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A survey of sea turtles and their nesting and foraging habitats was carried out in the Lakshadweep archipelago in the Arabian Sea, from July 2001 to May 2002. Secondary information, including literature reviews and interviews with Forest and Fisheries Department officials, offshore patrolling agencies and local fishermen were used to identify potential sea turtle habitat. Island beaches were surveyed for nesting, and lagoons were sampled for estimating the relative abundance and size class distributions of turtles. Three species of sea turtles were recorded nesting on the islands, Green Turtles (*Chelonia mydas*) being the most common followed by Olive Ridley (*Lepidochelys olivacea*) and Hawksbill (*Eretmochelys imbricata*) turtles. Uninhabited islands provided the best nesting sites for Green Turtles. Both juveniles and adults of Green Turtles and Hawksbill were sighted and captured in the lagoons. There was considerable beach alteration because of sand mining and beach armouring with cement blocks to prevent erosion. Increasing coastal development poses a major threat to sea turtle habitats in the Lakshadweep islands and lagoons.

Key words: Green Turtle, *Chelonia mydas*, nesting beach, lagoon, beach armouring

INTRODUCTION

The Olive Ridley Turtle (*Lepidochelys olivacea*) is the most abundant sea turtle on the mainland coast of India. The Leathery Turtle (*Dermochelys coriacea*), Green Turtle (*Chelonia mydas*) and Hawksbill Turtle (*Eretmochelys imbricata*) too have been reported to nest mainly on island beaches from both the Lakshadweep and Andaman & Nicobar Islands (Bhaskar 1978; Kar and Bhaskar 1982; Bhaskar 1993; Andrews *et al.* 2001). All the four species have been reported from the Lakshadweep islands in the Arabian Sea, off the southwest coast of India (Bhaskar 1978, 1979; Silas 1984; Lal Mohan 1989). Loggerhead Turtles (*Caretta caretta*) have not been reported from Lakshadweep and are rare throughout India. All five species of sea turtles mentioned so far are listed as endangered in the IUCN Redlist category and are protected under Schedule I of the Indian Wildlife (Protection) Act, 1972.

Green and Hawksbill turtles are reported to be most common in the island groups of the northwestern Indian Ocean (Frazier 1982), such as in the Seychelles and Chagos (Mortimer and Broderick 1999; Mortimer 2000). Many islands in the Indian Ocean, including the Lakshadweep, were historically important for Hawksbill trade and have been important producers of tortoiseshell and its products (Parsons 1972). There are historical reports of hunting and commercial exploitation of Chelonians for oil even before 1922. Ayangar (1922) reported trade of Green Turtles for oil and Hawksbills being hunted for tortoiseshell in Lakshadweep. Shanmugasundaram (1968) and Chari (1964) have also reported trade of Green Turtles for oil and Hawksbills for shell from the west coast, mainly from Gujarat and Lakshadweep. Prior to 1978, Hawksbill scutes from Lakshadweep were sold to mainland dealers in Mangalore and Cochin for Rs. 150/- per kg (Frazier 1980). Kar and Bhaskar (1982) reported exploitation of Green Turtles in Lakshadweep primarily for oil, used for boat caulking. However, there was no exploitation of turtles for food, either for consumption or trade on the islands (Kar and Bhaskar 1982). Meylan and Donnelly (1999) have also mentioned that the Lakshadweep islands may have been an important source for tortoiseshell exported to European countries during the seventies. Although reports indicate that the Lakshadweep archipelago was an important chelonian fishing region in the northern Indian Ocean in the past, and was once a centre for oil and tortoiseshell trade (Frazier 1980), the intensity of exploitation is not known.

Given the number of islands, beaches and extent of shallow water marine pastures and coral reefs, the Lakshadweep islands may provide important developmental and feeding habitats for turtles that nest elsewhere in the region. Bhaskar (1978) provides some information on distribution and threats to sea turtles in the Lakshadweep, but there is very little additional information available since

then. After a gap of 25 years, an exhaustive survey of the Lakshadweep islands was conducted during 2001-2002 to obtain detailed information on the status and threats to sea turtles in this poorly studied area.

STUDY AREA

The Lakshadweep group of islands are located in the Arabian Sea off the southwest coast of India (8°-12° 30' N and 71°-74° E) ranging between 220-440 km from the mainland. They are located on the northern end of 2,500 km Laccadive-Chagos ridge, presumed to have resulted from the northward migration of the Indian tectonic plate. There are a total of 36 atolls, which includes 10 inhabited and 14 uninhabited islands, three reefs and five submerged banks and four temporary sandbars that remain exposed at least for four months in a year. The total land area of the entire archipelago is 32 sq. km, of which the inhabited islands cover an area of 28.5 sq. km, while the remaining uninhabited islands/islets/ sandbars among others are only 3.45 sq. km. Although the total land area of this archipelago is quite small, these islands are scattered over a vast stretch in the sea with about 4,200 sq. km of the lagoon, 20,000 sq. km of Indian territorial waters and 40,000 sq. km of Exclusive Economic Zone. Most of the islands are completely enclosed within coral reefs. The lagoons are saucer-shaped shallow water depressions between the reefs and the islands, varying considerably in depth (3.6-8.0 m) and in area (1 sq. km to 150 sq. km). The vegetation on the lagoon (western) side of the islands is dominated by sand dune species like *Clerodendrum inerme*, *Ipomoea pescaprae*, *Launaea sarmentosa*, *Spinifex littoreus*, *Suriana maritime* and littoral shrubs such as *Pemphis acildula* and *Scaevola sericea*. The eastern shore is dominated by *Cordia subcordata* and *Guettarda speciosa* (Radhakrishnan *et al.* 1998). Mangroves are absent from this archipelago except for a tiny patch in Minicoy Island consisting of two species, *Ceriops candolleana* and *Bruguiera cylindrica*. The shallow water lagoons of these atolls support rich beds of sea grass. Among the seven species found on the lagoon beds, the dominant sea grasses are *Thalassia hemprichii*, *Syringodium isoetifolia* and *Cymodocea* spp. (Jagtap 1987).

