Review of the Status of Marine Turtles in the Maldives

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Ministry of Fisheries and Agriculture
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Introduction

The Maldivian archipelago, comprised of approximately 1,200 islets surrounded by coral reefs, serves as an important habitat for the marine turtles of the central Indian Ocean. Of the seven species of marine turtles in the world, five species have been recorded in the Maldives, the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), loggerhead turtle (*Caretta caretta*) and leatherback turtle (*Dermachelys coriacea*) (Frazier et al., 1984). The most commonly occurring are the green and hawksbill turtles and they are known to occur throughout the Maldives. There have been few recorded sightings of loggerhead turtles and leatherback turtles and sightings of the latter are extremely rare in the Maldives (Didi, 1992). Olive ridley turtles are not known to nest in the archipelago, yet they are frequently encountered entangled in drifting ghost nets (Stelfox et al., 2013). Nesting of turtles is extremely scattered in the Maldives. There is no documented nesting season in the Maldives, and nesting is known to occur year-round, although some islands report that nesting occurs from June-December (Frazier et al., 1984).

Until recently, there has not been any systematic data collection to establish estimates of turtle abundances in their feeding and nesting grounds throughout the Maldives. Earlier data collection was limited to harvest records of turtles and their eggs. All five species of turtles found in the Maldives are on the Red List of the International Union for Conservation of Nature (IUCN). Green and hawksbill turtles are listed as endangered and critically endangered, respectively (Seminoff, 2004; Mortimer and Donnely, 2008). Several management and conservation measures were taken by the government of the Maldives to conserve turtle populations, initially imposing restrictions on their harvest and eventually completely banning the exploitation of turtles with restrictions on turtle egg harvest on a limited number of islands.

This paper aims to provide a preliminary analysis of status of marine turtle abundance in the Maldives and attempts to review the effectiveness of the 2006-2016 Marine Turtle Moratorium and egg harvesting restrictions. The paper also proposes policy recommendations to conserve marine turtles and their habitats in the future.

Background

Historical exploitation

Historically, marine turtles were exploited for domestic consumption only. Frazier et al. (1984) estimated that initial exploitation of turtles for the local trade and consumption of turtle eggs began centuries ago. Egg collection for trade was regarded as an important livelihood activity in islands such as Mulhadhoo (Haa Alif Atoll). In the 1960s, about 2000-3000 eggs were harvested annually from Kunfunadhoo (Baa Atoll) (Frazier et al., 1984), now developed as Sonevafushi tourist resort. In earlier days, turtle exploitation was limited to harvesting of eggs and so turtle killings were minimal. Prior to 1950s, eating turtle meat was a taboo, considered as religiously prohibited, and people that consumed turtle meat were prosecuted (Didi, 1992).

The consumption of turtle meat became prevalent when the religious ban on turtle meat consumption was lifted in the 1948 (Didi, 1992), leading to the active catching and killing of green turtles for meat. In the 1970s, with the advent of tourism, there was an increasing request for hawksbill turtle shells for the local and international market. The high prices fetched for turtle shells led to rise in direct take of juvenile turtles for the souvenir market. Records of harvest for local trade have not been kept, but in a single day, about 400 turtles were counted displayed on sale at the waterfront market in 1977 in Malé. Since 1970s, the government has been keeping records of hawksbill shell exports. Exports dramatically rose from 1970-75 before showing gradual declines. The declines could be due to concurrent factors such as unsustainable catches (Frazier et al., 1984) and the implementation of the CITES ban on tortoiseshell trade which would have reduced demands for turtle shells.

Legislation

Even though a significant market for turtle souvenirs had developed in the 1970s, the same time period saw more awareness on environmental conservation amongst tourists and locals. This rose concerns on the intense exploitation of turtles. These concerns prompted several management and conservation measures on turtles to be put in place by the government. The following is a timeline of legislative measures and developments in turtle conservation that took place in the Maldives (Table 1).

Table 1 A timeline of developments on turtle conservation and management in the Maldives

Year	Legislation
1978	Parliament passed Bill No. 24/78 prohibiting the catching of hawksbill turtles less than 61 cm in carapace length and all other turtles less than 76 cm in carapace length
1979	Parliament passed Bill No. 31/79 prohibiting the export of raw hawksbill turtle shells, however export of items from processed hawksbill turtle shells were permitted
1980	Ministry of Fisheries banned the sale and display of turtles below the size limits specified in Bill 24/78
1995	Under a Presidential Decree, killing, fishing and harvesting of all species of turtles were banned for 10 years. This replaced the Bill No. 31/79 of 1979
1995	Exports of all species of turtles were banned by the Ministry of Trade
1995	Ban on importations of turtles and turtle products in the country
1996	Ban on sale of turtle and turtle products in the country
2006	Ministry of Fisheries, Agriculture and Marine Resources renewed the moratorium on turtle killing and harvesting for another ten years
2006,2007	Egg harvesting was banned from 14 islands identified as significant nesting sites; HA. Mulidhoo, HDh. Muiree, HDh.Vaikaramuraidhoo, R. Furaveri, R. Vandhoo, B. Maamaduvvari, B. Maaddoo, B. Olhugiri, B. Miriyandhoo, Th. Kanimeedhoo, Th. Funaddoo, Th. Kan'doodhoo, L. Gaadhoo, GDh. Gan (Fig. 1)
2010	Maldives became a signatory to Indian Ocean and South-East Asian Memorandum of Understanding on Marine Turtles (IOSEA-MoU)
2015	Launching of citizen-science program Turtlewatch Maldives
2015	Upon Marine Research Centre's (MRC) initiative, a North Indian Ocean-Marine Turtle Task Force (NIO-MTTF) was established. NIO-MTTF comprises of country representatives and NGOs of Pakistan, Bangladesh, India, Sri Lanka and the Maldives.

Fig.1 Islands with egg harvest bans in place from 2006-2016

Methods

In 2015, a citizen-science program, Turtlewatch Maldives was launched by MRC and IUCN Project REGENERATE to establish estimates of turtle abundances throughout the Maldives. Turtlewatch Maldives, initiated in January 2015, was designed to collect data on both foraging and nesting turtles. Marine biologists stationed at tourist resorts, with assistance from resort dive centres, take part in data collection.

In-water surveys

The in-water survey component of the program was carried out entirely by tourist resorts. There were two components of in-water surveys; simple and full surveys. In both components, the divers recorded the date and time of the survey, survey duration, surveyed atoll and sites, number of sighted turtle per species and, when possible, their gender. In the full survey, the divers estimated the carapace lengths of each turtle they recorded and also recorded their behaviors at the time of sighting.

Survey area

During the survey period of February-December, in-water surveys were conducted at eight atolls. The atolls were Noonu atoll, Baa atoll, Lhaviyani atoll, North Malé atoll, South Malé atoll, North Ari atoll, South Ari atoll and Dhaalu atoll (Fig.2).

