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Chapter 2

The status of sea turtle populations on the Gujarat coast of India

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INTRODUCTION

The state of Gujarat on the west coast of India has 92 species of reptiles from 63 genera belonging to 20 families (Vyas, 1998), which includes four species of sea turtles, namely olive ridley, green, leatherback and hawksbill turtles. However, nesting of only olive ridley and green turtles has been documented on the Gujarat coast (Bhaskar, 1978, 1984; Kar and Bhaskar, 1982), while the other two species are occasionally sighted by local fishermen. Though sea turtle research activities started in late 70's in Gujarat coast, most of them were short term and rapid surveys. Frazier (1980) has discussed the threats to the sea turtles of Gujarat in terms of egg and animal poaching, and there is information on an international tag return (Firdous, 1991) and a necropsy of a stranded animal (Frazier, 1989). Except for these notes and a few sketchy and old survey reports, there is no other information on these nesting populations and potential nesting habitats. A recent study by Sunderraj *et al.* (2002), based on one time survey, discussed nesting density, egg predation and provided qualitative information on threats like mining and beach contamination due to spread of oil particles and sea garbage. Though the Gujarat coast supports the only significant nesting of green turtles along the mainland coast of India, no long term data is available for this region.

Threat to coastal and marine environments

The Gujarat coast and marine environment faces threats from rapid industrial and urban development. Since Gujarat is one of the industrial states of the country, many large scale industries are located along the coast. It is estimated that, out of 1.7 million registered small scale industries in the state, one third are located in the coastal districts. Cements, petrochemicals, pharmaceutical, textile pulp and paper, pesticides and insecticides and salt are the water polluting industries of the state. A total of 563 large and medium industries are listed as water polluting units. It is mentioned that, Tapi estuary discharges 26.3 Mm³ waste water every year. The eastern shore of Gulf of Khambhat receives 174 mm³ effluents annually from the large and medium sized industries (Sen Gupta and Deshmukhe, 2000).

Gujarat also has the highest number of ports (41), handling 9% of total cargo of the country, which is expected to increase to 25% of India's total cargo. Increase in vessel traffic with its associated problems of oil spill, garbage and ballast water disposal and spillage of other transport materials are a direct threat to marine ecosystems. Presence of oil storage terminals and refineries are the main threats to Gulf of Kachchh. Currently, the petroleum product consumption of the state is 78 MT and likely to exceed 270 MT by 2020. Four Single Buoy Moorings (SBM) have been placed in the Gulf of Kachchh to handle 40-80 MT of crude oil per year, which is expected to increase to 100 MT (Desai, 1997). Overall it is estimated that the coastal waters of Gujarat can expect to receive 606 mm³ domestic sewage and 215 mm³ of industrial effluents every year.

Gujarat ranks first in marine fish production in India, accounting for 23% of the national total. The revenue generated through fish export was Rs. 637.85 crores, which formed 13.6% of the national share (Anon, 1999). The average annual growth rate of the number of fishing centers and villages showed a 5.27% increase with an active fishermen population of 13.76% in the state (Sunderraj *et al.*, 2002). In addition to urban and industrial related problems, a rapid increase in fishery related activity will also be

detrimental to the sea turtle population in terms of an increase in the incidental catch of turtles in fishing nets.

Threats to sea turtles

There are a few studies which have discussed the direct and indirect threats to sea turtles and their habitats in India. Nest predation by animals and local people for consumption of eggs is a common threat to sea turtles along the Indian coast (Frazier, 1980; Kar and Bhaskar, 1982; Bhaskar, 1984, 1993; Rajagopalan *et al.*, 1996; Pandav *et al.*, 1998). Incidental catch in fishing gear like trawl and gill net has been reported as the major threat in different coastal districts (Rajagopalan *et al.*, 1996; Pandav and Choudhary, 1999; Pandav *et al.*, 1997.; Pandav 2001; Tripathy *et al.*, 2003). Coastal plantations (Pandav *et al.*, 1998) and sand mining along the nesting beaches have been documented as major threats to turtle habitat (Bhaskar, 1984; Andrews, 2000). All these threats have been reported along the Gujarat coast (Bhaskar, 1984; Sunderraj *et al.*, 2002). However, the magnitude of their impacts need to be studied with long term monitoring programmes.

Rationale of the project

The absence of recent baseline data on sea turtle nesting populations and the impacts of above mentioned developmental activities on the marine ecosystem suggests the need for long term surveys along Gujarat coast. Even though the GOI-UNDP sea turtle project (2000-01) came up with baseline status for many coastal districts, full breeding season surveys were not carried out at all the sites. Considering the necessity of more extensive surveys and intensive long term data collection, the Centre for Herpetology/Madras Crocodile Bank Trust (MCBT), Tamil Nadu launched this project in January 2004. This project aims to assess the nesting population status through long term intensive monitoring and capacity building of different stakeholders towards the conservation of sea turtles along the Indian coast. The Gujarat Institute of Desert Ecology (GUIDE) – Bhuj, Gujarat is one of the collaborative agencies involved in the project to coordinate and implement this project along the Gujarat coast.

STUDY AREA

The state of Gujarat, situated in the northwestern frontier of India (20°01' – 24°07' N and 68°10' – 74°28' E) encompasses a total land area of 196,024 km² constituting 6.0% of the total land area of the country. The total population of the state was estimated to be 5.05 million in July 2001. Gujarat has the longest coastline in India, covering more than 1600 km which is around 22% of the total coastline (7100 km) of the country. The coastline of the state stretches from Lakhpat in the northwest, in Kachchh district to Umargaon in the south, in Valsad district. Out of 184 talukas of 25 districts, 40 talukas of 13 districts are on the coast. Among the coastal talukas, 19 were totally marshy in nature and not suitable for sea turtle nesting (Fig. 2.1). The coastal area, up to 20 km from the shoreline, covers 30,022.25 km² encompassing 59 towns and 2802 villages. The human population of this coastal limit is 9 million, and contributes 21.8% of the total population of the state.

The Arabian Sea and Gulfs of Kachchh and Khambhat border the coast of the Gujarat. The Gulf of Kachchh, aligned in an east-west direction, has depth from less than 20m at the head to about 60m at the mouth. The Gulf of Khambhat is aligned in a north-south direction and the depth ranges from 5 – 27m. The continental shelf off the west coast of Saurashtra slopes very gently to a depth of 60m up to a distance of 350 km. There are four major, five medium, 25 minor and five desert rivers in the state.

The coastal zone can be broadly divided into three geographical parts and five sub-regions based on specific inter-tidal characteristics (Table 2.1). The coastal tract of the sub-regions vary in length from 200 to 300 km and in width from 5 – 40 km. The tide on the Gujarat coast is semi-diurnal with large diurnal inequality and varying amplitudes leading to remarkable variation in different sub-regions with the minimum range of 2-3 m in the open sea stretch between Dwarka-Div segments to a maximum of 10 m in the Bhavnagar-Bharuch segment in the Gulf of Khambhat area. These currents develop a

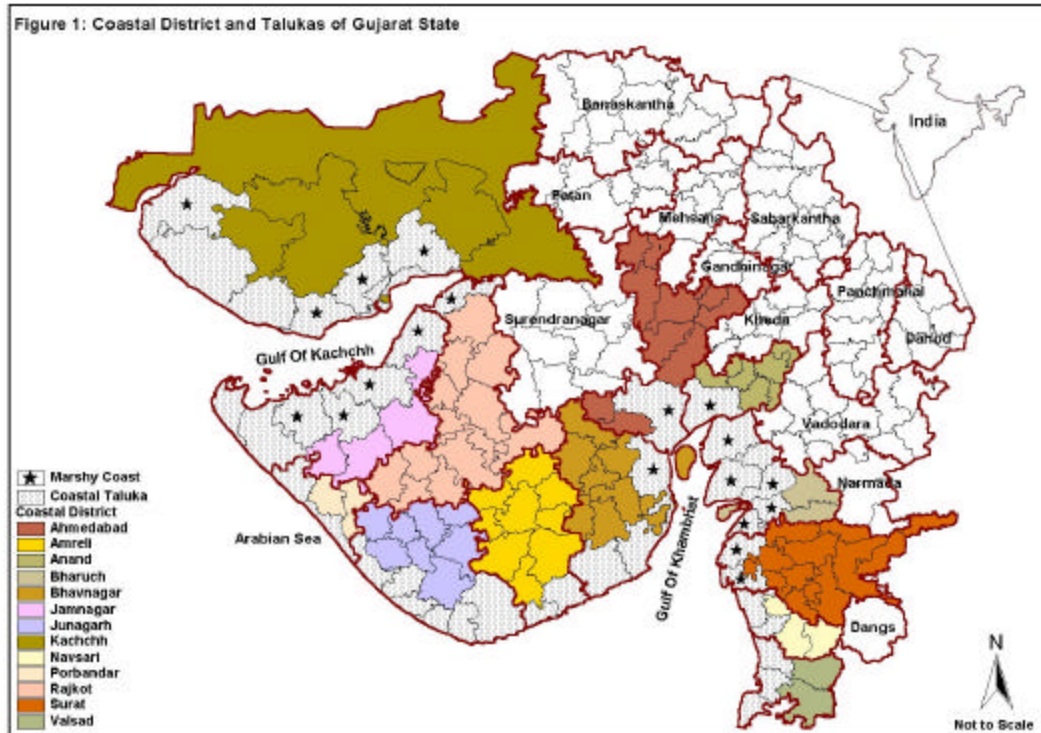


Figure 2.1: Coastal District and talukas of Gujarat

shoreward component during the SW monsoon. The soil types in the inter-tidal area are predominately sandy, silty and muddy in nature (Table 2.1) and with no contiguous rocky shore along the coast. Shallow depths, medium to high tidal amplitudes, moderately strong tidal currents with associated turbulence create a perennially homogenous one-layer water mass all along the coast.

