Important nesting habitats of olive ridley turtles *Lepidochelys olivacea* along the Andhra Pradesh coast of eastern India

Basudev Tripathy, Kartik Shanker and B. C. Choudhury

Abstract Olive ridley turtles *Lepidochelys olivacea* nest along the east and west coasts of India, with major mass nesting beaches in the state of Orissa. The coast of Andhra Pradesh, the state immediately south of Orissa, has sporadic nesting of olive ridley turtles and is believed to form part of the migratory route of the turtles that nest in Orissa. A survey of nesting beaches and offshore waters of the Andhra Pradesh coast was carried out from November 2000 to April 2001. Preliminary interviews and secondary data were used to determine potential nesting beaches. During January–March 2001 intensive surveys of seven beaches and monthly surveys of the rest of the coast provided a lower bound of *c*. 4,000 nests along the Andhra Pradesh coast. Nesting densities were higher at beaches near river mouths, at 60–100 nests km^{-1} in northern and central Andhra Pradesh, and 15–20 nests km^{-1} in southern Andhra Pradesh. Sightings and incidental catch in experimental trawls indicated the presence of olive ridley turtles in offshore waters. Fisheries related mortality is the major threat to the species, with nearly 1,000 dead turtles being washed ashore during January–March, but depredation of eggs by humans and feral animals was also widespread. Conservation efforts need to address these issues, and also the effects of coastal development and artificial illumination, especially at beaches that support relatively high densities of nesting olive ridley turtles.

Keywords Andhra Pradesh, bycatch, India, *Lepidochelys olivacea*, nest density, olive ridley turtle, Orissa.

This paper contains supplementary material that can only be found online at http://journals.cambridge.org

Introduction

Five species of marine turtles have been reported from Indian waters: the leatherback *Dermochelys coriacea*, hawksbill *Eretmochelys imbricata*, loggerhead *Caretta caretta,* green *Chelonia mydas* and olive ridley turtle *Lepidochelys olivacea* (Kar & Bhaskar, 1982). All except the loggerhead turtle have been reported from the State of Andhra Pradesh on the east coast of India (Dutt, 1976, 1979; Biswas, 1982; Kar & Bhaskar, 1982) but only olive ridley turtles have been reported to nest (Kar, 1983; Subba Rao *et al*., 1987). All five species are included in Schedule I of the Indian Wild Life (Protection) Act 1972, and are thereby accorded the highest degree of protection under the law; hunting of the turtles or damaging the eggs is strictly prohibited.

Olive ridley turtles are globally distributed and categorized as Endangered on the IUCN Red List (IUCN, 2002). Large nesting aggregations occur in Costa Rica and Mexico in the eastern Pacific and in the State of Orissa on the east coast of India (Pritchard, 1997). More than 100,000 turtles are believed to nest during mass nesting events or *arribadas* (spanish for arrival) at Gahirmatha, the northernmost rookery in Orissa, and >10,000 nest at other rookeries, mainly the mouth of Devi River and Rushikulya (Shanker *et al*., 2004). In recent years, the Orissa population has suffered severe fisheries related mortality with >90,000 dead adult turtles counted along the Orissa coast since 1994 (Pandav, 2001; B. Mohanty, pers. comm.).

Because Rushikulya, the southernmost mass nesting rookery in Orissa, is only 50 km from the Orissa–Andhra Pradesh border, the Andhra Pradesh coast could be an important nesting habitat for olive ridley turtles. The species is known to nest on the northern Andhra Pradesh coast (Raja Sekhar & Subba Rao, 1993; Priyadarshini, 1998) and large numbers have been reported to travel through the offshore waters of the states of Tamil Nadu and Andhra Pradesh to and from the nesting beaches of Orissa (Kar, 1983; Raja Sekhar & Subba Rao, 1993). However, little is known about the distribution and density of offshore aggregations or nesting along the coast, and there has been growing concern that, due to a rapid increase in the intensity of mechanized fishing along the Andhra Pradesh coast, significant mortality of

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turtles may be occurring during their breeding migrations. Although fisheries related mortality of marine turtles has been reported along this coast (Rao, 1984; Subba Rao *et al*., 1987; Raja Sekhar & Subba Rao, 1993; Priyadarshini, 1998), there have been no systematic surveys of the entire coast. In this context, a survey of the Andhra Pradesh coast was conducted to assess the status of marine turtles and their nesting habitats. In this paper, we report the results of nesting and offshore surveys, assess the threats to this population and to its nesting habitats, and suggest conservation strategies based on our findings.

