Overview of the Sharkwatch Programme

2009 – 2013

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Executive Summary

Sharkwatch was launched in 2009 to collect baseline information on abundance of reef associated sharks in Maldivian waters, so as to assess the status of stocks and monitor the effectiveness of the fishing ban implemented the same year.

Since its inception, a number of resorts/dive centres have participated in the programme and continue to send monitoring data on a monthly basis. The survey uses the Roving Diver Technique which is a rapid and effective assessment technique that can be used by volunteers to collect fish data. The survey form includes 8 species of sharks which are most likely to be encountered, while other species are recorded as "Others" and identified if possible.

Over the 4 years, a total of 11,704 surveys were undertaken at 540 sites, with a total of 8,255 hours spent surveying. A total of 23,798 sharks were recorded on these surveys. The geographic spread of the survey area is quite wide-spread from the north to south of Maldives, though a greater number of surveys were done in the central atolls.

The number of surveys conducted and time spent surveying increased over the four year survey period, with the number of surveys during the 4th year being almost thrice that during the 1st year. This indicates that participants realised the importance of Sharkwatch and wanted to contribute to the programme.

The majority of sites surveyed showed the presence of sharks, while 24% of the sites did not have any sharks. However, the numbers of sharks observed at the sites were low, with 1 to 10 sharks being observed at about 50% of sites. The average number of sharks per survey varied amongst the atolls. Baa Atoll, which used to be one of the atolls where shark fishing was carried out prior to the ban has one of the lowest averages. This suggests that shark fishing at Baa Atoll may have caused a population decline.

The most commonly seen species was the Whitetip Reef Shark (*Triaenodon obesus*), which was followed by Grey Reef Shark (*Carcharhinus amblyrhynchos*) and Blacktip Reef Shark (*Carcharhinus melanopterus*). An increase in number of sharks seen per survey was seen for Whitetip Reef Shark and Grey Reef Shark at some of the key sites. While these were not

significant increases and was not a common occurrence it is encouraging to see that the average number of sightings has not declined over time.

The average number of sharks seen per survey at the 10 most surveyed sites was seen to vary greatly from one site to another, with Site 4 having the highest average, which also showed an increase in average sightings over the four year period. These are encouraging results as they are indicative of possible increase in shark abundance at these sites. The average number of sharks seen at the 10 sites with the highest shark abundance, showed that the highest abundance was seen at a site which was surveyed 1/3 the number of times of the most surveyed site. This is another indication of good shark abundance at the site.

Results of this overview are from a four year survey period and do not show clear cut increases in shark abundance. However, given the 'slow' life history of sharks, it is not surprising that significant population increases have not occurred within this time frame. It is encouraging to see that some results are indicative of an increase, and this fact emphasises the importance of long term continued and consistent monitoring of the selected survey sites. We hope these results are an incentive for more resorts/dive centres to participate in this programme. We also hope these results are useful to the Ministry of Tourism and other relevant authorities, whose cooperation is critical for the successful implementation of Sharkwatch.

Introduction

Sharks are top predators that play an important ecological role on coral reefs. Due to their slow growth, late maturity and low fecundity, sharks are very vulnerable to over-exploitation. For the same reasons, depleted stocks are very slow to recover. Studies in the Chagos Archipelago showed declines in mean shark sightings per scientific dive from 4.2 in 1975 to 0.6 in 2006 (Graham et al., 2010). While the Chagos is a relatively uninhabited group of islands, this decline was attributed to poaching which is evidenced by a number of illegal fishing vessels which had been captured from the area with large numbers of sharks on board the vessels (Graham et al., 2010).

Initially, sharks were fished in the Maldives on a small scale for their liver oil. However, in the late 1970s the fishery intensified mainly because of the value of dried sharks fin and salted shark meat as export commodities. After 1975, the estimated annual shark catch of around 575 metric tonnes (MT) rose rapidly to 1500 MT and subsequently fluctuated between 1100 MT and 2000 MT annually until 1998 (MRC, 2009). Conversion of these weights into numbers using the average weight of 20kg per shark (as reported in MRC 2009) shows that number of sharks caught annually between 1975 and 2007 fluctuated between 55,000 and 100,000 sharks. Main species caught in the Deepwater, Oceanic and Reef shark fisheries included the Gulper shark species (*Centrophorus niaukang*, *C. squamosus* and *C. tessellatus*), Silky shark (*Carcharhinus falciformis*), Oceanic Whitetip shark (*Carcharhinus longimanus*), Silvertip shark (*Carcharhinus albimarginatus*), Bignose shark (*Carcharhinus altimus*), Whitetip Reef shark (*Triaenodon obesus)* and Blacktip Reef shark (*Carcharhinus melanopterus*). Additional species details are reviewed in MRC (2009).

The shark fishery came into direct conflict with the tourism industry which places a considerable value on being able to see live sharks in the wild. In 1998, in an effort to minimize conflict, the government of Maldives declared a 10-year moratorium on all types of shark fishing inside and within 12 miles from the atoll rim of 7 major 'tourism' atolls in the Maldives (Baa, Lhaviyani, Kaafu, North Ari, South Ari, Vaavu and Addu).

However, this ban was not enforced properly and shark fishing continued. A survey of the fishery in 2003 revealed that shark fishing was being carried out in 22 islands and involved a total of 132 vessels and 528 fishermen, accounting for 3.5% of the total number of fishermen in the Maldives (MRC, 2009).

The effectiveness of the moratorium was reviewed towards the end of the 10-year moratorium. Declining shark numbers (MRC, 2009, Le Berre et al., 2008), as well as increasing pressure from the tourism sector, led the government to announce a ban on all reef shark fishing from the 1st March 2009. Under this legislation it was prohibited to kill, capture or extract any species of shark within 12 miles from the outer atoll rim of all Maldivian Atolls.

A total ban on all shark fishing, capture, killing or extraction from Maldivian waters was imposed from the 15th March 2010. The whale shark (*Rhincodon typus*) had already been declared a protected species in the Maldives since the 24th June 1995.

The Darwin Reef Fish Project, is a Darwin Initiative Funded four year collaboration between the Marine Research Centre and Marine Conservation Society of UK was initiated in Aril 2009. The aim of the project was to assess the status various reef fisheries of Maldives and formulate management plans for the

fisheries so as to allow sustainable utilization of the resources. As one of the first programmes of the project, 'Sharkwatch' was launched in July 2009 to collect baseline information and monitor the outcomes and effectiveness of the shark fishing ban. This is the first time that stock surveys have been attempted in the Maldives and the data collected is proving invaluable in providing a better understanding of the current population of reef shark species and how they respond to the recently-introduced protection measures.

Sharkwatch methodology and data analysis

Sharkwatch uses the 'Roving Diver Technique (RDT), which is a rapid and effective assessment technique that can be used by volunteers to collect fish data. Given the interest of the tourism industry in maintaining healthy populations of sharks on the Maldives reefs, it is appropriate that divers are playing a pivotal role in the monitoring programme.

During a Sharkwatch survey, the observer swims freely during an approximate period of 45 – 50 minutes recording the sharks he/she encounters. The method is employed during regular diving activities and the observer starts recording the number of sharks as soon as he/she enters the water. The 8 species of shark most likely to be encountered are included on the survey sheet. Additional species were counted under 'others'. Environmental data such as current strength, visibility and depth are also recorded. The survey form used for data collection is shown in Appendix 1.

The results of each Sharkwatch recording dive are entered into an excel spreadsheet and submitted monthly to MRC. Survey dives at sites where sharks are not sighted are included as these provide a vital 'zero' baseline against which recovery (if it occurs) can be monitored.

The data which has to-date been sent to MRC has now been analysed and published in 4 annual survey reports for the survey periods of July 2009 – June 2010, July 2010 – June 2011, July 2011 – June 2012 and July 2012 to June 2013 (Ushan and Wood, 2010, Ushan, Sattar and Wood, 2011, Sattar, Wood, Ushan and Ali, 2014a and Sattar, Wood, Ushan and Ali, 2014b).

Results

General trends

Table 1 shows the number of participants in the programme from the 1st year onwards. It should be noted that 4 have been involved in the programme from the first year onwards. Details of participating resorts and their locations are in Table 2.

