Motivations behind the 'Site Fidelity' of whale sharks (*Rhincodon typus*) in South Ari Atoll and Baa Atoll, Maldives

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Disclaimer: I confirm that all the work presented is my own and was carried out in the manner described below. My word count is 4927 words, discounting the title page, the disclaimer, my acknowledgments, my bibliography, both my appendices and all figures, tables, graphs and their legends.

Acknowledgments

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Abstract

Relatively little is known about what the primary factors are that drive whale shark aggregations. Their biological characteristics of slow growth, late sexual maturation and infrequent productivity make them particularly vulnerable to anthropogenic mortality from target fisheries and bycatch. This can make discerning influences on their movement patterns even more challenging. This study looks at two key aggregations sites in the Republic of Maldives. South Ari MPA is perhaps unique in facilitating an annual aggregation of whale sharks, whereas Hanifaru Bay in Baa Atoll is famous for attracting whale sharks primarily to feed. In recent years whale shark sightings have drastically decreased in Baa atoll in comparison to South Ari Atoll where whale shark sightings have remained fairly constant. This study uses photo identification methods to track where the whale sharks are going when they disappear from Baa. Satellite imagery is also used to extract data on sea surface temperature, chlorophyll-a and bathymetry for the Maldives in order to develop a hypothesis to what factors are driving whale sharks to abandon Baa Atoll.

1. Introduction

The whale shark (*Rhincodon typus*) is the largest fish in the world, with reliable reports suggesting they can grow to 18m (Pierce and Norman, 2016). Like many large marine mega-fauna with a long life span, they have slow growth rates, late sexual maturation and infrequent reproduction (Pierce and Norman, 2016). These biological characteristics make them particularly vulnerable to exploitation from both target fisheries (Riley et al., 2010), and as bycatch, predominantly from purse seine fisheries (Li et al., 2012).

In 2016, the International Union for the Conservation of Nature (IUCN) upgraded the classification of whale sharks from vulnerable to endangered on their IUCN Red List (IUCN, 2016). This re-designation was primarily in response to the increased threat posed to whale sharks by continued high levels of exploitation, which resulted in a global reduction of population estimates by over 50% in the last 75 years, (Pierce and Norman, 2016). Despite target whale shark fisheries being banned in the majority of countries where key aggregations occur, their highly mobile nature places them in particular danger when they cross international boundaries into countries where they are either not protected, or enforcement is minimal, like China where large-scale commercial take of whale sharks is increasing (Li et al., 2012). Little is currently known on whale shark movement patterns, and this limited knowledge makes assessing effects fishery pressures difficult to ascertain (Rhoner et al., 2013). Understanding therefore what environmental factors influence whale shark aggregations can be an important step in helping develop effective global management and conservation strategies to protect them.

Global whale shark aggregations tend to occur seasonally along coastlines (Riley et al., 2010). They have a circum-global distribution within a range of latitudes, being primarily found in tropical and subtropical waters 30°N-35°S and have only occasionally been recorded to extend beyond these boundaries, (Sequiera et al., 2014). Sea Surface Temperature (SST) is believed to be one of the main environmental variables that drives seasonal whale shark aggregations as they are rarely sighted in waters with surface temperatures below 21°C (Tomita et al., 2014). It has been proposed that habitat suitability within the Indian Ocean is particularly strongly correlated with spatial variations in SST as Whale Sharks appear to have a narrow range with +90% of sightings occurring in waters 26.5-30°C (Sequiera et al., 2012).

Other studies link movements of whale sharks to elevated chlorophyll-a levels (Afonso et al., 2014). Several aggregations have been recorded in locations near upwellings (Sequiera et al., 2012) or during periods of mass coral spawning (Berumen et al., 2014). These studies all support the notion that varying levels of productivity and seasonal food availability primarily drives whale shark movements (Rhoner et al., 2013). Connections have also been made with chlorophyll levels to bathymetry as key predictors of global aggregations (Rowat and Brooks, 2012). Some studies suggest whale sharks prefer to aggregate along steep shelf ridges, such as in Djibouti or the Gulf of Mexico, as these areas produce rich upwellings (Rowat et al., 2011). Tagging studies with remote sensing devices have also demonstrated whale sharks regularly feed at great depths in bathymetrically non-restricting habitats, which implies such areas could drive seasonal aggregations in areas with little productivity in costal or surface waters. (Brunnschweiler et al., 2012).

One of the main anthropogenic pressures believed to influence whale shark movement patterns is tourism. Several global hotspots have developed into large tourism sites (Sequiera et al., 2013) and many whale sharks as a result suffer from boat injuries (Donati et al., 2016). Furthermore the presence of tourism vessels have been seen to alter the behaviours, primarily through increasing the frequency of directional changes (Raudino et al., 2016). It has also been observed that whale sharks in some areas appear to avoid boats by diving toward the seabed in response to the noise of boats' engines (Martin et al., 2007).

The Indian Ocean is the region where the most data on whale shark aggregations has been collected (Sequiera et al., 2013). Though highly mobile appear to display site fidelity to certain aggregations spots that they will regularly return to (Sequiera et al., 2013). In particular the Maldives records the highest levels of re-sightings relative any other countries in the same region, which makes it the perfect place to develop a hypothesis on factors that potentially influence whale shark aggregations. (Riley et al., 2010).

This study compares two sites in the Maldives with the aim of developing a hypothesis on what factors drive whale shark aggregations there. South Ari atoll is unusual and perhaps unique in that it is one of the very few places in the world that hosts an annual aggregation of whale sharks, which are interestingly predominantly made up of immature males (Riley et al., 2010). Due to this region being an important annual hotspot for juvenile whale sharks, the government of the Maldives declared the South Ari Atoll Reef a Marine Protected Area (MPA) in 2009, (See appendix). Whale sharks here have demonstrated unprecedented levels of site fidelity, with annual numbers of encounters remaining fairly consistent (Donati et al., 2016).

Baa Atoll, though more commonly associated with an abundant manta ray (*Manta alfredi*) population, is also famous for attracting aggregations of whale sharks during the southwest Monsoon primarily to feed, particularly at the world-renowned site

Hanifaru Bay, (Anderson et al., 2011) (see appendix). During the southwest monsoon, the currents that hit Baa Atoll create areas of upwelling, which brings deep nutrient rich water to the surface (Anderson et al., 2011). After passing through to the eastern side of Baa atoll these waters filled with productivity attracts zooplankton (Anderson et al., 2011). The lunar current then pulls this zooplankton filled water back towards Hanifaru where the monsoonal current pushes it through the mouth of the bay, trapping the zooplankton inside (Anderson et al., 2011). This attracts aggregations of whale sharks who feed on the densely packed zooplankton. Hanifaru bay is one of the few locations in the Maldives where feeding is the most commonly observed behaviors during whale shark encounters (Anderson et al., 2011). It is therefore a site of particular importance to consider when assessing motivations behind whale shark aggregations in the Maldives.

In contrast to South Ari, whale shark sightings in Baa have drastically fallen in recent years (Manta Trust, 2015). Making comparisons between varying environmental conditions between these two sites, as well as tracking the movements of individuals across atolls, could offer key clues to why this is happening. Therefore this study's primary aims were to first identify where the whale sharks were going when they disappeared from Baa. Essentially is their disappearance due to increasing mortality, resulting from anthropogenic pressures, or are they simply migrating permanently away from Baa. If the latter was found to be the case, the next project aim would be to identify what environmental factors were prompting whale sharks to leave Baa and why they are reluctant to return.

2. Methods

2.1. Study Sites

Figure 1 shows a map of the Maldives, illustrating where my study sites are in relation to one another. The South Ari MPA is located approximately 03 27°50-03 39°00 N and 72 41°40-72 56°50E. It is the largest MPA in the Maldives at 42km^2 in and stretches from the islands of Conrad to Dhigurah, with the boundary extending 1km from the reef crest. (Cagua et al., 2014). Unlike Hanifaru Bay, the South Ari MPA's protected status is merely preliminary and there is currently no management plan in place to regulate the large tourism presence there (Cagua et al., 2014).

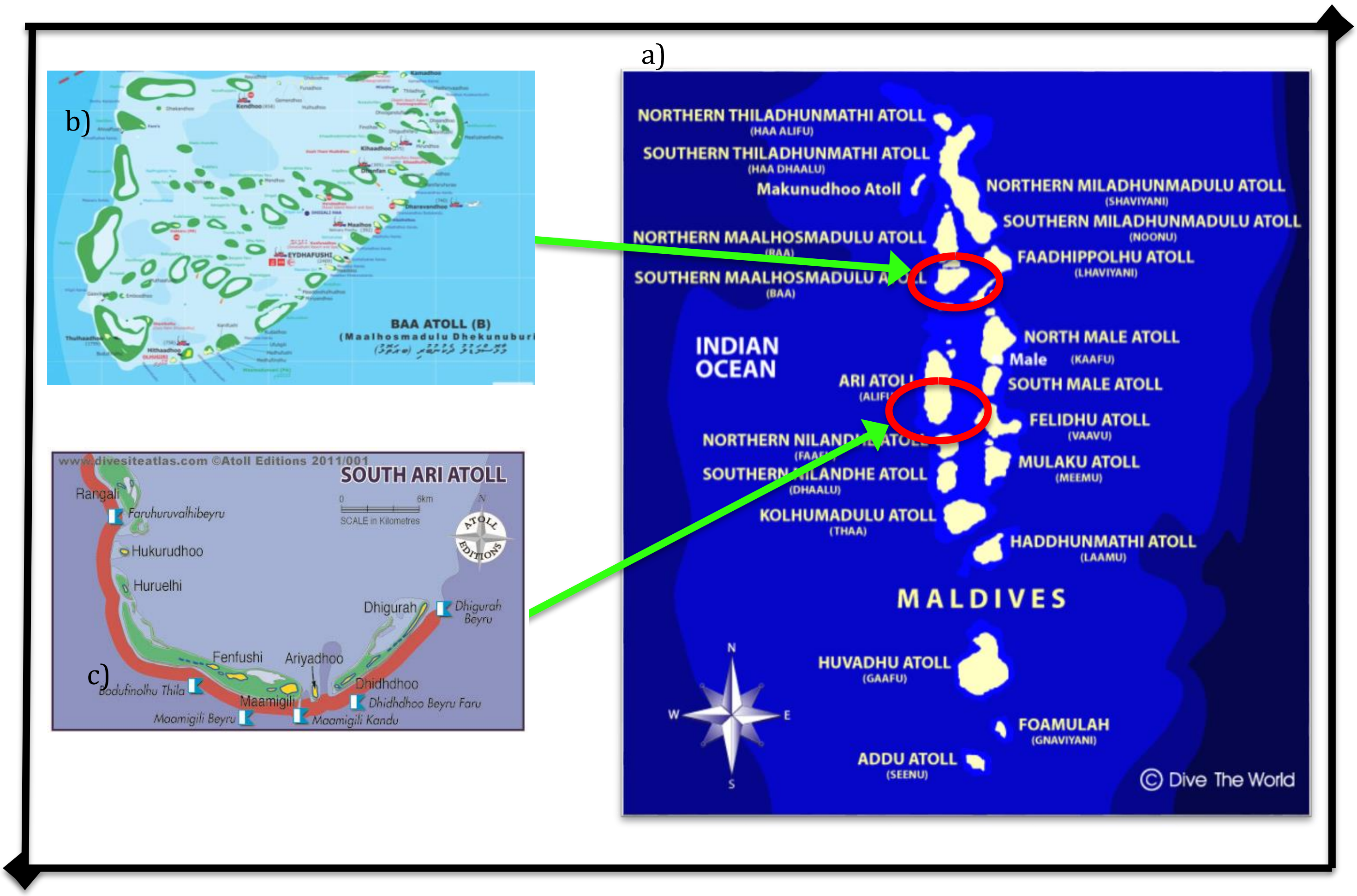


Figure 1: a) Map of the Maldives showing locations of study sites: b) Baa Atoll and c) South Ari Atoll.
Reference: http://www.dive-the-world.com/maps-maldives.php

