A CASE STUDY ON OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) SOLITARY NESTS IN GAHIRMATHA ROOKERY, ODISHA, INDIA

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Introduction

Sea turtles are known to occupy a series of different habitats in their life time: the developmental habitat in which juveniles feed and grow, the adult foraging habitat and the off-shore nesting beach habitat occupied by adult sea turtles during their breeding season (Musick & Limpus 1997). The habitat of interest here is the terrestrial habitat of the nesting females. Sea turtles come on land to lay eggs and they need beaches with deep, loose sand above the high tide mark (Hendrickson 1982). Conservation of sea turtles can include management of nesting beaches, nest translocation to protected hatcheries, head starting, reduction or removal of natural predators and protection against poaching and fishing (Bjorndal 1995; Ehrenfeld 1995). The protection of nesting beaches and nests is considered part of a broader sea turtle conservation strategy, where mortality factors at other stages of the life cycle have to be addressed (Spotila *et al.* 2000).

Olive ridley turtles arrive on the Odisha coast (eastern India) during early November and remain in the near shore waters for more than six months forming offshore breeding congregations. The breeding season for olive ridleys in Odisha extends from November to May during which mating, egg-laying and hatching take place (Dash & Kar 1990; Pandav & Choudhury 2000). Olive ridleys are listed as vulnerable by the IUCN Red List (Abreu-Grobois & Plotkin 2008) and as per CITES trade of any kind is prohibited; they are also included in schedule I of the Indian Wildlife (Protection) Act (1972) and are legally protected. However, in recent decades the Government or departmental agency has failed to record solitary nests and predation rate precisely.

Numerous studies have been conducted on the nesting of olive ridleys along the Odisha coast (Bustard & Kar 1981; Silas & Rajagopalan 1984; Dash & Kar 1990; Pandav & Choudhury 2000; Shanker *et al.* 2004). Most studies have focussed on the mass nesting of olive ridleys at their *arribada* in Gahirmatha, but information on the solitary nesting of olive ridleys is scanty and anecdotal. In spite of its importance, solitary nesting has never been evaluated adequately in many important nesting rookeries (Castro 1986). However, some information is available on solitary nesting of olive ridleys at Gahirmatha, Devi and Rushikulya rookeries (Pandav & Choudhury 2000; Tripathy 2008). Since the discovery of the Gahirmatha rookery, mass nesting has been recorded by the Odisha Forest Department. Nevertheless, solitary nesting has not been adequately evaluated. To remedy this, we carried out intensive monitoring of olive ridley nesting beaches and evaluated the conservation status of solitary nests along the 35-km coast of Gahirmatha rookery during three successive turtle breeding seasons. Our aim was to assess whether intensive beach monitoring is a valuable conservation strategy for a sea turtle nesting beach.

Methodological approach

Gahirmatha is the only marine wildlife sanctuary in Odisha and is situated on the north-eastern side of the Odisha coast (Fig. 1). The sanctuary encompasses an area of 1435 sq km, of which 1408 sq km are coastal waters whilst the rest constitutes mangrove forests, mudflats and sand spits. The 35km of turtle nesting rookery extends from the Dhamra river mouth to the Barunei river mouth and this forms the eastern boundary of the Bhitarkanika National Park (20° 52′ N to 20° 72′ N and 86° 45′ E to 87° 05′ E) (Fig. 1). The entire 35km of Gahirmatha rookery was divided into five sectors to monitor for the presence of solitary nests from November to May 2007-2008, 2008-2009 and 2009-2010. The study area encompasses three mainland beaches and two islets respectively: Barunei to Chinchiri (7km), Chinchiri to Satabhaya (11km) and Satabhaya to Ekakula Nasi (14km) are on the mainland and Nasi-I (2km) and South beach (1km) are islets (south-western part of Wheeler Island) (Fig. 2). South beach is the only nesting beach where the *arribada* has been taking place since 2009.