Table 1. Numbers of participating resorts /dive centres/safari vessels

Year	No. of participating resorts/dive centres
Year 1 (July 2009 – Jun 2010)	14 resorts
Year 2 (July 2010 – Jun 2011)	12 resorts + 1 safari vessel
Year 3 (July 2011 – Jun 2012)	13 resorts + 1 Dive centre (inhabited island)
Year 4 (July 2012 – Jun 2013)	13 resorts + 1 safari vessel

Table 2. Details of participating resorts/dive centres

Atoll	Resort/Dive Centre
Haa Alifu	Beach House Manafaru
Noonu	Hilton Irufushi Lazy Gecko Dive Centre (N. Velidhoo)
Baa	Coco Palm Dhunikolhu Four Seasons Resorts Maldives at Landaa Giraavaru Reethi Beach Resort Royal Island Resort and Spa
Lhaviyani	Kuredu Island Resort Palm Beach Island Resort
North Male'	Baros Maldives Coco Palm Boduhithi Four Seasons Maldives at Kuda Huraa Gili Lankanfushi One and Only Reethi Rah Paradise Island Resort and Spa Taj Exotica
South Male'	Adaaran Prestige Vaadoo Anantara Resorts Cocoa Island Resort Embudu Village Velassaru Maldives
North Ari	Kuramathi Island Resort W Retreat and Spa Maldives
South Ari	Lux* Maldives
Dhaalu	Niyama Maldives
Laamu	Six Senses Laamu
	Four Seasons Explorer (safari vessel)

While survey effort was mostly concentrated within the atolls of the resorts, some resorts visited dive sites at nearby atolls as well. Furthermore, Four Seasons Explorer conducted surveys within various atolls during its trips. A map showing geographic spread of survey effort is shown in Appendix 2.While this map shows whole atolls where surveys were carried out, the individual reports for each survey period shows individual sites where surveys were conducted.

Over the 4 years, a total of 11,704 surveys were undertaken at 540 sites, with a total of 8,255 hours spent on surveying. A total of 23,798 sharks were recorded on these surveys, with species-wise data being recorded for the following categories in Table 3.

Table 3. Species listed in the survey form

Code	English name	Scientific name
BRS	Blacktip Reef Shark	*Carcharhinus melanopterus*
WRS	Whitetip Reef Shark	*Triaenodon obesus*
GRS	Grey Reef Shark	*Carcharhinus amblyrhynchos*
SHS	Scalloped Hammerhead Shark	*Sphyrna lewini*
SS	Silvertip Shark	*Carcharhinus albimarginatus*
TNS	Tawny Nurse Shark	*Nebrius ferrugineus*
VS	Variegated Shark	*Stegostoma fasciatum*
WS	Whale Shark	*Rhincodon typus*
OT	All other Sharks	

Figure 1 shows a breakdown of the number of surveys undertaken over the four survey periods, while Figure 2 shows the time spent on these surveys. As can be very clearly seen from both figures, the number of Sharkwatch surveys and the time spent on conducting these surveys have been on an increasing trend since the first year. While the number of surveys which were conducted in the 4th survey period is almost thrice that conducted during the 1st survey period, the time spent on conducting these surveys has more than doubled over the 4 years. This is a good indication of the realization of the importance of these surveys and the interest of the participants in contributing to the Sharkwatch programme.

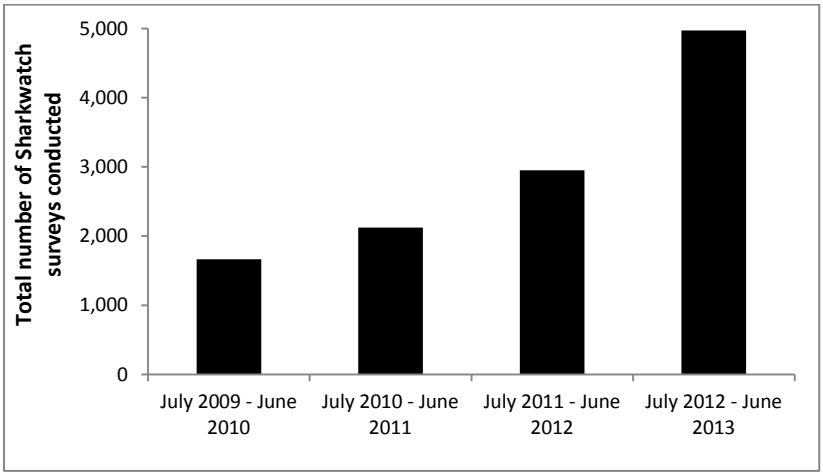

Figure 1. Number of Sharkwatch surveys undertaken during the different survey periods

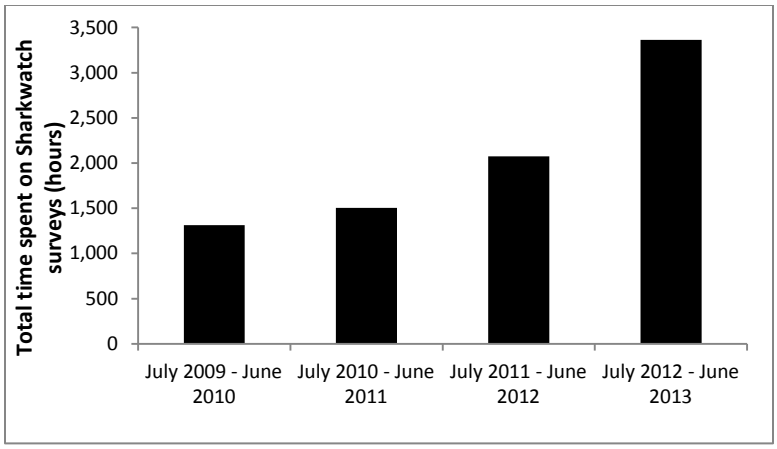

Figure 2. Number of hours spent on Sharkwatch surveys during the different survey periods

Figure 3 shows the number of sites reported for the 4 survey years. The number of sites surveyed annually has increased slightly over the 4 year period, which is expected with the addition of new resorts to the programme. However, given that the number of participants has remained almost the same each year (with some discontinuing and new resorts joining in), it is not surprising that there has not been a significant increase in the number of sites surveyed annually.

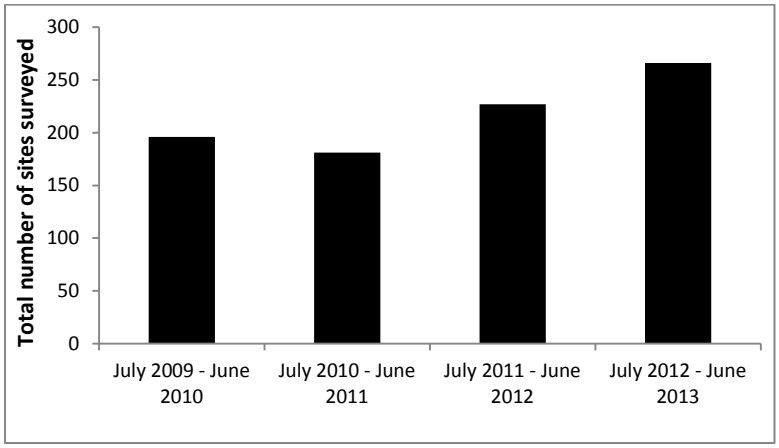

Figure 3. Number of sites surveyed annually over the four year survey periods

Figure 4 shows a frequency distribution of the number of sharks sighted at all sites. As evident from the figure, sharks were observed at the majority of the sites (76% of sites), while none were observed at 24% of the sites surveyed over the four year period. Of the sites where sharks were observed, 1 to 10 sharks were observed at the majority of the sites, with 1 shark being observed at 15% of the sites.