The present monitoring was carried out along the Saurashtra coast covering three coastal districts namely Jamnagar, Porbandhar and part of Junagadh. The coast is mostly sandy in nature with discontinuous rocky shore varying in length from 100 to 500 m and no marshy coast.

Table 2.1: Coastal Zone of Gujarat Coast

Regions	Sub-region	Coastal – Km		Rainfall (mm)	Tide (m)	Soil type
		Length	Width			
Kachchh coast		300	10	250-400	3-8	Silty/Sandy
Saurashtra coast	Navalakhi – Dwarka	250	10-15	350-400	3-5	Muddy
	Dwarka–Div	300	15-25	350-550	2-3	Sandy
	Div – Bhavnagar	250	20-25	500-600	6	Sandy/Muddy
Mainland Gujarat coast	Bhavnagar–Bharuch	250	20-40	600-800	10	Silty/Muddy
	Hansot – Umbergaon	200	5-20	800-1800	8-9	Sandy/Silty

Source: Patel, 1997

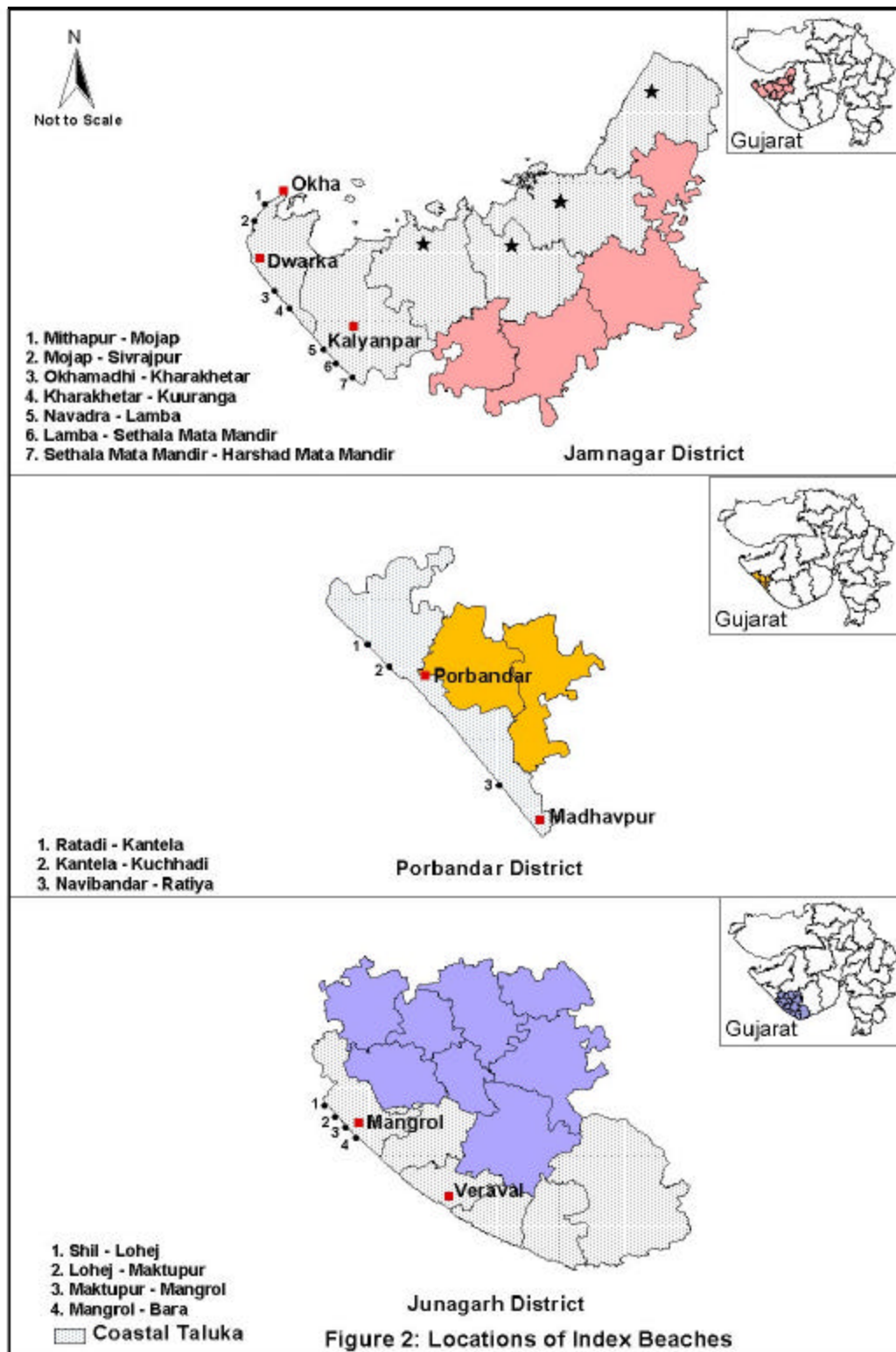


Figure 2.2: Locations of the index beaches

PROJECT APPROACH

Networking of stakeholders

One of the aims of the project was to enhance the knowledge of different stakeholders (government and non-government) by providing training towards the conservation and management of sea turtles in the state. Under this scope of work, some of the coastal stretches were selected for making the coastal populace aware of the project and of the importance of sea turtle conservation along Gujarat coast. These stretches were selected based on the following criteria: sites with higher nesting records, based on data from GOI-UNDP project (2000-01), adequate coverage of the potential coast, villages located closer to nesting beach and involvement of local communities or residents during the GOI-UNDP project.

Gujarat State Forest Department

Co-coordinating the project with the Gujarat State Forest Department (GSFD) was another objective of the project. Therefore, implementation of project was informed to State and concerned district level authorities such as the Chief Conservator of Forest (state), Conservators and Deputy Conservators of forest of Kachchh, Jamnagar, Porbandhar and Junagadh districts. Forest department field staff at the level of foresters, forest guards, and watchers were involved in nest monitoring with the guidance of their senior officers. Further, the trained staff of Kachchh and Porbandhar districts were actively involved in nest monitoring, which provided nesting data to the project.

Training workshop

Under this project, two training workshops were conducted in Kachchh and Porbandhar districts for the state forest department staff and a few interested local villagers. These workshops had lectures in *Gujarati* (the local language) to introduce the participants to the basic sea turtle biology, nesting biology, threats, and sea turtle conservation and management. A field visit was included in the afternoon session and training was imparted on sea turtle survey and nest monitoring techniques. A field guide was prepared in Gujarati with pictures and distributed to the participants.

NESTING SURVEY AND MONITORING

Selection of coastal districts

Based on the Survey of India topo sheets, four major shore types were identified along the Gujarat coast, which were pure sandy beaches, rocky shore with sandy patches, pure marshy shores, and marshy shore with sandy patches. Based on the 2000-01 sea turtle nesting survey it was found that only 520 km of coast was suitable for nesting (Sunderraj *et al.*, 2002). Though the state has the longest coastline of the country with 13 coastal districts, five districts – namely Rajkot, Ahmedabad, Kheda, Anand, Bharuch and Surat – did not have suitable nesting habitats. The remaining seven districts formed 82.06% of the coastline, of which only Kachchh, Jamnagar, Porbandhar and Junagadh had significant nesting, while Amreli, Bhavnagar and Surat coasts had very low nesting density (Table 2.2). Thus, only Jamnagar, Porbandhar and Junagadh were selected for intensive monitoring in this study.

Field survey

In Gujarat, the nesting season of the olive ridley begins in June and ends in early November, while green turtles nest between July and January (Bhaskar, 1984). However, since the hatchery programme of the Gujarat State Forest Department at Madhavpur village of Porbandhar district in 2002 showed sporadic nesting of both olive ridley and green turtles till March, it was decided to carry out nest monitoring for one full year covering all the months. Monitoring of nesting was carried out using the following methods:

1. Intensive monitoring of index beaches by the project personnel
2. Co-ordination of nesting surveys and hatchery programmes by the state forest department
3. Involvement of a few interested individuals from NGOs in index beach monitoring.

Selected index beaches were monitored from February 2004 to March 2005. All the index beaches were monitored once every week during the nesting season from June – January (including the nesting season of both olive ridley and green turtles), and only once a month outside the nesting season (rest of the months). An additional three beaches were monitored once a month for a period of nine months, while state forest department personnel also surveyed some stretches for selected periods.

Table 2.2: Status of suitable nesting habitat and its density in different districts

District	Coastal length (km)	Potential coast (km)	Total nests	Density /km
1. Kachchh	406	83.50	61	0.73
2. Jamnagar	342	111.5	324	2.91
3. Rajkot		No potential nesting habitat		
4. Junagadh/5.Porbandhar	261	170.50	279	1.64
6. Amreli	62	25.0	5	0.20
7. Bhavnagar	152	100.75	7	0.07
8. Ahmedabad		No potential nesting habitat		
9. Kheda /10 Anand		No potential nesting habitat		
11. Bharuch		No potential nesting habitat		
12.Surat		No potential nesting habitat		
13.Valsad *	90	28.50	21*	0.23*
Overall Total	1313	519.75	676	1.38

*Very old nesting locations. Source: Sunderraj *et al.*, 2002

Nest survey

During the field surveys, data related to nesting activities like nests with eggs, false crawls, crawl distance, crawl pattern and width were recorded. Nest monitoring was carried out once a week during the nesting season and once in 30 days outside the nesting season. Since monitoring interval varied from 7 -30 days, nests were categorised into three types: very fresh nests (clear wet crawl marks), moderately fresh nests (faint dry crawl marks) and old nests (no crawl marks).

Threat assessment

Threats to sea turtles were evaluated at two levels: 1. Direct threat to sea turtle populations in terms of nest predation and sea turtle mortality due to incidental catch in fishing nets 2. Threats to nesting beaches mainly sand mining, spread of oil particles and beach pollution due to domestic garbage and sea debris. Among these, only nest predation, sea turtle mortality and mining were studied quantitatively at the index beaches.

Nest predation

Nests predated by animals were enumerated; they were easily differentiated from human predation by the presence of scattered eggshells and partially consumed eggs around nests. Human predated nests were differentiated from hatched nests by relatively deep excavations in the former case and presence of other signs like foot and hand marks around the nests. Size of unhatched eggs, depth of excavated nests, crawl width and crawl patterns were checked with care (Pritchard and Mortimer, 1999) to identify the species of turtle. Predation rate was estimated by calculating relative percent of the total nests recorded with the eggs (excluding false crawls) and that showed signs of predation.

Stranding

Stranded dead turtles in different stretches were enumerated along the coast. Sex was identified by the presence of a long tail and curved claws on the fore flippers in males. Curved carapace length was

measured from the anterior tip at the point of the nuchal scute to the posterior tip of the supra-caudal. Curved carapace width was measured at the widest part of the carapace.

Sand mining

Incidence of sand mining was recorded along the index beaches and magnitude of this impact was assessed in two ways: (1) Based on the frequency of occurrence (i.e encounter rate/km), and (2) Location of mining closer to the nesting beaches. Subjective rating was given to sand mining based on the frequency of occurrence: low = 1 (two incidences/1 km), medium = (3-4 incidences /1 km) and high = 3 (> 4 incidences/1 km). Sand mining location was rated as: low = (landward side of the coast), Medium = (on the coast) and high = (on the nesting beach). Overall impact was assessed based on the relative percent of frequency of occurrence in different impact zones.

Data analysis

All the analyses were based on only very fresh nests recorded from 14 index beaches. Since monitoring frequency varied from seven days to 30 days gap, the estimated nesting density was found to be very low. Therefore nesting density was calculated based on the following factors: (1) Even though moderately fresh nests were also recorded, only very fresh nests were used for density estimation (2) Relative density was estimated based on only the number of very fresh nests and number of monitoring days for overall coastal density, and (3) Index Beach specific density was estimated by extrapolation for each month. Nesting survey carried out by the GSFD under sea turtle hatchery development has been discussed separately.

RESULTS

NETWORKING OF STAKEHOLDERS

A total of 32 stretches/villages were rapidly surveyed in four coastal districts and five types of stakeholders were identified. They were representatives of NGO groups, GSFD staff, coastal villagers, fisherfolk and others (naturalists). These different groups of people were briefed about the importance of the project and conservation of sea turtles along the Gujarat coast. They were also briefed about their role in the project and the work involved. In total 79 people of different stakeholder groups were contacted. These included 18 forest department staff (FD), 24 fisherfolk (FF), 20 coastal villagers (CV), and 12 representatives of six NGOs (Table 2.3). In addition five naturalists from the area also showed interest in being part of the sea turtle conservation network (Annexure 1).

Table 2.3: Details of Stakeholders involved in networking

Coastal district	No of villages surveyed	Types of stakeholders				
		FDS	FF	CV	NGO	O
Kachchh	6	8	4	4	3	4
Jamnagar	12	2	8	4	6	
Porbandhar	8	4	6	10	3	
Junagadh	6	4	6	2		1
Total	32	18	24	20	12	5

FDS- Forest Department Staff, FF – Fisherfolk, CV-Coastal Villagers, NGO – Non Government Organisation, O – Others

NGO involvement

During the stakeholder identification survey, a few NGOs like Panchjany Pariyavaran Trust - Bet Dwarka, Amateur Rangers Nature Club, Mithapur – Okha, Okha-Mandal Pariyavaran Vikas Trust in Jamnagar district, Kachba Unchar Kendra – Madhavpur, of Porbandhar district showed great interest in participating in the sea turtle conservation network. In addition, Gir Youth Nature Club of Amreli district

also showed interest in joining the sea turtle conservation network. Details of NGOs and other individuals identified for the sea turtle conservation network are given in Annexure 2.

Capacity building of GSFD staff

Project coordination

Before initiation of this project, concerned state and district level forest department authorities were contacted and requested for logistic and other support. Conservators of the concerned regions were also approached to carry out capacity building and training workshop for field level department staff. Numerous officers of the forest department were informed about the project (Table 2.4). The Conservators of Kachchh and Junagadh took necessary action and provided support from their concerned field level staff to carryout training workshops for Kachchh and Porbandhar districts respectively (Table 2.4).

Table 2.4: Coordination of project with GSFD authorities

District	GSFD – Authorities	
Gandhinagar	Chief Conservator of Forest – Wildlife	
	Conservator of Forest	Deputy/ Asst Conservator of Forest
Kachchh	1	1, DCF, 2 ACF
Jamnagar	1 Director Marine National Park	1. DCF
Porbandhar	1	1 DCF, 1 ACF
Junagadh	1 – Wildlife , 1- Territorial	1. DCF

Training Workshop

In this project, two training workshops were conducted in Kachchh and Porbandhar districts for the state forest staff. In total, 58 participants took part in the workshops, which included two Deputy Conservators of Forest (DCF) of Kachchh and Porbandhar districts who inaugurated the workshop in their respective areas. The other officer who participated included two Assistant Conservators of Forest (ACF) and six Range Forest Officers (RFO). The field level staff trained in this workshop were nine foresters, 30 forest guards and eight watchers (Table 2.5). In addition six representatives from NGOs also attended the workshop. As a result of these workshops and concern of the existing high nest predation pressure, the forest department in Kachchh and Porbandhar coasts initiated two sea turtle hatchery programmes each.

Table 2.5: Details of workshop participants

Participants	Kachchh coast	Porbandhar coast	Total
No. of Officers			
DCF	1	1	2
ACF	2		2
RFO	5	2	7
No. of Field Staff			
Foresters	3	6	9
Forest Guards	17	13	30
Forest watchers	4	4	8
Total	32	26	58

These workshops had three lectures in Hindi and Gujarati and a field demonstration. In the first session the participants were introduced to basic facts about sea turtles. The second was on techniques to identify turtle species and monitoring of nesting beaches. The third lecture was on sea turtle egg collection, translocation and hatchery management. They were also taught about the advantages and disadvantages

of sea turtle hatchery programmes and the need for proper management. Details of different themes covered in the workshop are given in the Table 2.6.

Table 2.6: Details of themes covered in the training workshop

Major themes	Details
Sea turtles – General	Number of species and their distribution (International, National and State); size, range, longevity, diving, long distance migration, food habits, natal homing. Temperature – sex determination etc.
Sea turtle biology	Species specific morphology, nesting activity, clutch size, egg size, crawl pattern, etc.
Sea turtle conservation	General threats - pollution, coastal development, coastal plantation, artificial illumination, beach armoring, egg predation, incidental catch, survival rate, conservation activities needed, etc.
Nest survey and monitoring	Identification of nests, morphometric measurement, identification of species and sex and predation types. Egg collection, transportation.
Hatchery management	Site selection, hatchery construction, nest relocation, nest record maintenance, hatchling monitoring and release. Advantages and disadvantages of hatcheries.

In the afternoon participants were taken to the nearest beach and data collection was demonstrated in the field. Model turtle nests were constructed on the beach with dummy eggs. The participants were trained to locate and identify the nests of different species based mainly on the nest size and crawl pattern and size. Further they were shown how to differentiate nests that were predated along with differentiation of predators based on the field tracks and signs present in and around the model nests.

A field guide was prepared in the local language (Gujarati) with pictorial representation and distributed to the participants. This guide carried information on the basic biology of the sea turtles, pictorial representation of five species of sea turtles found in Indian coastal waters with their, size, weight, crawl pattern and width, clutch size, egg size, nesting season and major distributional range. It also explained the techniques involved in species identification with key characters and morphometric measurements. Further details about the nest survey, egg collection, transportation and relocation in the hatchery were also given in the guide. Sea turtle hatchery management was also covered, with information starting from selection of hatchery sites, materials (cheap and locally available), regular maintenance of nest record, collection and release of hatchlings.

GSFD activity

GSFD staff surveyed Kachchh and part of the Porbandhar coast under their sea turtle hatchery programme for a period of four months covering a coastal distance of around 50 and 70 km respectively. Two new turtle hatcheries were established on the Porbandhar coast, in addition to the one at Madavpur, while one new hatchery was established in Kachchh coast at Pingleshwar, in addition to the one at Mandvi, which was shifted to a new site closer to the beach.

MONITORING OF INDEX BEACHES

A total of 14 index beaches were surveyed from February 2004 to March 2005, which includes seven, three and four beaches on Jamnagar (Feb 2004 – Mar 05), Porbandhar and Junagadh coasts (Mar 2004 – Mar 05) respectively. In addition, three beaches, two in Jamnagar and one in Porbandhar were monitored for a period of seven and nine months respectively (Table 2.7). Under this project, a total of 17 beaches with the varying length of 3-5 km covering a total distance of 73.5 km were monitored. All these index beaches were surveyed once a week, while additional beaches were monitored once in a month during early morning and late evenings.

Table 2.7: Details of index beaches and their monitoring schedule

Coastal districts	No. of beaches	MP (months)	MF	Total days	Beach length	Total distance (km)
JMC - IB	7	14	Weekly	56	4 – 5 km	32
PBC - IB	3	13	Weekly	52	4 – 5 km	13.5
JUC	4	13	Weekly	52	3 – 4.5 km	15
JMC-AB	2	9	Monthly	9	3 – 4 km	8
PBC-AB	1	7	Monthly	7	5 km	5
Total	17					73.5
KUC -GSFD		4				Ca. 40
PBC - GSFD		4				Ca. 80

JMC – Jamnagar Coast, PBC – Porbandhar Coast, JUC – Junagadh Coast, AB – Additional Beach, KUC – Kachchh Coast. IB-Index Beach, MP- Monitoring Period, MF- Monitoring Frequency

Nesting population

Nesting population - Index beach

During the study period, 1902 very fresh nests were recorded on the 14 index beaches. Along the Jamnagar coast, a total of 946 nests were recorded, of which 859 nests were documented from seven index beaches monitored for 13 months and 86 nests from two additional beaches monitored for only nine months. Porbandhar coast accounted for 363 nests from three index beaches monitored for 14 months and 86 nests from one additional beach surveyed for nine months, totaling 449 nests. In the case of Junagadh, three index beaches were monitored for 14 months recording 508 nests (Table 2.8).

Table 2.8: Status of nesting population along the index beaches

Coast	Nature of data	CDM (km)	NDM	Olive ridley	Green turtle	Overall
Jamnagar	7 index beaches			338	521	859
	2- additional beaches			23	63	86
Sub total		32	37	361	584	945
Porbandhar	3 index beaches			121	242	363
	1- additional beaches			22	64	86
Sub total		13.5	38	143	306	449
Junagadh	4 index beaches	15	38	164	344	508
Grand total		60.5	37.67	668	1234	1902

CDM – Coastal distance monitored, NDM – Number of Days Monitored, IB- Index Beaches, AB- Additional Beaches

Nesting population - GSFD Survey

Under sea turtle hatchery programme, GSFD staff recorded a total of 195 nests. Of that, 176 nests were reported from the Porbandhar coast and 19 from the Kachchh coast. Out of 19 nests recorded in Kachchh coast, 17 were olive ridley and two were green turtle nests. In Porbandhar, a total of 176 nests were reported from two hatcheries (Tukda Miyani – 70 and Rangbai Odadar - 106 nests). Of these, 47 were olive ridley and 127 were green turtle nests (Table 2.9). Two nests were reported as hawksbill nests based on egg size (reportedly smaller than olive ridley eggs), but this identification was not confirmed. These nests were located close to the Tukda miyani hatchery 27 km west of Porbandhar and close to Gosa village 19 km east of Porbandhar. The nests had 164 and 114 eggs respectively. There is no additional data to confirm species identification.

Table 2.9: Status of nesting reported by the Gujarat State Forest Department

Species	Coastal districts			Overall	
	Kachchh	Porbandhar-Tukda Miyani	Porbandhar – Rangbai Odadar	Porbandhar	All coasts
Olive ridley	17	24	23	47	64
Green turtle	2	45	82	127	129
Hawksbill		1	1	2*	2
Total	19	70	106	176	195

*Reported as hawksbill (see Box 1)

Species composition

Species composition - index beaches

Out of 1902 nests reported, 1234 were green turtle nests (65%), while the rest (35%) were olive ridley nests. Coast specific species composition showed the same trend with more green turtle nests, the Jamnagar coast had a comparatively lower proportion of green turtles (62%) than the Porbandhar and Junagadh coasts (68%) (Table 2.10).

Table 2.10: Species composition of different coasts

Coast	Overall	Olive ridley		Green turtle	
		Total nests	R%	Total nests	R%
Jamnagar	945	361	(38.20%)	584	(61.80%)
Porbandhar	449	143	(31.85%)	306	(68.15%)
Junagadh	508	164	(32.28%)	344	(67.72%)
Grand total	1902	668	(35.12%)	1234	(64.89)

R% - Relative per cent

Species composition- GSFD Survey

Species composition was estimated excluding the two reported hawksbill nests from Porbandhar coast. In Kachchh, out of the 19 nests, a majority were olive ridley nests (17), which formed 89% of the total. Green turtles dominated the Porbandhar coast with 73% (127 nests) out of the total 174 nests reported (Table 2.11).

Table 2.11: Status of species composition – GSFD

Species	Kachchh		Porbandhar		Overall	
	TN	R%	TN	R%	TN	R%
Olive ridley	17	89.47	47	27.01	64	33.16%
Green turtle	2	10.53	127	72.99	129	66.84%
Total	19	100.00	174	100.00	193	100.00

TN – Total Nests, R% - Relative per cent

Overall population and species composition

During the project period, monitoring of 14 index beaches and three additional beaches and survey of Kachchh and Porbandhar coast by the GSFD resulted in a total record of 2095 nests along the Gujarat coast. Out of 2095 nests reported, 732 were olive ridley and 1363 were green turtle nests. (Table 2.12).

Nest Density

Monthly beach specific nest density

Beach specific olive ridley density varied from maximum of 10.75 nests/km at Mojap-Sivrajpur beach to minimum of 5.20 nests/km at Okhamadhi-Kharakheta beach on the Jamnagar coast. Green turtle nest density showed a maximum of 17.60 nests/km and minimum of 7.60 nests/km at Navadra-Lamba and Okhamadhi-Kharakheta beaches respectively. Similar variations in beach specific density of the two species was observed along the Junagadh and Porbandhar coasts (Table 2.12).

Table 2.12: Monthly nesting density for index beach along different coasts

Index beach	BD	Olive ridley			Green turtle			Overall		
		TN	EN	MD/Km	TN	EN	MD/km	TN	EN	Total /km
Jamnagar	N= 37 Days									
1. Mithapur – Mojap	4.0	45	36	9.0	51	48	12.0	96	78	19.5
2. Mojap-Sivrajpur	4.0	53	43	10.8	74	60	15.0	127	103	25.8
3. Okhamadhi - Kharakheta	5.0	32	26	5.2	47	38	7.6	79	64	12.8
4. Kharakheta - Kuranga	5.0	36	29	5.8	66	54	10.8	102	82	16.4
5. Navadra-Lamba	5.0	62	50	10.0	109	88	17.6	171	139	27.8
6. Lamba-SMM	5.0	62	50	10.0	91	74	14.8	153	124	24.8
7. SMM-HMM	4.0	48	39	9.8	83	67	16.8	131	106	26.5
<i>Sub Total</i>	<i>32</i>	<i>338</i>	<i>274</i>	<i>8.6</i>	<i>521</i>	<i>422</i>	<i>13.2</i>	<i>859</i>	<i>696</i>	<i>21.8</i>
Porbandhar	N=38 Days									
1. Ratadi–Kantela	4.0	42	33	8.3	76	60	15.0	118	93	23.3
2. Kantela - Kuchhadi	4.5	55	45	10.0	114	90	20.0	169	133	29.6
3. Navibandar-Ratiya	5.0	24	19	3.8	52	41	8.2	76	58	11.6
<i>Sub Total</i>	<i>13.5</i>	<i>121</i>	<i>96</i>	<i>7.1</i>	<i>242</i>	<i>191</i>	<i>14.2</i>	<i>363</i>	<i>287</i>	<i>21.3</i>
Junagadh	N= 38 Days									
1. Shil –Lohej	3.0	36	28	9.3	91	72	24.0	127	100	33.3
2. Lohej – Maktupur	4.5	52	41	9.1	85	67	14.9	137	108	24.0
3. Maktupur – Mangrol	3.0	24	19	6.3	51	40	13.3	75	59	19.7
4. Mangrol – Bara	4.5	52	41	9.1	117	92	20.4	169	133	29.6
<i>Sub Total</i>	<i>15</i>	<i>164</i>	<i>129</i>	<i>8.6</i>	<i>344</i>	<i>271</i>	<i>18.1</i>	<i>508</i>	<i>401</i>	<i>26.7</i>
Overall (37.67 Days & total distance 60.50 km)		623	496	8.2	1107	881	14.6	1730	1378	22.8

IB – Index Beaches, BD-Beach Distance, TN – Total Nests, EN-Estimated Nests/month, MD – Monthly Density, SMM Sethala Mata Mandir , HMM, Harshad Mata Mandir

For example, in Porbandhar, Ratadi– Kantela and Kantela-Kuchhadi were the two beaches which recorded higher density of 8 and 10 olive ridley nests/km and 15 and 20 green turtle nests/km than the coastal average (7 olive ridley and 14 green turtle nests/km) respectively. In Junagadh, beach specific olive ridley density varied from a minimum of 633 nests to a maximum of 9.33 nests/km at Maktupur–Mangrol and Shil–Lohej beaches respectively. Shil–Lohej, Lohej–Maktupur and Mangrol–Bara were the three beaches that recorded a marginally higher density of olive ridley nests (9 nests/km) than the coastal average (8.60 nests/km). In the case of green turtle nest density, only two beaches, Shil–Lohej with 24 nest/km and Mangrol–Bara with 20 nests/km showed a higher density than the coastal estimate (18 nests/km). The overall nesting density was also high in these two beaches with 33 nests/km in Shil–Lohej and 30 nests/km in Mangrol–Bara compared to total coastal density (27 nests/km).

Nesting activity

Monitoring of nesting activity along the index beaches showed nesting of olive ridley in all the months except in the month of April 2004. Green nesting was reported in all the months except in May and June (2004). Olive ridleys showed peak nesting in July and second peak was observed in November whereas in case of green turtles, the peak was between November and January (Fig. 2.3). Sporadic nesting was observed throughout the year.

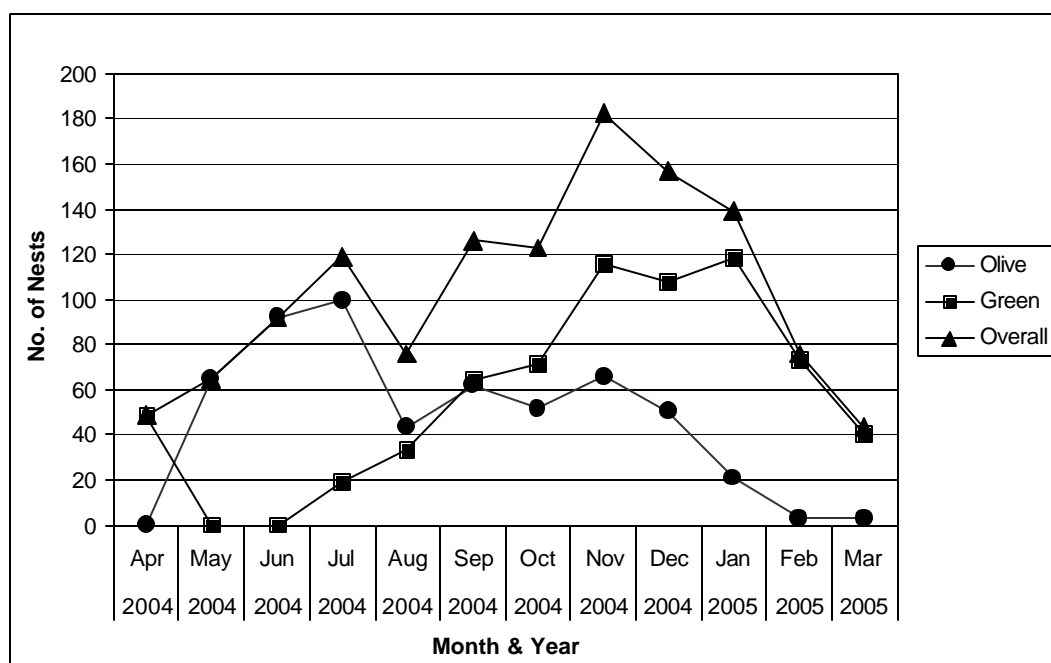


Figure 2.3: Monthly nesting activity on the Gujarat coast

THREATS

Nest predation

Nest predation and source

The rate of nest predation estimated from 14 index beaches showed that, out of 1730 nests, 755 were predated, which constituted 44% of the total. A comparison of predation pressure among the coasts revealed that Jamnagar coast was under more predation pressure (47%) than Junagadh (42%), and Porbandhar (37%) (Table 2.15). Out of the 1730 nests reported along the index beaches, 469 were

predated by animals (27%) and 286 by local people (17%). There was not much difference in animal predation among the coasts, as it varied from maximum of 28% at Jamnagar to minimum of 26% at Junagadh. Human predation also showed a little variation among the coasts with high human predation recorded at Jamnagar (19%) followed by Junagadh (16%) and Porbandhar (11%) (Table 2.13).

Table 2.13: Status of nest predation sources along the index beaches

Coasts	Overall			Human predation		Animal predation	
	TN	PN	%	PN	%	PN	%
Jamnagar	859	405	47.15	166	19.32	239	27.82
Porbandhar	363	136	37.47	40	11.02	96	26.45
Junagadh	508	214	42.13	80	15.75	134	26.38
Total	1730	755	43.64	286	16.53	469	27.11

TN – Total Nests, PN – Predated Nests

Species specific nest predation

Comparison of nest predation between species showed that olive ridley nests were under higher predation (52%) than green turtle nests (39%) (Table 2.16). Among the different coasts, Jamnagar showed more predation of green turtle nests (42%) than Junagadh (37%) and Porbandhar (35%). Porbandhar coast recorded the lowest predation pressure on olive ridley nests (37%) compared to other coasts (Table 2.14).

Table 2.14: Species specific nest predation status along the index beaches

Coasts	Olive ridley			Green turtle		
	TN	PN	%	TN	PN	%
Jamnagar	338	185	54.73	521	220	42.22
Porbandhar	121	51	42.15	242	85	35.12
Junagadh	164	87	53.05	344	127	36.92
Total	623	323	51.85	1107	432	39.02

TN – Total Nests, PN – Predated Nests

Sources of nest predation

Olive ridley nests were comparatively under more predation by animals (36%) than human being (16%). Even though, the same trend was observed in green turtles, predation by animals was comparatively lower (22%) than olive ridleys. Comparison of predation types between the coasts showed that there was not much difference in animal predation. In olive ridleys, animal predation ranged from 35% at Junagadh to 37% at Jamnagar. This ranged from 23% at Porbandhar to 22% at Junagadh for green turtles. In case of human predation, Porbandhar had the lowest predation of 8% and 12% in olive ridley and green turtles respectively. A maximum of 21% and 18% of human predation was estimated at Jamnagar and Junagadh coasts respectively (Table 2.15).

Table 2.15: Species specific and sources of nest predation

Districts	Olive ridley			Green turtle		
	TN	HPN (%)	APN (%)	TN	HPN (%)	APN (%)
Jamnagar	338	60 (17.75)	125 (36.98)	521	106 (20.35)	114 (21.88)
Porbandhar	121	10 (8.26)	41 (33.88)	242	30 (12.40)	55 (22.73)
Junagadh	164	30 (18.29)	57 (34.76)	344	50 (14.53)	77 (22.38)
Total	623	100	223	1107	186	246
Overall		16.05	35.79		16.80	22.22

TPN – Total Nests, HPN – Human Predated Nests, APN – Animal Predated Nests,

Beach specific nest predation

The magnitude of predation pressure was derived by comparing the percent of predation at index beaches with the overall coastal predation pressure. Olive ridley nest predation pressure on the Jamnagar coast ranged from a maximum of 73% at SMM-HMM beach to a minimum of 36% at Mithapur-Mojap beach. A comparison of predation pressure of index beaches with the nest predation pressure (55%) of that coast showed that among the seven beaches monitored, three beaches namely Mojap-Sivrajpur, Lamba-SMM, and SMM-HMM were under high predation with a report of 66%, 61% and 73% respectively. Nest predation on green turtles ranged between 54% in SMM-HMM and 35% in Okhamadhi-Kharakhatar beach. Higher predation pressure compared to coastal predation pressure (42%) was reported only from two beaches (SMM-HMM 54% and Lamba-SMM 46%) (Table 2.16). Since olive ridley nests were subjected to very high predation, Mojap-Sivrajpur, Lamba-SMM, and SMM-HMM were also found to have high overall predation of 50, 52 and 61% respectively (Table 2.16).

Table 2.16: Status of beach specific nest predation in different coasts

Index Beaches	Olive ridley			Green turtle			Overall		
	TN	PN	%	TN	PN	%	TN	PN	%
Jamnagar									
1. Mithapur – Mojap	45	16	35.6	51	20	39.2	96	36	37.5
2. Mojap – Sivrajpur	53	35	66.1	74	29	39.2	127	64	50.4
3. Okhamadhi – Kharakhatar	32	14	43.8	47	16	34.0	79	30	37.9
4. Kharakhatar – Kuranga	36	16	44.4	66	23	34.9	102	39	38.2
5. Navadra – Lamba	62	31	50.0	109	45	41.3	171	76	44.4
6. Lamba – SMM	62	38	61.3	91	42	46.2	153	80	52.3
7. SMM – HMM	48	35	72.9	83	45	54.2	131	80	61.1
<i>Sub Total</i>	<i>338</i>	<i>185</i>	<i>54.7</i>	<i>521</i>	<i>220</i>	<i>42.2</i>	<i>859</i>	<i>405</i>	<i>47.2</i>
Porbandhar									
1. Ratadi – Kantela	42	20	47.6	76	28	36.8	118	48	40.7
2. Kantela – Kuchhadi	55	22	40.0	114	37	32.5	169	59	34.9
3. Navibandar – Ratiya	24	9	37.5	52	20	38.5	76	29	38.2
<i>Sub Total</i>	<i>121</i>	<i>51</i>	<i>42.3</i>	<i>242</i>	<i>85</i>	<i>35.1</i>	<i>363</i>	<i>136</i>	<i>37.5</i>
Junagadh									
1. Shil – Lohej	36	14	38.9	91	25	27.5	127	39	30.7
2. Lohej – Maktupur	52	24	46.2	85	25	29.4	137	49	35.8
3. Maktupur – Mangrol	24	16	66.7	51	22	43.1	75	38	50.7
4. Mangrol – Bara	52	33	63.5	117	55	47.0	169	88	52.1
<i>Sub Total</i>	<i>164</i>	<i>87</i>	<i>53.1</i>	<i>344</i>	<i>127</i>	<i>36.9</i>	<i>508</i>	<i>214</i>	<i>42.1</i>
Total	623	323	51.9	1107	432	39.0	1730	755	43.6

TN – Total Nests, PN – Predated Nests, SMM Sethala Mata Mandir, HMM, Harshad Mata Mandir

Out of three beaches monitored along Porbandhar coast, only Ratadi-Kantela estimated more predation (48%) on olive ridley nests compared to 42% along the entire coast. Ratadi-Kantela and Navibandar-Ratiya were the two beaches that recorded higher predation (37 and 38% respectively) on green turtle nests compared to coastal pressure (35%). These two beaches reported overall higher predation pressure of 41% and 38%.

On the Junagadh coast, beach specific nest predation on olive ridley and green turtles varied from 67-39% and 47-27% respectively, while overall pressure was between 52 and 31%. Maktupur-Mangrol and

Mangrol–Bara were the two beaches which showed higher nest predation on olive ridleys (67% and 63%) and green turtles (43% and 47%) (Table 2.16). Since these two beaches had higher predation on both the species, they reported higher overall predation pressure of 51 and 52% respectively.

Stranding

Turtle mortality and density

A total of 22 dead turtles were reported along the index beaches of Jamnagar coast. Of these, 16 were green turtles and rest were olive ridleys. Eight were male and fourteen were females. Along the Porbandhar, coast a total of 10 dead turtles were recorded, of which six were green turtles and four were olive ridleys. On the Junagadh coast, out of 20 dead turtles reported, 14 were green and six were olive ridleys. There were more dead green turtles (36) than olive ridleys (16) and more females (33) than males (19) (Table 2.17).

Table 2.17: Dead turtles reported along the index beaches

Coasts	Olive ridley			Green turtle			Overall		
	M	F	T	M	F	T	M	F	T
Jamnagar	2	4	6	6	10	16	8	14	22
Porbandhar	2	2	4	2	4	6	4	6	10
Junagadh	3	3	6	4	10	14	7	13	20
Total	7	9	16	12	24	36	19	33	52

M=Male, F-Female, T - Total

The dead turtle density varied from a minimum of 0.19 to a maximum of 0.40 turtle / km for olive ridley in Jamnagar and Junagadh coasts respectively. The same for green turtles was a minimum of 0.44 at Porbandhar and a maximum of 0.93 turtle / km in Junagadh. Combined, a maximum density of 1.33 dead turtles / km was encountered in Junagadh followed by Porbandhar coast (0.74 turtle / km). The estimated overall density for the entire coast was 0.86 turtles/km (Table 2.18).

Table 2.18: Density (turtle/km) of dead sea turtles on the index beaches

Coasts	TDM	Olive ridley		Green turtle		Overall	
		NDT	TD	NDT	TD	NDT	TD
Jamnagar	32	6	0.19	16	0.50	22	0.69
Porbandhar	13.5	4	0.29	6	0.44	10	0.74
Junagadh	15	6	0.40	14	0.93	20	1.33
Total	60.5	16	0.26	36	0.59	52	0.86

NDT-No.of Dead Turtles, TD-Total Density

Size class of stranded turtles

In addition to 52 dead turtles reported on the index beaches, a further 13 were reported from the three additional beaches and other areas visited. Size class measurements were made and assessed for a total of 65 animals. The size class of olive ridleys varied from minimum of 47 cm to maximum of 68 cm with the mean of 59.8 cm. Minimum, maximum and mean size class in green turtle was 31, 106 and 88.1 cm respectively (Table 2.19). Green turtles showed more variation in size class than olive ridleys. Out 16 olive ridley measured, only one was < 50cm CCL, whereas in the case green turtles, six animals were <70cm CCL, which showed that sub adult turtles also occur in these areas.

Table 2.19: Species specific size class of stranded turtles

Species	No of Turtles	Curved carapace length (cm)			SD
		Minimum	Maximum	Average	
Olive ridley	16	47	68	59.75	5.89
Green turtle	49	31	106	88.08	16.71

Sand mining

In total, 67 locations with sand mining were recorded along the 14 index beaches. The highest mining activity (55%) was recorded along the Jamnagar coast followed by Junagadh (24%). Further, based on the encounter rate of sand mining, all the coasts reported just little more than one incidence of mining per kilometer with a range of 1.16 incidence /km in Jamnagar coast to 1.04/km in Porbandhar coast. All three coasts scored low mining impact values. The overall encounter rate of mining was 1.11 incidences/km (Table 2.20).

Table 2.20: Impact status assessment of sand mining activity along the index beaches based on frequency of occurrence

Coasts	DS-Km	Frequency of mining	R%	ER/Km	Impact scale & value
Jamnagar	32	37	55.22	1.16	Low
Porbandhar	13.5	14	20.90	1.04	Low
Junagadh	15	16	23.88	1.07	Low
Total	60.5	67	100.00	1.11	Low

DS-Distance, R%- Relative%, ER-Encounter Rate

Out of 37 sand mining events recorded on the Jamnagar coast, 46% were located on the coast and fall under medium impact zone. On the Porbandhar coast, 50% of the mining was reported on landward side and only 21% (three incidences) was on nesting beaches. In Junagadh, a maximum of eight and five mining locations were reported in medium and high impact zones, which formed 50 and 31% of the total mining locations respectively. When both medium and high impact zones are included, Junagadh was considered to be the most threatened (81.25%) followed by Jamnagar (73%). Overall, 27% of mining activities were located in the high impact zone or on the nesting beach (Table 2.21).

Table 2.21: Assessment of sand mining activity impact status along the index beaches based on occurrence at different impact zones

Coasts	No of mining locations	Frequency & Relative% of occurrence at different impact zones		
		Low	Medium	High
Jamnagar	37	10(27.03)	17 (45.95)	10 (27.03)
Porbandhar	14	7 (50.00)	4 (28.57)	3 (21.43)
Junagadh	16	3 (18.75)	8 (50.00)	5 (31.25)
Total	67	20 (29.85)	29 (43.28)	18 (26.87)

HATCHERY PROGRAMME*Hatching success*

In Kachchh, a total of 1446 eggs from 19 nests were placed in the hatchery. Of that 750 eggs hatched with a hatching rate of 52%. Species specific hatching success showed a hatching rate of 55% in olive ridleys and 39% in green turtles. Excluding the reported hawksbill nests, a total of 6970 eggs collected from 69 nests were kept in Tukda-Miyani hatchery. Overall, this hatchery had 71% hatching success and

the species specific hatching success showed a slightly higher rate for green turtles (72%) than for olive ridleys (69%) (Table 2.22). A total of 10,702 eggs were collected from 105 nests for Rangbai - Odadar hatchery, which had a overall estimated hatching rate of 74%. This hatchery reported slightly higher hatching rate for olive ridley nests (77%) than green turtles (73%).

Table 2.22: Rate of hatching success in GSFD turtle hatcheries

Area	Kachchh			P- Tukda Miyani			P- Rangbaj-Odadar		
	Eggs	H	H%	Eggs	H	H%	Eggs	H	H%
Olive ridley	1175 (17)	643	54.72	2425 (24)	1677	69.15	2514 (23)	1925	76.57
Green turtle	271 (2)	107	39.48	4545 (45)	3250	71.51	8188 (82)	5956	72.74
Overall	1446 (19)	750	51.86	6970 (69)	4927	70.69	10702 (105)	7881	73.64

Eggs - No. of eggs relocated (nests in parenthesis), H - Hatchlings, H% - Hatching success

Tagging and tissue sample collection

Permits were received to tag and collect tissue sample of both olive ridley and green turtles from the Ministry of Environment and Forest –New Delhi, Government of India. Under this project, a total of 300 Inconel tags 1005-681 have been supplied by the Madras Crocodile Bank Trust- Chennai, Tamil Nadu. However, due to delay in permission, the peak nesting period was missed. Added, due to lack of financial support the tagging activity was not able to continue. Nevertheless, tagging and tissue sample collection will be done whenever funding is available.

DISCUSSION

Nesting population

Under this project, only potential nesting beaches were monitored in selected coastal districts. Monitoring of 14 index beaches round the year in Jamnagar, Porbandhar, and Junagadh coasts (all on the Saurashtra coast) and two additional beaches for nine months by the project personnel, recorded a total of 1902 nests and partial surveys of Kachchh and Porbandhar by the Gujarat State Forest Department yielded a total of 193 nests (excluding two hawksbill nests). Bhaskar (1984) estimated a total of 2109 of both olive ridley and green turtle nests along the Saurashtra coast surveyed during August to October 1981. A recent one time survey reported 603 nests on the Saurashtra coast (Jamnagar, Porbandhar and Junagadh) out of the total 676 nests estimated for the entire Gujarat coast (including Kachchh, Amreli and Bhavnagar) (Sunderraj *et al.*, 2002). Even though the present survey recorded a higher number of nests, these estimates cannot be compared as this survey was carried out in selected beaches for whole year, while the earlier estimates were based on surveys restricted to specific time period.

Inter-annual fluctuations in nesting populations, adaptation of different survey techniques by researchers and beach specific variation, and duration of surveys makes it difficult to compare results (Schroeder and Murphy, 1999). Further, it takes many years to determine accurate population trends on nesting beaches, thus emphasising the value of long-term standardised surveys. Even though monitoring of nesting beaches is the easiest and least expensive, short-term surveys (<10 years) are inadequate to assess green turtle population due to several reasons (Chaloupka and Limpus, 2001). Green turtles are long-lived (Limpus and Chaloupka, 1997; Zug *et al.* 2002), and females skip several nesting seasons because of nutritional constrain (Bjorndal, 1997). Since Gujarat coast provides an important nesting habitat for green turtles, long term monitoring is essential to ascertain population status.

Species composition

Though four turtle species are believed to occur in the state, only the breeding of olive ridleys and green turtle has been established (Bhaskar, 1978; Kar and Bhaskar, 1982; Bhaskar, 1984; Sunderraj *et al.*, 2002), while hawksbill and leatherback turtles have been occasionally sighted by local fishermen. Even though GSFDD survey on the Porbandhar coast claimed the record of two hawksbill nests based on the egg size and a clutch size of 164 eggs, it needs further verification.

Although both green turtles and olive ridleys were reported to nest on the Kachchh coast (Bhaskar, 1984), no green turtle nests were reported in the year 2000 due to loss of nesting habitats because of beach erosion (Sunderraj *et al.*, 2002). Under this project, out of 19 nests reported by the department staff, two were green turtle nests while 17 were olive ridley nests. This study reported a total of 1363 green turtle and 732 olive ridley nests with an overall species composition of 65% and 35% respectively. This is similar to the previous survey where 68% of recorded nests were green turtles (Sunderraj *et al.*, 2002).

Potential nesting beaches

The extrapolated overall monthly density for olive ridley and green turtles was 8 nests/km and 14 nests/km respectively, which was 23 nests/km for the Gujarat coast. Beach specific monthly density showed that Mojap-Sivrajpur (26 nests), Navadra-Lamba (28 nests), Lamba-SMM (25 nests) and SMMT-HMM (27) were high nesting density beaches compared to the overall coastal density of 22 nests/km reported on the Jamnagar coast. Ratadi- Kantela (23 nests) and Kantela-Kuchhadi (29 nests) reported more nests than the coastal density of Porbandhar coast (21 nests /km). Shil -Lohej and Mangrol - Bara had higher density of 33 and 30 nests/km than the coastal estimate of 27 nests/km in Junagadh. Out of 14 beaches monitored for a full year, intensive monitoring on a daily basis of these eight high density beaches can indicate actual nesting on the coast.

Nesting season

Olive ridleys were reported to nest between June and early November on the Gujarat coast, while green turtle nesting starts in July and ends in January (Bhaskar, 1984). However, the present observation showed that both species nest till March. However, olive ridley peak nesting occurred between July and November. Sporadic nesting takes place throughout the year along the Gujarat coast. Since this is the first survey that covers the entire year and many factors influence nesting, long term observations will provide a better picture of nesting seasonality.

Threats

Nest predation

The overall estimated rate of egg predation was 44% of which 17% were by animals and 20.8% were by local people. Nest predation by animals and local people is a common threat to sea turtles along the Indian coast (Frazier, 1980; Kar and Bhaskar, 1982; Bhaskar, 1984, 1993; Rajagopalan *et al.*, 1996; Pandav *et al.*, 1998). Bhaskar (1984) mentions Waghiris and Kolis as the two communities mainly involved in egg collection for consumption and also listed dogs, jackals, monitor lizards, crabs, crows and perhaps wild pigs and hyenas as predators of turtle eggs and hatchlings on Gujarat coast. However, the estimated nest predation pressure of 44% is lower than the previous estimate of 57% (Sunderraj *et al.* 2002). The continuous monitoring of the index beaches and egg collection by the forest department for ex situ conservation might have restricted local people from egg poaching. Boulon jr (1999) states that the presence of researchers or surveillance personnel (department staffs and community activities) on nesting beaches can reduce or even eliminate egg poaching and nest predation. Overall nest predation by humans is lower (16.5%), than the previous estimate of 21% (Sunderraj *et al.*, 2002). Further, since the Porbandhar coast was frequently under surveillance for egg collection by the forest department staff it had a comparatively lower overall nest predation (37%) and human predation (11%) compared to the Jamnagar and Junagadh coasts.

Species-specific nest predation

Olive ridley nests were comparatively under more predation (52%) than green turtles (39%). Within species, olive ridleys showed a considerable difference between human (16%) and animal predation (36%). In the case of green turtles, there was not much difference between human (17%) and animal (22%) predation. The difference in animal predation between the species was mainly due to the nest depth. The olive ridley makes a shallower nest than green turtles, which is easier for animals to locate and dig. Bhaskar (1984) reported higher animal predation on olive ridleys than green turtle nests on the Kachchh coast and reasoned that green turtle nests escape predation by animals more frequently than olive ridleys for the reason stated above.

Stranding

During the survey, 52 dead turtles were encountered along the index beaches of the Gujarat coast. The rate was comparatively high along the Junagadh coast (1.33 turtle/km) compared to the other two coasts which were monitored. Incidental catch in fishing gear like trawl nets and gill nets is believed to be the major threat (Rajagopalan *et al.*, 1996). Even though 12,648 mechanized and 8370 non-mechanized fishing vessels operating on the Gujarat coast (Anon., 1995), record of only 52 dead turtles appears to be a fairly low level of mortality. The number of dead turtles reported (52) and overall density (0.86) was higher than the earlier report of 37 dead turtles, (Sunderraj *et al.*, 2002); however this survey was based on the entire year of monitoring. However, onshore surveys of turtle mortality do not provide a true picture of at-sea mortality (Epperly *et al.*, 1996).

Sand mining

Sand mining in the nesting beaches is one of the threats affecting nesting activity in terms of habitat loss and has been reported in many states on the mainland coast (Bhaskar, 1984; Abraham, 1990; Jayakumar, 2000) and in Andaman and Nicobar Islands (Andrews 2000). The mining of calcareous sandy beaches for construction and cement industries was reported in Gujarat, especially on the Saurashtra coast (Bhaskar, 1982, 1984). However, no attempts were made to quantify the impact of sand mining on nesting activity. Under this study an attempt was made to qualitatively assess this impact on nesting beaches. This study reported one mining activity per kilometer and is assessed as low impact based on the frequency of occurrence. Nevertheless, since 27% of mining takes place on the nesting beaches, it may affect the nesting activity. During the monitoring survey, false crawls were reported in the mined area in four locations. Witherington (1999) suggests that persistent removal of the beach sand disrupt stabilizing vegetation exacerbates erosion and eliminates nesting habitat. Sand mining need to be studied very intensively considering its frequency of occurrence, extent of area under mining and distance to nesting sites, etc.

Hatchery programme

Overall nest predation along Gujarat coast was reported to be 57%, while it was 100% on the Kachchh coast; other threats like sand mining on nesting beaches, spread of oil particles, sea debris and sewage pollution were also reported (Sunderraj *et al.*, 2002). Though there are many inherent problems in moving sea turtle eggs and incubating them under artificial conditions, which also results in lower hatchling rates than undisturbed natural nests (Pritchard, 1992), under certain conditions translocated nests may do better (Wyneken *et al.*, 1988).

In order to overcome high predation pressure and other threats to the nesting habitat, in addition to existing sea turtle hatchery at Madhavpur, the Gujarat State Forest Department established three hatcheries. These hatcheries were managed by department staff who were trained as part of the capacity building of government stakeholders under this project. In addition to protecting the eggs through translocation into hatcheries, regular surveying of the nesting beaches for egg collection may have reduced egg poaching by local people. The decline in overall nest predation from 57% to 44% and the decline in predation by humans on the Porbandhar coast could be attributed to increased surveillance.

CONSERVATION AND MANAGEMENT STRATEGIES

Research activities

Sea turtle surveys started in Gujarat coast in late 1970s, but most of the surveys were one time surveys and discussed possible nesting sites and threats. Two nation wide projects have been conducted to monitor nesting populations (GOFUNDP in 2002 and present projects), but need to continue in order to provide long term datasets. Lack of basic data on feeding and nesting populations and rapid coastal and maritime developments and threats to nesting populations and their habitats necessitate long term in depth study on the Gujarat coast, as data procured through short term studies or poor data can be detrimental to the conservation of these species. Hence, the following long term research activities need to be initiated to promote conservation of sea turtles in these areas. Continuous and long term monitoring of nesting populations for a period of at least five years covering 20-25 index beaches along the coastal districts of Kachchh, Jamnagar, Porbandhar and Junagadh is essential to establish nesting population status for the Gujarat coast. In addition, the following activities and studies are recommended:

- Annual survey of nesting populations covering the entire Gujarat coast during the peak nesting season of both olive ridley and green turtles to understand the nesting potential of rest of the coast.
- Monitoring of feeding populations, their distribution and the impact of incidental catch through off shore surveys
- Monitoring of migration through tagging of nesting and feeding populations which would also help to study the population structure (age and size class) and sex ratio of both species.
- Monitoring and quantitative assessment of threats related to coastal development including coastal industries, ports, cargo movements and fisheries (increase in fishing vessels and fisher populations) to understand sea turtle mortality
- Study on quantitative assessment of threats to nesting population and habitats like animal and egg predation, status of predators, sand mining and spread of invasive species, oil particles and domestic sewage pollution along the coast are very important.
- Basic research to understand nesting biology including nesting seasonality, re-nesting intervals, nesting behavior, clutch size, egg morphology, incubation period, hatching success etc.

Public awareness and training

The best approach to reducing the impact of coastal development and human impacts to nests and nesting beaches is the creation of public awareness among different stakeholders. Awareness must be created at various levels to reduce the different types and magnitude of threats. Sea turtle research and conservation activities are intensive, and therefore an integrated sea turtle conservation approach would need well trained stakeholders at different levels in order to have significant impacts on conservation. The following stakeholders need to be involved in sea turtle conservation:

- Fisherfolk and coastal residents – educating these groups regarding the conservation significance of sea turtles can help to reduce egg poaching, sewage pollution, sand mining, etc. Fisherfolk need to be trained to survey offshore feeding populations and recovery of turtles in their fishing nests.
- NGOs and students: NGOs and students of the coastal villages, talukas and districts form a massive human force that can be utilised for conducting nature education in coastal villages, nest surveys, hatchery programmes, beach cleaning etc.
- Government departments: Awareness among Port Authority, Maritime Board, Pollution Control Board, and Fisheries Department authorities can facilitate control of industrial development in sea turtle nesting and feeding habitats along the coasts, regulation of vessel movements and fishing activities, control and monitoring of pollution, etc.
- Coastal industrial sectors: They can help in control of further expansions and developments along the coast and reduce coastal pollution. In addition they can also provide infrastructural facilities and financial support for research and conservation.

- Defense force: Awareness and training of Coast Guard, Naval Force and Border Security Force (water wing) will help in coastal and nesting beach protection. They can be utilised for monitoring of offshore turtle populations, identification of feeding and breeding habitats and also for offshore tagging programmes which requires manpower, infrastructure and financial support.

Thus an intensive sea turtle conservation campaign should be carried out along the Gujarat coast. These awareness programmes need to be carried out for stakeholders at five levels. 1. Coastal communities (fisherfolk, coastal villagers, NGOs), 2. Education institutions (college and school staff and students), 3. Government departments, 4. Coastal Industrial sectors and 5. Coastal Protection Forces.

Training and capacity building of GSFD staff

Most sea turtles take over a decade to mature and year –to year fluctuations occur in nesting activities. The importance of nesting beaches can only be determined from standard, repeatable long-term data on nesting activity. In general, it is not possible to find researchers and experts for long term monitoring of the entire coast of the state. Therefore, the best option is to enhance the knowledge of forest department field staff. The importance and significance of capacity building workshops is given below:

- Even though two workshops were carried out under this project, only 58 candidates were trained in two coastal districts, which forms very small fraction when considering that 13 districts share the coastline of the state.
- The advantage of extensive training programmes is that, since all the staff can be trained in standard techniques, the services of any staff can be availed in any area.
- The trained staffs can generate quality data that can be reliable and comparable with different time periods and areas.

Considering the necessity of long term monitoring, it may be useful to carry out intensive capacity building and training workshops on sea turtle conservation and management for the field level forest department staff which would include Range Officers, Foresters, Forest Guards and Watchers. Since, department staff are frequently transferred it may be necessary to carry out workshops involving initially all the field level staff of coastal districts and later extend it to the entire state.

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Annexure 1: Details of villages surveyed for stakeholder networking

Coastal district	Details of stakeholders approached and informed about the project	
	Area	Type of stakeholder
Kachchh		
1	Pingleshwer	Fisherfolk 1, Forest Dept 2
2	Suthri	Forest Dept 2, Coastal villager 1
3	Chhachhi	Fisherfolk 1
4	Bada village	Fisherfolk 1
5	Nanalayja	Fisherfolk1 , Coastal villager 2
6	Mandvi,	Forest Dept 4, NGO 1, Coastal villager 1, Others 1
7	Bhuj	NGO 2. Others 3
Jamnagar		
1	Bet Shankodher	NGO 1
2	Okha	NGO 1
3	Mithapur	NGO 1, Forest Dept-1,
4	Mojap	Fisherfolk -4
5	Sivrajpur	NGO 1
6	Varwala	NGO 1, Coastal villager -1
7	Dwarka	Forest Dept -1, NGO 1
8	Okha – Madhi	Fisherfolk -2
9	Kuranga	Coastal villagers 2
10	Navadra	Coastal villagers 1
11	Lamba	Fisherfolk -1
12	Miyani	Fisherfolk -1
Porbandhar		
1	Visavada	Forest Dept 2,
2	Kanttela	Coastal villagers 3, Fisherfolk 1
3	Kuchhadi	Fisherfolk 1, Coastal villagers 2
4	Birla sagar	Forest Dept 1, NGO Coastal villagers 3
5	Navibandar	Forest Dept 1
6	Balej	Fisherfolk -1
7	Chingariya	Fisherfolk -1
8	Madhavpur	Coastal villagers 2, NGO -3, Fisherfolk 2
Junagadh		
1	Shil	Fisherfolk 1, Forest Dept 1
2	Rahij	Fisherfolk 1,
3	Mangrol	Coastal villagers 1, Forest Dept 2
4	Bara	Fisherfolk 4
5	Khambaliya	Coastal villagers 1
6	Chorwad	Forest Dept 1, Others 1

Annexure 2: Details of stakeholders - sea turtle conservation network

Name of the Group	Contact person	Nature of activity
Panchjany Pariyavaran Trust - Bet Dwarka – NGO	Mr. Himatsinghji. M. Vadher, Mr, Dhanshyam. H. Vadher (Chairman) Bet Dwarka, Okhamandal, Dist: Jamnagar - 361 330, Phone: (02892) 23824 & 62338.	They do nature education and awareness programmes. They also coordinate with Center for Environmental Education (CEE) and WWF (Ahmedabad) for nature education and conservation activities.
Amateur Rangers Nature Club Mithapur – Okha.	Mr. Satish H. Trivedi E-1, New Merchant Colony Mithapur 361 345 Dist: Jamnagar, Phone: 02892- 223489, MB: 9824169937 E-mail: mcafuser@tatachemicals.com	This nature club is involved in conducting environment awareness and nature education programmes for villagers, school and college students. They are involved in bird and marine animal watching and also monitoring of wetlands. They do monitor turtle nesting activity along Mithapur, Mojav beaches.
Okha-Mandal Pariyavaran Vikas Trust - NGO	Mr. Shivbha K. Subhaniya (Programme Offiver) Mr. Devisingh. S. Manek P.O Varwala – 361 335 Taluka- Dwarka Okhamandal District Jamnagar	Community based development activities like water resource development and soil conservation activities. Mr. Shivbhai is capable of writing poems and slogans on environment.
Kachba Unchar Kendra – Madhavpur	Mr. Praveen M. Solanki Mr. Santhi bhai Solanki Mr. Vinubhai Solanki Kachba Unchar Kendra, Madhavpur village, Post- Sheel, Porbandar. Phone: (0286) 2272560	A small group of 4-6 people involved in turtle hatchery programme in Madhavpur village. This hatchery is under the control of Director, Marine National Park – Jamnagar. They have more than five years of experience in turtle egg collection and hatchery management.
Gir Nature Youth Club	Amit B. Jethava President Gir Office – Main Bazar, Khambha, Amreli, District –Amreli, Gujarat 365 650 Ph: 02797-260181, Tele Fax: 02797-260121 Email: amitjethava@rediffmail.com	This nature club is actively involved in sea turtle nest monitoring and also conduct public awareness campaign on wildlife conservation
Kachchh Environment and Ecological Cell – KEE Cell	Mr. Rajni Patwa President KEE-Cell Akshyaraj Appartment Bankers Colony, Bhuj – 370 001 Ph: 02832-254600®, 230232(o) Fax: 02832-252516 Mobile: 098252 25932 Rajnipatwa@yahoo.com	This NGO group is involved in environment and community related development works. Very keen to take part in sea turtle conservation activities

Interested Individuals		
Dr. Prashant Vasa	Dr. Prashant Vasa Kutch Netramani Clinic Sea Face, Near Court' Kachchh, - Mandvi – 370 465 E-Mail vasa_prashanth@yahoo.com	He is ophthalmologist by profession; very much interested in sea turtle conservation. He conducts turtle walks along the Mandvi beach of Kachchh coast.
Fakirmohmed A. Turk	Fakirmohmed A. Turk Jamadar Wadi Village. Dharab, Mundra Taluka ,Kachchh District	He is an amateur bird watcher and wildlife lover and interested in sea turtle conservation activities
Arpit N. Devmurari	Arpit N. Devmurari 1-Navneet Society, Opp. Pankaj Scociety , Jamnagar – 361 008 Phone: (R) 0288 – 2676457, Mobile: 9426442243 E-mail: deomurari@gmail.com	BE Computer Engineer by profession: naturalist and bird watcher.