Hanifaru Bay is much smaller being the roughly size of a football pitch, and is located approximately 03 05°16 –03 05°19N and 72 73°12 –72 73°17E. Due to increasing threats that had developed from the unregulated growth of tourism in the area, the government of the Maldives designated Hanifaru an MPA in 2009 (Pierce and Norman, 2016). It is one of the best-managed MPAs in the country with regulations relatively well enforced. Some key restrictions include access via permits only, a maximum of 10 clients per tourist guide with only 80 people in the water at any one time; and only snorkeling allowed within the bay as SCUBA diving was prohibited in 2012. (Manta Trust, 2015).

2.2. Datasets

For this project I received two historical datasets from the Maldives Whale Shark Research Programme (MWSRP), who are based in Dhigurah, South Ari, and the Manta Trust, who are based in Baa. These compromised all data collected during whale shark encounters recorded by the two organisations.

The MWSRP travels along the reef edge of the South Ari MPA ~7 hours per day, 5 days a week on their research Dhoni, purposefully trying to locate whale sharks. A combination of staff and volunteers with the programme actively search for on the roof of the Dhoni. When a whale shark was spotted, one person would remain on the roof to direct the rest of the team in the water towards the shark to collect the data. During the northeast monsoon season they are able to search along the entire length of the MPA. However during the southwest monsoon weather conditions usually only permits searches from Dhigurah to around Fenfushi as the wind and currents become too strong and dangerous. The MWSRP has run a volunteer programme to assist with the data collection since December 2009. Year round surveys of the area began in April 2014 when the organisation moved their base from Conrad to Dhigurah. Prior to this, research was undertaken seasonally during the northeast monsoon only.

In comparison, the Manta Trust does not actively search for whale sharks when carrying out their research in Baa. ~90% of sightings occur incidentally, when whale sharks turn up in locations where mantas are being observed feeding. However, individuals are known to be in the area, the Manta Trust does carry out reef crest surveys, sometimes with a manta tow-board, which includes searching for whale sharks. The Manta Trust undergoes its research seasonally during the southwest monsoon on the east side of Baa Atoll.

2.3. Data Collection

In July and August 2016, I collected data for the MWSRP in South Ari Atoll. However in this study I only use data from 2007-2015 in the datasets I was provided with and will therefore not include any data collected personally. This is because I wanted to use full annual records for my analysis of both sites, and inclusion of the data I collected would result in only partial records for 2016. However, the methods I describe regarding my data collection are identical to those used for this project's time period, 2007-2015.

Photo identification methods were used for identifying individual whale sharks and tracking their movements between atolls. Their spot patterns are believed to be unique to each individual and appear to remain consistent over time during their life span (Meekan et al., 2006). During encounters photos were taken using underwater digital cameras of the whale shark's left and right flanks (Figure 2). These are the standardised areas used for whale shark identification worldwide as they contain larger and more distinctive spots, making them more suitable reference points for distinguishing between the unique patterns (Pierce, 2007). These photos were then uploaded into a computer software programme called I3S. The following measurement boundaries were then identified on the image: 1) the top of the fifth gill slit, 2) the tip of the pectoral fin 3) the bottom of the fifth gill slit (Figure 2). Next, a minimum of 12 spots within these boundaries were selected, which I3S was then able to process and identify the unique spot patterns by cross-referencing the image which other identification photos of whale sharks already in the database. This revealed whether the shark was a new individual to the area, or whether the encounter was a re-sighting. The ID photos were then uploaded to the MWSRP's 'Big Fish Network.'

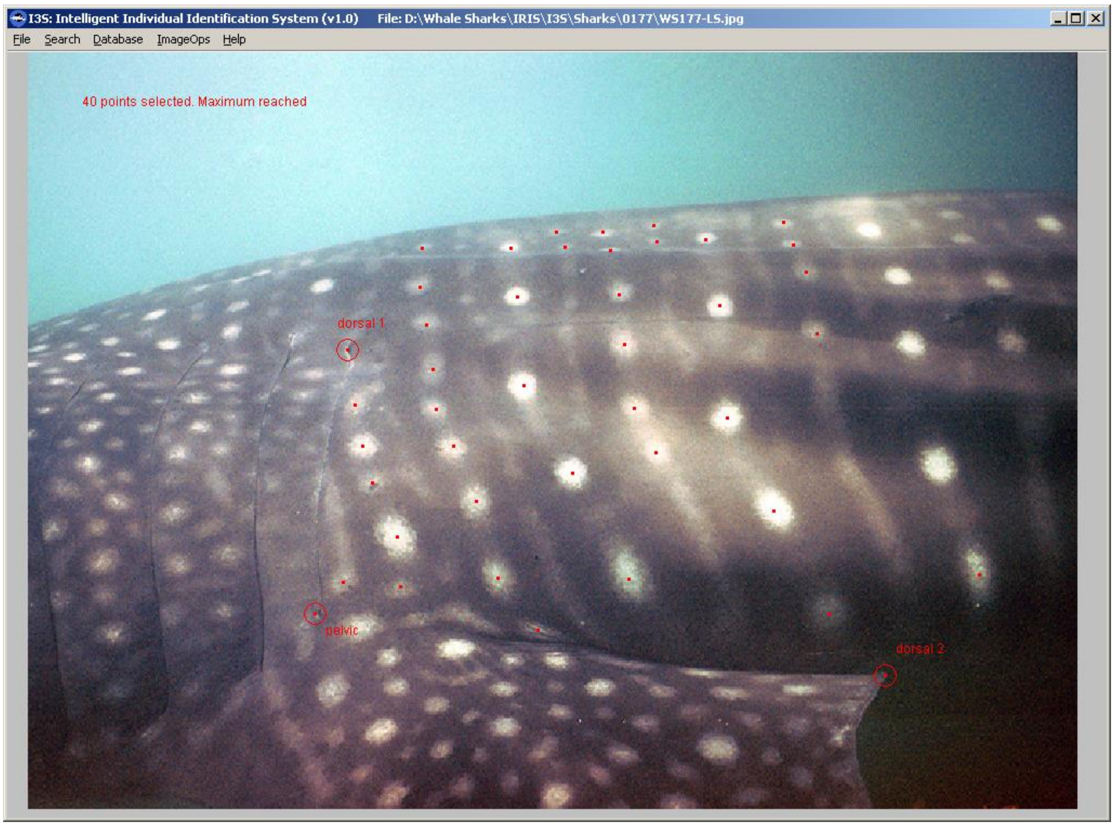


Figure 2: Shows an example of a left photo ID image that has been uploaded into I3S. The red circles indicate the 3 reference point parameters, and the red dots represent the spots that should be selected in between those boundaries (Pierce, 2007)

Other organizations operating in the Maldives such as whale shark tour operators for resorts and livaboards or other research programmes like the Manta Trust can also contribute to this database. As of September 2016, there are 66 members who upload the ID images and data from their whale shark encounters into the Big Fish Network, which is then verified by MWSRP staff.

During encounters, photos were also taken of injuries the whale sharks had sustained, as well as photos of the pelvic fin to check for the absence or presence of claspers to determine the sex (see appendix). Other data was also collected during encounters including physical and observational data on the shark, the tourism presence at encounters and a range of environmental variables (see datasheet in appendix for more details).

Global satellite images of sea surface temperature (SST) were extracted from the Terra MODIS Satellite. Daily records were combined to create maps that display annual averages of SST for 2007-2015. Global satellite images of levels of chlorophyll-a were also extracted from the Terra MODIS Satellite. Similarly, daily records were combined to create maps that display annual averages of chlorophyll-a levels for 2007-2015. Bathymetric data was downloaded from FishTrack, which provides daily satellite images on basic information regarding bathymetric depths of the ocean.

2.4. Excel Analysis

To track the movements of whale sharks visiting both atolls, the two historical datasets needed combining. Changes were therefore made to the Manta Trust's dataset so it fitted the same format as the MWSRP. 47 whale sharks had been allocated their own unique ID by the Manta Trust and therefore needed uploading into I3S to obtain their MWSRP ID number.

Once a unified dataset had been created, it next needed filtering and splitting into atolls. All sightings listed either location identification numbers, place names, atoll names or GPS co-ordinates for the exact locations encounters had occurred. Place names and location IDs were converted into atoll names. GPS co-ordinates were copied into Google Maps to determine their location and then converted into atoll names. When this was completed, the data could be filtered and split into atolls so that all encounters in Baa and South Ari could be extracted for analysis (see appendix). All individual whale sharks that had visited the study sites in 2007-2015 could then be identified and placed into a table to ascertain which years they had visited the atoll. Sharks sighted at both atolls were then highlighted in blue (see appendix). These whale sharks were then placed in a combined table to more easily track their annual movements between atolls (Table 1). All individuals from Baa were then tracked using the combined dataset to see if they had been spotted in other atolls besides South Ari. This data on individual sightings could then be used to create graphs on total annual and monthly sightings as well as determine the proportion of encounters with new or re-sighted individuals.