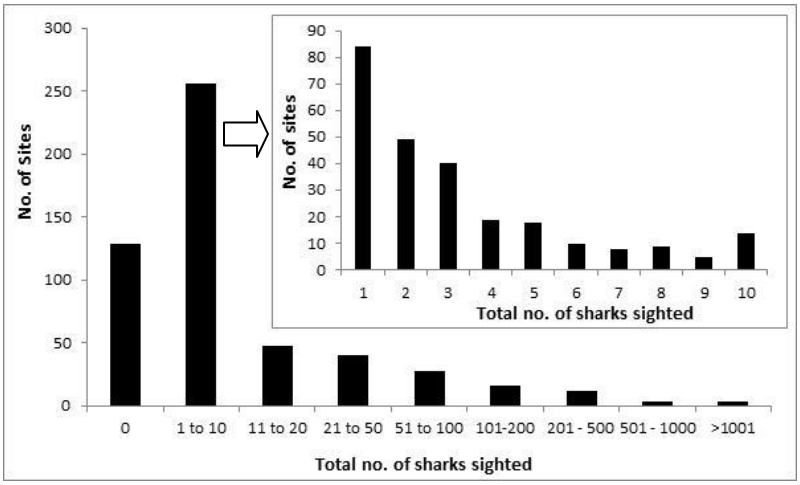

Figure 4. Frequency distribution of total number of sharks sighted on all sites. The smaller chart shows a breakdown of category of 1 to 10 sharks sighted

Figure 5 shows the average number of sharks observed per survey conducted at the different survey atolls. As evident from the figure, the average number of sharks observed from the different atolls varies slightly, with Noonu Atoll and South Male' Atoll having the highest averages. Interestingly, Baa atoll where reef shark fishing was quite intensively carried out prior to the ban has one of the lowest averages, hence possibly indicating the detrimental impact of fishing on shark stocks.

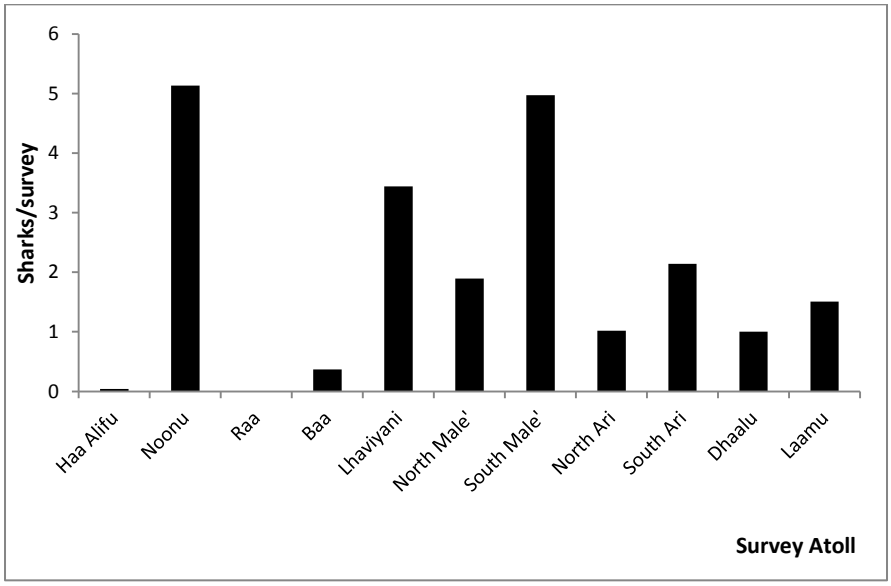

Figure 5. Number of sharks observed per survey conducted at the different atolls

Figure 6 shows the number of sharks recorded for the 4 survey periods. The number of sharks observed per year over the 4 year period shows a clear increasing trend. However, this cannot necessarily be attributed to increasing shark stocks, but may be the result of increased survey effort and inclusion of different sites. This possibility has been investigated by looking at the average number of sharks per survey and at specific sites which have been identified as good shark spots (see Figures 11 to 15).

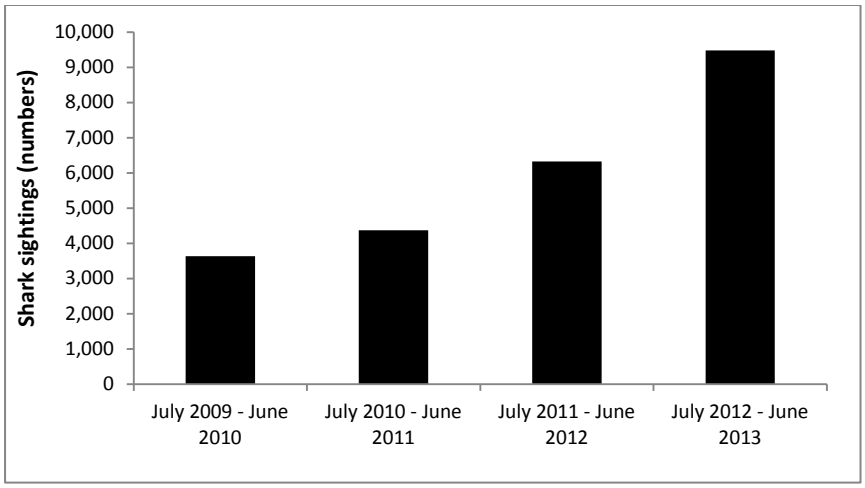

Figure 6. Total number of sharks observed during the different survey periods

A breakdown of the total number of sharks observed during the 4 years into the different species recorded (Figure 7) shows that the Whitetip Reef Shark (*Triaenodon obesus*) was the most commonly recorded species over the four years.

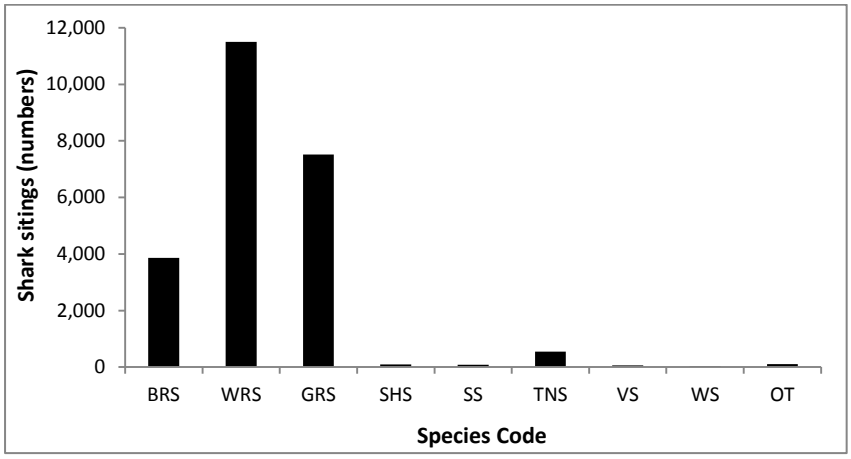

Figure 7. Total number of each species of sharks observed over the 4 year survey period (BRS – Blacktip Reef Shark, WRS – Whitetip Reef Shark, GRS – Grey Reef Shark, SHS – Scalloped Hammerhead Shark, SS – Silvertip Shark, TNS - Tawny Nurse Shark, VS – Variegated Shark, WS – Whale Shark, OT – Other sharks)

A breakdown of Figure 7 into the number of sharks for each species observed during the individual survey periods (Figure 8) shows that, similar to Figure 6, the Whitetip Reef shark is the most commonly observed species for all survey periods, except for Year 3 (July 2011 to June 2012). Survey year 3 shows that a greater number of Grey Reef Sharks was observed in comparison the Whitetip Reef Sharks, although the difference between the two species was very small (1.6%).Therefore, it is reasonable to say that the most commonly observed species for all years was the Whitetip Reef shark.

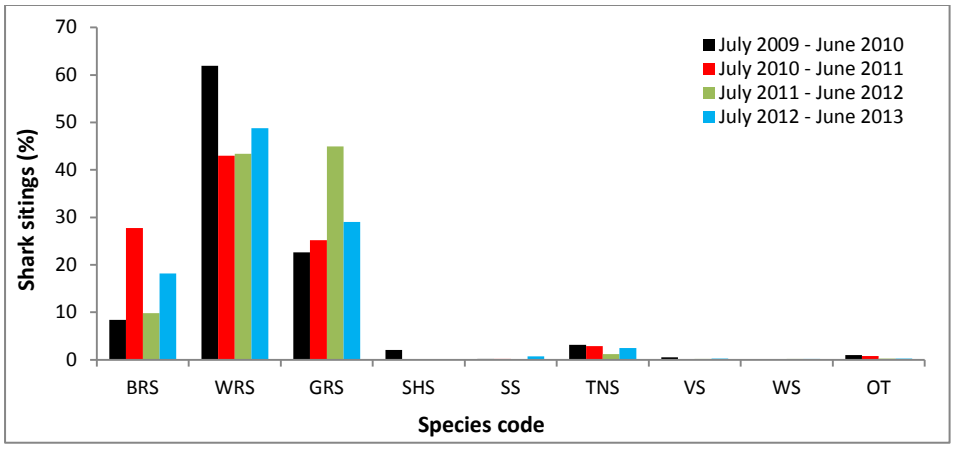

Figure 8. Breakdown of species-wise shark sightings into the four survey periods

Specific trends

Analysis based on top survey sites

While a total of 540 sites were reported to have been surveyed over the 4 year period, some sites were surveyed repeatedly over the 4 year period. These sites were generally those that were regular dive sites and might not necessarily have been top shark sighting spots. However, 1 or more sharks were seen at the majority of the sites (407), while 133 sites reported no shark sightings over the 4 year period. Figure 8 shows a breakdown of the number of years that sites were surveyed.