Each week four continuous days were spent in covering the entire 35-km stretch of beach. This work was carried out each morning by three trained field assistants and the main author. Occasionally nest monitoring was executed at night time, working in groups, when the intensity of solitary nesting was high along the coast. Nests were located by following nesting crawls. The nesting crawl was characterized by presence of a nest pit. In contrast, non-nesting crawls lacked a nest pit and the turtle had returned to the sea without nesting (Pandav & Choudhury 2000). Successful nest and false crawl data were recorded. The status of nests was recorded, whether in good condition or predated. At each predated nest, the species of predator was determined from footprints and faeces (Macdonald & Barrett 1993). In

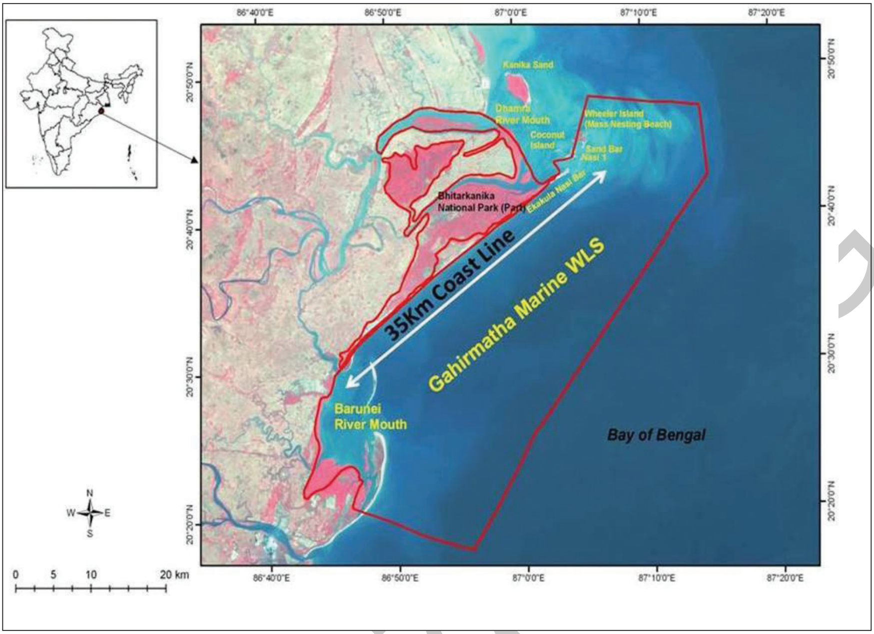

Fig. 1. Map of Gahirmatha rookery, extending along 35km of the Odisha coast line.

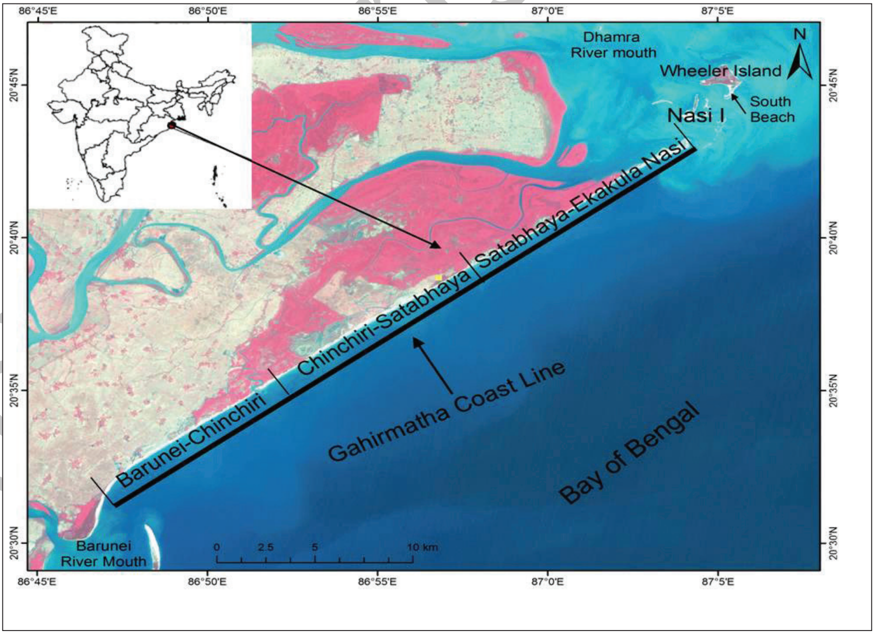

Fig. 2. Map showing the three mainland and two island sites of the Gahirmatha rookery.

Fig.3. Temporary hatchery at Chinchiri with eggshells at the far end where clutches have hatched.

Fig. 4. Temporary hatchery at Pentha.

Fig. 5. Burying a clutch in the Pentha hatchery.

addition to nesting data, factors such as inundation, erosion and predation on nest sites were documented.