Table 1: Extract from table listing all individual whale sharks (n=25) that were spotted at both study sites. Years in which they were sighted at both atolls are marked with an 'x'.

Baa Population	2007	2007	2008	2009	2010	2011	2012	2013	2014	2015
WS005	Baa		X	X	X					
	SA				X		X			
WS008	Baa	X	X		X					
	SA				X					
WS010	Baa	X	X	X	X					
	SA	X	X	X		X	X	X	X	X
WS011	Baa	X								
	SA		X	X	X					
WS012	Baa	X	X	X	X					
	SA	X	X	X	X					
WS013	Baa	X	X							
	SA	X	X							
WS016	Baa	X								
	SA	X	X							
WS017	Baa	X	X	X	X					
	SA		X	X	X					
WS020	Baa				X					
	SA	X	X	X	X	X	X			
WS025	Baa			X						
	SA	X	X	X	X	X	X			
WS030	Baa		X							
	SA	X	X	X	X	X	X	X	X	X
WS035	Baa		X							
	SA	X	X							
WS039	Baa	X		X	X					
	SA	X	X	X	X	X	X			
WS046	Baa		X	X	X					
	SA	X	X	X	X					
WS057	Baa		X	X		X				
	SA						X			

3. Results

3.1 Excel Analysis

Figure 3 shows the annual number whale shark sightings for both atolls. They show a steep the drastic reduction in sightings first begins in 2009 and continues until no sharks were sighted by 2015. Comparatively in South Ari Atoll, the number of sightings steadily increases throughout the time period with sharp gains in 2014 and 2015, although this is most likely heavily influenced by the fact the MWSRP started doing surveys all year through from 2014 instead of seasonally. It is worth noting that sightings also significantly dropped in 2009 by ~40% from the previous year.

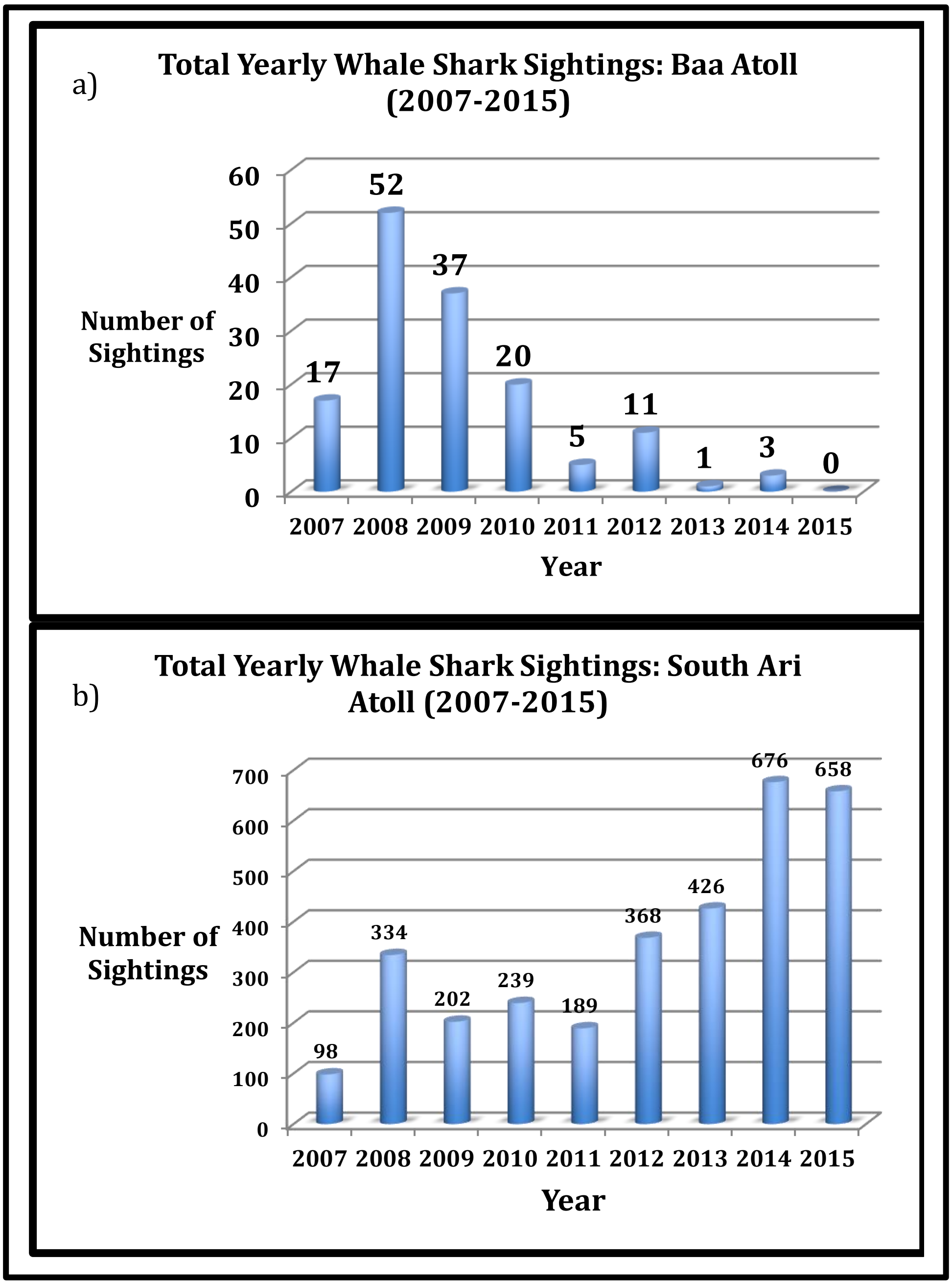
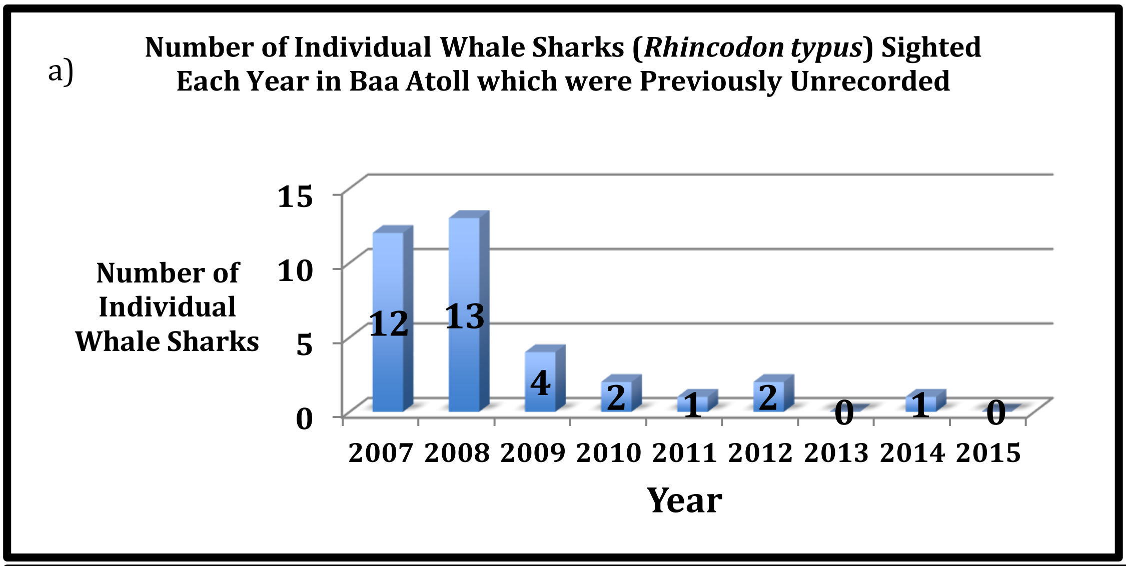


Figure 3: Graphs that's show the total yearly sightings of whale sharks at **a)** Baa Atoll (n=46) and **b)** South Ari Atoll.

Figure 4 shows the number of new individual whale sharks to the atolls. Both sites show large reductions in new individuals visiting the area in 2009. Again, whilst these figures show severe declines in Baa figures remain fairly consistent for South Ari. The total number of individual sharks visiting the study sites and the percentage of annual re-sightings can be seen in tables 2 and 3 for Baa and South Ari respectively.



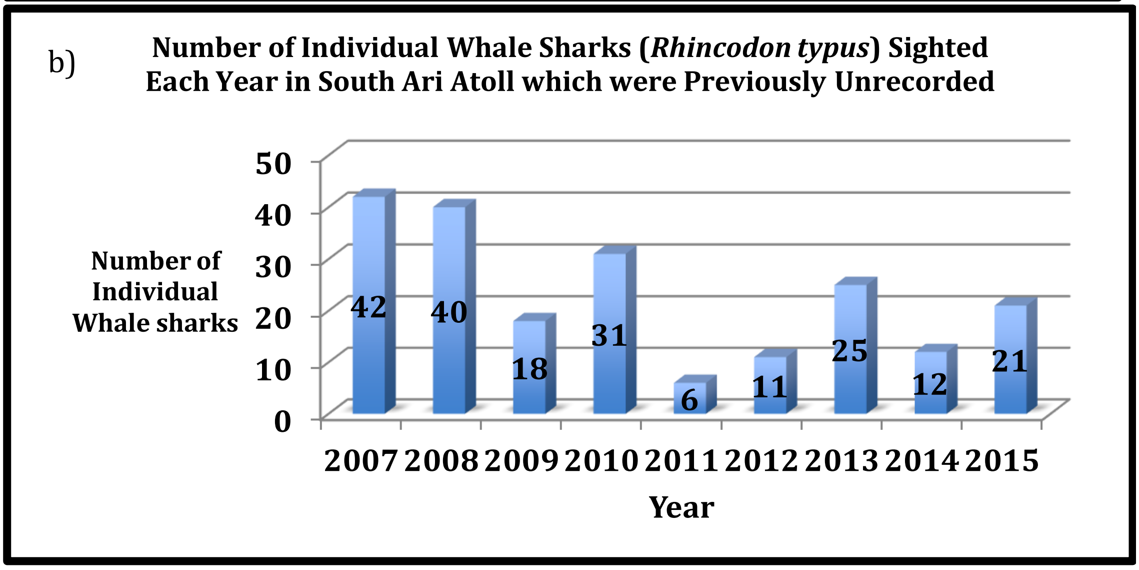


Figure 4: Graphs that's show number of individual whale sharks sighted each year that have previously been unrecorded in **a)** Baa Atoll and **b)** South Ari Atoll.