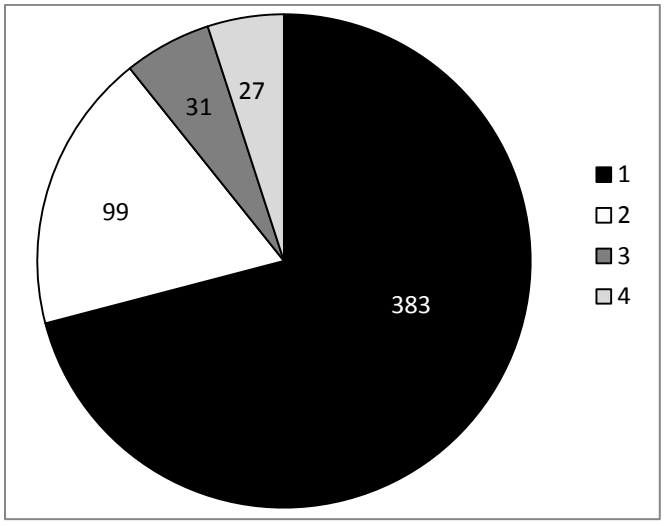

Figure 9. Depiction of the number of years sites were monitored (legend shows number of years surveyed)

The majority of sites (70.9%) were surveyed during only one of the survey years, though a small number of sites were surveyed 3 or 4 years (5.7% and 5% respectively) of the 4 year survey period. The ten top sites in terms of number of surveys have been selected for site-specific analyses. However, names of the

sites have been kept confidential as per the request of participating dive centres and resorts. The number of surveys conducted at these sites is shown in Figure 10.

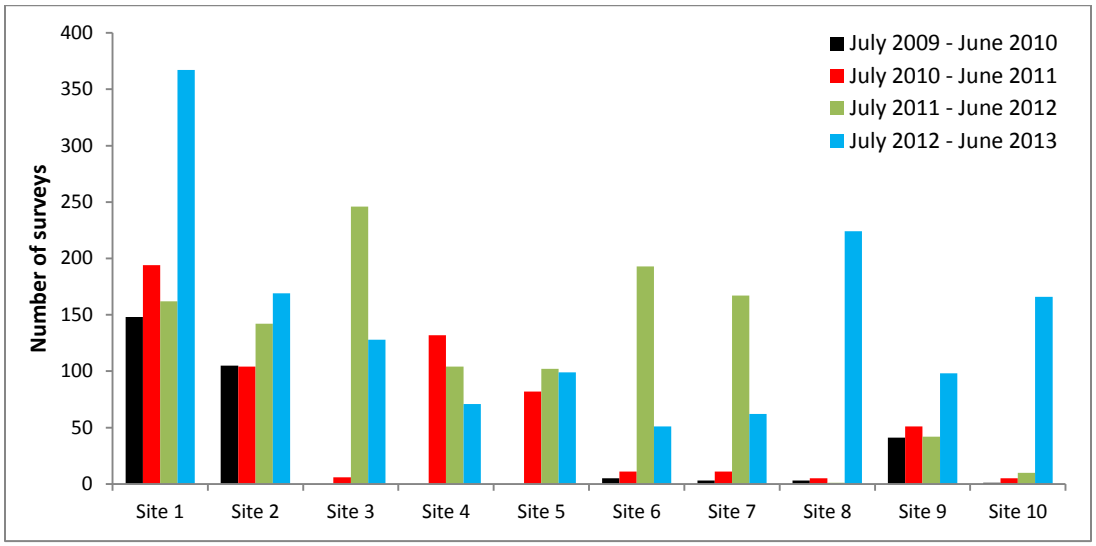

Figure 10. Number of surveys conducted at the top 10 most surveyed sites during the 4 survey periods

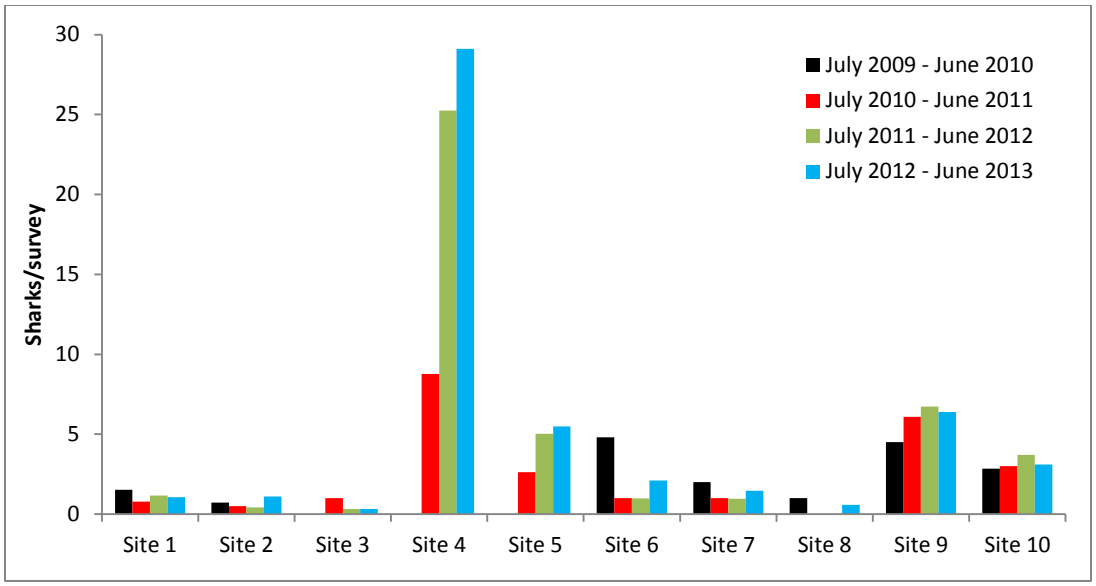

Figure 11. Average number of sharks seen per survey at the 10 most regularly surveyed sites (based on total number of surveys conducted)

As evident from Figure 11, the average number of sharks per survey for the different sites varies greatly from one to another, with Site 4, which has been surveyed 3 out of the 4 years having the highest number of sharks per survey. As also evident from the figure, the average number of sharks/survey is not connected to survey effort. Instead, it reflects the fact that participants were asked to select survey sites based on their dive frequency to the site and not just to choose sites that were known as good shark watching spots. It is also interesting to note that the average number of sharks per survey for Site 4 has increased over the 4 years, which is also seen for Site 5 and Site 2. Site 9 also has a higher number of

sharks per survey for the latter 2 years of the survey period. These are potentially encouraging results and could indicate possible increase in shark numbers.

The report looks at average number of sharks per survey for the 4 species which were most commonly reported during the surveys, the Whitetip Reef Shark, Grey Reef Shark, Blacktip Reef Shark and Tawny Nurse Shark. Average numbers of sharks for these 4 species per survey conducted at the top 10 sites are shown in Figures 12 to 15.