Marine fishing is the basic economic activity on these islands, with an estimated 6,000 fishermen and about 850 tuna fishing crafts (Anon. 2001). The fishing season in Lakshadweep extends from October to April. However, during the monsoon (June to September), fishing is carried out in near shore waters, mostly in the surrounding lagoons. Gill net, shore seine, anchor net and dragnets are popularly used for lagoon fishing, but the largest catch comes from pole and line, which is used for tuna fishing in the deep sea (Alagaraja *et al.* 1987). The current annual fish landing is an estimated 10,000 tonnes (Anon. 2001), which consists mostly of tuna and other commercially viable finfish, not including turtles, which are illegally exploited in the lagoons. During this study, all 10 inhabited and 14 uninhabited islands were visited. Intensive nesting surveys were conducted in 20 islands and foraging habitat surveys were conducted in 12 islands and both nesting and foraging surveys were conducted in 20 islands. The submerged banks, reefs and smaller islets were not covered due to inaccessibility and logistic constraints.

MATERIAL AND METHODS

The sea turtle survey in Lakshadweep islands was conducted in three phases: (i) Information was collected by interviewing island inhabitants from July to September 2001 (ii) lagoon surveys were conducted from September to December 2001 to assess sea turtle abundance, size class distribution and occurrence and distribution of sea grass (iii) day and night surveys were carried out on foot on the island beaches from October 2001 to February 2002. Additionally, 22 Green Turtles (17 adults and 5 juveniles), 6 Olive Ridleys (adults) and 5 Hawksbill turtles (2 adults and 3 juveniles) were captured for morphometric data. These turtles were also double tagged on the front flipper with monel tags (marked CG #### Return Address – "Wildlife Institute of India, PO Box 18, Chandrabani, Dehradun 248001, India").

Interviews

Information was gathered through interviews and discussions with local governmental forest and fisheries officials as well as representatives of non-government organizations, fish landing centres, islanders and fishers on all inhabited islands of Lakshadweep. A standard questionnaire (based on Tambiah 1999) was used for this survey (Appendix 1). Colour photographs of different sea turtle species were shown to the interviewees for species identification and to check if each species has a local name. Important questions in the interviews pertained to i) occurrence of different species of marine turtles ii) turtle nesting sites and seasons, and iii) awareness about legislation pertaining to sea turtle conservation and iv) the impact of developmental activities on sea turtles and their nesting beaches.

Lagoon survey

Sea turtle abundance in lagoons was initially evaluated by opportunistic sightings of turtles from boats and while snorkeling opportunistically at selected locations. Based on

preliminary results, twelve lagoons where turtle sightings were most frequent were selected for systematic survey of turtles. The surveys were carried out in the lagoon during 0900 hrs - 1200 hrs, using a boat fitted with outboard motor. The boat was anchored at several locations in the lagoons and the lagoon was scanned for turtles from the boat for 10-15 minutes. Turtles that were sighted within a 10 m radius from the point of observation were counted. The distance between the scan points ranged from 50-70 m and each survey session consisted of 5 to 30 sampling points depending on the size of the lagoon, to obtain an abundance index of turtles for the lagoon. A few lagoons were surveyed more than once.

Sea turtles were captured from different lagoons by hand by employing divers and fishermen as well as by deploying gill nets. Large mesh size (30-40 cm stretch) gill nets that ranged from 150-200 m in length and 2.5 m width were deployed at various locations in the lagoons. Nets were set for three hours during high tide. The catch per unit effort (CPUE) was calculated according to the method described in Snedecor and Cochran (1967) using the following formula $R = \sum T / \sum E$ where R = CPUE, T = number of turtles captured, E = effort (standardized to 50 m net hours). Effort was calculated by using the formula, E = number of nets x length of net/50 m x minutes fished/60. The length of fishing net was kept constant at 150 m and the duration of fishing at 180 minutes.

During a six-month period, nets were set 78 times; 53 times during the day and 25 times at night. Turtles that were caught in the net were hauled up into the boat, identified, measured, sexed, tagged and released. Curved Carapace Length (CCL) (anterior point at midline/nuchal scute to the posterior tip of the supracaudal) and Curved Carapace Width (CCW) were measured.