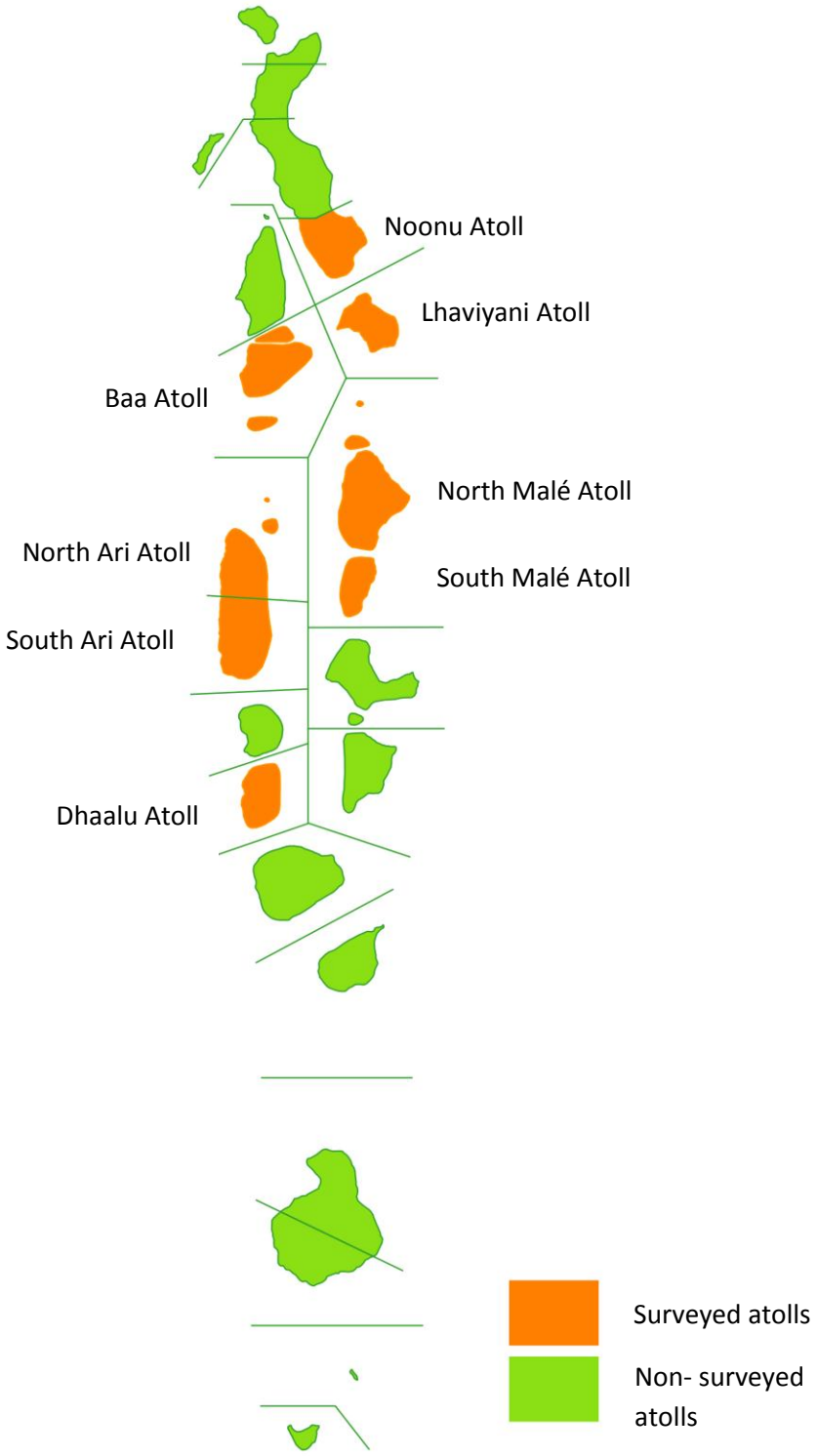

Fig. 2 Atolls where in-water surveys for foraging turtles were conducted

Nesting survey

The pilot-phase of the program was initially directed to tourist resorts only, but since most of the identified nesting sites are located on uninhabited islands, the program was extended to include significant nesting sites by involving locals in data collection on turtle nesting from selected nesting hotspots. Locals were involved by providing financial incentives. Field visits were made in May-June 2015 by MRC staff to hire local surveyors and to observe the nesting areas. In resort-component of nesting surveys, resort staff alerts the marine biologist whenever there is a nesting emergence. In local-component of nesting surveys, the surveyor monitored the beaches twice a week and recorded all nesting activities that occurred on the day of the survey and the previous days. In all the nesting surveys, nesting species, track sizes, estimated nesting dates and wherever possible, number of eggs laid, estimated hatching dates and number of hatchlings were collected. All surveyors were instructed to record any knowledge or observances of poaching incidences of turtles or their eggs.

Survey area

Nesting surveys were recorded from Velaa Private Island (Noonu atoll), Coco Palm Dhuni Kolhu (Baa atoll), Coco Palm Bodu Hithi (North Malé atoll) and Baros Maldives (North Malé atoll) (Fig. 2). Dhunikolhu resort also recorded observations of nesting in Emboodhoo (Baa atoll). The islands that were included in local component of nesting were Gaadhoo (Laamu atoll), Kan'doodhoo (Thaa atoll), Kanimeedhoo (Thaa atoll) and Funaddoo (Thaa atoll) (Fig.2). Due to their significance as turtle nesting sites, in all four of these islands, egg harvest bans were declared from 2006-16. During the visits to these atolls, wherever possible, interviews were conducted with island councils and residents of the island about turtles in their area.

Surveyed nesting hotspots

Laamu Gaadhoo

Gaadhoo is located on the south-east side of Laamu atoll sharing the same reef flat with Fonadhoo and Gan. A major channel is found on the left side of Gaadhoo (Fig.3). The shoreline of Gaadhoo is mainly rocky except for a few sandy strips of beach scattered around. Nesting occurs predominantly on an approximately 500m narrow beach strip with high elevation on the southern, windward side of the island. The nesting beach is located ~500m from the residential area and has no lighting or coastal development. Nesting turtles are known to make their way through the rocky reef crest to the highly elevated beach strip.

Thaa Kan'doodhoo

Kan'doodhoo is located on the large reef flats on the north-west side of Thaa atoll (Fig.3). South of Kan'doodhoo is the largest channel of Thaa atoll. Nesting beaches are located on the northern and southern tips of the island, far from the residential area.

Thaa Kanimeedhoo

Located in the south-eastern channel between Thimarafushi and Veymandoo, the island not connected to any major reefs of Thaa atoll, has been recognized as one of the major hotspots for turtle nesting (Fig. 3). During the visit to Kanimeedhoo in late June 2015, turtle body pits were seen to be abundant throughout the island's beach.

Thaa Funaddoo

Similar to Kanimeedhoo, Funaddoo (Fig.3) is located in the channel between Thimarafushi and Veymandoo, not connected to any major reefs of Thaa atoll. Funaddoo has seen some semi-industrial developments in the previous decade such as construction of a jetty, an ice-plant and a boat yard. All industrial work on the island had ceased some years ago. Like Kanimeedhoo, Funaddoo was under the supervision of the same caretaker who did the nesting surveys on Funaddoo as well. Compared to Kanimeedhoo, from beach observations, nesting activities were observed to be very low.

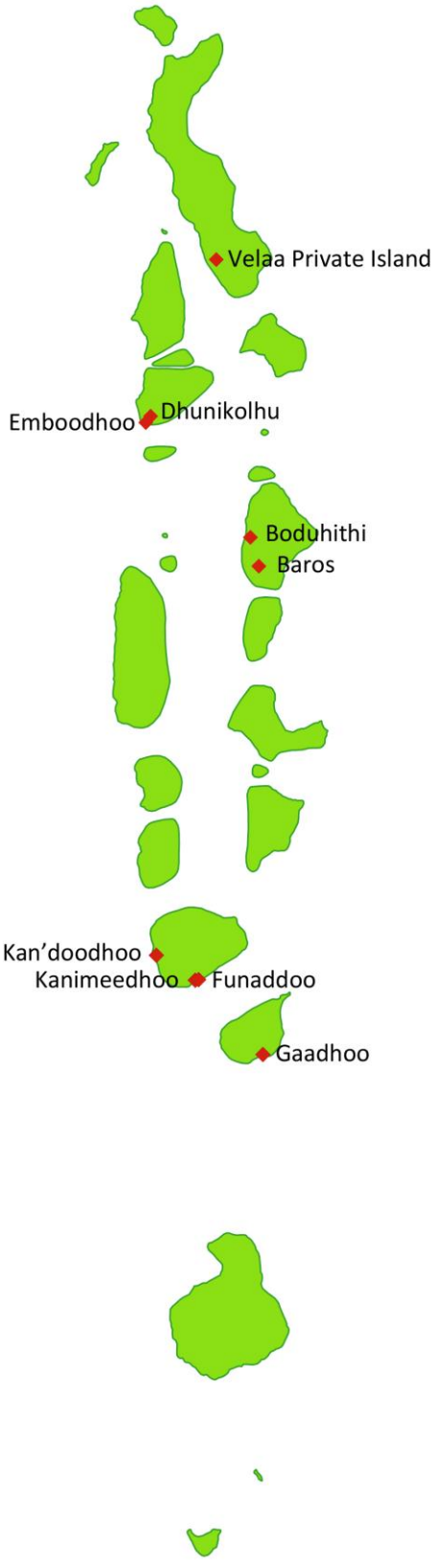

Fig. 3 Islands where nesting records were received during survey period

Results

Even though five species of marine turtles have been recorded foraging in the Maldives, results show that the most common nesting and foraging turtles are the green and hawksbill turtles. Earlier research showed that adult and juveniles of both species were found throughout the Maldives (Frazier et al., 1984). The current study of marine turtles in the Maldives are still in preliminary stages but have provided a basic understanding of the population structure, species composition, nesting frequency and turtle sighting rates.