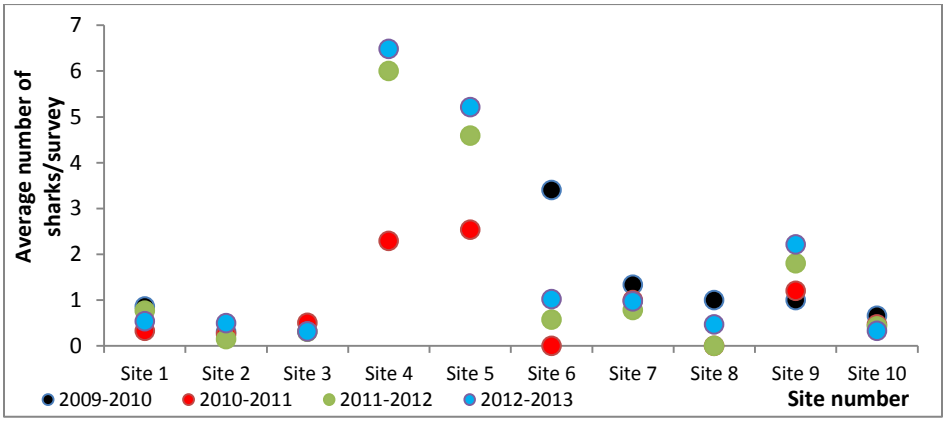

Figure 12. Average number of individuals of Whitetip Reef Shark observed per survey conducted at the 10 most regularly surveyed sites

Figure 12 shows the average number of individuals of Whitetip Reef Shark observed at the top 10 sites for the 4 survey periods. While this was the most common species to be reported for the whole survey period, only 3 of the sites (Sites 4, 5 and 9) show an increase in average number of individuals of this species observed at the site. From these, sites 4 and 5 show a greater increase in numbers.

Grey Reef Sharks were seen to be most abundant in Site 4, where the overall shark abundance was also seen to be the highest, with the highest number of sharks being observed on a single survey (Figure 13). Numbers of Grey Reef Sharks are also seen to be on the increase at this site and it would be ideal to continue monitoring the site for establishment of long term trends. This site is one of the many Marine Protected Areas of Maldives and has thus been a sanctuary for sharks for a number of years.

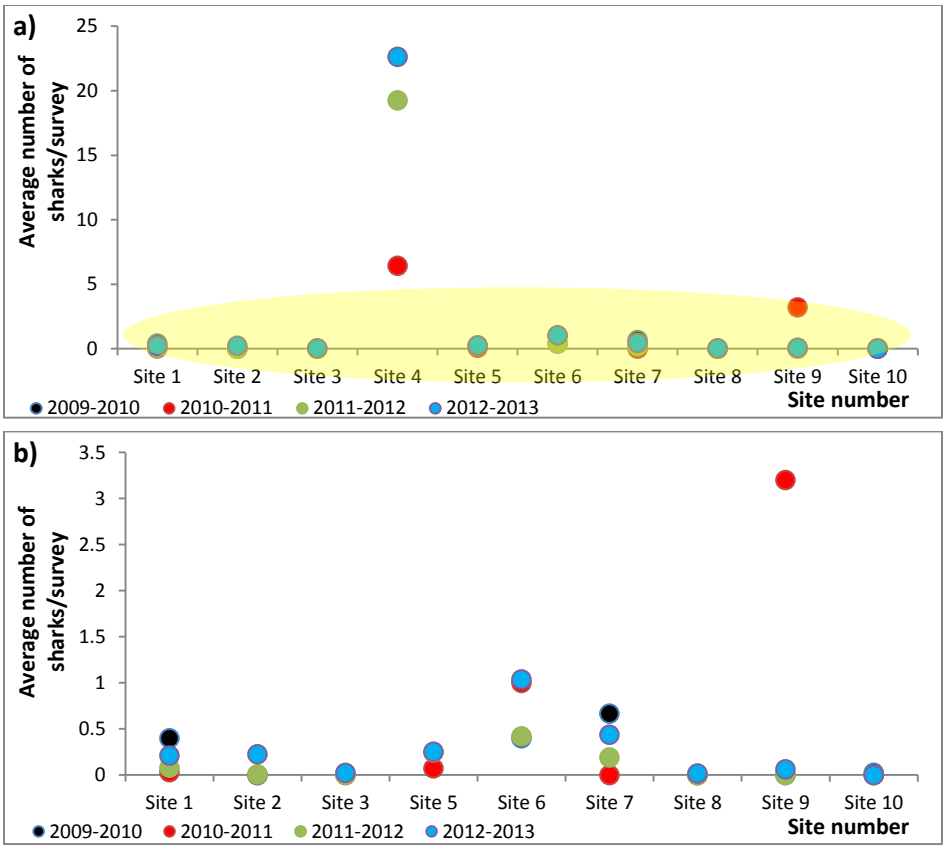

Figure 13. Average number of individuals of Grey Reef Shark observed per survey conducted at the 10 most surveyed sites (a); closer look at area highlighted in yellow in top figure (b)

Another interesting point to note is that, while only a few sites show an increase in average numbers of sharks observed per survey (for Grey Reef Sharks), there are no sites where numbers have declined by a significant amount. This is a good sign and also an indication of potential recovery of shark stocks in the future.

Figure 14a shows the average number of individuals of Blacktip Reef Shark observed per survey conducted at the top 10 sites earlier identified. As evident from the figure, individuals of this species are most common at site 10, with average numbers seen at this site being much greater for all years, in comparison to other sites. Sightings of this species were lower at other sites (Figure 14b), though for sites 2, 8 and 9 the latter years showed higher number of sharks than the former years. However, this difference is very small and not a reliable sign of increased abundance.

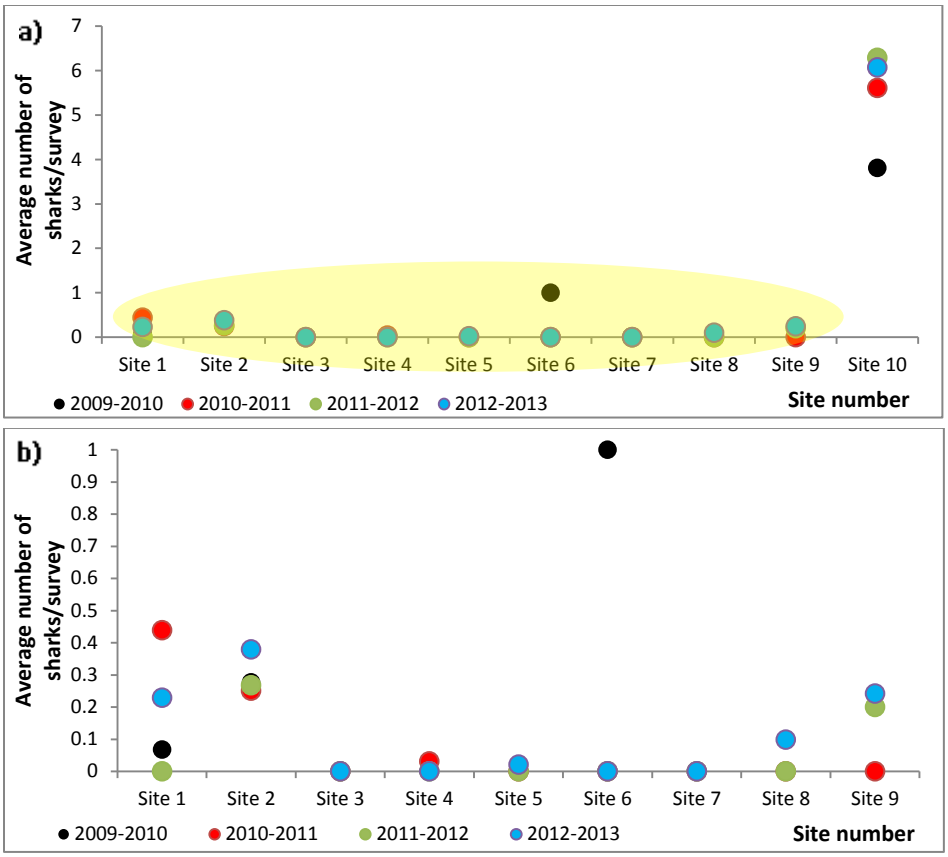

Figure 14. Average number of individuals of Blacktip Reef Shark observed per survey conducted at the 10 most surveyed sites (a); closer look at area highlighted in yellow in top figure (b)

The fourth most frequently recorded species of shark was the Tawny Nurse Shark. This species was reported in lesser numbers and average number of individuals of this species observed per survey at the 10 most surveyed sites is shown in Figure 15. The figure does not show significant changes in number of sharks observed per survey, although Sites 3 and 9 show a decline in average number. However, this decline is insignificant given the small sample number (total sightings of sharks over the four years).