The foraging habitat of sea turtles in island lagoons of Lakshadweep was evaluated by estimating the abundance of sea grass. Based on a preliminary survey of sea grass in the lagoon from a country boat (3 x 1 m) and snorkeling, nine island lagoons were sampled for sea grass abundance. Four strip transects of 5 m width and 100 m length, perpendicular to the shoreline, were selected at different locations in each lagoon. Each transect length was scanned in twenty 5 x 5 m quadrate blocks. Each block was snorkeled and scanned for assessing the sea grass beds. The percentage of sea grass coverage in each block was visually estimated, summed up for each transect, and extrapolated for estimating the sea grass density for each lagoon. Sea turtle sighting index was calculated as the number of turtles sighted per sampling point per session, and each session consisted of 5 to 30 sampling points.

Nesting beach survey of islands

During the survey, only 24 islands were covered while smaller islets and submerged banks that were considered unsuitable for sea turtle nesting because of their geomorphology were excluded from the survey. A total of 140 km of island beaches were surveyed. All island beaches were surveyed on foot several times during day and night. Indirect evidence such as crawl marks, nesting pits, eggshells, dead hatchlings and adult dead turtle remains washed ashore were collected. Hawksbill and Olive Ridley turtle nests were differentiated from Green Turtle nests on the basis of track width, symmetry, depth of body pit, and egg diameter (Pritchard and Mortimer 1999). Olive Ridleys and Hawksbill prefer different beach types and rarely nest together, and can be differentiated on the basis of nest habitat (Pritchard and Mortimer 1999). Observations and discussions with locals indicated that Olive Ridleys nest in open sandy beaches with creepers like *Ipomoea pescaprea* and *Spinifex*, while Hawksbill turtles nest under *Pemphis* and *Scavoela* bushes. The nesting density was calculated as the number of nesting crawls or pits/km counted during the survey of each island.

Besides threats to sea turtles and their nesting habitats, the level of developmental activities close to the marine turtle nesting beaches were also evaluated by interviews and discussions with islanders and fishermen, and actual observations during surveys. For habitat assessment, habitat parameters such as beach substratum (sandy/rocky), offshore approach, vegetation (coconut plantation/natural vegetation), human habitation (presence/absence), extent of beach erosion and armouring (concrete seawalls to prevent erosion) of the beach (presence/absence) were evaluated at every 500 m of the beach in all the inhabited and uninhabited islands.

Data Analyses

Since the timing, periodicity and frequency of surveys on each of the islands varied (due to logistic constraints), we indexed the nesting abundance to frequency of crawls/nesting pits counted during the first walk on any island. Fresh crawls were used to compare proportion of nesting of the three species, since Green Turtle nesting pits have much greater persistence than those of the other two species. Abundance of Green Turtle nesting pits was compared between islands to assess nesting site preference. Out of a total of 85 island surveys (each survey represents one walk covering the entire island), Kavaratti was walked 17 times, and Agatti 23 times between July 2001 and January 2002. These were used to assess seasonality of nesting. Non-parametric tests were used for comparisons between island groups and between inhabited and uninhabited islands.

RESULTS AND DISCUSSION

Interviews

A total of 300 individuals including islanders (n=112), fishermen (n=110) and mainland migrants (permanent government employees, skilled workers and frequent visitors) (n=78) were interviewed during the survey (Table 1). Unlike the fishermen, the islanders and mainland migrants come across sea turtles only occasionally, mostly during the nesting season. Most interviewees agreed that three species of marine turtles occurred regularly on the islands. However, Leathery Turtle was seen by fishermen operating in the sea, easily identified by its large size and leathery carapace. A few old residents indicated that nesting of Leathery Turtle used to occur till about 20 years ago. Among the islanders, only 10% indicated that they had seen Leathery Turtles in the islands and an equally low proportion of fishermen (12%) reported leathery turtle observations at sea.

Most interviewees (>90%) confirmed the occurrence and nesting of Green Turtles at the islands. Green Turtles were identified by them from its colour and the quantity of fat (used by fishermen for waterproofing boats). The oil extracted from Green Turtle fat is reported to be an excellent caulking agent. According to the interviewees, the practice of using Green Turtle oil is an ancient custom in the Lakshadweep islands. Hawksbill turtle occurrence and nesting is not very well known on the islands, and only *c.* 50% of the interviewees reported occurrence, while *c.* 35% reported nesting. With regard to the occurrence and nesting of Olive Ridleys, there were varying degrees of affirmative responses from the three categories of interviewees. Olive Ridleys and Green Turtles were differentiated by their size and oil content. While interviewees indicated that sea turtles occur and nest throughout the year in the islands and did not specify a nesting season for any species, full moon nights were believed to be particularly favourable for Green Turtle nesting.

