

Part 3

MARINE TURTLES
OF THE ARABIAN SEA

GREEN TURTLE (PHOTO: BASUDEV TRIPATHY)



Sea Turtles and their Habitats in the Lakshadweep Islands

Basudev Tripathy, Kartik Shanker and B C Choudhury

All five species of sea turtles that occur in Indian territorial waters, barring the loggerhead, have been reported from the Lakshadweep Islands (Bhaskar 1978, 1979, Silas 1984, Lal Mohan 1989). The Laccadive, Maldives and Chagos islands are part of a continuous submarine archipelago, and provide important nesting and feeding habitats for sea turtles. Many islands in the Indian Ocean including Lakshadweep were historically important for the hawksbill trade and have been important producers of tortoiseshell products in the past (Parsons 1972). Although reports indicate that Lakshadweep was an important chelonian fishery in the northern Indian Ocean, and was once a centre for the green turtle oil trade as well as the tortoiseshell trade (c.f. Frazier 1980), the intensity of exploitation is not known. Green and hawksbill turtles are reported to be most common in the island groups of the western Indian Ocean (Frazier 1982). In addition to having significant nesting, the Lakshadweep Islands may be important developmental and feeding habitats for turtles that nest elsewhere in the region.

Sea turtles and their nesting beaches in the Lakshadweep Islands are not well documented. There are no studies on the status, distribution and threats to sea turtles in Lakshadweep, apart from a survey by the Madras Crocodile Bank Trust about twenty five years ago (Bhaskar 1978, 1979). This chapter presents the results of a survey (conducted between July 2001 and June 2002) of the Lakshadweep Islands. The objectives of the survey included:

- * Documentation of occurrence and nesting of sea turtles in Lakshadweep,
- * Assessment of nesting and foraging habitats of sea turtles in Lakshadweep,
- * Assessment of threats to sea turtles in Lakshadweep,



- * Formulation of a conservation action plan for the sea turtles of Lakshadweep, and
- * Creation of a network to monitor sea turtles, and design and implement sea turtle conservation in Lakshadweep.

Study Area

The Lakshadweep archipelago is located in the Arabian Sea off the southwest coast of India (8° – 12° 30' N and 71° – 74° E), about 220–440 km from the mainland (Figure 1). It is located on the 2,500-km Laccadive–Chagos ridge, presumed to be a hotspot trace resulting from the northward migration of the Indian plate. There are a total of 36 islands, which include 10 inhabited and 14 uninhabited islands, three reefs, five submerged banks and four temporary sand bars that remain exposed for at least 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 and sand bars cover only 3.45 sq km (Figure 1). Although the total land area of this archipelago is quite small, these islands are scattered over a vast stretch of sea, with about 4,200 sq km of lagoons, 20,000 sq km of Indian territorial waters and 40,000 sq km of EEZ (Exclusive Economic Zone). The islands are identical in their topography, completely enclosed within coral reefs and generally situated on the windward reef flat on the eastern side. The lagoons are saucer-shaped, shallow-water depressions, varying considerably from 1–150 sq km in area and 3–8 m in depth.

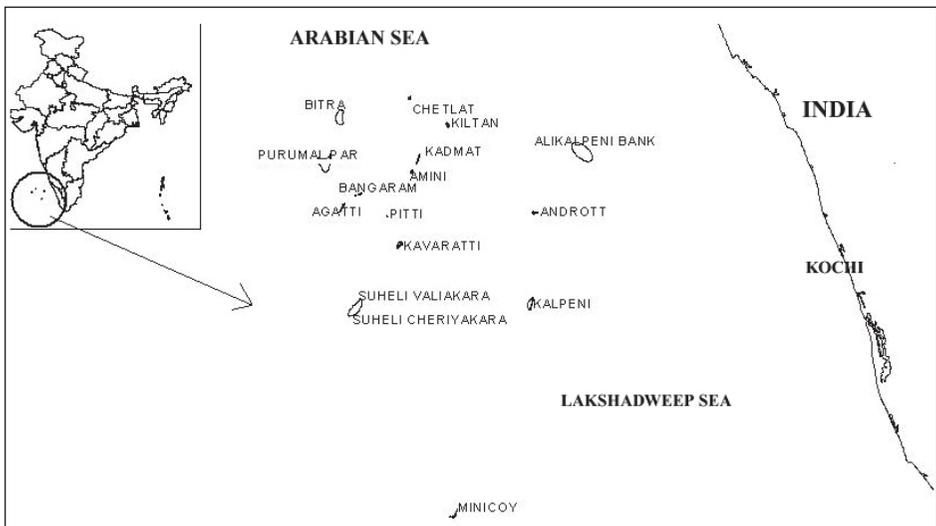


Figure 1. The Lakshadweep archipelago in the Arabian Sea, off the west coast of India.

COASTAL VEGETATION

The vegetation on the lagoon side of the islands is dominated by littoral species like *Clerodendrum inerme*, *Ipomoea pescaprae*, *Launaea sarmentosa*, *Spinifex littoreus* and *Suriana maritima* and shrubs such as *Pemphis acidula*, *Scaevola sericea*, while the eastern shore is dominated by *Cordia subcordata* and *Guettarda speciosa* (Radhakrishnan et al 1998). Mangroves are practically absent from this archipelago except for a tiny patch consisting of two species, *Ceriops candolleana* and *Bruguiera cylindrica*, in Minicoy Island. 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* and *Cymodocea isoetifolia* (Jagtap 1987).