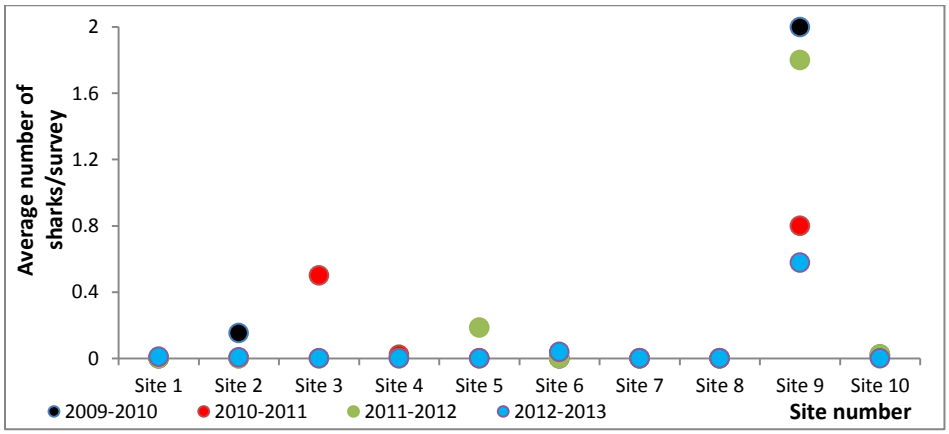

Figure 15. Average number of individuals of Tawny Nurse Shark observed per survey conducted at the 10 most surveyed sites

Analysis based on top shark abundance sites

When data was ranked based on total counts over 4-years of surveys rather than number of surveys, a different set of sites was identified as the top 10 sites for this criteria. However, both sets of top 10 sites were seen to have 4 sites in common.

Figure 16 shows the number of surveys carried out at these top 10 sites and the number of individual sharks seen per survey.

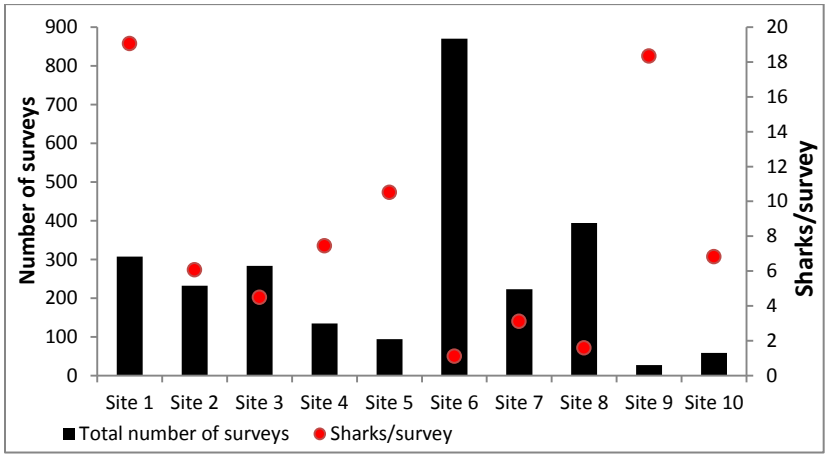

Figure 16. Number of surveys and sharks/survey at top 10 sites based on shark abundance at site (different from top 10 based on number of surveys)

The above figure shows a few points of interest;

- Site 6 was surveyed the most but has the lowest average number of sharks/survey
- Site 1 has the highest average number of sharks/survey but was surveyed approximately 1/3 the number of times Site 6 was surveyed. In this case, high abundance at the site is indicative of a good shark stock at the site as shown by the high sharks/survey sighting average
- Site 9 which was surveyed the least also has a high sharks/survey average

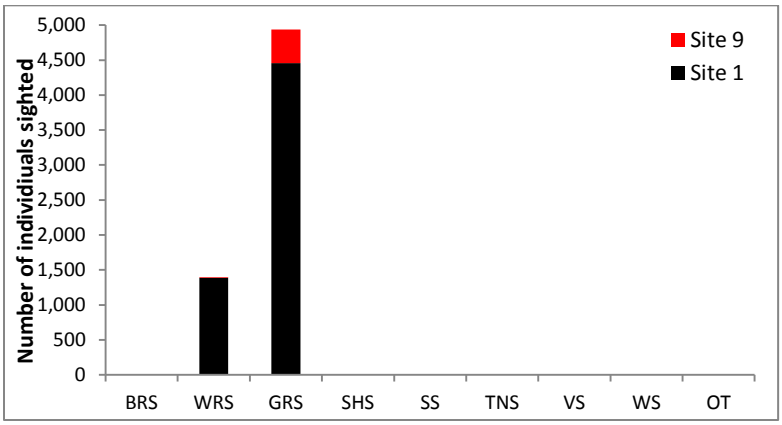

Figure 17. Species of sharks sighted at the two sites with highest sharks/survey average (based on shark abundance)

A look at shark species diversity at Sites 1 and 9 which show the highest sharks/survey average shows that for both sites, Grey Reef Sharks were the most commonly sighted species of shark (Figure 17). It should be noted here that Site 1 here corresponds to Site 4 in Figures 9 to 14.

Encounter rates

Encounter rates (sharks per hour) for the whole survey period for all sharks was calculated to identify whether there were any seasonal trends (Figure 18). However, the graph showing encounter rates of all sharks obersved over the whole survey period does not show any trends in seasonality of sightings.

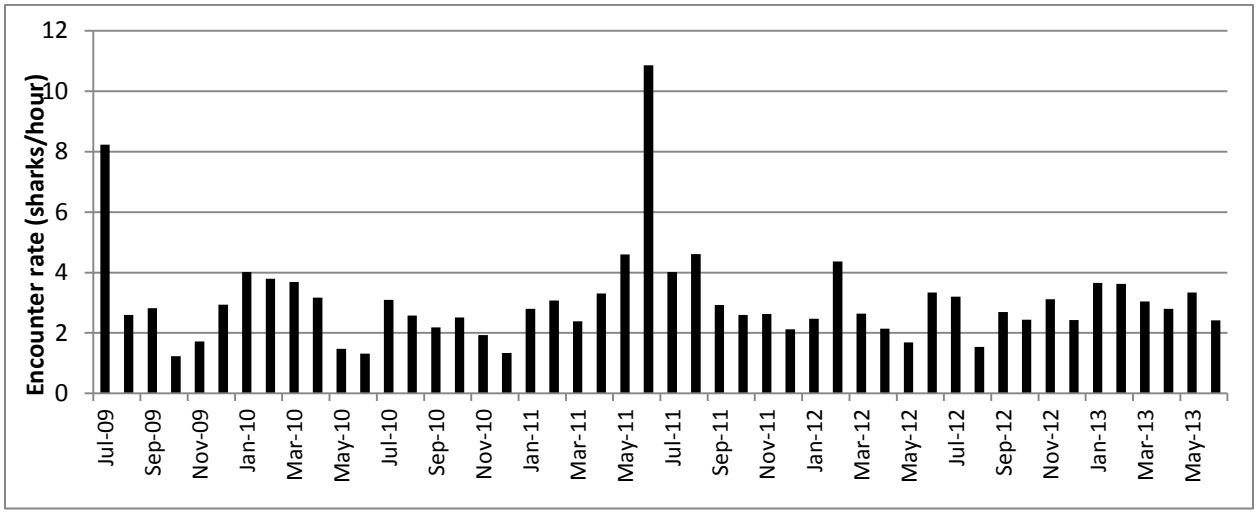

Figure 18. Encounter rates of all sharks observed for the whole survey period

Figure 19 shows encounter rates for the individual species of sharks which were surveyed. While consistent surveying of same sites is likely to reveal trends in encounter rates, Figure 19 does not depict such a trend for any of the species. The charts for individual species show more fluctuation in encounter rates.

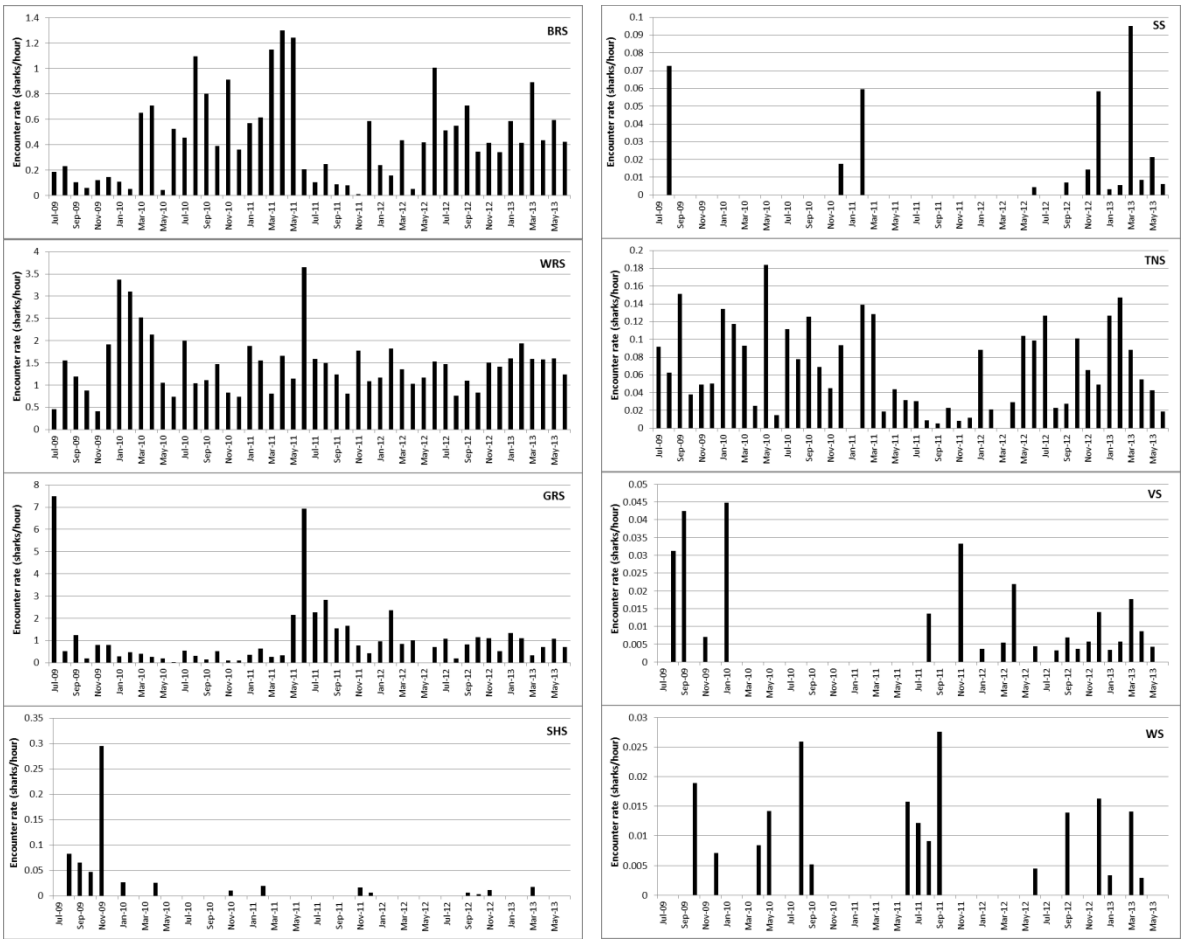

Figure 19. Encounter rates for individual species for the whole survey period

Encounter rates of sharks at individual sights was also analysed. Sites were chosen based on abundance of sharks and number of surveys. In this respect, 4 sites which were in common between the top sites based on abundance and number of surveys were chosen.

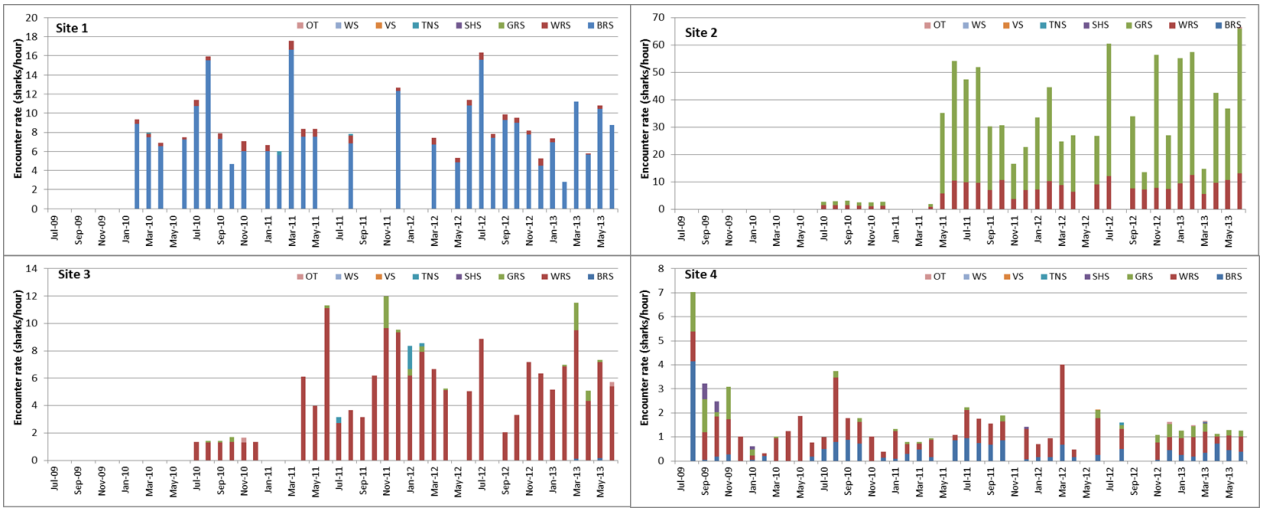

Figure 20. Encounter rates of individual species at chosen sites

As with earlier graphs, these charts also do not show a seasonality in trend for encounter rate. It is possible that this analysis needs to be carried out on longer term data, hence again stressing the importance of continued surveying.

Discussion

In efforts to revive the shark populations of Maldives, which had been showing signs of decline due to fishing practices, the Government of Maldives in 2010 introduced a total ban on shark fishing, capture, killing or extraction from Maldivian waters. This was preceded by a number of management measures, including a ban on fishing, capture, killing or extraction of any shark species, within 12 miles from the outer atoll rim of all Maldivian Atolls in March 2009.

Sharkwatch Maldives was launched by the Darwin Reef Fish Project (DRFP) in July 2009 to assess the effectiveness of the shark fishing ban. The aim was to collect baseline information on status of shark stocks at the time of introduction of the fishing ban. The programme was initiated with the assistance and cooperation of the Ministry of Tourism, Arts and Culture, in the hopes of getting the cooperation of the tourist resorts and dive schools. However, it should be noted that participation amongst the 100+ resorts has been low although some of the individual Dive Centres have submitted a large number of records.

Four survey reports for the programme have so far been finalized and circulated to all participants, each an annual report for a given survey period. This report discusses the results over the four year period (duration of DRFP) and provides a final overview formulated through the Darwin Reef Fish Project. The Sharkwatch programme is now been undertaken by the Marine Research Centre (MRC). It is our hope that Sharkwatch is an ongoing long term monitoring programme as this is the only means by which we will be able to study the impact of the ban on shark populations of Maldives. To this effect, we have had discussions with both IUCN's Project REGENERATE which will focus on North Ari Atoll and the CCTF project on establishing a framework for Maldives National Coral Reef Network to include Sharkwatch in their monitoring programmes (Wood, Sattar and Ali, 2014).

While the number of participants was low and not consistent over the four years, the geographic spread of survey effort has covered atolls from the north to south of Maldives. However, surveys have been discontinued in the north due to various reasons.

Over the 4 years, a total of 11,704 surveys were undertaken at 540 sites, with a total of 8,255 hours spent on surveying. A total of 23,798 sharks were recorded on these surveys, with species wise data being taken for the most commonly seen shark species. The Whitetip Reef Shark (*Triaenodon obesus*) was seen to the most sighted species, followed by the Grey Reef Shark (*Carcharhinus amblyrhynchos*) and Blacktip Reef Shark (*Carcharhinus melanopterus*).

Both the number of sites surveyed and time spent on surveying was observed to be on an increasing trend, indicating that the participants realized the importance of the programme and wanted to contribute to Sharkwatch. A total of 540 sites were surveyed and sharks were observed at 76% of the sites. The majority of these sites had low shark abundances with 1 to 10 sharks being observed at the sites over the 4 year period. This is not necessarily an indication of depleted shark stocks, but is more possibly linked to the fact that participants were asked to choose a diverse range of sites and not just focus on good shark watching spots.

A look at average number of sharks sighted from the different survey atolls shows an interesting result. The average number of sharks per survey is seen to be very low for Baa Atoll (third lowest), which used to be a key shark fishing atoll (MRC, 2009). While shark fishing within the atoll was prohibited from 1998 onwards for a 10 year period, enforcement of this regulation was poor, which eventually led to further decline in shark abundance within the atoll (Le Berre et al. 2008). The above result is further evidence of this decline. Noonu Atoll and South Male' Atoll were seen to have the highest average number of sharks/survey. Noonu Atoll was not a key shark fishing atoll, which could be the contributing factor for this result, while one of the key survey sites in South Male' Atoll is a protected area, which could be the contributing factor for the high average for the atoll.

Ten sites were chosen for a closer look, based on the number of surveys conducted at the sites. The average number of sharks seen per survey at the 10 most surveyed sites was seen to vary greatly from one site to another, with Site 4 having the highest average. While not all sites showed an increase in average sightings over the four year period, an increase was seen for Sites 4, 5 and 2. These are encouraging results as they are indicative of possible increase in shark abundance at these sites.

A closer look at species data showed that average number of sharks per survey for the Whitetip Reef Shark, Grey Reef Shark and Blacktip reef shark also varied at the different sites. While a significant increase in numbers at the different sites over the years was not a common occurrence, it was also encouraging to see abundance did not decline either. Whitetip Reef Shark and Grey Reef Shark species has increased in abundance to some extent at Sites 4 and 5.

A second set of top 10 sites were selected based on shark abundance at the sites. Observations at these sites showed that the site with the highest abundance (average number of sharks/survey) was surveyed 1/3 the number of times as that for the most surveyed site. This is indicative of good shark stock at the site. The same is true for the least surveyed site, which had a high average number of sharks per survey.

This report gives a preliminary analysis of four years of data collected through the Sharkwatch programme. While some results give an indication of possible increase in shark numbers, results are inconclusive as yet. However, it is very encouraging to see that there have been no decreases in shark abundance since the introduction of the ban and the start of Sharkwatch in 2009. The present results also stress and highlight the importance of continued and consistent monitoring, in order to establish trends at specific sites and henceforth assess the effectiveness of the ban. The results also highlight the importance of participation by more resorts and dive centres, as an increase in data decreases the uncertainty gap and increases accuracy of the data.

Strengths and limitations of Sharkwatch (Wood, Sattar and Ali, 2014)

Strengths of Sharkwatch

Public engagement / citizen science

Sharkwatch provides an excellent way of engaging people and enabling them to widen their knowledge whilst contributing to a nationally-important monitoring programme. It is well known that support for conservation and protection measures is enhanced when people have 'hands-on' experience in research programmes related to the species or habitat in question. It is also very appropriate for people to contribute to field surveys that focus on species of public interest. Despite some fears about how dangerous sharks can be (unfounded in the Maldives where unprovoked shark attacks do not occur), people are fascinated by them and enjoy shark encounters. They also often want to learn more about the biology of sharks, threats to shark populations and measures being taken to protect them.

Simple technique

Conducting Sharkwatch is very straightforward because it is carried out on 'standard dives' without any modification to the usual dive procedure. Shark species are easily identified one from another and the only equipment required is a small recording slate. Data entry is straightforward with results being entered into an excel data sheet and submitted to MRC for analysis.

Wide geographic coverage

One of the most important features of Sharkwatch is that involvement of volunteer divers hugely increases the capacity to collect information about sharks. There are over 100 resorts in the Maldives, many of which have a diving centre attached. There are also numerous safari boats. Dives are conducted on all atolls and there are many hundred dive sites. Because of the simplicity of Sharkwatch there is potential for it to be carried out throughout the Maldives at a wide range of locations. In 2012, Sharkwatch was conducted at over 200 sites, demonstrating that it already has a wide reach. If adopted as a long-term monitoring scheme within the Maldives Coral Reef Monitoring Programme, Sharkwatch could effectively cover the whole country at an increasingly finer scale.

Indicates overall trends

Participants in Sharkwatch are requested to conduct surveys on regular dives and to repeat them out as often as possible. Whilst these dives are not carried out along fixed transects identified by markers, it is likely that repeat surveys at the same site cover a very similar track on each visit because these are regular dive sites well known to the dive guides. This means that temporal changes or trends in shark species abundance can be identified.

Although the size of the area surveyed is not recorded, abundance can very approximately be expressed as numbers seen per hour because most dives in the Maldives last for about 50-60 minutes (including safety stops, when sharks would still be recorded).

Helps pinpoint shark 'hotspots' suitable for detailed long-term monitoring

Sharkwatch not only has the potential to cover a wide geographic area but also to include current points and deeper sites that might be unsuitable for fixed transects. As such, it is a good method for pinpointing locations that might be suitable for more detailed long-term monitoring. These could include sites where sharks are seen either regularly and / or in large numbers.

Limitations of Sharkwatch

Surveys are not based on fixed transects

Sharkwatch surveys are not based on transects identified by markers and therefore do not necessarily cover precisely the same track on each occasion that a particular site is surveyed. Monitoring at fixed points / transects provides a more accurate way of determining populations trends although it is relevant to note that the area covered on a Sharkwatch survey from one visit to the next is likely to be fairly similar.

Abundance is measured per site or unit time rather than /unit area

Sharkwatch surveys are not area-restricted (all sharks within the range of visibility are recorded) and the area of survey is not recorded. Divers participating in Sharkwatch are not asked to move at any particular pace but to conduct the dive 'as normal'. The area covered during the dive will depend on a range of factors with current strength having a major influence. Many hundreds of metres are often covered during a drift dive, but a thila dive may be centered on only a small area. Water visibility also plays a part in determining the area covered by the survey. Dive time is an additional factor. Abundance is therefore calculated per site or per unit time, rather than by area.

Data entry could be streamlined

Whilst the current excel reporting is straightforward, on-line data entry would probably, in most cases, be preferred by participants in Sharkwatch.

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Adaaran Prestige Vaadoo
Anantara Resorts (South Male' Atoll)
Baros Maldives
Beach House Manafaru
Coco Palm Bodu Hithi
Coco Palm Dhunikolhu
Cocoa Island
Embudu Village
Four Seasons Explorer
Four Seasons Maldives at Kuda Huraa
Four Seasons Maldives at Landaa Giraavaru
Gili Lankanfushi Maldives
Hilton Irufushi
Kuramathi Island Resort
Kuredu Island Resort
Lazy Gecko Dive Centre (N. Velidhoo)
Lux* Maldives
Niyama Maldives
One and Only Reethi Rah
Palm Beach Island Resort
Paradise Island Resort and Spa
Reethi Beach Resort
Royal Island Resort and Spa
Six Senses Laamu
Velassaru Maldives
W Retreat and Spa Maldives

We, the authors appreciate the time spent on the Sharkwatch Programme and we also acknowledge the fact that for some of you continual of the programme was difficult, with your busy schedules. However, we hope that these preliminary results is a form of encouragement for you to continue with the programme, so that we are able to establish long term trends in shark abundance and monitor the impact of the ban.

We also express our gratitude to the Darwin Initiative for funding the Darwin Reef Fish Project and enabling the Sharkwatch Programme to take place. We also thank all the Staff of the Marine Conservation Society of UK and the Marine Research Centre of Maldives who have assisted us during various phases of the programme and Darwin Reef Fish Project. We would especially like to thank Marie Saleem for her role and initiative in starting the Sharkwatch Programme in 2009.

Appendix 1 Survey form used for Sharkwatch surveys

Observer name(s):	**Resort name:**	**Atoll:**

Dive details									**Number of sharks observed**									**Notes**
Date	Site	Location (reef crest, water column, channel etc)	Currents (none, weak, strong)	Estimate horizontal visibility metres	Water temp ^{o}C	Max. Depth	Start time	Dive duration	BRS	WRS	GRS	SHS	SS	TNS	VS	WS	OT	Please include notes on sex of sharks if known and on any sharks with identifying marks e.g BRS 4 x F; 1 x M WS long scar on back

Appendix 2 Geographic spread of survey effort (survey atolls outlined in red)

Map sourced from: http://www.mapofthemaldives.com/images/