Table 1: Secondary sources of information on sea turtles of Lakshadweep

Question	Islander (n = 112)	Fishermen (n = 110)	Others (n = 78)
Occurrence			
Green	100.0	86.3	96.1
Hawksbill	60.7	57.2	35.9
Olive Ridley	69.1	50.9	30.7
Leathery	21.2	10.9	12.8
Nesting			
Olive Ridley	100.0	93.6	92.3
Hawksbill	43.7	40.0	20.5
Green	31.2	27.2	17.9
Leathery	8.0	7.2	16.6
Season of nesting			
Monsoon	39.2	45.4	37.1
Throughout the year	60.7	54.5	75.6

All values represent the percentage of affirmative answers to the question

Lagoon survey

We obtained point sampling indices for sea turtle abundance in selected lagoons of the Lakshadweep islands (Table 2). Among the 12 islands (10 inhabited and 2 uninhabited) surveyed, sightings were highest in Agatti, followed by Kadmat, Minicoy and Tinnakara. However, turtles were also observed in the lagoons during high tide, close to the reef in Amini, Kavaratti and Bangaram Island, but sightings were rare in the lagoons of Kiltan and Chetlat. This may be because of the smaller size and intensive fishing activities in these lagoons. Sea grass abundance was maximum in Kadmat, Agatti and Minicoy. However, the abundance of sea grass and sea turtles did not show significant correlation ($r^2=0.28, p=0.1$).

Sea turtle captures

Sea turtles were captured during 21.8% (0.07 turtles per hour) of net sessions during the day and 72% (0.24 turtles per

Table 2: Lagoon survey on seagrass and sea turtles at Lakshadweep

Island	Sea grass abundance	Sighting index
Agatti	45.0 (14.1)	1.18 (4,38, 0.23)
Kavaratti	32.5 (15.8)	0.25 (1,8)
Kadmat	52.0 (17.2)	0.71 (4,80, 0.53)
Kiltan	6.5 (2.7)	0.00 (1,6)
Chetlat	28.8 (13.7)	0.00 (1,8)
Bitra	6.5 (2.7)	0.20 (1,5)
Amini	7.8 (2.5)	1.70 (1,6)
Andrott	-	0.00 (1,4)
Minicoy	55.5 (6.9)	0.62 (1,26)
Suheli	10.3 (6.9)	0.30 (1,10)
Tinnakara	2.0 (1.4)	0.64 (2,35)
Bangaram	23.0 (5.9)	0.33 (1,6)

Standard deviation, number of sessions and total sampling points are given in parentheses

In Agatti and Kadmat, sampling was carried out more than once in different months, but during the same survey season

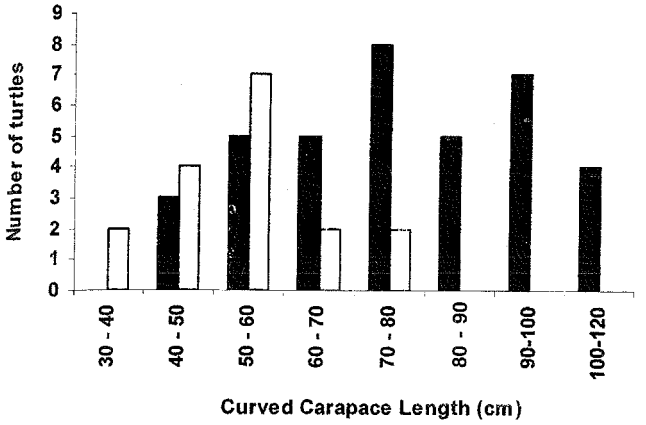

Fig. 1: Size class distribution of Green and Hawksbill turtles captured from the lagoon system of Lakshadweep

hour) of sessions during the night. A total of 35 Green Turtles and 17 Hawksbill turtles were captured from five island lagoons (Kavaratti, Agatti, Tinnakara, Suheli and Minicoy). Besides, four juvenile Green Turtles and one juvenile Hawksbill Turtle were also caught from Kadmat and Androtт island lagoons, respectively. Both species were caught throughout the survey period, but peak capture occurred during December to January. The CPUE for adult and juvenile Green and Hawksbill turtles was more or less evenly distributed across the lagoons, ranging from 0.01 to 0.064 (Table 3). However, CPUE was 0.184 for juvenile Green Turtles in Suheli lagoon, (and 0.22 for juvenile Hawksbill Turtles in Minicoy, though this was based on only a single capture). There were no recaptures of tagged turtles.

The mean curved carapace length for Green Turtles was 79.6 cm ±3.4 (n=35), with a range of 43-111.5 cm. According to the criteria of Hirth (1971), 68.5% of the captured Green Turtles were juvenile to immature (Fig. 1). The mean CCL for captured Hawksbill turtles was 55.2 cm ±3.0 S.E. (n=17), with a range of 30-72.5 cm. Of the 17 Hawksbills captured, only four were more than 60 cm CCL and the rest (76.5%) were in the range of juvenile to sub adults.