MARINE FISHERIES

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, fishing is carried out in nearshore waters, mostly in the surrounding lagoons. Gill net, shore seine, anchor net and drag nets 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)(Table 1). The current annual fish-landing is an estimated 10,000 tonnes (Anon. 2001), which consists mostly of tuna and other commercially viable finfish.

Table 1. Marine fishing in the Lakshadweep archipelago.

Item	Number
Fishing villages	10
Landing centres	11
Fisher folk	10,700
Mechanised fishing crafts	502
Gill nets	600
Boat seines	210
Shore seines	305
Cast nets	1,360
Total fish-landing/year	10,000 t.

Methods

During the study, surveys were conducted in 24 islands, of which 10 are inhabited and 14 are uninhabited islands. The submerged banks, reefs and smaller islets were not covered by the survey, being inaccessible, and also due to logistic constraints. The sea turtle survey in the Lakshadweep Islands was conducted in three phases: (i) secondary information on sea turtles was collected by conducting interviews from July 2001 to September 2001, (ii) lagoon surveys were conducted from September–December 2001, for size class distribution of turtles, and assessment of sea turtle and seagrass abundance, and (iii) day and night surveys were carried out on foot on all island beaches from October 2001 to February 2002. Additionally, morphometric data was collected opportunistically from 22 green turtles (17 adults and 5 juveniles), 6 olive ridleys (adults) and 5 hawksbill turtles (2 adults and 3 juveniles). These turtles were also double-tagged with monel tags (marked CG ####; Return Address: Wildlife Institute of India, PO Box 18, Chandrabani, Dehradun 248 001, India).

Secondary sources of information

Information on sea turtle occurrence and nesting was gathered from both published and unpublished literature, through interviews and discussions with local forest and



fisheries department officials, non government organisations, fish-landing centres, islanders and fisher folk in the inhabited islands of Lakshadweep. A standard questionnaire (based on Tambiah 1999) was used for this survey (see Appendix). Colour photographs of different sea turtle species were shown to interviewees for species identification.

Sea turtle capture from lagoons

Sea turtles were captured from different lagoons by employing divers and fisher folk as well as by deploying gill nets. Large mesh size (30–40 cm stretch) gill nets, ranging from 150–200 m in length, were deployed at various locations in the lagoons. Nets were soaked for three hours at high tide. During a six-month period, nets were soaked 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) and curved carapace width (CCW) were measured.

Lagoon survey

Sea turtle abundance in lagoons was initially evaluated by both opportunistic sightings of turtles from boats and while snorkelling. Based on the preliminary results, twelve lagoons (where turtle sightings were most frequent) were selected for detailed density determination. The surveys were carried out in the lagoon using a boat fitted with an outboard motor. The boat was kept in a stationary position at different points in the lagoon and the lagoon was scanned from the boat for 10–15 minutes. Turtles that were sighted within a 10-m radius from the point of observation were counted. Each survey session consisted of 5–30 sampling points depending on the size of lagoon; these were averaged to obtain an index of abundance of turtles for the lagoon. A few islands were surveyed more than once.

The abundance of seagrass in the lagoons was estimated. Based on a preliminary survey from a country boat (3 × 1 m) and while snorkelling, twelve island lagoons were sampled for seagrass abundance. Four strip transects of 5-m width and 100-m length were selected in each lagoon perpendicular to the island. Each transect was scanned in twenty 5 × 5 m quadrat blocks. Each block was snorkelled and scanned to assess the seagrass beds. The percentage of seagrass coverage in each block was visually estimated and summed for each transect; the transects were then averaged to obtain an estimate for each lagoon.

Nesting beach survey

During the survey, only 24 islands were covered; the smaller islets and submerged banks were excluded from the survey, as most of these were inaccessible and unlikely to have much nesting. A total of 140 km of island beaches were surveyed. All island beaches were walked several times, both day and night. Indirect evidence such as crawl marks, nesting pits, eggshells, dead hatchlings and dead adult turtles were documented from 10 inhabited and 14 uninhabited islands of Lakshadweep. 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 hawksbills prefer different beach types and rarely nest together; they can be differentiated on the basis of nest habitat (Pritchard and Mortimer 1999). Observations

and discussions with fisher folk and local inhabitants indicated that olive ridleys nest in open sandy beaches with creepers like *Ipomea pescaprea* and *Spinifex*. Hawksbill turtles nest under *Pemphis* and *Scavoela* bushes.

Threat analysis

Threats to sea turtles and their nesting habitats, and the level of development activities close to nesting beaches, were also evaluated based on interviews and discussions with islanders and fisher folk and 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), erosion and armouring of the beach (presence/absence) were evaluated every 500 m along the beach in all the inhabited and uninhabited islands.