All solitary nests were marked during the field work with a stick placed 30cm away from the nest to avoid disturbing the eggs in the chamber. They were translocated using a plastic gunny bag, either the same morning or later in the day, to the nearest forest beat (forest outpost) for *ex situ* conservation in one of our two hatcheries, placed near our research camps about 12km apart. Depending on the tide, the eggs could be carried by bicycle if necessary. Our intention was not to leave even a single nest behind in the beach, as there is a high possibility of predation, inundation and erosion. Each translocated nest was incubated in the temporary hatchery nearest to each survey sector (Figs 3-5). After incubation successful hatchlings were carefully released back into the surf zone of the sea.

Results

The study encompassed 21 months and involved 336 daily beach surveys on solitary nesting *Lepidochelys olivacea*. In total, 3,046 nests were counted and 4,981 non-nesting crawls documented. The frequency of nests laid from November to May peaked at 70% of nests laid in March (Fig. 6).

The mean number of nests estimated in the 35km study site for the 21 months was 145/month (S.D. = 93.3), with a peak in March (mean = 555.3,

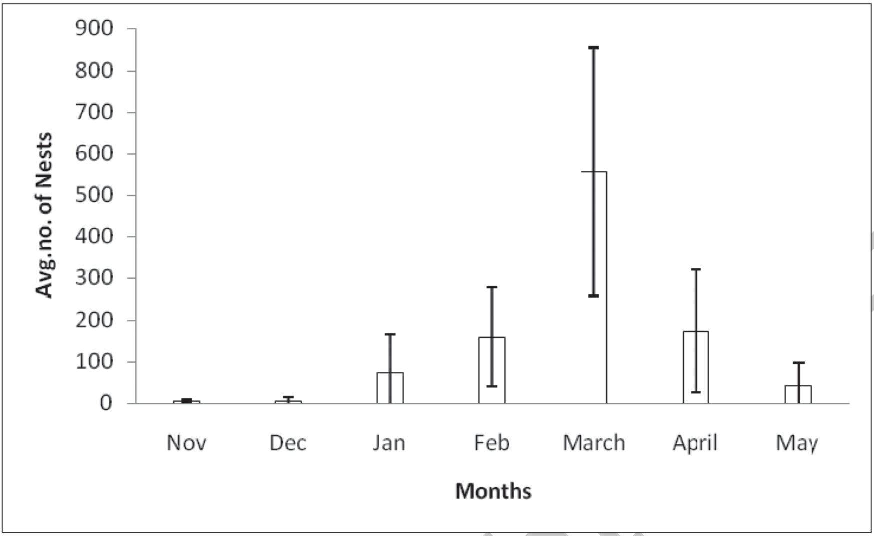

Fig. 6. Annual nesting pattern of olive ridleys (*Lepidochelys olivacea*) at Gahirmatha beach, from 2007-2008 to 2009-2010. A total of 3,046 nests were counted, averaging 145 (S.D. 93.3) nests per month.

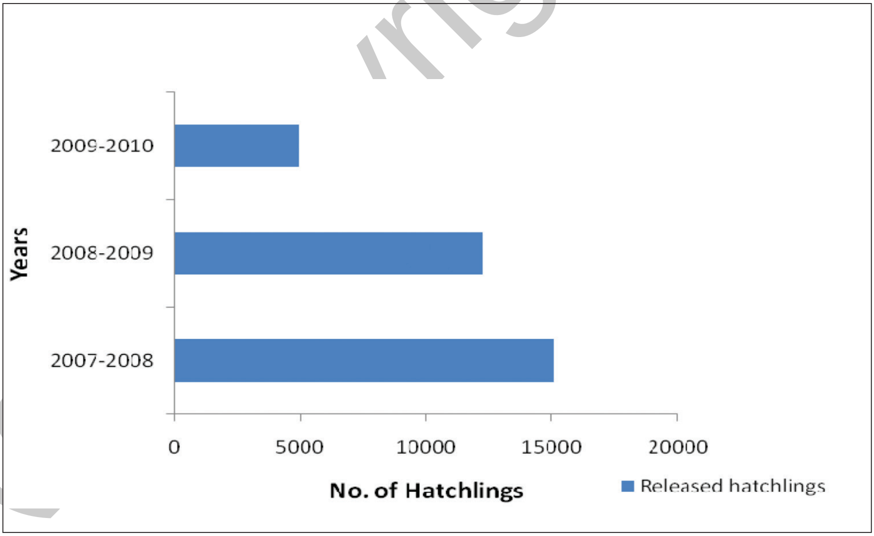

Fig. 7. Released olive ridley hatchlings (*Lepidochelys olivacea*) at Gahirmatha rookery, from 2007-2008 to 2009-2010.

S.D. = 298) and lowest number in November (mean = 3.3, S.D. = 3). The comparison of nests/km in the five nesting sectors is given in Table 1. The lowest number of nests recorded per km were in Satabhaya-Ekakula and Chinchiri-Satabhaya, and the highest on the two islands followed by the Chinchiri-Barunei mainland beach.

Table 1. Relative importance (nests/km) of the different beaches for solitary nesting olive ridleys (*Lepidochelys olivacea*) from 2007-2008 to 2009-2010.

Breeding Years	**South beach (1km)**	**Nasi-I (2km)**	**Satabhaya-Ekakula (14km)**	**Chinchiri-Satabhaya (11km)**	**Barunei-Chinchiri (7km)**
2007-08	375	50.5	6.1	5.6	125.7
2008-09	272	168	6	8.6	41.4
2009-10	360	14.5	0.6	0.1	9.2

Nests located within 2m from the high tide line were inundated by sea water, and counted as inundated nests; nests placed near the vegetation line were depredated by predators such as wild pig (*Sus scrofa*), hyenas (*Hyaena hyaena*), jackal (*Canis aureus*), water monitor lizard (*Varanus salvator*) and stray dogs (*Canis familiaris*). Some portions of the nests were depredated partially by ghost crabs (*Ocypode* spp) and seagulls (*Larus brunnicephalus*).

A total of 294 fresh solitary nests were translocated to hatcheries. There were 32,340 hatchlings released from translocated nests (Fig. 7). The mean hatching success rate of the 294 nests was 54.7% (S.D. = 23.8). The remaining 2,752 nests were destroyed by inundation and predation (Table 2). The highest tidal inundation was observed on Nasi-I (89.2%) and South beach (80%) while high predation took place in Barunei-Chinchiri (79.5%). Inundation and predation were common throughout the study area with peak levels observed during the 2007-2008 breeding season.

Table 2. Solitary nesting record, inundation, predation and percentage of nest survival in each sector during three years of study. All surviving nests were translocated to the hatchery.

Year	Site	Total nests	Erosion & Inundation (%)	Predation (%)	Nest survival (%)
2007-08	South beach (1km)	375	300 (80)	54 (14.4)	21 (5.6)
2008-09	South beach (1km)	272	192(70.5)	66(24.2)	14(5.1)
2009-10	South beach (1km)	360	287(79.7)	45(12.5)	28(7.8)
2007-08	Nasi-I (2km)	101	72(71.2)	20(19.8)	9(8.9)
2008-09	Nasi-I (2km)	336	300(89.2)	19(5.6)	17(5.1)
2009-10	Nasi-I (2km)	29	23(79.3)	6(20.6)	0(0.0)
2007-08	Satabhaya-Ekakula (14km)	86	10(11.6)	73(84.8)	3(3.5)
2008-09	Satabhaya-Ekakula (14km)	84	6(7.1)	77(91.6)	1(1.2)
2009-10	Satabhaya-Ekakula (14km)	9	0(0)	9(100)	0(0.0)
2007-08	Chinchiri-Satabhaya (11km)	62	5(8)	50(80.6)	7(11.3)
2008-09	Chinchiri-Satabhaya (11km)	95	6(6.3)	78(82.1)	11(11.6)
2009-10	Chinchiri-Satabhaya (11km)	2	0(0)	2(100)	0(0.0)
2007-08	Barunei-Chinchiri (7km)	880	63(7.1)	700(79.5)	117(13.3)
2008-09	Barunei-Chinchiri (7km)	290	45(15.5)	198(68.2)	47(16.2)
2009-10	Barunei-Chinchiri (7km)	65	7(10.7)	39(60)	19(29.2)

Discussion

Solitary nesting emergence of olive ridleys is known to occur almost every month along the Odisha coast (Dash & Kar 1990). However, solitary nesting is found in greater numbers from January to May, signifying that this is the main nesting season for this species (Pandav & Choudhury 2000). Our results indicate that solitary nest numbers increase from January and peak in March, followed by decreases in April and May. Satellite telemetry has revealed that olive ridleys have left the Odisha coast by the last week of May or first week of June (WII-DGH Turtle Project Interim Report, 2011); this may account for the low intensity of nesting during May.

Arribadas did not take place during 2007-2008 in Gahirmatha, but high sporadic nesting was observed in the following period all over the area (Annual Report WII, 2010). Cornelius (1982) considered all non-*arribada* nesters to be solitary nesters. The number of nesters gradually increases from and then returns to solitary or sporadic numbers after an *arribada*. These solitary nests are reproductively highly effective and their nests need to be protected to achieve good conservation (Eckrich & Owens, 1995; Tripathy, 2005, unpublished PhD thesis). In 2009-2010 the numbers of sporadic nesters were drastically reduced in all sectors with the exception of South beach. South beach is the preferred nest site for olive ridleys and *arribadas* have been observed there since 2008-2009. In addition in 2009-2010 two *arribadas* were observed at South beach with a gap of 14 days. As a result, after the 2009-2010 *arribada* a low intensity of sporadic nests was recorded in the remaining sectors. The intensity of nesting was low at Chinchiri-Satabhaya and Satabhaya-Ekakula possibly because of heavy anthropogenic disturbances and high predator risk along these sectors. Movements of local people and considerable fishing activity also occurred along these nesting sectors. Additionally local inhabitants collected mangrove stumps and casuarinas for fuel wood. All these activities may have affected the turtles' nesting behaviour.

The olive ridleys in this study exhibited preference to lay their nests in locations with no vegetation cover, which has previously been observed in green turtles at Tortuguero, Costa Rica (Bjorndal & Bolten 1992). However, observations were made that a few nests were placed near the vegetation line and those nests were destroyed by predators. Mrosovsky (1983) found that ridley turtles nest close to the sea and many nests were inundated by sea water. Our study indicates that nests deposited within 2m of the high tide line were destroyed by spring tidal water. Several olive ridley clutches laid below the high-water mark were covered by subsequent high tides in northern Australia (Whiting *et al.* 2007). Most of the solitary nests were damaged by inundation and some were found to be destroyed by predators. Predation is also a major cause of sea turtle nest losses in many other beaches of the world (Stancyk 1995).

An important part of this study was the translocation of nests to an enclosed hatchery near the forest beat to avoid nest losses by beach inundation or erosion and predation, particularly due to frequent tidal influx after the nesting season in the study area (Dash & Kar 1990). After the peak nesting season in March heavy erosion is generally observed all along the Odisha coast.

Nest translocation is an important conservation tool on beaches where natural hatching is low or non-existent due to poaching, predation and erosion (Grand & Beissinger 1997). Nests should only be translocated if they are low enough on the beach to be washed daily by tides or if they are situated in well documented high risk areas that routinely experience serious erosion and egg loss. Due to heavy anthropogenic and predator pressure occurring on the Madras coastline, local conservationists relocate eggs to a protected area or hatchery (Shanker 2003).

Beach erosion, inundation and predation are common at this study site. This study indicated that 35% of nests on average were damaged by erosion and inundation and 43% of nests were destroyed through predators. Therefore, along with the protection of *arribada* nests, it is necessary to monitor the beach intensively and to safeguard olive ridley sporadic nests as well as their habitat at Gahirmatha rookery.

Intensive beach patrolling and nest translocation was an effective way to reduce nest losses in Gahirmatha. The mean hatching success rate of the 294 nests was 54.7%, but we have checked only the translocated nest hatching success rate, so another study is needed to assess the success rate in *in situ* solitary nests. Since the study area was especially vast and extended along 35km of nesting beach, sometimes it was difficult to locate a nest in good time. An important part of this study was translocation of the remaining successful nests in the beach to the nearest forest beat to avoid nest losses by further beach inundation or erosion and predation. This current study strengthens the conclusion that beach protection is a priority strategy for sea turtle conservation (Garcia *et al.* 2003). Beach erosion, inundation and predation were natural causes of severe nest loss. Direct sightings were made of egg-laying olive ridleys being attacked by wild pigs between Satabhaya and Ekakula nesting segments (personal observation). Therefore wire mesh should be erected near the vegetation line to deter intruding predators such as wild pig, jackal and hyenas onto the nesting beach. The long-term conservation of olive ridleys in Gahirmatha, as in other regions of the world, depends on their protection at nesting sites as well as their critical habitat.

Acknowledgements

We thank the Director and Dean, Wildlife Institute of India, and also the Government of Odisha Forest Department for giving us permission to carry out this research. We are grateful to our funding agency Director General of Hydrocarbon (DGH), Government of India. Lastly we are extremely thankful to our three trained assistants for their utmost help in the field.

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