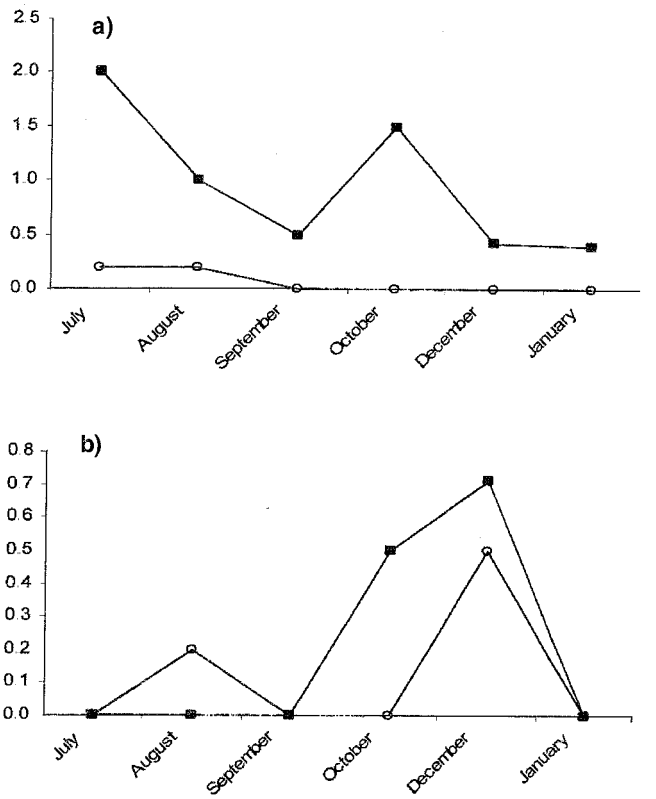

Fig. 2: Nesting abundance (no. of nests/km) between July 2001 and January 2002 of (a) Green turtles and (b) Olive Ridley turtles in Agatti (■) and Kavaratti (○). The islands were not surveyed in November 2001.

Nesting survey

Freshly laid nests (with undisturbed crawl marks) and old nests (with only the nesting pit visible) were enumerated. In the 140 km of beach that was covered during the survey from August 2001 to February 2002, a total of 154 fresh crawls, 154 recently dug nest pits and 736 nests were counted. Of the 94 nests that were excavated, 86 nests had eggs and 8 nests had eggshells and dead/live hatchlings in them.

Of the 554 Green Turtle nests identified, 432 nests (78%) were found under *Pemphis* bushes at a distance of approximately 20 m from the high tide line, and the rest were on the wide sandy beaches with creepers *Ipomoea* and

Table 3: Sea turtle catch/unit effort in various lagoons of Lakshadweep

Island	Lagoon area (sq. km)	Green turtles		Hawksbill turtles	
		Adult	Juvenile	Adult	Juvenile
Agatti	2.8	0.016 (3)	0.064 (12)	0.010 (2)	0.036 (7)
Kavaratti	10	0.024 (2)	0.036 (3)	0.012 (1)	0.036 (3)
Minicoy	1.5	0	0	0	0.22 (1)
Suheli	81	0.036 (1)	0.184 (5)	0.036 (1)	0.036 (1)
Tinnakara	5.6	0.054 (3)	0.036 (2)	0.018 (1)	0

Table 4: Morphometric and clutch size of nesting sea turtles at Lakshadweep during 2001-2002

Species	No. (n)	CCL		CCW		Clutch size	
		Average	Range	Average	Range	Average	Range
Green	16	110.8 (6.3)	98.4 -120	104.8 (8.2)	88 - 115	116.7 (7.7)	98 - 134
Hawksbill	2	74.6 (3.4)	72.2 - 77	68.7 (8.9)	62.4 - 75	134.5	112 - 157
Olive Ridley	6	72.8 (3.1)	69 - 77	68.8 (3.1)	62.4 - 64.5	137.0 (6.7)	128 - 148

Standard deviation is given in parentheses

Spinifex. Olive Ridley and Hawksbill nests were differentiated on the basis of location. 15 nests found deep inside the *Pemphis* and *Scavoela* bushes were almost certainly Hawksbill nests (two were observed nesting). 167 nests found in open sandy beaches at a maximum distance of 15 m from the high tide line were likely to have been predominantly/ entirely Olive Ridley nests (28 were observed nesting). Morphometric measurements and clutch sizes were taken for all three species (Table 4).

Encounter rates were calculated as the number of tracks or pits per km, counted during the first survey of any island (Table 5). A large number of Green Turtle and Olive Ridley nest pits were encountered in the uninhabited island of Suheli Valiyakara. The other uninhabited islands – Karingikuppu, Tinnakara, Parali I and Parali II – also had relatively large numbers of tracks and nest pits of both species. Fresh Green Turtle tracks were encountered at the rate of 1.07 tracks per km and there was a trend towards greater density on uninhabited islands (1.7 per km) than inhabited islands (Mann Whitney $p = 0.08$). Olive Ridley tracks were encountered at 0.17 tracks per km; there was no difference between uninhabited (0.4 per km) and inhabited islands (0.01 per km). Old Green Turtle nest pits were encountered at the rate of 10.4 pits per km, with a significant difference between uninhabited (21.6 per km) and inhabited islands (1.3 per km) (Mann Whitney $p < 0.01$). The difference was significant even when the data for Suheli Valiakara was removed from the uninhabited island dataset (4.8 per km). Olive Ridley nest pits were encountered at the rate of 1.8 pits per km, with a significant difference between uninhabited (3.8 per km) and inhabited islands (0.1 per km) (Mann Whitney $p < 0.01$). Green Turtle tracks were encountered more frequently than Olive Ridley tracks on both uninhabited (Wilcoxon $p < 0.05$) and inhabited islands (Wilcoxon $p < 0.05$).