Results

Secondary sources of information

A total of 300 individuals including fisher folk (n=110), islanders (n=112) and mainland inhabitants (n=78 permanent government employees, skilled workers and frequent visitors) were interviewed during the survey (Table 2). Unlike the fisher folk, the islanders do not encounter sea turtles frequently, but most interviewees agreed that three species of sea turtles occurred regularly in most of the islands. The leatherback was easily identified by its large size and leathery carapace. A few old residents indicated nesting of leatherbacks more than 20 years ago, but it is not currently encountered at sea or seen nesting. The green turtle is identified by its colour and the quantity of fat, which is used by the fisher folk to paint boats. Hawksbill turtle occurrence and nesting is not well known on the islands and only ~50 per cent of the interviewees reported occurrence, while ~35 per cent reported nesting. With regard to the occurrence and nesting of olive ridleys, there were varying responses from the three categories of interviewees. Olive ridley 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 2. Results of interviews with islanders, fishers and others in different islands of Lakshadweep. All values represent the percentage of affirmative answers to the question.

Question		Islander (n=112)	Fisher folk (n=110)	Others (n=78)
Occurrence of turtles	Green	100	86.3	96.1
	Hawksbill	60.7	57.2	35.9
	Olive ridley	69.1	50.9	30.7
	Leatherback	21.2	10.9	12.8
Nesting of turtles	Olive ridley	100	93.6	92.3
	Hawksbill	43.7	40	20.5
	Green	31.2	27.2	17.9
	Leatherback	8	7.2	16.6
Season of nesting	Monsoon	39.2	45.4	37.1
	Throughout the year	60.7	54.5	75.6

Sea turtle capture from lagoons

A total of 35 green turtles and 17 hawksbill turtles were captured from seven island lagoons (Kavaratti, Agatti, Tinnakara, Suheli and Minicoy). Both species were caught throughout the survey period, but the peak for capture was December–January. Captures of adult green turtles was evenly distributed across the lagoons, but juvenile green turtles were most frequently caught in Suheli (Table 3). There were no instances of recapture of tagged turtles.

The mean curved carapace length for green turtles was $79.6 \text{ cm} \pm 3.4$ ($n=35$), with a range of 43–111.5 cm. Of the captured green turtles, 68.5 per cent had >80 cm CCL (presumably juveniles and sub-adults). The mean CCL for captured hawksbill turtles was $55.2 \text{ cm} \pm 3.0 \text{ SE}$ ($n=17$), with a range of 30–72.5 cm. Of the 17 hawksbills captured, only four had >60 cm CCL and the rest (76.5 per cent) were in the juvenile to sub-adult size class.

Table 3. Sea turtles captured in various lagoons of the Lakshadweep Islands.

	Lagoon area (sq km)	NO. OF TURTLES CAPTURED			
		Green turtle		Hawksbill turtle	
		Adult	Juvenile	Adult	Juvenile
<i>Amindivi group</i>					
Kadmat	3.2	0	4	0	0
<i>Laccadive group</i>					
Agatti	2.8	3	12	2	7
Andrott	0	0	0	0	1
Kavaratti	10	2	3	1	3
Suheli Valiakara	81	1	5	1	1
Tinnakara	5.6	3	2	1	0
Minicoy	1.5	0	0	0	1

Lagoon and nesting survey

The Lakshadweep archipelago comprises three groups of islands—the Amindivi, Laccadive and Minicoy groups. The survey results are presented group wise and island wise below and summarised as per seagrass abundance (Table 4), habitat surveys (Table 5), nesting data by island groups, seasons and species (Table 6), and complete nesting data for each island (Table 7).

Table 4. Sea turtle and seagrass abundance in various lagoons of Lakshadweep. The abundance index is the number of turtles sighted per sampling session. Each session consisted of 5 to 30 sampling points. The number of sessions and total sampling points are given in parentheses. Seagrass abundance is in per cent from the transect results of the survey.

Island	Seagrass abundance	Abundance Index
<i>Amindivi Group</i>		
Amini	7.75	1.7 (1,6)
Bitra	6.5	0.2 (1,5)
Chetlat	28.75	0.0 (1,8)
Kadmat	52	0.71 (4,80)
Kiltan	6.5	0.00 (1,6)

Table 4 (contd.)

Island	Seagrass abundance	Abundance Index
<i>Laccadive group</i>		
Agatti	45	1.18 (4,38)
Andrott	23	0. (1,4)
Bangaram	10.25	0.33 (1,6)
Kavaratti	32.5	0.25 (1,8)
Suheli	7.75	0.3 (1,10)
Tinnakara	2	0.64 (2,35)
<i>Minicoy</i>	55.5	0.62 (1,26)

Table 5. Habitat assessment for sea turtle nesting suitability in 10 inhabited and 11 uninhabited islands of Lakshadweep. Values are represented as proportions 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.

Island	Beach length	Width	Sandy beach	Natural vegetation	Human habitation	Artificial lighting	Beach armouring
<i>Inhabited islands</i>		21.3	56.4	49.5	72.9	76.2	53.8
<i>Amindivi group</i>							
Amini	4	0	100	100	150	150	100
Bitra	1	0	100	0	100	100	50
Chetlat	4	25	50	50	100	100	75
Kadmat	22	22.7	45.5	54.5	45.5	22.7	36.4
Kiltan	6	0	33.3	66.7	66.7	66.7	50
<i>Laccadive group</i>							
Agatti	14	57.1	71.4	57.1	71.4	71.4	42.9
Andrott	10	0	30	30	50	60	60
Kalpeni	10	0	30	20	60	60	40
Kavaratti	12	75	37.5	75	27.1	72.9	50
Minicoy	24	33.3	66.7	41.7	58.3	58.3	33.3
<i>Uninhabited islands</i>		22.7	25.8	37.9	3	3	0
<i>Laccadive group</i>							
Bangaram*	3	0	33.3	33.3	33.3	33.3	0
Cheriyam	6	33.3	33.3	33.3	0	0	0
Kalpitti	2	50	50	50	0	0	0
Kodithala	2	0	0	0	0	0	0
Parali I	2	0	75	100	0	0	0
Parali II	2	0	0	0	0	0	0
Pitti	1	100	0	0	0	0	0
Suheli V	3	33.3	33.3	33.3	0	0	0
Suheli C	4	0	0	0	0	0	0
Tilakam	2	0	25	100	0	0	0
Tinnakara	6	33.3	33.3	66.7	0	0	0