Table 2: Table showing the total number sightings at Baa atoll as well as the, total number of individuals, total number of new individuals, % of re-sightings, and the number of whale sharks also sighted in South Ari atoll the same year.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total Baa
Total Sightings	17	52	37	20	5	11	1	3	0	146
Total Individuals	12	20	17	12	3	4	1	2	0	
New Sharks	12	13	4	2	1	2	0	1	0	35
Re-sighting %	0%	35%	76.5%	83.3%	66.7%	50%	100%	50%	0%	
Baa/Ari Shark	8	16	13	11	2	1	0	2	0	25

Table 3: Table showing the total number sightings at South Ari atoll as well as the, total number of individuals, total number of new individuals, % of re-sightings, and the number of whale sharks also sighted in Baa Atoll the same year.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total SA
Total Sightings	98	334	202	239	189	368	426	676	658	3190
Total Individuals	42	71	64	78	45	57	60	60	60	
New Sharks	42	40	18	31	6	11	25	12	21	206
Re-sighting %	0%	43.6%	71.9%	60.3%	86.7%	80.7%	58.3%	80%	65%	
Baa/Ari Shark	11	17	14	14	9	9	5	5	4	25

Overall results indicate that 72% (n=35) of the whale sharks that have visited Baa between 2007-2015 also visited South Ari during the same period. From those individuals 68% (n=25) ended up remaining in South Ari indefinitely. Only 4% (n=25) of the sharks spotted at both sites ended up remaining in Baa indefinitely, with the remainder disappearing the same year as their last sightings at both atolls. Of the total number of sharks that only Baa (n=10), 20% migrated indefinitely to Thaa Atoll and 70% have only ever been recorded once in Maldives, at Hanifaru.

3.2. Satellite Telemetry

Figure 4 on page 18 shows the Sea Surface Temperature (SST) maps for the Indian Ocean in and around the Maldives. Subtle differences can be seen in 2007, 2009, 2014 and 2015 in comparison to other years, where SST levels appear to be slightly higher. Similarly, figure 5 on page 19 also reveals subtle changes in chlorophyll-a levels for the same region, with most notably 2009 showing a small reduction. Although the resolution of these maps is very poor, making it impossible make any distinctions between the two study sites, they do give provide a good general indication of subtle changes for the whole of the Maldives.

Figure 6 on page 20 shows bathymetric maps of the Maldives, which display the varying approximations of the maximum depths surrounding atolls. The general area of the ocean adjacent to Hanifaru is indicated to reach maximum depths of ~300m. This is in stark contrast to the South Ari MPA, adjacent areas of open ocean are estimate to reach bathymetric depths of ~3,150m.

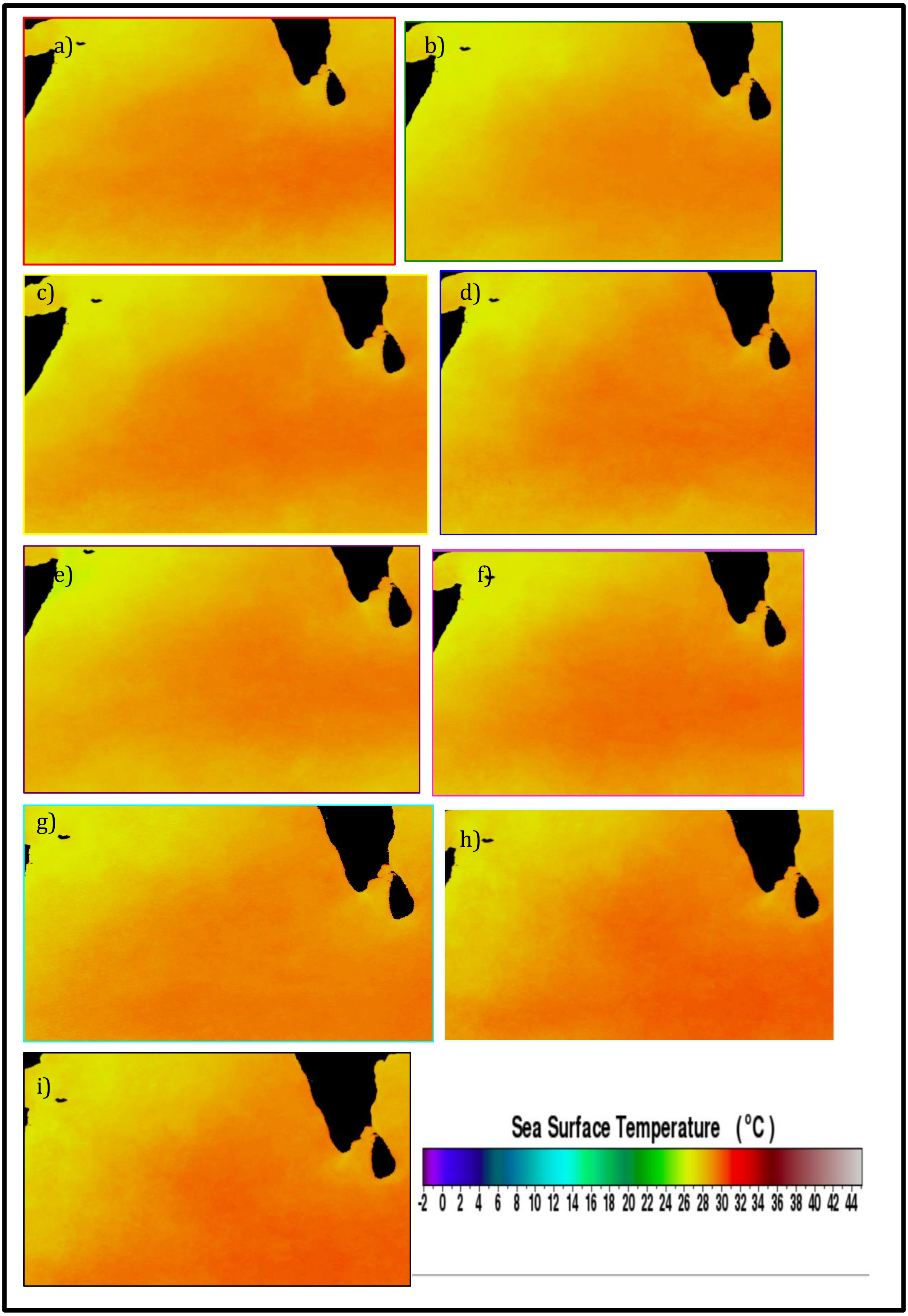


Figure 4: Shows the annual average SST obtained from the Terra MODIS satellite for the Indian Ocean covering the Maldives for the years a) 2007, b) 2008 c) 2009 d) 2010 e) 2011 f) 2012 g) 2013 h) 2014 and i) 2015.

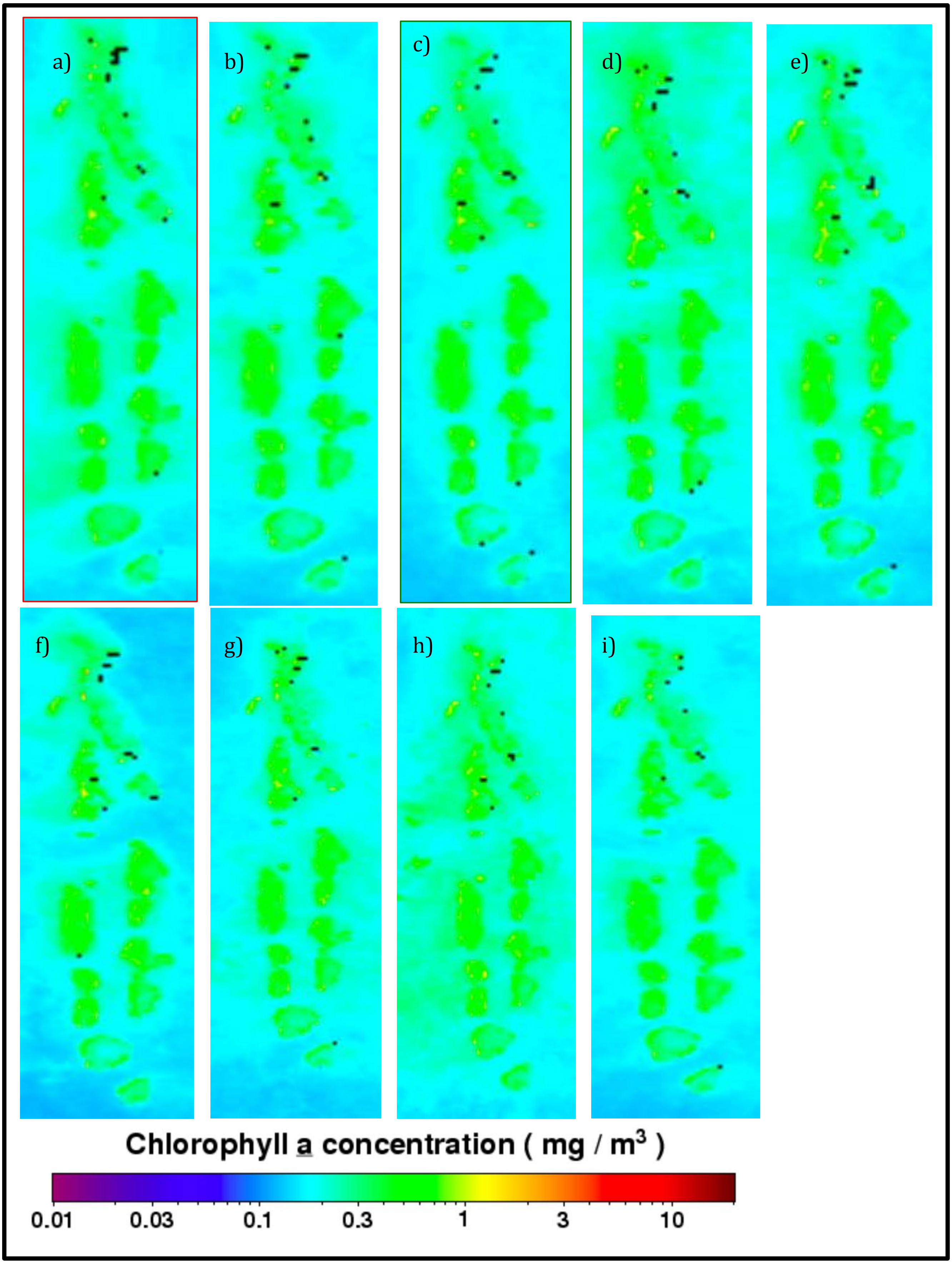
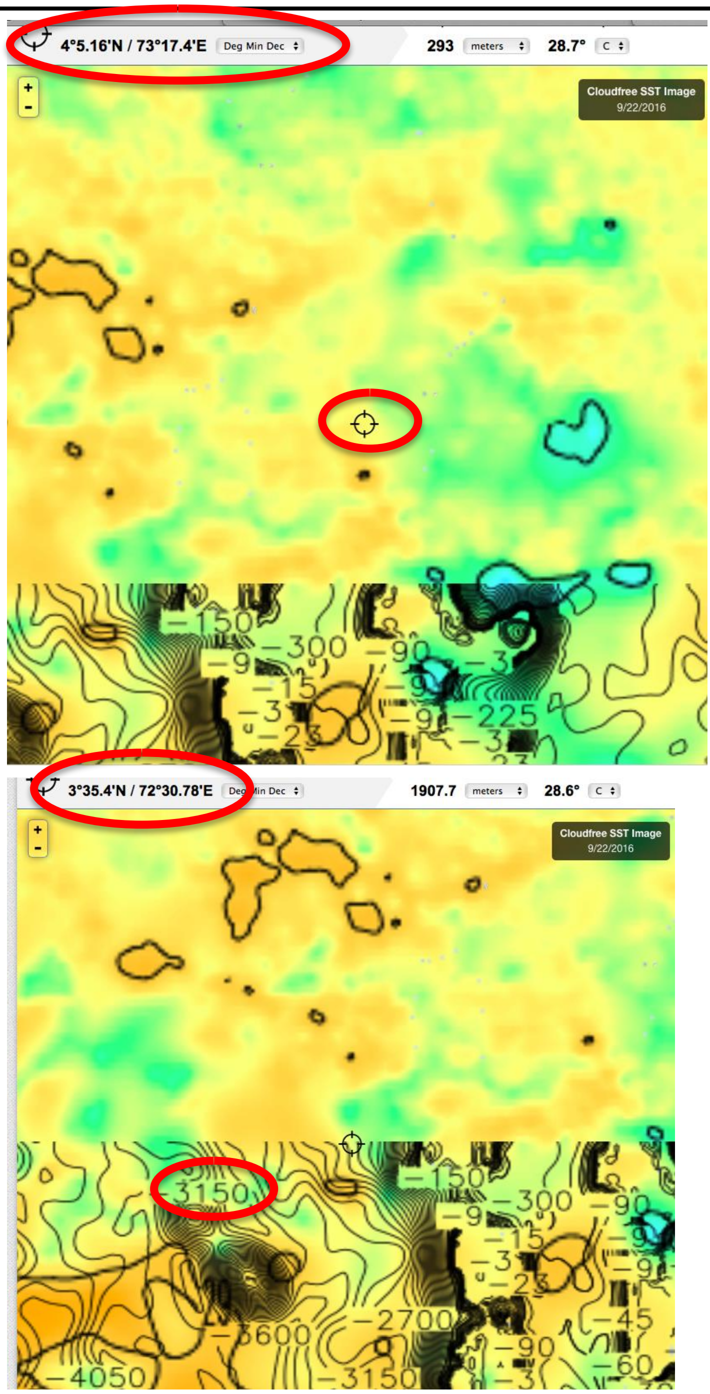


