta and whale shark sightings respectively occurring in the month of August alone. It is worth noting that this season manta sightings peaked in October and November resulting in an asymmetric trend in the season's frequency distribution - sightings suddenly peak in August and gently drop off until the end of the season.



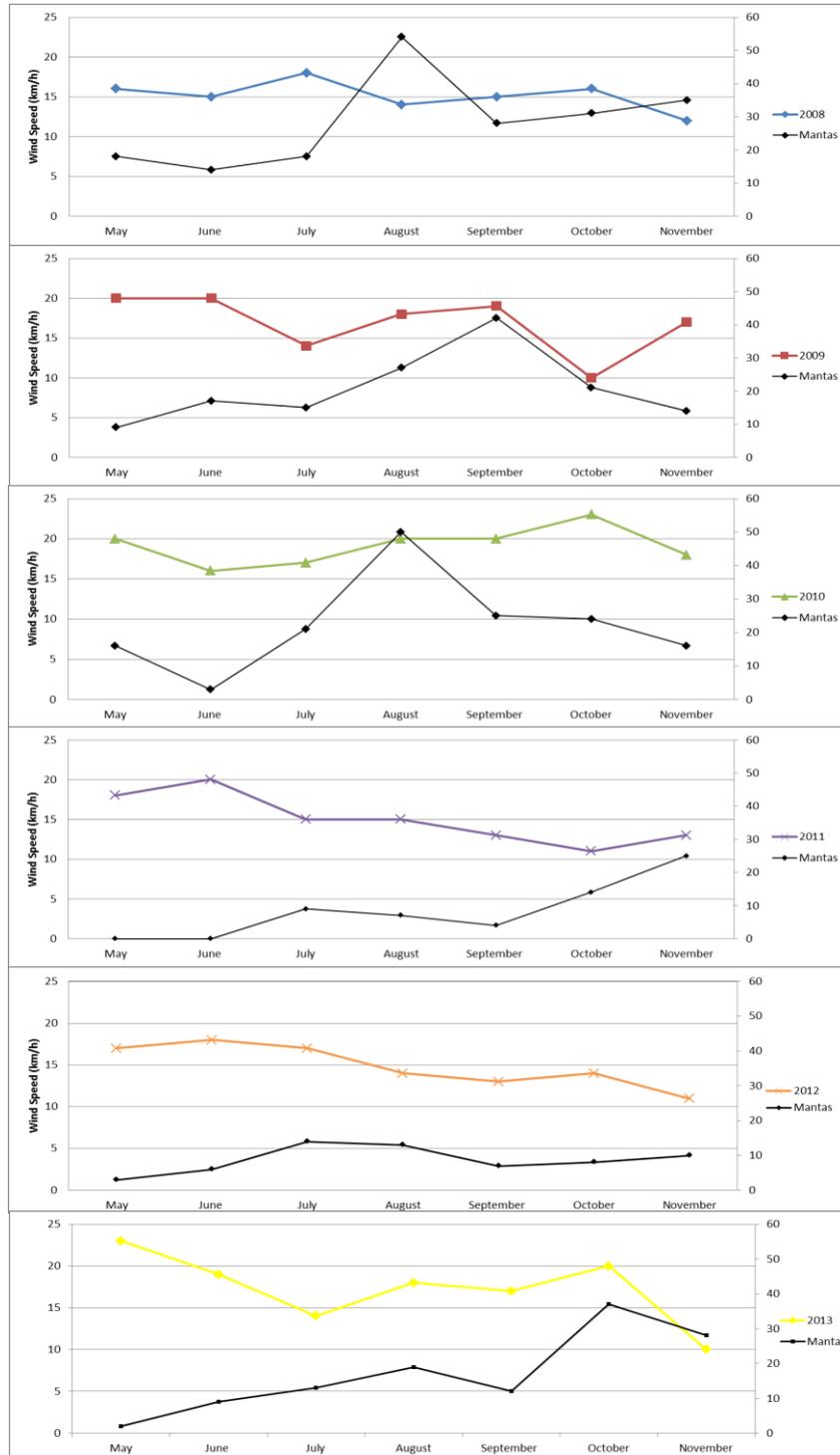


Weather and Climatic Variation

As a continuation of the investigation instigated in 2011 to look into the possible links between manta ray sightings and the strength of the Southwest Monsoon, the MMRP continued to look at the correlations between weather patterns and mega fauna abundance in 2013. The average wind speed observed in 2013 was 17.28 Km/h, the second highest recorded (19.14 Km/h in 2010) and also followed a similar monthly pattern to that observed in 2010, with wind speed peaking in August - October. Somewhat puzzling is that the similarity in wind pattern between 2010 and 2013 was not followed by a similarity in the monthly manta sightings pattern (see graph on page 6), although irregular wind direction may explain such discrepancy.