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



Table 6. Sea turtle nesting in different island groups in Lakshadweep, including the Amindivi group of islands (Amini, Bitra, Chetlat, Kadmat, and Kiltan), the Laccadive group (Agatti, Andrott, Bangaram, Cheriyam, Kalpeni, Kalpitti, Kavaratti, Kodithala, Parali, Pitti, Suheli Cheriyakara, Suheli Valiakara and Tinnakara), and the Minicoy group (Minicoy and Viringili).

Island Group	NESTING SEASON			Nests estimated
	July–September	October–December	January–March	
Total nesting				
Amindivi group	17	6	18	41
Laccadive group	385	190	106	681
Minicoy group	5	4	5	14
Green turtle nesting				
Amindivi group	13	4	11	28
Laccadive group	352	127	37	516
Minicoy group	5	2	3	10
Total number of nests	370	133	51	554
Olive ridley nesting				
Amindivi group	4	2	7	13
Laccadive group	27	58	65	150
Minicoy group	0	2	2	2
Total number of nests	31	62	74	167
Hawksbill nesting				
Amindivi group	0	0	0	0
Laccadive group	6	5	4	15
Minicoy group	0	0	0	0
Total number of nests	6	5	4	15

Table 7. Indirect evidence of sea turtle nesting in different islands in Lakshadweep.

Name of the island	Beach length (km)	No. of walks conducted	No. of crawl marks observed	No. of nesting pits observed	No. of nests with eggs	No. of nests with hatchlings
<i>Amindivi group</i>						
Amini	4	2	1	8	4	2
Bitra	1	2	1	6	1	0
Chetlat	5	2	7	7	4	0
Kadmat	22	7	8	17	4	0
Kiltan	8	3	0	3	1	0
<i>Laccadive group</i>						
Agatti	14	23	25	102	11	3
Andrott	16	2	1	8	6	0
Bangaram*	2	2	4	10*	2	0
Kalpeni	10	2	3	10	4	1
Kalpitti	1	1	4	4	4	0
Karingikuppu*	5	1	18	53*	0	0
Kavaratti	12	17	4	5	2	0

Table 7 (contd.)

Name of the island	Beach length (km)	No. of walks conducted	No. of crawl marks observed	No. of nesting pits observed	No. of nests with eggs	No. of nests with hatchlings
Parali-I*	1	3	12	38*	2	0
Parali-II*	1	1	3	18*	0	0
Pitti*	2	1	3	10*	0	0
S. Valiakara*	2	4	20	365*	16	0
S. Cheriyaakara*	2	2	1	4*	0	0
Tinnakara*	4	6	35	54*	23	0
<i>Minicoy group</i>						
Minicoy	24	4	2	12	2	1
Viringili*	2	1	2	2*	0	0
Total	140	85	154	736	86	7

* In uninhabited islands, old nesting pits remained undisturbed and, unless closely examined, it was difficult to determine a fresh pit from an older nest.

THE LACCADIVE GROUP OF ISLANDS

Agatti and Kalpitti

Agatti is the western-most island of Lakshadweep. It is about 7 km in length and about 1-km wide at its broadest point. Human habitation is confined to the broader northern part of the island. The southern part is narrow and less than 100 m in width. The airport is situated on the southern end of the island, with daily flights to mainland India. South of Agatti and separated by a shallow strait of about 200 m is the uninhabited islet of Kalpitti. Among the 11 lagoons surveyed (9 inhabited and 2 uninhabited), sightings were highest in Agatti lagoon ($n=20$, 9 in the preliminary survey, 11 in the intensive survey). The abundance of seagrass in the lagoon was also high (45 per cent). A total of 102 old nests were counted from a 14-km beach stretch in Agatti Island, of which 80 were green turtle, 16 olive ridley and 6 hawksbill turtle nests. The adjacent Kalpitti Island had only one old nest. During the night visits, 28 green turtles, 16 olive ridley and 6 hawksbill turtles were directly observed nesting on this island.

Andrott

Andrott is one of the nearest islands to the mainland coast of India. It lies east-west and fills the entire reef leaving no lagoon, unlike other islands, which lie north-south and have vast lagoons. The island is thickly planted with coconut trees and human population is very high. No turtles were sighted nor was seagrass observed in the offshore waters of Andrott Island. Two old green turtle nests and six olive ridley nests were counted along the 16-km stretch of beach. No direct nesting was observed in this island.

Bangaram, Tinnakara and Parali

These are uninhabited islands adjacent to each other and 8 km north of Agatti. Bangaram Island is situated in an extensive lagoon and the two tiny islets, Tinnakara and Parali, lie in the lagoon east of Bangaram. Parali touches the reef in the east while Tinnakara has sandy beaches and vast lagoon all around. Bangaram has a resort for high-end tourism.