Since surveys were conducted between July and January, nesting season of turtles could not be determined with any certainty. Furthermore, only two islands, Kavaratti and Agatti, were covered intensively during the survey period. Both islands were surveyed each month during this period (barring November), and nesting for each month was averaged for each island for Green Turtles and Olive Ridleys (Fig. 2). While both species were encountered throughout the survey period, Green Turtles appeared to peak in July (during the monsoon) and again from October to January. Green Turtles may thus have multiple peaks of nesting during the year. Olive Ridley nesting peaked during October to January. All Hawksbill nests in these two islands were encountered in December and January, and 86.6% of all Hawksbill nests on the islands were encountered during these months.

Table 5: Index of nesting density for 10 inhabited and 10 uninhabited islands

Island	Beach length (km)	Month	No. of crawls counted/km		Green turtle nesting pits counted/ km
			Green Turtle	Olive Ridley Turtle	
Inhabited					
Agatti	14	July	0.1	0.0	0.6
Kavaratti	12	July	0.1	0.0	0.1
Kadmat	22	August	0.2	0.0	0.2
Kiltan	8	November	0.0	0.0	0.4
Chetlat	5	November	0.6	0.0	0.4
Bitra	1	November	1.0	0.0	6.0
Amini	4	January	0.0	0.0	1.8
Kalpeni	10	January	0.3	0.0	0.3
Andrott	16	January	0.0	0.1	0.1
Minicoy	24	September	0.0	0.0	0.3
Uninhabited					
Parali-I	1	September	0.0	0.0	10.0
Parali-II	1	December	3.0	0.0	10.0
Tinnakara	4	September	2.5	0.8	2.5
Bangaram	2	September	0.0	0.0	2.0
Suheli Valiakara	2	December	4.0	1.5	155.5
Suheli Cheriyakara	2	December	0.5	0.0	1.0
Kalpitti	1	August	4.0	0.0	4.0
Pitti	2	January	1.5	0.0	5.0
Karingikuppu	5	December	2.6	1.0	7.2
Viringili	2	September	1.0	0.0	1.0

Threats to sea turtles in Lakshadweep

Direct threats: Curing and stuffing of sea turtles for keeping as souvenirs has been a traditional custom in the islands for as long as its inhabitants remember. Juvenile Hawksbills are caught from the lagoon and stuffed as curios. Seven stuffed Hawksbill turtles curios were documented from households in Agatti, Kavaratti and Minicoy Island. Although illegal, this is still an occasional practice in many islands. During the survey, two fresh Hawksbill turtles were found stuffed by an islander in Kavaratti. According to the interviewed islanders, a stuffed specimen fetches about Rs. 1,500/- (30 US $) and is sold to tourists visiting the island or on the mainland in the cities of Mangalore, Kozhikode and Kochi.

The islanders – predominantly Muslim – do not eat turtle meat because of religious taboo. However, opportunistic take of foraging and nesting turtles for oil is common. The Green Turtle is considered to be the most valuable for its fat, which is used as a caulking agent for traditional wooden boats, locally called '*odhum*'. Each Green Turtle yields about 10-20 litres of oil, which is sufficient for one boat. Twenty two old carcasses of adult Green Turtles (4 females and 18 males) were found in the uninhabited/partially inhabited islands of Tinnakara, Parali I and II, Suheli Valiakara and Cheriyam Island. Seven carcasses were found in Parali II Island alone, and they are suspected to have been killed for oil as in all the carcasses the plastron had been cleanly cut away and there was no flesh. In some islands, gravid females are also occasionally harpooned for the consumption of enlarged follicles in the ovary usually prepared with coconut, jaggery and several other ingredients. But this practice is rare in the islands at present due to availability of alternate food items.

Fishing related mortality of turtles in Lakshadweep is negligible, as fishing methods are different from the mainland coasts. The only method used for tuna fishing is pole and line, which poses no threat to turtles. During the entire survey, only three freshly dead Hawksbill Turtles were encountered on the beaches of Minicoy, Agatti and Kavaratti. They are presumed to have died due to drowning in gill nets, as there were no injury marks on their body. There was evidence of an increase in gill net fishing in lagoons of the inhabited islands during the survey. This is a cause for concern for the future.

Developmental activities on the nesting beach: Out of the 140 km coastline surveyed, sandy beaches comprise 56.4% of 107 km in inhabited islands and 25.8% of 33 km in uninhabited islands. In the inhabited islands 72% of the beaches are adjacent to human habitation, 76.2% are exposed to artificial lighting and 53.8% have been armoured with concrete structures to check erosion (Table 6). The uninhabited island beaches are free from human habitation, beach armouring, lighting or any other anthropogenic disturbance. The human population of the islands has increased from 31,810 in 1991 to 51,707 in 2001 (Census Report, Govt. of India). This has resulted in loss of nesting habitat due to construction activities, and increased illumination of the beach. Additionally, coconut, which is the second most important economical resource for the islanders after fish, is increasingly planted near the coast after clearing natural vegetation inland of the beach. Coconut roots have been observed to be completely exposed due to erosion, particularly in Agatti, Tinnakara, Bangaram and Suheli Cheriyakara. Sewage and other pollution from the islands, which drain directly into the lagoons, may also make the lagoons unsuitable habitats for sea turtles, corals and other associated marine organisms.