Study area

Andhra Pradesh is one of the largest maritime states in India (Fig. 1). The 980 km coastline extends from the Bahuda River mouth at the border with Orissa in the north to Pulicat, a large brackish water lagoon, in the south. The northern coastline is rocky with some sandy beaches, the central coast has river deltas and mangrove swamps, and the southern coast is largely sandy. The natural beach flora along this coastline comprises mostly psammophytes, particularly *Ipomea pes-caprae*, *Spinifex littoreus* and *Launea sarmentosa*. There are also patches of mangroves in the Godavari and Krishna deltaic systems, and degraded mangroves occur at a few other sites. However the dominant flora along the coast are palmyra *Borassus flabellifer* and *Casuarina litorea* plantations on the beach, mostly established by the state Forest Department as barriers against cyclones. Cashew *Anacardium occidentale* and coconut *Cocos nucifera* have also been planted in some areas.

Andhra Pradesh has nine coastal districts with 453 fishing villages and 280 landing centres; in 1998 the population of fishers was 0.87 million, with 8,642 mechanized boats, 3,269 motorized craft (boats fitted with outboard motors for gill-net operations) and 54,000 non-mechanized boats (traditional craft) in coastal Andhra Pradesh (Anon., 1999). Of the total marine fish catch, 32% is from trawl nets, 24% from non-mechanized drift gillnets, 14% from bottom set gillnets, 13% by shore seine nets and the remainder by boat seine nets, driftnets, hooks and lines and other gear (Alagaraja *et al*., 1987).

Material and methods

Based on broad topographical differences, the entire coast was divided into three zones, i.e. northern, central and southern Andhra Pradesh (Fig. 1). Each zone was divided into sectors based on physiographic features such as river mouths, bays and estuaries. The survey was conducted in three phases: a pre-nesting survey, an offshore survey and a nesting survey. During the pre-nesting survey of May–September 2000 one coastal village or fish landing centre was visited per 20 km of coastline, covering all 10 sectors. Information was collected from 100 fishers,

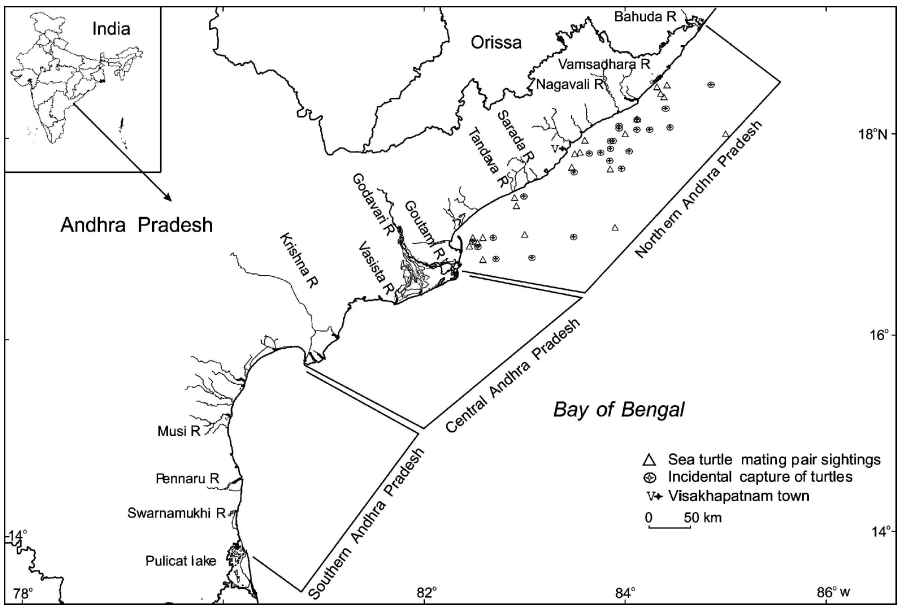

Fig. 1 The coast of Andhra Pradesh in eastern India. For the survey the coast was divided into northern, central and southern zones, and these were further subdivided into sectors, based mainly on the position of river mouths (see Table 3). Visual sightings of olive ridley mating pairs during offshore surveys and incidental capture during experimental trawls are also indicated.

18 coastal Forest Department offices and 32 state Fisheries offices using questionnaire interviews (Tambiah, 1999; Appendix 1). Beach characteristics (topography, lighting, plantations and human habitation close to the beach) were evaluated subjectively.

The offshore survey was conducted on board the Fishery Survey of India's *Matsya Darshini*, a 37 m trawler designed for bottom trawling, with instruments for depth measurement. Two 2-week cruises were made, one each in November and December 2000. Each survey covered 350 nautical miles between the Orissa–Andhra Pradesh border and the mouth of the Krishna River. A total of 30 and 32 trawls, conducted 5–20 km offshore, each for 90 min, were conducted on each survey at depths of 30–60 m. As effort was equal, catch per unit effort (CPUE) was calculated as the number of turtles captured per trawl. Locations of sightings of single turtles and mating pairs were recorded with a Global Positioning System.