Fourteen turtles were sighted during the lagoon surveys. The seagrass abundance in the lagoon was 25 per cent. Between July 2001–March 2002, a total of 10, 56 and 54 old nests were counted in Bangaram, Tinnakara and Parali (I and II) islands respectively. Besides, one hawksbill in Bangaram, 16 green turtles in Tinnakara and four green turtles in the Parali islands were observed nesting on the beaches.

Kalpeni

Kalpeni lies 76 km southwest of Andrott Island. Kalpeni, with the satellite islets of Cheriyam, Tilakkam, Pitti I and II, and Kodithala, lies in an extensive shallow lagoon. The reef, which connects Cheriyam and Kalpeni, dries up at low tide. Geomorphological evidence suggests that the action of sea has split the islets of Tilakkam and Pitti into 5 small islets. A peculiar feature of Kalpeni is the huge storm bank of coral debris along the eastern and southeastern shores. Only three turtles were sighted during the survey in the lagoon of Kalpeni and its adjacent islands; and seagrass abundance survey was not conducted. There were a total of 10 old nests (four green turtle and six olive ridley) on the island beaches of Kalpeni and no nesting was observed.

Kavaratti

Kavaratti is the headquarters of the union territory of Lakshadweep and lies between Agatti and Andrott. Kavaratti is approximately 300 km from Kozhikode/Kochi. The length of this island is about 6 km and greatest breadth is 1 km. At the south end, the island shrinks to a width of just a few yards at a point known as Chicken Neck. The lagoon on the western side is about 1½ km wide. During the lagoon survey in Kavaratti, only two turtles were sighted. However, compared to the number of turtles sighted, seagrass abundance was quite high in this lagoon (32.5 per cent). There were five (two green turtle and three olive ridley) old nests counted from this island, and three olive ridleys were observed nesting.

Perumal par

Perumal par is located 10 nautical miles north of Agatti Island and is a small sand bar surrounded by a vast reef and lagoon. This sand bar gets submerged during high tide. There is no vegetation on this island. Perumal par was not visited during the survey.

Pitti

Pitti Island lies 24 km northwest of Kavaratti. It has a small reef with a tiny sand bank at its southern end and no vegetation. This small island covers an area of 1.21 hectares and is the breeding ground of thousands of terns. The sooty tern *Sterna fuscata*, noddy tern *Anous stolidus*, large-crested tern *Sterna bergii* and brown-winged tern *Sterna anaethetus* are reported to nest on this barren island from June to September. Pitti Island has been gazetted as a bird sanctuary in Lakshadweep. The island is devoid of any lagoon and hence no sighting or seagrass abundance surveys were conducted here. However, during the visit to Pitti, a total of 10 old green turtle nests were counted.

Suheli Valiakara

Suheli par has a large reef, which encloses a lagoon with two uninhabited islands known as Suheli Valiakara and Suheli Cheriyakara. Suheli Valiakara is completely uninhabited, and is about 3 m above MSL. The island is less than 2 sq km in area and is almost oval in shape. There is a small patch of reef close to the northern part of the island. In Suheli

lagoon, only three turtles were sighted during the lagoon survey. The seagrass abundance in the lagoon was 10.25 per cent. A total of 358 old green turtle nests and seven old hawksbill nests were counted on Suheli Valiakara. During the night visit, seven green turtles were observed nesting.

Suheli Cheriyakara

Suheli Cheriyakara is situated 10 km north of S. Valiakara and is partially inhabited by the fisher folk of Kavaratti, Agatti and Kadmat during the post-monsoon months, when the weather permits (generally October–April). There are sandy beaches almost all around the island. There are extensive coconut plantations in the interior of the island and islanders visit these for an annual coconut harvest. Only four old green turtle nests were documented from this island and no nesting was observed during the survey.

There is a temporary sand bar approximately 2-km long and 100-m wide between Suheli Valiakara and Suheli Cheriyakara, named Karingikuppu. During the survey, five old green turtle nests and 48 olive ridley nests were counted on this sand bar. Three olive ridley turtles were observed nesting on this sand bar.

THE AMINDIVI GROUP OF ISLANDS

Amini

Amini is the principal island of the Amindivi group. The length of this island is approximately 3 km and its width is about 1½ km. It is oblong-shaped, and almost fills the entire ring reef, leaving only a very shallow and narrow lagoon all around. The lagoon survey in Amini had 10 turtle sightings; the lagoon has only 7.5 per cent seagrass cover. There were no direct observations of any turtle nesting on this island. During the survey, eight old green turtle nests were documented from this island.

Bitra

Bitra is among the smallest inhabited islands of Lakshadweep with a land area of only 10.52 ha, lying on the northeastern tip of the large coral ring reef enclosing a vast lagoon. The sandy beach on the eastern side of the reef dries up during low tide. Though fishermen frequently visited this island from Kiltan and Chetlat, islanders permanently inhabited it only very recently. In Bitra lagoon, only one turtle was sighted during the lagoon survey. The seagrass abundance was also quite low (6.5 per cent). During a single visit to this island, six old green turtle nests were documented and no nesting was observed in this island.

Byramgore (Valiabani and Cheriyabani reef)

Byramgore, also called the Valiabani and Cheriyabani reef and is approximately 7 hours journey from Bitra by tuna fishing boat. It is situated 30 nautical miles northwest of Bitra and is comprised completely of coral stones with a surrounding reef. The lagoon is vast with shallow sandy patches, which get submerged during high tide. This island was not visited during the survey.

Chetlat

Chetlat is the northern-most inhabited island in the Amindivi group. This long narrow island is shaped like a feeding bottle and is 55 km north of Amini. Along the eastern side



of the island is a wide belt of coral debris believed to be caused by storms; it broadens at the south, covering the southern end of the island. The lagoon is shallow with two entrance channels on the reef. During the survey, no turtles were recorded from Chetlat lagoon. However, seagrass abundance was found to be more than one fourth of the lagoon (28.5 per cent). No fresh nest was counted nor was turtle nesting observed in this island. Only seven old green turtle nests were counted on the beaches of Chetlat.

Kadmat

Kadmat Island lies 10 km north of Amini, and is about 11 km long and 500 m wide at its widest point. Apart from harbouring a very large lagoon on the western side which abounds in coral reefs, this island also has a narrow lagoon on the eastern side, which almost dries up during low tide. There is accretion of sand on the southern side of the island. The lagoon survey in Kadmat documented four turtles during the preliminary survey and 15 turtles during intensive survey. The seagrass abundance in the lagoon was more than half of the lagoon area (52 per cent). A total of 11 old green turtle and six olive ridley nests were counted from the 22-km beach. However, during night visits, barring six olive ridleys, no other turtles were observed nesting.

Kiltan

Kiltan Island lies 51 km northeast of Amini on the international trade route between the Persian Gulf countries and Sri Lanka. This island is only 3-km long and both ends have stormy beaches. The lagoon on the west is shallow, and is in the process of being developed. No turtles were sighted in this lagoon and seagrass abundance was as low at 6.5 per cent. Three old green turtle nests were recorded on the island.

THE MINICOY GROUP OF ISLANDS

Minicoy and Viringili

Minicoy is the southern-most island in Lakshadweep and is close to the Maldives. This island is crescent-shaped and is more than 10 km in length from north to south. The lagoon is large and deep. There is a small uninhabited island close to the northern tip of Minicoy called Viringili. Within the lagoon of Minicoy, the reef dries up at low tide at the northwestern entrance, and this connects to the main island—Viringili Island. The lagoon survey in Minicoy resulted in the sighting of six turtles during the preliminary survey and 16 turtles during the intensive survey. The seagrass abundance in this lagoon was highest among all the islands in Lakshadweep (55.5 per cent). No turtle nesting was observed on this island. However, a total of 10 old green turtle and two olive ridley turtle nests were counted. The adjacent uninhabited island of Viringili had two old green turtle nests.

SEA TURTLE NESTING SUMMARY

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 laid nest pits and 736 old/new nests were counted. Of the 94 nests that were excavated, 86 nests had eggs and 8 nests had eggshells and dead/live hatchlings in it. Out the 554 green turtle nests identified, 432 nests (78 per cent) 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 *Ipomoea* and *Spinifex* creepers vegetations. 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 HTL and were likely to have been predominantly/entirely olive ridley nests (28 were observed nesting). Since surveys were conducted between July and January, the nesting season could not be determined with any certainty. 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. More than 80 per cent of all hawksbill nests were encountered in December and January.

The morphometric measurements and clutch size data of all nesting turtles shows green turtle ranges between 98.4–120 cm CCL and 88–115 cm CCW, with a clutch size of 98–134 eggs. Similarly for hawksbill turtles, the CCL ranged between 72.2–77 cm and CCW 62.4–75 cm; and clutch size between 112–157 eggs. All the nesting olive ridleys measured were within the range of 69–77 cm CCL and 62.4–64.5 cm CCW, with a clutch size range of 128–148 eggs (Table 8).

Table 8. Morphometric and clutch size of nesting sea turtles in Lakshadweep during 2001–02. Standard deviations are given in paranthesis.

Species	No. (n)	CCL		CCW		Clutch size	
		Average	Range	Average	Range	Average	Range
Green turtle	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

Threats

The stuffing of sea turtles is an ancient custom in the islands. 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 islands. 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 (US\$ 30) and is sold to island tourists and even in the mainland cities of Mangalore, Kozhikode or Kochi.

The islanders—predominantly Muslim—do not eat turtle meat for religious reasons. However, opportunistic collecting 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 patchwork in the traditional boats, locally called *odhum*. Each green turtle yields about 10–20 litres of oil, which is sufficient for one boat. Twenty-two 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 Cheriyaam. Seven carcasses were found in Parali II Island alone, and they are suspected to have been killed for oil as all the carcasses were cut cleanly and had no plastron or flesh.



In some islands, gravid females are also occasionally harpooned for consumption of unshelled eggs, which are prepared with coconut jaggery and other ingredients. But this practice is rare in the islands at present. Fishing-related incidental mortality of turtles in Lakshadweep is negligible. The only method used for tuna fishing is pole and line, which poses no threat to the turtles. During the survey, three dead hawksbill turtles were encountered on the beach; the cause of their mortality could not be determined, and they are presumed to have drowned in gill nets. The increase in the level of gill net fishing in the lagoons will be a cause for concern in the future.

Developmental activities that may impact sea turtles include construction of houses and buildings close to the beach, coconut plantations on the beach and beach armouring by concrete tetrapods, sand bags and hollow boxes. Out of the total 140 km of coastline surveyed, 107 km of beaches are in inhabited islands and 33 km in uninhabited islands. In the inhabited islands, only 54 per cent of the beach is suitable for nesting, while the rest has been armoured. The human population of the islands has increased from 31,810 in 1991 to 51,707 in 2001 (Lakshadweep Census). This has resulted in loss of nesting habitat due to construction activities, disturbance to turtles while nesting and increasing illumination of the beach. Additionally, coconut, which is the second most important economic resource for the islanders after fish, is increasingly planted near the coast after clearing natural vegetation on the beach. Coconut roots have been observed completely exposed due to erosion in several islands of Lakshadweep, 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 unhealthy for sea turtles, corals and other marine organisms.

Discussion

Bhaskar (1978) observed three species of turtles in the Lakshadweep Islands. The leatherback turtle is occasionally sighted by fishermen, but rarely comes ashore to nest. Green and hawksbill turtles were the most common species of sea turtles in the islands' lagoons. While the olive ridley is reported to be rare in the lagoon, it nests more frequently than hawksbill turtles. The occurrence of green and hawksbill turtles in the lagoons adjoining the coral reefs is presumed to be due to the availability of forage. The green turtle is known to feed on seagrass and algae (Bjorndal 1985, Ernst et al 1994), while hawksbills are a tropical reef-dwelling species that feed on jellyfish, sea urchins, and sponges and may also eat the algae that grows on the reef (Bjorndal 1985, Meylan 1988).

The sighting and capture of a significant number of juvenile green and hawksbill turtles in Agatti and Kavaratti during this survey suggests that these lagoons are important developmental habitats for sea turtles. Juvenile and sub-adult hawksbill and green turtles are found in the lagoon throughout the year; these turtles are known to spend their intermediate period, i.e. sub-adult to adult phase, in shallow water areas (Musick and Limpus 1997). The Lakshadweep lagoons are typically shallow (3–5 m depth) tropical marine habitats with abundant availability of food throughout the year. Therefore, even though nesting beaches are not in great abundance, the presence of juvenile, sub-adult and adult green and hawksbill turtles in the lagoons throughout the year makes the ~4,000 sq km of lagoon area an important habitat for sea turtles in the Indian Ocean.

Adult sea turtles, especially green turtles, are killed for oil, while juveniles are killed for stuffing as curios. Although historical records are inadequate, the interview results and reports of previous studies indicate a general decline in the population of green and hawksbill turtles in Lakshadweep. This pattern has been repeated throughout the Indian Ocean (Frazier 1980, 1982), but the absence of data makes it impossible to assess historic trends in the population of sea turtles in Lakshadweep. No green or hawksbill turtles were re-sighted or re-captured during the survey. It is not clear whether the hawksbills in Lakshadweep are migratory or a local non-migratory population. Hawksbill and green turtles could potentially migrate between India, Sri Lanka, Maldives, Madagascar, Seychelles and Oman, and thus these Indian Ocean populations warrant further studies to trace migratory routes and delineate genetic stocks.

Although sea turtle nesting in Lakshadweep 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 therefore identified nesting beaches must be safeguarded from developmental activities.

Since land is limited, one of the greatest concerns for the island administration is control of beach erosion. The method and practice of beach erosion control is a far greater concern for the continued nesting of sea turtles in Lakshadweep. Of the available nesting beaches in inhabited islands, almost 89 per cent are subject to erosion and have been armored with cement tetrapods, making the beach unavailable for sea turtle nesting. Beach armoring prevents sea turtles from accessing the nesting beach and decreases beach area for nesting. Tetrapods have not proved to be effective against beach erosion in islands elsewhere (Schroeder and Mosier 2000). Fortunately, beaches on uninhabited islands have not yet been armoured and continue to be major nesting grounds. Notably, the uninhabited islands are not subject to a great degree of erosion.

Recommendations

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. The Department of Environment and Forests, Lakshadweep has banned the killing and poaching of sea turtles. However, due to lack of awareness and protection staff, this is ineffective. Areas with high sea turtle nesting and foraging populations such as Suheli Valiakara, Tinnakara and Agatti should be protected. Adult female turtles should be protected, especially during nesting. The Lakshadweep administration should provide a suitable caulking agent as a substitute for green turtle oil to discourage the killing of turtles for oil.

Nesting beaches with natural vegetation appear to be the preferred environment for sea turtle nesting. Therefore, natural vegetation near the beach should not be removed and their role in beach formation as well as in checking erosion should be studied. There should be a complete ban on coral collection, sand mining and removal of other natural resources from the island coast for any purpose. Developmental activities such as human



encroachments, beach illumination and beach armouring need to follow the guidelines of the Lakshadweep Coastal Zone Management Plan, 1997. Tourism development should also follow the same legislation while formulating any tourism promotion activities. There is an urgent need for Environmental Impact Assessment in areas where the Lakshadweep administration plans to carry out development activities for tourism and other purposes. Tinnakara and Suheli Valiakara islands have been earmarked as suitable areas for tourism. This may have severe impact on sea turtle nesting and needs to be evaluated carefully.

An effective educational campaign should be initiated in all the islands, on the importance and benefit of turtles to islanders and to the coral ecosystem. Considering the importance of networking among NGOs, different organisations working in the islands were approached for assistance during the survey. The NGOs are keen to participate in such activities, but require guidance from agencies like the Departments of Science and Technology, and Environment and Forests. A one-day workshop on sea turtle conservation and management in Lakshadweep was organised at Kavaratti with the support of the administration and involved non government organisations. In the workshop, more than 25 NGOs, members of the village (dweep) panchayat, Departments of Social Welfare, Planning, Fisheries, Science and Technology, and Environment and Forests participated and shared their views on the problems and prospects for sea turtle conservation and management in the Lakshadweep. Sea turtle based tourism has a bright future in Lakshadweep, which could benefit the islanders but should be monitored properly. Setting up of a sea turtle education and interpretation centre at Kavaratti will benefit the islanders as well as tourists.

Acknowledgements

The funding support for this study was provided by the GOI–UNDP Sea Turtle Project. We thank the administration of Lakshadweep for permission and logistic support while carrying out the survey. We would like to thank Syed Ismail Koya, director, Department of Science and Technology, and George Jacob, conservator of forests, Department of Environment and Forests, for their support; and Syed Ali, Syed Shaikh Koya, K P Mohammed and Mohammed Ali, environment wardens, for their assistance during fieldwork. We are also grateful to the director, Wildlife Institute of India, Dehradun.

Literature Cited

- Alagaraja, K, K C Yahannan, P L Ammini, and P P Pavitran. 1987. An appraisal of marine fisheries of Lakshadweep and Andaman and Nicobar. *Bull. of Central Marine Fisheries Research Inst.* 39: 1–16.
- Anonymous. 2001. *Union Territory of Lakshadweep: Basic statistics*. Planning Department, Secretariat, Kavaratti.
- Bhaskar, S. 1978. Marine turtles in India's Lakshadweep Islands. *Marine Turtle Newsl.* 8: 5.
- Bhaskar, S. 1979. Notes from Lakshadweep. *Hamadryad* 4(1): 7–9.
- Bjorndal, K A. 1985. Nutritional ecology of sea turtles. *Copeia* 3: 736–751.

- Ernst, C H, R W Barbour, and J E Lovich. 1994. *Turtles of the United States and Canada*. Washington D C: Smithsonian Institution Press.
- Frazier, J. 1980. Exploitation of marine turtles in the Indian Ocean. *Human Ecology* 8(4): 329–370.
- Frazier, J. 1982. Status of sea turtles in the central western Indian Ocean. In *Biology and conservation of sea turtles*, ed. K A Bjorndal. Washington D C: Smithsonian Institution Press. 385–398.
- Jagtap, T G. 1987. Distribution of algae, marine grasses and coral communities from Lakshadweep Island, eastern Arabian Sea. *Indian J. of Marine Sc.* 16(4): 256–60.
- Lal Mohan, R S. 1989. Turtle resources. *Bull. of Central Marine Fisheries Research Inst.* 43: 71–76.
- Meylan, A B. 1988. Spongivory in hawksbill turtles: A diet of glass. *Science* 239: 393.
- Musick, J A, and C J Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. In *The biology of sea turtles*, ed. P L Lutz and J A Musick. Boca Raton: CRC Press. 137–163.
- Parsons, J J. 1972. The hawksbill and tortoise shell trade. In *Etudes de geographic tropicale offertes a Pierre Gourou*. Sorbonne: Ecole Pratique des Hautes Etudes.
- Pritchard, P C H, and J A Mortimer. 1999. Taxonomy, external morphology and species identification. In *Research and management techniques for the conservation of sea turtles*, ed. K L Eckert, K A Bjorndal, F A Abreu-Grobois and M Donnelly. Pennsylvania: IUCN/SSC Marine Turtle Specialist Group Publication No 4. 21–38.
- Radhakrishnan, K, A G Pandurangan, S Rajasekharan, and P Pushpangadan. 1998. Ecofloristic studies of Lakshadweep Islands, India. *J. of Ecology and Taxonomic Botany* 22(1): 37–48.
- Schroeder, B, and A E Mosier. 2000. Between a rock and a hard place: Coastal armoring and marine turtle nesting habitat in Florida. In *Proceedings of the Eighteenth International Symposium (Supplement of Sixteenth Annual Symposium on Sea Turtle Conservation and Biology, Addendum)*, compiled by F A Abreu-Grobois, R Briseno-Duenas, R Marquez, L Sarti. US Dept. of Commerce, NOAA Tech. Memo. NMFS-SEFSC-436. 290–292.
- Silas, E G. 1984. Observation of turtles at sea and in Lakshadweep. In *Sea turtle research and conservation*, ed. E G Silas. Central Marine Fisheries Research Institute Bulletin. 59–61.
- Tambiah, C. 1999. Interviews and market surveys. In *Research and management techniques for the conservation of sea turtles*, ed. K L Eckert, K A Bjorndal, F A Abreu-Grobois and M Donnelly. Pennsylvania: IUCN/SSC Marine Turtle Specialist Group Publication No 4. 156–161.



Appendix

Questionnaire used for interviews in the Lakshadweep Islands (Wildlife Institute of India, Dehradun, GOI-UNDP Sea Turtle Project).

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 in this island?

Local names:

How are different species identified?

What turtles occur in your island lagoon (species)?

How many turtles are 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 sea turtles (beneficial/ harmful / irrelevant)?

Are turtles protected ? By whom?

Comments