Bhaskar (1978) found that three species of turtles occurred and nested in Lakshadweep. He also reported that the leathery turtle is occasionally sighted by fishermen, but rarely comes ashore to nest. Twenty five years later, our study also recorded Green and Hawksbill turtles as being the most common turtles in the lagoons of the Lakshadweep islands. We also found that the Olive Ridley occurred rarely in the lagoons. However, we found that they nest more frequently than Hawksbill Turtles. The occurrence of Green and Hawksbill turtles in the lagoons adjoining coral reefs are presumed to be due to the availability of forage. Green Turtles are mostly herbivorous and they spend most of their time feeding on algae in the sea and the grass that grow in shallow waters (Bjorndal 1985; Ernst *et al.* 1994). Hawksbill turtles are a tropical reef dwelling species that feed on jellyfish, sea urchins, and sponges and they may also eat algae that grow on the reef (McElroy and Alexander 1979; Meylan 1998). The sighting and capture of a significant number of adult and juvenile Green and Hawksbill turtles in the Agatti and Kavaratti lagoons suggests that these lagoons are important developmental habitats for these two species of sea turtles. Juvenile and immature Hawksbill and Green Turtles are reported to be found in the lagoons throughout the year. Green and Hawksbill turtles are known to spend an intermediate period of development, i.e. juvenile to adult phase, in shallow water areas (Musick and Limpus 1997). The Lakshadweep islands' lagoons are typically shallow (3-5 m depth) tropical marine habitats with availability of sea grass, algae and coral throughout the year. Therefore, even though nesting beaches are not in great abundance, the presence of juvenile, subadult and adult Green and Hawksbill turtles in the lagoons throughout the year makes the *c*. 4,000 sq. km of Lakshadweep lagoons an important area for sea turtles in the Indian Ocean.

No individual Green or Hawksbill turtle was sighted or captured more than once during the survey. It is still not certain whether the Hawksbill turtles in the Lakshadweep archipelago are migratory or a regional non-migratory population confined only to the Lakshadweep archipelago. The Hawksbill and Green Turtles may migrate between the Archipelago and India, Sri Lanka, Maldives, and Oman. Further studies are required to determine the genetic identity and structure of these populations and whether they represent a regional stock.

Although sea turtle nesting in Lakshadweep group of islands occurs on both inhabited and uninhabited islands, Green Turtles in particular appear to prefer uninhabited islands like Suheli Cheriyakara. If the peak-nesting season is during the monsoon, as reported it is likely to help Green and Hawksbill turtles, as anthropogenic activities do not spread to uninhabited islands during this season. However, uninhabited islands are being increasingly encroached upon and identified nesting beaches must be safeguarded from developmental encroachments.

Adult sea turtles, especially Green Turtles in the Lakshadweep islands, are killed only for oil and juveniles are killed for stuffing as curios. Although historical records are inadequate, the interview results of the present study and reports of previous studies (Bhaskar 1979) appear to indicate a general decline in the population of Green and Hawksbill turtles in the Lakshadweep. This pattern has been repeated throughout the Indian Ocean (Frazier 1980, 1982). The absence of regular monitoring data makes it impossible to assess the historical trends in populations of marine turtles in Lakshadweep islands. However, with centuries of exploitation

Table 6: Assessment of nesting beaches in the islands of Lakshadweep

Island	Beach length (km)	Width	Sandy beach	Natural vegetation	Human habitation	Artificial lighting	Beach armouring
		21.3	**56.4**	**49.5**	**72.9**	**76.2**	**53.8**
Inhabited islands							
Agatti	14.0	57.1	71.4	57.1	71.4	71.4	42.9
Kavaratti	12.0	75.0	37.5	75.0	27.1	72.9	50.0
Kadmat	22.0	22.7	45.5	54.5	45.5	22.7	36.4
Kiltan	6.0	0.0	33.3	66.7	66.7	66.7	50.0
Chetlat	4.0	25.0	50.0	50.0	100.0	100.0	75.0
Bitra	1.0	0.0	100.0	0.0	100.0	100.0	50.0
Amini	4.0	0.0	100.0	100.0	150.0	150.0	100.0
Kalpeni	10.0	0.0	30.0	20.0	60.0	60.0	40.0
Andrott	10.0	0.0	30.0	30.0	50.0	60.0	60.0
Minicoy	24.0	33.3	66.7	41.7	58.3	58.3	33.3
		22.7	**25.8**	**37.9**	**3.0**	**3.0**	**0.0**
Uninhabited islands							
Parali I	2.0	0.0	75.0	100.0	0.0	0.0	0.0
Parali II	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Tinnakara	6.0	33.3	33.3	66.7	0.0	0.0	0.0
Bangaram*	3.0	0.0	33.3	33.3	33.3	33.3	0.0**
Suheli V	3.0	33.3	33.3	33.3	0.0	0.0	0.0
Suheli C	4.0	0.0	0.0	0.0	0.0	0.0	0.0**
Kalpitti	2.0	50.0	50.0	50.0	0.0	0.0	0.0
Pitti	1.0	100.0	0.0	0.0	0.0	0.0	0.0
Tilakam	2.0	0.0	25.0	100.0	0.0	0.0	0.0
Cheriyam	6.0	33.3	33.3	33.3	0.0	0.0	0.0**
Kodithala	2.0	0.0	0.0	0.0	0.0	0.0	0.0

Values are represented as % of (a) Beach with width > 20 m (b) Sandy beach (versus rocky beach) (c) Natural vegetation (versus coconut plantation) (d) Human habitation (e) Artificial lighting (f) Beach armouring

*Bangaram is classified as uninhabited, but has a beach resort, which is functional during part of the year

** Over 40% beach armouring as of 2006

of Green Turtles for oil and Hawksbill for tortoiseshell till recent times, their populations are likely to have declined on these islands.