Figure 5: Shows the annual average Chlorophyll-a levels obtained from the Terra MODIS satellite for the Indian Ocean covering the Maldives for the years a) 2007, b) 2008 c) 2009 d) 2010 e) 2011 f) 2012 g) 2013 h) 2014 and i) 2015.



a)

b)

Figure 6: Shows the latest satellite data obtained from the FishTrack which indicate basic bathymetric depths around in the waters surrounding the atolls. **a)** Shows exact GPS location of Hanifaru and indicates that the ocean bottom is ~293m. **b)** Shows the approximate location of the South Ari MPA and indicates depths in adjacent waters to the MPA to be ~2,000–3150m.

4. Discussion

4.1 Analysis of Results

Determining whether reductions of resident whale shark populations occur due to unsustainable fishing pressures resulting in mortality or simple changes in movement patterns can be difficult (Riley et al., 2010). The results of this study appear to indicate reductions in sightings at Baa appear to be down to the majority of the population migrating permanently to southern atolls. ~74% (n=35) of the whale sharks displayed inter-toll migrations with ~54% (n=35) making permanent migrations, predominantly to South Ari, but also Thaa Atoll. Comparing multiple environmental variables between the two sites will help identify the why these whale sharks are disappearing from Baa.

Results from the satellite telemetry suggest SST could have been a contributing factor influencing the whale sharks decision to leave Baa in 2009. Though distinctions cannot be made between the two study sites due to the poor resolution of the images, they do reveal that a slight rise in temperature in 2009 coincided with reductions in the number of whale shark encounters at Baa and South Ari by 25% and 40% respectively. Seasonal aggregations in other regions of the Indian Ocean have also been observed to be highly influenced by inter-annual changes in SST. (Ca'rdenas-Palomo et al., 2010). Furthermore, some studies adopted future climate change scenarios for 2070 to suggest that projected increases in SST could result in changes in the distribution patterns of whale sharks by forcing them to retreat from current aggregation hotspots and relocate in areas closer to the poles (Afonso et al., 2014; Sequiera et al., 2014).

However, just how strong a predictor SST is for the movement patterns of whale sharks in this study is questionable given that after 2009, the abundance of whale sharks continued to decline in Baa yet increase in South Ari, despite similar temperatures across the Maldives. The answer may therefore lie in the two different ways in which whale sharks use the study sites. As previously mentioned, large numbers of whale sharks gather around Hanifaru bay to feed on the plankton rich waters brought in by the southwest monsoon (Reference et al., Year). 73% (n=118) of encounters here exhibited feeding behaviour, compared to the much lower 11% (n=353) for South Ari during the same time period. The clear difference in behaviour observed within the two sites highlights the importance environmental factors that influence food availability are in Baa Atoll in promoting aggregations. For Hanifaru, this is partly supported by results from the satellite images, which show that a subtle drop in chlorophyll-a levels in 2009, coincided with reductions in whale shark sightings in Baa and rises in average SST that same year. A study by McKinney et al., (2012) also observed that whale shark aggregations are more strongly associated with foraging behaviour of whale sharks in the Gulf of the Mexico, with sightings primarily responding to variations in chlorophyll-a levels. Whale sharks have indeed been shown to feed opportunistically in certain coastal areas at the surface such as in Australia and Belize where dense patches of zooplankton are produced, but display no otherwise discernable foraging patterns elsewhere (Rowat and Gore, 2007).

As indicated by the low numbers of whale sharks exhibiting feeding behaviour at South Ari, factors other than chlorophyll-a levels must be encouraging high levels of site fidelity to this area. The direct relationship between chlorophyll-a as a predictor of whale shark occurrence was questioned in a study by Sequiera et al., (2011), who found that despite close associations between SST and Chlorophyll-a levels, the latter was more of an indicator of zooplankton availability than of predicting whale sharks movements. This is because time-lags were found to occur between peaks of chlorophyll-a and planktonic food availability that attracts whale sharks (Sequiera et al., 2011). Ultimately the study found that SST was the key determinant of whale shark movement patterns (Sequiera et al., 2011).

It has been hypothesized that whale sharks primarily aggregate around the surface waters at South Ari atoll not to feed, but with the primary purpose of thermoregulation (MWSRP, 2015). In a study that tagged whale sharks with remote sensing devices in order to observe their diving behaviors, Thums et al., (2013) found that temperature was the most important predictor of whale shark aggregations in areas where chlorophyll-a levels at the surface were low. This was found to be due to sharks spending lots of time feeding at depth followed by extended periods at the surface to recuperate and replenish the energy lost from such dives (Thums et al., 2013). Several studies that have tagged whale sharks to obtain data on their feeding or foraging behaviour and have linked diel oscillations with the diving patterns of the whale sharks (Graham et al., 2006). Berumen et al., (2014) used data obtained from remote sensing devices that were attached to 47 sharks in the Red Sea from 2009-2011 to further demonstrate that sharks in the area regularly fed at depths beyond the euphotic zone at ~500-1360m. A study by Afonso et al., (2014) based in the Azores archipelago in Portugal found that both seamounts and areas with increased bathymetric slopes attract aggregations of whale sharks primarily these deep regions also coincide with higher chlorophyll biomass. The bathymetric maps in figure 6 indicate that the area adjacent to the South Ari MPA is significantly deeper than those at Baa. As only 11% of whale sharks are observed feeding at the surface, the whale sharks are hypothesized to primarily feed at depth, and use the shallow waters and reefs in South Ari both for thermoregulation, and to shelter from predators.

Interestingly the whale shark aggregations at both study sites were predominantly made up of immature males, constituting 93% (n=14) of individuals where sex was determined in Baa, and 87% (n=190) of individuals where sex was determined in South Ari. All whale sharks located at both locations during this period were identified as immature. This age and sex bias in the local whale shark demographics is similar to other coastal aggregations worldwide (Riley et al., 2010). The lack of global data on aggregations of adults has been hypothesized to be a consequence of larger sharks requiring wider and deeper ocean basins to move and feed, which unfortunately reduces the likelihood of them being spotted (Rhoner et al., 2013). Similarly, it has been suggested that female whale sharks also feed away from shallow waters as they need larger prey to grow more quickly for reproductive purposes (Graham and Roberts, 2007). Whatever the cause however, the presence of predominantly juvenile males along coastal waters are believed to provide an adequate enough proxy for monitoring wider population trends in global whale shark abundance (Reference et al., Year).

4.2. Limitations & Recommendations

One of the main limitations of this study was the inability to use tagging methods, which provide an important insight into both the horizontal and vertical movement patterns of whale sharks (Wilson et al., 2007). Although the use of satellite and archival tags were initially adopted by the MWSRP in June 2008 and 2009 to record depth, temperature and light levels, these were abandoned due to the negative backlash it created amongst members of the tourism industry who believed such methods were harmful to the sharks and would drive them permanently away from South Ari. Furthermore false accusations were made that such tags provided certain advantages to some tour operators by allowing them access to the data to track and locate sharks more easily. As an alternative, the use of photo identification was embraced and I3S does have advantages that includes being a non-invasive method of tracking sharks which reduces the likelihood of changing the whale shark's behaviour when such data is collected (Pierce, 2007). Furthermore photo identification methods can provide an easy way of combining multiple datasets across wide geographical ranges, in order to track seasonal whale shark movements between different countries (Pierce, 2007). A study by Brooks et al., (2010) did just this, by comparing identification images from aggregation sites from the Seychelles, Djibouti, Mozambique and Tanzania, although at the time this paper was written, no matches had been found yet.

Another limitation of this study was the inconsistent search efforts between the 66 different stakeholders that contribute to the MWSRP's 'Big Fish Network' database. Furthermore, the inclusion of so many stakeholders increases the possibility of mistakes being made when taking and entering data from encounters. However, methods are already being adopting to prevent such potential errors, like inviting stakeholder members to personally assist the MWSRP in collecting data as a form of training.

Finally, due to the time constraints of this project's word limit, other factors which could potentially influence movement patterns of whale sharks were not explored. One key variable is the impact of tourism between the two sites. The current infield co-ordinator for the MWSRP South Ari believed that over the course of her 15 months at the programme, whale sharks were beginning to recognise the sound of approaching vessels and consequently actively evaded boats in response to the noise by diving to deep depths (Childs, Pers. Obs.). This behaviour has been previously recorded at aggregation sites that attract large numbers of tourists, such as Ningaloo in Australia (Martin et al., 2007; Sanzogni et al., 2015). Future studies should look at the varying levels of tourism between the two sites and determine whether any discernable changes in behaviour can be detected. One possible way to monitor this in the future would be to employ aerial surveys as studies that have employed this tracking technique have demonstrated whale sharks would be unable to detect or respond to their presence from such heights (Rowat et al., 2009). Other variables that should be explored further in future studies include the impact of wind direction, strength and ocean visibility.

5. Concluding Remarks

This study has attempted to explain where the whale sharks go when they permanently leave Baa Atoll. Using photo identification methods and the computer software program I3S, the majority of sharks were shown to migrate to South Ari Atoll, with some going further south to Thaa Atoll. Satellite imagery suggests this was perhaps influenced by subtle rises in sea surface temperature and declines in chlorophyll-a levels. The poor resolution of these images however made any distinctions between the two study sites difficult to discern. Although stark differences in bathymetry between the two sites, as shown by the bathymetric depths of the areas adjacent to the two study sites, provides some clues as to the different ways the whale sharks use the two sites. Ultimately whale shark aggregations appear to be highly influenced by levels of productivity in Baa atoll, yet prefer the deeper bathymetry of South Ari where they can thermoregulation and feed at depth. This study has only provided a basic analysis of the main environmental factors that could determine whale shark aggregations. Despite this however, results from this study have at the very least provided a baseline on the some of the key factors that have potentially motivated whale shark aggregations to decline in Baa yet remain in south Ari, which future studies can develop further.

6. Bibliography

Afonso, P., McGinty, N. and Machete, M. (2014). Dynamics of Whale Shark Occurrence at Their Fringe Oceanic Habitat. *PLoS ONE*, 9(7), p.e102060.

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

Berumen, M., Braun, C., Cochran, J., Skomal, G. and Thorrold, S. (2014). Movement Patterns of Juvenile Whale Sharks Tagged at an Aggregation Site in the Red Sea. *PLoS ONE*, 9(7), p.e103536.

Borrell, A., Aguilar, A., Gazo, M., Kumarran, R. and Cardona, L. (2011). Stable isotope profiles in whale shark (Rhincodon typus) suggest segregation and dissimilarities in the diet depending on sex and size. *Environ Biol Fish*, 92(4), pp.559-567.

Bouchet, P., Meeuwig, J., Salgado Kent, C., Letessier, T. and Jenner, C. (2014). Topographic determinants of mobile vertebrate predator hotspots: current knowledge and future directions. *Biol Rev*, 90(3), pp.699-728.

Brooks, K., Rowat, D., Pierce, S., Jouannet, D. and Vely, M. (2010). Seeing Spots: Photo-identification as a Regional Tool for Whale Shark Identification. *Western Indian Ocean Journal of Marine Science*, 9(2), pp.185-194.

Brunnschweiler, J., Baensch, H., Pierce, S. and Sims, D. (2009). Deep-diving behaviour of a whale shark Rhincodon typus during long-distance movement in the western Indian Ocean. *Journal of Fish Biology*, 74(3), pp.706-714.

Brunnschweiler, J. and Sims, D. (2012). Diel Oscillations in Whale Shark Vertical Movements Associated with Meso- and Bathypelagic Diving. *American Fisheries Society Symposium*, 76, pp.457-469.

Cagua, E., Collins, N., Hancock, J. and Rees, R. (2014). Whale shark economics: a valuation of wildlife tourism in South Ari Atoll, Maldives. *PeerJ*, 2, p.e515.

Chen, C.T., Lui, K.M. & Joung, S.J. (1997). *Preliminary Report on Taiwan's Whale Shark Fishery*. Taipei: TRAFFIC East Asia.

De Boer, M., Saulino, J., Lewis, T. and Notarbartolo-Di-Sciara, G. (2015). New records of whale shark (Rhincodon typus), giant manta ray (Manta birostris) and Chilean devil ray (Mobula tarapacana) for Suriname. *Mar. Biodivers. Rec.*, 8.

Donati G, Rees RG, Hancock JW, Jenkins TK, Shameel I, Hindle K, Zareer I, Childs A, Cagua EF. New insights into the South Ari atoll whale shark, Rhincodon typus, aggregation. QScience Proceedings (Fourth International Whale Shark Conference) 2016:iwsc4.16 http://dx.doi.org/10.5339/qproc.2016.iwsc4.16

Gleiss, A., Wright, S., Liebsch, N., Wilson, R. and Norman, B. (2013). Contrasting diel patterns in vertical movement and locomotor activity of whale sharks at Ningaloo Reef. *Marine Biology*, 160(11), pp.2981-2992.

Graham, R. and Roberts, C. (2007). Assessing the size, growth rate and structure of a seasonal population of whale sharks (Rhincodon typus Smith 1828) using conventional tagging and photo identification. *Fisheries Research*, 84(1), pp.71-80.

Graham, R., Roberts, C. and Smart, J. (2006). Diving behaviour of whale sharks in relation to a predictable food pulse. *Journal of The Royal Society Interface*, 3(6), pp.109-116.

IUCN 2016. *The IUCN Red List of Threatened Species. Version 2016-2*.

Ketchum, J., Galván-Magaña, F. and Klimley, A. (2012). Segregation and foraging ecology of whale sharks, Rhincodon typus, in the southwestern Gulf of California. *Environ Biol Fish*, 96(6), pp.779-795.

Lavaniegos, B. (2012). Seasonal variability of copepods and cladocerans in Bahía de los Ángeles (Gulf of California) and importance of Acartia clausi as food for whale sharks. *Cienc Mar*, 38(1A), pp.11-30.

Li, W., Wang, Y. and Norman, B. (2012). A preliminary survey of whale shark Rhincodon typus catch and trade in China: an emerging crisis. *Journal of Fish Biology*, 80(5), pp.1608-1618.

McKinney, J., Hoffmayer, E., Wu, W., Fulford, R. and Hendon, J. (2012). Feeding habitat of the whale shark Rhincodon typus in the northern Gulf of Mexico determined using species distribution modelling. *Marine Ecology Progress Series*, 458, pp.199-211.

Pierce, S. (2007). Processing Photographic Identifications of Whale Sharks Using the Interactive Individual Identification System (I3S). *Draft Data Collection Protocol*, pp.1-5.

Pierce, S.J. & Norman, B. 2016. *Rhincodon typus*. The IUCN Red List of Threatened Species 2016: e.T19488A2365291. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T19488A2365291.en

Raudino, H., Rob, D., Barnes, P., Mau, R., Wilson, E., Gardner, S. and Waples, K. (2016). Whale Shark Behavioural Responses to Tourism Interactions in Ningaloo Marine Park and Implications For Future Management. *Conservation Science Western Australia*, 20(2), pp.1-7.

Riley, M., Harman, A. and Rees, R. (2009). Evidence of continued hunting of whale sharks Rhincodon typus in the Maldives. *Environ Biol Fish*, 86(3), pp.371-374.

Riley, M., Hale, M., Harman, A. and Rees, R. (2010). Analysis of whale shark Rhincodon typus aggregations near South Ari Atoll, Maldives Archipelago. *Aquat. Biol.*, 8, pp.145-150.

Rohner, C., Pierce, S., Marshall, A., Weeks, S., Bennett, M. and Richardson, A. (2013). Trends in sightings and environmental influences on a coastal aggregation of manta rays and whale sharks. *Marine Ecology Progress Series*, 482, pp.153-168.

Rowat, D. (2007). Occurrence of whale shark (Rhincodon typus) in the Indian Ocean: A case for regional conservation. *Fisheries Research*, 84(1), pp.96-101.

Rowat, D. and Gore, M. (2007). Regional scale horizontal and local scale vertical movements of whale sharks in the Indian Ocean off Seychelles. *Fisheries Research*, 84(1), pp.32-40.

Rowat, D., Gore, M., Meekan, M., Lawler, I. and Bradshaw, C. (2009). Aerial survey as a tool to estimate whale shark abundance trends. *Journal of Experimental Marine Biology and Ecology*, 368(1), pp.1-8.

Rowat, D., Brooks, K., March, A., McCarten, C., Jouannet, D., Riley, L., Jeffreys, G., Perri, M., Vely, M. & Pardigon, B. (2011). Long-term membership of whale sharks (*Rhin- codon typus*) in coastal aggregations in Seychelles and Djibouti. *Marine and Freshwater Research* **62**, 621–627.

Sequeira, A., Mellin, C., Rowat, D., Meekan, M. and Bradshaw, C. (2011). Ocean-scale prediction of whale shark distribution. *Diversity and Distributions*, 18(5), pp.504-518.

Sequeira, A., Mellin, C., Meekan, M., Sims, D. and Bradshaw, C. (2013). Inferred global connectivity of whale shark Rhincodon typus populations. *Journal of Fish Biology*, 82(2), pp.367-389.

Sequeira, A., Mellin, C., Fordham, D., Meekan, M. and Bradshaw, C. (2014). Predicting current and future global distributions of whale sharks. *Glob Change Biol*, 20(3), pp.778-789.

Sleeman, J., Meekan, M., Fitzpatrick, B., Steinberg, C., Ancel, R. and Bradshaw, C. (2010a). Oceanographic and atmospheric phenomena influence the abundance of whale sharks at Ningaloo Reef, Western Australia. *Journal of Experimental Marine Biology and Ecology*, 382(2), pp.77-81.

Sleeman, J., Meekan, M., Wilson, S., Polovina, J., Stevens, J., Boggs, G. and Bradshaw, C. (2010b). To go or not to go with the flow: Environmental influences on whale shark movement patterns. *Journal of Experimental Marine Biology and Ecology*, 390(2), pp.84-98.

Tomita, T., Kawai, T., Matsubara, H. and Kobayashi, M. 2014. Northernmost record of a whale shark *Rhincodon typus* from the Sea of Okhotsk. *Journal of Fish Biology* 84: 243-246.

Thums, M., Meekan, M., Stevens, J., Wilson, S. and Polovina, J. (2012). Evidence for behavioural thermoregulation by the world's largest fish. *Journal of The Royal Society Interface*, 10(78), pp.20120477-20120477.

Wilson, S., Stewart, B., Polovina, J., Meekan, M., Stevens, J. and Galuardi, B. (2007). Accuracy and precision of archival tag data: a multiple-tagging study conducted on a whale shark (Rhincodon typus) in the Indian Ocean. *Fisheries Oceanography*, 16(6), pp.547-554.

7. APPENDIX I

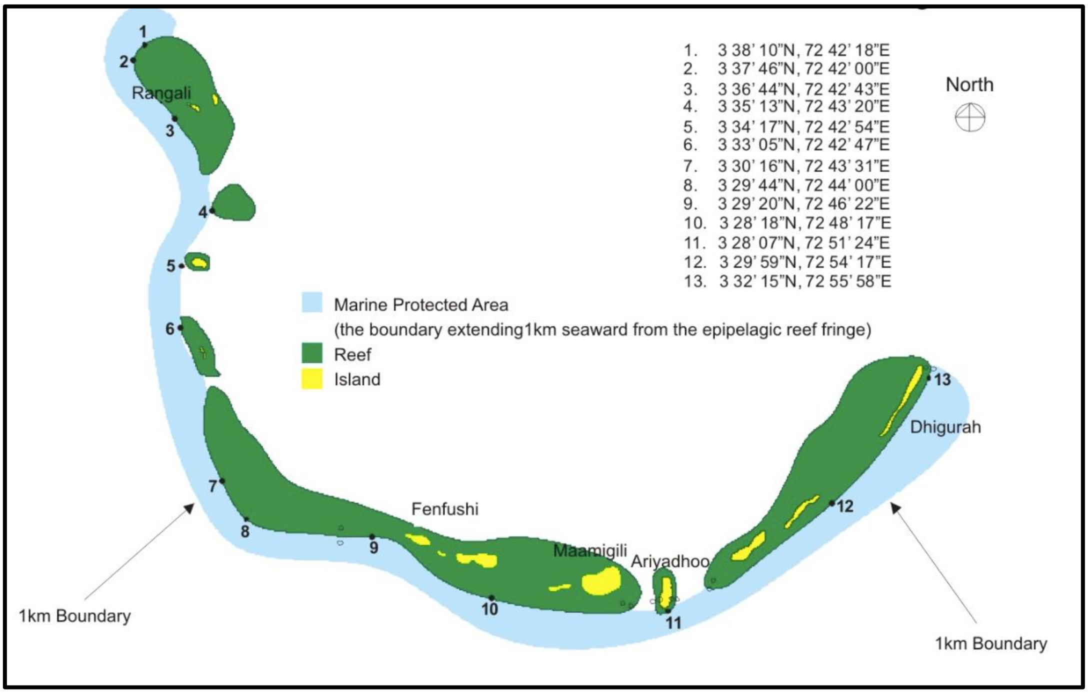


Figure 1: Map of the South Ari MPA (reference: https://sampamaldives.files.wordpress.com/2011/07/alif-dhaalu-maamigili.jpg)

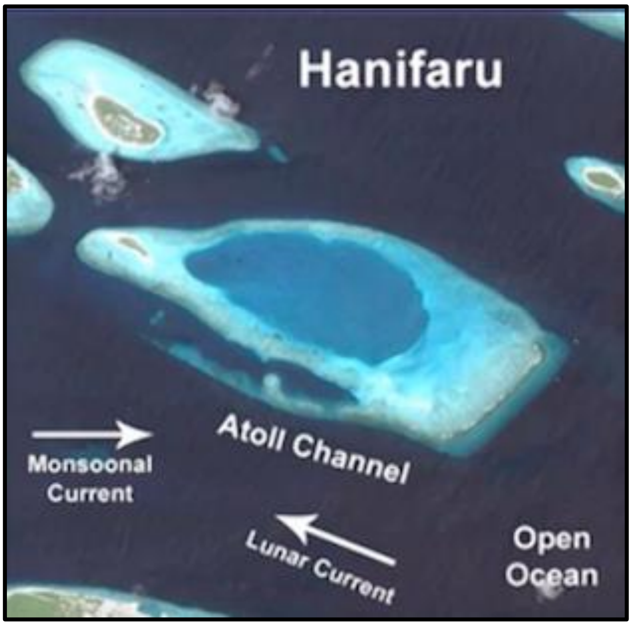


Figure 2: Map of Hanifaru showing how directions of the monsoonal and lunar currents trap zooplankton inside Hanifaru bay. (Reference: https://maldivesfinest.com/wp-content/uploads/2016/02/hanifaru-bay-map.png)

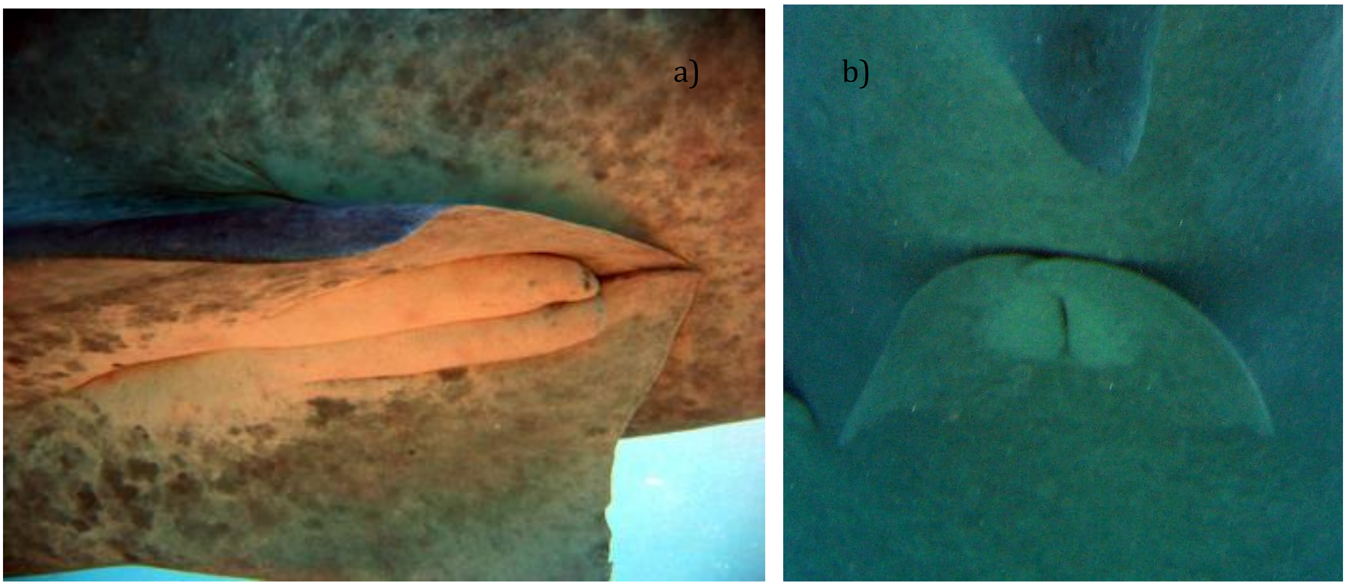
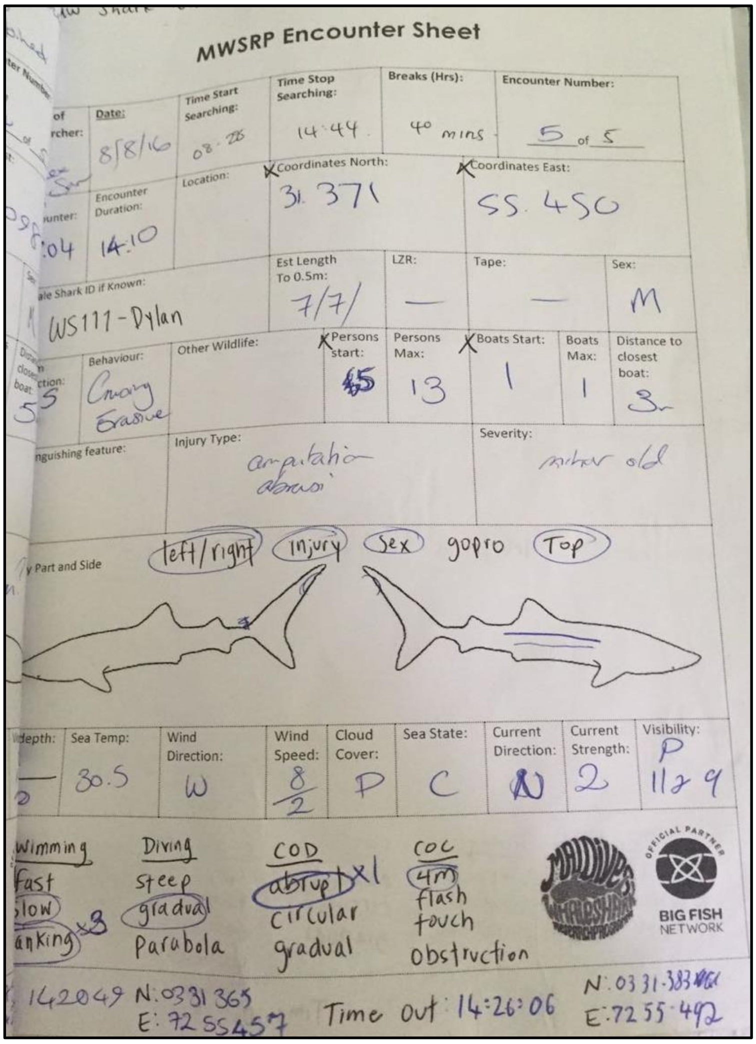


Figure 3: Pictures of the pelvic fins of two whale sharks. a) shows a male with the presence of two adjacent claspers. b) shows a female with the absence of claspers.


MWSRP Encounter Sheet

Date: 8/8/16
Time Start Searching: 08:25
Time Stop Searching: 14:44
Breaks (Hrs): 40 mins
Encounter Number: 5 of 5
Encounter Duration: 14:10
Location:
Coordinates North: 31.371
Coordinates East: 55.450
Whale Shark ID if Known: WS111 - Dylan
Est Length To 0.5m: 7/7/
LZR: —
Tape: —
Sex: M
Behaviour: Cruising Evasive
Other Wildlife:
Persons start: 45
Persons Max: 13
Boats Start: 1
Boats Max: 1
Distance to closest boat: 3m
Distinguishing feature:
Injury Type: amputation abrasion
Severity: minor old
Body Part and Side: left/right injury sex gopro Top
Sea Temp: 30.5
Wind Direction: W
Wind Speed: 8/2
Cloud Cover: P
Sea State: C
Current Direction: N
Current Strength: 2
Visibility: P 11/2 9

Swimming: fast, slow, banking x3
Diving: steep, gradual, parabola
COD: abrupt x1, circular, gradual
COC: 4m, flash, touch, obstruction

BIG FISH NETWORK

142049 N:0331 365 E:72 55457
Time out 14:26:06
N:0331-383 E:7255-492

Figure 3: Example of MWSRP whale shark encounter sheet.

3901	**Gaafu Dhaalu Atoll**								
3902									
3903	trip_date	id	contributor	approval_state	approval_co	staff_name	trip_id	encounter_time	northing
3904	25/02/2011		Manta Trust					11:24:00	
3905	25/02/2011		Manta Trust					11:44:00	
3906	01/04/2011		Manta Trust					05:00:00	
3907									
3908									
3909	**Radshoo Atoll**								
3910									
3911	trip_date	id	contributor	approval_state	approval_co	staff_name	trip_id	encounter_time	northing
3912	20/04/2004	4260	Manta Trust	Approved			2159	09:10:00	4.256744
3913	27/08/2014	2564	Carpe Diem	Approved		Richard	1192	07:30:00	
3914									
3915									
3916	**Lhaviyani Atoll**								
3917									
3918	trip_date	id	contributor	approval_state	approval_co	staff_name	trip_id	encounter_time	northing
3919	29/11/2009	4262	Manta Trust	Approved			2161	14:00:00	5.343267
3920	25/10/2010		Manta Trust					11:53:00	
3921	25/10/2010		Manta Trust					12:10:00	
3922	26/10/2010	3239	Manta Trust	Approved			1605	13:00:00	
3923	28/10/2010	3240	Manta Trust	Approved			1606	13:00:00	
3924	28/10/2010		Manta Trust					13:00:00	
3925	29/10/2010	3241	Manta Trust	Approved			1607	16:30:00	
3926	05/11/2010	3242	Manta Trust	Approved			1608	12:00:00	
3927	07/06/2012	4259	Manta Trust	Approved			2158	15:44:00	5.797606
3928									
3929									
3930	**Fuvahmulah Atoll**								
3931									
3932	trip_date	id	contributor	approval_state	approval_co	staff_name	trip_id	encounter_time	northing
3933	01/02/2011		Manta Trust					12:00:00	

Figure 4: Example of dataset being split into atolls.

Table 1: Table listing all the whale sharks (n=35) that were sighted at Baa Atoll. Years in which they were sighted at Baa are marked with an 'x'. Whale sharks also sighted at South Ari are highlighted in blue.

Baa Population	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total Baa
WS005		X	X	X						
WS007	X									
WS008	X	X		X						
WS009	X									
WS010	X	X	X	X						
WS011	X									
WS012	X	X	X	X						
WS013	X	X								
WS014	X	X	X	X		X	X			
WS015	X	X	X		X					
WS016	X									
WS017	X	X	X	X						
WS020				X						
WS025			X							
WS030		X								
WS035		X								
WS039	X		X	X						
WS046		X	X	X						
WS057		X	X		X					
WS059		X		X		X		X		
WS078				X						
WS086		X								
WS087		X	X							
WS088		X								
WS089		X	X	X						
WS090		X								
WS098		X	X							
WS116		X	X							
WS137			X							
WS138			X							
WS162			X							
WS178					X					
WS187								X		
WS255						X				
WS257						X				

8. APPENDIX II: Extra-Curricular Activities

As well as completing research on my summer placement dissertation I was also involved a large number of extra curricular activities. During my time with the MWSRP I was able to get involved in a wide variety of community out-reach projects. Several involved going into different schools to get children interested and enthusiastic about protecting whale sharks and the marine environment. In the local school at Dhigurah I helped run special lesson given by the MWSRP staff and volunteers on the basic biology and ecology of whale sharks, and introduced them to the basic research we carry out.

Figure 1: Community project at the local school in Dhiguarh.

I also helped write a play about the effect climate change and anthropogenic threats such as littering and pollution were having on whale sharks, coral reefs, and other charismatic species such as turtles and mantas. I helped design and make many of the costumes and also performed the play myself to a school in Mamagilli. Following this, we each took charge of around 15 children and went through some basic educational activities on the effects climate change and anthropogenic threats have for the oceans and marine wildlife and how they could help combat this.

Figure 2: Community project at the local school in Mamagilli, where the play was also performed.

We also organised several beach community beach cleans to help stimulate interest and enthusiasm in protecting their local marine environment. One such beach clean was organised with a school in Mamagilli and another was organised with the local community in Dhigurah.

Figure 3: Community beach clean at Dhigurah

During my time with the MWSRP the IUCN Maldives invited us to send a representative of the programme to participate in an event in Male to raise awareness of the effects of climate change amongst local children. For this the MWSRP decided to design a story-book which I helped write and illustrate. It told the story of a whale shark and piece of coral and the trouble they run into to because of climate change and coral bleaching. It also included fun facts on whale sharks and educational activities to keep children entertained and engaged on every page.

For the duration of my stay at Dhigurah I assisted the MWSRP with all of their fieldwork, collecting data during whale-shark encounters to add to their database. This required me to spend 7 hours a day, 5 days a week on top of the programmes research Dhoni searching for whale sharks. When one was spotted a variety of data regarding the physical condition of the whale shark was noted. The length of the shark was calculated using either laser photogrammetry or a tape measure or was estimated by sight. Photos were taken of the pelvic fins to check for the presence and absence of claspers to determine the sex of individuals.

Figure 4: Collection of photo IDs and observational data during whale shark encounter.

A variety of environmental variables were also collected during encounters. These included temperature using a thermometer; visibility using a secchi disk; wind speed, strength direction using a anemometer and compass; and current strength using a tennis ball and marking the change in coordinates over a 5 minute period using a GPS. The number of boats, people in the water, were also noted as well as people's interactions with the whale shark to monitor whether any codes of conduct were broken during encounters.

Figure 5: Collecting Environmental Variables for the MWSRP

I also assisted a volunteer collect plankton samples for her undergraduate dissertation. This was done using the net method, where a net with a fine mesh is towed along the back of the Dhoni for 5 minutes. By attached this mesh to a sample bottle, the plankton that have stuck to the mesh can be collected by spraying it with water. I also assisted in collecting photo identification images of Manta Rays in the lagoon on the opposite of Dhigurah to the MPA. These images were then sent to the Manta Trust in Baa Atoll to be added to their database.

During research excursions data was also collected on the diversity and abundance of other mega-fauna spotted within the MPA, which included various species of turtles, dolphins, sharks and even whales. This was then compiled in an annual report that was sent to the IUCN and the Environmental Minister for the Maldives for assessment. Further data on the number of vessels spotted along the MPA and the number of people on-board were also calculated by sight with the assistance of binoculars, in order to assess the approximate number of tourists that were visiting and using the MPA each year. This data was again compiled in an annual report, which was then forwarded to the Maldivian government.

During my time with the MWSRP I was also given several responsibilities. I was in charge of the technical equipment used by the MWSRP including the GPS, and underwater cameras. I also was in charge of writing the daily log, which involved noting the whale shark ID numbers that were seen each day, the start and end times of the search times for the day, and any significant events that occurred during the course of the day. I also helped supervise the volunteers when they entered the data collected at the end of each day into the online database.

Figure 6: Giving presentations to volunteers on whale sharks.

I was also given the opportunity to give several behavioural talks to presentations on the biology and ecology of Whale sharks and the research the MWSRP undertakes to new volunteers joining the programme. I also assisted other staff members who gave presentations on liveaboards in helping to answer any questions guests may have had.

Finally I also wrote two blogs for the MWSRP which described my time with the programme, the work I was doing them, and my own personal research on this summer placement dissertation.

Blog

I was lucky enough to spend my summer placement dissertation with the Maldives Whale Shark Research Programme on the Island of Dhigurah, in South Ari Atoll, Maldives. My project compared data from whale shark encounters within South Ari, where sightings have remained constant in recent years, with those in Baa Atoll, where numbers have drastically fallen. My aims were to first track where the whale sharks were going when they left Baa and determine what environmental variables were driving the whale sharks out of Baa in the first place.

Alongside this, I assisted the MWSRP in their data collection. This unfortunately meant getting in the water with these amazing animals primarily to take photo identification shots. Nothing can describe that unbelievable and awe inspiring feeling you get when you see a whale shark underwater for the first time. It's hard to truly appreciate the sheer size of these gentle giants until you find yourself swimming next to one for the first time… as well as the following 20 times!

As well as collecting data on whale sharks you also get the opportunity to see and collect data on a wide variety of other mega-fauna that you encounter, including turtles, dolphins, many other species of sharks, and on one occasion false killer whales!

One of the best aspects about my summer placement was the many opportunities to get involved in community projects. During my stay I co-wrote a play about whale sharks, coral reefs and the effects of climate change, which I performed in front of a local school. I also assisted in giving educational lessons to two local schools on the ecology and biology of whale sharks, and the basic research aims of the MWSRP. I also helped design a storybook on whale sharks and climate change, which was presented to local school children in Male for a special IUCN Maldives event on Climate Change. I was also involved with two community beach cleans (surprisingly more fun than it sounds!).

One of the best parts about being based on a local island, was you got to experience and appreciate more authentic Maldivian culture. The people were also very warm and welcoming. There where opportunities to play sports with the local children in the afternoon including football, badminton, cricket and volleyball. As well as this there is a water sports centre on the island were you can wakeboard, water ski or rent canoes for the day to explore the island. There are also two dive centres for those enjoy SCUBA diving or are interested in learning.

Ultimately my time with the MWSRP was one of the most memorable experiences of my life, and I am very privileged and grateful to have been given the opportunity to do my summer placement there.