Foraging turtle abundance

A total of 2,990 sightings of turtles in their foraging grounds in the Maldives were reported from February- December 2015 from 3,157 surveys, from eight atolls. Surveys showed that the hawksbill turtle was the most commonly found foraging turtle in the Maldives comprising 67% of the turtles sighted while the remaining 33% were green turtles (Fig. 4).

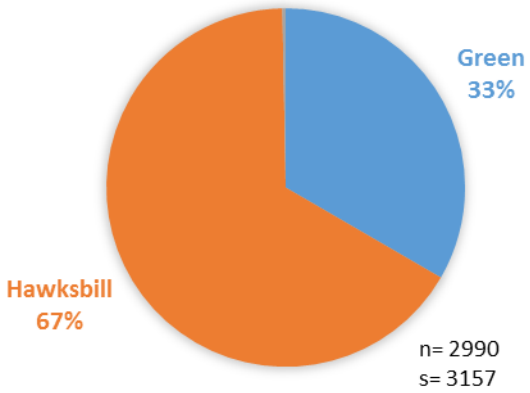

Fig. 4 Percentages of in-water observations of turtles February- December 2015

Out of the 997 in-water sightings of green turtles, juveniles made up only a small proportion (11%) while adult females made up the majority of sightings (62%) (Fig. 5). Adult male green turtles constituted only 5% of the observations. The ages of 22% of the observed greens were reported as unknown (Fig. 5). The small size of the juvenile population suggests that the lagoons of the Maldives do not serve as an important feeding area for juvenile green turtles. Large expanses of sea grass (the green turtle's preferred food) are now rarely found in the Maldives (Frazier et al., 1984). The average reported carapace lengths of green turtles were 76 ± 15 cm for adult females (n=6); 75cm for adult males (n=1) and 50cm for juvenile green turtles (n=1) (Fig. 7).

Of the 1,984 sightings of hawksbills, most were juvenile (44%) (Fig. 6). Average carapace length of juvenile hawksbills reported from full surveys was 45 ± 8 cm (n=52) (Fig. 7). Adult females were the second highest hawksbill group (34%) and average carapace

length reported from full surveys was 66 ± 6 cm (n=71) (Fig. 6 and Fig. 7). The adult male population of hawksbills was very small (2%) and average carapace length reported from full surveys was 73 ± 8 cm (n=6) (Fig. 6 and Fig. 7).

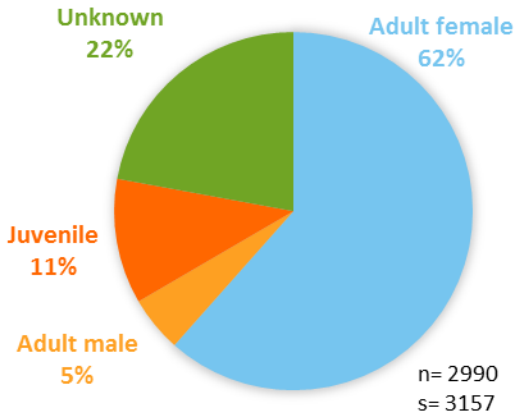

Fig. 5 Age and gender compostion of green turtles

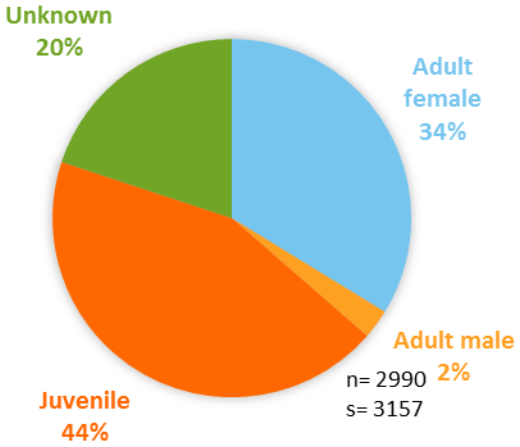

Fig. 6 Age and gender composition of hawksbill turtes

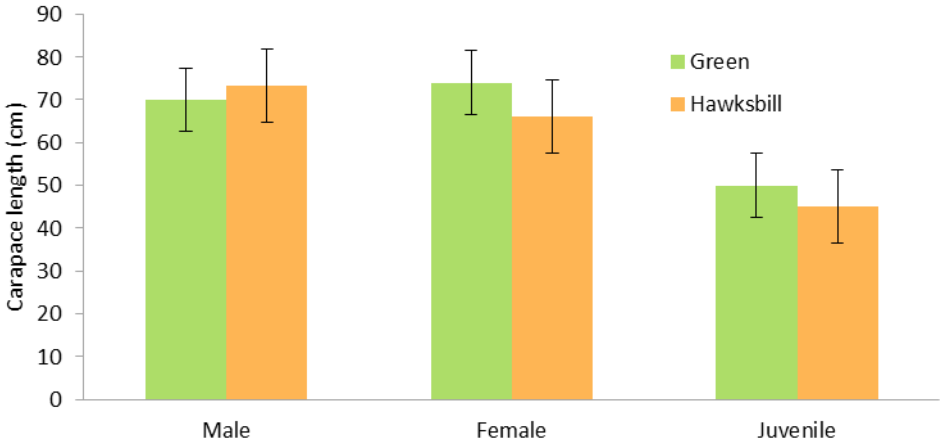

Fig. 7 Average reported carapace lengths of observed turtles

The highest in-water survey effort was seen in North Ari atoll, followed by North Malé, Lhaviyani and South Malé atoll (Fig. 8). Noonu, Baa and South Ari atoll had comparatively lower effort and survey effort in Dhaalu atoll was almost negligible (Fig. 8).

Average number of turtles sighted per survey varied amongst the surveyed atolls (Fig. 9). Although Baa atoll had a very low survey effort, Baa showed the highest average turtle sightings per survey (2.54) from all the surveyed atolls (Fig. 9). The second highest average number of turtles sighted per survey was seen from South Ari atoll (1.38) followed by North Malé (1.33) and Lhaviyani atoll (1.04) (Fig. 9). Although North Ari had the highest survey effort (s=881), lowest average turtle sightings per survey (0.50) was seen from North Ari (Fig. 9). Dhaalu atoll showed high sightings per survey (1.0), but since the survey effort was very low (s=2), results from Dhaalu was considered negligible (Fig. 9).