Since land is limited, one of the greatest concerns for the island administration is beach erosion. The method and practice of beach erosion control is as great a concern as erosion itself for the suitability of nesting habitat and continued nesting of sea turtles in the Lakshadweep islands. Of the available nesting beaches in inhabited islands, almost 89% are subject to erosion and have been armoured with cement blocks, making the beach unavailable for sea turtle nesting. Beach armouring prevents sea turtles from accessing the nesting beach and thereby decreases beach area for nesting. Such armouring structures have not proved to be effective against erosion in Maldives or elsewhere (Schroeder and Mosier 2000). Fortunately, the uninhabited islands do not suffer from beach armouring and still continue to be major nesting grounds. Notably, the uninhabited islands are not subject to a great degree of erosion.

Recommendations

1. All species of sea turtles occurring in Indian waters are listed as endangered and are included in Schedule I of the Indian Wildlife (Protection) Act, 1972. Hence, the Department of Environment and Forests, Lakshadweep prohibits capture and killing of all species of sea turtles in the Island groups. However, due to lack of public awareness and protection staff, this legislation is largely ineffective. There are substitutes such as synthetic enamel, rubber paint and metallic coats for curing of wooden boats, which can replace Green Turtle oil. A subsidized supply of such materials to the islanders could prove useful and effective.

2. Nesting beaches with natural vegetation of *Pemphis* and *Scaevola* appear to be the preferred environment for sea turtle nesting. Two decades ago, most of these plants were removed from the beaches by the Agriculture Department of Lakshadweep on the grounds that they help propagate rodents. The removal of beach vegetation for rodent control may also have led to increasing erosion and consequently to the loss of sea turtle nesting beaches. Bringing back the natural vegetation adjoining known Green Turtle nesting beaches may prove beneficial. Corals are the flagship species of any healthy marine reef ecosystem and preserving corals in Lakshadweep may help other associated endangered fauna such as sea turtles, sharks, dolphins and dugongs. There should be a complete ban on coral collection and destruction, sand mining, and removal of natural vegetation from the island coast. Maintenance of natural beach vegetation and safeguarding corals may also help check beach erosion and eliminate the need for beach armouring.

3. Sea turtles in the lagoons and their nesting activities on beaches are potential tourist attractions as is the case in Brazil, Sabah, Malaysia, Australia, and elsewhere (http://www.tamar.org.br; http://oneocean.org; Limpus, 1985). While turtle based tourism development has a bright future in Lakshadweep, which could be beneficial to the islanders, it needs to be implemented carefully. The Lakshadweep Administration has plans to develop island ecotourism on currently uninhabited islands such as Tinnakara and Suheli Valiakara. These are important sea turtle nesting sites in the Lakshadweep and developmental activities at these sites may have severe adverse impacts on sea turtle nesting. Conservation efforts should also include the people living around turtle nesting localities.

4. Most local fishermen are not aware of the legal status of sea turtles, nor are they aware of fishing regulations that protect the rights of traditional fishing communities. The awareness drive targeted at fishing communities will help both the fishermen and the local people. Important turtle nesting areas such as Suheli Valiakara, Tinnakara and the important foraging grounds of turtles such as the Agatti lagoon need to be protected. New protection regimes such as the Community and Conservation Reserves under the amended Indian Wildlife (Protection) Act (2003) may provide suitable frameworks where sea turtles and habitats are protected, while artisanal fishing and some forms of tourism can be allowed. Establishment of marine parks at key sites such as Suheli will also provide additional support for the conservation of sea turtles in the northern Indian Ocean region.

5. The island administration needs to develop a sea turtle conservation management programme along with their coral reef monitoring and conservation programme projecting the sea turtles as the flagship species of the lagoons and coastal habitats of Lakshadweep.

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Appendix 1: Questionnaire used for interview in Lakshadweep islands

Wildlife Institute of India, Dehradun
GOI UNDP Sea Turtle Project – Lakshadweep Survey
Nesting beach Interview Questionnaire

Date of Survey _____ Time start _____ Time End _____ Beach Name/zone _____

_____

Observer _____

Name and occupation of interviewee: _____

Turtle information
How many types of turtles you have seen on this island?

Local names:

How are different species identified?

Which turtles occur on your island lagoon (species)?

How many turtles were seen nesting (species wise abundance/ area/ day)?

How many turtles were there earlier (20/50 years ago)?

Is there a decline? Why?

Are turtles or turtle eggs consumed?

What is the perception of marine turtles – beneficial / harmful / irrelevant?

Are turtles protected? By whom?

Comments: