

## Sea Turtles and their Nesting Habitats in Gujarat

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Four species of sea turtles—olive ridley turtles, green turtles, leatherback turtles and hawksbill turtles—are found in the waters off Gujarat, but only the first two are known to nest along its coast (Bhaskar 1978, 1984, Kar and Bhaskar 1982). Only a few studies have reported possible nesting sites and status, threats such as egg depredation and sand mining, and killing of turtles for oil and flippers (Frazier 1980); no detailed, recent information is available. Apart from Bhaskar's early work, some notes on an international tag return (Firdous 1991), necropsies from stranded animals (Frazier 1989), and some unpublished reports by Trivedi,<sup>1</sup> little information on sea turtles has been recorded from Gujarat.

The major threat to coastal ecosystems in Gujarat has been rapid industrialisation and urbanisation along the coast; Gujarat ranks second in industrial development among the Indian states. In 1995, out of 2,258 large-scale and 170,208 small-scale industrial units, nearly 66 per cent (1,495) large-scale and 33 per cent (55,971) small-scale units were located in coastal districts. It is estimated that coastal waters here receive 215 mm<sup>3</sup> of industrial effluents and 606 mm<sup>3</sup> of domestic sewage annually (Sen-Gupta and Deshmukhe 2000).

Gujarat also has the highest number of ports in the country (one major, 11 intermediate and 29 minor ports). These ports handled 25.7 MT cargo in 1997–98, forming nine per cent of the total cargo handled in India. They are eventually expected to handle 100 MT of cargo, accounting for 25 per cent of the country's total cargo. Additionally, four single

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<sup>1</sup> Satish H Trivedi used to monitor nesting activity along Okha, Mithapur and Mojap, sending information to the Centre for Environment Education (CEE) and the WWF.

buoy moorings (SBMs) were placed in the Gulf of Kachchh to import 40–80 MT crude oil per year. The increase in shipping traffic has brought with it the associated problems of oil spills, garbage and ballast water disposal, and spillage of transport materials like coal, fertilisers, soda ash and cement—which increase pollution in and around the ports.

One of the chief factors responsible for sea turtle mortality is incidental catch in fishing gear. In 1977, there were 477 fishing centres along the Gujarat coast. This increased to 854 in 1992, an annual growth rate of 5.3 per cent. The number of active fisher folk also increased from 45,570 in 1977 to 139,608 in 1992, an annual growth rate of 14 per cent. The 1995 records of the fisheries department show a total of 12,648 mechanised and 8,370 non-mechanised vessels operating along this coast (Anon. 1995). The increase in population and vessels indicates an intensification of fishing activities, which is likely to be detrimental to sea turtles.

Barring a few stretches along the south Gujarat coast—where human habitation and coastal plantations have left no place for resting—there are no other coastal development activities like resorts, coastal highways or beach armouring.

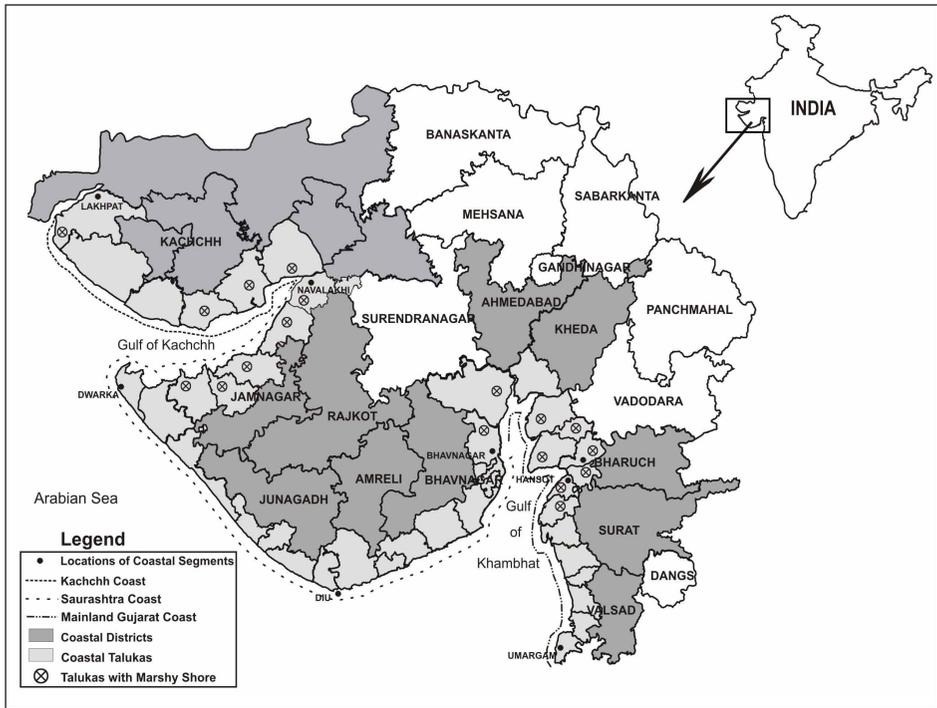
## Study Area

Gujarat is situated in the northwestern region of India ( $20^{\circ}01' - 24^{\circ}07' \text{ N}$  and  $68^{\circ}10' - 74^{\circ}28' \text{ E}$ ) and encompasses a total land area of 196,024 sq km. It has one of the longest coastlines for an Indian state, covering more than 1,600 km, and accounts for 22 per cent of the total coastline of the country. It stretches from Lakhpat in the northwest of Kachchh district to Umargaon in the south of Valsad district (Figure 1). Out of 184 talukas in 19 districts, 40 talukas in 11 districts enjoy the coast. (Among the 40 coastal talukas, 18 are very marshy and unsuitable as sea turtle nesting habitat.) The coastal region extends up to 20 km from the shoreline and covers 30,022.25 sq km in area, encompassing 59 towns and 2,802 villages. Coastal population is estimated to be nine million, about 21.8 per cent of the state's total population.

The coast is bordered by the Arabian Sea and the Gulfs of Khambhat and Kachchh. The Gulf of Kachchh, aligned in an east–west direction, has depths ranging from less than 20 m at the head to about 60 m at the mouth. The Gulf of Khambhat is aligned in a north–south direction and the depth ranges from 5–27 m. The continental shelf off the west coast of Saurashtra slopes very gently to a depth of 60 m, over a distance of 350 km. Four major, five medium, 25 minor and five ephemeral rivers annually drain 71,000 cubic metres of water into the sea.

The coastal zone can be broadly divided into three geographical parts and five sub-regions based on area-specific inter-tidal characteristics (Table 1). The coastal tract of the sub-regions varies from 200–300 km in length and 5–40 km in width. The tide is semi-diurnal with large diurnal inequality. Varying amplitudes lead to remarkable variations in different sub-regions, with a minimum range of 2–3 m in the stretch of open sea between the Dwarka–Div segments, to a maximum of 10 m in the Bhavnagar–Bharuch segments in the Gulf of Khambhat. These currents develop a shoreward component during the southwest monsoon. The soil types in the inter-tidal area are predominantly sandy, silty and muddy in nature (Table 1) with no contiguous rocky

shore along the coast. Shallow depths, medium-to-high tidal amplitudes, and moderately strong tidal currents with associated turbulence create a perennially homogenous one-layer water mass all along the coast.



**Figure 1.** Coastal districts and talukas of Gujarat.

**Table 1.** Coastal zones of Gujarat

Region/ Coast	Sub-region	Length (km)	Width (km)	Rainfall (mm)	Tide (m)	Soil type
Kachchh		300	10	250–400	3–8	Silty/Sandy
Saurashtra	Navalakhī–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	Bhavnagar–Bharuch	250	20–40	600–800	10	Silty/Muddy
Gujarat	Hansot–Umbergaon	200	5–20	800–1,800	8–9	Sandy/Silty

(Source: Patel, 1997)

**Methods**

FIELD SURVEY

Prior to the field survey, potential nesting beaches (i.e. continuous and discontinuous sandy beaches, interrupted by rocks/marshes) were identified from topographical maps (1:50,000) published by the Survey of India. Information from Bhaskar (1978), Kar and Bhaskar (1982), Bhaskar (1984) and interviews with fisher folk during the reconnaissance survey substantiated the occurrence and distribution of nesting beaches.

Since the breeding season of olive ridleys and green turtles typically occurs from June to January (Bhaskar 1984), the survey was carried out in August–January 2000 to enable comparisons between Kachchh, Jamnagar, Junagadh, Amreli, Bhavnagar and Valsad districts, all of which had nesting habitats. However, since there was no prior published information on nesting in Amreli and Valsad, these districts were selectively surveyed based on information given by fisher folk and local villagers. The entire coast was surveyed once. Field surveys were carried out on foot early in the morning and at night. The areas covered were characterised by continuous sandy shore, rocky shore with sandy patches, and marshy shore with sandy patches, excluding totally marshy patches.

During the field survey, data pertaining to nests with eggs, false crawls, crawl distance, crawl pattern and width were recorded. The nests encountered were categorised into fresh nests (with clear crawl marks), old nests (faint crawl marks), and very old nests (no crawl mark). Nesting density was calculated based on the number of nests with eggs recorded per kilometre.

#### NEST PREDATION

Nests predated upon by animals were easily differentiated from those predated upon by humans, with the presence of scattered eggshells and partially consumed eggs around the former. Human-predated nests were differentiated from hatched nests by relatively deeper excavations in the former case. Since the olive ridley is comparatively smaller (track width: 70–80 cm, track type: asymmetrical and tail drag mark lacking or inconspicuous, egg size: 37–42 mm) than the green turtle (track width: 100–130cm, track type: symmetrical and tail drag mark present as solid/broken line, egg size: 40–46 mm) (Pritchard and Mortimer 1999), the size of unhatched eggs, depth of excavated nests, crawl width and crawl patterns were checked with care to identify the species of turtle. Predation rate was estimated by calculating a relative per cent, by dividing the total nests recorded with eggs (excluding false crawls) by those that showed signs of predation.

#### STRANDING

Dead turtles, stranded in different stretches, were counted along the coast. Morphometric measurements were taken and key characteristics were checked to identify the species.

#### OTHER THREATS

Industry-related threats, spread of oil particles (gravel-size tar balls), habitat destruction (sand mining), pollution due to domestic sewage and sea debris were recorded. Existing threats along the coast were assessed using a subjective qualitative rating: low (1), medium (2) and high (3). Whenever oil particles, garbage and sea debris were encountered on the beach, its rate of occurrence was assessed using a 10-m radius plot. If the spread was < 25 per cent, it was rated as low=1, 25–50 per cent as medium=2, and >50 per cent as high=3. Sand mining was rated based on frequency of occurrence: low=1 (one incidence/5 km), medium=2 (two incidences/5 km) and high=3 (>three incidences/5 km). The total of the values for all the threats was averaged and again categorised from low to high (1–3) to facilitate overall comparison between districts and regions.



## Results

### SHORE EVALUATION

Out of the 1,313 km surveyed, the potential nesting area extended to only 520 km (39.6 per cent). Even excluding the districts that were selectively surveyed, there was no change in the proportion of total coast available for nesting (466 km or 40.2 per cent). Among the districts surveyed, Bhavnagar and Junagadh had large potential nesting coasts, 66.3 per cent and 65.3 per cent respectively (Table 2).

**Table 2.** Availability of active nesting area along the Gujarat coast.

Coastal districts	Length of coastline (km)	Distance surveyed (km)	Per cent of nesting area
Kachchh	406	83.5	20.56
Rajkot	No potential nesting habitat		
Jamnagar	342	111.5	32.6
Junagadh	261	170.5	65.33
Amreli	62	25*	40.32
Bhavnagar	152	100.75	66.28
Ahmedabad	No potential nesting habitat		
Kheda	No potential nesting habitat		
Bharuch	No potential nesting habitat		
Surat	No potential nesting habitat		
Valsad	90	28.5*	31.67
<b>Total</b>	<b>1,313</b>	<b>519.75</b>	<b>39.58</b>
Relative per cent #	1,161	466.25	40.16

\*selectively surveyed

# excluding selectively surveyed districts

### NESTING POPULATION

A total of 676 nests were encountered during this survey, of which 451 nests (68 per cent) were of green turtles and the rest were of olive ridleys. Nesting of leatherback and hawksbill turtles was not recorded. Even though both green turtle and olive ridley nesting had been reported earlier on the Kachchh coast (Bhaskar 1984), only olive ridley nests were recorded during this survey, and this was the only species recorded from Bhavnagar district as well. Cyclones in two consecutive years in Kachchh (1998 and 1999) had resulted in severe beach erosion towards the western side of Mandvi, which has been documented as a nesting site for both species (Kar and Bhaskar 1982, Bhaskar 1984).

The districts with the greatest number of olive ridley nests were Jamnagar (90), Kachchh (61) and Junagadh (54), while green turtle nests were most abundant in Jamnagar (234) and Junagadh (225). Nesting was very poor in Amreli (5) and Bhavnagar (7) (Table 3). Though only 28.5 km out of 90 km were surveyed in Valsad district, one-month-old to one-year-old nests were recorded by locals in 10 of 18 locations. Therefore, it is necessary to survey this coast within the nesting season.

## NESTING DENSITY

Nesting density was calculated as an index of relative nesting in various districts. Since counts were based on single surveys of the beaches, these do not represent absolute densities. Nor are olive ridley and green turtle densities comparable since the persistence of tracks may vary. The density of olive ridley and green turtle nests for the entire area surveyed was 0.44 and 0.94 nests/km respectively (Table 3). The highest density of olive ridley nests was in Jamnagar (0.81), followed by Kachchh (0.73); while for green turtles, nesting density was highest in Jamnagar (2.10) and Junagadh (1.32) (Table 3).

The estimated overall nesting density for Jamnagar and Junagadh was 0.51 nest/km for olive ridleys and 1.63 nests/km for green turtles. This estimate is much lower than Bhaskar's (1984) estimate—3.95 for olive ridleys and 3.88 for green turtles, also based on single surveys between August and October—for the western part of Saurashtra peninsula (between Okha to Veraval), a considerable area of which comprises these two districts. Egg-collection (for the hatchery programmes run by the forest department), gaps in surveys and inadequate survey during peak nesting season may have contributed to the low estimates. Since these stretches have higher nesting densities than other districts, index beaches need to be monitored for the entire length of the nesting season.

**Table 3.** Estimated nesting density for different districts. Estimates are based on a single survey, and densities are based on number of nests per km.

District	Coast surveyed (km)	Olive ridley nests		Green turtle nests		Total nests	
		number	density	number	density	number	density
Kachchh	83.5	61	0.73	0	0	61	0.73
Jamnagar	111.5	90	0.81	234	2.1	324	2.91
Junagadh	170.5	54	0.32	225	1.32	279	1.64
Amreli	25	3	0.12	2	0.08	5	0.2
Bhavnagar	100.75	7	0.07	0	0	7	0.07
<b>Total</b>	<b>491.25</b>	<b>215</b>	<b>0.44</b>	<b>461</b>	<b>0.94</b>	<b>676</b>	<b>1.38</b>
Valsad		10*		11*			

\* old nesting locations

## KEY NESTING SITES

## Kachchh coast

In total, 83.5 km were surveyed during the night. The coastal stretches surveyed varied from 3.5 km in Jakhau area to 13 km between Bada–Layja Nana and Layja Nana–Mandvi. The number of nests in each stretch varied from 1 to 22 nests. The estimated nest density ranged from a low of 0.09 nests/km between Chhachi and Bambhdai to a high of 1.69 nests/km between Layja Nana and Mandvi.

Among the top five stretches, the area between Bada–Layja Nana and Layja Nana–Mandvi showed comparatively higher densities (1.61 and 1.69 nests/km respectively) than other stretches. Even though the Kachchh coast showed very low density, monitoring of at least the top three nesting stretches (Layja Nana–Mandvi, Bada–Layja Nana and Bambhdai–Bada, which had 50 out of 61 nests reported for the entire coast)

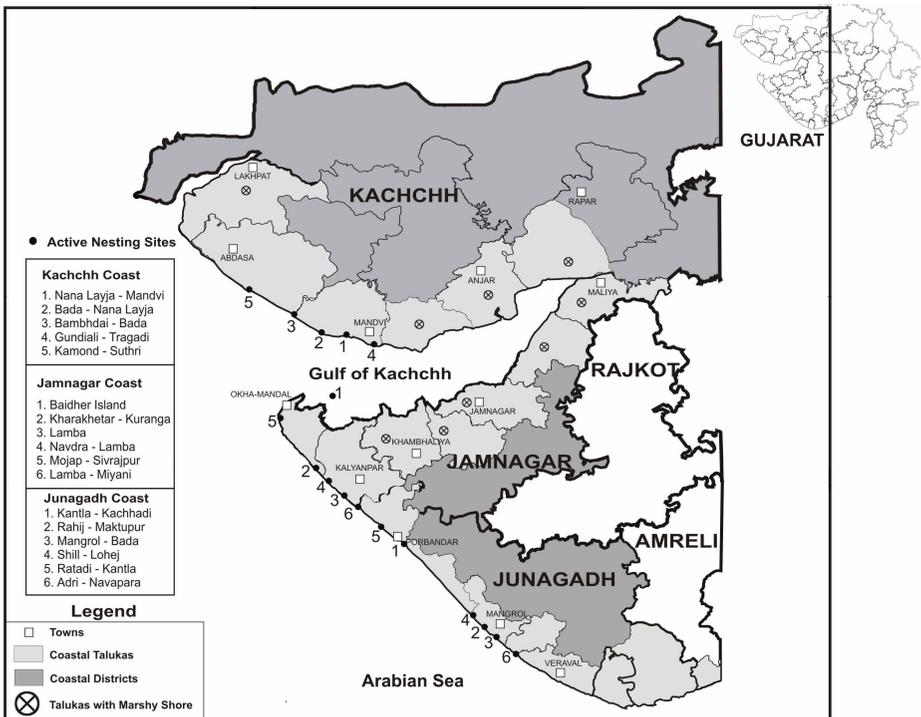


remains essential (Table 4, Figure 2). The Kachchh coast, due to its position in the funnel-shaped gulf, experiences high wind velocities. The heavy wind-blown sand covers olive ridley nests in a few days making them untraceable (Bhaskar 1984), which could also be a reason for the low encounter of nests during this survey.

**Table 4.** Status of nest abundance and density along the Kachchh coast.

Coastal stretch	Distance surveyed (km)	No of Nests recorded		Total Nests	Density/km
		olive ridley	green turtle		
Jakhau	3.5	0	0	0	0
Pingleshwer–Kamond	8.5	1	0	1	0.12
Kamond–Suthri	5	2	0	2	<b>0.4 (5)</b>
Suthri–Chhachhi	10.5	3	0	3	0.28
Chhachhi–Bambhdai	10.5	1	0	1	0.09
Bambhdai–Bada	8	7	0	7	<b>0.87 (3)</b>
Bada–Layja Nana	13	21	0	21	<b>1.61 (2)</b>
Layja Nana–Mandvi	13	22	0	22	<b>1.69 (1)</b>
Mandvi–Gundiali	6	0	0	0	0
Gundilal–Tragadi	5.5	4	0	4	<b>0.73 (4)</b>
<b>Total</b>	<b>83.5</b>	<b>61</b>			<b>0.73 (4)</b>

The top five high-density stretches are highlighted and their rank is given in parenthesis.



**Figure 2.** Locations of top five nesting sites.

## Jamnagar coast

A total of 19 stretches of beach were surveyed, the distance varying from 2.5 km (Baidher Island) to 14 km (Kalpat–Navodra). The maximum density (14.4 nests/km) was recorded in Baidher Island, while minimum density (0.54 nests/km) was reported between Baradi and Gorinja. The Kharakheta–Kuranga stretch had the second highest density of 7.2 nests/km (Table 5, Figure 2). Species-specific density showed maximum density of olive ridleys in Baidher Island (13 nests/km), and green turtles between Kharakheta–Kuranga (5 nests/km). Baidher Island is free from human activity and can be used for long-term monitoring and biological studies. Bhaskar (1984) recorded upto 76 nests in a single night at this site and also discussed the undisturbed nature of the habitat.

**Table 5.** Status of nest abundance and density along the Jamnagar coast.

Coastal stretch	Distance surveyed (km)	No of nests recorded (density/km)		Total nests	Density/km with rank order
		olive ridley	green turtle		
Pirotan Island	3	0	0	0	0
Baidher Island	2.5	33 (13.2)	3 (1.2)	36	<b>14.4 (1)</b>
Bet Shankodher	3	6 (2)	3 (1)	9	3
Okha–Mithapur	12.5	5 (0.4)	9 (0.72)	14	1.12
Mithapur–Mojap	6.5	0	21 (3.23)	21	3.23
Mojap–Sivrajpur	4	2 (0.5)	18 (4.5)	20	<b>5 (4)</b>
Sivrajpur–Varwala	6	5 (0.83)	9 (1.5)	14	2.33
Varwala–Rupen Bandar	4	1 (0.25)	2 (0.5)	3	0.75
Dwarka–Baradi	6.5	0	7 (1.07)	7	1.08
Baradi–Gorinja	5.5	0	3 (0.52)	3	0.54
Gorinja–Navi Dhrewad	4.5	1 (0.22)	4 (0.89)	5	1.11
Navi Dhrewad–Okha Madh	5	4 (0.8)	16 (3.2)	20	4
Okha Madh–Kharakheta	5	7 (1.4)	15 (3.5)	22	4.4
Kharakheta–Kuranga	5	10 (2)	26 (5.2)	36	<b>7.2 (2)</b>
Kuranga–Kalpat	6	7 (1.17)	14 (2.33)	21	3.5
Kalpat–Navodra	14	0	0	0	0
Navodra–Lamba	7	2 (0.29)	33 (4.71)	35	<b>5 (4)</b>
Lamba	5	5 (1)	24 (4.8)	29	<b>5.8 (3)</b>
Lamba–Miyani	6.5	2 (0.3)	27 (4.15)	29	<b>4.46 (5)</b>
<b>Total</b>	<b>111.5</b>	<b>90</b>	<b>234</b>	<b>324</b>	

The top five high-density stretches are highlighted and their rank is given in parenthesis.

## Junagadh coast

A total of 31 stretches of beach were surveyed, varying in length from 2–13 km, and covering 170.5 km. There were no nests in eight of these stretches. Stretch-specific nest density varied from a minimum of 0.2 to a maximum of 7.8 nests/km (Table 6). The maximum density (3.2 nests/km) for olive ridleys was recorded between Rahij and Maktupur; the maximum density for green turtles was 7.8 nests/km in Kantla–Kachhadi.

**Table 6.** Status of nest abundance and density along the Junagadh coast.

Coastal stretch	Distance surveyed (km)	No of nests recorded (density/km)		Total nests	Density/with rank order
		olive ridley	green turtle		
Miyani–Bhavpara	5	3 (0.6)	10 (2)	13	2.6
Bhavpara–Visavada	5	2 (0.4)	15 (3)	17	3.4
Visavada–Ratadi	5	0	9 (1.8)	9	1.8
Ratadi–Kantla	5	0	24 (4.8)	24	<b>4.8 (4)</b>
Kantla–Kachhadi	5	0	39 (7.8)	39	<b>7.8 (1)</b>
Kachhadi–Bara Utar	5	0	1 (0.02)	1	0.2
Birla Sagar–Gosabara	12	0	5 (0.42)	5	0.42
Gosabara–Naviband	13	1 (0.07)	5 (0.36)	6	0.46
Navibandar–Ratia	6	10 (1.67)	2 (0.33)	12	2
Ratia–Balej	6	4 (0.66)	10 (1.67)	14	2.33
Balej–Gorsar	6	4(0.67)	5 (0.83)	9	1.5
Gorsar–Chingariya	5	4 (0.8)	1 (0.2)	5	1
Chingariya–Madhavpur	6	0	1 (0.17)	1	0.17
Madhavpur–Antroli	6	0	6 (1)	6	1
Antroli–Shill	6	0	0	0	0
Shill–Lohej	3	1 (0.33)	14 (4.69)	15	<b>5 (3)</b>
Lohej–Rahij	2	0	0	0	0
Rahij–Maktupur	2.5	8(3.2)	9 (3.6)	17	<b>6.8 (2)</b>
Maktupur–Mangrol	3	0	0	0	0
Mangrol–Bada	5	6 (1.2)	28 (5.6)	34	<b>6.8 (2)</b>
Bada–Khambaliya	6	0	0	0	0
Khambaliya–Chorwad	6.5	1 (0.15)	10 (1.53)	11	1.69
Chorwad–Vadodara	4	0	6 (1.5)	6	1.50
Vadodara–Adri	3	0	0	0	0
Adri–Navapara	3	5 (1.67)	6 (2)	11	<b>3.67 (5)</b>
Navapara–Jhalashwar	4.5	1 (0.22)	5 (1.11)	6	1.33
Somnath–Hirakot	6	1 (0.17)	8 (1.33)	9	1.5
Hirakot–Suthrabada	5	0	0	0	0
Suthrabada–Vadodarajala	5	3 (0.6)	6 (1.2)	9	1.8
Vadodarajala–Dhamlej	10	0	0	0	0
Dhamlej–Mul Dwarka	6	0	0	0	0
<b>Total</b>	170.5	54	225	279	

The top five high-density stretches are highlighted and their rank is given in parenthesis.

## Threats

### NEST PREDATION

Nest predation was assessed only for the three districts which had key nesting sites. Excluding the 37 olive ridley nests collected by the forest department as part of its

hatchery programme in Kachchh district, the overall estimated rate of egg predation was 57 per cent, of which 36.2 per cent was by animals and 20.8 per cent by local people (Table 7). Nest predation 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). The Waghiris and Kolis are the two main communities involved in collecting eggs for consumption in Gujarat.

Egg loss due to animal predation is comparatively higher here than in Rushikulya on the Orissa coast, where it is estimated at 20–30 per cent (Pandav et al 1998). Kachchh is a sporadic nesting area and all the nests were predated (100 per cent) by jackals (*Canis aureus*). Bhaskar (1984) also reported high levels of animal predation along the Kachchh coast. Comparison between Jamnagar and Junagadh showed more predation (75 per cent) in Jamnagar. Bhaskar (1984) mentioned dogs, jackals, monitor lizards, crabs, crows, and perhaps wild pigs and hyenas, as predators of turtle eggs and hatchlings on the Gujarat coast. During our survey, jackals were sighted on 17 occasions along the coast. These have been reported to predate eggs while turtles are still ovipositing (Madhavpur villagers, pers. comm.).

#### Species-specific nest predation

Species-specific analysis revealed that the depredation rate for olive ridley nests (62 per cent) was higher than for green turtles (55.33 per cent). Within species, depredation in olive ridley nests exhibited a considerable variation: humans (18.45 per cent) and animals (43.45 per cent). In the case of green turtles, there was not much difference between human (22 per cent) and animal (33 per cent) predation (Table 7). The difference in animal predation rates was mainly due to the difference in nest depths. Olive ridleys dig shallower nests than green turtles, and are easier for animals to locate and dig. Bhaskar (1984) had reported that out of 28 animal-predated nests along the Kachchh coast, 21 were of olive ridleys.

**Table 7.** Overall and species-specific nest predation in different districts.

Districts	Olive ridley			Green turtle			Overall		
	TN	HP(%)	AP(%)	TN	HP(%)	AP(%)	TN	HP(%)	AP(%)
Kachchh	24	37.5 (9)	62.5 (15)	0	0	0	24	37.50 (9)	62.5 (15)
Jamnagar	90	12.22 (11)	41.11 (37)	234	23.5 (55)	42.3 (99)	324	20.37 (66)	41.09 (136)
Junagadh	54	20.37 (11)	38.89 (21)	225	20 (45)	24.44 (55)	279	20.07 (56)	27.24 (76)
<b>Total</b>	<b>168</b>	<b>18.45 (31)</b>	<b>43.45 (73)</b>	<b>459</b>	<b>21.79 (100)</b>	<b>33.55 (154)</b>	<b>627</b>	<b>20.81 (131)</b>	<b>36.20 (227)</b>
Overall predation	TN	TPN	PR	TN	TPN	PR			
	168	104	61.9%	459	254	55.33%			

TN=Total Nests; HP=Human Predation (in per cent); AP=Animal Predation (in per cent); TPN=Total no. of Predated Nests; PR=Predation Rate (in per cent). The number of predated nests is within parenthesis.



## STRANDING

During the survey, 37 dead turtles were encountered along the coast of Gujarat. The rate was comparatively high along the Kachchh coast (0.12 turtles/km). Although no green turtle nesting was recorded along the Kachchh coast, five dead turtles were found (Table 8).

**Table 8.** Number of dead stranded turtles recorded in different districts

Districts	No. of dead turtles recorded		Total	Distance covered (km)	Stranding rate (turtles/km)
	green turtle	olive ridley			
Kachchh	5	5	10	83.5	0.12
Jamnagar	10	1	11	111.5	0.1
Junagadh	13	1	14	205.5	0.07
Amreli	–	0	0	0	25
Bhavnagar	0	2	2	100.75	0.02
<b>Total</b>	<b>28 (0.05)</b>	<b>9 (0.01)</b>	<b>37</b>	<b>526.25</b>	<b>0.07</b>

Species-specific stranding density is given in parenthesis.

Incidental catch in fishing gear, like trawl nets and gill nets, is the major threat (Rajagopalan et al 1996). Even though more than 20,000 fishing vessels operate along the Gujarat coast (Anon 1995), only 37 dead turtles were counted, which is a fairly low level of mortality. Over 100,000 dead turtles have been counted along the Orissa coast in the past eight years (Pandav et al 1998, Operation Kachhapa, unpubl. data). Epperly et al (1996) suggested that onshore surveys of turtle mortality do not provide a true picture of at-sea mortality. Therefore, offshore surveys of fishing vessels may give a better picture of turtle mortality due to incidental catch.

## OTHER THREATS

Other threats recorded during the field survey were the spread of oil particles (gravel-sized tar balls), sand mining, pollution due to domestic sewage, and sea debris. Spread of oil particles was found to be highest along the Jamnagar coast with a rating of 3 (high) followed by Kachchh (2=medium). The import of oil through the Gulf of Kachchh, and the establishment of SBMs to import crude oil are major sources of oil pollution in Kachchh and Jamnagar.

High frequency of sand mining was recorded along the Jamnagar (3=high) and Junagadh (3=high) coasts (Table 9). This is known to affect nesting habitats all over the world (Lutcavage et al 1997) as well as in India (Bhaskar 1984, Jayakumar 2000, Andrews 2000). Presence of cement industries and rapid urban development are some reasons for severe sand mining in Jamnagar and Junagadh coasts as mentioned by Kar and Bhaskar (1982) and Bhaskar (1984). A combination of all such threats revealed that Jamnagar (3) was subject to high disturbance.

Marine debris has been reported in the digestive tracts of many sea turtles (Lutcavage et al 1997). Accumulation of domestic sewage and marine debris was reported all along the Gujarat coast, with moderate to high levels of debris accumulation in Junagadh and Bhavnagar areas respectively. The presence of the highest number of ports (41), rapid

increase in cargo movement, and the establishment of one of the largest ship-breaking yards in India (at Alang in Bhavnagar) are the main causes of pollution. Accumulation of sewage and marine debris along the coasts leads to the loss of nesting habitat and increases chances of ingestion of debris by turtles.

**Table 9.** Existing threats and their values among the districts

Districts	Types of threats			Total	Final value
	Spread of oil particles	Sand mining	Domestic waste and sea debris		
Kachchh	2	1	1	4	1.33=2
Jamnagar	3	3	1	7	2.33=3
Junagadh	1	3	2	6	2=2
Bhavnagar	1	1	3	5	1.67=2

Assessment for final value (0–1=1) (1.1–2=2) (2.1– 3=3)

## Recommendations

### Research and monitoring

No data on population sizes, feeding biology, habitat use or migratory patterns is available for sea turtles along this coast. Surveys of nesting habitats and long-term monitoring in offshore waters during breeding season is essential. The present study identified active nesting beaches along the Kachchh, Jamnagar and Junagadh coasts. Monitoring of these beaches for a period of five years is suggested to create a database and to understand the population trends. It is now crucial to monitor and study feeding populations, habitat use, migration patterns, mortality due to incidental catch and the impact of developmental activities and biotic pressures on nesting beaches.

### Public awareness and training

Loss of habitat due to industrial activity and nest depredation are of serious concern. Much can be achieved through public education. Awareness must be created at various levels—among local NGOs, fisher folk and coastal residents—in order to grasp the hazards faced by these threatened species. Training programmes on basic turtle biology, conducting surveys and managing hatcheries need to be conducted for school and college students, and volunteers and employees of NGOs, all of who can contribute to running the hatchery programmes and monitoring activities. Offshore surveys require enormous time, labour, logistics and financial support. Providing proper training to deep-sea fisher folk, with simple data sheets in the local language, can generate enormous amounts of information on offshore populations.

### Establishment of hatcheries

Hatchery management is a common practice where there is severe threat to eggs and hatchlings. Given the rates of depredation, it is suggested that hatcheries be established at Veraval along the Junagadh coast, and one each at Mithapur and Kuranja along the Jamnagar coast, in addition to the two existing hatcheries along this coast. Establishment of smaller hatcheries will facilitate safe and timely transport of eggs, improve management, and even reduce egg-loss due to predation. Hatcheries can act as centres



to train local villagers, fisher folk and school children. Identifying egg poachers and providing them employment in hatcheries, and survey and monitoring activities will mitigate threats and gain support for conservation.

#### Educating decision-makers

Government departments—like the Port Authority, Maritime Board, Pollution Control Board, Border Security Force (water wing), the navy and coast guard, fisheries and customs departments—and the industrial sector are high-level stakeholders in marine areas. Creation of awareness among these groups can help in safeguarding the coastal and marine environment with timely and appropriate decisions in the following areas:

- \* control of development in active nesting and feeding areas along the coast,
- \* regulation of vessel movements and fishing activities,
- \* control and monitoring of pollution, and
- \* help in providing financial and infrastructural facilities for research and conservation.

#### Habitat protection

This study revealed the impacts of nest depredation and poaching, fishery-related mortality, sand mining, pollution due to oil particles, domestic sewage and sea debris. Strict vigilance and patrolling of potential nesting beaches by the forest department with the help of local villagers needs to be carried out to minimise egg poaching and sand mining. The coast guard and navy can be involved to monitor and regulate trawling, and to clean liquid cargo (oil and petroleum products) vessels to prevent accidental spillage of oil in offshore waters. An effective and regular pollution and environmental monitoring survey (both offshore and onshore) needs to be instituted as a joint venture between the state forest department and Pollution Control Board. The loading and unloading of oil and other products in the port area needs to be strictly monitored by the Port Authority and Maritime Board.

#### Protected Areas

A major action towards the conservation of turtle population is identifying and notifying potential nesting beaches and offshore feeding and mating areas as protected areas that will curb developmental activity. The stretch covering 45 km from Mandvi to Chhachhi village in Kachchh, 55 km east of Navi Dhrewad to Miyani in Jamnagar, and the 50-km stretch from west of Shill to Jhalashwar in Junagadh are important nesting beaches and must be protected from developmental activities.

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