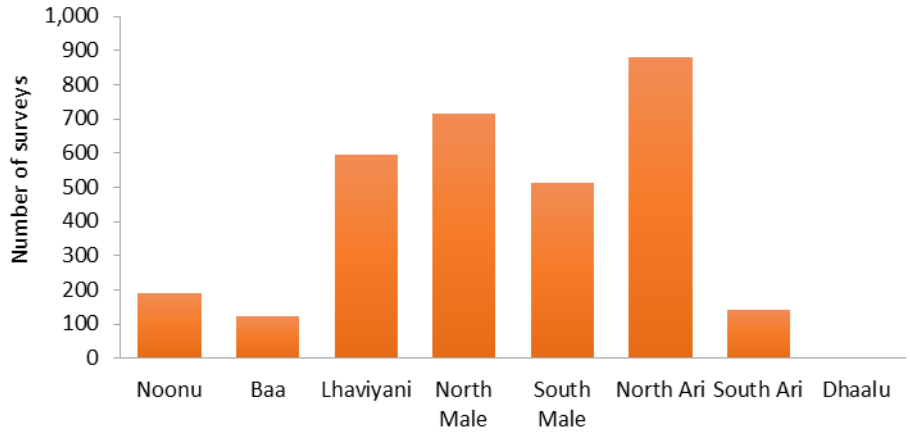

Fig. 8 Comparison of survey effort per atoll

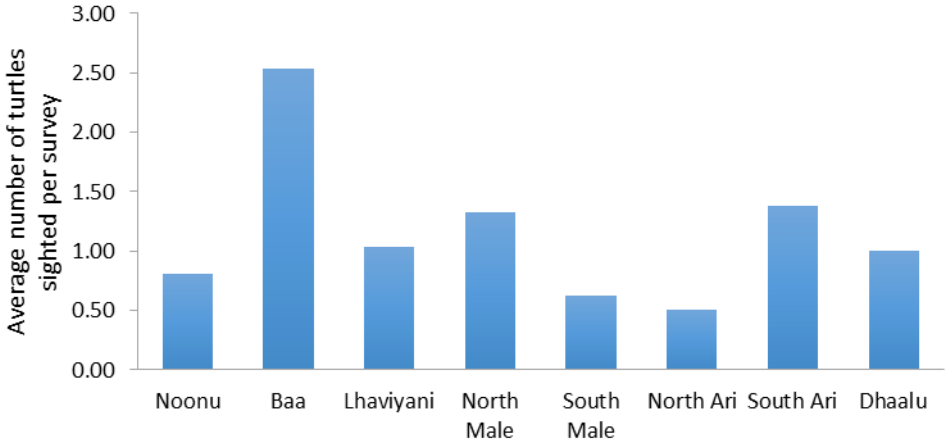

Fig. 9 Average number of turtles sighted per survey per atoll (assuming survey length=60 mins)

Species composition of foraging turtle sightings showed that except for Lhaviyani atoll, in all other surveyed atolls hawksbill turtle was the most frequently sighted species (Fig. 10). Baa atoll showed the highest number of hawksbill turtles per survey from all the surveyed atolls. Second highest hawksbill turtles per survey were seen from South Ari atoll. North Malé atoll and Noonu atoll showed moderate levels of hawksbill sightings per survey. Except for Lhaviyani, North Malé and Baa atoll, all atolls showed a very low number of green turtle sightings per survey (Fig. 10). Dhaalu atoll showed no green turtle sightings and survey effort was negligible (Fig. 10). Since Baa atoll has most of the protected nesting islands, and islands like Kunfunadhoo and Maaddoo earlier identified as important green turtle nesting islands, (Frazer et al, 1984) high sightings of foraging green turtles were expected from Baa atoll. However, compared to the high number of hawksbill turtles sighted per survey in Baa atoll, the results showed an overall low number of green turtle sightings per survey from Baa atoll (Fig. 10).

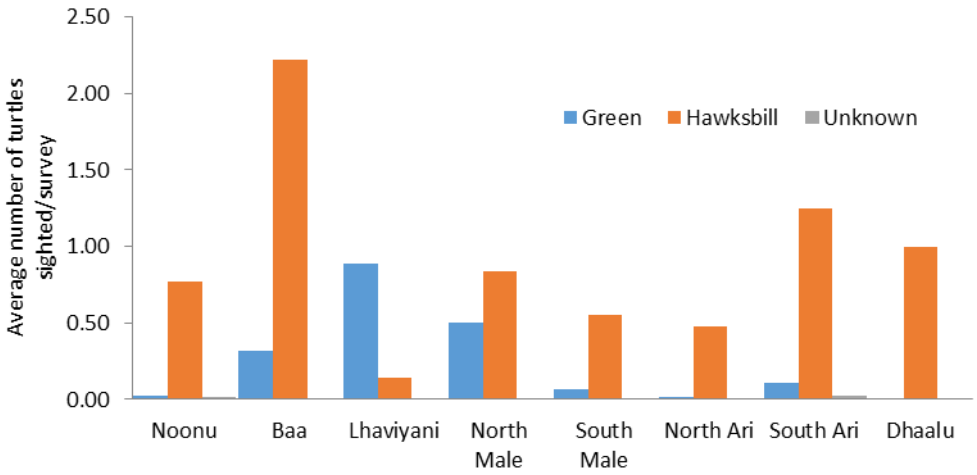

Fig. 10 Breakdown of species / survey by atolls (assuming survey length = 60 mins)

A breakdown of age-gender groups of foraging green turtles by species per atoll (Fig. 11) showed that the highest adult female green turtle sightings per survey was from Lhaviyani atoll followed by North Malé atoll and Baa atoll. Lhaviyani showed the highest adult male green turtle sightings per survey as well from all surveyed atolls, although the value is low compared to the sightings of adult female green turtles in the atoll (Fig. 11). Lhaviyani is also the only atoll that showed considerable sightings of adult green turtles of both gender as well as juvenile green turtles (Fig. 11).

Baa atoll which had the third highest average green turtle sightings per survey (Fig. 10), and age-gender breakdown showed that juvenile green turtles was the most frequently sighted green turtles in Baa atoll followed by adult female green turtles (Fig. 11).

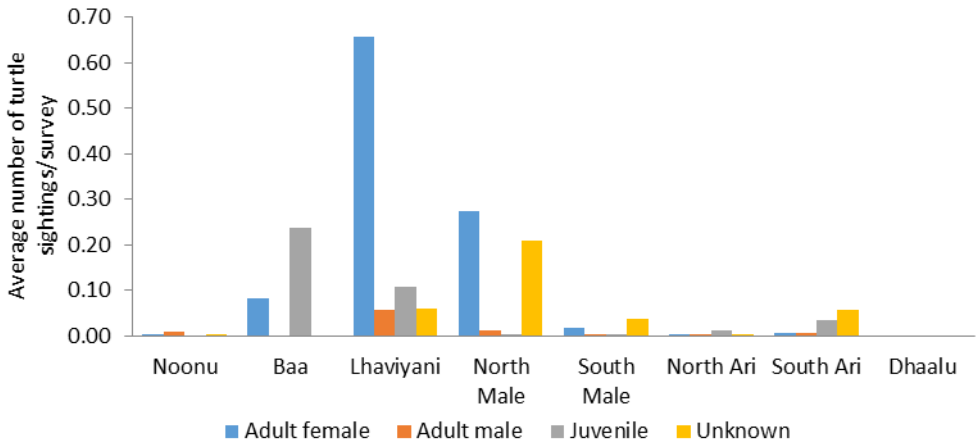

Fig. 11 Breakdown of green turtle sightings by age-gender groups per surveyed atoll (assuming survey length = 60mins)

A breakdown of age-gender groups for hawksbill turtles per atoll shows that, except for Lhaviyani atoll which showed low hawksbill sightings per survey and Dhaalu atoll where survey effort was negligible, all other atolls showed juvenile hawksbill turtles as the most frequently observed hawksbill turtle group per survey (Fig. 12). From all the atolls, highest average juvenile and adult male hawksbill turtle sightings per survey were

observed from Baa atoll (Fig. 12). In all of the surveyed atolls, average adult female hawksbill turtle sightings per survey were seen to be very low (Fig. 12).

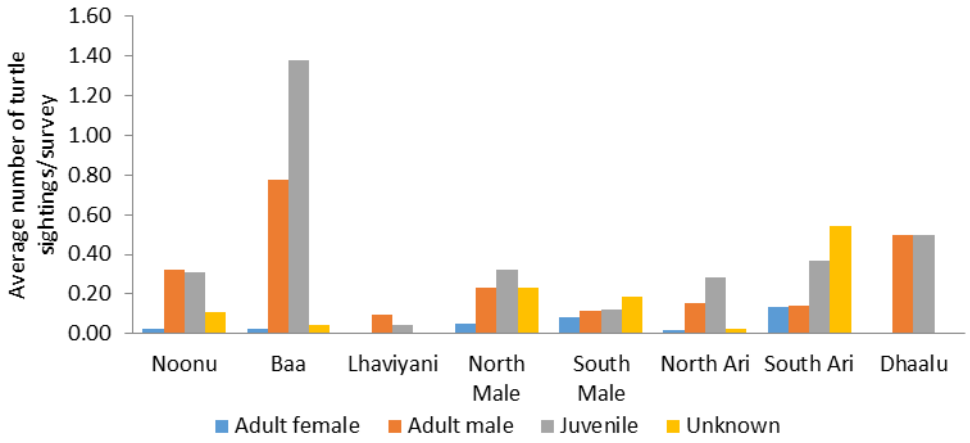

Fig. 12 Breakdown of hawksbill sightings by age-gender groups per surveyed atoll

Nesting turtle abundance

Nesting emergences were recorded from a total of nine islands, including four tourist resorts, two local and three uninhabited islands. The resorts that participated in monitoring of nesting were Velaa Private Island (Noonu atoll), Coco Palm Dhuni Kolhu (Baa atoll), Coco Palm Bodu Hithi (North Malé atoll), Baros Maldives (North Malé atoll). Some nesting emergences in Emboodhoo (Baa atoll) was recorded by Dhunikolhu resort. Hired locals aided in the monitoring of Kan'doodhoo (Thaa atoll), Kanimeedhoo (Thaa atoll), Funaddoo (Thaa atoll) and Gaadhoo (Laamu), which were islands where egg harvest bans were imposed from 2006-2016. As of December 2015, a total of 172 nests were recorded from nine islands; 30 recordings were from tourist resorts and 142 nesting records were from local island surveys.

The green turtle is the most common nesting turtle in the Maldivian archipelago. During 1983-84 visits by Frazier, green turtle nesting was confirmed from several atolls (Frazier et al., 1984). The islands particularly noted were Kunfunadhoo and Maadoo (Baa atoll), Hukurudhoo (Ari atoll), Gaadhoo, Hithadhoo and Isdhoo islands (Laamu atoll). MRC's 2015 data collection efforts confirmed that green turtles still nest at Gaadhoo (Laamu atoll), Kan'doodhoo (Thaa atoll), Kanimeedhoo (Thaa atoll), Funaddoo (Thaa atoll), Coco Palm Dhuni Kolhu (Baa atoll), Coco Palm Bodu Hithi (North Malé atoll), Velaa Private Island (Noonu atoll), and Emboodhoo (Baa atoll).

Ninety nine percent of turtle nesting was by green turtles and 1% was by hawksbill turtles. Hawksbill nesting was recorded from Baros. Regular nesting surveys by locals began in the 26th week of 2015, and prior to that nesting records were low due to no surveys being conducted in those nesting hotspot islands (Fig. 13). A total of eight resorts took part in the pilot phase of the Turtlewatch Maldives but nesting on most of these resort islands was minimal. Many of these resorts were not identified as important

nesting sites but resorts' reefs and their dive sites serve as important foraging grounds, typically for hawksbill turtles.

Of all the 172 nests recorded from the nine islands, Gaadhoo showed highest nesting with 75 true nests (44%) from June-December (Fig.13, Fig.14, & Fig.15). The second highest nesting was seen from Kanimeedhoo where 49 true nests (29%) were recorded from July-December (Fig.13, Fig.14 & Fig.15). Dhuni Kolhu came in third with 18 true nests (10%) recorded from February-December (Fig.13, Fig.14 & Fig.15). Although Kan'doodhoo and Funaddoo were protected as nesting hotspots, nesting emergences were surprisingly very low. Two distinctive peaks in nesting were observed from late July- mid August and late September (weeks 30-33 and 38-39) where an average of 8-10 nests were recorded weekly. After the end of September (week 39), a gradual decline in nesting was observed (Fig. 13)

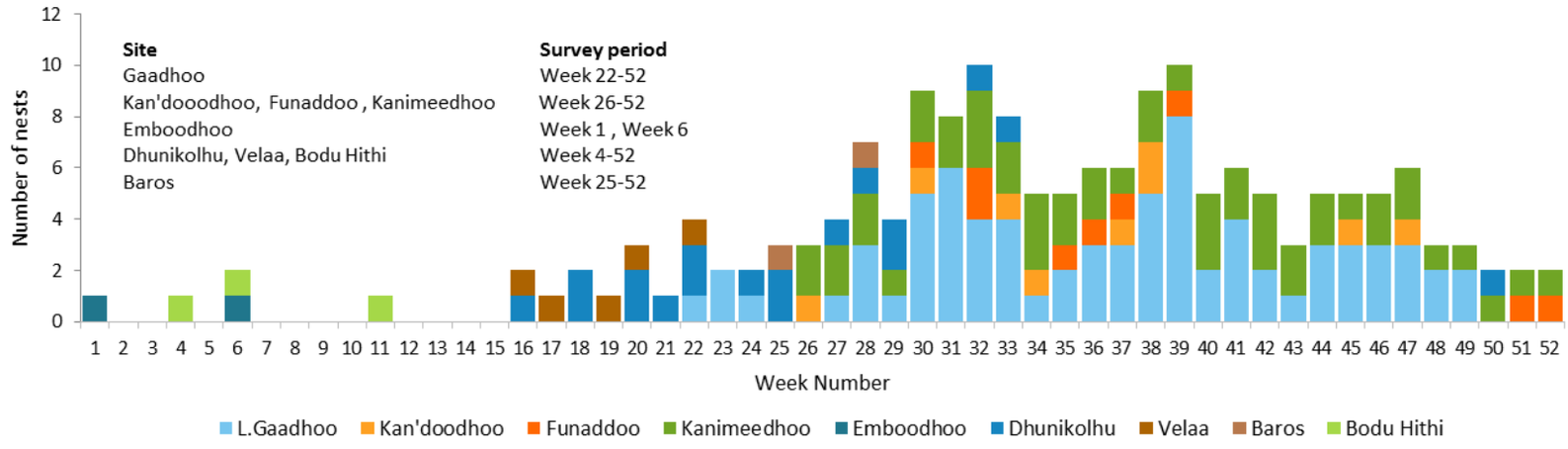

Fig. 13. Breakdown of weekly nesting per surveyed island

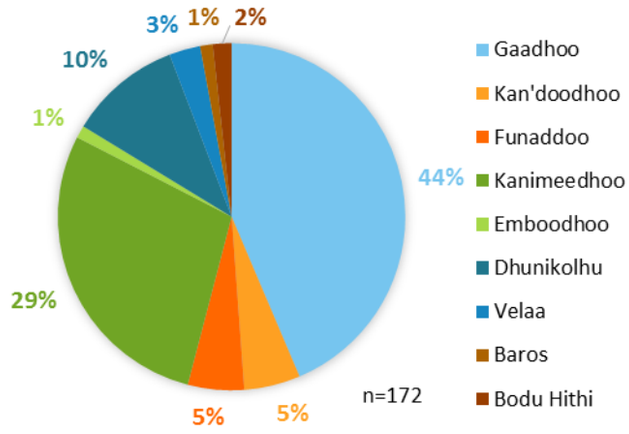

Fig. 14 Percentages of turtle nesting from surveyed islands and resorts

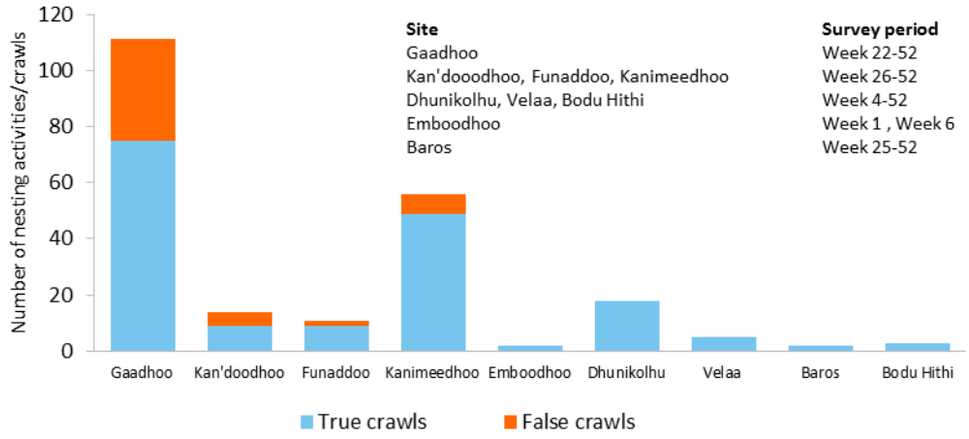

Fig.15 Total number of nesting activities per island with a breakdown of true and false crawls

Nesting estimates

Based on the 6-month and 11-month nesting data from local/uninhabited islands and tourist resorts respectively, annual estimates of green turtle nesting were calculated. Annual estimates of nesting for L.Gaadhoo in 1984 was 240 nests/year (Frazier et al., 1984) and for Th.Kan'doodhoo was over 100 nests/year in 2000s (Zahir, 2010). To compare with baseline annual nesting estimates, annual nesting estimated in this study used methods similar to the ones used by Frazier (et al., 1984) and Zahir (2000). Most of the nesting surveys were conducted in the latter six-month period of the year (June-December) and since we do not have a documented nesting season, nesting estimates were calculated by assuming nesting in the first six-month period is similar to second six-month period. Nesting estimates were done by doubling the six-month recordings from local and uninhabited island surveys and for the resorts calculating the average monthly nesting and estimating the nesting for a 12-month period. Number of nesting females was estimated by dividing the estimates of annual nests by three, assuming the turtle nested thrice in the year. Since the study did not determine the clutch frequency for green turtles, clutch frequency of 3.0 estimated for a green turtle rookery in Florida was used (Johnson and Ehrhart, 1996). The total number of nests and nesting females were estimated to be 305 and 103, respectively. Table 2 shows the annual estimates of green turtle nests and female green turtles for each surveyed island.

Table 2 shows annual estimates of green turtle nests and green turtle nesting females from surveyed sites

	True nests		**Annual estimates**	
Island	**6-month period**	**11-month**	**Nests**	**No.of females**
Gaadhoo	71	--	142	47
Kanimeedhoo	49	--	98	33
Funaddoo	9	--	18	6
Kan'doodhoo	9	--	18	6
Dhunikolhu	--	18	20	7
Velaa	--	5	6	3
Bodu Hithi	--	3	3	1
Total	**164**		**305**	**103**

A further look into factors affecting rates of nesting emergences is shown in Table 3. For the local and uninhabited islands, these factors were evaluated based on the observations we made during our visits to those islands. For tourist resorts, factors such as distance from residential area to nesting beach, light pollution, degree of coastal development were evaluated considering basic resort developmental concept in the Maldives, where it is common to have bungalows and restaurants built in lagoons and also built in close proximity to beaches. Except for the threat of poaching of turtles and eggs, Gaadhoo and Kan'doodhoo are seen to be ideal sites for turtle nesting with few indirect threats such as light, noise pollution and few coastal developments. Kanimeedhoo was also recognized as

an optimal site for turtle nesting with almost no indirect threats to turtles and a medium level threat from poaching. Funaddoo, although scoring low on most indirect threats, showed the highest industrial activity in the past decade. Dhunikolhu, Velaa, Bodu Hithi and Baros, albeit having no direct threats to turtles, showed moderate levels of indirect threats.

Table 3 shows factors that could have indirect or direct threats to turtles (DNP, 2016)

				Indirect threats					**Direct threat**
Atoll	**Island**	**Degree of nesting**	**No.of inhabitants**	**Distance from residential area to nesting beach**	**Light pollution**	**Coastal development (jetties, bungalows, furniture)**	**Industrial activities**	**Night-time activities**	**Level of poaching(eggs, turtles)**
Laamu	Gaadhoo	Very high	178	498m	Nil	Nil	Nil	Nil	Very high
Thaa	Kan'doodhoo	Low	430	500m	Nil	Low	Low	Nil	Very high
Thaa	Kanimeedhoo	High	Uninhabited	N/A	Nil	Nil	Nil		Medium
Thaa	Funaddoo	Low	Uninhabited	N/A	Nil	Low	Moderate	Low	Low
Baa	Dhunikolhu	Moderate	Tourist resort	<50m	Medium	Medium	Nil	Medium	Nil
Noonu	Velaa	Low		<50m	Medium	Medium	Nil	Medium	Nil
Baa	Bodu Hithi	Low		<50m	Medium	Medium	Nil	Medium	Nil
North Malé	Baros	Low		<50m	Medium	Medium	Nil	Medium	Nil

Direct threats

Poaching of turtles and eggs

During the survey period, a total of 142 nests were recorded from local surveys. Eggs from 37 nests were poached and a total of 14 green turtles were reported as poached (Fig. 16 & Fig. 17).

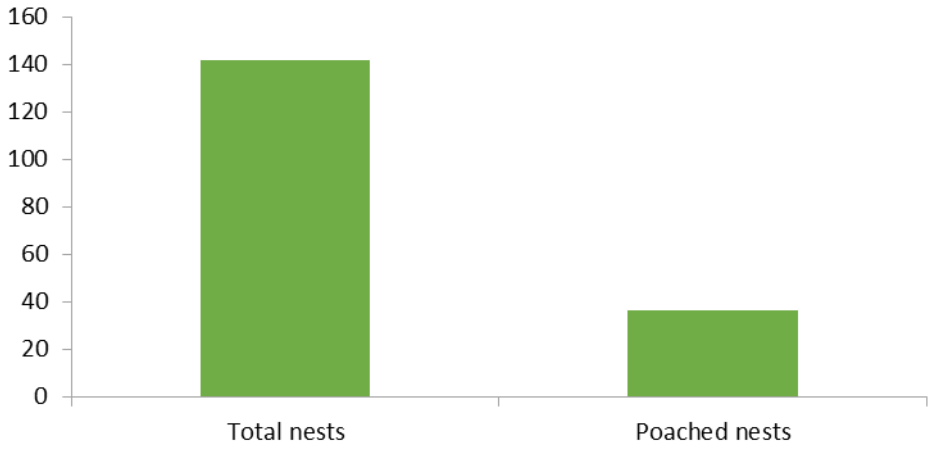

Fig. 16 Level of poaching of nests from surveyed locations

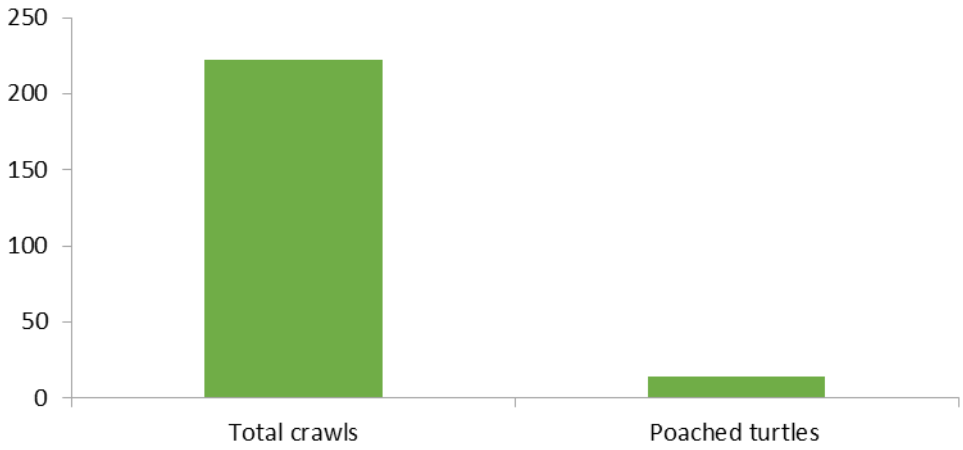

Fig. 17 Level of turtle poaching from surveyed locations

Turtles as pets

Keeping turtles, particularly turtle hatchlings in captivity, which is popular in the Maldives, can also be regarded as a form of exploitation. A lot of times public are not aware that keeping hatchlings in captivity reduces the chances of that turtles' survival in the wild following its release, which often happens. The turtles are often kept under the mis-information that people are helping the turtle survive by releasing it at a larger size when it would be less susceptible to natural predators. Further education campaigns on this subject are urgently needed.

Indirect threats

Light pollution, noise, beach activities can reduce the chances of turtle nesting since turtles prefer quiet, dark environments for nesting. In addition, beach furniture, coastal development and armoring structures, such as jetties and seawalls, can prevent turtles from coming ashore to lay their eggs.

Discussion

Results show that high in-water survey effort does not necessarily provide high sightings of foraging turtles. This is apparent in the case of North Ari atoll which had the highest survey effort but showed the lowest number of turtles sighted per survey (Fig. 8 and Fig. 9).

Juvenile hawksbill turtles were the most sighted hawksbill turtle group per survey in most surveyed atolls (Fig. 12), indicating that coral reefs of the archipelago serves as an important foraging ground for hawksbill turtles. The exceptionally high sightings of juvenile hawksbill turtles per survey from Baa atoll suggest the atoll is an important foraging site for hawksbill turtles.

Although the highest adult female green turtle sightings per survey was observed in Lhaviyani atoll (Fig. 11), the atoll has only one island, Kanifushi, that has been reported as a nesting hotspot (Zahir, 2010). However, to the west of Lhaviyani atoll is Baa atoll, which has the most number of identified significant nesting islands including many confirmed green turtle nesting islands. Therefore, it is possible the nesting green turtles could be making inter-atoll migrations between the atolls during inter-nesting periods or there is a high possibility for unidentified significant nesting sites in Lhaviyani atoll.

99% of nesting was by green turtles and adult female green turtles were the most sighted green turtle per survey. This strongly indicates that the Maldivian archipelago is a significant nesting site for green turtles. The sighted adult females could be year-round residents foraging in those atolls or could be coming to nest from other areas and sighted foraging around nesting areas during inter-nesting periods.

Current results show low nesting records of hawksbill turtles with low number of sightings of adult female hawksbill turtles per survey in all surveyed atolls (Fig. 12). This suggests that the archipelago is not an important nesting site for hawksbill turtles as it is to green turtles. However, with only surveying four out of 14 nesting hotspot islands, these results are still inconclusive and further monitoring of hotspot islands are required to determine the status of nesting hawksbill turtles.

Gaadhoo's high nesting estimate of 142 (Table 2) is not surprising since the island has long been identified as one of the most important hotspots for nesting in the Maldives. During the field visit to Gaadhoo, islanders recounted exceptionally high nesting in earlier times where nesting occurred every night with an average of about 5-10 turtles nesting per night. During a visit by Frazier in 1984, he estimated that about 10 nests/night had been laid on Gaadhoo in previous years; but, in 1984, Frazier estimated the nesting to be

less than 1 nest/night (Frazier et al., 1984). The current nesting estimate of Gaadhoo is still a 40% decline from the 240 annual nests estimated in Gaadhoo by Frazier in 1984. In earlier times, residents of Gaadhoo were known for their remarkable monitoring of the nesting beach. The beach was protected from turtle poachers and islanders did regular beach patrols. The eggs were harvested and distributed among the residents for subsquent auctions. The income from egg selling was used for community purposes such as the purchase of an electric generator for islands' powerhouse or construction of a mosque. In 2006, when the egg harvesting ban was imposed on Gaadhoo, eliminating all financial incentives from turtles, the beach patrols ceased and illegal harvesting of eggs started with some cases of poaching of turtles as well.

Kan'doodhoo was previously identified as a nesting hotspot with more than 100 estimated nests per year (Zahir, 2010). The current, extremely low estimate of 18 nests/year for Kan'doodhoo indicates that nesting has declined by over 80% in the past decade.

Despite Kan'doodhoo being considered as an ideal nesting site with few indirect threats to nesting such as in Gaadhoo (Table 3), the differences in nesting in these islands could be subjective to surveyor's data collection consistency or could be symptomatic of direct disturbances to nesting turtles in Kan'doodhoo. In the current survey, 37 nests and 14 turtles were reported to be poached (Fig. 16 & 17). From the interviews with locals during field visits, it was evident that poaching of turtles and eggs was still commonplace, despite the government legislation. In cases where islands were leased, incidences of poaching of turtles from the islands' lagoon occurs at times as poachers claim that the lagoon is not under the jurisdiction of the lessee. The lack of enforcement of turtle conservation measures, particularly in outer islands, and low levels of punishments for violations of such measures have not been successful in deterring illegal poaching.

During field visits to Kanimeedhoo, it was observed that turtle body pits were abundant throughout the beaches of Kanimeedhoo. Nesting records in Kanimeedhoo was a bit lower than in Gaadhoo. Unlike Gaadhoo where nesting is almost exclusive to a particular strip of the beach, in Kanimeedhoo nesting occurs throughout the islands' beaches. As a result, surveys in Kanimeedhoo would require longer coverage and hence have the possibility of surveyor missing some nests.

Funaddoo, although declared protected from egg harvesting for being a nesting hotspot, suprisingly showed very few nesting. The current low nesting on this island could be indicative of disturbances to nesting turtles in the past due to semi-industrial work that occurred in the past, which could have dettered turtles from nesting on the island.

Apart from Dhunikolhu resort, most resorts reported low nesting. Albeit resorts having no direct threats to turtles, levels of indirect threats were seen to be moderate, which could potentially reduce nesting levels. Baa atoll is an important atoll for turtle nesting with many nesting hotspot islands, and this is the first time in a study Dhunikolhu was noted for considerable nesting. Baros in North Malé atoll, reported the only hawksbill nesting with a total of two true hawksbill turtle nests. Baros also had an earlier reputation of high turtle nesting (Frazier et al., 1984) but reported extremely low level of nesting in the current study. It is noteworthy that although resorts pose few direct threats to turtles

in terms of poaching of nests and turtles, nesting emergences were recorded to be much higher on local/uninhabited islands than resorts. This may be because, many of the nesting hotpots are located on uninhabited or local islands, and aside from direct threat of poaching for meat and eggs, many of these surveyed uninhabited/local islands, including Gaadhoo, an inhabited island at the time of survey with the highest nesting record, were extremely underdeveloped with almost no coastal development, light pollution and night-time activities at the nesting beaches. These developments and associated activities at resorts, though seen as indirect threats, could be of permanent hindrance to nesting activities of turtles and possibly be making the beaches unfavorable for nesting.

Limitations

Low cooperation from lessees of protected nesting islands

Among the 14 nesting islands where egg harvesting was banned, many of the islands have been subsequently leased for agricultural, industrial or tourism development purposes. Although the islands have been declared protected, when approached to conduct the local nesting surveys, many of lessees were not aware of the legislations, and some objected to have nesting surveys carried out on their island's beaches as the surveys were perceived as a disturbance to the developmental activities taking place. And in some cases, lessees of some islands were not reachable.

Dispersed nature of the islands

In the Maldives, turtle nesting sites are scattered throughout the archipelago. Although having identified some significant nesting sites, the dispersed and remote nature of these islands make regular surveying for nesting emergences extremely difficult and costly. The main data collection office located in the capital has limited human resources and is unable to have staff stationed in the outer atolls to undertake regular nesting surveys. However, recent developments in citizen-science programs, involving marine biologists and dive centre staff of tourist resorts and motivated locals, have enabled for the first time ever, large data sets on foraging and nesting turtles in the Maldives.

Limited survey period

Since most of the nesting surveys in significant sites of nesting were conducted only for a six-month period, this did not allow us to identify a nesting season, thus preventing the use of more robust methods in estimating annual nesting. However, the current calculations of nesting are consistent with estimation methods used by Frazier (et al., 1984) and Zahir (2000), and allow for a comparison between the past and current estimates. Though this method is preferred, it has a very high likelihood of overestimating the nest numbers and number of nesting females. The method assumes that number of nests is equal both in surveyed and non-surveyed periods. This assumption may not hold true if peak periods of nesting season occur in the last six months of the year surveyed. For instance, it has been observed at Gaadhoo that there are three peak nesting periods during the surveyed period, which may or may not be the case for the initial six months of the year. Hence doubling the nest counts of six months could possibly provide an

overestimate of nest numbers, hence number of nesting females. Furthermore, assuming the clutch frequency to be three may have overestimated the number of nesting females since clutch frequencies of 3-5 have been recorded in Maldives (Hudgins, 2016, pers comm, 02 February). The knowledge of these limitations provides a good basis to infer the results more cautiously. It is hoped that extension of the local nesting survey program will provide a more complete dataset, based on which the current annual estimates can be revised.

Conclusion

With only nesting records from eight islands, it is difficult to estimate the nesting population of turtles for the entire archipelago of the Maldives. When compared with earlier records of the most reputed islands for turtles, a 40% decline in nesting estimates were observed on Gaadhoo and on Kan'doodhoo over 80% decline in nesting estimates was observed. This is symptomatic of significant overall declines in turtle populations nesting in both Gaadhoo and Kan'doodhoo in the previous decade or an indication of disturbances to nesting turtles that have led them to nest on other nearby islands. From interviews with locals, it was evident that there are some levels of poaching, which the residents believed had deterred turtles from nesting and may have directly reduced the population of nesting females. Despite legislations on turtles becoming stringent in recent decades, consumption for turtle meat as a delicacy is still a commonplace in certain parts of the Maldives. This is particularly of concern in hotspot atolls for turtle nesting as turtles are most commonly poached when they come ashore to nest.

Lhaviyani atoll, not having much known sites of significant nesting but showing high sightings of foraging green turtles, indicates this is an important foraging site for adult female green turtles. It is also possible that there could be unknown sites of significant nesting in the atoll. Future nesting survey efforts could include Lhaviyani atoll to find out potential significant nesting sites in the atoll. From the current surveys, Baa atoll was found to be the most important foraging site for juvenile and adult male hawksbill turtles. Since Baa atoll has most of the known significant islands for turtle nesting and current results show high sightings of foraging hawksbill turtles, future surveys could include nesting hotspots from Baa atoll to understand the status of nesting turtles in Baa atoll.

In spite of the moratorium on turtle killings in place for the last 20 years and 14 turtle reserves where egg harvest bans imposed, there is a consensus that awareness on turtle conservation issues is very low and limited among the public. The situation is made worse by the little regard for conservation measures by the public, which is also due to very limited law enforcement and far too lenient penalties in place for violating conservation measures such as poaching of turtles and their eggs. However, it was comforting to see that when nesting beach was regularly surveyed, in the 6-month period of surveying an appreciable decline in poaching rates of both turtles and eggs were seen. This is proof that by engaging locals in surveying protected species, they are made more aware about the conservation issues and there is more buy-in of legislations on conservation of threatened species such as marine turtles.

Recommendations

1. Prohibit killing, harvesting and keeping them in captivity for an indefinite period from the entire Maldives
2. Prohibit the harvesting of turtle eggs from the entire Maldives, since the intense rates of egg poaching would entirely eliminate hatching recruitment of turtles
3. Protect important habitats of nesting turtles. Renewal of protection of currently protected 14 turtle nesting hotspot islands for habitat protection purposes
    a. The protection would make the public to be more considerate when visiting such sites
    b. Coastal development such as construction of breakwaters, seawall or jetties can prevent nesting turtles from coming ashore to nest. If any developmental projects are to take on these nesting hotpots, then the Environmental Impact Assessment should propose effective mitigation strategies to mitigate as much as possible impacts of development on nesting turtles
4. Establish stringent penalties for:
    a. Anyone catching or killing turtles or collecting eggs
    b. Make island leases dependent on co-operation with management and conservation plans on protected marine fauna such as turtles and ensure strategies for mitigation of coastal development impact on turtles
5. Launch a nation-wide campaign on marine turtle conservation in cooperation with local NGOs
    a. Save the Beach Maldives is NGO representative of the Maldives to North Indian Ocean Marine Turtle Task Force established in October 2015 and has assured their commitment in collaborating on nation-wide campaigns and citizen-science programs on turtles
6. Regular information sessions with law enforcement bodies example Marine Police or environmental department of Maldives Police Services
7. Continue the survey of the islands best known for nesting to establish estimates of turtle abundance for the entire archipelago. Include additional islands from the 14 currently protected hotspots. This was also a recommendation by Frazier in 1984 to survey the "best turtle islands" to establish the status of turtle populations
    a. Wherever possible involve locals in nesting surveys, with financial incentive at the beginning and slowly phasing out to voluntarily participation possibly with NGO assistance. Explore opportunities for financial returns to local communities through community-managed "turtle-watching" conservation programs
    b. Select the two "best turtle islands" to include in the IOSEA-MoU network site
8. Continue and increase the number of data collectors for the citizen-science programs with tourist resorts and locals to establish the status of both nesting and foraging turtle populations

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Addendum

Turtle bycatch in fisheries

Logbook records show no bycatch of turtles in pole and line and handline tuna fisheries (Table 4). The only bycatch of turtles was recorded from longline fishery. In tuna longline fishery total of 7,730,281 hooks were deployed in 2014. Incidental catch rates (per 1000 hooks) for sea turtles were quite low at 0.0031 (Table 5). Of the 24 turtles caught, majority was released with no damage (Fig. 18).

Table 4 Percentages of interactions with marine turtles in pole and line, hand line and longline fisheries for tuna

	PL	HL	LL
Catch	**0**	**0**	**24**
Percentage	**0.00**	**0.00**	**100**

Table 5 Incidental catch rates for marine turtles

Incidental catch	Total interactions	Incidental catch rate (per 1000 hooks)
Marine turtles	24	0.0031

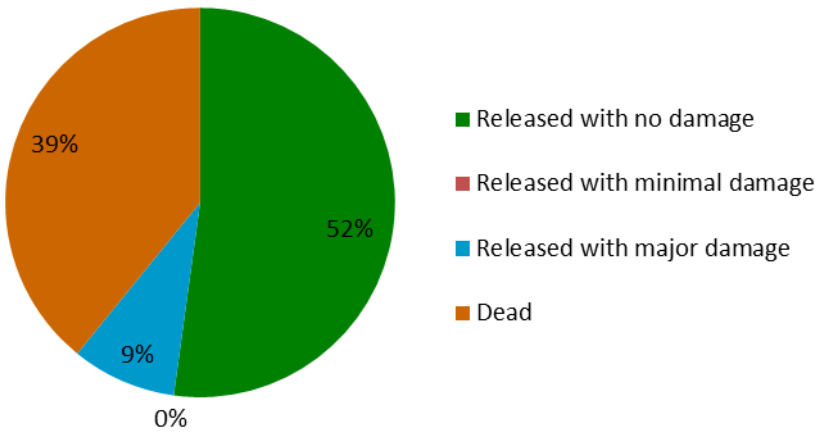

Fig. 18 Status of marine turtle bycatch upon release

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