Without the wind and therefore the strong monsoonal currents required to kick start the plankton production through upwelling, food availability for these planktivorous species is greatly reduced. The graphs below show that when there is an increase in the average wind speed, in the following weeks there is often a subsequent increase in the average number of manta sightings.

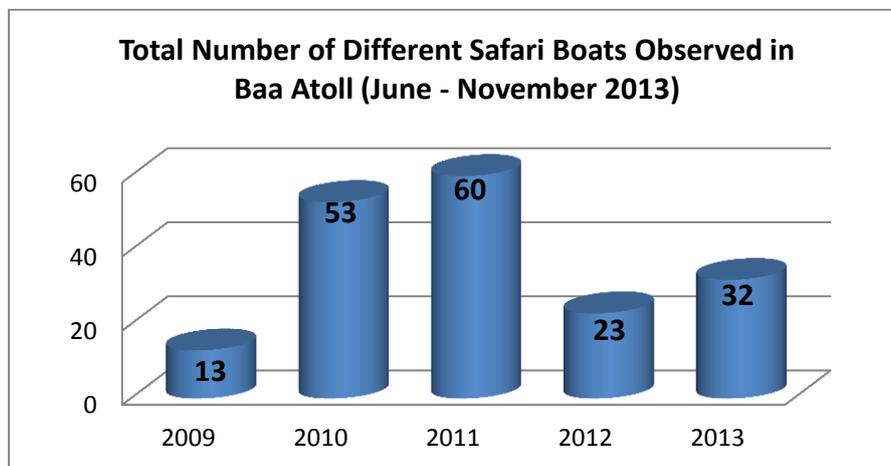


These observations might be part of a natural cycle of variable weather patterns which occur within the Maldives over time, or more worryingly, they may be connected to larger climatic phenomenon such as the Indian Ocean Dipole (IOD) and the El-Niño Southern Oscillation (ENSO), both of which are linked to the increased fluctuations in climate change recorded in the Indian Ocean in recent decades. Only ongoing and consistent monitoring will show what might be causing such changes, and therefore what measures need to be taken to manage them. Regardless of cause, and leaving aside the ecological ramifications, these observations should be considered very seriously because of the negative economic consequences they will have if these trends continue. Not only will these trends affect manta ray tourism directly, but also on a wider scale they will affect the rest of the tourism and fishing industries which heavily rely upon the ocean's productivity, and therefore the strength of the monsoons.

It is very likely that this lack of food, brought about by the weakened Maldives monsoon, is responsible to some extent for the lack of pregnancies observed in the Maldivian manta ray population in recent years. Elasmobranch reproduction varies widely between species and reproduction within the genus *Manta* is very poorly understood, with much of what we know coming from just a few studies globally. Sharks and rays within the subclass Elasmobranchii have a wide range of reproductive techniques with some species able to store sperm or to repress or stagger pregnancies. It is likely these strategies have been developed in order to provide offspring with the best chances of survival. It is likely that manta rays are using similar strategies to ensure that their offspring are born during years which have a greater abundance of food to increase their chances of survival.

Tourism

Continuing the mandate put in place in 2011, liveaboard vessels and resorts had access to Hanifaru Bay MPA only every other day on an alternating schedule. Differently from last year, though, the schedule was not enforced due to the lack of EPA rangers on site throughout the entire season.



The ban on SCUBA diving in Hanifaru that came into effect starting January 2012, have had a significant impact on the number of safari boats observed, despite the good manta ray sightings inside the MPA in 2013. Many liveaboard vessels cater strictly to SCUBA divers and have a diving intensive schedule. As a result, these boats will not take the time to travel to Hanifaru if they cannot dive, while those vessels that clearly market the benefits of snorkelling with manta rays at this site



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have continued to run successful trips. For many liveaboard operators however, the lack of diving coupled with poor manta sightings in 2011, the alternate day restrictions which make it very hard for liveaboard to schedule a practical itinerary, and the increased cost of fuel, have all contributed to a significant reduction in the number of liveaboard vessels which are prepared to travel up to Baa Atoll in the last two years. The resorts have continued to visit the MPA as in previous years.

Baa Atoll Biosphere Reserve Education Programme

During this 2013 season the Manta Trust started a Baa Atoll Educational Programme with the aim to introduce school children of all ages to the world of marine biology, using mantas as the charismatic species to drive the wider conservation and educational message. While many tourists are increasingly educated about the marine life by biologists and scientists based on the resort islands and onboard dive liveaboard vessels, the local communities are for the most part unaware of the ecological and economical value of their country’s natural wealth. In order to successfully protect the resident population of manta rays and the wider marine environment in the Maldives it is essential that the next generation of Maldivians become aware of the increasing threats facing the oceans and their inhabitants. The ultimate objectives of the Baa Atoll Biosphere Reserve Education Programme are to increase awareness and understanding of the natural world and the threats it faces, whilst benefiting the local community.



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In 2013 our assistant project manager, Moosa Mohamed and project volunteers visited four different islands in Baa Atoll (Maalhoss, Dhonfanu, Kihaadhoo and Kamadhoo). At each school over 100 students (divided in grade groups) were given a presentation about manta rays' biology, emphasizing their ecological and economic value. A quiz was then presented to the students and prizes awarded to the winners. We recognised a high level of engagement and interest in our work amongst local school children of all ages and currently we are the only existing marine education programme within the Biosphere Reserve. The students were keen to learn more about mantas and the wider marine environment, they were especially eager to learn how they could become further involved in the science being carried out on their doorstep. This year three young Maldivian's also joined the project team for several weeks each in the field to get involved in the work of the MMRP.

To further increase the awareness of our work to the local population we organised *Manta Awareness Events* for the Four Seasons employees. During such events the staff were given a brief presentation about manta rays, shown short documentaries and finally engaged in games as well as given the possibility to name some of the newly identified mantas recorded throughout the season.

We believe the involvement and appreciation of young Maldivians for the marine environment is crucial for long term conservation and management of the unique marine resources found in the Maldivian waters. We look forward to working in collaboration with Maldivian governmental bodies and other environmental organisations in order to improve and expand this educational programme in 2014.



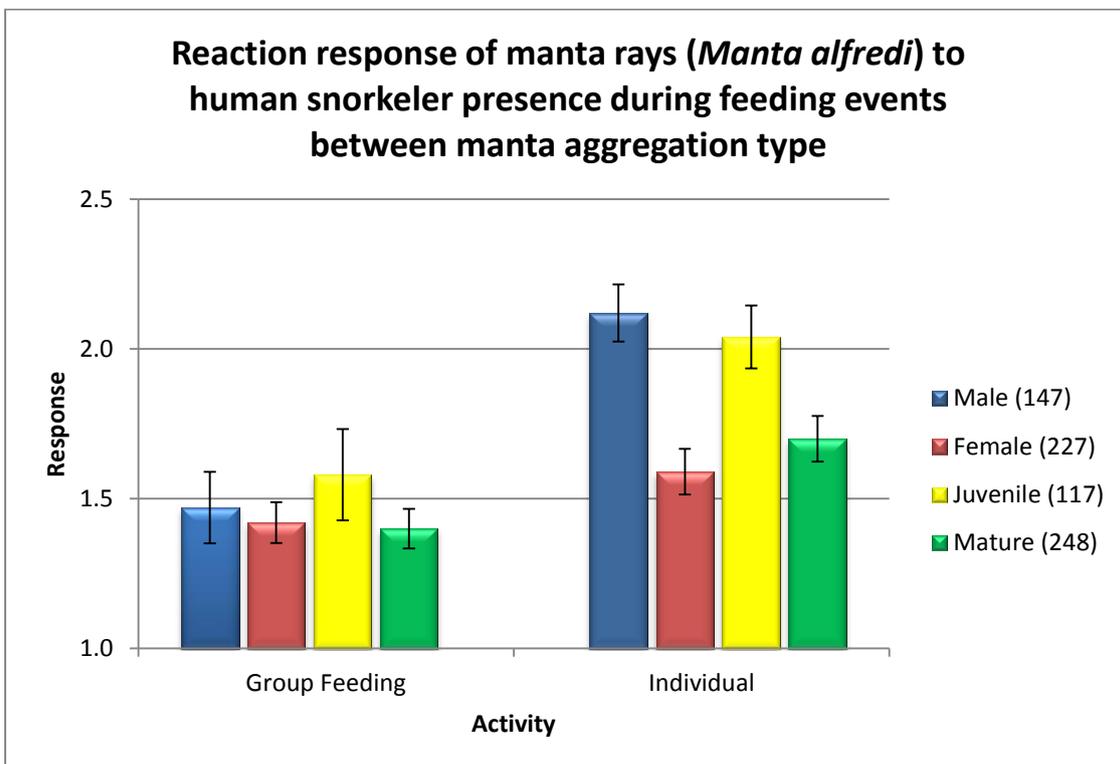
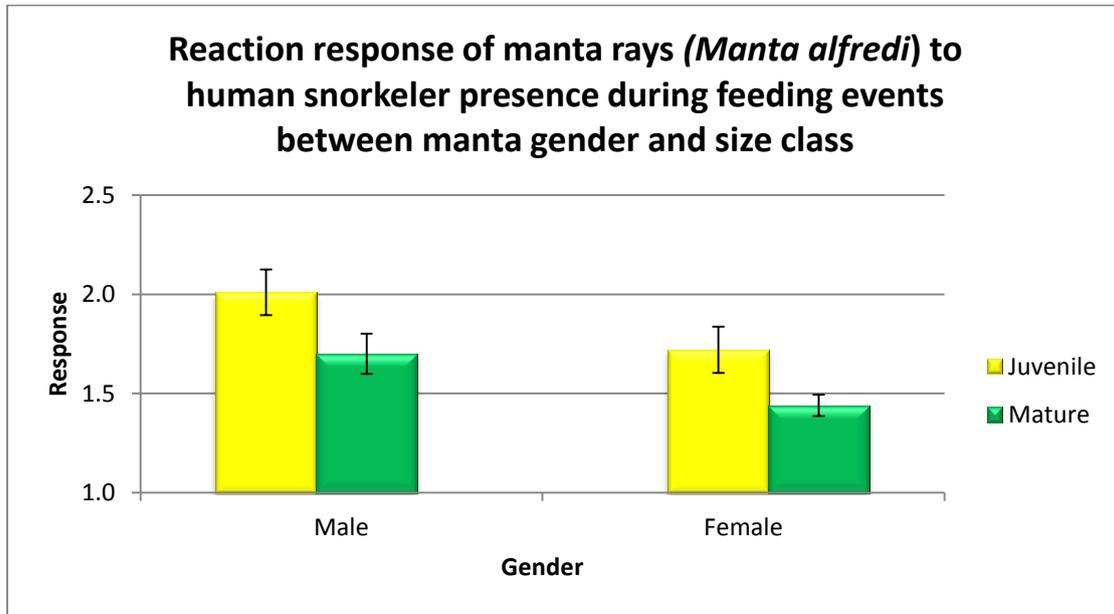
Study of Manta Ray Social Interactions with Snorkelers

During this season Annie Murray, MSc candidate at the University of York (UK) completed her MSc thesis studying the social interactions of manta rays in Baa Atoll. The aim of this study was to assess what, if any, variations are observed between the different size and sex classes of manta rays to human snorkeler presence in the water. Between June and August a total of 400 manta-snorkeler interactions were recorded. Data collected included intensity of the manta's reaction (1-4 scale), gender and age (juvenile vs adult) of the individual, site location, type of feeding aggregation (group feeding vs individual activity) and number of snorkelers in the water.

The results of the study show a clear distinction between the reactions of the manta sexes and age classes. Female manta rays display the lowest level of reaction, with juveniles' exhibiting higher levels

of disturbance in comparison to mature adults. Mantas feeding individually also react significantly more to the presence of snorkelers than when feeding in a group (see graphs below).

These differences in the manta's behaviour have implications for the ecotourism industry and must be considered in order to reduce negative impacts on manta populations.





Conservation and Management

The declaration, at the end of June 2011, that Baa Atoll was to become a UNESCO World Biosphere Reserve remains an important milestone for the Maldivian manta rays, with great implications for their ongoing protection, especially given the designation of Hanifaru Bay MPA as a core zone of the reserve. Management of these newly protected areas is crucial and we look forward to a more constant commitment in the near future by the Maldivian government's Environmental Protection Agency (EPA) and the Baa Atoll Biosphere Reserve Office to manage this site and the tourism that takes place within.

A World Biosphere Reserve strives to better understand the human impact and help safeguard natural ecosystems for the future. Long term, consistent data collection is crucial to grasp the influence and impact of tourism on this very unique population of animals and gain a broader understanding of manta rays worldwide. Without access to consistent and reliable manta ray sightings and the constant monitoring of tourism, little weight can be placed on any data collected. Interrupted and inconsistent data collection is much harder to accurately analyse or extrapolate trends from, resulting in more inconclusive results. Although previously gathered data is useful as a baseline, continuous and ongoing research of manta rays in Baa Atoll and throughout the Maldives must remain a priority if Baa Atoll's UNESCO World Biosphere Reserve is to be successful.

Maldivian Manta Ray Project (MMRP)

The MMRP is highly regarded within the scientific community. It is one of the longest running manta ray research programmes in the world. We would welcome the opportunity to continue to work with the Maldivian government for the long term management and conservation of these species in Maldivian waters. The opportunity we have to learn about manta rays in the Maldives is unique and has many implications on a global scale for manta ray conservation.

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

Guy Stevens - BSc (Hons), PhD Candidate: Chief Executive / Founder - The Manta Trust.

Niv Froman - BSc (Hons), MSc (Hons): Project Manager - Maldivian Manta Ray Project.

The MMRP and the Manta Trust are happy to share any data collected as a part of this study. For further information or please email: guy@mantatrust.org or niv@mantatrust.org.