The nesting survey was carried out in two parts: intensive surveys of seven beaches and monthly surveys of the rest of the coast. Nesting in Orissa to the north and Tamil Nadu to the south is primarily between January and March, with very low levels of nesting in December and April (Shanker, 1995; Pandav *et al.*, 1998). During November–December 2000 and April 2001 short surveys were conducted to verify the beginning and end of the nesting season. During the monthly surveys a total of 723, 361, and 608 km were surveyed by motorcycle and on foot during January, February and March 2001, respectively. Because of logistic constraints the entire coast was not surveyed, and the number of nests was therefore interpolated within each sector where the entire sector was not surveyed, and within each zone when sectors were incompletely surveyed. Nesting crawls and depredated nests were counted to evaluate nesting densities. Because locations were visited monthly and only fresh crawls were counted, it is unlikely that crawls were recounted. However, since these were not daily counts, the nesting figures may be underestimates of total nesting and were therefore considered only as a relative index for each zone.

Olive Ridley turtles are believed to prefer nesting sites near river mouths (Pritchard & Mortimer, 1999) and as mass nesting sites of ridley turtles in Orissa are known to be adjacent to river mouths (Pandav *et al.*, 1998), six of the seven intensive surveys were therefore on such beaches. All river mouth beaches were first assessed for suitability for nesting based on physiography and degree of nearby development (i.e. rocky beaches or beaches with major townships nearby were considered unsuitable; Appendix 2). For three of these intensive surveys 28 km of coastline between the rivers Vamsadhara and Nagavali (Fig. 1) in northern Andhra Pradesh was divided into three segments, two adjacent to river mouths, and one between the towns of Bandarvanipeta and Kundavanipeta, and each was surveyed with a variable intensity of 6–23 days per month. The total number of nests per month was extrapolated from those of the days surveyed. Four further beaches, all adjacent to river mouths, were selected on the basis of the preliminary survey and patrolled daily; only fresh crawls and freshly depredated nests were counted, and the results therefore represent the total nesting during these months.

Stranded dead turtles were counted during the monthly surveys. Sex was determined by the presence of a long tail and strongly curved claw on the fore flipper in males. Curved carapace length was measured from the anterior point at the midline (nuchal scute) to the posterior tip of the supracaudal. Curved carapace width was measured at the widest part of the shell.

Potential nesting along the entire coast of Andhra Pradesh was estimated from the results of the intensive nesting surveys. Nesting was estimated separately for the beaches adjacent to river mouths and for the rest of the coast. Average nest density for river-mouth beaches was calculated from the intensive surveys of the six river-mouth beaches. Total nesting was calculated as: number of river mouth beaches suitable for nesting * average length of beach * average nest density of river mouth beaches. To calculate the total nesting for the other beaches the relative nest densities in the three zones (north, central and south) were first of all calculated from the extensive surveys. The nest density for beaches in the northern zone was then estimated from the intensive survey of the one beach (within this zone) that was not on a river mouth. For the central and southern zones nest densities were calculated from the relative densities. Total nesting was estimated based on available beach length in each of the zones.

Non parametric tests (Mann Whitney U test, SPSS Version 8.0) were used to test differences in sizes between male and female turtles and dead turtles and turtles captured in offshore trawls.

Results

Pre-nesting survey

All interviewees reported nesting by olive ridley turtles (Table 1). A slightly larger percentage of Fisheries Department offices (21.9%) and fishers (20%) reported the presence of other species (leatherback, hawksbill and green turtles) compared to Forest Department offices (11.1%). Both Departments reported the consumption of eggs. However, while 38.9% of Forest Department offices reported the consumption of meat, 78.1% of Fisheries offices reported this. One third of Forest Department offices

Table 1 Results of interviews (Appendix 1) with coastal Forest Department offices, state Fisheries Department offices and fishers (by zone, see Fig. 1, and the total) along the Andhra Pradesh coast. All values are the percentage of affirmative answers to each question. (DNC, did not comment/did not know).

Question	Forest Department ($n = 18$)	Fisheries Department ($n = 32$)	Fishers			
			Northern zone ($n = 46$)	Central zone ($n = 26$)	Southern zone ($n = 28$)	Total ($n = 100$)
Olive ridley nesting?	94.4	100.0	100.0	100.0	100.0	100.0
>50 nests per season?	DNC	DNC	78.3	84.6	64.3	76.0
Decline in nesting?	DNC	DNC	97.8	88.5	85.7	92.0
Other turtle species?	11.1	21.9	28.3	15.4	10.7	20.0
Fisheries related mortality?	100.0	100.0	100.0	100.0	100.0	100.0
Mortality due to mechanized fishing?	DNC	65.7	93.5	80.7	75.0	85.0
Seasonality of bycatch						
Dec.–Jan.	DNC	DNC	47.8	7.7	17.9	29.0
Jan.–Feb.	DNC	DNC	89.1	96.2	89.3	91.0
Feb.–Mar.	DNC	DNC	47.8	34.6	50.0	45.0
Mar.–Apr.	DNC	DNC	10.9	3.8	7.1	8.0
>10 dead turtles per season?	DNC	DNC	65.2	53.8	21.4	50.0
Consumption of eggs?	88.9	100.0	DNC	DNC	DNC	DNC
Consumption of meat?	38.9	78.1	DNC	DNC	DNC	DNC
Forest Department protection?	33.3	0.0	0.0	11.5	0.0	3.0

reported measures of protection by their Department, but Fisheries Department offices and fishers reported that there was no and little protection, respectively.

Nearly 30% of the fishers in northern Andhra Pradesh and 10–15% in other zones reported the presence of species other than olive ridley turtles (Table 1), namely, leatherback, green and hawksbill turtles. The fishers identified the species from photographs and had local names for each species. Olive ridley turtles are known as *punuku tambelu* (*punuku* = hole, *tambelu* = turtle) for the small pore near the rear margin of each of the four infra-marginal scutes in their plastron. The hawksbill turtle is identified from its beak and is known as *chilaka tambelu* (*chilaka* = parakeet). The Green turtle is called *pedda tambelu* (*pedda* = large) and the leatherback is known as *doni tambelu* (*doni* = bullock cart wheel), as an indication of its size. The occurrence of loggerhead turtles could not be confirmed.

Seventy-six percent of fishers reported nesting intensities of >50 nests per season; 92% reported a decline in the last decade and 85% reported that they thought this was due to trawling-related mortality (Table 1). All zones reported high mortalities in January–February (91%), moderate levels in February–March (45%) and low levels in March–April (8%). 92% of fishers said that marine turtles were neither beneficial nor harmful, while the other 8% said they were negatively affected by the entanglement of turtles in their nets. The fishers identified the breeding and nesting seasons of olive ridley turtles as November–March.

In Hindu mythology marine turtles are worshipped as an incarnation (*kurma*) of one of the Hindu gods, and hence most fishing communities along the coast do not consume turtle meat. In northern Andhra Pradesh there is a caste named after the turtle (*kurma kulam*) and there are two temples devoted to turtles, the only ones of their kind in India. However, a few fishing communities collect turtle eggs for local consumption and sale at Rs 0.50 (1 US cent) each. In a few fishing villages in northern Andhra Pradesh an extract of marine turtle liver and bile is used to treat pregnancy related and rheumatic diseases.

Offshore surveys

A total of 27 mating pairs and 25 single turtles were sighted within 5–10 km of the coast during the offshore survey (Fig. 1). During this time >100 trawlers (an exact count was not made) were observed fishing within 5–10 km of the coast, where mechanized fishing is illegal. We caught and released a total of 32 and 30 olive ridley turtles in November and December, respectively, with an average of one turtle per trawl. The average number of turtles caught during trawls was 0.79 at 30–40 m ($n = 14$), 1.03 at 40–50 m ($n = 32$), 1.2 at 50–70 m ($n = 10$), and 0.5 at depths >70 m ($n = 6$). The November catch of marine turtles in trawl nets was dominated by males (97%) whereas all turtles caught in December were females. There was little if any difference in the mean sizes of male and female turtles (Table 2).

Table 2 Summary of size measurements of male and female olive ridley turtles captured and released during offshore trawls, and dead turtles stranded on beaches.

		Curved carapace length		Curved carapace width	
Location	Sex (n)	Mean (SE)	Range	Mean (SE)	Range
Offshore	Males (15)	66.3 (3.8)	57.0–70.0	63.8 (5.4)	51.0–69.0
	Females (14)	67.3 (4.0)	57.0–71.5	65.7 (3.7)	51.0–70.5
Dead on beach	Males (41)	68.4 (3.4)	58.2–78.0	65.5 (5.0)	48.3–75.5
	Females (35)	67.4 (6.7)	44.4–78.0	64.5 (7.0)	42.2–75.4
	Unknown (35)	68.2 (4.2)	56.5–76.3	65.8 (4.9)	48.3–72.5

Nesting survey

The results of the extensive survey indicated higher intensity of nesting in northern (2.7 nests km^{-1}) and central (3.8 nest km^{-1}) than southern Andhra Pradesh (0.96 nests km^{-1}) (Table 3). These represent counts from monthly surveys for January–March 2001 and are underestimates of the total nesting.

The intensive surveys of the single beach, in northern Andhra Pradesh, that was not adjacent to a river mouth (Bandarvanipeta–Kundavanipeta) indicated a nest density of 13 nests km^{-1} (Table 4). Intensive surveys of the six river mouth beaches indicated nest densities of 60–114 nests km^{-1} in northern and central Andhra Pradesh and 15–18 nests km^{-1} in southern Andhra Pradesh (Tables 4 & 5).

Short surveys carried out in November, December and April indicated that nesting during these months was negligible. The intensive surveys indicated maximum nesting in February and March (Tables 3–5), although peaks at different sites were not synchronous (Fig. 2). Almost all nests of olive ridley turtles along the Andhra Pradesh coast were depredated. Dogs *Canis familiaris* were frequently observed depredating nests, and jackals *Canis aureus* and hyenas *Hyeana hyaena* were also sighted along the coast and are known to depredate turtle nests.

Potential nesting

Although the intensive surveys in Andhra Pradesh (Tables 4 & 5) and nesting distributions in Orissa (Pandav *et al.*, 1998) indicated that nesting densities were generally higher near river mouths, no data is available to determine the relationship between nest density and distance from a river mouth. However, based on the fact that mass nesting beaches occur within *c.* 5 km of river mouths in Orissa (Pandav *et al.*, 1998), and on results from the intensive survey (Tables 4 & 5), we assumed a conservative length of 3 km for high density nesting at river-mouth beaches. There are 18 rivers in northern

Table 3 Number of olive ridley turtles nesting in the 10 sectors of the Andhra Pradesh coast (Fig. 1). Length indicates the extent of suitable nesting beaches within each sector. Nesting numbers represent the counts from single surveys only and hence may be underestimates of total nesting in each sector. Nesting was extrapolated within each sector when the entire sector was not surveyed, and within each zone when sectors within the zone were incompletely surveyed (in italics, with distances surveyed in parentheses).

			Number nesting			
Zone	Sector	Length (km)	Jan.	Feb.	Mar.	Total
Northern	Bahuda–Vamsadhara	100	2	270	111	
	Vamsadhara–Nagavali	28	0	112	68	
	Nagavali–Sarada	117	1	*56 (25)*	*77 (65)*	
	Sarada–Goutami	63	2	71		
	Subtotal	308	5	509	*321*	835
Central	Goutami–Veineteya	25	9	28	122	
	Veineteya–Krishna	160	23	*259 (120)*	*261 (30)*	
	Subtotal	185	32	287	383	702
Southern	Krishna–Musi	130	5		78	
	Musi–Pennaru	100	20		40	
	Pennaru–Swarnamukhi	80			17	
	Swarnamukhi–Pulicat	50			20	
	Subtotal	360	*39*	*150**	155	344
	Total		76	946	859	1,881

*Southern Andhra Pradesh was not surveyed in February, and hence nesting from March was used to arrive at a total for the zone.

Table 4 Nesting between the Rivers Vamsadhara and Nagavali from January to March 2001. The three beaches were separated by the towns Bandarvanipeta and Kunduvanipeta, and represented a stretch of beach south of a river mouth (Vamsadhara to Bandarvanipeta), north of a river mouth (Kunduvanipeta to Nagavali) and the coast in between (Bandarvanipeta to Kunduvanipeta). Beaches were surveyed multiple times during each month and nesting was extrapolated for the entire month from the days surveyed.

		Vamsadhara–Bandarvanipeta	Bandarvanipeta–Kunduvanipeta	Kunduvanipeta–Nagavali
	Name of Beach	Kalingapatnam	Srikakulam	Srikurmam
	Length of beach (km)	5	20	3
Jan.	No. of nests counted	45	10	76
	No. of days surveyed	13	6	17
	Estimated no. of nests	107	52	139
Feb.	No. of nests counted	143	23	91
	No. of days surveyed	12	6	23
	Estimated no. of nests	334	107	111
Mar.	No. of nests counted	50	44	13
	No. of days surveyed	12	13	12
	Estimated no. of nests	129	105	34
Estimated total no. of nests		570	264	283
Estimated nest density (km^{-1})		114	13	94

Table 5 Nesting at four beaches adjacent to river mouths: Kapaskudi, south of Bahuda River in northern Andhara Pradesh; Sacramento, south of Goutami River in central Andhara Pradesh; Krishna River mouth and Sriharikota, north of Pulicat estuary in southern Andhara Pradesh.

		Kapaskudi	Sacramento	Krishna	Sriharikota
Length of beach (km)		10	10	12	15
Number of nests	Jan.	15	36	8	154
	Feb.	343	241	118	106
	Mar.	289	331	56	14
Total nests counted		647	608	182	274
Nest density (km^{-1})		65	61	15	18

and central Andhra Pradesh, with 22 adjacent beaches suitable for nesting, and nine rivers with 12 adjacent beaches suitable for nesting in southern Andhra Pradesh (Appendix 2). Total nesting was calculated using a conservative value of 50 nests km^{-1} for northern and central Andhra Pradesh (for 18*3 = 54 km) and 20 nests km^{-1} for southern Andhra Pradesh (for 12*3 = 36 km), giving total potential nesting of *c.* 3,500 nests at river-mouth beaches along the Andhra Pradesh coast.

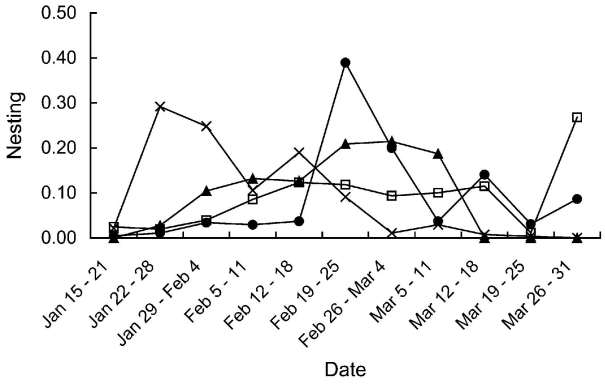

Fig. 2 Weekly nesting of olive ridley turtles at four beaches based on daily surveys, represented as a proportion of total nesting at that beach. The beaches are (a) Kapaskudi (filled circles) (b) Sacramento (crosses) (c) Krishna (filled triangles) (d) Sriharikota (open squares).

For beaches not adjacent to river mouths the extensive survey results indicated that the nesting density in the northern and central zones was twice that of southern Andhra Pradesh. The intensive survey of 20 km of beach, not adjacent to river mouths and between rivers in northern Andhra Pradesh, gave a nest density of 13 nests km^{-1}. Nest densities were therefore calculated for beaches in northern and central Andhra Pradesh (at 10 nests km^{-1} over 430 km) as 4,300 nests, and for southern Andhra Pradesh (at 5 nests km^{-1} over 324 km) as 1,600 nests, giving a total of 5,900 nests. Combining this with the estimated nesting on beaches adjacent to river mouths gives a total potential nesting for the Andhra Pradesh coast of *c.* 9,400 nests.

Strandings

806 dead olive ridley turtles were counted along the Andhra Pradesh coast between November and April 2001. Only five of these were in November and December, but

172 and 146 were counted during January and February, respectively, along the northern Andhra Pradesh coast alone. The number of dead turtles was less in central and southern Andhra Pradesh. During March and April the mortality declined in all three zones (Fig. 3). Of the 401 dead turtles that were sexed, 105 (26.5%) were males and 296 (73.5%) were females. Of 111 dead olive ridley turtles measured, seven were <60 cm and two were <50 cm in curved carapace length, indicating the occurrence of sub-adult turtles in these areas. There was no difference in size between male and female dead turtles, or between dead turtles and turtles captured during offshore trawls (Mann Whitney U test $P > 0.05$; Table 2).

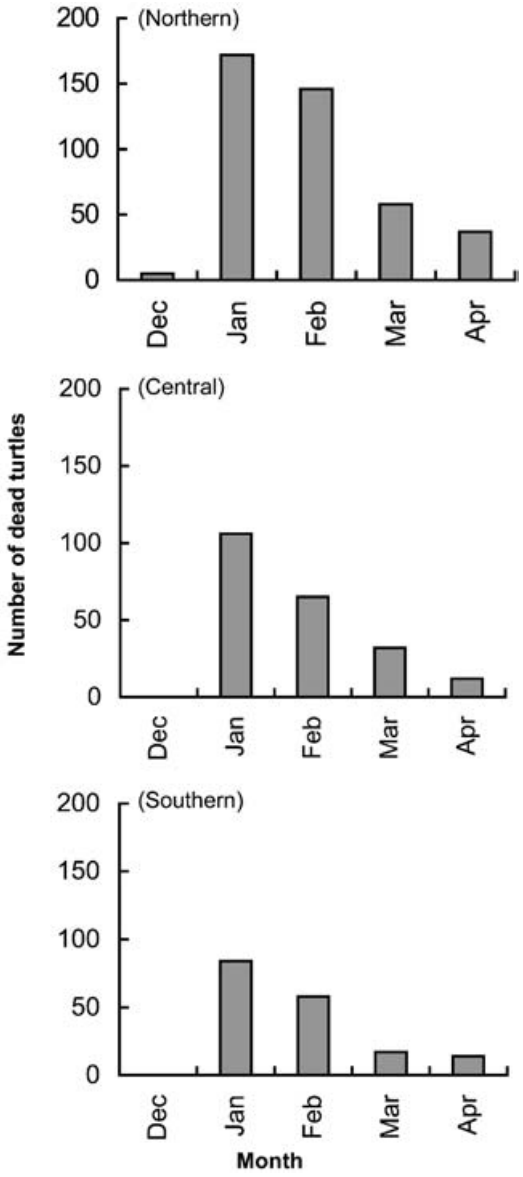

Fig. 3 Monthly tally of dead turtles washed ashore along the three zones of the Andhra Pradesh coast (Fig. 1).

Impact of coastal development along the coast

Collection of young shrimp was observed all along the coast. Nets are placed parallel to the coastline, and obstruct turtles from nesting. Shrimp hatcheries and prawn farms close to nesting beaches were most abundant along the central Andhra Pradesh coast. These were a major source of disturbance and lighting in this zone.

Discussion

The abundance of olive ridley turtles at a few sites could give the impression that they are not Endangered, but many sporadic and mass nesting populations of marine turtles may be in decline (Limpus, 1995). In this context a recent response to a petition against the 1996 Red List category of the olive ridley turtle, on the basis that there is evidence of large numbers of nesting turtles and increasing numbers in some areas, ruled that the species should continue to be listed as Endangered (IUCN Red List S&PS, 2001). Although population trends on the Andhra Pradesh coast could not be evaluated, the surveys described here provide a baseline for future assessments and also indicate potential threats to the population.

The *c.* 4,000 nests counted during the survey provide a lower bound for the numbers of olive ridley turtles nesting along this coast. The estimate of a total nesting population of *c.* 9,500 will need to be revalidated with data on the number of river mouths used for nesting, the length of important nesting beaches, and any variation in nesting between years. However, our data clearly demonstrate that beaches adjacent to river mouths are preferred nesting habitats for olive ridley turtles; these beaches had densities of 50–100 nests km^{-1} whereas densities averaged *c.* 10 nests km^{-1} along other parts of the Andhra Pradesh coast (Tables 3 & 4) and Tamil Nadu (Shanker, 1995; Bhupathy & Saravanan, 2002). In Orissa mass nesting beaches are also located in close proximity to river mouths (Pandav, 2001). Whether this preference is due to sediment deposits, salinity or other physiographic features is not known, although it merits investigation. Clearly, however, there is a need to focus conservation and management efforts at specific sites of high turtle density, rather than diffusely along the entire coast.

Olive ridley turtles arrive in Orissa in October and November, when they mate in offshore waters (Pandav, 2001). In both Orissa and Tamil Nadu nesting begins in December and usually peaks after January (Shanker, 1995; Pandav, 2001). In Andhra Pradesh, turtles were sighted in offshore waters during November and December, but nesting was negligible during these months. Nesting occurred during January–March, and was negligible in

April. This is also supported by information from fishers in Andhra Pradesh, who indicated that the breeding and nesting season occurs between November and March.

Marine turtles occupy a wide variety of habitats from the time they leave their natal beaches; they drift through pelagic habitats as hatchlings, feed in nearshore waters as juveniles, and return to nest as adults. Whereas their behaviour on nesting beaches is relatively well known, the foraging habitats of juvenile marine turtles are poorly documented. Two sub-adult green turtles were found dead near Vishakapatnam, northern Andhra Pradesh (Tripathy & Choudhury, 2002), and sub-adult olive ridley turtles were captured during experimental trawls and found dead along the Andhra Pradesh coast, suggesting that this coast may also serve as an intermediate developmental habitat for sub-adult ridley turtles and for juvenile and sub-adult green turtles.

The importance of the Andhra Pradesh coast also has to be considered in the context of the large numbers of turtles that nest in Orissa. Genetic studies indicate that all olive ridley turtles along the east coast of India form part of a single large population (Shanker *et al*., 2000). Olive ridley turtles use multiple nesting sites along the coast of Orissa, separated by up to 300 km (Pandav, 2001). Beaches used for mass nesting of olive ridley turtles in Orissa are dynamic habitats that may be altered by both human and natural causes (Pandav *et al*., 1998), and these turtles may be forced to change nesting beach (Shanker *et al*., 2004). Since the southernmost mass nesting rookery in Orissa is <50 km from the Andhra Pradesh border, there is a possibility that turtles from Orissa may also use beaches in Andhra Pradesh. It would therefore be prudent to protect suitable nesting habitats along this coast.

Tagging studies (Pandav, 2001) and satellite telemetry (WII, 2001) show that turtles that nest in Orissa migrate to Sri Lanka after nesting, and there are anecdotal reports of large numbers of turtles migrating together along the east coast of India (Dash & Kar, 1990). Recent satellite telemetry studies have also shown that olive ridley turtles that nest in Orissa migrate through Andhra Pradesh waters and may even remain in the offshore waters of northern Andhra Pradesh after nesting (WII, 2001). Hence, the turtles that nest in Orissa may face fishery related threats during their migration through Andhra Pradesh waters. The incidental mortality of olive ridley turtles in Orissa may already have caused a serious decline in that population (Shanker *et al*., in press).

Incidental capture in trawl and gill nets is a major cause of marine turtle mortality along the east coast of India (Rajagopalan *et al*., 2001) and our study also revealed high levels of fisheries related mortality along the Andhra Pradesh coast. Mortality was higher along the northern coast, which is probably due to the higher density of turtles in that region. Management interventions that would reduce fisheries-related mortality include:

(i) Declaring no-fishing zones during the nesting season in areas where the concentration of marine turtle nesting is high, especially near river mouths.
(ii) Enforcement of existing laws: the Andhra Pradesh Marine Fishing (Regulation) Rules, 1995, state that <15 m mechanized vessels may not operate within 8 km of the coast and vessels >15 m in length may not operate within 25 km of the coast. However, mechanized fishing was observed close to the shore during the present study and clearly the law is not enforced.
(iii) Use of the Turtle Excluder Device: although there is currently substantial opposition within the trawler community to their use in Orissa, the indigenous Turtle Excluder Device developed by the Central Institute of Fisheries Technology, Kochi, is being successfully promoted in Andhra Pradesh by the State Institute of Fisheries Technology, Kakinada (Bavani Sankar & Ananth Raju, 2003).

The Government of Andhra Pradesh has recently planned a number of new harbours, which are likely to result in an increase in fishing craft, gear and operations, leading to increased fisheries related mortality along the coast. Other problems include pollution from major industries, urban and military sewage, and sand mining. Many of these industries are also sources of light pollution. *Casuarina* and Palmyra plantations close to the beach render the habitat unsuitable for nesting and provide shelter to egg and hatchling predators, particularly jackals.

It is clear that olive ridley turtles must be protected throughout their nesting and migratory habitats along the east coast of India. However, the State Fisheries Department has only recently initiated measures to curb trawling related mortality (Bavani Sankar & Ananth Raju, 2003), and none of the nesting beaches or offshore areas are protected by law. The GOI UNDP marine turtle project has conducted preliminary workshops in Andhra Pradesh (Tripathy & Choudhury, 2001) as well as workshops on coastal development and the relationship between turtles and fisheries, in December 2002. Such workshops serve to increase awareness and participation amongst all stakeholders in marine turtle conservation.

The involvement of state agencies in marine turtle conservation in Andhra Pradesh has so far been minimal, as indicated by interviews with the Forest and Fisheries departments and with fishers, and NGO conservation programmes have focused only on the northern Andhra Pradesh coast (e.g. Ramana Murthy, 2001). During our survey four non-governmental organizations, from all three zones, were invited to assist with data collection and awareness programmes (Tripathy & Choudhury,

2001). Their continued involvement will provide a source of data and help with other aspects of turtle conservation such as the inclusion of local communities. In general the traditional fishers are not aware of the legal status of marine turtles, or even of their own fishing rights. Most do not actively fish for turtles and do not have any particular antipathy towards them, and turtles are worshiped along some parts of the coast. Given the high human densities along the coast, it is unlikely that exclusionary protection measures could either be initiated or successfully implemented. In this context it seems most useful to develop programmes based on a participatory approach, rooted in other aspects of coastal conservation and sustainable fishing practices that will also be beneficial to the communities. This would help in protecting multiple nesting habitats and also in protecting the turtles during their breeding migrations through offshore waters. The involvement of these communities and their welfare may thus be critical to the long term survival of marine turtles as well as coastal habitats along this coast.

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Biographical sketches

Basudev Tripathy has carried out research on olive ridley turtles in several states in India, including Andhra Pradesh and Orissa. He has recently completed an extensive survey of the sea turtles of the Lakshadweep islands, the first such study in over 20 years.

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